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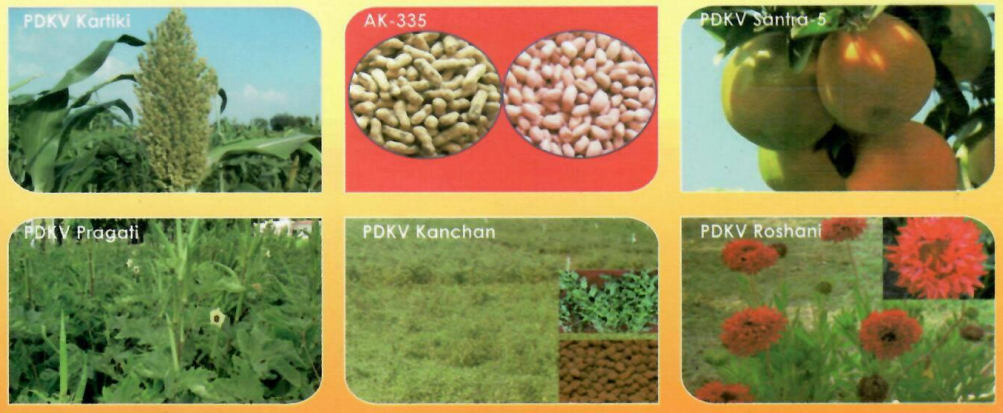

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CONTENT

Vol. 41 **No. 1** **January 2017**

Research Notes

PKV Res. J. Vol. 41 (1), January 2017

Assessment of Genetic Variability and Diversity in Cultivars of Rice

N. V. Kayande[1] and N. K. Patke[2]

ABSTRACT

A set of sixty-five rice (*Oryza sativa* L.) accessions were screened for twelve morphological characters to study the nature and magnitude of genetic divergence using Mahalanobis D^2 statistics. The genotypes showed wide range of variation for all the characters indicating the presence of high genetic variability among the genotypes. Higher values of genotypic and phenotypic coefficient of variability were recorded for test weight, L:B ratio, plant height and spikelets per panicle. High heritability estimates coupled with high genetic advance values were observed for spikelets per panicle and plant height. Based on D^2 statistics, sixty-five genotypes were classified into ten clusters. The maximum inter-cluster distance was observed between cluster VIII and IX and the genotypes from these clusters can be used in further breeding program. The clustering pattern of the genotypes was quite random, however indicated the importance of traits viz. test weight and grain L:B ratio.

The rice crop improvement program should necessarily be aimed at broading the genetic base of the breeding stock (Vanaja and Babu,2004) to accomplished the future development. India is having tremendous biodiversity. The number of landraces cultivated locally are rapidly replaced by improved varieties, thereby narrowed down the genetic base (Guei, 2000). This reduction in genetic variability, underscores the need to collect landraces for *ex-situ* conservation and to characterize them for future rice breeding program.

Germplasm collection constitutes the foundation of any genetic improvement program of crop. The pace and magnitude of genetic improvement generally depends on the amount of genetic variability present in the germplasm. Majority of economically important characters including grain yield, grain quality traits and disease and pest resistance are amenable for genetic improvement through *inter se* breeding among genetically diverse parents. Murthy and Arunachalam (1966) stated that multivariate analysis with "Mahalanobis D^2 statistics" is a powerful tool to know the clustering pattern to establish the relationship between genetic and geographical divergence and to determine the role of different quantitative characters towards the maximum divergence. In view of this, the present study was conducted to evaluate the extent of genetic variability and diversity among 65 rice genotypes based on important morphological traits.

MATERIAL AND METHODS

Sixty five diverse genotypes of rice including 25 landraces, 8 local selections and 32 improved varieties maintained at Agriculture Research Station, Sindewahi, District, Chandrapur, (M.S.) India were evaluated during rainy season of 2013. The experiment was laid out in Randomized Block Design with two replications. The plant spacing of 15 cm and row spacing of 20 cm was adopted for experiment. All agronomic package of practices were carried out to ensure the healthy plant growth. Observations were recorded on randomly selected ten plants in each replications for twelve quantitative traits viz., Days to 50 per cent flowering, days to maturity, panicle length (cm), plant height (cm), spikelets panicle^{-1}, spikelet fertility (%), tillers plant^{-1}, test weight (gm), grain length (mm.), grain breadth (mm), L: B ratio, seed yield plant^{-1} (gm).

The data were analyzed following the standard method given by Panse and Sukhatme (1985). Genoypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated following the method suggested by Burton (1952), whereas heritability was calculated following Burton and Devane (1953) and the genetic advance was calculated as per Johnson *et al.*, (1955) using Windostat Genetic Analysis Software. The genetic divergence was estimated using D^2 statistics given by Mahalanobis (1936) as described by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed that mean sum of squares due to the genotypes were highly significant for all morphological traits under study, designating considerable variation among the genotypes for all the traits under study. The present material therefore could serve a pool for selection of suitable material for breeding

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program. Results are in agreement with the findings of Gahalain (2006) and Naik *et al.* (2002), who reported significant differences for all the characters in their studies. Low, medium and high GCV, PCV, h^2 and ga classification was provided by Deshmukh *et al.,* (1986), Dhabholkar (1992) and Johnson *et.al.*, (1955) was used in the present study for their classification. Among the characters studied, grain length: breadth ratio exhibited highest GCV and PCV (26.12 and 26.44) respectively, followed by test weight (24.60) and 240.61) whereas, spikelet fertility exhibited the lowest GCV (1.42) as well as PCV (1.75) (Table 1). The results are in confirmation with Singh and Choudhary (1985) who were reported higher PCV and GCV for number of panicles per plant and test weight and Marekar and Siddique (1997) who were reported higher GCV and PCV for grain length : breadth ratio. The difference between the magnitudes of GCV and PCV was observed very low for all the characters studied, thereby indicating the good correspondence between genotypic and phenotypic expression of traits with low level influence of environmental factor. The proportion of genetic variability, which is transmitted from parents to its progeny, is reflected by heritability. In the present investigation, all the characters exhibited high estimates of broad sense heritability ranged from 66 per cent for spikelet fertility to 99 per cent for test weight and grain length (Table1). Naik *et al.*, (2002) and Raut *et al.*, (2009) also reported high heritability estimates for morphological traits studied by them. As heritability in broad sense includes both additive and non-additive gene effects, heritability estimates should be considered in combination with genetic advance (Johnson *et al.*, 1955). Based on this consideration in present investigation, high heritability coupled with high genetic advance was observed for spikelets per panicle, plant height, days to maturity and days to 50 per cent flowering. Direct selection based on these traits would be effective as heritability and genetic advance might be due to additive gene action. Genetic advance for seed yield per plant was low indicating the predominance of non-additive gene interaction, however, when it was expressed as percentage of mean, it seems to be fairly high. Raut *et. al.*, (2009) also reported high heritability and high genetic advance for grains per panicle, plant height, days to maturity, 1000 grain weight and highlighted the importance of these characters in direct selection.

The important objective in obtaining biometrical measurements is to understand the possibilities of classifying individual genotypes into different groups. With this view, the genetic divergence among 65 genotypes of rice was measured as per Mahalanobis's D^2 statistics. The D^2 values corresponding to the pair of genotypes was ranged from 4.21 to 24015.45 indicating the presence of huge diversity among genotypes. Wide variation for agro-morphological traits of rice was also observed by many researchers (Naik *et al.*, 2002, Gahalain, 2006, Raut *et al.*, 2009). The land races reported higher D^2 values indicating their variedness as compared to the local selection and improved varieties.

Table 1 : Variability parameters of sixty five genotypes of rice

S. N.	Character	Range	Mean	G.C.V.	P.C.V.	Heritability % (BS)	Genetic of mean	G.A. as % advance
1.	Days to 50% flowering (number)	62.25-124.75	105.115	9.805	10.224	92.00	20.362	19.371
2.	Days to maturity (number)	86.00-155.25	135.108	9.105	9.604	89.90	23.748	17.784
3.	Plant height (cm)	65.03-152.48	107.237	20.932	21.591	94.00	44.829	41.804
4.	Panicle length (cm)	17.00-27.55	23.033	11.014	11.885	85.90	4.843	21.027
5.	Spikelets per panicle (number)	76.70-239.10	153.115	20.094	21.027	91.30	60.571	39.559
6.	Spikelet fertility (%)	87.61-96.43	94.249	1.423	1.749	66.10	2.246	2.383
7.	Tillers per plant (number)	5.45-9.45	7.393	11.342	13.123	74.70	1.493	20.193
8.	Test weight (g)	9.46-33.70	21.624	24.605	24.612	99.90	10.957	50.671
9.	Grain length (mm)	3.88-8.05	6.088	16.148	16.197	99.40	2.019	33.163
10.	Grain breadth (mm)	1.60-2.92	2.139	14.128	17.169	67.70	0.512	23.947
11.	L :B ratio	1.44-5.05	2.959	26.123	26.437	97.60	1.573	53.175
12.	Seed yield per plant (g)	6.69-21.38	16.073	17.445	19.515	79.90	5.164	32.126

Table 2 : Distribution of 65 genotypes of rice into different clusters.

Cluster number	Total No. of genotypes included	Name of Genotype
I	22	Phule Samruddhi, RDN 99-12, KJT-2, Indrayani, RDN 99-14, Haryana Basmati, Kasturi, RDN 01-2-10-9, Ratna, Improved Pusa Basmati, Taroari Basmati, Karnal local, RTN purple, S.D.-7, Basmati 370, Bhogavati, Sugandhamati, E.K. 70, RDN 99-18, Sonsali, Antersal, Juhibengal.
II	7	Ghansal, Ajara local-1, Ambemohar 157, Ajara local-3, Badshabhog, BPT-5204, Phule Radha.
III	14	Halvi Sal 17, RDN 185-2, Pomendi local, Jaya, Pinjarwadi local, L.K. 248, Nalabhat, RTN-1, Heera, Kunchi, Mahisugandha, IGT 13857, MC-4, Pawana
IV	12	Velkat, Tulshi tall, RDN 98-2-3-5-14, RDN 97-2, Vikram, Ambemohar 102, RDN 02-80, Kalajirga, Jagatpuri, Kothimbire, Champakali.
V	1	Pusa Basmati-1.
VI	1	Pavsal.
VII	1	SD 17
VIII	4	Vivek Dhan 82, Siddhagiri, Phule Maval, Patni.
IX	2	Diwani, Shyam Jeer.
X	1	Khalibagh.

Table 3 : Average intra and inter cluster D^2 values of 10 clusters .

Cluster number	I	II	III	IV	V	VI	VII	VIII	IX	X
I	191.55	3940.07	1188.18	1128.96	377.53	509.41	820.25	3516.49	6947.22	724.69
II		256.64	8277.36	1296.00	4563.00	5095.10	7638.76	13656.26	641.61	3666.30
III			282.58	3642.12	1612.83	638.07	668.74	998.56	12624.77	2770.97
IV				350.06	1627.32	1710.65	3306.25	7394.28	3090.24	1428.84
V					0.00	1168.96	554.60	3976.56	7572.48	184.69
VI						0.00	1087.68	2328.06	8602.56	1944.81
VII							0.00	1832.70	11664.00	1285.22
VIII								457.10	19165.63	5776.00
IX									111.94	6144.99
X										0.00

Table 4 : Mean performance of 10 clusters for morphological characters in rice

S.N.	Character	Cluster number									
		I	II	III	IV	V	VI	VII	VIII	IX	X
1.	Days to 50% flowering (No.)	107.36	109.00	98.82	105.50	98.25	121.25	106.50	101.38	109.75	107.00
2.	Days to maturity (No.)	136.55	138.00	125.91	133.90	123.75	151.00	136.25	128.25	140.00	136.50
3.	Plant height (cm)	99.59	123.43	104.78	108.03	98.28	138.55	104.18	124.06	115.94	83.03
4.	Panicle length (cm)	22.85	24.32	22.75	21.67	25.13	23.90	25.65	24.64	23.91	24.60
5.	Spikelets per panicle (No.)	143.80	206.27	134.44	159.68	131.45	141.50	166.65	141.44	196.53	148.20
6.	Spikelet fertility (%)	93.76	95.26	93.99	94.52	93.52	94.80	94.10	94.93	95.41	93.68
7.	Tillers per plant (No.)	7.73	6.91	6.88	7.79	7.35	9.10	6.90	6.61	7.10	8.40
8.	Test weight (g)	22.05	13.17	26.97	17.98	21.75	24.35	25.27	31.13	9.65	19.83
9.	Grain length (mm)	6.65	4.69	6.27	5.41	7.75	5.23	7.95	6.39	4.68	8.05
10.	Grain breadth (mm)	2.01	2.05	2.34	2.11	1.67	2.37	1.75	2.52	2.49	1.60
11.	L :B ratio	3.40	2.35	2.75	2.62	4.65	2.21	4.56	2.63	2.08	5.05
12.	Seed yield per plant (g)	16.07	15.35	15.69	16.04	15.39	16.54	16.54	18.73	16.50	15.27

The classification by Tocher's method grouped the rice genotypes into 10 clusters (Table 2). Cluster I was the largest including 22 genotypes followed by cluster III (14 genotypes) cluster VIII (4 genotypes) and cluster IX (2 genotypes). The clusters V, VI, VII and X had single genotypes. Cluster I is having largest number of genotypes, mainly comprised of improved varieties having dwarf plant types with long-slender grain types and medium test weight. Whereas, cluster II consisting of seven genotypes was characterized by short slender or short-bold grained genotypes with long panicle length and higher number of spikelets. The widely cultivated fine grain varieties BPT 5204 and Phule Radha were grouped in this cluster. Cluster III represents medium-slender or long- bold genotypes with medium grain length, broader grain width and higher test weight, whereas the four genotypes (Vivek Dhan 82, Siddagiri, Phule Maval, Patni) with very bold grains, low length-breadth ratio and high grain yield per plant were grouped in the cluster VIII.

The cluster IX comprised of two landraces, one each from Uttar Pradesh (Diwani) and another from Bihar (Shyamjeer). These genotypes have short-slender grain with very low test weight (9.65 g) grouping them separately from the other genotypes. These land races can be utilized for breeding of fine grain varieties.

Intra and inter cluster D^2 values were worked out from divergence analysis (Table 3) showed maximum intra-cluster distance between cluster VIII ($D^2 = 457.10$), followed by cluster IV (350.06) and cluster III ($D^2 = 282.58$), indicating that the genotypes in these clusters might have different genetic architecture. The minimum intra-cluster distance was found in cluster IX ($D^2 = 111.94$), followed by cluster I ($D^2 = 191.55$) and cluster II ($D^2 = 256.64$).The cluster III, V, VI and VII being monogenotypic, had intra-cluster distance 0.00.

The maximum inter-cluster distance was observed between cluster VIII and IX ($D^2 = 19165.63$), followed by cluster II and VIII ($D^2 = 13656.26$) indicating a wide range of divergence among these clusters, whereas, the cluster V and X ($D^2 = 184.69$) reported minimum inter –cluster distance followed by cluster I and V ($D^2 = 377.53$ suggesting minimum genetic relatedness among the genotypes of concern clusters. Genotypes of distinct clusters separated by high genetic distances would be utilized in breeding program for obtaining a wide range of variability in segregating generation.

Cluster means for twelve characters are presented in table 4 and revealed wide range of variability among the clusters for the characters plant height, days to 50

Table 5: Percent contribution of 12 morphological characters for divergence in rice.

S. N.	Character	No. of times appearing Ist in ranking	Per cent contribution
1.	Days to 50% flowering (number)	10	0.48
2.	Days to maturity (number)	0	0.00
3.	Plant height (cm)	24	1.15
4.	Panicle length (cm)	0	0.00
5.	Spikelets per panicle (number)	2	0.10
6.	Spikelet fertility (%)	2	0.10
7.	Tillers per plant (number)	1	0.05
8.	Test weight (g)	1644	79.04
9.	Grain length (mm)	269	12.93
10.	Grain breadth (mm)	4	0.19
11.	L :B ratio	123	5.91
12.	Seed yield per plant (g)	1	0.05
	Total	**2080**	**100.00**

per cebt flowering, days to maturity, spikelets per panicle, tillers per plant, test weight, grain length, grain breadth and L:B ratio. Gahalain (2006) also reported wide variation in mean performance among twelve clusters of 55 rice genotypes, whereas Raut *et al.*, (20009) reported wide variation in the performance of three clusters formed from 40 rice genotypes for the characters studied by them. The per cent contribution of the twelve characters towards total divergence (Table 5) indicated that test weight has contributed a major part of divergence (79.04 %), followed by grain length (12.93 %) and length: breadth ratio (5.91 %). The contribution of other characters is meager. This suggested that test weight, grain length and length: breadth ratio should deserve the consideration while choosing parents for breeding program. Higher contribution of test weight and length: breadth ratio was also reported by Bharadwaj *et al.*, (2001). Based on the diversity study, the genotypes from genetically diverse clusters can be selected to exploit maximum heterosis and to get the best tansgressive segregants in advance generations. The crosses between genotypes from clusters II, III, VIII and IX may give high heterotic performance. Genotypes from these clusters with higher grain yield and /or specific traits can be used in further breeding program.

LITERATURE CITED

Bharadwaj, C. C., T. Satyavati and D. Subramanyam, 2001. Evaluation of different classificatory analysis methods in rice (*Oryza sativa*) collections, Indian J. Agric. Sci. 71(2) : 123-125.

Bouman, B.A., X. Yang, H. Wang, Z. Wang, Zhaojunfang, C. Wang and B. Cheug, 2002. Aerobic rice (Han Dao): A new way of growing rice in water short areas, 12th ISCO Conference : 175-181.

Burton, G.W.1952. Quantitative inheritance in Grasses, Proc. 6th Int. Grassland Congress 1: 227-283.

Burton, G.W and E. H. Devane, 1953. Estimating heritability in tall fescue from replicated clonal material, J Agron 45: 478-481.

Dabholkar, A.R., 1992. Elements of Biometrical Genetics.Concept publication company, New Delhi, India :138-140

Deshmukh, S.N., M.S. Basu and P.S. Reddy, 1986. Genetic variability, character association and path coefficients of quantitative traits in Virginia bunch varieties of groundnut, Indian J. Agric. Sci.,56 : 816-821

Gahalain, S. S. 2006. Genetic divergence in rice (*Oryza sativa* L.) genotypes grown in Kumaun Himalaya, Indian J. Genet. 66(1) : 37-38.

Guei, G.R. 2000. Participatory varietal selection and rice biodiversity at community levels. Paper presented at the participatory varietal selection workshop, West Africa Rice development Association,13-21.

Johnson, H.W., H.E. Robinson and R.E. Comstock, 1955. Estimation of genetic and environmental variability in soybean, Agron. J. 47 (7) : 314-318.

Mahalanobis, P. C. 1936. On the generalized distance in statistics, Proc. Natl. Inst. Sci. India. (2): 49-55.

Manomani, S and A.K. Fazlullah Khan, 2003. Studies on combining ability and heterosis in rice, Madras Agric. J.,90: 228 – 231.

Marekar, R. V. and M. A. Siddiqui, 1997. Genetic variability and correlation studies in rice, J. Maharashtra Agric. Univ. 21 (2) : 249-251.

Murthy, B. R. and V. Arunachalam, 1996. The nature of divergence in relation to breeding systems in some crop plants, Indian J. Genet. 26(1) : 188-198.

Naik, A. R., D. Choudhary and J. N. Reddy, 2002. Genetic variability, heritability and genetic advance in scented rice, The Andhra Agric. J. 49 (1&2) : 143-145.

Panse, V. G. And P. V. Sukhatme, 1985. Statistical methods for agricultural workers, ICAR, New Delhi. Ed.4.pp359.

Rather, A. G., G. N. Mir and F. A. Sheikh, 1998. Genetic parameters for some quantitative traits in rice, Advances Plant Science. 11(2) : 163-166.

Rao, C. R., 1952, Advanced statistical methods in Biometrical Research. Ed.1. John Willey and Sons, Inc., New York.

Raut, K. R., P.N. Harer and P.S. Yadav, 2009. Genetic divergence in rice (*Oriza sativa* L.) using morphological, physiological and SSR markers, J. Mah. Agri. Univ., 32(2) : 172-174

Sharma, D., G.S., Sanghera, P., Sahu, M., Parikh, B., Sharma, S., Bhandarkar Chaudhari, B., and B.K. Jena, 2013. Tailoring rice plants for sustainable yield through ideotype breeding and physiological interventions, African J Agric Res. 40:5004-5019.

Singh, S. and B.S. Choudhary, 1985. Variability, heritability and genetic advance in cultivars of rice (*Oriza sativa* L.), Crop Res., 12(2) :165-167

Vanaja, T. and L.C. Babu, 2004. Heterosis for yield and yield components in rice (*Oriza sativa* L.), J. Trop. Agric., 42:43-44

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Influence of Source Manipulation on Morpho-Physiological Parameters, Biomass Yield and Quality of Kalmegh cv. Anand Kalmegh-1

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ABSTRACT

An attempt was made to study the influence of source manipulation on morpho-physiological parameters, biomass yield and quality of kalmegh *cv.* Anand Kalmegh -1 during *Kharif* 2013 and 2014 at AAU, Anand. The treatments comprising of different levels of leaf removal *viz.* nipping of buds (apical/ auxillary bud), defoliation at 25 per cent, 50 per cent and 75 per cent and control (without leaf removal)at 45 days after transplanting (DATP). The morpho-physiological parameters includes the plant height (cm) number of leaves and branches per plant, dry weight of leaves, shoot and root (g), leaf area (cm^2), leaf area index, specific leaf weight (g cm^{-2}), lead area duration (days), relative growth rate (g g^{-1} $days^{-1}$), crop growth rate (g cm^{-2} $days^{-1}$), net assimilation rate (g cm^{-2} $days^{-1}$) and root and shoot ratio. The biomass yield and quality (andrographolide content) were also recorded at 60, 90 and 120 DATP. The results indicated that, nipping of buds recorded the significantly higher growth parameters, yield and quality.

Among the different medicinal plants, kalmegh (*Andrographis paniculata* Burm.f.) Wall.exNees) is a herbaceous plant belongs to the family Acanthaceae, native to India and Sri Lanka. It is one of the important species, which is now recently introduced for cultivation. It is widely cultivated in Southern Asia, where it is used to treat infections and some diseases, often being used before antibiotics were created. Mostly the Panchang (whole plant parts) were used for medicinal purposes. In India, it is occasionally being cultivated in plains area of Uttar Pradesh, Madhya Pradesh, Chattisgarh, West Bengal, Karnataka, Deccan, Assam, Gujarat and Kerala. *Andrographis paniculata* is an erect annual herb extremely bitter in taste in all parts of the plant body. The major bitter constituent in kalmegh is due to the presence of diterpene lactone called androgrpholide (Raina, *et al.* 2013). The plant is known in north-eastern India as Mahatita, literally "king of bitters" and known by various vernacular names. As an Ayurveda herb it is known as kalmegh or kalamegha, meaning "dark cloud". It is also known as Bhui-neem, meaning "neem of the ground", since the plant, though being a small annual herb, has a similar strong bitter taste as that of the large neem tree (*Azadirachta indica*).

The leaf has been ascribed the role of photosynthesis, various morpho-physiological functions blend with it have been studied and evaluating with a special reference to their impact on biomass production and yield. Both natural and artificial senescence also influenced the leaf functions and as such the photosynthetic activity. The manifestation and the development of various leaf functions have been determined in response to artificial leaf removal. The plants leaf removal 25 to 50 per cent could compensate various physiological forms and functions of much higher rate as a consequence promoted the yield. However, due to leaf removal beyond 50 per cent, the absolute values of growth and development were significantly low there by depressing the yield.

MATERIAL AND METHODS

The experiment was carried out at Medicinal and Aromatic Plant Research Station, Anand Agricultural University, Anand during *Kharif* 2013-2014, Kalmegh *var.* Anand Kalmegh -1 was sown on nursery beds on 29thJune 2013 and 20thJune 2014. The seedlings were transplanted on 5th and 14th August 2013 and 2014, respectively with 45 x 30 cm spacing. The necessary agronomic practices as par requirements were followed. The experiment was laid out in split plot design with three replications with five treatments *viz.*, nipping of buds (apical / auxillary bud), 25 per cent defoliation, 50 per cent defoliation, 75 per cent defoliation and control (without leaf removal) were applied at 45 days after transplanting (DATP). The growth parameters along with

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biomass yield and the quality parameters (andrographolide contents) were recorded. Andrographolide contents of the whole plant of dry powder was analysed with the help of LC-mass spectrometry.

RESULTS AND DISCUSSION

Growth parameters: Non-significant differences among the different levels of leaf removal were recorded at most of all the growth stages *i.e.* 60, 90 and 120 DATP in pooled analysis. The higher plant height 75.41 and 90.85 cm was observed under the treatment of D_2 (25 % defoliation) at 90 and 120 DATP, respectively (Table 1). Similarly, the nipping of plant to decreased plant height was also observed by Gnyandev (2009) in chickpea and Kubsad *et al.* (2001) in sunflower. In case of number of leaves per plant recorded significant differences were recorded at 60, 90, and 120 DATP among the treatments of source manipulation during both the years and in pooled analysis (except 60 DATP). Significantly higher number of leaves per plant was noted with the treatment of nipping of bud *i.e.* 168.22, 399.77, and 446.49 at 60, 90 and 120 DATP, respectively in pooled analysis (Table1). These results are in conformity with those obtained by Patel *et al.* (2011) in pigeon pea.

It is evident from the data (Table 1) that the source manipulation treatments for dry weight of leaf per plant showed significant difference at 60, 90, and 120 DATP in both the years and in pooled analysis. Significantly higher dry weight of leaf plant^{-1} were recorded in the treatment of (D_1) nipping of buds *i.e.* 12.58, 24.87 and 27.12 g at 60, 90 and 120 DATP respectively in pooled analysis (Table 1). Similar trend was observed in respect to the dry weight of shoot at different growth stages. There were significant differences among the treatments in both years as well as in pooled analysis at different growth stages 60, 90, and 120 DATP. The treatment of D_1 (nipping of buds) noted the higher value *i.e.* 10.46, 41.79, and 65.80 g at 60, 90 and 120 DATP respectively in pooled data. The treatment 50 per cent defoliation (D_3) recorded the significantly higher dry weight of root *i.e.*, 1.05, 2.63, and 4.16 g at respective growth stages in the pooled analysis. In case of number of branches plant^{-1} results showed at 60, 90 and 120 DATP growth stages recorded significant differences among the treatments of source manipulation during both the years and in pooled analysis. Significantly higher number of branches plant^{-1} was noticed with the treatment of nipping of buds (16.44, 21.79, and 29.30) at 60, 90, and 120 DATP, respectively in pooled analysis.

Physiological parameters: Leaf area plant^{-1} recorded at 60, 90 and 120 DATP showed significant differences among the treatments of source manipulation in both the years, and in pooled analysis (Table 2a). Highest leaf area was recorded with the treatment of nipping of buds *i.e.* 1319.39, 4410.05 and 5588.86 cm^{2}in pooled analysis at 60, 90 and 120 DATP, respectively.

There were significant differences among the treatments of source manipulation for leaf area index at 60, 90 and 120 DATP in the year 2013-14 and 2014-15 as well as in pooled analysis. Significantly higher leaf area index was recorded with the treatment of nipping of buds *i.e.* 0.98, 3.27 and 4.14 at 60, 90 and 120 DATP in pooled analysis. Similar results were also reported by Endan *et al.*, 2006: Ahmadi and Joudi, 2007 and Alimohammadi and Azizov (2011) in sunflower. Similarly, Sajjan *et al.* (2002) reported that apical bud pinching of okra resulted significant increased in leaf area index.

The LAD followed the similar trend as shown by leaf area index. However, at 60-90 DATP significantly higher LAD (83.34 days) was noted with the treatment of D_1 (Table 2b) in pooled analysis. Similarly, significantly higher LAD in the treatment of nipping of buds, D_1(*i.e.* 75.20 days) at 90-120 DATP in pooled analysis.

It is evident from the results that treatment of source manipulation effects for RGR and CGR at 60-90 and 90-120 DATP was showed non-significant differences during both of the year and in pooled analysis, except RGR in 2013-14 (60-90 DATP) whereas, CGR 60-90 DATP and NAR were significantly different during both of the year and pooled analysis. Significantly higher NAR was recorded with the treatment of 50 per cent defoliation*i.e.* 3.28 g cm^{-2} day^{-1} at 60-90 and 1.40 g cm^{-2} day^{-1} and 90-120 DATP in the treatment of nipping of bud in pooled analysis. Similar tends in respect of RGR (3.70 and 1.31 g g^{-1} day^{-1}). Whereas in CGR the treatment nipping of bud recorded higher value (1.10 and 0.66 g cm^{-2} day^{-1}) at 60-90 and 90-120 DATP in pooled analysis. These results were also supported by Sarkar and Pal (2005).

Results for Specific leaf weight influenced by treatments of source manipulation showed significant difference at 60, 90 and 120 DATP during both the years

Table 1: Influence of source manipulation treatments on growth parameters of kalmegh(60, 90 and 120 DATP)

Treatments (source manipulation)	Plant height cm)			Number of leaves plant^{-1}			Number of branches plant^{-1}			Dry weight of leaf (g)			Dry weight of shoot (g)			Dry weight of root (g)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
60 DATP																		
D_1 : Nipping of buds (Apical/Auxillary bud)	46.64	52.89	49.77	165.68	170.76	168.22	15.68	17.20	16.44	11.91	13.26	12.58	10.14	10.78	10.46	0.82	1.00	0.91
D_2 : 25% Defoliation (Removal of leaf)	48.24	53.76	51.00	152.93	157.20	155.06	14.83	16.35	15.59	10.00	11.20	10.60	8.26	8.96	8.61	0.84	1.01	0.93
D_3 : 50% Defoliation (Removal of leaf)	47.41	53.36	50.39	149.57	153.61	151.59	14.63	16.15	15.39	9.50	10.76	10.13	8.26	9.12	8.69	0.97	1.14	1.05
D_4 : 75% Defoliation (Removal of leaf)	47.71	53.20	50.45	145.23	149.42	147.33	14.59	16.11	15.35	9.02	10.14	9.58	7.69	8.20	7.94	0.82	0.99	0.90
D_5 - Control (without leaf removal)	47.71	50.69	49.20	150.48	154.04	152.26	14.28	15.80	15.04	9.16	10.27	9.71	8.15	8.89	8.52	0.72	0.90	0.81
SE (m) ±	1.10	1.57	0.95	1.77	3.04	1.75	0.115	0.38	0.19	0.25	0.23	0.17	0.35	0.26	0.22	0.01	0.02	0.01
CD (P=0.05)	NS	NS	NS	5.05	8.69	NS	0.329	NS	0.56	0.71	0.65	0.47	0.99	0.75	0.61	0.04	0.06	0.04
90 DATP																		
D_1 : Nipping of buds (Apical/Auxillary bud)	70.24	74.59	72.41	394.21	405.33	399.77	20.99	22.58	21.79	24.20	25.54	24.87	41.18	42.40	41.79	1.85	2.00	1.92
D_2 : 25% Defoliation (Removal of leaf)	73.31	77.52	75.41	367.71	371.96	369.84	18.4	20.26	19.33	20.38	21.61	20.99	35.09	36.30	35.69	1.83	1.97	1.90
D_3 : 50% Defoliation (Removal of leaf)	73.11	76.65	74.88	346.83	354.36	350.60	18.25	20.05	19.15	19.58	21.01	20.30	34.16	35.49	34.82	2.55	2.70	2.63
D_4 : 75% Defoliation (Removal of leaf)	72.16	73.21	72.69	335.51	335.28	335.40	17.84	19.64	18.74	19.26	20.30	19.78	33.67	34.65	34.16	1.87	2.03	1.95
D_5 - Control (without leaf removal)	70.64	74.86	72.75	343.48	344.56	344.02	17.24	19.04	18.14	19.43	20.62	20.03	34.83	35.75	35.29	1.73	1.88	1.80
SE (m) ±	1.24	1.62	1.02	6.99	6.70	4.84	0.203	0.51	0.28	0.37	0.49	0.31	0.49	1.06	0.58	0.04	0.05	0.03
CD (P=0.05)	NS	NS	NS	19.99	19.15	13.65	0.579	1.46	0.78	1.05	1.41	0.87	1.41	3.02	1.65	0.12	0.14	0.09

												120 DATP						
D_1 :	Nipping of buds (Apical/Auxillary bud)	86.59	88.80	87.69	449.25	443.73	446.49	28.85	29.74	29.30	26.41	27.83	27.12	65.20	66.41	65.80	2.79	3.00	2.90
D_2 :	25% Defoliation (Removal of leaf)	88.55	91.69	90.12	418.97	423.20	421.09	24.59	25.72	25.15	22.48	23.58	23.03	57.30	59.78	58.54	2.69	2.89	2.79
D_3 :	50% Defoliation (Removal of leaf)	87.40	88.51	87.96	390.09	389.66	389.87	24.91	25.53	25.22	21.75	23.02	22.38	56.44	57.14	56.79	4.05	4.27	4.16
D_4 :	75% Defoliation (Removal of leaf)	85.69	87.75	86.72	378.61	381.47	380.04	23.16	24.44	23.80	21.55	22.34	21.95	55.11	56.20	55.65	2.72	2.93	2.83
D_5 -	Control (without leaf removal)	84.31	86.40	85.35	387.14	392.73	389.93	24.35	25.30	24.82	21.65	22.68	22.17	56.35	57.35	56.85	2.65	2.87	2.76
	SE (m) ±	1.61	1.30	1.03	7.12	10.08	6.17	1.04	0.78	0.65	0.39	0.57	0.35	1.63	1.36	1.06	0.06	0.06	0.04
	CD (P=0.05)	NS	NS	NS	20.35	28.82	17.40	2.96	2.23	1.82	1.13	1.63	1.00	4.66	3.88	2.99	0.17	0.16	0.12

Table 2 : Influence of source manipulation treatments on physiological parameters of kalmegh(60, 90 and 120 DATP)

Treatments(source manipulaton)	Leaf area plant^{-1} (cm^2)			Leaf area index			Specific leaf weight (g cm^{-2}) X 100			Root / shoot ratio (dry weight basis)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
60 DATP												
D_1:Nipping of buds (Apical/Auxillary bud)	1148.00	1490.80	1319.39	0.85	1.10	0.98	1.04	0.87	0.96	4.10	4.60	4.38
D_2:25% Defoliation (Removal of leaf)	1036.90	1359.90	1198.40	0.77	1.01	0.89	1.03	0.85	0.94	4.50	5.00	4.76
D_3:50% Defoliation (Removal of leaf)	858.19	1161.30	1009.74	0.64	0.86	0.75	1.13	0.87	1.01	5.40	5.70	5.52
D_4:75% Defoliation (Removal of leaf)	805.55	1066.20	935.86	0.60	0.79	0.69	1.14	0.88	1.01	4.80	5.40	5.09
D_5- Control (without leaf removal)	982.14	1254.90	1118.53	0.73	0.93	0.83	0.91	0.77	0.84	3.70	4.20	3.94
SEm±	45.86	48.60	33.41	0.03	0.04	0.03	0.04	0.02	0.02	0.10	0.10	0.10
CD (P=0.05)	131.09	138.90	94.19	0.09	0.10	0.08	0.12	0.07	0.10	0.30	0.30	0.20
90 DATP												
D1:Nipping of buds (Apical/Auxillary bud)	3923.59	4896.50	4410.05	2.91	3.63	3.27	0.64	0.54	0.59	3.20	3.30	3.25
D2:25% Defoliation(Removal of leaf)	3320.37	4116.13	3718.25	2.46	3.05	2.75	0.63	0.56	0.59	3.30	3.40	3.36
D3:50% Defoliation (Removal of leaf)	2848.94	3575.49	3212.21	2.11	2.65	2.38	0.73	0.64	0.69	4.70	4.70	4.71
D4:75% Defoliation (Removal of leaf)	2571.02	3082.14	2826.58	1.90	2.28	2.09	0.79	0.65	0.72	3.50	3.70	3.61
D5- Control (without leaf removal)	3198.55	3956.63	3577.59	2.37	2.93	2.65	0.63	0.54	0.59	2.80	3.00	2.91
SEm±	158.02	150.14	108.92	0.12	0.10	0.10	0.03	0.02	0.02	0.10	0.10	0.10
CD (P=0.05)	451.65	428.58	307.07	0.33	0.32	0.30	0.08	0.05	0.07	0.30	0.30	0.20
120 DATP												
D1:Nipping of buds (Apical/Auxillary bud)	5479.46	5698.26	5588.86	4.06	4.22	4.14	0.50	0.50	0.50	3.40	3.60	3.50
D2:25% Defoliation (Removal of leaf)	4497.12	4767.57	4632.35	3.33	3.53	3.43	0.51	0.52	0.52	3.40	3.60	3.50
D3:50% Defoliation (Removal of leaf)	3903.75	4073.32	3988.53	2.89	3.02	2.95	0.59	0.58	0.58	5.10	5.30	5.20
D4:75% Defoliation (Removal of leaf)	3492.09	3585.84	3538.96	2.59	2.66	2.62	0.65	0.63	0.64	3.60	3.80	3.69
D5- Control (without leaf removal)	4270.51	4409.52	4340.01	3.16	3.27	3.21	0.53	0.49	0.51	3.10	3.30	3.18
SEm±	195.11	165.70	127.99	0.14	0.12	0.09	0.02	0.02	0.01	0.10	0.10	0.10
CD (P=0.05)	557.67	473.62	360.82	0.41	0.35	0.27	0.06	0.06	0.06	0.30	0.30	0.20

Table 3 : Influence of source manipulation treatments on physiological parameters of kalmegh(60-90 and 90-120 DATP)

Treatments(source manipulation)	Leaf area duration (days)			Relative growth rate X 100 (g g^{-1} day^{-1})			Crop growth rate X 1000 (g cm^{-2} day^{-1})			Net assimilation rate x 100 (g cm^{-2} day^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
60-90 DATP												
D_1 : Nipping of buds (Apical/Auxillary bud)	74.44	92.25	83.34	3.82	3.45	3.64	1.10	1.11	1.10	3.23	2.39	2.81
D_2 : 25% Defoliation (Removal of leaf)	62.87	77.53	70.20	3.69	3.54	3.62	0.94	0.95	0.95	3.32	2.42	2.87
D_3 : 50% Defoliation (Removal of leaf)	53.77	66.55	60.16	3.85	3.54	3.70	0.93	0.93	0.93	3.53	3.03	3.28
D_4 : 75% Defoliation (Removal of leaf)	48.18	56.65	52.41	3.70	3.52	3.61	0.92	0.93	0.92	3.35	2.73	3.04
D_5 - Control (without leaf removal)	59.56	72.82	66.19	3.65	3.48	3.57	0.94	0.94	0.94	2.83	2.36	2.60
SEm±	3.11	2.94	2.14	0.05	0.08	0.10	0.01	0.01	0.01	0.15	0.10	0.10
CD (P=0.05)	8.89	8.39	6.03	0.15	NS	NS	0.03	0.02	0.03	0.42	0.28	0.20
90-120 DATP												
D_1 : Nipping of buds (Apical/Auxillary bud)	78.17	72.22	75.20	1.22	1.35	1.28	0.67	0.66	0.66	1.31	1.48	1.40
D_2 : 25% Defoliation (Removal of leaf)	63.04	60.21	61.63	1.21	1.33	1.27	0.62	0.62	0.62	1.00	1.17	1.08
D_3 : 50% Defoliation (Removal of leaf)	55.10	50.79	52.94	1.25	1.37	1.31	0.64	0.63	0.64	1.19	1.36	1.28
D_4 : 75% Defoliation (Removal of leaf)	49.04	45.44	47.24	1.21	1.33	1.27	0.61	0.60	0.60	0.97	1.14	1.06
D_5 - Control (without leaf removal)	59.36	54.03	56.69	1.14	1.26	1.20	0.61	0.60	0.61	0.89	1.07	0.98
SEm±	2.74	2.83	1.97	0.05	0.05	0.10	0.03	0.03	0.03	0.04	0.04	0.00
CD (P=0.05)	7.83	8.09	5.55	NS	NS	NS	NS	NS	NS	0.12	0.12	0.01

Table 4 : Influence of source manipulation treatments on biomass yield and Andrographolide content (%) of kalmegh

Treatments (source manipulation)	Biomass yield (g plant^{-1})			Biomass yield (kg plot^{-1})			Andrographolide content (%)								
							60 DATP			90 DATP			120 DATP		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
D_1 : Nipping of buds (Apical/Auxillary bud)	109.76	113.27	111.51	5.27	5.38	5.32	0.57	0.60	0.59	2.03	2.10	2.07	0.96	1.01	0.99
D_2 : 25% Defoliation (Removal of leaf)	96.42	101.06	98.74	4.69	4.85	4.77	0.56	0.60	0.58	1.98	2.04	2.01	0.93	0.98	0.96
D_3 : 50% Defoliation (Removal of leaf)	94.73	97.48	96.11	4.48	4.68	4.58	0.56	0.59	0.57	1.98	2.05	2.02	0.93	0.98	0.95
D_4 : 75% Defoliation (Removal of leaf)	93.40	96.14	94.77	4.48	4.68	4.58	0.55	0.59	0.57	1.95	2.03	1.99	0.92	0.97	0.94
D_5 - Control (without leaf removal)	93.03	96.26	94.64	4.47	4.62	4.54	0.56	0.59	0.58	1.83	1.89	1.86	0.92	0.96	0.94
SEm±	1.89	2.38	1.52	0.14	0.15	0.10	0.00	0.01	0.00	0.01	0.02	0.01	0.02	0.02	0.01
CD (P=0.05)	5.40	6.80	4.30	0.39	0.42	0.28	0.00	NS	NS	0.02	0.07	0.03	NS	NS	NS

and in pooled analysis (Table 2a). Significantly higher SLW (1.01, 0.72 and 0.64 g cm^{-2}) was registered with the treatment of 75 per cent defoliation at 60, 90 and 120 DATP, respectively, in pooled analysis. Similar results were also observed by Mayer (1998).

In case of root /shoot ratio the treatment D_3 *i.e.* 50 per cent defoliation (5.52, 4.71 and 5.20) noted the numerically higher value of root / shoot ratio in pooled analysis at 60, 90 and 120 DATP. These finding was in agreement with the result obtained by Kaur *et al.* (2009) in Safed musli.

Dry biomass yield and yield attributing parameters: Significantly higher dry biomass yield i.e. 111.51 g $plant^{-1}$ and 5.32 kg $plot^{-1}$ was noted in the treatment of nipping of buds compared to rest of treatments of source manipulation in pooled analysis at harvest stage (Table 3). Similar observation was reported by Nabizadeh *et al.* (2011), Li-xiangium *et al.* (2005) in soybean.

Quality: The results pertaining to the andrographolide per cent content of kalmegh were showed significant differences during both the years *i.e.* 2.03 and 2.10 per cent in the treatment of nipping of bud. However, significantly higher value (2.07%) was observed in pooled analysis at 90 DATP (Table 3).

LITERATURE CITED

Ahmadi, A. and M. Joudi, 2007. Effects of timing and defoliation intensity on growth, yield and gas exchange rate of wheat grown under well-watered and drought conditions, Pak. J. Biol. Sci. 10: 3794–3800.

Alimohammadi R. and Azizov, 2011. Defoliation effects on yield and yield components of sunflower cultivars (*Helianthus annuus* L.), International J. Agri. Sci., 1(7) : 361-365

Endan, J. B., J. H. Young, and M. A. Awal, 2006. Effect of hand defoliation on peanut growth, Asian J. Plant Sci., 5: 281–286.

Gnyandev, B., 2009. Seed technological studies in chickpea (*Cicerarietinum* L.), Ph.D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India).

KaurJagmeet , Kaur Jasdeep and S. S. Saini, 2009. Effect of plant growth regulators and pinching on biochemical changes and productivity of safedmusli, Indian J. Pl. Physiol., 14(3): 283-289.

Kubsad V. S, C. P. Mallapur and G. G. Gulaganju, 2001. Response of safflower cultivars to thinning and nipping, Karnataka J. Agric. Sci.,14 (2) : 459-461

Li-Xiangjun Anping Inanaga, S., A. E. Enejj and A. M. Ali, 2005. Mechanisms promoting recovery from defoliation in determinate and indeterminate soybean cultivar, J of Food Agric. and Env.,3 (3/4): 178-183.

Meyer G. A., 1998. Mechanisms promoting recovery from defoliation in goldenrod (*Solidagoaltissima*) Can, J. Bot. 76 : 450-459.

Nabizadeh Esmail, Elnaz Taherifard and Farzad Gerami, 2011. Effect of pruning lateral branches on four varieties of medicinal castor bean plant (*Ricinuscommunis* L.) yield, growth and development, J. Medic. Pl. Res., 5 (24) : 5828-5834.

Patel, A. D., T. Patel, S. S. Jagtap and K. P. Patel, 2011. Influence of micronutrients and source manipulation on growth and yield in different pigeonpea (*Cajanus cajan* L.) genotypes, Abstracts national seminar on sustainable crop productivity through physiological intervention, Nov., 24-26: 20.

Raina, Archana P., Veena Gupta , N. Sivaraj and M. Dutta, 2013. Andrographis paniculata (Burm. f.) Wall.exNees (kalmegh), a traditional hepato protective drug from India, Genet. Resour. Crop Evol., 60 (2): 1-9.

Sajjan, A. S., M. Shekhargouda and V. P. Badanur, 2002. Influence of apical pinching and fruit picking on growth and seed yield of okra, Karnataka J. Agric. Sci., 15 (2): 367-372.

Sarkar, R. K. and P. K. Pal, 2005. Effect of crop geometry fertility levels and nipping on physiological parameters in relation to productivity of sesame, Indian J. Agric. Sci.,75 (3): 143-147.

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Genetic Divergence Studies for Yield and Physiological Attributes in Groundnut Germplasm (*Arachis hypogaea* L.)

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ABSTRACT

Divergence was studied among fifty-two genotypes based on data of thirteen agronomical and three physiological attributes *viz.* leaf area index, chlorophyll content index and canopy temperature. The analysis of variance indicated significant differences among the genotypes for all the sixteen attributes studied. The genotypes were grouped into nine clusters. The mode of distribution of genotypes to various clusters was at random suggesting that there is no relationship between geographical distribution and genetic diversity. The cluster size varied from single to 29 genotypes. Plant height (21.87%) followed by pod yield (21.27%) contributed maximum to the total divergence and highest inter-cluster distance (145.6) was recorded between cluster V (TAG-24) and VIII (AK-14) therefore crosses between these genotypes would be more rewarding. The diversity among the genotypes measured by intra-cluster & inter cluster distance was adequate for improvement of groundnut by hybridization and selection. Based on the intra and inter-cluster distances and cluster means, parents were identified for further breeding programmes for isolation of useful transgressive segregants.

Groundnut (*Arachis hypogaea* L.) is the one of the important oilseed crops of India. Economically it is an important oil, food, and feed legume crop grown in over 100 countries. It covered 245.6 lakh ha area worldwide with a total production of 453.08 lakh tonnes and the productivity of 1780 kg ha^{-1} in 2014. (Anonymous, 2014). It is expected that the utilization of divergent parents in hybridization results in promising recombinants. Hence, the present investigation was undertaken to study the genetic divergence in groundnut (*Arachis hypogaea* L.) germplasm to identify potential lines for various yield and its traits which could be utilized in the hybridization programme to improve yield. Most of the earlier genetic diversity studies are based on morphological and yield attributes. In the present study, diversity was assessed taking a set of physiological attributes those ultimately determine yield.

MATERIAL AND METHODS

The experimental material consisted of fifty-two genotypes of groundnut, evaluated in a Randomized Block Design with three replications during *Kharif* 2015 in the experimental farm of Oilseeds Research Unit, Dr.PDKV, Akola. Recommended package of practices for *Kharif* groundnut cultivation were followed and protective irrigation was provided whenever the crop experienced moisture stress. Each genotype was sown in three rows of 5m length with inter row spacing of 30cm and intra-row spacing of 10cm. Five plants were taken at random from each genotype in each replication for recording the observations. The data on 13 agronomical characters namely days to 50 per cent flowering, days to pod maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pods per plant, biomass per plant (g), hundred pod weight (g), hundred kernel weight (g), shelling per cent (%), pod yield per plant (g), kernel yield per plant (g), oil content (%) and 3 physiological characters viz. leaf area index, chlorophyll content index and canopy temperature at vegetative, reproductive and harvesting stage were recorded. Genetic diversity was studied using Mahalanobis (1936) generalized distance (D^2) extended by Rao (1952). Based on the D^2 values, the studied genotypes were grouped into clusters according to the Tocher's method (Rao, 1952). The methods of Singh and Chaudhary (1985) were used for calculating the intra and inter cluster distances.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the traits studied. The fifty-two genotypes were grouped into 9 clusters (Table 1). Cluster IV was the largest with a maximum number of genotypes (29) followed by cluster I with 16 genotypes. The remaining seven clusters were mono genotypic. The grouping of genotypes revealed that there

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was no perfect relationship between genetic diversity and geographical diversity as genotypes from different geographical origin were included in one cluster. Lack of correlation between genetic and geographic diversity was also reported by Venkataravana *et al.* (2000) and Sudhir Kumar (2010).

Highest intra-cluster (32.0) distance was observed in cluster IV including 29 genotypes followed by cluster I (20.9) having 16 genotypes. The cluster in which only one genotype was grouped; the intra-cluster distance was zero (D=0) and the cluster was II, III, V, VI, VII, VIII, IX including genotypes AK-265, TG-70, TAG-24, TG-75, ICGV-11, AK-14 and AK-303, respectively. The magnitude of D^2 values indicated substantial diversity for agronomical and physiological attributes among the genotypes included in the study. In accordance with above value of intra-cluster distances, clusters showing higher intra-cluster distance, suggested wider diversity among genotypes within these clusters and the parents for hybridization can be selected from these clusters.

The maximum average inter-cluster distance was observed between clusters V and VIII (D=145.6), where both the cluster are solitary with the genotypes TAG-24 and AK-14 respectively, followed by cluster VI and VIII including TG-75 and AK-14 in respective clusters (D=126.3), cluster V and IX (D=120.3), cluster VII and cluster IX (D=119.8), cluster IV and IX (D=118.9), cluster VII and VIII (D=116.4) and cluster III and VIII (D=116.3). The lowest average inter-cluster distance was found between cluster III and VI (D=16.1), followed by cluster III and V (D=23.9) (Table 2).

Above results revealed that, the inter-cluster distance were larger than the intra-cluster distance which indicated that greater diversity is present among the

Table 1: Distribution of genotypes in different clusters by Tocher's method

Cluster	Total No. of Genotypes	Genotypes
I	16	Ak-344, AK-360, CO-2, AK-345, AK-359, AK-280, JL-501, PKVG-8, ROBOUT-33-1, AK-358, JL-776, Dh-180, AK-340, TG-68, X0II-2-71, AK-357
II	1	AK-265
III	1	TG-70
IV	29	AK-277, Ah-1, AK-190, Dh-101, AK-147, AK-314, ICGV-06420, AK-327, AK-284, AK-331, AK-206, TG-60, CO-1, GP-201, AK-171, AK-159, AK-34, AKG-18-1, ICGV-76, AK-295, AK-350, AK-174, AK-322, Spancross, AK-355, POL-2, CHICO, TAG-24 (SEL.), AK-329
V	1	TAG-24
VI	1	TG-75
VII	1	ICGV-11
VIII	1	AK-14
IX	1	AK-303

Table 2: Average Intra and Inter-Cluster Distance

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	20.9	33.1	29.2	38.4	31.3	26.1	58.9	91.4	96.4
II		0.0	50.0	37.1	66.6	55.5	77.0	29.1	55.0
III			0.0	51.7	23.9	16.1	43.9	116.3	73.5
IV				32.0	51.8	51.9	56.3	75.3	118.9
V					0.0	26.7	66.4	145.6	120.3
VI						0.0	56.9	126.3	105.1
VII							0.0	116.4	119.8
VIII								0.0	86.8
IX									0.0

genotypes of distant group (Zaman *et al.*, 2010). Those genotypes included in clusters with maximum inter-cluster distance are obviously genetically more divergent. Hence, from the obtained inter-cluster distance result, it would be logical to choose genotypes from these clusters in the breeding programme. On this basis, TAG-24, AK-14, TG-75, AK-303, Chico, ICGV-06420, ICGV-11, TG-70, AK-171 and AK-344 can be selected.

Relative contribution of characters towards diversity is presented in Table 3. The trait plant height ranked first with 290 times and recorded maximum contribution towards total divergence, contributing 21.87 per cent in grouping the genotypes; similar results were obtained for highest contribution of plant height towards total genetic divergence by Bhakal *et.al.* (2015). Pod yield (21.27%) ranked second with 282 times, followed by hundred pod weight (11.76%), biomass per plant (10.78%), hundred kernel weight (10.26%) and number of pods plant^{-1} (5.43%) also gives higher contribution to the total divergence, Venkateswarlu *et al.* (2011) also recorded the similar results in groundnut where greater contribution of hundred kernel weight was found.

Relatively less contribution was reported by leaf area index (4.3) (Reproductive stage), chlorophyll content index (2.26%) (Harvesting stage), number of secondary branches per plant (2.11%), leaf area index (harvesting), chlorophyll content index (Vegetative) (2.04%) and kernel yield (1.43%) (Table 3). Very less contribution was recorded by leaf area index (0.75%) at vegetative stage, Shelling per cent (0.6%), days to 50 per cent flowering (0.53%), canopy temperature at harvesting (0.38%), number of primary branches per plant (0.3%), days to maturity and Oil content (0.15%) towards genetic divergence. In accordance with these results Sudhir Kumar *et. al.* (2010) also reported little contribution of primary and secondary branches per plant towards genetic divergence. From above findings it has been observed that no single character had greater contribution to total divergence. There is zero contribution by canopy temperature at vegetative and reproductive stage towards genetic divergence.

Based on diversity analysis and superiority with respect to agronomical and physiological traits studied, the identified promising genotypes are presented in Table 4.

Table 3: Contribution of various characters towards genetic divergence

S.N.	Character	Times ranked 1st	Contribution percentage
1	Days to 50 per cent flowering	7	0.53%
2	Days to maturity	2	0.15%
3	Plant height (cm)	290	21.87%
4	Number of primary branches per plant	4	0.3%
5	Number of secondary branches per plant	28	2.11%
6	Number of pods per plant	72	5.43%
7	Biomass per plant (cm)	143	10.78%
8	Hundred pod weight (g)	156	11.76%
9	Hundred kernel weight (g)	136	10.26%
10	Shelling per cent (%)	8	0.6%
11	Pod yield per plant (g)	282	21.27%
12	Kernel yield per plant (g)	19	1.43%
13	Oil content (%)	2	0.15%
14.1	Leaf area index (vegetative stage)	10	0.75%
14.2	Leaf area index (reproductive stage)	57	4.3%
14.3	Leaf area index (harvesting stage)	27	2.04%
15.1	Chlorophyll content index (vegetative stage) (g m^{-2})	27	2.04%
15.2	Chlorophyll content index (reproductive stage) (g m^{-2})	21	1.58%
15.3	Chlorophyll content index (harvesting stage) (g m^{-2})	30	2.26%
16.1	Canopy Temperature (vegetative stage) (^{0}C)	0	0.0%
16.2	Canopy Temperature (reproductive stage) (^{0}C)	0	0.0%
16.3	Canopy Temperature (harvesting stage) (^{0}C)	5	0.38%

Table 4: Suggested cross combination

SN.	Cluster combination	Average inter-cluster distance	Suggested cross combination	Potential traits
1	V × VIII	145.6	TAG-24 x AK-14	**TAG -24**: Dwarf, early maturing, and high number of pods, high shelling, high oil content, high CCI, LAI and low canopy temperature.**AK-14**- Early mature, high CCI.
2	VI x VIII	126.3	TG-75 X AK-14	**TG-75:** Early maturing, dwarf, high pod yield, high CCI and low canopy temperature.**AK-14:** Early maturity, high CCI.
3	V x IX	120.0	TAG-24 X AK-303	**TAG-24:** Dwarf, early maturing, high oil and shelling %, high LAI and CCI.**AK-303:** Bold seeded with high pod and kernel weight.
4	VII x IX	119.8	ICGV-11 X AK-303	**ICGV-11**: Medium height, high CCI, LAI and low canopy temperature.**AK-303**: Bold seeded, High oil and shelling per cent with low canopy temperature.
5	IV x IX	118.9	Chico X AK-303	**Chico:** Earliest, dwarf, high oil content.**AK-303:** Bold seeded, high pod and kernel weight.

LITERATURE CITED

Anonymous, 2014. Status paper on Oilseeds, Ministry of Agriculture, Govt of India, Available at: www.nmoop.gov.in.

Bhakal, M. and G.S. Lal, 2015. Studies on Genetic diversity in groundnut (*Arachis hypogaea* L.) germplasm, J. Plant Sci. and Res. 2.

Mahalanobis, P. C.1936. On the generalized distance in statistics, Proceedings of National Institute of Science, India, 2: 49-55.

Rao, C. R. 1952. Advance statistical methods in biometric research Edn.J.John Wiley and Sons , Newyork.

Singh, R.K. and B.D.Chaudhary, 1985. Biometrical Methods in Quantitative Genetic Analysis, Kalyani Publishers, New Delhi :252.

Sudhir, K., M. Govindaraj andV.K. Kumar, 2010. Estimation of Genetic diversity of new advanced breeding lines of groundnut (*Arachis hypogaea* L.),World J.Agric.Sci.5 (6):547-554.

Venkataravana, P., R.A. Sheriff, R.S. Kulkarni, V.V. Shankaranarayana and P. Fathima, 2000. Genetic divergence in groundnut (*Arachis hypogaea* L.), *Mysore* J.agric. Sci., 34. (2): 125-129.

Venkateswarlu, O., B.V.G. Sudhakar, M. Reddy and P. Sudhakar, 2011. Genetic divergence in confectionary types of groundnut (*Arachis hypogaea* L.), Legume Res.34 (1):1-7.

Zaman, M. A., M.Tuhima-Khatum, M.M.H. Bhuiyan and M.N.Yusuf, 2010. Genetic divergence in groundnut (*Arachis hypogaea* L.), Bangladesh J. Pl. Breed. Genet., 23(1): 45-49.

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*Influence of Fumigants and Number of Fumigations on Seed Quality and Storability of Groundnut (*Arachis hypogaea* L.)*

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ABSTRACT

The present study entitled "Influence of fumigants and number of fumigations on seed quality and storability of groundnut" was conducted during 2014-2015 at the experimental laboratory of Seed Technology Research Unit, Dr. PDKV, Akola to identify the best fumigants for effective control of groundnut beetle during storage and to find out influence of number of fumigations on maintenance of seed quality parameters during storage of groundnut pods. The results revealed that groundnut seed pods fumigated with both the fumigants (aluminium phosphoid and ethylene dibromide) retained satisfactory germination of 70 per cent (MSCS) up to four months of storage period. Groundnut seed fumigated with ethylene dibromide performed better for maintaining seed quality i.e. germination (52.46 %), speed of germination (19.03) seedling length (11.65 cm) and seedling vigour index (615) at the end of the tenth month of storage. The seeds fumigated once at 30, 90 and 150 days after harvest maintained germination above MSCS up to eight month storage. The seed fumigated with aluminium phosphide noticed less (5.38) number of groundnut beetle population compared to EDB (6.38) at the end of ten month of storage indicating the toxicity of respective fumigant but affected the seed quality parameters adversely. In the interaction between fumigants and number of fumigation, groundnut seeds fumigated with either of the fumigant namely; aluminium phosphoid and Ethylene dibromide once at 30, 90 and 150 days after harvest retained satisfactory germination of 70 per cent up to eight months of storage period with higher values for all the seed quality parameters.

During storage, quality of groundnut seed gets deteriorated due to several reasons, out of which, storage pest infestation contributes its major share. The loss in seed quality may be quantitative or qualitative or both. Damage by *Caryedon serratus* (Olivier) in groundnut seeds to the extent of 45 per cent results in 65 per cent loss in dry weight of damaged seeds (Kapadia, 1994).

The quality of seed can be maintained for a longer period by adopting several prophylactic measures viz., disinfestation of storage room, physical and chemical treatments, fumigation, etc. Among these methods, fumigation is said to be a convenient, rapid and effective method to control infestation of store pests. For fumigation, many chemicals are in use to achieve the desired results. Aluminum phosphide is one of the most toxic fumigant used to kill stored grain pests like insects, mites and rodents. Despite its harmful effect, aluminum phosphide, being highly inflammable is a safe and convenient fumigant. Ethylene dibromide (EDB) has high boiling point and its vapours are noninflammable and is absorbed by many materials, but does not penetrate well. Ethylene dibromide does not normally react with constituents of foodstuff.

Seed sanitation usually requires more than one fumigation to prevent attack from insect pests. Effect of repeated fumigation on germination of seed is an important factor to be considered in storage. In some cases increased injury to germination capacity may be observed due to two fumigations. But in general, two fumigations with Ethylene dibromide did not have any extreme effect on germination of seeds. A thorough knowledge of these factors is very much required for successful fumigation process with a given gas. Hence in the present study an attempt has been made to find out ideal fumigant with proper number of fumigations to control bruchids and maintenance of seed quality parameters of groundnut.

MATERIAL AND METHODS

The present investigation entitled "Influence of fumigants and number of fumigations on seed quality and storability of groundnut (*Arachis hypogaea* L.) var. TAG 24" was conducted during 2014-2015 at the laboratory of Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.).

The experiment consisted of 16 treatment combinations involving two fumigants (F) viz., Aluminium phosphide (0.9 g q^{-1}) and Ethylene dibromide (3 ml q^{-1}) (Ranga Rao et al. 2010). The calculated quantities of fumigants were placed in the plastic tins measuring 30 cm (length) 30 cm (breadth) and 44 cm (height) containing pods and the boxes were closed with lid. The cover portion

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of lid was made air tight by plastering with celephine tape. After the required exposure period, the cover was opened and pods were removed from boxes and were stored in aerated gunny bags under ambient storage conditions. This process of fumigation was repeated as per the treatment combinations for effecting repeated fumigation of the pods. Fumigation treatments were give as no fumigation (Control), 30, 90, 150, 30 and 90 days after harvest. In combination the treatments were 30 and 150 DAH 90 and 150 DAH, and 30, 90, 150 DAH. The seed quality parameters like germination percentage, speed of germination, seedling length, vigour index, per cent reduction in germination, beetle population and electrical conductivity were recorded bimonthly. The germination test was conducted as per ISTA rules (Anon., 1999), SVI as per Abdul- Baki and Anderson (1973) and speed of germination using the formula suggested by Maguire (1962).

RESULTS AND DISCUSSION

The data revealed that, the seeds fumigated with EDB recorded higher seed quality parameters namely the germination percentage (52.46 %), speed of germination (19.03), seedlng length (11.65 cm), seedling vigour index (615), and lower electrical conductivity of seed lachates (0.933 dSm-1) besides this treatment also recorded less percent reduction in germination (44.19%) compared to seeds fumigated with aluminium phosphide at the end of tenth month of storage. The better performance of the EDB is due to its lesser penetration into seed and its vapours are non inflammable. So, it did not react with constituents of food stuff and reduced residual effect on seed is observed and it was which is also supported by Agrawal et al. (1987) in maize crop seed.

The seed fumigated with Aluminium phosphide noticed less (5.38) number of groundnut beetle population compared to EDB (6.38) at the end of ten month of storage indicating the toxicity of respective fumigant but affected the seed quality parameters adversely. Aluminium phosphide could maintained the satisfactory germination (70 %) up to six months with less pest population. Similar results were reported by Lindgren et al. (1962) and Kamble et al. (2013). The seed quality parameters declined with the increase in number of fumigation from 30-150 days with combinations in all the months of storage, more prominent after 90 days of fumigation.

1. Germination percentage

Significant differences in germination per cent due to fumigants were noticed at sixth and tenth month the storage period irrespective of number of fumigations. Seeds fumigated with EDB recorded numerically more (78.00 and 52.46%) germination while it was numerically less (77.17 and 51.79%) in aluminium phosphide fumigated seeds during six and ten months of storage respectively. During second, fourth and eight month non-significant differences on germination were noticed due to fumigants (Table 1).

The seeds which received one fumigation at 30 days after harvest recorded significantly maximum (89.17, 88.17, 79.50, 75.17 and 58.34%) germination while, it was minimum (84.17, 78.83, 77.17, 58.67 and 46.34%) in the seeds fumigated thrice at 30, 90 and 150 days after harvest during two, four, eight and ten months of storage respectively.

Irrespective of the fumigants, among the number of fumigations, the seeds which received one fumigation at 30 days after harvest maintained the germination per cent above the minimum seed certification standard (70%) up to eight months of storage. The once fumigated seeds either at 30, 90 and 150 DAH (N_1, N_2 and N_3) could retain above 70 per cent germination up to eight months only. In general with increase in number of fumigations, the per cent germination was found to decline irrespective of the fumigants and also with the advancement of storage period gradual decrease in per cent germination was noticed in all the treatments.

In interaction between fumigants and number of fumigations, F_2N_1 treatment combination recorded significantly highest (88.67, and 75.33%) germination while, it was least (78.33, and 58.33%) in F_1P_7 treatment during four and eight months of storage respectively. During other months of storage, the interaction effects were non- significant. Similarly decrease in seed quality by repeated fumigations with ethylene dibromide and aluminium phosphide were also reported by Rathod (1999) in wheat and Kamble *et al.* (2013) in groundnut.

2. Speed of germination

Seed fumigated with EDB recorded numerically higher (24.59, 22.13, 21.06, 19.72 and 19.03) speed of

Table 1. Influence of fumigants and number of fumigation on germination percentage of groundnut seeds.

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	86.00	86.00	86.00	84.33	84.00	84.17	77.00	78.33	77.67	62.00	63.33	62.67	52.67	53.00	52.84
	(68.04)	(68.04)	(68.04)	(66.69)	(66.43)	(66.56)	(61.35)	(62.26)	(61.80)	(51.94)	(52.73)	(52.34)	(46.53)	(46.72)	(46.62)
N1	88.67	89.67	89.17	87.67	88.67	88.17	79.33	79.67	79.50	75.00	75.33	75.17	58.00	58.67	58.34
	(70.33)	(71.25)	(70.79)	(69.44)	(70.33)	(69.89)	(62.96)	(63.20)	(63.08)	(60.00)	(60.22)	(60.11)	(49.60)	(49.99)	(49.80)
N2	86.67	87.33	87.00	86.00	88.33	87.17	78.00	78.33	78.17	74.67	75.00	74.84	57.33	58.00	57.67
	(68.59)	(69.15)	(68.87)	(68.03)	(70.03)	(69.03)	(62.03)	(62.26)	(62.15)	(59.78)	(60.00)	(59.89)	(49.22)	(49.60)	(49.41)
N3	86.33	86.33	86.33	85.00	86.00	85.50	77.67	78.00	77.84	74.00	74.67	74.34	55.00	56.33	55.67
	(68.31)	(68.31)	(68.31)	(67.22)	(68.04)	(67.63)	(61.80)	(62.03)	(61.92)	(59.35)	(59.78)	(59.56)	(47.87)	(48.64)	(48.25)
N4	85.67	85.67	85.67	83.00	77.00	80.00	77.00	77.33	77.17	61.33	62.00	61.67	49.67	50.67	50.17
	(67.76)	(67.76)	(67.76)	(65.66)	(61.35)	(63.50)	(61.35)	(61.57)	(61.46)	(51.55)	(51.94)	(51.75)	(44.81)	(45.38)	(45.10)
N5	85.00	85.33	85.17	82.67	83.33	83.00	76.67	77.00	76.84	63.00	60.00	61.50	48.67	49.00	48.84
	(67.22)	(67.48)	(67.35)	(65.40)	(65.91)	(65.65)	(61.12)	(61.35)	(61.23)	(52.54)	(50.77)	(51.65)	(44.24)	(44.43)	(44.33)
N6	84.67	85.00	84.84	80.33	81.67	81.00	76.00	76.67	76.34	59.33	59.67	59.50	47.00	47.33	47.17
	(66.95)	(67.22)	(67.09)	(63.68)	(64.65)	(64.16)	(60.67)	(61.12)	(60.89)	(50.38)	(50.57)	(50.48)	(43.28)	(43.47)	(43.38)
N7	84.00	84.33	84.17	78.33	79.33	78.83	75.67	78.67	77.17	58.33	59.00	58.67	46.00	46.67	46.34
	(66.43)	(66.69)	(66.56)	(62.26)	(62.96)	(62.61)	(60.44)	(62.49)	(61.47)	(49.80)	(50.19)	(49.99)	(42.71)	(43.09)	(42.90)
Mean	**85.88**	**86.21**	**86.04**	**83.42**	**83.54**	**83.48**	**77.17**	**78.00**	**77.58**	**65.96**	**66.13**	**66.04**	**51.79**	**52.46**	**52.13**
	(67.95)	**(68.24)**	**(68.09)**	**(66.05)**	**(66.21)**	**(66.13)**	**(61.46)**	**(62.03)**	**(61.75)**	**(54.42)**	**(54.53)**	**(54.47)**	**(46.03)**	**(46.42)**	**(46.22)**
For compairing means of	SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%	
F	0.12	NS		0.11	NS		0.11	0.31		0.10	NS		0.09	0.27	
N	0.25	0.71		0.23	0.66		0.21	0.62		0.21	0.59		0.19	0.54	
F × N	0.35	NS		0.32	0.93		0.30	NS		0.29	0.84		0.26	NS	

*Figures in the parenthesis indicates arc sine transformed values **NS** : Non significant

Fumigant (F)

F_1 : Aluminium phosphide

F_2 : Ethylene dibromide

Exposure periods (P)

N_0 : No fumigation (Control)

N_1 : fumigation at 30 days after harvest

N_2 : fumigation at 90 days after harvest

N_3 : fumigation at 150 days after harvest

N_4 : fumigation at 30 and 90 days after harvest

N_5 : fumigation at 30 and 150 days after harvest

N_6 : fumigation at 90 and 150 days after harvest

N_7 : fumigation at 30, 90 and 150 days after harvest

germination, while it was numerically lower (24.05, 21.48, 20.19, 19.00 and 18.30) in aluminium phosphide fumigated seeds during two, four, six, eight and ten months of storage, respectively (Table 2).

The seeds given one fumigation at 30 days after harvest recorded significantly highest speed of germination of (30.15, 28.10, 25.92, 25.20 and 24.25) while, it was lowest (19.83, 17.98, 16.62, 15.95 and 15.50) in seeds fumigated thrice, at 30, 90 and 150 days after harvest during two, four, six, eight and ten months of storage respectively.

The interaction effect between fumigants and number of fumigations, the F2N1 treatment recorded significantly highest (30.70, 26.20 and 25.30) and F1N7 recorded lowest (19.76, 15.80 and 14.90) speed of germination during two, eight and ten month of storage respectively. During other months of storage, the interaction effects were non-significant. Results of similar nature were reported by Vasudevan *et. al.* (2014) and Kamble *et al.* (2013).

3. Seedling length (cm)

The seeds fumigated with EDB recorded numerically higher seedling length (13.43, 12.43, 12.17, 11.69 and 11.65 cm) while it was numerically lower (12.89, 12.25, 11.91, 11.43 and 11.35 cm) in aluminium phosphide fumigated seeds at the end of two, four, six eight and ten month of storage, respectively (Table 3).

Irrespective of the fumigants, the seeds fumigated once at 30 days after harvest recorded significantly higher seedling length of (15.85, 13.85, 14.05 and 13.15 and 12.90 cm) while, it was lower (11.15, 11.26, 10.20, 9.70 and 9.50 cm) in seeds fumigated thrice at 30, 90 and 150 days after harvest at the end of second, fourth, sixth, eighth and tenth month of storage, respectively.

In interaction effect the treatment F_2N_1 recorded significantly highest (16.00 and 13.30 cm) seedling length while it was lowest (11.00 and 9.10 cm) in treatment F_1N_7 during two and eight months of storage, respectively. During other months of storage, the interaction effects were non-significant. The interaction treatment of, F_1N_1 and F_2N_2 were at par with F_2N_1 during two and eight months of storage. Similar results were reported by Vasudevan *et al.* (2014) and Kamble *et al.* (2013).

4. Seedling vigour index

Irrespective of the number of fumigations, EDB fumigated seeds recorded significantly higher (1160, 1041, 950, 779 and 615) seedling vigour indices while, lower (1109, 1024, 921, 760 and 592) indices were recorded in aluminium phosphide at the end of two, four, six, eight and ten months of storage, respectively (Table 4).

Irrespective of fumigants, significantly higher vigour index values were recorded in the seeds which received one fumigation at 30 DAH (N_1) followed by the seeds fumigated at 90 days after harvest (N_2) throughout the storage period. Statistically higher indices values (1413, 1221, 1117, 989 and 753) were recorded in seeds which were fumigated once at 30 days after harvest. While, the seeds which received three fumigations at 30, 90 and 150 days after harvest (N_7) registered significantly lower indices values of (938, 888, 787, 569 and 440) during two, four, six, eight and ten months of storage, respectively.

In the interaction effect, the seeds fumigated with EDB at 30 days after harvest (F_2N_1) recorded significantly higher (1435, 1241 and 1002) vigour indices while it was lower in seeds which received three fumigations at 30, 90 and 150 days after harvest at the end of second, fourth and eighth month of storage, respectively. During other months of storage, the interaction effects were non-significant. Results of similar nature were reported by Vasudevan *et al.* (2014), Kamble *et al.* (2013) and Umapathi *et al.* (1988).

5. Electrical conductivity of seed leachate (dSm^{-1})

The significantly differences in seed leachate values as influenced by fumigants were noticed during entire storage period. The seeds fumigated with EDB recorded numerically minimum (0.614, 0.820 and 0.933 dSm^{-1}) seed leachate values, whereas maximum (0.632, 0.832 and 1.398 dSm^{-1}) values were observed in aluminium phosphide fumigated seeds during second, eighth and tenth month of storage respectively. During other months of storage, the fumigant effects non-significant (Table 5).

Electrical conductivity due to number of fumigations differed significantly minimum (0.520, 0.500, 0.755 and 0.877 dSm^{-1}) and maximum (0.735, 0.750, 0.905 and 1.910 dSm^{-1}) seed leachate values in once fumigated at 30 DAH and thrice fumigated at 30, 90 and 150 DAH seeds during second, fourth, eighth and tenth months of storage respectively. During other month of storage, the number of fumigation effects was non-significant.

Table 2. Influence of fumigants and number of fumigation on speed of germination of groundnut seeds

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	24.40	24.40	24.40	22.00	21.90	21.95	20.10	20.10	20.10	19.20	19.10	19.15	17.96	18.10	18.03
N1	29.60	30.70	30.15	27.60	28.60	28.10	25.30	26.55	25.92	24.20	26.20	25.20	23.20	25.30	24.25
N2	27.10	28.40	27.75	25.20	26.20	25.70	23.30	24.20	23.75	21.30	22.20	21.75	21.10	22.10	21.60
N3	25.20	25.70	25.45	22.20	23.20	22.70	21.10	22.20	21.65	19.86	20.10	19.98	18.84	20.10	19.47
N4	23.90	23.30	23.60	20.20	20.60	20.40	19.30	19.90	19.60	18.10	19.20	18.65	17.31	17.70	17.51
N5	21.70	23.00	22.35	19.20	19.90	19.55	19.10	19.60	19.35	17.20	17.70	17.45	17.06	16.96	17.01
N6	20.70	21.30	21.00	18.11	17.96	18.03	17.10	18.90	18.00	16.30	17.11	16.70	16.06	15.88	15.97
N7	19.76	19.90	19.83	17.30	18.65	17.98	16.25	17.00	16.62	15.80	16.10	15.95	14.90	16.10	15.50
Mean	**24.05**	**24.59**	**24.32**	**21.48**	**22.13**	**21.80**	**20.19**	**21.06**	**20.62**	**19.00**	**19.72**	**19.36**	**18.30**	**19.03**	**18.67**
For compairingmeans of	SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%	
F	0.10	0.30		0.09	0.27		0.09	0.26		0.08	0.24		0.08	0.23	
N	0.21	0.60		0.19	0.54		0.18	0.51		0.17	0.49		0.16	0.47	
F x N	0.29	0.85		0.27	NS		0.25	NS		0.24	0.69		0.23	0.66	

Table 3. Influence of fumigants and number of fumigation on seedling length (cm) of groundnut seeds

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	10.80	13.30	12.05	12.10	12.16	12.13	12.00	12.10	12.05	11.60	11.20	11.40	11.50	11.90	11.70
N1	15.70	16.00	15.85	13.70	14.00	13.85	13.80	14.30	14.05	13.00	13.30	13.15	12.80	13.00	12.90
N2	15.00	15.50	15.25	13.30	13.50	13.40	13.20	13.40	13.30	12.60	12.80	12.70	12.40	12.60	12.50
N3	13.60	13.80	13.70	12.88	13.10	12.99	12.70	13.10	12.90	12.10	12.30	12.20	12.00	12.20	12.10
N4	13.10	13.20	13.15	11.90	12.03	11.96	11.50	11.70	11.60	11.30	11.40	11.35	11.33	11.73	11.53
N5	12.40	12.60	12.50	11.60	11.70	11.65	11.30	11.40	11.35	11.10	11.20	11.15	11.00	11.20	11.10
N6	11.50	11.70	11.60	11.40	11.50	11.45	10.80	11.00	10.90	10.60	11.00	10.80	10.60	10.80	10.70
N7	11.00	11.30	11.15	11.10	11.42	11.26	10.00	10.40	10.20	9.10	10.30	9.70	9.20	9.80	9.50
Mean	**12.89**	**13.43**	**13.16**	**12.25**	**12.43**	**12.34**	**11.91**	**12.17**	**12.04**	**11.43**	**11.69**	**11.56**	**11.35**	**11.65**	**11.50**
For compairingmeans of	SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%	
F	0.06	0.16		0.05	0.15		0.04	0.13		0.05	0.14		0.05	0.14	
N	0.11	0.32		0.10	0.29		0.09	0.26		0.10	0.28		0.09	0.27	
F x N	0.16	0.45		0.14	NS		0.13	NS		0.14	0.39		0.13	NS	

Table 4. Influence of fumigants and number of fumigation on seedling vigour index of groundnut seeds.

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	929	1144	1037	1020	1021	1021	924	948	936	719	709	714	606	631	618
N1	1392	1435	1413	1201	1241	1221	1095	1139	1117	975	1002	989	743	762	753
N2	1300	1354	1327	1144	1193	1168	1030	1050	1040	941	960	951	711	731	721
N3	1174	1191	1183	1095	1127	1111	987	1022	1004	895	918	907	660	687	674
N4	1122	1131	1127	988	926	957	886	905	895	693	707	700	563	594	579
N5	1054	1075	1065	959	975	967	867	878	872	699	672	686	535	549	542
N6	973	995	984	916	939	928	821	843	832	629	656	643	498	511	505
N7	924	953	938	870	906	888	757	818	787	531	608	569	423	457	440
Mean	**1109**	**1160**	**1134**	**1024**	**1041**	**1032**	**921**	**950**	**935**	**760**	**779**	**770**	**592**	**615**	**604**
For compairingmeans of	SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%	
F	5.3	15.3		4.9	14.2		4.1	11.8		4.4	12.7		3.3	9.4	
N	10.6	30.6		9.9	28.5		8.2	23.6		8.8	25.3		6.6	18.9	
F x N	15.0	43.26		14.0	40.2		11.6	NS		12.4	35.8		9.3	NS	

Table 5. Influence of fumigants and number of fumigation on electrical conductivity of seed leachate (dSm^{-1}) of groundnut seeds.

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	0.670	0.630	0.650	0.660	0.650	0.655	0.720	0.710	0.715	0.770	0.850	0.810	0.990	0.960	0.975
N1	0.530	0.510	0.520	0.560	0.440	0.500	0.640	0.650	0.645	0.760	0.750	0.755	0.885	0.870	0.877
N2	0.537	0.530	0.533	0.560	0.540	0.550	0.663	0.660	0.662	0.790	0.780	0.785	0.910	0.888	0.899
N3	0.603	0.573	0.588	0.620	0.590	0.605	0.660	0.660	0.660	0.830	0.780	0.805	0.920	0.890	0.905
N4	0.607	0.590	0.599	0.660	0.640	0.650	0.690	0.650	0.670	0.850	0.800	0.825	0.950	0.930	0.940
N5	0.660	0.653	0.657	0.670	0.660	0.665	0.720	0.700	0.710	0.847	0.840	0.844	1.810	0.940	1.375
N6	0.707	0.700	0.704	0.690	0.687	0.688	0.750	0.740	0.745	0.900	0.860	0.880	1.910	0.977	1.444
N7	0.740	0.730	0.735	0.760	0.740	0.750	0.710	0.770	0.740	0.910	0.900	0.905	2.810	1.010	1.910
Mean	**0.632**	**0.614**	**0.623**	**0.647**	**0.618**	**0.633**	**0.694**	**0.693**	**0.693**	**0.832**	**0.820**	**0.826**	**1.398**	**0.933**	**1.166**
For compairingmeans of	SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%		SE(M)±	CD at 5%	
F	0.002	0.007		0.013	NS		0.014	NS		0.003	0.009		0.004	0.013	
N	0.005	0.014		0.026	0.074		0.028	NS		0.006	0.019		0.009	0.026	
F x N	0.007	NS		0.036	NS		0.039	NS		0.009	0.026		0.013	0.036	

Interaction effect between fumigants and number of fumigations on EC were significant during eighth and tenth month of storage, significantly minimum (0.750 and 0.870 dSm^{-1}) and maximum (0.910 and 2.810 dSm^{-1}) seed leachate values were recorded in F_2N_1 and F_1N_7 interaction treatments during eight and tenth month of storage respectively. During other months of storage, the interaction were non-significant. Kamble *et al.* (2013) reported the similar results in an experiment conducted on groundnut seed.

6. Per cent reduction in germination

Irrespective of number of fumigations, between the fumigants, EDB recorded Minimum (44.19%) reduction in germination, while it was maximum (44.90%) in aluminium phosphide fumigated seeds at the end of tenth month of storage (Table 6).

Irrespective of fumigants, the seeds which received one fumigation at 30 days after harvest recorded minimum (37.94%) reduction in germination, while it was maximum (50.71%) in seeds fumigated thrice at 30, 90 and 150 days after harvest at the end of tenth month of storage.

In interaction effect between fumigants and number of fumigations, the treatment combinations F_2N_1 and F_1N_7 recorded minimum (37.58%) and maximum (51.06%) reduction in germination respectively at the end of tenth month of storage from initial germination value.

Table 6. Influence of fumigants and number of fumigation on per cent reduction in germination after ten months of storage of groundnut seeds.

Treatments	Per cent reduction in germination(%)		
	F1	F2	Mean
N0	43.96	43.61	43.79
N1	38.29	37.58	37.94
N2	39.01	38.29	38.65
N3	41.48	40.07	40.78
N4	47.15	46.09	46.62
N5	48.22	47.87	48.05
N6	50.00	49.64	49.82
N7	51.06	50.35	50.71
Mean	**44.90**	**44.19**	**44.54**

7. Beetle population

Irrespective of number of fumigations, between the fumigants, the seeds fumigated with aluminium phosphide spared minimum number of insects (1.58, 1.54, 2.50, 3.79 and 5.38) while, ethylene dibromide allowed more number of insects to survive (2.00, 2.04, 3.13, 5.00 and 6.38) during two, four, six, eight and ten months of storage respectively (Table 7).

Irrespective of fumigants, among the number of fumigations, unfumigated groundnut seeds recorded highest (5.00, 6.83, 9.00, 11.50 and 13.67) number of groundnut beetles while, it was lowest (0.00, 0.00, 0.00, 0.00 and 2.00) in seeds that received three fumigations at 30, 90 and 150 DAH during two, four, six, eight and ten month of storage.

In interaction treatment, the seeds fumigated with ethylene dibromide once at 30 DAH recorded highest (0.00, 2.67, 4.67, 7.67 and 9.33) number of groundnut beetles while, aluminium phosphide the least (0.00, 0.00, 0.00, 0.00 and 1.00) population of beetles was registered in the seeds exposed to three fumigations at 30, 90 and 150 DAH during two, four, six, eight and ten months of storage. The present findings were confirmed with the findings of Gupta and Kashyap (1995) in pulses.

LITERATURE CITED

Abdul-Baki, A. A. and J.D. Anderson, 1973. Vigour determination in soybean by multiple criteria, Crop Sci. (13): 630-633.

Agarwal, R. M., K. Krishnamurthy and G.K. Girish, 1987. Studies on the residues of ethylene dibromide in stored maize, Bulletin of Grain Tech. 25(2): 105-121.

Anonymous., 1999. International Rules of Seed Testing (Supplement rules), Seed Sci. and Tech. (27): 25-30.

Birthal, P. S., P. P. Rao, S. N. Nigam, C. S. Bantilan and S. Bhagvatulu, 2010. Groundnut and Soybean Economies in Asia: Facts, Trends and outlook. Patancheru: International Crop Research Institute for the Semi- Arid Tropics.

Junaithal Begum, M. A., P. Balamurugan and K. Prabakar. 2013. Seed Quality Deterioration in Groundnut Due to Fungi during Storage, Plant Path. J. 12(4): 176-179.

Table 7. Influence of fumigants and number of fumigation on beetle population in groundnut seeds.

Treatments	Months after storage														
	Two			Four			Six			Eight			Ten		
	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean	F1	F2	Mean
N0	4.33	5.67	5.00	6.33	7.33	6.83	8.67	9.33	9.00	11.00	12.00	11.50	13.33	14.00	13.67
N1	0.00	0.00	0.00	1.33	2.67	2.00	3.67	4.67	4.17	6.00	7.67	6.83	7.67	9.33	8.50
N2	1.67	2.67	2.17	0.00	0.00	0.00	4.33	6.33	5.33	5.33	5.67	5.50	6.67	7.33	7.00
N3	3.00	3.33	3.17	3.67	4.67	4.17	0.00	0.00	0.00	1.33	2.00	1.67	5.33	3.67	4.50
N4	0.00	0.00	0.00	0.00	0.00	0.00	2.00	3.67	2.83	3.67	6.33	5.00	5.00	5.33	5.17
N5	0.00	0.00	0.00	1.00	1.67	1.33	1.33	1.00	1.17	2.00	3.67	2.83	3.00	4.67	3.83
N6	3.67	4.33	4.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.67	1.83	1.00	3.67	2.33
N7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	3.00	2.00
Mean	**1.58**	**2.00**	**1.79**	**1.54**	**2.04**	**1.79**	**2.50**	**3.13**	**2.81**	**3.79**	**5.00**	**4.40**	**5.38**	**6.38**	**5.88**

Gupta, M. and R.K. Kashyap, 1995. Phosphine fumigation against pulse beetle: germination and vigour of green gram seeds, Seed Sci. and Tech. (23): 429-438.

Kamble V. R., S. N. Vasudevan, D. S Airani, A. Nagangouda, B. M. K. Naik and S. I. Macha, 2013. Influence of fumigants and number of fumigation on seed quality and storability of groundnut (*Arachis hypogaea* L), Global *J. of Sci. Frontier Res.* 13 (3).

Kapadia, M. N., 1994. Losses in weight and germination in groundnut due to seed beetle, Caryedon serratus Oliv, J. of Applied Zoological Res. (5): 134.

Kirsur, M. V., 1985. Study on the effect of repeated fumigation on the quality of maize seed (Zea mays L.) in relation to seed moisture content temperature and exposure period, M.Sc. (Agri) Thesis, University of Agricultural Sciences, Bangalore.

Lindgren, D. L., F. A. Guntherand and L. E. Vincent, 1962. Bromine residues in wheat and milled wheat fractions fumigated with methyl bromide, J. of Econ. Ento.(55): 773-776.

Maguire, J. D., 1962. Speed of germination, aid in selection evaluating for seedling emergence and vigour. *Crop Sci.* (2): 176-177.

Nigam, S. N., 2014. Groundnut at a glance. pp.121

Panse, V. G. and P. V. Sukhatme, 1985. Statistical Methods for Agricultural Workers, Indian Council of Agriculture Research, New Delhi.

Ranga Rao G. V., V. Rameshwar Rao and S. N. Nigam, 2010. Post-harvest Insect Pests of Groundnut and their Management, ICRISAT Information Bulletin No. 84.

Rathod, R., 1999. Effect of fumigation on seed quality and field performance on Dicoccum wheat (Triticum dicoccum L.). M.Sc. (Agri.) Thesis, University of Agric. Sci. Dharwad.

Umapathy, P. N., 1988. Effect of fumigation on seed quality and field performance in wheat, M.Sc. (Agri) Thesis, University of Agric. Sci., Dharwad.

Vasudevan, S.N., N.M. Shakuntala, S. Teli, S. Goud, B. Gowda and Ravi, 2014. Studies on Effect of Modified Atmospheric Storage Condition on Storability of Groundnut (*Arachis Hypogaea* L.) Seed Kernels, Int. J. of Res. Studies in Bio. sciences (IJRSB).2 (2): 25-36.

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Effect of Imbibition Patterns on Germination of Different Pearl Millet Cultivars

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ABSTRACT

The investigation was carried out to study the imbibitions on germination in the cultivars of of four hybrid seeds of pearl millet viz., GHB-719, GHB-905,GHB-744 and GHB-732 along with their inbred lines, in all total 10 entries, were stored to study imbibitions patterns. Imbibition rate at 0-4 hours, 4-10 hours and 10-16 hours of different entries were observed at advancing storage period.The imbibition rate 0-4 hours differed significantly among the entries and over the storage period. The interaction between entries and storage period was also significant. The highest imbibition rate was recorded in female line 04999 A followed by GHB-905. The entries and the storage period differed significantly with respect to germination percentage after 24, 36, 48, and 72 hours and 7 days. Overall the hybrids GHB-744 (85.75) recorded the highest germination percentage followed by GHB-905 (84.95), GHB-719 (77.40) and GHB-732 (76.50) respectively. However among parents female 96222A recorded the highest germination percentage.

Pearl millet is an important *Kharif* crop, which is known by various vernacular names such as *Bajra (Hindi, Punjabi and Urdu), Bajri (Rajasthan, Marathi and Gujarati), Sajje (Kannada), Gantilu (Telugu) and Kambu (Tamil)*. It is well adapted to drought prone areas, low soil fertility, and high temperature situation. It also performs well in soils with high salinity or low pH. It can be grown in all those soil and climatic conditions where other cereal crops, such as maize or rice, would not even survive. India is the largest producer of pearl millet in the world. In 2013-14, it occupied an area of 7.95 million ha with the production of 8.79 million tons per year and average productivity of 1106 kg ha^{-1} (Anonymous, 2014). Rajasthan, Maharashtra, Gujarat and Uttar Pradesh are the major pearl millet growing states of India. Gujarat has an area of 0.872 million hectares under pearl millet cultivation and production of 1.50 million tons with 1720 kg ha^{-1} productivity (Anonymous, 2013).

The early stages of imbibition or water uptake into a dry seed represent a crucial period for seed germination. It is the first key event that moves the seed from a dry, quiescent, dormant organism to the resumption of embryo growth. Thus, any consideration of seed germination physiology and its resultant impact on stand establishment should focus initially on water uptake. The extent to which water imbibition occurs is dependent on three factors: (1) composition of the seed, (2) seed coat permeability, and (3) water availability

MATERIAL AND METHODS

The investigation was carried out to study the effect of imbibitions on germination of different cultivars of pearl millet during 2014, at the Department of Seed Science and Technology and Department of Biochemistry, College of Agriculture, Junagadh Agricultural University, Junagadh. The seeds of parents (95222A, J 2454, 04999 A, 98444 A, J 2340 and 96222) of pearl millet hybrids GHB 719, GHB 905, GHB 744 and GHB 732 were procured from Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar and were multiplied as well as hybrids were produced in the *Kharif* season of 2013 at Sagadividi farm of Department of Seed Science and Technology, J.A.U., Junagadh. The harvesting was done in the month of November 2013 and ear heads were kept for air-drying. Threshing was made in the month of January 2014. Since pearl millet seeds have time bound dormancy, the seeds were stored in the month of February 2014, once the dormancy was released (Joshi *et al.*, 1996a).

Hundred seeds of each entry were weighed and kept in wet paper towel. The seed were weighed after 4, 10 and 16 hours of imbibition. The rate was calculated by subtracting the initial value from the subsequent ones and presented as percentage of water imbibed during different periods of imbibitions (Makwana P. K., 2005). Hundred seeds of each entry were weighed and kept in wet paper towel. Four samples of each entry were weighed after 4, 10 and 16 hours of imbibition and the index was calculated employing CRD with four repetitions. The data were analyzed as per completely randomized design (Gomez and Gomez 1984).

The seeds were surface sterilized with 0.1 per cent mercuric chloride solution for 10 minutes and kept

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for germination between moistened filter paper in the Petri dishes placed at 30° C (ISTA, 1996, Joshi *et al.*, 1997b). There were four replications each comprised 100 seeds. Germination percentage was observed after 24, 36, 48, 72 hours and 7 days period. The counts taken at 3rd day and 7th day were considered as first and final count, respectively. The germination percentage recorded at 7 th day represented the standard germination test (SGT).

Germination index was calculated as per formula given by Maguire (1962), using average value derived from germination trial.

$$GI = S\ (dGP/dt)$$

$$\text{Germination Index} = \Sigma \frac{\text{Increase in germination percent over time}}{\text{Change in time in day}}$$

RESULTS AND DISCUSSION

Generally germination commences with water uptake *i.e.* imbibition by the dry seed followed by a series of metabolic changes and ends with the protrusion of the radicle of the embryo through all the surrounding tissue. In the current investigation imbibition rate at 0-4 hours, 4-10 hours and 10-16 hours of different entries at advancing storage period are presented in the Table 1, 2, 3 respectively. The imbibition rate index is presented in Table 9. The data in tables revealed that imbibition rate 0-4 hours differed significantly among the entries and over the storage period. The interaction between entries and storage period was also significant. The highest imbibition rate was recorded in female line 04999 A followed by GHB-905. Imbibition rate 0-4 hours may be regarded as first phase of imbibition. The second phase of imbibition *i.e.* 4-10 hours is presented in Table 2. In this case the storage period did not differ significantly. The imbibition rate 10-16 hours (Table 3) represented the third phase of imbibition which differed significantly among entries and advancing storage period. Interestingly the advancing storage period *i.e.* seed ageing resulted in the decrease of this third phase of imbibition. With the advancement of the imbibition time, there was an increasing in the imbibition percentage but an overall overview suggested that there were three distinct phases- the first one was fast, second one was comparatively steady and third one was again faster (Gardner *et al.*, 1988). Comparing the imbibition rate at different duration in the seeds of pearl millet entries at the initiation of storage (Feb-2014) and that of fourth storage interval, the decline in imbibition rate in second phase and an increase in imbibition rate in the third phase did not remain very much discrete. Nonogaki *et al.* (2007) depicted that initial water uptake is a physical process which occurs in both leaving and dead seeds. Thus, for viable and non-dormant seeds there are three phase pattern of water uptake. In first phase rapid water uptake takes place and thereby increases volume of seed and some physiological activities are activated. In second phase is known as lag phase of imbibition. Physiological activities are enhanced, storage reserve mobilized. Although net water uptake is minimal but major metabolic events take place in the seed. Only seeds that complete germination enter in third phase of imbibition, which occurs due to cellular expansion associated with radical protrusion. Thus water uptake during phase third is not proper imbibition *per se* but rather the initial consequence of the completion of germination (Bewley *et al.*, 2013). The deceleration of the water uptake in the third phase in the aged seeds (Oct-2014) signifies impairment of important metabolic and physiological processes.

The interactions due to entries and storage period were non significant with regard to germination percentage recorded after increasing germination time *i.e.* after 24, 36, 48 and 72 hours of germination. However, germination percentage recorded after 7 days had significant interaction effect (Table 4,5,6,7,8 and 9). Although after 16 hours there were no distinctly visible signs of germination, physiologically germination *sensustricto* is associated with many metabolic, cellular and molecular events, rendering the radicle able to emerge from the seed (Bailly 2004b). Thus it is worth noting that in the frame work of seed germination, cell division is not necessary for radicle emergence (Haber and Luippold, 1960). But recent transcriptomic analyses show that the activation of the cell cycle in the Arabidopsis root meristem precedes the penetration of the seed envelops by the radicle and that D cyclines are limiting factors for this process (Masubeleve *et al.*, 2005). Although seed technology point of view the germination percentage is considered on the basis of fully established normal seedlings but never the less initial germination is very vital in depicting the vigour of the seed lot. Hence in the current investigation germination percentage was recorded right from 16 hours

Table 1: Imbibition rate 0-4 hours (%) in seeds of pearl millet entries (four hybrids and their respective parents) after different periods of storage

Entries	Dates of Sampling					
	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	13.45	12.60	11.48	11.33	10.41	11.85
95222 A	7.38	7.38	6.93	7.18	6.87	7.15
J 2454	12.21	11.90	10.88	10.41	10.31	11.14
GHB 905	16.59	19.13	17.46	18.23	18.71	18.02
04999 A	25.40	19.95	19.55	19.36	17.65	20.38
GHB 744	19.60	17.18	14.12	13.34	13.39	15.52
98444 A	21.88	15.72	14.64	14.31	14.48	16.20
J 2340	25.74	14.64	13.91	17.64	13.26	17.04
GHB 732	14.56	15.95	15.53	14.15	13.35	14.71
96222 A	15.67	11.90	12.19	12.49	13.55	13.16
Mean	17.25	14.63	13.67	13.84	13.20	
S.Em.±	1.21	0.53	0.42	1.32	1.32	0.87
C.D. at 5 %	3.48	1.52	1.22	3.80	2.27	2.49
C.V. %	13.99	7.18	6.18	19.01	11.93	12.72
D						
S.Em.±						0.61
C.D. at 5 %						1.76
D×E						
S.Em.±						0.92
C.D. at 5 %						2.58

Table 2: Imbibition rate 4-10 hours (%) in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	7.60	6.40	6.11	5.76	5.33	6.24
95222 A	9.25	8.52	7.68	7.21	7.15	7.96
J 2454	7.19	7.14	6.24	6.17	7.26	6.80
GHB 905	5.45	6.48	6.37	6.25	5.75	6.06
04999 A	6.63	6.37	7.68	5.82	5.44	6.39
GHB 744	6.98	5.30	12.34	11.32	10.84	9.36
98444 A	7.47	12.14	12.62	11.08	11.84	11.03
J 2340	5.39	8.57	8.28	7.29	7.66	7.44
GHB 732	5.64	5.66	6.49	6.25	11.56	7.12
96222 A	6.89	5.95	6.19	5.98	13.85	7.77
Mean	6.85	7.25	8.00	7.31	8.67	
S.Em.±	0.40	0.29	0.49	0.31	0.31	0.83
C.D. at 5 %	1.16	0.85	1.42	0.90	1.57	2.37
C.V. %	11.68	8.08	12.32	8.53	12.57	11.03
D						
S.Em.±						0.58
C.D. at 5 %						NS
D×E						
S.Em.±						0.42
C.D. at 5 %						1.18

Table 3: Imbibition rate 10-16 hours (%) in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	18.04	16.09	15.84	16.03	16.28	16.46
95222 A	13.13	11.87	11.73	11.67	11.31	11.94
J 2454	18.99	19.93	18.30	17.10	17.16	18.29
GHB 905	10.37	10.05	9.59	7.79	7.90	9.14
04999 A	17.25	17.08	16.40	16.24	15.74	16.54
GHB 744	14.55	13.99	12.63	13.43	12.58	13.43
98444 A	13.61	14.07	12.57	11.65	11.50	12.68
J 2340	18.10	18.34	17.38	17.47	17.35	17.72
GHB 732	16.82	17.45	17.09	16.67	16.35	16.87
96222 A	15.62	15.15	15.42	14.77	14.46	15.08
Mean	15.65	15.40	14.69	14.28	14.06	
S.Em.±	0.96	0.41	0.23	0.70	0.70	0.28
C.D. at 5 %	2.76	1.19	0.67	2.02	1.71	0.79
C.V. %	12.22	5.37	3.17	9.79	8.42	8.49
D						
S.Em.±						0.20
C.D. at 5 %						0.56
D×E						
S.Em.±						0.63
C.D. at 5 %						NS

Table 4: Germination % after 24 hours in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	68.75(55.98)	65.25(53.85)	62.00(51.94)	59.00(50.18)	56.00(48.45)	62.20
95222 A	61.00(51.35)	58.25(49.72)	51.75(45.97)	47.75(43.11)	48.25(43.97)	53.40
J 2454	53.50(47.01)	53.25(46.83)	59.50(50.48)	57.25(49.14)	54.50(47.58)	55.60
GHB 905	68.50(55.86)	64.75(53.55)	61.75(51.77)	59.25(50.30)	57.00(49.02)	62.25
04999 A	62.00(51.94)	59.00(50.18)	56.75(48.85)	53.75(47.12)	54.25(47.41)	57.15
GHB 744	73.50(59.02)	71.00(57.42)	71.25(57.54)	67.75(55.37)	66.25(54.45)	69.95
98444 A	67.00(54.94)	60.50(51.06)	58.50(49.89)	51.75(45.97)	51.25(45.69)	57.80
J 2340	60.25(50.89)	57.50(49.31)	57.00(49.02)	51.25(45.69)	56.25(48.56)	56.45
GHB 732	58.00(49.60)	60.75(51.18)	58.25(49.72)	57.25(49.14)	54.00(47.29)	57.65
96222 A	69.00(56.17)	66.25(54.45)	63.25(52.65)	59.75(50.59)	58.25(49.72)	63.30
Mean	64.15(53.19)	61.65(51.71)	60.00(50.77)	56.48(48.68)	55.60(48.22)	
S.Em.±	1.53	2.49	2.63	1.73	1.73	0.98
C.D. at 5 %	4.42	7.18	7.61	5.01	6.71	2.74
C.V. %	4.77	8.07	8.78	6.14	8.36	7.33
D						
S.Em.±						0.69
C.D. at 5 %						1.93
D×E						
S.Em.±						2.18
C.D. at 5 %						NS

Table 5: Germination % after 36 hours in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	70.75(57.23)	68.25(55.67)	65.50(54.03)	63.50(52.83)	58.25(49.72)	65.25
95222 A	66.00(54.33)	63.00(52.54)	54.25(47.41)	54.50(47.58)	52.75(46.55)	58.10
J 2454	60.50(51.06	56.00(48.45)	62.00(51.94)	59.75(59.80)	58.00(49.60)	59.25
GHB 905	74.75(59.80)	66.75(54.76)	65.75(54.15)	62.50(52.24)	60.00(50.77)	65.95
04999 A	67.75(55.37)	64.75(53.55)	60.25(50.89)	59.00(50.15)	54.00(47.29)	61.15
GHB 744	80.00(63.43)	72.50(58.37)	74.50(59.67)	71.75(57.86)	68.75(55.98)	73.50
98444 A	68.50(55.86)	67.50(55.24)	61.25(51.47)	57.75(49.43)	57.25(49.14)	62.45
J 2340	65.75(54.15)	63.50(52.83)	59.50(50.48)	57.50(49.43)	58.75(50.01)	61.00
GHB 732	62.00(51.94)	63.75(52.95)	60.50(51.06)	59.75(50.59)	55.50(48.16)	60.30
96222 A	74.00(59.34)	69.75(56.60)	66.25(54.45)	61.50(51.65)	59.50(50.48)	66.20
Mean	69.00(56.17)	65.58(54.03)	62.98(52.48)	60.75(51.18)	58.28(49.72)	
S.Em.±	1.34	2.00	2.44	2.24	2.24	0.96
C.D. at 5 %	3.88	5.78	7.03	6.48	7.17	2.68
C.V. %	3.90	6.10	7.73	7.39	8.52	6.77
D						
S.Em.±						0.68
C.D. at 5 %						1.90
D×E						
S.Em.±						2.14
C.D. at 5 %						NS

Table 6: Germination % after 48 hours in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	75.75(60.47)	70.75(57.23)	66.25(54.45)	65.00(53.73)	60.00(55.77)	67.55
95222 A	71.75(57.86)	66.00(54.33)	56.00(48.45)	54.50(47.58)	54.75(47.70)	60.60
J 2454	66.50(54.63)	57.75(49.43)	63.25(52.65)	61.00(51.35)	59.50(50.48)	61.60
GHB 905	81.75(64.67)	68.25(55.67)	72.00(58.05)	64.00(53.13)	61.25(51.47)	69.45
04999 A	73.25(58.82)	67.75(55.37)	65.00(53.73)	60.75(51.18)	56.25(48.56)	64.60
GHB 744	85.25(67.37)	74.50(59.67)	78.00(62.03)	73.25(58.82)	71.00(57.42)	76.40
98444 A	75.00(60)	69.00(56.17)	68.50(55.86)	60.25(50.89)	59.50(50.48)	66.45
J 2340	71.25(57.54)	65.75(54.15)	63.50(52.83)	59.50(50.48)	60.75(51.18)	64.15
GHB 732	76.00(60.67)	64.50(53.43)	62.50(52.24)	61.25(51.47)	57.75(49.43)	64.40
96222 A	78.75(62.51)	71.25(57.54)	68.00(55.55)	63.50(52.83)	60.75(51.18)	68.45
Mean	75.53(60.33)	67.55(55.24)	66.30(54.51)	62.30(52.12)	60.15(50.83)	
S.Em.±	1.43	2.03	2.21	2.24	2.24	0.94
C.D. at 5 %	4.14	5.86	6.40	6.47	7.02	2.63
C.V. %	3.79	6.01	6.68	7.19	8.08	6.32
D						
S.Em.±						0.66
C.D. at 5 %						1.86
D×E						
S.Em.±						2.10
C.D. at 5 %						NS

Table 7: Germination % after72 hours in seeds of pearl millet entries after different periods of storage

Entries	Dates of Sampling					
	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	75.75(60.47)	70.75(57.23)	66.25(54.45)	65.00(53.73)	60.00(50.77)	67.55
95222 A	71.75(57.86)	66.00(54.33)	56.00(48.45)	54.50(47.58)	54.75(47.70)	60.60
J 2454	66.50(54.63)	57.75(49.43)	63.25(52.65)	61.00(51.35)	59.50(50.48)	61.60
GHB 905	81.75(64.67)	68.25(55.67)	72.00(58.05)	64.00(53.13)	61.25(51.47)	69.45
04999 A	73.25(58.82)	67.75(55.37)	65.00(53.73)	60.75(51.18)	56.25(48.56)	64.60
GHB 744	85.25(67.37)	74.50(59.67)	78.00(62.03)	73.25(58.82)	71.00(57.42)	76.40
98444 A	75.00(60)	69.00(56.17)	68.50(55.86)	60.25(50.89)	59.50(50.48)	66.45
J 2340	71.25(57.54)	65.75(54.15)	63.50(52.83)	59.50(50.48)	60.75(51.18)	64.15
GHB 732	76.00(60.67)	64.50(53.43)	62.50(52.24)	61.25(51.47)	57.75(49.43)	64.40
96222 A	78.75(62.51)	71.25(57.54)	68.00(55.55)	63.50(52.83)	60.75(51.18)	68.45
Mean	75.53(60.33)	67.55(55.24)	66.30(54.51)	62.30(52.12)	60.15(50.83)	
S.Em.±	1.43	2.03	2.21	2.24	2.24	0.94
C.D. at 5 %	4.14	5.86	6.40	6.47	7.02	2.63
C.V. %	3.79	6.01	6.68	7.19	8.08	6.32
D						
S.Em.±						0.66
C.D. at 5 %						1.86
D×E						
S.Em.±						2.10
C.D. at 5 %						NS

onwards but the germination was seen only after 24 hours of incubation time. The entries and the storage period differed significantly with respect to germination percentage after 24, 36, 48 and 72 hours and 7 days. Overall the hybrids GHB-744 (85.75) recorded the highest germination percentage followed by GHB-905 (84.55), GHB-719 (77.40) and GHB-732 (76.50), respectively. However among parents female 96222A recorded the highest germination percentage. As per ISTA rules (1996),the germination percentage recorded after three day is considered first count and that recorded after seven days is considered as final count which is also known as the standard germination test (SGT). The standard germination test over predicts the field performance and field establishment under (Pourhadian and Khajehpour, 2010) natural, adverse condition. So far as storage period is concerned there was a significant decline in the germination percentage at all level of times. There are a number of studies which reported a significant decline in seed germinablity and deterioration under natural ageing and storage (Kulik and Yaklich, 1982).

The germination percentage recorded at different intervals was utilized incalculating GI, which reflected the overall performance of the seed lot and used for evaluation of the physiological quality of the seed. The simplest assessment of rate of germination can be made from the first count or preliminary count in germination test. The first count is indicative of quality of seed lot, the higher the percentage of normal seedlings, the higher the vigour (Powell and Matthews, 1995). More assessment of rate of germination can be made by including more frequent counts of germination. These assessments therefore also reflect the pattern of germination. The entries and storage period differed significantly while the interaction between them was not significant with regard to germination index (Table 9). Overall the hybrids recorded the higher value as was the case in germination percentage, the hybrid GHB-744 recorded the highest value followed by GHB-905, GHB-719 and GHB-732 respectively. Among parents female parent 96222A recorded the highest value of germination index. There was a distinct decline in the germination index with the advancement of storage period.

Table 8: Germination % after 7 days in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	87.75(69.47)	84.75(66.97)	78.75(62.38)	71.00(57.42)	64.75(53.55)	77.40
95222 A	84.25(66.58)	80.25(63.58)	74.25(59.47)	66.75(54.76)	61.50(51.65)	73.40
J 2454	81.00(64.16)	84.00(66.42)	70.50(57.10)	67.50(55.24)	63.25(52.65)	73.25
GHB 905	93.25(74.88)	90.75(72.24)	85.25(67.37)	80.00(63.43)	73.50(59.02)	84.55
04999 A	84.50(66.82)	80.75(69.47)	75.50(60.33)	70.75(57.23)	68.75(55.98)	76.05
GHB 744	97.25(80.37)	93.25(74.88)	87.00(68.87)	78.50(62.38)	72.75(58.50)	85.75
98444 A	87.50(69.30)	84.25(66.58)	77.75(61.82)	73.25(58.82)	69.00(56.17)	78.35
J 2340	84.75(66.97)	81.25(64.30)	73.25(58.82)	72.50(58.37)	64.50(53.43)	75.25
GHB 732	89.25(70.81)	80.50(63.79)	76.75(61.14)	71.00(57.42)	65.00(53.73)	76.50
96222 A	89.00(70.63)	84.50(66.82)	79.00(62.73)	68.75(55.98)	67.50(55.24)	77.75
Mean	87.85(69.56)	84.43(66.74)	77.80(61.89)	72.00(58.05)	67.05(54.94)	
S.Em.±	1.30	1.05	1.15	1.43	1.43	0.82
C.D. at 5 %	3.75	3.02	3.32	4.12	3.76	2.36
C.V. %	2.96	2.48	2.95	3.96	3.88	3.22
D						
S.Em.±						0.58
C.D. at 5 %						1.67
D×E						
S.Em.±						1.25
C.D. at 5 %						3.50

Table 9: Germination index in seeds of pearl millet entries after different periods of storage

Treatment	Feb-14	Apr-14	June-14	Aug-14	Oct-14	Pooled
GHB 719	600.36	576.05	539.62	520.93	492.86	545.96
95222 A	555.42	526.40	454.97	437.83	439.27	482.78
J 2454	506.54	474.56	512.55	495.30	484.35	494.66
GHB 905	626.75	559.22	559.50	521.18	507.17	554.76
04999 A	565.24	536.72	509.05	484.10	472.60	513.54
GHB 744	664.30	611.03	623.21	590.08	580.14	613.75
98444 A	591.30	562.98	526.11	473.72	476.53	526.13
J 2340	551.28	525.40	503.48	472.03	497.04	509.85
GHB 732	551.65	536.17	506.11	499.67	476.91	514.10
96222 A	616.43	577.10	550.94	513.37	507.55	553.08
Mean	582.93	548.56	528.56	500.82	493.44	
S.Em.±	11.43	18.22	18.15	15.35	15.35	8.14
C.D. at 5 %	33.01	52.61	52.42	44.34	NS	22.79
C.V. %	3.92	6.64	6.87	6.13	10.15	6.86
D						
S.Em.±						5.75
C.D. at 5 %						16.11
D×E						
S.Em.±						18.20
C.D. at 5 %						NS

LITERATURE CITED

Anonymous, 2013. Agriculture and co-operation department, Government of Gujarat (India Stat.com).

Anonymous, 2012. National Rainfed Area Authority (NRAA), New Delhi.

Bewley, J. D., K. J. Bradford, H. W. M. Hilhorst and H. Nonogaki, 2013. Seeds Physiology of development, germination and dormancy, 3rd Edition, Springer.

Bailly, C., J. Leymarie, A. Lehner, S. Roysseau, D. Come, Feuty, A. and Corbineau, F.2004b. Catalase activity and expression in developing sunflower seeds as related to drying, J. Experi. Bot., 55: 475-483.

Dagle, M. C., R. H. Gadag and O. Sharma, 2014. Estimation of heterosis for grain yield and quality traits in sweet corn (*Zea mays*varsacharato L), Electronic J. Pl. Breeding.5(4): 775-780.

Gardner, F. P., R. B. Pearce and R. L. Mitchell, Physiology of crop science, 1988. Scientific Publisher, Jodhpur. 2: 209-245.

Haber, A. H. and H. J. Luippold, 1960. Seperation of mechanisms initiating cell division and cell expansion in lettuce seed germination, plant physiology. 35: 168-173

ISTA, 1996. International rules for seed testing association, Seed science and technology, 24, supplement.

Joshi, A. K., I. D. Patel, N. D. Rathod, K. V. Pethani, and H. R. Dave, 1997b. Assessment of physiological maturity in pearlmillet (*Pennisetum glaucum*) hybrids, J. Sci. Agric. Res. 58: 43-50.

Joshi, A. K., I. D. Patel, J. N. Pandya, K. V. Pethani and H. R. Dave, 1996a. Study of seed dormancy in pearl millet (*Pennisetum glaucum*) hybrids, J. Sci. Agric. Res., 57: 41-54.

Kulik, M. M. and R. W. Yaklich, 1982. Evaluation of vigour tests in soybean seeds. Relationship of accelerated aging, cold, sand bench and speed of germination tests to field performance, Crop Science, 22: 766-770

Maguire, J. D., 1962. Speed of germination aid in selection and evaluation for seedling emergence and vigour, Crop Sci., 2: 176-177.

Masubeleve, N.H., W. Dewitte, M. Menges, S. Maughan, C. Collins, R.Huntly, J. Nieuwland, S Scofeild and J.A. Murray, 2005. D-type cyclins activate division in the root apex to promote seed germination in Arabidopsis, Proceedings of the National Academy of Sciences, USA, 102 : 15694-15699.

Nonogaki, H.; F. Chen, K. Bradford, 2007. Mechanisms and genes involved in germination sensustricto, In: Bradford K, Nonogaki H, eds, Seed Development, Dormancy and Germination. Blackwell, Oxford : 264–304.

Makwana, P. K., 2005. Germinative evaluation of physiological quality of seed in pearlmillet (*Pennisetum glaucum* L) M.Sc. (Agri.) Thesis (Unpub), J.A.U., Junagadh, India.

Pourhadian, H. and M. R. Khajehpour, 2010. Relationship between germination test and field emergence of wheat, Asian J. Applied Sci.

Powell,A. A. and S. Matthews, 1995.Techaniques in seed science and techanology : 98

Received on Date 27.08.2016

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Effect of Application of Post Harvest Chemicals on Shelf Life of Mango

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ABSTRACT

A laboratory experiment was conducted at Department of Horticulture, VNMKV, Parbhani during 2014, to study the effect of post harvest treatments on shelf life of Kesar mango. Experiment consisted of seven treatment combination of 1-Methylcyclopropene (1-MCP) at two concentrations 50 ppb and 100 ppb for 12 hrs duration and coated with Chitosan at different concentrations (0.5% and 1.0%) and was laid out in completely randomized block design with three replications. Treated fruits were subsequently packed in corrugated fibre board boxes and stored for 35 days at 13° C temperature and 14 days at ambient temperature. Results revealed that significantly lowest PLW (6.15%) and rate of respiration (6.22 ml Co_2 kg^{-1} h^{-1}) were found in treatment 1-MCP 100 ppb + 1.0 per cent Chitosan over rest of the treatments and control. On 35th days of storage, the decay incidence was not observed in treatment of combination of 1-MCP 100 ppb and 1.0 per cent of Chitosan. Fruits treated with the combination of 1-MCP 100 ppb and 1.0 per cent of Chitosan showed delayed PLW, respiration rate, ethylene evolution and decay incidence.

Mango is a short season fruit with less shelf life. The shelf life of mango varies among its varieties depending on storage conditions. It ranges from 4 to 8 days at room temperature and 2-3 weeks in cold storage at 13°C (Carrillo *et. al.*, 2000). This short period seriously limits the long distance commercial transport of this fruit (Gomer-Lim, 1997). Several environmental conditions like higher moisture content, soft textures of fruit and susceptibility to various pathogenic infections are the limiting factors to its shelf-life.

Ripening of climacteric fruits such as mango is followed by a peak in respiration and a concomitant production of ethylene. Ethylene is a plant hormone that regulates many processes of growth and development, including ripening and is also an important mediator of plant responses to biotic and abiotic stresses (Wang *et al.* 2002). Some commercial strategies used to withdraw deleterious effects of ethylene over produce are practiced. For instance, avoid exposure to ethylene, minimize ethylene production and action during produce ripening, harvesting, storage and transport (Watkins, 2002).

1-MCP is a synthetic cyclic olefin capable of inhibiting ethylene action. It acts as a competitor of ethylene, blocking its access to the ethylene-binding receptors (Sisler and Serek, 1997). 1-MCP is a gaseous nontoxic product that delays softening and improves post-storage quality of several climacteric fruits (Blankenship and Dole, 2003) and it is applied to extend their postharvest life.

Susceptibility of fruits to postharvest diseases results from physiological changes during ripening and increasing senescence that develops during storage (Prusky 1996), necessitating treatments to control diseases, such as hot water, fungicides, or their combination. Synthetic fungicides are the primary means to control postharvest diseases (Eckert, 1990). Many importing countries now impose strict limits for post harvest fungicidal residues because excessive use of fungicides has resulted in serious problems for the environment and human health and the increasing chemical resistance of pathogens (Bautista-Banos *et al.* 2006).

Chitosan, a polycationic polymer of (3-1,4, linked D-glucosamine chemically derived from crustaceans and soluble in organic acids is one of a range of natural compounds that have been successfully used to maintain the quality of harvested fruits and vegetables (El Ghaouth *et al.* 1991 and Jiang and Li, 2001). The use of Chitosan as an alternative to control phytopathogenic fungi during postharvest is important because this polymer exhibits antifungal activity against several important pathogens that affect horticultural commodities. Chitosan forms a semi permeable coating which generates a mechanical barrier against the diffusion of gases that affect the metabolism of agricultural products (Miguel Gerardo *et al.*, 2012). This may assist to highlight the antifungal potential of Chitosan and may spread its use within a sustainable agriculture. Kesar variety of mango has been planted on large area and production is expected to be

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increased by many folds in near future in the state of Maharashtra. Hence, the present research work is undertaken with the objective to study the influence of 1-MCP and Chitosan on shelf life of mango var. Kesar.

MATERIAL AND METHODS

Mango fruits of cv. Kesar were procured from Fruit Research Station, Aurangabad (Maharashtra). Fruits were harvested at commercial maturity and immediately transported to the laboratory. Experiment was conducted in a completely randomized design, including seven treatments and three replications. Mango fruits were subjected to uniform manual grading and washed using tap water to remove dirt and spray residues and dried under fan. The clean dried fruits were then divided into six main lots each containing 180 fruits and subjected to 1-MCP (50 ppb and 100 ppb) and Chitosan (0.5%, 1.0%) treatment combinations and replicated thrice. After treatments, the treated and control fruits were packed in corrugated fibre board boxes and stored at ambient temperature 13°C and relative humidity 40 per cent and at 13 °C temperature and relative humidity 90 per cent. After 7, 14, 21, 28 and 35 days, fruits for each treatment were sampled and further stored at 20°C for 3 days. The observations of fruit weight loss, fruit decay, respiration rate, ethylene evoluation were recorded during storage of mango fruit. The data obtained from 3 replicates under different treatments in respect to various functional properties during storage were subjected to analysis of variance (ANOVA). All analyses were performed with SPSS software package.

RESULTS AND DISCUSSION

Data presented in Table 1 was found to increase PLW of fruits with the advancement of storage period irrespective of treatments. At 14th day of storage at ambient temperature, significantly lowest PLW was recorded in treatment T_7 (8.36%) over rest of all treatments while highest PLW was recorded in treatment T_9 (18.18%). There was a marked increase in PLW during the low temperature storage period. At 7th day of storage of fruits at low temperature, lowest PLW was recorded with treatment T_7 (2.03%) while highest PLW was recorded in treatment T_6 (3.42%). Similar trend was observed at 14th, 21st and 28th day of storage of fruits at low temperature. During the 35th day of observation, significantly lowest PLW was recorded in treatment T_7 (6.15%) over rest of the all treatments except treatment T_3 (6.99%) whereas the highest PLW was recorded in treatment T_9 (8.35%).

PLW of fruits stored at 13 °C temperature was registered at low compared to fruits stored at ambient temperature. PLW of fruits was altered with treatment of 1-MCP + Chitosan gave superior results over other treatments with respect to keeping PLW rate low under both the storage conditions. The low PLW of fruits may be attributed to the diminished biological activities (respiration, ethylene evolution, inactivation of enzymes

Table 1. Effect of 1-MCP and Chitosan on physiological loss in weight (PLW %) of mango cv. Kesar during storage

Treatments	Ambient Storage period		13°C temperature Storage period (days)				
	7	14	7	14	21	28	35
T1	10.91	14.35	2.95	4.37	5.88	6.83	7.51
T2	10.24	13.39	2.60	4.24	5.75	6.49	7.14
T3	7.32	11.57	2.47	3.88	4.83	6.03	6.99
T4	8.33	13.09	3.12	4.39	5.96	6.57	7.65
T5	9.98	15.01	2.73	4.30	5.97	6.64	7.88
T6	10.90	12.04	3.42	4.55	5.67	6.75	7.51
T7	7.06	8.36	2.03	3.35	4.75	5.67	6.15
T8	8.75	10.44	2.43	4.04	5.02	6.15	7.06
T9	14.39	18.18	2.78	4.53	6.22	7.06	8.35
S.E.+	0.76	0.51	0.21	0.08	0.20	0.18	0.25
C.D.@5%	2.28	1.51	0.62	0.25	0.62	0.54	0.77

Table 2. Effect of 1-MCP and Chitosan on decay (%) of mango cv. Kesar during storage

Treatments	Ambient temperature Storage period		13°C temperature Storage period (days)				
	7	14	7	14	21	28	35
T1	9.97 (4.44)	9.97 (4.44)	0	9.97 (4.44)	11.49 (6.67)	11.49 (6.67)	1.49 1(6.67)
T2	9.97 (4.44)	9.97 (4.44)	0	9.97 (4.44)	11.49 (6.67)	11.49 (6.67)	11.49 (6.67)
T3	0.00	9.97 (4.44)	0	0.00	4.98 (2.22)	11.49 (6.67)	11.49 (6.67)
T4	0.00	0.00	0	0.00	0.00	4.98 (2.22)	9.97 (4.44)
T5	0.00	0.00	0	0.00	0.00	4.98 (2.22)	11.49 (6.67)
T6	0.00	4.99 (2.22)	0	0.00	9.97 (4.44)	0.00	9.97 (4.44)
T7	0.00	0.00	0	0.00	0.00	0.00	0.00
T8	0.00	0.00	0	0.00	0.00	9.97 (4.44)	9.97 (4.44)
T9	9.97 (4.44)	11.49 (6.67)	0	9.97 (4.44)	11.49 (6.67)	11.49 (6.67)	13.71 (8.89)
S.E.+	1.28	1.48	-	1.28	1.04	1.28	1.48
C.D.@5%	3.80	4.39	-	3.80	3.11	3.808	4.39

Table 3.Effect of 1-MCP and Chitosan on rate of respiration ($mlCo_2\ kg^{-1}\ h^{-1}$) of mango cv. Kesar during storage

Treatments	Ambient temperature Storage period (days)		13°C temperature Storage period (days)				
	Initial	7	Initial	7	14	21	28
T_1	8.47	7.70	7.17	7.77	8.42	7.99	8.15
T_2	8.69	7.91	7.83	7.99	8.28	8.15	8.21
T_3	7.91	6.98	8.53	7.90	6.81	6.54	6.44
T_4	8.75	7.90	8.69	7.71	7.27	7.21	6.98
T_5	8.76	7.76	8.69	7.64	7.49	7.42	6.91
T_6	8.59	7.11	8.18	7.62	7.47	7.06	6.72
T_7	7.32	6.57	7.67	6.73	6.44	6.24	6.22
T_8	7.71	6.96	7.52	6.76	6.54	6.46	6.24
T_9	15.74	5.10	17.05	12.38	9.53	7.76	5.84
S.E.±	0.61	0.47	0.52	0.46	0.48	0.30	0.38
C.D.@5%	1.82	1.41	1.54	1.36	1.43	0.89	1.13

and restricted movement of free water). The above findings confirmed with the work done by Jeong *et al.* (2002) and Prange and Delong (2003).

The effect of various treatments on percentage of decay incidence is presented in Table 2. At initial day of storage of mango fruits at ambient temperature, decay

incidence (4.44%) was recorded in treatments T_9, T_1 and T_2. At 7th day of storage, no decay was found in treatments T_7, T_8, T_4 and T_5 while highest decay incidence was observed in treatment T_9 (6.67%). The rate of decay incidence was increasing significantly with the advancement of time under the storage period. At initial day of storage of mango fruits at 13 °C temperature the rate of decay incidence was not found in all treatments. At 35th day of storage, the decay was not found in treatment T_7 while highest decay incidence was observed in treatment T_9 (8.89%).

It was found that the decay control of treated mango fruits was better as compared with untreated fruits. Chitosan treated fruit inhibited the growth of a wide variety of bacteria and fungi as compared to the control treatments. El-Ghaouth *et al,* (1991) suggested that Chitosan induces chitinase, a defense enzyme (Mauch *et al,* 1984), which catalyzes the hydrolysis of chitin, a common component of fungal cell walls (Hou *et al,* 1998). The results suggested that Chitosan extend the shelf life, limit the growth of fungi, and decrease the spoilage without affecting on ripening characteristics of fruit (Lam and Diep, 2003). The lower decay in treated fruits may be due to stimulation of some natural defence mechanism included by 1-MCP, in addition to maintaining tissue integrity during storage and ripening.

The effect of 1-Methylcyclopropene and Chitosan coating on the rate of respiration of mango at ambient temperature and 13°C temperature is presented in Table 3. There was a gradual increase in the rate of respiration. At initial of storage of mango fruits under ambient condition, lower rate of respiration was observed in treatment T_7 (7.32 ml Co_2 kg^{-1} h^{-1}) followed by treatment T_8 (7.71 ml Co_2 kg^{-1} h^{-1}) and T_3 (7.91 ml Co_2 kg^{-1} h^{-1}) while higher rate of respiration was found in treatment T_9 (15.74 ml Co_2 kg^{-1} h^{-1}). At 14thday of storage mango fruits at ambient temperature, there was decrease in the rate of respiration in all treatments.

The rate of respiration was increased initially followed by a sharp decline with the advancement of storage of fruits at low temperature 13 °C. At initial stage of storage of fruits under low temperature, treatment T_9 (17.05 ml Co_2 kg^{-1} h^{-1}) exhibited higher rate of respiration while lower rate of respiration was observed in treatment T_1 (7.17 ml Co_2 kg^{-1} h^{-1}). At 28th day of storage, the least rate of respiration was showed in treatments T_7 (6.22 ml Co_2 kg^{-1} h^{-1}).

An increase in ethylene production was detected after 21 days in 1-MCP treated fruit. The 1-MCP treated fruit showed a decrease in respiration rate compared to low temperature stored. The respiration rate of untreated fruits began to increase after 7 days at 13 °C and reached a maximum after 14th days. The respiration rate of 1-MCP treated fruit did not show a distinct climacteric peak and initially respiration rate declined, then slightly increased at 14 days of storage.

Data presented in Table 4 revealed that there was a gradual increase in the rate of ethylene evolution. At

Table 4. Effect of 1-MCP and Chitosan on ethylene evolution (ppm) of mango cv. Kesar during storage

Treatments	Ambient temperature Storage period (days)		13°C temperature Storage period (days)				
	Initial	7	Initial	7	14	21	28
T_1	0.40	0.87	0.33	0.33	0.63	0.87	1.00
T_2	0.43	0.83	0.50	0.50	0.73	0.90	1.03
T_3	0.43	0.80	0.43	0.43	0.67	0.90	1.10
T_4	0.60	1.03	0.53	0.53	0.67	0.83	1.07
T_5	0.37	0.90	0.37	0.37	0.70	0.93	1.03
T_6	0.50	1.07	0.50	0.57	0.77	0.87	1.07
T_7	0.07	1.13	0.00	0.00	0.87	1.00	1.17
T_8	0.20	1.10	0.10	0.10	0.80	0.97	1.13
T_9	1.33	0.27	1.07	0.63	0.43	0.37	0.33
S.E.±	0.04	0.06	0.03	0.03	0.04	0.05	0.05
C.D.@5%	0.12	0.18	0.11	0.09	0.13	0.15	0.15

initial of storage of fruits under ambient condition, treatment T_9 (1.33 ppm) showed higher rate of ethylene evolution while lower rate of ethylene evolution observed in treatment T_7 (0.07 ppm).

There was a gradual increase in the rate of ethylene evolution as storage period increases in treated mango fruits but it was gradually decreases in case of control fruits. At initial day of storage of mango fruits under low temperature, treatment T_9 (1.07 ppm) showed highest rate of ethylene evolution, while treatment T_7 has no ethylene evolution and T_8 exhibited lower ethylene evolution rate of 0.1. At 28th day of observation, the least ethylene evolution rate showed by treatment T_9 (0.33 ppm).

Ethylene production of non treated mango showed the maximum evolution rate on 7th day of storage. Ethylene evolution of treated fruit was found to be less than untreated fruit. The treatments T_7, T_8 and T_3 had maximum rate of ethylene evolution on day 28th. The treated fruits had a lower rate of ethylene evolution than other treatments.

LITERATURE CITED

Bautista-Ban osa S., A.N. Hernandez-Lauzardoa, M.G. Velazquez-del Vallea, M. Hernandez-Lopeza, E. Ait Barkab, E. Bosquez-Molinac and C.L. Wilsond, 2006. Review : Chitosan as a potential natural compound to control pre and postharvest diseases of horticultural commodities, Crop Protection, 25:108–118.

Blankenship, S.M. and J.M.Dole, 2003. 1-Methylcyclopropene : a review, Postharvest Biology and Technology, 28:1-25.

Carrillo, L.A., F. Ramirez-Bustamante, J.B. Valdez-Torres, R. Rojas Villegas and E.M. Yahia, 2000. Ripening and quality changes in mango fruit as affected by coating with an edible film, J. Food quality. 23: 479-486.

Eckert, J.W., 1990. Recent development in the chemical control of postharvest diseases, In: R.E. Paull (ed.) Tropical Fruit in International Trade, Acta Horti., 269: 477-494.

El-Ghaouth, A, J. Arul, R. Ponnampalam and M. Boulet, 1991. Chitosan coating effect on storability and quality of fresh strawberries, J. Food Sci., 56: 1618-31.

Gomer-Lim, M.A., 1997. Post harvest physiology. In: *The Mango*: Botany, Production and Uses.(Es.): R.E. Litz. 425-446, CAB Interntl, New York, Aust. J. Exp. Agric. 41: 567–72.

Hou, W.C., Y.C. Chen and Y.H. Lin, 1998. Chitinase activity of sweet potato (*Ipomoea batatas* L. Lam var. Tainong 57), Bot. Bull. Acad. Sinica, 39: 93-97.

Jeong, J., D.J. Huber, and S.A. Sargent, 2002. Influence of 1-methylcyclopropene (1-MCP) on ripening and cell-wall matrix polysaccharides of avacado (Persea americana) fruit, Postharvest Biol. Tech., 25: 241-56.

Jiang Y and J Li, 2001. Effect of Chitosan coating on postharvest life and quality of longan fruit, Food Chemistry., 73: 139-143.

Lam, N.D. and T.B. Diep, 2003. A preliminary study on radiation treatment of Chitosan for enhanceent of antifungal activity tested on fruit-spoiling strains, Nuclear Sci. Technol., 2 (2): 54-60.

Mauch, F., L.A. Hadwiger and T. Boller, 1984. Ethylene symptoms not signal for the induction of chitinase and beta-1, 3-glucanase in pea pods by pathogens and elicitors, Plant Physiol., 76: 607-611.

Miguel Gerardo Velázquez-de Valle, Ana Niurka Hernández-Lauzardo, María Guadalupe Guerra-Sánchez and Gloria Isabe Mariaca-Gaspar, 2012. *Review*: Chitosan as an alternative to control phytopathogenic fungi on fruits and vegetables in Mexico, African Journal of Microbiology Research, 6(37): 6606-6611.

Prange, R.K. and M. DeLong, 2003. 1-Methylcyclopropene: the magic bullet for horticultural products, *Chronica Hortic.*, 43: 11-14.

Prusky D., 1996. Pathogen quiescence in postharvest diseases, Annual Review Phytopathology, 34 : 413-434.

Sisler, E.C. and M. Serek. , 1997. Inhibitors of ethylene responses in plants in plants at the receptors level: Recent developments, physiol plant, 100 : 577-582.

Wang, K.L.C., H. Li and J.R. Ecker, 2002. Ethylene biosynthesis and signaling networks, Plant Cell, 14: 131-151.

Watkins, C.B., 2002. Ethylene Synthesis, Mode of Action, Consequences and Control. In: Fruit Quality and its Biological Basis, Knee, M. (Ed.), CRC Press USA, ISBN : 0849397812 : 180-224.

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Efficacy of Humic Acid on Growth Parameter and Seed Yield of Soybean

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ABSTRACT

The field experiment was conducted at Regional Research Center, Amravati (Maharashtra) during *Kharif* season of 2012-13, 2013-14 and 2014-15. The topography of experimental site was fairly uniform, leveled and have medium deep black soil. The experiment was laid out in Randomized block design with four replications consisting of eight treatments comprising of control (T_1), humic acid (6 %) (T_2), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5), humic acid 6 per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6 per cent (T_6), humic acid 6 per cent spray schedule + 75 per cent recommended dose of fertilizers with humic acid 6 per cent (T_7), humic acid 6 per cent spray schedule + 50 per cent recommended dose of fertilizers with humic acid 6 per cent (T_8). Soil application mixing with fertilizer @ 2.5 liter ha^{-1} at the time of along with basal dose (30:75:30 N, P, K kg ha^{-1}) were given to the treatment T_6, T_7 and T_8 only. From the three years pooled data, it can be indicated that significantly highest seed and straw yield (2065 and 2890 kg ha^{-1}, respectively) of soybean was obtained with application schedule of humic acid 6per cent at different growth stages of crop with 100 per cent RDF along with 2.5 l ha^{-1} of humic acid (6 %) as soil application at the time sowing but it was found at par with 25 per cent lesser dose of treatment i.e. T_7 (75 % RDF + 6 % HA foliar spray)

Today there is a recognized and increasing use of humic acids for their beneficial impact on the growth and cultivation of crop. Humic acid is not a fertilizer as it does not directly provide nutrition to plants, but is a compliment fertilizer. Humic acid can break up compacted soils, allowing for enhanced water penetration and better root zone growth and development. Plant growth is also improved by the ability of the plant to uptake and receives more nutrients. Humic acid is especially beneficial in freezing up nutrients in the soil so that they are made available to the plant as needed. Humic acid is also especially important because of its ability to chelated micronutrients increasing their bio availability. To increase the production of soybean by using the bio stimulants like humic acid. Humic acids are intermediates in complexity between humins and fulvic acids persist in soil for a larger period, so that to be useful to the crops. Humic acid with high molecular weight are not known to be assimilated while, those with low molecular weight are said to be assimilated by the plant (Chandrashekharan, 1992). Among three humic substances, humic acid has received the most attention and has been extensively studied to find out its effect on several crop plants. Therefore, the present investigation was undertaken to study the

MATERIAL AND METHODS

The field experiment was conducted on medium deep black soil at Regional Research Center, Amravati during *Kharif* season of 2012-13, 2013-14 and 2014-15. The topography of experimental site was fairly uniform and leveled. The experiment was laid out in Randomized block design with four replications consisting of eight treatments comprising of control (T_1), foliar application of humic acid (6 %) (T_2), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5), humic acid (6 %) spray schedule +100 per cent recommended dose of fertilizers with humic acid 6per cent (T_6), humic acid 6per cent spray schedule +75 per cent recommended dose of fertilizers with humic acid (6 %) (T_7), humic acid (6 %) spray schedule + 50 per cent recommended dose of fertilizers with humic acid (6 %) (T_8). Foliar application as per guideline followed in T_2, T_6, T_7 and T_8.

Table 1: Schedule for foliar spray of humic acid on soybean

S. N.	Crop stag for spray	Dose lit^{-1} water
1st spray	4-5 leaves stage	1.5 ml
2nd spray	Branching stage	2.5 ml
3rd spray	Flower initiation stage	2.5ml
4th spray	Pod formation stage	2.5ml
5th spray	Grain development stage	2.75ml

Soil application of 6 per cent humic acid mixing with fertilizer @ 2.5 liter ha^{-1} at the time sowing along

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with dose of fertilizer application to treatment T6, T7 and T8.

Soybean variety JS-335 was used for the study. The gross plot size was 5m x 3.6m and net plot size was 4.8 m x 2.7 m. The mean number of pods per plant and number of filled pods plant^{-1}, number of unfilled pods per plant, number of seeds plant^{-1}, test weight, seed yield and straw yield were recorded. Recommended practices were adopted for control of pest and diseases.

RESULTS AND DISCUSSION

Number of pods per plant

Significantly more number of pods plant^{-1} were recorded with humic acid 6per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6per cent @ 2.5 l ha^{-1} (T_6) followed by humic acid 6per cent spray schedule + 75 per cent recommended dose of fertilizers with humic acid 6per cent @2.5 l ha^{-1} (T_7), humic acid 6per cent spray schedule +50 per cent recommended dose of fertilizers with humic acid (6 %) @ 2.5 l ha^{-1} (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5) and Humic acid 6 per cent (T_2) over the control (T_1). Results were also in line with that of Shui xiu and Ruizhen (2001) who reported that KOMIX, a HA-containing organic fertilizer significantly increased number of pods plant^{-1} in spring soybean.

Number of filled and unfilled pods plant^{-1}

Number of filled pods plant^{-1} increased significantly and it was found maximum under humic acid 6per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6per cent @ 2.5 l ha^{-1} (T_6) followed by humic acid 6per cent spray schedule + 75 per cent recommended dose of fertilizers with humic acid 6 per cent @2.5 l ha^{-1} (T_7), humic acid 6per cent spray schedule +50 per cent recommended dose of fertilizers with humic acid 6 per cent @2.5 l ha^{-1} (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4) and 50 per cent recommended dose of fertilizers (T_5) whereas number of unfilled pods plant^{-1} were maximum in control and minimum with humic acid 6per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6per cent @ 2.5 l ha^{-1} (T_6).

Number of seeds plant^{-1} and test weight

Yield contributing characters mainly includes number of seeds plant^{-1} and test weight in soybean. From the data it is evident that yield contributing parameters (seeds plant^{-1} and test weight) increased in treatments of humic acid 6 per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6 per cent @ 2.5 l ha^{-1} (T_6) followed by humic acid 6 per cent spray schedule + 75 per cent recommended dose of fertilizers with humic acid 6per cent @ 2.5 l ha^{-1} (T_7), humic acid 6 per cent spray schedule +50 per cent recommended dose of fertilizers with humic acid (6 %) @ 2.5 l ha^{-1} (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5) and Humic acid 6 per cent (T_2) over the control (T_1). The uptake of N, P and K during reproductive stages greatly influenced the pod formation and quality aspects of seed. Photosynthetic rate at grain filling are also increased. Cheng *et al.*, (1995) reported that spraying of humic acid increased thousand grain weight and retarded senescence in wheat.

Seed yield and straw yield

Seed yield is the economic yield which is final result of physiological activities of plants. Economic yield is that part of biomass that is converted into economic product (Nichiporvic, 1960)

Significantly maximum seed yield(2065 kg ha^{-1}) was recorded when humic acid 6 per cent spray schedule + 100 per cent recommended dose of fertilizers with humic acid 6 per cent @ 2.5 l ha^{-1} (T_6) as compared to control (1333 kg ha^{-1}) and rest of the combination of humic acid spray.

Next to T6 seed yield was recorded in humic acid 6per cent spray schedule + 75 per cent recommended dose of fertilizers with humic acid 6 per cent @ 2.5 l ha^{-1} (T_7) followed by humic acid 6 per cent spray schedule +50 per cent recommended dose of fertilizers with humic acid 6 per cent @2.5 l ha^{-1} (T_8), 100 per cent recommended dose of fertilizers (T_3), 75 per cent recommended dose of fertilizers (T_4), 50 per cent recommended dose of fertilizers (T_5) and Humic acid 6 per cent (T_2) over the control (T_1). Similar trend was observed in case of straw yield also.

Table 1: Effect of humic acid (6 %) on number of pods/plant, number of filled and unfilled pods, number of seeds/plant of Soybean

Treatment	No. of pods plant^{-1}				No. of filled pods plant^{-1}				No. of unfilled pods plant^{-1}				No. of seedsplant^{-1}			
	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled
T1 - Control	36.46	31.13	18.87	28.82	28.70	24.04	14.40	22.38	7.76	7.10	4.47	6.44	72.46	71.07	49.87	64.46
T2 - Humic acid 6% foliar spray	34.27	31.27	21.27	28.93	30.63	26.81	16.87	24.77	3.63	4.46	4.40	4.16	90.59	85.40	52.17	76.05
T3 - 100 % recommended dose of fertilizers	39.33	41.47	27.40	36.06	35.20	37.67	22.07	31.64	4.13	3.80	5.33	4.42	101.71	112.47	69.53	94.57
T4 - 75 % recommended dose of fertilizers	38.64	38.53	22.20	33.12	34.97	34.67	18.93	29.52	3.67	3.87	3.27	3.60	84.31	104.00	59.60	82.64
T5 - 50 % recommended dose of fertilizers	36.43	34.73	23.53	31.57	32.80	30.60	20.20	27.87	3.63	4.13	3.33	3.70	83.41	97.80	59.00	80.07
T6 - Humic acid (6 %) spray schedule + 100 % recommended dose of fertilizers with humic acid 6% @ 2.5 l/ha	47.55	57.53	33.40	46.16	45.75	54.63	27.80	42.73	1.80	2.91	5.60	3.44	114.86	154.60	89.73	119.73
T7 - Humic acid (6 %) spray schedule + 75 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	45.52	50.44	28.20	41.39	42.95	47.49	22.27	37.57	2.57	2.95	5.93	3.82	99.68	134.40	62.93	99.00
T8 - humic acid (6 %) spray schedule +50 % recommended dose of fertilizers with humic acid (6 %) @2.5 l/ha	40.95	44.93	27.80	37.89	37.57	41.22	23.33	34.04	3.38	3.72	4.47	3.86	99.35	127.67	67.33	98.12
SE (m) ±	1.71	2.02	1.35	1.71	1.79	1.99	1.37	1.77	0.35	0.27	1.22	0.75	6.79	4.99	3.10	5.26
CD at 5%	5.18	6.12	3.95	4.90	5.42	6.03	4.00	5.07	1.07	0.80	NS	2.13	20.61	15.12	9.06	15.02

Table 2: Effect of humic acid (6 %) on test weight, seed yield, and straw yield characters of soybean

Treatment	Test weight (g)				Seed yield (kg/ha)				Straw yield (kg/ha)			
	2012	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled
T1 - Control	9.09	9.29	12.02	10.14	1414	1454	1131	1333	1735	1769	1304	1602
T2 - Humic acid (6 %) foliar spray	9.81	9.78	12.42	10.67	1759	1596	1231	1529	2322	2222	1540	2028
T3 - 100 % recommended dose of fertilizers	10.86	10.47	12.82	11.38	1853	2108	1387	1783	2464	2690	1630	2261
T4 - 75 % recommended dose of fertilizers	10.37	10.45	12.82	11.21	1795	2012	1339	1715	2314	2568	1581	2154
T5 - 50 % recommended dose of fertilizers	10.13	10.04	12.45	10.87	1733	1914	1156	1601	2276	2525	1491	2097
T6 - Humic acid 6% spray schedule + 100 % recommended dose of fertilizers with humic acid (6 %) @ 2.5 l/ha	12.14	12.00	12.90	12.35	2207	2451	1539	2065	2759	3965	1946	2890
T7 - Humic acid (6 %) spray schedule +11.71 75 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	11.26	12.68	11.88	2074	2269	1450	1931	2516	3463	1694	2558	
T8 - Humic acid (6 %) spray schedule +11.16 50 % recommended dose of fertilizers with humic acid 6% @2.5 l/ha	10.65	12.22	11.34	1878	2123	1426	1809	2329	2748	1739	2272	
SE (m)±	0.25	0.32	0.51	0.37	91.21	95.11	80.57	87.29	125.87	165.69	84.26	128.04
CD at 5%	0.76	0.98	NS	1.05	276.64	288.47	235.72	249.45	381.78	502.53	246.50	365.90

The higher seed yield due to humic acid application in the present investigation corroborates the findings of Khan *et al.*, (2010), Vanitha and Mohandass, (2014), Thenmozhi *et al.*, (2004), David and Samule (2002), Albayrak (2002) Almarshadi and Ismail (2014). These authors suggested the use of humic acid due to its beneficial effect on grain yield in several crop species like wheat, aerobic rice, groundnut, mustered, Brassica raya, and barley.

LITERARURE CITED

Albayrak, S.C., 2005. Effects of different levels and application times of humic acid on root and leaf yield and yield components of forage turnip (*Brassica rapa* L.), J.Agron.y, 4:130-133.

Almarshadi, M. S. and S.M. Ismail, 2014. Barley Growth and Productivity as Affected by Soil Amendments under Fully and Minimum Irrigation Conditions in Saudi Arabia, Life Sci. J., 11: 223-230.

Chandrashekharan, S., 1992. Efficient use of fertilizers by crops with humic acids addition in soils, Indian J. Agric. Chem. 25(3): 129-141.

Cheng, Fujiu, Yang Daoqi and Wu Qungsheng, 1995. Physiological effect of humic acid on drought resistance of wheat, Chinese J. Appl. Eco. 6(4): 363-367.

Shui xiu. H and W. Ruizhen, 2001. A study on the effect of komix, humic acid containing organic fertilizer as spring soybean, Acta Agri. Universities Jiangxiensis, 23 (4): 463 -466.

Nichiporvic, A.A., 1960. Photosynthesis and the theory of obtaining high yields, Fld. Crop Abstr. 13:169-175.

Thenmozhi, S., S. Natarajan, and G. Selvakumari, 2004. Effect of humic acid on quality parameters of groundnut, Crop Research, 27: 210-213.

Vanitha, K. and S. Mohandass, 2014: Effect of humic acid on plant growth characters and grain yield of drip fertigated aerobic rice (*Oryza sativa* L.), The Bioscan, 9:45-50.

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Productivity Augmentation and Yield Gap Analysis of Post-Rainy Sorghum (*Sorghum bicolor*) Through Farmer's Participatory Demonstrations in Tribal Area

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ABSTRACT

Frontline demonstrations (FLD's) were conducted in a participatory mode during three years from 2013-14 to 2015-16 to evaluate the effect of technology package of post-rainy sorghum. This study was conducted on 732 farmers' fields in 13 villages in Buldhana district of Maharashtra. Demonstrated post-rainy season sorghum variety was PDKV-Kranti. The package of improved technologies like, line sowing, nutrient management, seed treatment and plant protection, as a whole package was used in the demonstration. The findings of the study revealed that the improved technology recorded mean yield of 1377 kg ha^{-1} which was 42.42 per cent higher than the farmers practice. Technology gap between improved and farmers' practices was 1123 kg ha^{-1}. The technology index was 44.92 and the extension gap was 334 kg ha^{-1}, which can be minimized by disseminating adequately the technological packages effectively in the district in order to boost-up adoption and increase the productivity.

Sorghum (*Sorghum bicolor* [L] Moench) is an important cereal and major staple food in dryland areas in the country. India contributes about 16 per cent of the world's sorghum production. It is the fourth most important cereal crop in the country. It was one of the major cereal staple during 1950's cultivated on more than 18 million hectares, However, it was reduced to 5.72 million hectares in 2013-2014, production increased from 9 million tons in the early 1970s to 10.62 million tonne in 2013-2014. Despite, the decrease in area over the years, production has been sustained at 10.62 million tons due to mainly adoption of improved varieties and hybrids. Productivity of rainy sorghum in India is1170 kg ha^{-1} and 880kg ha^{-1} of post-rainy sorghum in recent year (Zalkuwi *et. al.*, 2014).

Maharashtra, Karnataka and Telangana are major post-rainy sorghum growing states in the country. Post-rainy (*Rabi*) sorghum is one of the important cereals in the Buldhana district of Maharashtra occupying an area of 16 thousand ha (Anonymous, 2015). This district has sizable tribal population depends on agriculture which is resource-poor and dryland in nature.

Productivity of post-rainy sorghum is lower than the potential production technology, mainly due to its cultivation on marginal lands, under poor management with less or no inputs, non-use of quality seeds, etc. The foremost constraints accountable for lower yield are inappropriate use of production technologies like, no or very less use of fertilizers and untimely or no inter cultivation which were recorded in other crop like, sesame (Singh and Gautam, 2016). The improved technology packages were also found to be financially expensive. Adoption levels for several components of the improved technology were low, emphasizing the need for better dissemination (Kiresur *et al.*, 2001). Several biotic, abiotic and socio-economic constraints inhibit exploitation of the yield potential and these needs to be addressed. Use of improved production technologies offers a great scope for increasing productivity and profitability of post rainy sorghum. To appraise the impact of an improved cultivar with a balanced use of nutrients, inter-cultivation and other need-based production practices to enhance productivity, profitability and to identify the yield gaps of post rainy sorghum. Several frontline Demonstrations were conducted in a participatory mode especially in tribal areas in the Buldhana district of Maharashtra State during three years from 2013 to 2015 under tribal sub-plan initiative of the ICAR.

MATERIAL AND METHODS

Frontline demonstrations (FLD's) were conducted in a participatory mode during three years from 2013-14 to 2015-16 to evaluate the effect of technology package of post-rainy sorghum. This study was conducted

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on 732 farmers' fields in 13 villages namely,Titwi, Nandra, Gotra, Raygaon, Garpet, Umapru, Rasulpur, Hanwatkhed, Dhanora Gorala, Charban, Alewadi and Chichari in three blocks (Lonar, Jalgaon Jamod and Sangrampur) in Buldhana district of Maharashtra (Table 1). The Buldhana district is also one of the major sorghum growing districts in Maharashtra state in the country. Soil type of the trial site was upland medium deep black soils and clay loam in texture. It has low to medium nitrogen, low phosphorous and medium to high potash. Each demonstration was conducted on 0.40ha including 20-50 per cent or in few cases adjacent plot was taken as a farmers practice (FP). The package of improved technologies like, line sowing, nutrient management, seed treatment and plant protection, as a whole package was used in the demonstration. Demonstrated variety was PDKV- Kranti whereas local commonly used variety was used as check. The details of practices followed under FLDs (IP) and farmer's practices (FP) are given in Table 2. The spacing between rows was 45 cm and between plants 15 cm. Thinning was done at 15 Days after sowing (DAS) maintaining recommended plant population since excess or low plant population adversely affects yield of the crop. Sowing was done in the last week of October with a seed rate of 10 kg ha^{-1}. Data with respect to grain yield from FLD as well as farmers practice plots were collected and analyzed. Potential yield was considered as mentioned by the breeder in the released document. Different parameters as used by Kadian *et al.* (1997) and Yadav *et al.*(2004) in their studies were used for gap and economic analysis. The various parameters and formulae adopted for analysis are given here under:

Extension gap (EG) = Demonstration yield – Farmer's practice yield

Technology gap (TG) = Potential yield - Demonstration yield

Technology Index (TI) = (P-D/P) x 100

(Where, P= Potential yield, D= Demonstration yield)

Additional cost = Demonstration cost (Rs.) – Farmer's practice cost (Rs.)

Effective gain = Additional returns (Rs.) – Additional cost (Rs.)

Additional returns = Demonstration returns (Rs.) – Farmer's practice returns (Rs.)

Incremental B:C = Additional returns (Rs.)/ Additional cost (Rs.)

RESULTS AND DISCUSSION

The grain yield of post-rainy sorghum with improved production technology was ranged between 1136 and 1713 kg ha^{-1} with an average of 1377 kg ha^{-1} (Table 3). The grain productivity under improved production technology was 1608, 1568 and 1210 kg ha^{-1}, whereas it was 1282, 1258 and 865 kg ha^{-1} under farmer's practice during 2013, 2014 and 2015, respectively. Thus, the increase of 25.41 per cent, 24.80 per cent and 42.42 per cent was observed under demonstrated improved technologies during the same years. Moreover, fodder yield under improved production technology was registered more by 22.22 per cent, 22.18 per cent and 52.96 per cent than the farmer's practice during 2013, 2014 and 2015 (Table 4).The increased grain and fodder yield obtained under improved technologies was mainly because of high yield potential of improved cultivar PKV-Kranti (AKSV-13R), use of balanced fertilizers, pest management and timely inter-cultivation practices. The above findings elicited that the sorghum farmers of the Buldhana district were comfortable with adopting major practices namely, seed treatment, use of high yielding variety, use of nitrogen fertilizer, following time of sowing and maintaining plant spacing. The similar findings were also reported by Chapke, 2014.These findings are also similar to the findings reported under such field demonstrations by Sing and Meena (2011), Meena *et al.* (2016) in different dryland crops.

Yield gap analysis

The data on technology gap (TG), extension gap (EG) and technology index (TI) of the technology demonstrations conducted continuously during 2013, 2014 and 2015 on post-rainy sorghum was depicted in Table 5. It is indicated that technology gap between improved and farmers' practices was 892, 932 and 1290 kg ha^{-1} during the same period with an average gap of 1123 kg ha^{-1} which was close to potential yield of the demonstrated variety (2500 kg ha^{-1}). It indicates that the improved technology packages involving the above variety were more effective in the district. Similarly, the technology index (TI) was 35.68, 37.27 and 51.60 during 2013 to 2015 with an average index value of 44.92. It was also found to be closed to the cultivar potential yield, indicating its

suitability to this area. The extension gap (EG) was found to be 327, 310 and 345 kg ha^{-1} during the same period with the mean value of 334 kg ha^{-1}, which can be minimized by disseminating adequately the technological packages effectively in the district in order to boost-up adoption and increase the productivity. These findings are in conformity with the results of such field demonstration trials on different crops published by Meena and Singh (2014), Meena *et al.* (2016) and Singh and Gautam (2016).

Economics

Different productivity factors like, seed, fertilizers, bio-fertilizers and pesticides were considered as cash inputs for the demonstrations and in farmers' practice. On an average additional investment of Rs.3098/ - , Rs. 1221/-and Rs.4638/- ha^{-1} was made by the farmers since 2013 to 2015. The highest gross returns of Rs.40067 ha^{-1} was recorded during 2013 whereas, the lowest gross returns of Rs. 27507 ha^{-1} was recorded during 2015.The higher additional returns and the effective gain obtained under demonstrations could be due to good performance of improved technology coupled with non-monetary inputs like, timely operations and regular monitoring. The highest and lowest incremental benefit cost ratio (IBCR) of 5.71:1 and 1.76:1were observed in 2014 and 2015, respectively. The results obtained were found to be similar to the findings reported by Yadav *et al.* (2004), Meena *et al.* (2016) and Singh and Gautam (2016).

CONCLUSION

The frontline demonstrations conducted on post-rainy sorghum at the farmers' field revealed that adoption of improved technologies was resulted into significantly increased in grain and fodder yields and ultimately the net returns to the farmers. Therefore, there is a need to replicate such encouraging results and disseminate the improved technologies among the farmers of such resource-poor dryland area with effective extension methods. The farmers should be encouraged to adopt the proven package of practices in realizing higher returns and to support their livelihood in resource-poor tribal areas.

LITERATURE CITED

Chapke, R.R. (2014). Feasibility and appropriateness of recommended sorghum production technologies. *SpingerPlus* 2014, 3: 453 (Available at: http://www.springerplus.com/content/pdf/2193-1801-3-453.pdf)

Jimjel. Zalkuwi, Rakesh Singh, Madhusudan Bhattarai, O.P Singh and B. Dayakar, 2014. profitability analysis of sorghum production in India, IRACST –International J. Commerce, Business and Management,: *3(5): 2319–2828*

Kadian. K.S., Sharma R and Sharma A.K. 1997. Evaluation of frontline demonstration trials on oilseeds in Kangra Vally of Himachal Pradesh, Annals of Agric. Res. 18:40.

Kiresur V.R., S.V. Ramana Rao and D.M. Hedge, 2001. Improved technologies in oilseeds production- An assessment of their economic potentials in India, Agril Eco. Res. Rev., 14(2): 95-108

Meena, M.L. and D. Singh, 2014. Impact of frontline demonstrations in adiption of improved gram production technology, Indian J. Social Res., 55(2) : 277-283

Meena, M.L. and D. Singh, 2016. Productivity enhancement and gap analysis of moth bean through improved production technologies on farmer's participatory mode, Indian J. Dryland Res. & Develop., t31(1): 68-71

Singh, A.K. and U.S. Gautam, 2016. Technological interventions for productivity improvement of sesame in Kymore plateau and Satpura hills zone of Madhya Pradesh, Indian J. Dryland Res. and Develop.. 31(1): 56-62

Chapke, R.R., 2014. Feasibility and appropriateness of recommended sorghum production technologies, SpingerPlus 2014, 3: 453 (Available at: http://www.springerplus.com/content/pdf/2193-1801-3-453.pdf)

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Growth and Yield of Wheat as Influenced by Different Sowing Times and Wheat Genotypes on Under Varied Environmental Condition

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ABSTRACT

The field experiment was conducted to study the "Growth and Yield of wheat as influenced by different sowing times and Wheat Genotypes on under varied environmental condition at the farm of Wheat Research Unit, Dr. PanjabraoDeshmukh KrishiVidyapeeth, Akola, during *Rabi* season of 2014-15. Among the sowing times,crop sown at 48th MW recorded the highest test weight (39.80 g), grain yield (3486 kg ha^{-1}) and straw yield (9457 kg ha^{-1}) recorded over 46th MW and 51stMW .Genotype AKAW-4210-6.The highest gross and net monetary returns and B:C ratio was obtained when wheat was sown in 48th MW followed by 46th MW . Among the genotypes, AKAW-4210-6 registered significantly higher grain yield (3365 kg ha^{-1}), straw yield (9172 kg ha^{-1}) and test weight (41.19 g). grain to straw ratio (0.37), followed by AKAW-3722, and AKAW-4627. The highest gross monetary returns and B:C ratio were obtained from AKAW-4210-6 which was Rs.53386 ha^{-1}, Rs.27560 ha^{-1} and 1:2.07, respectively.

Wheat is India's widely adapted major food grain crop. Growth and development of wheat is adversely affected by environmental stresses like high temperature, soil moisture deficit, low light intensity, etc. Among these, temperature plays an important role in growth, development and yield of wheat.The optimum temperature for wheat is 15^{0}C. It is grown from temperate, irrigated to dry and high rainfall areas and from warm, humid to dry, cold environments.(Anonymous,2015).In Maharashtra, the life cycle of the wheat crop covers a period from October-November to March-April during which thermal and photo period undergo gradual changes. Under this thermal regime, the wheat plant completes its vegetative phase and switches over to reproductive phases. Important physiological changes occur during this period. Solar radiation incident on leaf surface and soil surface increases air, leaf and soil temperature. Howard (1924) pointed out that "wheat growing in India is a gamble with temperature".

The productivity of wheat governed by improved genotypes coupled with particular agro climate is the most important factor in realizing their yield potential.Among different agronomic practices proper time of sowing is a most important factor and it is a non-cash input about which the information is to be find out for obtaining maximum yield. Environmental conditions prevailing over a particular agro climatic zone cannot be altered, however sowing time of crop can be adjusted to take maximum advantage of the environmental factors to all the growth stages of crop.

Taking above views into consideration the studies were undertaken to study the agronomic performance of wheat genotypes under early, late and very late sowing condition, to monitor the weather parameters influencing plant growth to estimate the correlation coefficients for growth and yield and to study the economics of these practices.

MATERIAL AND METHODS

The experiment was conducted at the farm of Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during *Rabi* season of 2014-2015. The experiment was carried out in split plot design with three replications consisting of twenty one treatment combinations. Three sowing times, i.e 46th MW (1-20 Nov), 48th MW (26 Nov-5 Dec), 51st MW (17 -23 Dec) and seven genotypes viz., AKAW-4627, AKDW- 4021, AKAW- 3722, AKW-1071, NIDW-295, AKAW- 3997 and AKAW-4210-6 were tested. In all 6 irrigations were applied to D1i.e.(46MW), whereas, in D2 (48MW) 6 irrigations were applied and in D3(51MW) only 5 irrigations were applied.

The soil of experimental field was clayey in texture slightly alkaline in reaction having pH 8.28, moderate in organic carbon (5.9g kg^{-1}) low in available nitrogen(212 kg ha^{-1}) content, and low in available phosphorus (369 kg ha^{-1}) .

The chlorophyll content index (%) of plant was measured by Portable chlorophyll content meter CCM-

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200 (Opti-sciences). The observations were taken at an interval of 20 days up to 100 DAS. The leaf water potential of plant was measured by leaf samples were placed in a sample cup, and the cup bottom should be completely covered. Then, water potential was measured using chilled-mirror dew Point technique with a WP4-T DewpiontPotentia Meter (USA). To know the chlorophyll content and water potential in plants at various interval i.e. at 20 days .

The experimental site situated in the subtropical zone at the latitude of 22.42^0 N and longitude of 77.02^{0}E. Altitude of the place is 307.41 m above the mean sea level. The total rainfall received (46th MW of year 2014 to 13th MW of year 2015) at Akola centre was 119.2 mm, in 9 rainy days which was deficient for the crop. Observation were taken on the growth parameter, yield parameter, yield and economics of the wheat genotypes under varied sowing times and the statistical analysis was carried out as per the procedure by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

Effect of sowing Time

Data pertaining in table 1.revealed that all the growth attributes weresignificantly influenced by different sowing dates and genotypes. The crop sown on 48th MW recorded significantly higher plant height (95.52cm), number of functional leaves plant^{-1} (7.15), leaf area plant^{-1} (2.09 dm^{-2}), dry mater accumulation plant^{-1} (14.48 g), chlorophyll Content index (36.13 %), Leaf water potential (-7.08 Mpa).The increased plant height and Number of functional leaves in early sowing might be the enhanced vegetative developmentof crop due to the favorable weather condition(minimum temperature during the growth stage. Similar results were reported by Kushwaha*etal.* (2011) .The reason for maximum dry matter accumulation plant^{-1} in timely sowing may bethe enhanced vegetative development of crop and higher temperature accumulation. There was favorable temperature experienced by wheat crop sown on 48th MW during early growth or immediately after seedling emergence which might have resulted in accumulation of higher dry matter. Similar results were reported by Kalita *et al.* (2009).Higher leaf area plant^{-1} of 48thMW was mainly due to better leaf growth for longer period than late sown crop. Similar results were Ahmed and Farooq (2013).

Effect of genotypes

Among the seven genotypes, significantly higher plant height (94.91cm) in genotype AKDW-4021., number of functional leaves plant^{-1} (6.88) at harvest followed by genotype AKDW-4021(6.87). Among the seven wheat genotypes, significantly lowest leaves plant^{-1}wasrecorded by genotype AKAW-3997(5.49) at all growth stages. Among all genotypes at harvest the leaf area plant^{-1} (1.73dm^{-2}), dry mater accumulation plant^{-1}(15.16 g), chlorophyll content index (35.71%), Leaf water potential (-6.25 Mpa) is recorded. This may be referred toinherent difference between genotypes for leaf area, number of leaves per plant and theirtillering capacity during growing seasons. The leaf water potential indicates the turgidity of plant at a given point.

Interaction effect

The interaction effect of sowing dates and genotypes on growth attributes was found tobe non-significant during the course of investigation

Yield attributes as influenced by different sowing time

Effect of sowing time

Data pertaining to Yield attributes in Table 2. revealed that all the Yield attributeswere significantly influenced by different time of sowing and genotypes. The crop sown on 48thMW recorded significantly higher test weight (39.80 g), grain yield (3486 kg ha^{-1}), and Strawweight (9457 kg ha^{-1}). The lower grain yield in delayed sowing might be due to reducednumber of days to complete phonological stages, reduced heat use efficiency and yieldattributing characters like effective tillers, grains per plant and test weight. The highest strawyield in early sown crop could be attributed to higher vegetative growth, and more tillerproduction due to low temperature prevailing during the vegetative growth and lower strawyield in the late sown crop was due to poor vegetative growth and less number of tillers. Similar results were reported by Gill et al. (2013).The grain to straw ratio was significantly influenced by different sowing dates. Thehighest grain to straw ratio (0.37) was obtained in 48th MW sowing followed by (0.36)when sowing was done at 46thMW and (0.35) when sowing was done at 51st MW. This might be due to optimum consumption of helio thermal units and more vegetativegrowth by wheat crop sown at 48th MW and 46th MW. Similar results were reportedby Nagarjuna *et al.* (2014).

Table 1: Growth attributes as influenced by different sowing times.

Treatments	Plant height (cm) atharvest	Number offunctional leaves plant^{-1} at harvest	Leaf area plant^{-1} (dm^{-2}) at harvest plant^{-1}	Dry matter accumulation (g) atharvest	Chlorophyll content Index at harvest (Dried Leaves)	Leaf water potential Mpa) (atharvest
Sowing times						
46th MW(17Nov)	92.88	6.66	1.86	13.26	33.85	-6.81
48th MW(28 Nov)	95.52	7.15	2.09	14.48	36.13	-6.58
51st MW (17Dec)	89.46	5.1	0.83	11.91	29.17	-7.08
SE (m) ±	0.24	0.09	0.05	0.31	0.72	0.13
CD at 5%	0.93	0.36	0.21	1.21	2.82	NS
Genotypes						
AKAW4627	93.35	6.38	1.67	13.24	34.71	-6.89
AKDW4021	92.48	6.87	1.47	12.68	34.15	-6.88
AKAW3722	93.78	6.06	1.69	13.14	34.55	-6.66
AKW 1071	91.31	5.98	1.61	12.72	31.83	-7.08
NIDW 295	91.81	6.48	1.53	13.46	30.77	
AKAW3997	90.7	5.49	1.45	12.12	29.62	-7.08
AKAW4210-6	**94.91**	**6.88**	**1.73**	**15.16**	**35.71**	**-6.25**
SE (m) ±	0.58	0.17	0.04	0.36	0.69	0.2
CD at 5%	1.65	0.5	0.13	1.03	1.99	NS
Interaction(DXG)						
SE (m) ±	1	0.3	0.08	0.62	1.20	0.35
CD at 5%	NS	NS	NS	NS	NS	NS
GM	93.47	6.49	1.78	13.23	33.04	-6.87

Effect of genotypes

AKAW-4210-6 genotype, significantly recorded highest test weight (41.19 g), grain yield (3365 kg ha^{-1}), Straw weight (9172kg ha^{-1}), highest grain to straw ratio (0.37) was recorded in genotype which was statistically at par with genotype AKAW-4627.

Interaction effect

Interaction effect of sowing dates and genotypes in respect all the yield attributes was found to be non significance for grain and straw yield.

Economics

Yield and Economics as influenced by different sowing times and genotypes.

Data pertaining to Yield and Economics is given in Table 3.

Effect of sowing dates

The gross monetary returns were significantly influenced by different sowing times. 48th MW sowing recorded significantly higher gross returns of Rs. ha^{-1} 55283 over Rs. ha^{-1} 50810 when sowing was done at 46st MW and Rs. ha^{-1} 44787 when sown at51st MW.

Net monetary returns of Rs. 29457 ha^{-1} over Rs. 23984 ha^{-1} when sown at 46th MWand Rs.ha^{-1}19961 sown at 51stMW. This might be due to crop sown on 48th MW produced more grain and straw yield than crop sown crop 49th MW and sown crop 51st MW. Similar results were reported by Nagarjuna *et al.* (2014). The highest B: C ratio (1: 2.14) wasrecorded in 48thMW sown crop, which was superior over rest all other times of sowing.While lowest B: C ratio (1: 1.80) was achieved in 51st MW sown crop. This might be due to higher grain and straw yield as obtained from treatment48th MW sowing. It is clear from the data that B: C ratio reduced with delay in sowing. Similar results were reported by Mukherjee (2012).

Effect of genotypes :

Among the Genotype AKAW-4210-6 recorded

Table 2 : Test weight (g), Grain yield, straw yield, and grain to straw ratio of wheat as influenced by different sowing windows and genotypes

Treatments/ Sowing Times	Test weight (g)	Grain weight (kg ha^{-1})	Straw weight (Kg ha^{-1})	Grain to Straw ratio	Heat use efficiency for grain yield (Kg ha^{-1}c^{-1} day^{-1})
46th MW (17Nov)	39.53	3196	8909	0.36	1.35
48th MW (28 Nov)	**39.80**	**3486**	**9457**	**0.37**	**1.39**
51st MW (17 Dec)	38.06	2811	8048	0.35	1.24
SE (m) ±	0.08	34.99	60.21	—	0.01
CD at 5%	0.32	137.38	236.38	—	0.06
Genotypes					
AKAW 4627	39.71	3238	8754	0.36	1.39
AKDW 4021	37.71	3088	8861	0.35	1.26
AKAW 3722	39.77	3256	8938	0.36	1.35
AKW 1071	38.79	3066	8708	0.36	1.32
NIDW 295	39.88	3152	8783	0.35	1.26
AKAW 3997	36.86	2986	8418	0.36	1.24
AKAW 4210-6	**41.19**	**3365**	**9172**	**0.37**	**1.49**
SE (m) ±	0.61	43.02	48.50	—	0.02
CD at 5%	1.74	123.50	139.22	—	0.05
Interaction D x G					
SE (m) ±	1.05	74.52	84.00	—	0.03
CD at 5%	NS	NS	NS	—	NS

Table 3 : GMR, NMR and B: C ratio a influenced by different sowing times and genotypes

Treatments	Sowing time	GMR (Rs.ha^{-1})	NMR (Rs.ha^{-1})	B:C ratio
	46thMW (17 Nov)	50810	23984	1.89
	48thMW (28 Nov)	55283	29457	2.14
	51stMW (17 Dec)	44787	19961	1.80
SE (m) ±		532	532	-
CD at 5%		2090	2090	-
	AKAW 4627	51533	25707	1.99
	AKDW 4021	48948	23122	1.89
	AKAW 3722	51454	25628	1.99
	AKW 1071	49608	23782	1.92
	NIDW 295	49612	23786	1.92
	AKAW 3997	47514	21688	1.84
	AKAW 4210-6	53386	27560	2.07
	SE (m) ±	617	617	-
	CD at 5%	1773	1773	-
SE (m) ± INTERACTION		1069	-	
CD at 5%		NS	-	

* Selling rate for wheat grain @ Rs.1450 q.$^{-1}$ * Selling rate for wheat straw @ Rs.50 q.$^{-1}$

significantly more gross monetary returns of Rs.ha-1 53386which was followed by Genotype AKAW-4627 Rs.ha-1 51533 and it was significantly superior over rest of the genotypes. Genotype AKAW-3997recorded significantly lower gross monetary returns Rs. 147514.50ha^{-1}. Genotype AKAW-3997 recorded significantly lowest gross monetary returns Rs. 21688 ha^{-1}. Genotype AKAW-4210-6 recorded significantly more net monetary returns Rs.ha-1 27560 followed by Genotype AKAW-4627 and it was significantly superiorover rest of the genotypes. Genotype AKAW-4210-6 recorded highest B: C ratio of 1:2.07 followed by AKAW-3722. Genotype AKAW-3997 recorded minimum B: Cratio of 1: 1.84

Interaction effect

Interaction effect of sowing dates and genotypes could not reach the level ofsignificance in respect of gross monetary returns and Net monetary returns.

LITERATURE CITED

Anonymous, 2015. RRC report of Wheat Research Unit, Dr. PDKV, Akola, submtted to Dr. PDKV, Akola.

Ahmed, M., and S. Farooq, 2013. Growth and physiological responses of wheat cultivars under various planting windows, The J. Anim. Plant Sci. 23(5): 1018-7081.

Gill, K.K., N. Kaur and R. Babuta, 2013. Crop Growth Behaviour and Yield Characteristics ofWheat (*Triticumae stivum* L.) in Two Different Agroclimatic Zones of Punjab, J. Agril. Phy., Vol.13, No. 2 : 126-132

Howard, A. 1924.Crop production in India, Oxford Univ. Press, London 36-42.

Kalita, P., R. Kalita and R. Das., 2009. Morpho-physiological characterization of some wheatgenotypes under rainfed condition, Indian J. Pl. Physiol. 14(4) : 402-406.

Kushwaha, S.R., D.S. Deshmukh, R.K. Sairam and M.K. Singh, 2011. Effect of high temperature stress on growth, biomass and yield of wheat genotypes, Indian J. Pl. Physiol. 16(1):93-97.

Mukherjee, D., 2012. Effect of different sowing dates on growth and yield of wheat (*Triticumae stivum*) cultivars under mild hill situation of West Bengal, Indian J. Agron. 57(2):152-156.

Nagarjuna, D. V.M. Bhale and M. Srinivasarao. 2014. Effect of sowing dates on yield attributes and yield of different new wheat (*Triticum dicoccum*) genotypes underpeninsular India, Environment & Ecology 32 (3A):1025-1030.

Singh, P., and P. Dwivedi, 2015. www.vegetosindia.org, Vol. 28 (1): 16-25.

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Soil Biological Properties as Influenced by Long Term Manuring and Fertilization Under Sorghum-Wheat Sequence in Vertisols

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ABSTRACT

A long term fertilizer experiment is continued since 1988-89 at Akola to study the changes in soil quality, crop productivity and sustainability. The present study was undertaken to assess the impact of long term fertilization on soil biological properties under sorghum-wheat sequence grown on Vertisols. The experiment comprised twelve treatments viz; 50, 75, 100 and 150 per ent NPK, 100 per ent NPK (-S), 100 per ent NPK + S, 100 per ent NPK + Zn, 100 per ent NPK + FYM @ 5 tonnes ha^{-1}, 100 per ent N alone, 100 per ent NP and control replicated four times in RBD. The results of the present study indicate that, continuous application of 100 per ent NPK + FYM @ 5 t ha^{-1} resulted improvement in soil microbial biomass carbon (SMBC) at flag leaf (255.68 µg g^{-1} soil) and dough stage (240.89µg g^{-1} soil). The soil respiration i.e. CO_2 evolution and urease activity were also influenced significantly with the application of 100 per cent NPK + FYM @ 5 tonnes ha^{-1}. The application of 100 per ent NPK + FYM @ 5 tonnes ha^{-1} recorded higher CO_2 evolution of 61.24 and 58.65 mg 100 g^{-1} soil and urease activity of 49.90 and 45.40 mg NH_4-N g^{-1} 24 hr^{-1} at flag leaf and dough stage, respectively. The application of FYM @ 10 tonnes ha^{-1} although proved beneficial in improving biological properties of soil, but could not sustain the productivity of sorghum and wheat in Vertisols. The grain yield of sorghum (46.05 q ha^{-1}) was influenced significantly with the application of 100 per ent NPK + FYM @ 5 t ha^{-1} followed by 150 per ent NPK (42.25 q ha^{-1}) which were superior over all remaining treatments.

Soil degradation is a major concern in agriculture because of non judicious use of agricultural inputs and over exploitation of natural resources which has emerged as great threat to sustain crop productivity and soil quality. The biological properties of soil are largely influenced by management and the change in biological properties of soil is exhibited only under long-term adoption of management measures. The important biological properties of soil *viz.*, soil microbial biomass carbon (SMBC), CO_2 evolution and soil enzymes such as urease, etc. are generally considered as soil quality indicators. Use of organic manure with optimum rate of fertilizer under intensive farming systems increases the turnover of nutrients in the soil plant system (Nambiar and Abrol, 1989). Long-term experiments have indicated the favorable effects of FYM on biological properties of soil and also as a source of plant nutrients, which are released on its mineralization and become available to plants. Incorporation of organic manures alone and in combination with inorganic fertilizers resulted into decrease in the pH, bulk density and penetration resistance and increased organic carbon content, porosity, infiltration rate, hydraulic conductivity and water stable aggregates (Chalwade *et al.* 2006). These properties have a close relationship with the soil microbial biomass, CO_2 evolution and soil enzymes. Soil micro-organisms play a vital role in soil health as they decompose the organic matter and assimilate a portion of the nutrients in soils to build their body. The nutrients in soil microbial biomass are mineralized from the dead micro-organisms. Therefore, soil microbial biomass is considered as a source and sinks for nutrients and is an active pool of organic matter in the soil. The contribution of organic matter to soil from mature plant residues or root secretion usually increases the levels of SMBC and N. In view of the above, present study was undertaken to assess the effect of long term manuring and fertilization on biological properties under sorghum-wheat sequence grown on Vertisol.

MATERIAL AND METHODS

The long term fertilizer experiment was initiated at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. P. D. K. V., Akola (MS) during 1988-89. The experiment comprised of twelve treatments replicated four times in RBD. The treatments consists of 50 per ent RDF (T1), 100 per ent RDF (T2), 150 per ent RDF (T3),100 per ent RDF (-S) (T4), 100 per ent RDF + 2.5 kg Zn ha^{-1} once in two years to wheat crop only (T5), 100 per ent RD of NP (T6),100 per ent RD of N (T7),100 per ent RDF + FYM @ 5 t ha^{-1} to sorghum only (T8), 100

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per ent RDF + S @ 37.5 kg ha^{-1} (T9), FYM @ 10 t ha^{-1} to sorghum and wheat (T10), 75 per ent RDF + 25 per ent N through FYM (T11) and Control (T12). The 25th cycle of the experiment during 2012-13 was studied in the present investigation. The recommended dose of fertilizer was 100:50:40 kg N, P_2O_5, K_2O ha^{-1} applied to sorghum while 120:60:60 N, P_2O_5, K_2O kg ha^{-1} to wheat. Farmyard manure (0.50 % N, 0.16 % P, and 0.52 % K) was added on oven dry basis one month before sowing of sorghum whereas, half dose of N and full dose of P and K was applied at the time of sowing to sorghum and remaining half dose of N was applied 30 days after sowing. The half dose of N and full dose of P and K was applied at the time of sowing to wheat and remaining half dose of N was applied 21 days after sowing.

The soil (Vertisol) of experimental site was deep, clayey having low hydraulic conductivity and high water holding capacity. The initial analysis indicated that the soil was low in organic carbon and available N, very low in available P and high in available K. Soil samples were collected from 0-20 cm depth treatment wise in all the four replications (48 nos.) after harvest of *Sorghum* during 2012-13. Soil sampling was carried out during flag leaf and dough stages of sorghum, immediately stored at 4 ^{0}C and analyzed for SMBC, CO_2 and urease activity. The CO_2 evolution was determined by alkali trap method as described by Anderson *et al.* (1982). Soil microbial biomass carbon was determined by chloroform fumigation extraction method as described by Jenkinson and Powlson (1976), whereas urease activity was determined by assay method as described by Pancholy and Rice (1973).

RESULTS AND DISCUSSION

CO_2 evolution

Soil respiration is a process in which mineralized C is evolved in terms of CO_2 and is an evaluation of soil biological activity and extent of organic matter decomposition. The data presented in the (Table 1) revealed that, CO_2 evolution of various treatments ranged from 31.91 to 61.24 mg 100 g^{-1} of soil at flag leaf stage and 28.35 to 58.65 mg 100 g^{-1} soil at dough stage of sorghum. Application of 100 per ent NPK + FYM @ 5 t ha^{-1} recorded significantly higher CO_2 evolution (61.24 and 59.61 mg 100 g^{-1}) soil at flag leaf stage of sorghum, while at dough stage, the CO_2 evolution was recorded to the tune of 58.65 mg 100 g^{-1} soil. The CO_2 evolved increased with increase in recommended dose of fertilizer from 50 per cent to 150 per cent. However, CO_2 evolution was also recorded significantly higher under FYM @ 10 t ha^{-1} for both stages of crop as compared to chemical fertilizers treatments.

The higher amount of CO_2 evolved under 100

Table 1 Long-term effect of manuring and fertilization on CO_2 evolution at flag leaf and dough stage of sorghum

Tr. No.	Treatment	CO_2 evolution (mg 100 g^{-1} soil)	
		Flag leaf stage	Dough stage
T_1	50%NPK	47.23	38.80
T_2	100% NPK	54.70	47.10
T_3	150% NPK	52.76	46.76
T_4	100% NPK (S free)	48.60	43.71
T_5	100% NPK	50.11	44.92
T_6	100% NP	45.10	37.14
T_7	100% N	42.50	34.51
T_8	100% NPK + FYM @ 5 t ha^{-1}	61.24	58.65
T_9	100% NPK + S @ 37.5 kg ha^{-1}	52.39	46.62
T_{10}	FYM @ 10 t ha^{-1}	59.61	56.54
T_{11}	75% NPK + 25% N through FYM	49.40	46.23
T_{12}	Control	31.91	28.35
	SE (m) ±	1.23	1.13
	CD at 5%	3.49	3.21

per ent NPK + FYM @ 5 t ha^{-1} and FYM @ 10 t ha^{-1} may be due to increased microbial biomass metabolically active carbon which resulted in increased soil respiration rate. Malewar *et al.* (1999) found that the long term application of 50 percent organics either in the form of FYM, wheat straw, green manure or subabul leaves in combination with fertilizers helped to increase CO_2 evolution. Maximum CO_2 evolution was recorded at 30 DAS and it decreased with passing of time till harvest of the crops. Whereas, continuous cropping without manure and fertilizers (control) resulted drastic reduction in the soil respiration probably due to a poor crop growth and decrease of soil organic matter due to its mineralization. The increase in soil microbial biomass carbon and soil respiration can be attributed to the incorporation of easily degradable materials, which stimulate the authoctonous microbial activity and to the incorporation of exogenous microorganisms (Tejada *et al.*, 2006 and Tejada *et al.*, 2008).

Soil microbial biomass carbon

The soil microbial biomass carbon act as the transformation agent of the organic matter in the soil. As such, the biomass is a both source and sink of the carbon, nitrogen and phosphorus contained in the organic matter. It is the centre of majority of biological activities in soil. The data presented in (Table 2) revealed the soil microbial biomass carbon (SMBC) influenced significantly at flag leaf and dough stage of sorghum and ranged from 157.72 to 255.68 µg g^{-1} soil and 139.13 to 240.89 µg g^{-1}soil respectively. There was a gradual increase in microbial biomass carbon with increase in the doses of NPK from 50 to 100 per cent. Application of 100 per cent NPK + FYM @ 5 t ha^{-1} (T_8) recorded significantly higher microbial biomass carbon *i.e.* 255.68 and 240.89 µg g^{-1} soil respectively at flag leaf and dough stage of sorghum followed by FYM @ 10 t ha^{-1} (T_{10}) (247.92 and 237.73 µg g^{-1} soil). It might due to the supply of additional mineralizable and readily hydrolysable carbon due to organic manure application which resulted in higher microbial activity and in turn higher microbial biomass carbon. These findings are in the line with the result reported by Gayatri Verma and Mathur (2009), Kaur *et al.* (2005) and Mishra *et al.* (2008). SMBC was found quite low in control, which was considerably improved due to INM indicating the need of addition of organic matter to the soil along with chemical fertilizers for achieving good soil biological activity. It was interesting to note the drastically low values of SMBC at dough stage of crop. It may be due to high MBC to MBN ratio at tillering compared to the dough stage due to temporal changes in the proportion of bacteria relative to fungi in soils; bacteria have lower C:N ratio compared with fungi or due to greater decrease in MBC compared to MBN, indicating C limiting in later stages. Mandal *et al.* (2007) reported that balanced application of NPK + FYM gave the highest values of SMBC and lowest at the control. Values were generally highest at tillering, followed by the flowering and dough stage.

Urease activity

Urease is an enzyme that catalyzes the hydrolysis of urea to CO_2 and NH_3. The urease enzyme is ranged from 23.83 to 49.90 and 21.76 to 45.40 (mg NH_4-N g^{-1} 24 hr^{-1}), respectively at flag leaf and dough stage. The urease activity was found to be significantly increased under the treatment of 100 per cent NPK + FYM @ 5 t ha^{-1} (49.90 and 45.40 mg NH_4-N g^{-1} 24 hr^{-1}) in comparison with only inorganic treatments (Table 3) and similar trend was also observed in the treatment receiving FYM @ 10 t ha^{-1} (T_{10}) followed by 150 per ent NPK. It might be due to the improvement in organic matter status of soil which in turn reflected in the higher enzymatic activity. Similar finding was reported by Kanchikerimath and Dhyan Singh (2001). The urease activity increased with increase in the doses of fertilizer from 50 to 150 per cent RDF. Similar results were also reported by Mishra *et al.* (2008). Slight reduction in the urease activity was observed at dough stage as compared to flag leaf stage of sorghum, it may be propably due to solubilizaion of complex organic compounds at faster rate. Organic manures (FYM alone or in combination with 100 per cent NPK) stimulated urease activity but inorganic fertilizers (NPK alone) could not found beneficial in improving urease activity might be due to continuous cropping devoid of organic matter provides a worst environment for stabilizing and protecting enzymes.

Productivity of sorghum

The application of 100 per ent NPK + FYM @ 5 t ha^{-1} recorded significantly higher grain yield (46.05 q ha^{-1}) of sorghum (Fig.1). The yield obtained from 100 per ent N, 100 per ent NP and 100 per ent NPK showed significant increasing trend from N to NPK. This suggests the importance of balance fertilization for achieving productivity of crop. More or less similar trend was also observed in case of fodder yield of sorghum. Significantly highest fodder yield of sorghum (110.48 q ha^{-1}) was obtained in treatment 100 per cent NPK + FYM @ 5 t

Table 2. Long-term manuring and fertilization on soil microbial biomass carbon at flag leaf and dough stage of sorghum

Tr.	Treatment Details	Soil microbial biomass carbon (µg g^{-1} soil)	
		Flag leaf stage	Dough stage
T_1	50% NPK	210.04	170.03
T_2	100% NPK	235.29	210.12
T_3	150% NPK	224.67	188.56
T_4	100% NPK (S free)	220.36	167.39
T_5	100% NPK	221.84	175.04
T_6	100% NP	198.27	162.33
T_7	100% N	186.51	150.79
T_8	100% NPK + FYM @ 5 t ha^{-1}	255.68	240.89
T_9	100% NPK + S @ 37.5 kg ha^{-1}	228.16	195.63
T_{10}	FYM @ 10 t ha^{-1}	247.92	237.73
T_{11}	75% NPK + 25% N through FYM	217.53	185.85
T_{12}	Control	157.72	139.13
	SE (m) ±	4.02	4.19
	CD at 5%	11.96	12.42

Table 3 Long-term effect of manuring and fertilization on urease activity at flag leaf and dough stage of sorghum.

Tr.	Treatment Details	Urease activity (mg NH_4-N g^{-1} 24 hr^{-1})	
		Flag leaf stage	Dough stage
T_1	50% NPK	33.16	30.93
T_2	100% NPK	41.10	37.66
T_3	150% NPK	45.60	42.10
T_4	100% NPK (S free)	39.63	35.93
T_5	100% NPK	40.90	37.86
T_6	100% NP	36.36	33.06
T_7	100% N	35.56	31.63
T_8	100% NPK + FYM @ 5 t ha^{-1}	49.90	45.40
T_9	100% NPK + S @ 37.5 kg ha^{-1}	40.26	37.26
T_{10}	FYM @ 10 t ha^{-1}	47.06	44.10
T_{11}	75% NPK + 25% N through FYM	39.40	37.10
T_{12}	Control	23.83	21.76
	SE (m) ±	1.04	0.98
	CD at 5%	2.98	2.77

ha^{-1} followed by 150 per cent NPK (101.48 q ha^{-1}) which was superior over all remaining treatments. Similar results were obtained by Donde *et al.* (2004) and Ravankar *et al.* (2005). They reported that the highest yield of sorghum was obtained with the application of full recommended dose of NPK + FYM @ 10 t ha^{-1} in Vertisol. This increase in crop productivity may be due to the combined effect of nutrient supply, improved physical properties like bulk density, available water capacity, mean weight diameter and hydraulic conductivity which provided a desirable soil condition for root development, enhanced nutrient uptake, crop growth and yield.

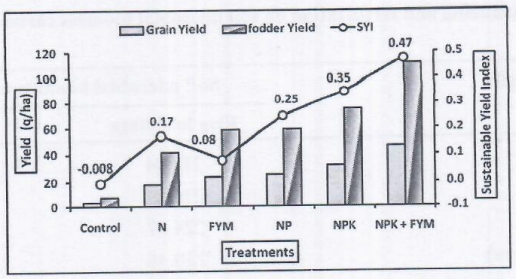

Figure 1. Long-term effect of manuring and fertilization on productivity and SYI of sorghum

LITERATURE CITED

Anderson, J.P.E. 1982. In A.L. Page, R.H. Miller and D.R. Keeney (ed.) Methods of Soil Analysis,. Part 2. Chemical and Microbiological Properties, Agronomy Monograph No. 9, ASA-SSSA Publisher, Madison, Wisconsin, USA, : 831-871.

Chalwade, P.B., V.K. Kulkarni and M.B. Lakade, 2006. Effect of inorganic and organic fertilization on physical properties of Vertisols, Soils and crops 16(1) : 148-152.

Dhonde, M.B., R.P. Andhale and S.H. Shinde, 2004. Effect of integrated nutrient management on growth and yield of sorghum, J. Maharashtra Agric. Univ. 29(2) : 130-132

Gayatri Verma and A.K. Mathur, 2009. Effect of integrated nutrient management on active pools of soil organic matter under maize–wheat system of a Typic Haplustept, J. Indian Soc. Soil Sci. 57(3) : 317-322.

Jenkinson, D.S. and D.S. Powlson, 1976. The effect of biological treatments on metabolism in soil, V.A. method for measuring soil biomass, Soil Biol. Biochem., 8 : 209-213.

Kanchikerimath, M. and Dhyan Singh, 2001. Soil organic matter and biological properties after 26 years of maize – wheat – cowpea cropping as affected by manure and fertilization in a Cambisol in semiarid region of India, Agric. Ecosyst, Environ., 86 :155-162.

Kaur, K., K. Krishan Kapoor and Anand P. Gupta, 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions, J. Plant Nutr. Soil Sci. 168 : 117-122.

Malewar, G.U., A.R. Hasnabade and S. Ismail, 1999. CO_2 evolution and microbial population in soil as influenced by organic and NPK fertilizers under sorghum-wheat system, J. Maharashtra agric. Univ. 24(2) : 121-124.

Mandal, A., A. K. Patra., D. Singh., A. Swarup and R. Ebhin Masto, 2007. Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages, Bioresour, Technol. 98(18) : 3585-3592.

Mishra, B., A. Sharma., S. K. Singh., J. Prasad and B. P. Singh, 2008. Influence of continuous application of amendments to maize – wheat cropping system on dynamics of soil microbial biomass in Alfisol of Jharkhand, J. Indian Soc. Soil Sci. 56(1) : 71-75.

Nambiar, K.M. and I.P. Abrol, 1989. Long-term fertilizer experiments in India: An overview, Fert. News 34(4) : 11-20.

Pancholy, S.L. and E.L. Rice, 1973. Soil enzymes in relation to old field succession: amylase, cellulose, invertase, dehydrogenase and urease, Soil Sci. Soc. Am. Proc. 37 : 47-50.

Ravankar, H.N., N.N. Gajbhiye and P.A. Sarap,. 2005. Effect of organic manures and inorganic fertilizers on yield and availability of nutrients under sorghum –wheat sequence, Indian J. Agric. Res. 39(2) : 142-145.

Tejada, M., C. Garcia, J. L.Gonzalez and M.T.Hernandez, 2006. Organic amendment based on fresh and composted beet vinasse: Influence on physical, chemical and biological properties and wheat yield, Soil Sci. Soc. Am. J. 70, 900–908.

Tejada, M., J.L. Gonzalez, A.M. Garcýa-Martý´nez, C. J. Parrado, 2008. Effect of different green manures on soil biological properties and maize yield, Bioresource Technology, 99, 1758–1767.

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Effect of INM on Soil Physical, Chemical and Biological Properties Under Soybean–Chickpea Sequence in Inceptisols

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ABSTRACT

A field experiment is continued since 2011-12 at Research Farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) with a view to find out effect of integrated nutrient management system on soil quality and productivity under soybean (*Glycine max* (L.) Merr.)- Chickpea (*Cicer arietinum* L.) cropping sequence. The impact of organic, inorganic and integrated nutrient management practices on soil physical, chemical and biological properties were studied after third cycle (2013-14). The treatments comprised of control, recommended dose of fertilizer (RDF), RDF+FYM @ 5 t ha^{-1}, 50 per cent RDF along with phosphocompost, 75 per cent RDF along with phosphocompost and whole RDF through FYM and phosphocompost. Based on the data generated, it was noticed that, the lowest bulk density (1.29 Mg m^{-3}) was recorded in the treatment 100 per cent RDF through organic fertilizers while it was found more in control (1.45 Mg m^{-3}). The highest mean weight diameter (0.75 mm) was observed under use of organics only through FYM and phosphocompost in *Kharif* and use of in situ soybean straw and phosphocompost in *Rabi*. The highest available N, P and K were registered with the application of 100 per cent RD + FYM @ 5 t ha^{-1} which were 241, 17.04 and 418 kg ha^{-1}, respectively, with application of 100 per cent RDF to chickpea. The application of 100 per cent RDF + FYM @ 5 t ha^{-1} to soybean and 100 per cent RD to chickpea recorded significantly highest SMB-C (246.18 µg g^{-1}) followed by 100 per cent RD + FYM @ 5 t ha^{-1} to soybean and 75 per cent RD to chickpea (232.11 µg g^{-1}). The application of 100 per cent RD + FYM @ 5 t ha^{-1} (100% RD to chickpea) had significant influence on SMB-N (41.77µg g^{-1}) which was closely followed by T_3 (41.08 µg g^{-1}) in which 100 per cent RDF + FYM @ 5 t ha^{-1} to soybean and 75 per cent RD to chickpea was applied. Nodule weight (0.42 g plant^{-1}), nodule count (37.67 plant^{-1}) and nodule biomass (185 kg ha^{-1}) were also influenced with the application of 100 per cent RDF + FYM @ 5 t ha^{-1}. It was observed that organic carbon and shaded biomass had positive and significant correlation with soil properties. However, the highest correlation coefficient exists among organic carbon and SOC stock (r= 0.834**) as well as shaded biomass and available nitrogen (r= 0.796**).

Soil fertility maintenance is the major concern in semi arid tropics due to high temperature which results into loss in SOC, since soil quality is largely regulated by soil organic matter (SOM). Soil microbial diversity is recognized as the most important microbial parameters in soil. It has been demonstrated that soil microbial diversity is affected by anthropogenic disturbance. Intensive and conventional agricultural production system resulted to a steady decline of farm productivity and increased deterioration of the soil environment. The decline in soil quality and ultimately of productivity was attributed to the degradation of the bio resources as a result of intensive agriculture. The changes in soil quality are closely related to soil physical, chemical and biological fertility (Zhang *et al.* 2007, Brady and Weil 2002). Integrated use of organic and inorganics through FYM, *in situ* incorporation of crop residues and green manuring improved organic carbon and other soil properties as well. There is a growing interest in the question of whether a combination of mineral fertilizer with crop residue will improve soil quality and, consequently, crop yields. The physical quality of agricultural soils refers primarily to the soil's strength and water transmission and storage properties in the crop root-zone (Reynolds and Elrick, 2002). These properties play a critical role in creating conditions that are favourable for crop growth and for many soil chemical and biological processes. Soil quality is largely regulated by soil organic matter (SOM). This is a dynamic property that responds to changes in residue and fertiliser management. Most soil properties such as soil structure, water retention capacity, and diversity and activity of soil organisms are greatly influenced by the quantity and quality of SOM (Reeves, 1997). The physical properties of soils determine their adaptability to cultivation and the level of biological activity that can be supported by the soil. Soil physical properties also largely determine the soil's water and air supplying capacity to plants. Many soil physical properties change with changes in management practices such as use of FYM, compost, *in situ* incorporation of crop residues along with inorganic

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fertilizers. In view of the above, we tried to assess the impact of different organics along with chemical fertilizers on soil physical, chemical and biological properties and their relation with organic carbon under soybean-chickpea sequence in inceptisols.

MATERIAL AND METHODS

the present investigation was a part of long term experiment undertaken 2010-11 at the experimental farm of Dr. PDKV, Akola. The experimental site has semi-arid with erratic climatic conditions (maximum temperature goes up to 45.9 ^{0}C in summer and 12^0 C during winters). The mean annual rainfall of the area is 778 mm. The experimental soil was Typic Haplusterts, alkaline in reaction (pH 8.0), with low soil organic carbon (4.8 g kg^{-1}), available N (158 kg ha^{-1}), available P (9.5 kg ha^{-1}) and has a relatively high potassium (320 kg ha^{-1}). The eight treatments (Table 1 and 2) were laid out in a randomized block design with three replications. The various combinations of chemical fertilizers with organics like FYM, phosphocompost, crop residues (*in situ* soybean straw) and cotton stalk were studied. The present study was restricted to soybean (cv. JS-335) in *Kharif* season (2013-14) only. FYM applied before sowing to soybean contains 0.56 per cent N, 0.19 per cent P and 0.58 per cent K. The harvested soybean straw analyzed for their N (1.14%), P (0.16%) and K (1.45%) content and applied before sowing to chickpea. Wheat straw along with 12 per cent rock phosphate, *Trichoderma viride* were decomposed for three months to prepare phosphocompost. The final product contains 0.76 per cent N, 1.65 per cent P and 0.61 per cent K. The phosphocompost was applied based on their P content, since the phosphorus requirement of soybean is comparatively higher as compared to N and K. The shredded cotton stalk was decomposed for one month and applied before sowing to soybean mainly to substitute N (0.44% N) in addition to P (0.26%) and K (0.71%). Surface soil samples (0–15 cm) were collected from plots of each treatment after the harvest of soybean and analyzed for physical, chemical and biological properties. Soil bulk density was determined by clod coating technique as described by Blake and Hartge (1986). Mean weight diameter of soil was determined by Yoder's apparatus method as per Kemper and Rosenau (1986). The soil samples were analyzed for Walkley-Black organic carbon (Jackson 1967). Available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija (1956), available phosphorous was determined by Olsen's method as described by Olsen *et al.,* 1954 using 0.5 M sodium bicarbonate pH (8.5) as an extractant. Available potassium was determined by the flame photometer using neutral N ammonium acetate (pH 7.0) as an extractant as described by Piper (1966). The soil microbial biomass carbon (SMB-C) was determined by chloroform fumigation method using Kc value of 0.45 (Vance *et al.*, 1987). For soil microbial biomass nitrogen (SMB-N) analysis, fumigated and un-fumigated soil samples were extracted with 2*M* KCl (1:10 ratio), biomass N was computed using K_N value of 0.54 by the method outlined by Brookes *et al.* (1985).

RESULTS AND DISCUSSION

Bulk density

The bulk density in different treatments after harvest of soybean varied from 1.39 to1.45 M gm^{-3} (Table 1). The lowest bulk density (1.39 Mg m^{-3}) has been recorded in the treatment 100 per cent RDF through organic fertilizers while it was found more in control (1.45 Mg m^{-3}). The significant reduction in bulk density under all the treatments involving farm yard manure (FYM), phosphocompost (PS), cotton stalk (CS) can be attributed to use of organics. However, the bulk density exhibited marginal reduction with the use of only chemical fertilizers (T_2) over control (T_1) which could be due to increased biomass production with consequent increase in organic matter content of soil and residual effect of organics added by soybean. Bharambe *et al.* (1999) reported that incorporation of crop residue of *Kharif* grown sorghum stalk was more effective in decreasing bulk density of the soil. Similar results were also reported by Bharadwaj and Omanwar (1992). Hati *et al.* (2007) studied the impact of fertilizers and manure application on bulk density for 28 year in Vertisol of Jabalpur and reported that the application of balanced fertilizers in combination with organic manure reduced the bulk density significantly.

In the present study, it was observed that use of organics recorded marginal changes in bulk density. The bulk density was reduced to 1.39 Mg m^{-3} in T_8 (100 % RDF through FYM + remaining P through phosphocompost) and1.42 Mg m^{-3} in T_5 (50 % RDF + 50 per cent P through phosphocompost) compared to 1.45 Mg m^{-3} in control (T_1). The bulk density in treatment T_8, where complete organics were used, was reduced by 4.13 per cent over control. Selvi *et al.,* (2003) revealed that the application of 10 t ha^{-1} of FYM along with 100 per cent NPK recorded significantly lower bulk density.

Mean Weight Diameter

The mean weight diameter of aggregate ranged from 0.60 mm to 0.75 mm under soybean. The highest mean weight diameter (0.75 mm) was observed under use of only organics through FYM and phosphocompost in *Kharif* and use of *in situ* soybean straw and phosphocompost in *Rabi* (T_8) followed by integration of organics and chemical fertilizers (T_6 and T_5). The increase in mean weight diameter with application of 100% organics (T_8) might be due to continuous addition of FYM along with phosphocompost which improved physical condition of soil. The increase in mean weight diameter in FYM applied plots could mainly be due application of farm yard manure, which significantly improved the soil aggregation through humic acids. Similar results were found by Selvi *et al.,* (2003) and Hati *et al.*, (2007). The added organics could supply additional fresh organic residues (water soluble and hydrolysable substrates) and carbon to the soil resulting in the production of microbial polysaccharides that increase aggregate cohesion, which could explain the progressive increase in aggregate stability to mechanical breakdown. The continuous application of only chemical fertilizers did not show much improvement in the MWD indicating an immense need of organics to improve soil physical properties which is reflected in the treatments of INM.

Nutrient Status

Available nitrogen

The available nitrogen in the soil ranged from 159 to 241 kg ha^{-1}(Table 1).The highest available nitrogen was documented in treatment T_4 (241 kg ha^{-1}) and T_3 (234 kg ha^{-1}) with application of 100 per cent RDF + FYM @ 5 t ha^{-1} in soybean and 100 per cent and 75 per cent RD to chickpea, respectively. Comparatively lower value of available nitrogen (218 kg ha^{-1}) was recorded in treatment (T_2) where sole RDF was applied. The available nitrogen content was found to increase substantially from 158 kg ha^{-1} (initial status) to 241 kg ha^{-1} (T_4) after 4th crop cycle. The significantly highest available soil nitrogen status was documented under integration of inorganics with FYM. Similarly, the amalgamation of phosphocompost and cotton stalk with inorganic fertilizers has showed promising status of available nitrogen as against 100 per cent RDF through organics (T_8) 195 kg ha^{-1}. The lowest available nitrogen (159 kg ha^{-1}) was recorded in unfertilized plot. Similar results were also reported by Bharadwaj and Omanwar (1992). Nitrogen is the most important primary nutrient largely required by the crops and at the same time it is very difficult to maintain in the soils in its plant utilizable form. This further suggests that the use of crops which add enough biomass to the soil can

Table 1. Effect of integrated plant nutrient system on physical properties of soil afterharvest of soybean

Treatments	Physical propertiesAvailable Nutrients (kg ha^{-1})				
	BD (Mg m^{-3})	MWD(mm)	N	P	K
T1-Control	1.45	0.60	159	10.22	310
T2-100% RD	1.44	0.67	218	14.99	388
T3-100% RD + FYM @ 5 tonnes ha^{-1}	1.41	0.70	234	16.96	414
T4-100% RD + FYM @ 5 tonnes ha^{-1}	1.41	0.72	241	17.04	418
T5-50% RD + 50 % P through PC	1.42	0.73	201	14.31	385
T6-50% RD + 50 % P through PC	1.41	0.73	209	14.92	392
T7-75% RD+ 25 % N through cotton stalk	1.43	0.71	201	12.23	381
T8-100% RDN through FYM + remaining P through PC	1.39	0.75	195	11.63	362
SE (m) ±	0.01	0.01	12.78	1.22	18.29
CD at 5 %	0.03	0.029	33.59	3.21	46.98
Initial	1.45	0.60	158	9.5	320

For *rabi*: T3- 75% RD, T4-100% RD , T5-75% RD + *in situ* soybean straw, T6-100% RDF + *in situ* soybean straw, T_7- 50% RDF + 50% P through phosphocompost and T_8- *in situ* soybean straw + remaining N and P through PC, PC-Phosphocompost, CS-Cotton stalk

save the chemical fertilizers partly reducing the cost on chemical fertilizers. The available nitrogen was relatively lower under the sole application of organics. Therefore, regular application of FYM is highly essential to maintain the sustainability of soil in respect of available nutrients. The available nitrogen although showed increase under INM, it has not been increased much due to the prevailing climatic condition accelerating oxidation of organic matter as well as its losses through volatilization and leaching. In this view, the results of present investigation suggest that the maintenance of soil available nitrogen levels is more challenging. This necessitates regular addition of organics for maintenance of soil fertility in the soils of semi-arid areas. The results have close agreement with the findings given by Chaturvedi and Chandel (2005).

Available phosphorus

The available phosphorus varied from 10.22 to 17.04 kg ha^{-1} after harvest of soybean (Table 1). The significant increase in available phosphorus was measured over control in all the treatments. The higher values of available phosphorous (17.04 kg ha^{-1}) was recorded in treatment receiving recommended doses of fertilizer along with FYM over the control. The comparable increase in available phosphorus in all the treatments might be due to addition of farm yard manure and crop residues. The increase in available phosphorus due to legume cultivation can be also ascribed to the development of phosphorus solubilising organisms in the root zone of legumes (Sharma *et al.*, 1986).

The black soils which have high phosphorus fixation problems are specifically becoming deficient under the intensive cropping systems. Under these circumstances the crops having potential of adding considerable biomass to the soil have special significance in black soils. The decomposition of leaf litter is useful for slight reduction in pH which favors availability of phosphorus in these soils. The appreciable build up in available phosphorus may also be due to the influence of organic matter in increasing the labile phosphorus in soil through complexing of cation like Ca^{2+}, which are mainly responsible for fixation of phosphorus. The results also suggested that in spite of phosphorus fixation in swell-shrink soil, the conjunctive use of organics with chemical fertilizers is beneficial for improving available phosphorus. Similar results were reported Chitale *et al.* (2003).

Available potassium

The available potassium varied from 310 to 318 kg ha^{-1} after harvest of soybean (Table 1). Significantly, higher value of available potassium (418 kg ha^{-1}) was noticed in treatment having combined application chemical fertilizer along with FYM. Amalgamation of chemical fertilizers with organic manures helps to increase

Table 2 . Effect of integrated plant nutrient system on biological properties and Nodule count and nodule biomass of soybean

Treatment	SMBC (µg g^{-1} soil)	SMBN (µg g^{-1} soil)	Nodule weight (g $plant^{-1}$)	Nodule count (Number $Plant^{-1}$)	Nodule biomass (kg ha^{-1})
T1 - Control	149.51	25.87	0.25	22.33	111
T2 - 100% RD	190.51	30.48	0.35	29.33	156
T3 - 100% RD + FYM @ 5 tonnes/ ha	232.11	41.08	0.38	36.00	164
T4 - 100% RD + FYM @ 5 tonnes/ ha	246.18	41.77	0.42	37.67	185
T5 - 50% RD + 50 % P through PC	201.81	37.90	0.33	28.67	147
T6 - 50% RD + 50 % P through PC	204.79	38.00	0.35	26.33	156
T7 - 75% RD+ 25 % N through cotton stalk	209.18	37.29	0.34	25.00	151
T8 - 100% RDN through FYM +remaining P through PC	244.57	40.61	0.28	31.33	146
SE(m)±	2.35	1.23	0.01	0.78	6.39
CD at 5%	6.843	3.576	0.04	2.26	18.58
Initial	149.51	25.87			

potassium content in the soil, this might be due to the reduction of potassium fixation and release of K due to the interaction of organic matter with clay, besides direct K addition in available K pool. The crop residues having considerable concentration of potassium have enough potential for enhancing the potassium availability in black soils which can partially reduce the chemical fertilizers to some extent.

Soil microbial biomass carbon

The application of 100 per cent RDF + FYM @ 5 t $ha^{-1}$and 100 per cent RD to chickpea recorded significantly highest microbial biomass carbon (246.18 $\mu g\ g^{-1}$) (Table 2). Treatment receiving 100 per cent RDN through FYM and remaining phosphorous compensated through Phosphocompost showed a higher value of soil microbial biomass carbon 244.57µg g^{-1} which was significantly superior over 50 per cent RD + 50 per cent P through PC and 75 per cent RD + in situ soybean straw to chickpea (209.18 µg g^{-1}). The addition of organics i.e. FYM in combination with chemical fertilizers resulted into almost doubled the biomass over the control. Similarly, sole use of organics also significantly increased the soil microbial biomass as compared to RDF alone. The increase in soil microbial biomass carbon under organic treatments might be due to additional supply of mineralizable and readily hydrolyzable carbon through organic sources which, resulted in higher microbial activity and in return higher microbial biomass carbon. Kanzawa *et al.* (1988) reported that soil microbial biomass carbon was largest with the use of FYM, followed by in chemical fertilizer treated plot and smallest in the control. Microbial biomass carbon was more in subsoil as against surface soil. The similar findings were also noted by Manna *et al.* (1996).

Soil microbial biomass nitrogen:

The soil microbial biomass nitrogen (SMB-N) was significantly influenced by different treatments in soybean (Table 2).The application of 100 per cent RD + FYM @ 5 t ha^{-1} (100% RD to chickpea), recorded significantly highest microbial biomass nitrogen (41.77µg g^{-1}) followed by 100 per cent RDF + FYM @ 5 t ha^{-1} (75% RD to chickpea) (41.08µg g^{-1}). Similarly, application of 100 per cent RD through FYM + remaining P through PC recorded comparable microbial biomass nitrogen to the extent of 40.61 per cent followed by 50 per cent RD + 50 per cent P through PC (38.00 µg g^{-1}). Application of organics in combination with inorganic fertilizers resulted in significantly highest soil microbial biomass nitrogen (SMB-N) as compared to rest of the treatments. High soil organic carbon, more root incorporation and additional supply of nitrogen through FYM to the micro organisms, might be the reason for improving microbial biomass nitrogen. The results are in agreement with earlier finding of Kaur *et al.* (2005) and Verma and Mathur (2009).

Table 3. Correlation coefficients illustrating relationship among the soil properties and organic carbon

S. N.	Soil properties	Organic Carbon
1	Mean Weight Diameter	0.474*
2	Available Phosphorus(P)	0.544*
3	Available Potassium(K)	0.632**
4	Biomass production	0.416*
5	Soil organic carbon stock	0.834**
6	SMBC	0.600**

Table 4. Correlation coefficients illustrating relationship among the soil properties and shaded biomass

S. N.	Soil properties	Shaded biomass
1	Mean Weight Diameter	0.463*
2	Available Nitrogen(N)	0.796**
3	Available Phosphorus(P)	0.743**
4	Available Potassium(K)	0.744**
5	Soil organic carbon stock	0.498*
6	SMBC	0.670**
7	SMBN	0.613**

* 5% significant, ** 1% significant, NS- Non significant (n=24)

Nodulation parameters

The nodule weight varied from 0.25 to 0.42 g $plant^{-1}$, whereas nodule biomass varied from 111 to 185 kg ha^{-1}(Table 2). The nodulation parameters (nodule count, nodule weight and nodule biomass) in soybean were improved significantly with the application of 100 per cent RDF along with FYM @ 5 tones ha^{-1}. The increase in nodule count, nodule weight and nodule biomass with integrated use of inorganic fertilizers and organic manure might be due to direct incorporation of organic matter which provides congenial environment for better root growth and more plant residues addition. The treatments

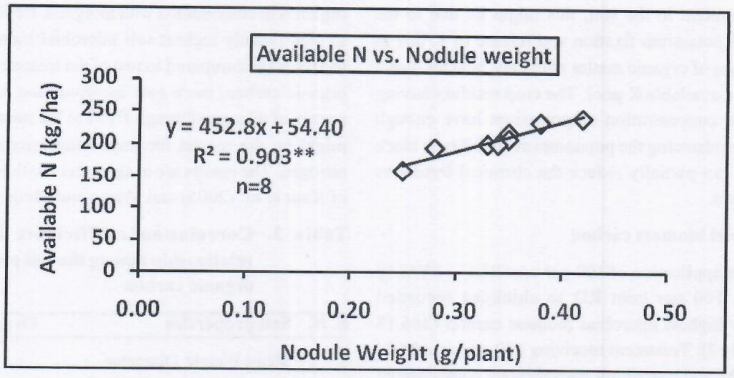

Fig. 1 Relationship between available N and nodule weight

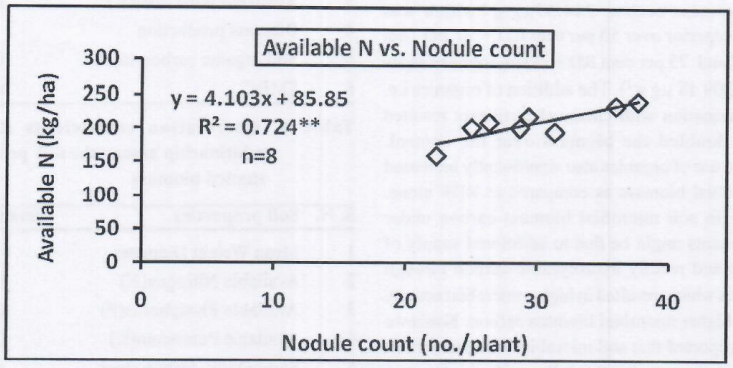

Fig. 2 Relationship between available N and nodule count

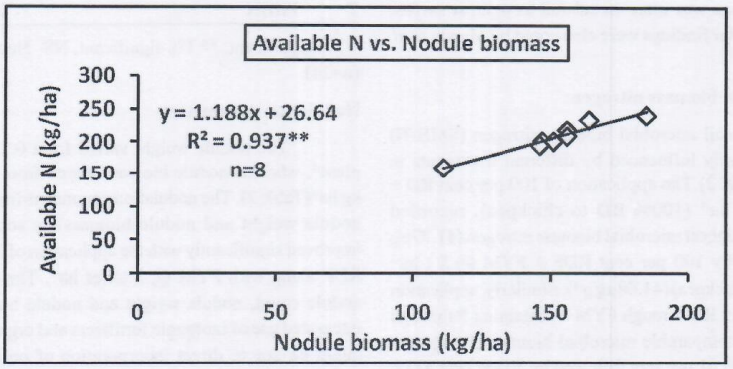

Fig. 3 Relationship between available N and nodule biomass

of chemical fertilizers also recorded higher amount of nodule biomass in comparison to unfertilized treatment (Control), which must be due to the significance of fertilizer in helping root and nodule development in the soil. Haider *et al.*, (1995) reported the application of fertilizer N increased root weight over the control. The significant results under IPNS might be due to balancing of organic and inorganic sources which resulted into adequate supply of macro and micronutrients. This ultimately provides better environment for root and nodule development.

Relationship of organic carbon and shaded biomass with soil properties:

The results thus suggest significance of organic carbon in maintaining soil health. The correlation of shaded biomass and the properties of soil were assessed. It was noted that soybean biomass has great significance with availability of nutrients as well as soil microbial biomass carbon and nitrogen. Similarly carbon stock was also positively correlated with biomass. The soybean adds considerable biomass to the soil and hence need to be included in cropping systems. Secondly it has greater significance as legume, which not only enhances the soil quality but also sustained the crop yield and also sequestered large quantity of carbon in soils through various plant parts. Considering adverse effect of climate change on agricultural crop production system as well as declining soil health, the magnitude of carbon sequestration need to be trapped for enrichment of soil biology. The development of soil properties is the only possible way to achieve yield maximization of crops by mitigating challenge of climate change. The results obtained under this study, would definitely provide pathway to reach environment friendly agriculture by sequestering carbon through improved agricultural practices.

The relationship between available N and nodulation parameters were observed as it is indicated from high correlation coefficient (R^2) among available N and nodule weight (R^2= 0.903**), nodule count (R^2=0.724**) and nodule biomass (R^2= 0.937**)

LITERATURE CITED

Bharadwaj, V. and P. K. Omanwar, 1992. Impact of long-term fertility treatments on bulk density, water contents and microbial population of soil, J.Indian Soc. of Soil Sci., 40, 553-555.

Bharambe, P.R., M. A. Patil, S.R. Oza and P. K. Shelke, 1999. Effect of crop residue incorporation and irrigation on sunflower yield and soil productivity under sorghum-sunflower cropping system, J. Indian Soc. of Soil Sci., 47(1), 169-171.

Blake, G.R. and K.H. Hartge, 1986. Bulk density. *In:* Methods of Soil Analysis, Part-I, Klute, A. (Ed.). American Society of Agronomy Inc. and Soil Science Society of America Inc. Madison, Wisconsin, USA, : 371-373.

Brady, A.C., R.R. Weil, 2002. The Nature and Properties of Soils. 13th Edn. Prentice Hall, New jersey, USA.

Brookes, P.C., A. Landman, G. Pruden, D.S. Jenkinson 1985. Chloroform fumigation and the release of soil nitrogen: A rapid direct extraction method to measure microbial biomass nitrogen in soil, Soil Biology and Biochemistry, 17, 837–842.

Chaturvedi, S. and A. S. Chandel, 2005. Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (*Glycin max* L.), Indian J. Agron., 50(4), 311-313.

Chitale S. R., R. K. Bajapai, S. K. Upadhyay and B. S. Joshi, 2003. Influence of cereal legume, legume-cereal and cereal sequence on productivity, economics and soil fertility status, Madras Agril. Journal 90(10-12), 733-73.

Haider, J., K.M. Rahman, Kh. Saiikddin, and T. Hossain, 1995. Response of soybean (*Glycme M.*(L.)) to rhizobium inoculation and urea fertilizer on shallow red brown tenace soil, Legume Res., 18(1):17-24.

Hati, K. M., A. Swarup, A. K. Dwivedi, A. K. Misra and K. K. Bandyopadhyay, 2007. Changes in soil physical properties and organic carbon status at the topsoil horizon of a Vertisol of central India after 28 years of continuous cropping, fertilization and manuring, Agriculture Ecosystem and Environment 119(1-2), 127-134.

Jackson, M. L., 1967. Soil chemical analysis, Prentice Hall of India, New Delhi.

Kanzawa, S., S. Asakawa and Y. Takai, 1988. Effect of fertilizers and manure application on microbial numbers, biomass and enzyme activities in volcanic ash soils, Soil Science Plant Nutrition 34(3), 429-439.

Kaur, K. K., K. Kapoor and A. P. Gupta, 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions, J. Pl. Nutrition and Soil Sci. 168 : 117-122.

Kemper, W.D. and R.C. Rosenau, 1986. Aggregate stability and size distribution. In A. Klute (Ed.) Methods of Soil Analysis Part-I. 2nd ed. ASA and SSA, Madison, Wisconsin : 425-442.

Manna, M. C., S. Kundu, M. Singh and P. N. Takkar, 1996. Influence of FYM on dynamics of microbial biomass and its turnover and activity of enzymes under a soybean - wheat system on a Typic Haplustert, J. Indian Soc. of Soil Sci., 44(3), 409-412.

Olsen, S.R., C.V. Cole, F.S. Watanabe, and L.A. Dean, 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate *USDA Circular No.* 939, Washington D.C. Piper, C. S., 1966. Soil and plant analysis, Hans Publisher, Bombay.

Piper, C.S., 1966. Soil and Plant Analysis, Hans. Pub. Bombay. Asian Ed. : 368-374.

Reeves, D.W., 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems, Soil & Tillage Research 43, 131–167. doi: 10.1016/S0167-1987(97)00038-X.

Reynolds, W.D., D.E. Elrick, 2002. Saturated and field-saturated water flow parameters. In 'Methods of soil analysis, Part 4. Physical methods. (Eds JH Dane, GC Topp) : 804–808. (Soil Science Society of America: Madison, WI).

Selvi, D., P. Santhy and M. Dhakshinamoorthy, 2003. Efficacy of long term integrated plant nutrient management on important soil properties of an Inceptisol, Madras Agriculture Journal 90 (10-12) : 656-660.

Sharma, C.P., H.S. Gupta and P.D. Bajpai, 1986. Residual effect of leguminous crop on some chemical and microbiological properties of soil, J. Indian Soc. of Soil Sci., 346 : 206-208.

Subbiah, B. V. and G. L. Asija, 1956. A rapid procedure for determination of available nitrogen in Soil, Current Science 25,256-260.

Vance, E.D., P.C. Brookes, D.S. Jenkinson, 1987. An extraction method for measuring soil microbial biomass carbon, Soil Biology and Biochemistry 19, 703– 707.

Verma, Gayatri and A. K. Mathur, 2009. Effect of Integrated Nutrient Management system on Active pool of Soil Organic Matter under Maize Wheat System of a Typic Haplustept, J. Indian Soc. Soil Sci., 57(3), 317-322.

Zhang, X.Y., X.Y. Sui, X.D. Zhang, K. Meng and S.J. Herbert, 2007. Spatial variability of nutrient properties in black soil of northeast China, Pedosphere 17, 19-29.

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Efficacy of Azadirachtin with Chemical Insecticides and *Verticillium lecanii* Against Sucking Insect Pests of Brinjal

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ABSTRACT

The present investigation entitled, "Efficacy of Azadirachtin with chemical insecticides and *Verticillium lecanii* against sucking insect pests of brinjal", was conducted, to find out the cost effective treatment. The experiment was conducted during *Kharif* 2014-15 on the field of Department of Entomology Dr.PDKV, Akola. The treatments under evaluation included (T1) Azadirachtin 10000 ppm (1% w/w) @ 2 ml L^{-1} of water, (T2) *Verticillium lecanii* 1 x 10^8 cfu/g @ 4 g L^{-1} of water, (T3) Imidacloprid 17.8 SL @ 0.0045 percent , (T4) Thiamethoxam 25 WG @ 0.01 per cent, (T5) Triazophos 40 EC @ 0.08 per cent, (T6) Fenpropathrin 30 EC @ 0.045 per cent, (T7) Azadirachtin 10000 ppm @ 2 ml L^{-1} + *Verticillium lecanii* 1 x 10^8 cfu g^{-1} @ 2 g L^{-1}, (T8) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Imidacloprid 17.8 SL 0.0023 per cent, (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG 0.005 per cent, (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC 0.04 per cent, (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC 0.023 per cent and (T12) untreated control.. Total five sprays of the above treatments were applied at an interval of 15 days commencing first application at 30 days after transplanting. The treatment Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g L^{-1} followed by Azadirachtin 10000 ppm @ 2ml L^{-1} + Imidacloprid 17.8 SL @ 0.12 ml L^{-1}, Thiamethoxam 25 WG @ 0.4 g L^{-1}, Imidacloprid 17.8 SL @ 0.25 ml L^{-1} and Azadirachtin 10000 ppm @ 2ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} were found significantly effective in reduction of sucking pests i.e. leafhopper, whitefly and mites. Whereas yield recorded was highest in Treatment T10 (127.59 q ha^{-1}) and T11 (125.00 q ha^{-1}). Treatment of Triazophos 40 EC @ 2 ml L^{-1} followed by Imidacloprid 17.8 SL @ 0.25 ml L^{-1}, Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} and Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1} were found economically most viable treatment as they had recorded the ICBR with net monetary return viz. 1:4.35 and Rs.32050 ha^{-1}, 1:4.27 and Rs.29108 ha^{-1}, 1:3.63 and Rs.41230 ha^{-1}, 1:3.47 and Rs.38810 ha^{-1}, respectively.

Brinjal or eggplant (*Solanum melongena* L.) is an important Solanaceous crop of subtropics and tropics. In India, it is one of the most common, popular and principal vegetable crop grown throughout the country except higher altitudes. It is often described as a poor man's vegetable because it is popular amongst small-scale farmers and low income consumers. Brinjal is also called by some as the 'King of Vegetables'. Though brinjal is a summer crop, it is being grown throughout the year under irrigated condition. Hence, it is subjected to attack by number of insect pests right from nursery stage to till harvesting (Ragupathy *et al.*, 1997).

Among the several sucking pests aphid, leaf hopper, whitefly, thrips and mites are of major importance due to their regular occurrence damaging the crop by sucking the cell sap constantly thereby arresting the growth of the crop. The leafhopper nymphs and adults suck the sap from underside of leaves and inject their toxic saliva into the tissue causing toxaemia. Patil and Mehta (2008) revealed that leafhopper (*A. biguttula biguttula*) appeared first on brinjal. The whitefly nymphs and adults suck the cell sap from leaves and tender apical shoots. In addition, these insects also secrete the 'honeydew' on which fungus or black sooty mould develops, which in turn interferes with the photosynthesis activity of the plant. Hasan et al. (2008) recorded *B. tabaci* peak population on the 60 days old crop, while the lowest was on the 30 days old. Red spider mite, (*Tetranychus telarius* L.) preferred most brinjal as a host among vegetables. These are minute, polyphagous pests found in large colonies on underside of leaves covered with fine silky webs result into arrest of growth of plant.

It is, thus, amply obvious that unless adequate, appropriate and effective measures are adopted to control these pest menace, brinjal production will suffer a serious setback resulting into the considerable yield loss. Hence in order to know the effect of Azadirachtin with chemical insecticides and *Verticillium lecanii* to test their synergistic or antagonistic action against the sucking pest and its effect on crop, the present investigation was carried out.

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MATERIAL AND METHODS

The experiment was laid out in randomized block design (RBD) with twelve treatments (Table 1) replicated thrice on the field of Department of Entomology Dr. PDKV, Akola with a view to evaluate the management of sucking insect pests of brinjal using botanicals, microbial, newer and conventional insecticides in field trial. About a one month old brinjal seedlings (variety: Aruna) were transplanted at 60 x 60 cm spacing and each gross plot size was 4.2 m × 3 m. The seedlings were raised as per the recommended package of practices except plant protection measures. The five rounds of insecticidal sprayings as per treatments were applied at fortnightly intervals commencing first application at 30 days after transplanting and last spraying of the treatments were taken 15 days before the last picking of the fruits.

Pre-treatment observations were recorded 24 hours before first spray and post treatment observations were recorded at 3, 7 and 14 days after each treatment spray and for next spray onwards pre-treatment count were of 14 days after treatment on randomly selected five plants from each net plot and from three leaves (top, middle and bottom) and leaf^{-1} population was worked out.

RESULTS AND DISCUSSION

Cumulative effect of various treatments against leafhopper population on brinjal crop after five sprays

The data on leafhopper population after five sprays was averaged and presented in Table 1. The cumulative average population of leafhoppers leaf^{-1} at 3 DAT in all treated plots were significantly lower (1.59 to

Table 1: Cumulative effect of various treatments against leafhopper population on brinjal crop after five sprays

Tr. No.	Treatment details	Conc.(%), /ml/Lg/L	Number of leafhoppers/leaf 3 DAT*	7 DAT*	14 DAT*
T1	Azadirachtin 10000 ppm	2ml/L	2.78 (1.64)*	3.43 (1.85)	4.20 (2.04)
T2	*Verticillium lecanii* 1.15% WP	4g/L	2.96 (1.72)	3.67 (1.89)	4.47 (2.11)
T3	Imidacloprid 17.8 SL	0.0045	1.99 (1.41)	2.80 (1.67)	3.15 (1.77)
T4	Thiamethoxam 25 WG	0.01	1.85 (1.36)	2.75 (1.66)	2.98 (1.72)
T5	Triazophos 40 EC	0.08	2.42 (1.56)	3.19 (1.79)	3.46 (1.86)
T6	Fenpropathrin 30 EC	0.045	2.49 (1.58)	3.32 (1.82)	3.61 (1.90)
T7	Azadirachtin 10000 ppm + *Verticillium lecanii* + 1.15% WP	2ml/L + 2g/L	2.62 (1.62)	3.38 (1.84)	3.88 (1.96)
T8	Azadirachtin 10000 ppm + Imidacloprid17.8 SL	2ml/L + 0.0023	1.71 (1.31)	2.72 (1.65)	2.93 (1.70)
T9	Azadirachtin 10000 ppm + Thiamethoxam25 WG	2ml/L + 0.005	1.59 (1.26)	2.35 (1.53)	2.72 (1.65)
T10	Azadirachtin 10000 ppm + Triazophos40 EC	2ml/L + 0.04	2.12 (1.45)	2.89 (1.70)	3.26 (1.80)
T11	Azadirachtin 10000 ppm + Fenpropathrin30 EC	2ml/L + 0.023	2.32 (1.52)	3.03 (1.73)	3.34 (1.82)
T12	Untreated control	-	5.81 (2.40)	7.58 (2.75)	8.74 (2.95)
	SE (M) ±		0.09	0.09	0.09
	CD at 5 %		0.25	0.27	0.27

* Figures in parentheses are square root transformations. DAT – Days after treatment

2.96) than the untreated control plot (5.81). The lowest population (1.59) was recorded due to treatment (T9) Azadirachtin 10000ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g L^{-1} and it was statistically at par T8, T4 and T3. The next effective treatment was (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1} (2.32 leafhoppers $leaf^{-1}$) harvest at par with T5, T6, T7, T1, T2 and T12. The above findings showed that the combination treatment (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1}+ Thiamethoxam 25 WG @ 0.2 g L^{-1} was significantly superior over untreated control but at par with T8, T4, T3 and T10. More or less similar trend was found on 7 DAT and 14 DAT. These results are in confirmation with the findings of Naik *et al.*, (2009).

Cumulative effect of various treatments against whitefly population on brinjal crop after five sprays

The cumulative average population of whiteflies $leaf^{-1}$ at 3 DAT in all treated plots were significantly lower (3.20 to 5.49) than the untreated control plot (Table 2). The lowest population (3.20) was recorded due to treatment (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g L^{-1} and it was statistically at par with treatments T8, T4, T3, T10 and T11. The next effective treatment was (T5) Triazophos 40 EC @ 2 ml L^{-1} (4.55 whiteflies $leaf^{-1}$) at par with T6, T7, T1 and T2. These results are in confirmation with the findings of Naik *et al.*, (2009). As regards the efficacy of (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g

Table 2: Cumulative Effect of various treatments against whitefly population on brinjal crop after five spray

Tr. No.	Treatment details	Conc.(%), ml Lg^{-1} L^{-1}	Number of Whitefly $leaf^{-1}$		
			3 DAT*	7 DAT*	14 DAT*
T1	Azadirachtin 10000 ppm	2ml L^{-1}	5.15 (2.26)	6.56 (2.57)	7.51 (2.73)
T2	*Verticillium lecanii* 1.15% WP	4g L^{-1}	5.49 (2.34)	7.02 (2.65)	7.89 (2.78)
T3	Imidacloprid 17.8 SL	0.0045	3.91 (1.97)	5.15 (2.27)	6.34 (2.52)
T4	Thiamethoxam 25 WG	0.01	3.74 (1.92)	4.91 (2.22)	6.14 (2.48)
T5	Triazophos 40 EC	0.08	4.55 (2.13)	5.81 (2.41)	6.68 (2.58)
T6	Fenpropathrin 30 EC	0.045	4.78 (2.18)	6.04 (2.46)	6.72 (2.59)
T7	Azadirachtin 10000 ppm + *Verticillium lecanii* 1.15% WP	2ml L^{-1} + 2g L^{-1}	4.97 (2.22)	6.43 (2.52)	6.79 (2.60)
T8	Azadirachtin 10000 ppm + Imidacloprid 17.8 SL	2ml L^{-1} + 0.0023	3.59 (1.89)	4.74 (2.17)	5.95 (2.44)
T9	Azadirachtin 10000 ppm + Thiamethoxam 25 WG	2ml L^{-1} + 0.005	3.20 (1.79)	4.39 (2.09)	5.65 (2.36)
T10	Azadirachtin 10000 ppm + Triazophos40 EC	2ml L^{-1} + 0.04	4.09 (2.02)	5.49 (2.34)	6.48 (2.54)
T11	Azadirachtin 10000 ppm + Fenpropathrin30 EC	2ml L^{-1} + 0.023	4.27 (2.07)	5.66 (2.37)	6.54 (2.56)
T12	Untreated control	-	11.04 (3.32)	12.74 (3.56)	13.52 (3.67)
	F test		Sig.	Sig.	Sig
	SE (M) ±		0.10	0.11	0.13
	CD at 5 %		0.31	0.33	0.39

* Figures in parentheses are square root transformations. DAT – Days after treatment

Table 3: Cumulative effect of various treatments against mite population on brinjal crop after five sprays

Tr. No.	Treatment details	Conc.(%), ml/Lg/L	Number of mite / leaf 3 DAT*	7 DAT*	14 DAT*
T1	Azadirachtin 10000 ppm	2ml/L	3.59 (1.89)	3.56 (1.89)	4.10 (2.02)
T2	*Verticillium lecanii* 1.15% WP	4g/L	3.82 (1.95)	3.69 (1.91)	4.26 (2.06)
T3	Imidacloprid 17.8 SL	0.0045	2.33 (1.52)	2.38 (1.54)	2.87 (1.69)
T4	Thiamethoxam 25 WG	0.01	2.22 (1.49)	2.14 (1.46)	2.59 (1.60)
T5	Triazophos 40 EC	0.08	2.96 (1.71)	3.00 (1.73)	3.46 (1.86)
T6	Fenpropathrin 30 EC	0.045	3.10 (1.76)	3.10 (1.76)	3.64 (1.91)
T7	Azadirachtin 10000 ppm + *Verticillium lecanii* 1.15% WP	2ml/L + 2g/L	3.40 (1.84)	3.35 (1.82)	3.92 (1.98)
T8	Azadirachtin 10000 ppm + Imidacloprid17.8 SL	2ml/L + 0.0023	1.98 (1.40)	2.01 (1.42)	2.41 (1.55)
T9	Azadirachtin 10000 ppm + Thiamethoxam 25 WG	2ml/L + 0.005	1.73 (1.31)	1.84 (1.36)	2.16 (1.47)
T10	Azadirachtin 10000 ppm + Triazophos140 EC	2ml/L + 0.04	2.52 (1.57)	2.50 (1.58)	3.11 (91.76)
T11	Azadirachtin 10000 ppm + Fenpropathrin30 EC	2ml/L + 0.023	2.70 (1.63)	2.77 (1.65)	3.24 (1.80)
T12	Untreated control	-	6.54 (2.55)	6.23 (2.49)	6.70 (2.58)
	F test		Sig.	Sig.	Sig
	SE (M) ±		0.10	0.08	0.08
	CD at 5 %		0.31	0.23	0.25

* Figures in parentheses are square root transformations. DAT – Days after treatment

L^{-1}, (T8) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Imidacloprid 17.8 SL @ 0.12 ml L^{-1} and (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} present finding are in confirmation with Omprakash and Raju, (2013) also has showed moderate efficacy against whiteflies.

Cumulative effect of various treatments against mite population on brinjal crop after five sprays

The cumulative average population of mites/leaf at 3 DAT in all treated plots were significantly lower (1.73 to 3.82) than the untreated control plot (Table 3). The lowest population (1.73) was recorded due to treatment (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g L^{-1} and it was statistically at par T8, T4, T3 and T10. The next effective treatment was (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1} (2.70 mites $leaf^{-1}$) at par with T5, T6, T7, T1 and T2. The present finding are in confirmation with Varghese and Mathew, (2013).

Yield of marketable brinjal fruits:

The highest yield of brinjal fruits (127.59 q ha^{-1}) was obtained from (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} followed by the treatments (T11). However, the data pertaining to ICBR (Table 5) the treatment (T5) Triazophos 40 EC @ 2 ml L^{-1} recorded highest ICBR i.e. 1:4.35 followed by the treatments (T3) Imidacloprid 17.8 SL @ 0.25 ml L^{-1}, (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC

Table 5: Incremental cost benefits ratio and net monetary return in different doses of treatments in brinjal

Treatments	Qty. of insecticide req. /ha	Cost of treatment (Rs/ha)		Total cost (A)	Yield (q/ha)	Increase yield over control (q/ha)	Value of increased yield (Rs./ha) (B)	Increment benefit (C) (B-A)	ICBR (C/A)	Rank
		Cost of insecticide	Labour + sprayer charges							
T1	5000 ml	5300	4750	10050	98.51	23.51	23510	13460	1:1.34	X
T2	10 kg	2000	4750	6750	97.95	22.95	22950	16200	1:2.4	VII
T3	625 ml	2062	4750	6812	110.92	35.92	35920	29108	1:4.27	II
T4	1 kg	5600	4750	10350	104.24	29.24	29240	18890	1:1.83	IX
T5	5000 ml	2620	4750	7370	114.43	39.42	39420	32050	1:4.35	I
T6	750 ml	2280	4750	7030	103.14	28.14	28140	21110	1:3.00	VI
T7	5000 ml+5 kg	6300	4750	11050	100.00	25.00	25000	13950	1:1.26	XI
T8	5000 ml + 312.5 ml	6331	4750	11081	122.96	47.96	47960	36880	1:3.33	V
T9	5000 ml + 500 gm	8100	4750	12850	117.77	42.77	42770	29920	1:2.33	VIII
T10	5000 ml + 2500 ml	6610	4750	11360	127.59	52.59	52590	41230	1:3.63	III
T11	5000 ml + 375 ml	6440	4750	11190	125.00	50.00	50000	38810	1:3.47	IV
T12	-	-	-	-	75.00	-	-	-		

1) Labour charges:- (For one spray) 5 labour ha^{-1} @ Rs. 180 $labour^{-1}$ day^{-1},

2) Spray pump charge:-Rs. 25 day^{-1}, 3). Sale price of brinjal fruit: Rs. 1000 qtl^{-1}.

	Chemical name.	Rate (Rs).
1)	Azadirachtin 10000 ppm	1060 L^{-1}
2)	*Verticillium lecanii* 1 x 10^8 cfu/ml	200 Kg^{-1}
3)	Imidacloprid (17.8 SL)	3300/L
4)	Thiamethoxam (25 WG)	5600 Kg^{-1}
5)	Triazophos (40 EC)	524 L^{-1}
6)	Fenpropathrin (30 EC)	3040 L^{-1}

@ 1 ml L^{-1}, (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1}. But, in the net monetary returns the order of efficacy which gave net monetary differed due to the cost of insecticides. The more net monetary return was gained in treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} i.e. Rs. 41230.00 followed by the treatments (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1} (38810.00), (T8) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Imidacloprid 17.8 SL @ 0.12 ml L^{-1} (36880.00) and (T5) Triazophos 40 EC @ 2 ml L^{-1} (32050.00).

CONCLUSION

It is concluded that the treatments (T9) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Thiamethoxam 25 WG @ 0.2 g L^{-1}, (T8) Azadirachtin 10000 ppm @ 2ml L^{-1} + Imidacloprid 17.8 SL@ 0.12 ml L^{-1}, (T4) Thiamethoxam 25 WG @ 0.4 g L^{-1}, (T3) Imidacloprid 17.8 SL@ 0.25 ml L^{-1} and (T10) Azadirachtin 10000 ppm @ 2ml L^{-1} + Triazophos 40 EC@ 1 ml L^{-1} were significantly effective in recording lower population of sucking pests i.e. leafhopper, whitefly and mites.

LITERATURE CITED

Hasan, W., M. S. Ansari and H. Ali, 2008. Distribution pattern of white fly, *Bemisia tabaci* under natural condition on okra cultivars, Ento., 33(2) : 113-117.

Naik, V. C. B., P. A. Rao, P. V. Krishnayya and M. S. V. Chalam, 2009. Seasonal incidence and management of *Bemisia tabaci* Gennadius and *Amrasca biguttula biguttula* Ishida of brinjal, Annals of Pl. Protec. Sci., 17(1): 9-13

Omprakash, S. and S.V.S. Raju, 2013. Bioefficacy of some insecticides against *Bemisia tabaci* (Genn.) on brinjal, Indian J. Ent., 75(4): 310-314

Patil, A. and P. K. Mehta, 2008. Pest complex of brinjal and their succession under mid hills of Himachal Pradesh, J. Insect Sci., 21(1): 67-71.

Ragupathy, A., S. Palaniswami, N. Chandramohan, and K. Gupta, 1997. Guide on Crop Pests. Sooriya Desk Top, Coimbatore.

Sharma ,D.R. and O.P. Lal, 2002. Bioefficacy of thimethoxam in camprison to recommended insecticides against leafhopper and white fily of brinjal (*Solanum melongena* L.), J. Ent. Res. 16 (3) ; 257-262.

Varghese, T. S. and T. B. Mathew, 2013. Bioefficacy and safety evaluation of newer insecticides and acaricides against chilli thrips and mites, J. Tropical Agri., 51 (1-2) : 111-115.

Vinodkumar, S., C. Chinniah, C. Muthiah and A. Sadasakthi , 2009. Field evaluation of certain newer acaricide / insecticide molecule for their bioefficacy against *Tetranychus urticae Koch* on brinjal, Karnataka J. Agril. Sci., 22(3) ;705-706.

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Influence of HaNPV Alone and in Combinaion with Insecticides Against *Helicoverpa armigera* (Hubner) in Chickpea

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ABSTRACT

The present investigation was conducted, to find out the cost effective treatment. The experiment was conducted during *Rabi* 2014-15 at the field of Department of Entomology, Dr. PDKV, Akola. Two foliar sprays of insecticides were undertaken, out of which 1st was at 50 per cent flowering and 2nd was at 15 days after first application. The treatment HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} followed by HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1}, HaNPV @ 500 LE ha^{-1} + emamectin benzoate 5 SG @ 0.15 g L^{-1} and flubendiamide 20 WG @ 0.5 g L^{-1} were found to be significantly effective in terms of lower larval population of *H. armigera*, pod damage and higher yield (22.63, 23.30, 20.96 and 19.80 q ha^{-1}, respectively) with ICBR and net monetary return 1:12.41 and Rs.45810 ha^{-1}, 1:12.99 and Rs.28681ha^{-1}, 1:11.29 and Rs.37736 ha^{-1}, 1:10.37 and Rs.42948 ha^{-1}, respectively. Deleterious effect of treatments either alone or in combination with HaNPV were not observed on predatory population on chickpea throughout the season.

Chickpea (*Cicer arietinum* L.), also known as Bengal gram or Gram, *channa*, *garbanzo* etc., is one of the most important pulse crops of India and is considered as "King of pulses" (Bhatt and Patel, 2001). Chickpea crop is attacked by many species of insect and other arthropods in India. Among them, pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is the most important and avoidable loss was estimated to the extent of 63.64 per cent the total damage caused by all the insect pests (Shinde *et al.* 2014). It is very serious, polyphagous pest and has assumed the status of 'National Pest' in India. Due to its high fecundity, migratory behaviour, wide adoption to various agro-climatic conditions and resistance development to various insecticides, it causes damage to various crops *viz.*,cotton, vegetables, pulses, cereals and oilseed crops. Due to *H. armigera* attack, extensive yield losses have been reported in some pulses from 28-40 per cent ensuring economic losses up to 300 million dollars annually. Damage potential of this pest is so great that an average infestation of single larva may destroy 30-40 pods per plant in chickpea (Ali *et al.* 2009)

Now a day there is a practice amongst farmers to mix three to four agro-chemicals together for management of pest and disease, without knowing their phytotoxic effects on the crop. Due to this reason, farmers have to face many problems of crop growth, nutritive quality and yield deterioration and also improper management of insect. Combination of two or three insecticides or chemicals could be more effective if they act synergistically and harmful when antagonistic in nature.

Microbial insecticides in combination with chemicals insecticides not only reduce the use of sole chemical insecticides to an extent but also increase the effectiveness of pesticides. Besides, both in combination would be economically viable reducing cost and risk by improving B:C ratio. Compatibility of bio-agents with chemical pesticides is very important to reduce the chances of development of resistances to newer chemical insecticides (Sirvi *et al.*, 2013).

MATERIAL AND METHODS

The experiment was laid out in randomized block design (RBD) with twelve treatments (Table 1) replicated thrice at Department of Entomology field, Dr. PDKV, Akola. The seeds of chickpea variety JAKI-9218 were sown at a spacing of 30 x 10 cm with gross plot size of 4.2 m × 2.1 m. The plants were raised as per the recommended package of practices except plant protection measures. Two foliar sprays of HaNPV, botanical and insecticide and their combination with HaNPV were given at an interval of 15 days starting from 50 per cent flowering stage of chickpea. Quantity of spray volume used per ha was 500 L. While applying HaNPV adjuvants like optical brightener blue nil was used @ 0.1 ml L^{-1}.

The observations on larval population of *H. armigera* were recorded on five randomly selected spots per plot from one meter row length of each row of net

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plot. Pre-treatment count was recorded 24 hrs. before application of each spray and at 3, 7, 10 and 14 days after every spray for evaluating effect of HaNPV and insecticide alone and combination. Observations on pod damage were made on five randomly selected plants per plot.

$$\text{Per cent pod infestation} = \frac{\text{Total number of damaged pods}}{\text{Total number of pods}} \times 100$$

The treatment wise yield was calculated by summation of yield obtained from replications. Subsequently converted to hectare basis. The data were subjected to statistical analysis after appropriate transformations as per randomized block design (RBD) for statistical comparison. The incremental cost benefit ratio of each pesticide was calculated by taking into account the prevailing market price of input, produce, labour charges and calculated avoidable losses.

RESULTS AND DISCUSSION

The effect of HaNPV alone and in combination with insecticides against *H.armigera* in chickpea was tested under field conditions. The cumulative mean larval population of *H. armigera* on chickpea was based on average of two sprays recorded at 3, 7, 10, and 14 days after application of treatments (Table 1). The results were found to be statistically significant at all observation window. All the treatments were found significantly superior with higher mortality of *Helicoverpa* larvae to the control. The data recorded 3 days after spray of the treatment T_{10} - HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}, T_{11} - HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1} and T_4 - Emamectin benzoate 5 SG @ 0.3 g L^{-1} were found to be significantly effective in order of merit in recording minimum larval population of *H.armigera* (0.40, 0.40 and 0.60 larvae^{-1}mrl), respectively as compared to 1.77 larvae mrl^{-1} in untreated control.

While the treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}, T_5 - flubendiamide 20WG @ 0.5 g L^{-1}, T_4 - Emamectin benzoate 5 SG @ 0.3 g L^{-1} and T_{11} - HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1} were found significantly effective in recording lower larval population of *H.armigera* (0.37,0.47,0.50 and 0.53 larvae mrl^{-1}) respectively as compared to 1.73 larvae^{-1}mrl in untreated control at 7th days after spray. However, treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} and T_{11} - HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1} were found significantly effective at 10th day after spray in keeping larval population of *H.armigera* to lower level (0.40 and 0.43 larvae $^{-1}$mrl), respectively as compared to 1.60 larvae mrl^{-1} in untreated control and 14th days after spray the treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}, T_{11} - HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1}, T_5 - flubendiamide 20WG @ 0.5 g L^{-1} and T_4 - Emamectin benzoate 5 SG @ 0.3 g L^{-1} were found significantly effective in keeping larval population of *H.armigera* at lower level (0.30, 0.33, 0.37 and 0.40 larvae^{-1}mrl), respectively as compared to 1.47 larvae $^{-1}$ mrl in untreated control. The result of the present investigation are in line with the findings of Bhatt and Patel (2002) who reported the effectiveness of fenvalerate 0.005 per cent + HaNPV 250 LE ha^{-1} for managing larval population of *H. armigera* on chickpea. The above findings are also supported by Sirvi *et al.* (2013). Above result regarding efficacy of flubendiamide 20WG @ 0.5 g L^{-1} are agreement with Baber *et al.* (2012) who reported that flubendiamide 0.01per cent recording highest reduction in larval population of *H. armigera* in chickpea. Similar result were obtained by Dodia *et al.* (2009) who reported efficacy of flubendiamide 20 WDG at 50 g a.i. ha^{-1} when sprayed against *H. armigera* infesting pigeonpea. As regards the efficacy of emamectin benzoate 5 SG @ 0.3 g L^{-1} present finding are in confirmation with Kambrekar *et al.* (2012) who reported Emamectin benzoate 5 SG @ 13 g a.i ha^{-1} resulted in maximum larval reduction of *H. armigera* on chickpea.

The treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} was found to be significantly most effective in recording minimum pod damage of chickpea (8.90 %) and was superior over all other remaining treatments (Table 3). The second next effective treatment T_5 - flubendiamide 20 WG @ 0.5 g L^{-1} was found to be statistically at par with T_9 - HaNPV @ 500 LE ha^{-1} + Emamectin benzoate 5 SG @ 0.15 g L^{-1} (10.35%) in recording comparatively lower pod damage (9.86%) and superior over rest of the treatments. Maximum pod damage was recorded in T_{12} - untreated control (23.55%), whereas, the results of the present investigation are in similar line with the findings of Baber *et al.* (2012) who reported that flubendiamide 0.01per cent recorded minimum per cent pod damage against *H. armigera* in chickpea.

The treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} was found to be significantly most effective in recording highest yield of chickpea (23.30 q ha^{-1}) and was followed by T_5 - flubendiamide 20 WG @ 0.5 g L^{-1} (22.63 q ha^{-1}) and T_9 - HaNPV @ 500 LE ha^{-1} + Emamectin benzoate 5 SG @ 0.15 g L^{-1} (20.96 q ha^{-1}). Significantly lowest yield (9.55 q ha^{-1}) was recorded in T_{12} - untreated control. As regards the efficacy of Emamectin benzoate 5 SG @ 0.3 g L^{-1} with HaNPV @ 500 LE ha^{-1} present finding are in confirmation with Singh and Kumar (2012) who reported that HaNPV @ 250 LE ha^{-1} + emamectin benzoate 5 SG @ 200g ha^{-1} contribution found to be effective increasing grain yield.

Effect of HaNPV alone and in combination with insecticide on Incremental Cost Benefit Ratio (ICBR) of chickpea

The findings on incremental cost benefit ratio for various treatments in Table 3, revealed that The treatment T_{10}- HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} ranked third in ICBR (1:12.41) but recorded highest net monetary return of Rs.45810 $^{-1}$ha by producing highest yield. The highest ICBR (1:19.31) with optimum net monetary return of Rs.22693 ha^{-1} was obtained in the treatment of T_6 - fenvalerate 20 EC @ 0.5 ml L^{-1} and proved as the economically most viable treatment. Followed by these treatment T_{11} - HaNPV @

Table 1. Effect of HaNPV alone and in combination with insecticides on larval population of *H. armigera* on chickpea (Average of two sprays).

Treatments	3 DAS	7 DAS	10DAS	14DAS
T_1 - HaNPV 1x10^9 POB^{-1}ml @ 500 LE ha^{-1}	1.27 (1.13)*	1.37 (1.17)*	1.20 (1.09)*	0.70 (0.84)*
T_2 - Azadirachtin 10,000 ppm @1ml L^{-1}	0.87 (0.93)	1.50 (1.22)	1.20 (1.09)	0.70 (0.84)
T_3 - Quinalphos 25 EC @ 2 ml L^{-1}	1.10 (1.05)	0.93 (0.96)	0.83 (0.91)	0.63 (0.80)
T_4 - Emamectin benzoate 5 SG @ 0.3 g L^{-1}	0.60 (0.77)	0.50 (0.70)	0.77 (0.87)	0.40 (0.63)
T_5 - Flubendiamide 20 WG @ 0.5 g L^{-1}	0.90 (0.95)	0.47 (0.68)	0.67 (0.82)	0.37 (0.60)
T_6 - Fenvalerate 20 EC @ 0.5 ml L^{-1}	1.00 (1.00)	0.87 (0.92)	0.70 (0.84)	0.43 (0.66)
T_7 - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + Azadirachtin 10,000 ppm @ 0.5 ml L^{-1}	0.87 (0.92)	1.03 (1.02)	1.03 (1.01)	0.60 (0.77)
T_8 - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + Quinalphos 25 EC @ 1ml L^{-1}	0.70 (0.84)	1.00 (1.00)	1.07 (1.03)	0.57 (0.75)
T_9 - HaNPV 1x10^9 POB ml^{-1} @ 500 LE $^{-1}$ha + Emamectin benzoate 5 SG @0.15 g L^{-1}	0.80 (0.89)	0.87 (0.92)	0.67 (0.82)	0.47 (0.68)
T_{10} - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}	0.40 (0.63)	0.37 (0.60)	0.40 (0.61)	0.30 (0.53)
T_{11} - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1}	0.40 (0.63)	0.53 (0.72)	0.43 (0.63)	0.33 (0.58)
T_{12} - Untreated Control	1.77 (1.33)	1.73 (1.32)	1.60 (1.26)	1.47 (1.21)
S.E.(m) ±	0.06	0.05	0.06	0.04
C.D. at 5%	0.17	0.16	0.17	0.12
CV %	11.25	10.27	10.87	9.63

N.B.- *Figures in parenthesis are square root transformed values DAS – Days after spraying

Table 2. Effect of HaNPV alone and in combination with insecticide on per cent pod damage and yield of chickpea.

Treatment	Pod Damage (%)	Yield (q ha^{-1})
T_1 - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1}	14.53(3.78)*	15.58
T_2 - Azadirachtin 10,000 ppm @1ml L^{-1}	15.85(3.94)	14.78
T_3 - Quinalphos 25 EC @ 2 ml L^{-1}	12.36(3.51)	16.05
T_4 - Emamectin benzoate 5 SG @ 0.3 g L^{-1}	10.48(3.22)	19.80
T_5 - Flubendiamide 20 WG @ 0.5 g L^{-1}	9.86(3.14)	22.63
T_6 - Fenvalerate 20 EC @ 0.5 ml L^{-1}	12.20(3.49)	16.58
T_7 - HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + Azadirachtin 10,000 ppm @ 0.5ml L^{-1}	13.68(3.70)	15.83
T_8 - HaNPV 1x10^9 POB^{-1} ml @ 500 LE ha^{-1} + Quinalphos 25 EC @ 1ml L^{-1}	10.71(3.27)	18.08
T_9 - HaNPV 1x10^9 POB^{-1}ml @ 500 LE ha^{-1} + Emamectin benzoate 5 SG @ 0.15 g L^{-1}	10.35(3.22)	20.96
T_{10} - HaNPV 1x10^9 POB^{-1} ml @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}	8.90(2.98)	23.30
T_{11} - HaNPV 1x10^9 POB^{-1} ml @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1}	10.70(3.27)	18.13
T_{12} - Untreated Control	23.55(4.85)	9.55
S.E.(m) ±	0.21	0.7
C.D. at 5%	0.61	2.1
CV %	10.33	7.14

N.B.- *Figures in parenthesis are square root transformed value. q ha^{-1} - quintal ha^{-1}

500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1} ranked second in ICBR (1:12.99) with optimum net monetary return of Rs.28681ha^{-1}. Treatment T_9 - HaNPV @ 500 LE ha^{-1} + emamectin benzoate 5 SG @ 0.15 g L^{-1} recorded optimum net monetary return of Rs. 37736 ha^{-1} with optimum ICBR (1:11.29). The treatment T_5 - flubendiamide 20 WG @ 0.5 g L^{-1} was found moderately effective in recording higher net monetary returns of Rs.42948 ha^{-1} with ICBR (1:10.37).

The lowest ICBR (1:7.46) and lowest net monetary return of Rs.16728 ha^{-1} was obtained in T_7- HaNPV @500 LE ha^{-1} + azadirachtin 10,000 ppm @ 0.5 ml L^{-1} and T_2 - Azadirachtin 10,000 ppm @1ml L^{-1}, respectively.

The maximum percent avoidable losses in decreasing order respectively in T_{12} - untreated control (59.01%), T_2 - azadirachtin 10,000 ppm @1ml L^{-1} (36.56%), T_1 - HaNPV @ 500 LE ha^{-1} (33.13%), T_3 - quinalphos 25 EC @ 2 ml L^{-1} (32.83%), T_7- HaNPV @ 500 LE ha^{-1} + azadirachtin 10,000 ppm @ 0.5 ml L^{-1} (32.06%), T_6 - fenvalerate 20 EC @ 0.5 ml L^{-1} (30.56%), T_8 - HaNPV @ 500 LE ha^{-1} + quinalphos 25 EC @ 1ml L^{-1} (22.40%), T_{11} - HaNPV @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1} (22.18%), T_4 - emamectin benzoate 5 SG @ 0.3 g L^{-1} (15.02%), T_9 - HaNPV @ 500 LE ha^{-1} + emamectin benzoate 5 SG @ 0.15 g L^{-1} (10.04%) and T_5 - flubendiamide 20 WG @ 0.5 g L^{-1} (2.87%).

The results of the present investigation are in line with the findings of Bhatt and Patel (2002) who reported the highest ICBR with increased in grain yield due to the combination of fenvalerate 0.005 per cent + HaNPV 250 LE ha^{-1}. As regards the efficacy of fenvalerate 20 EC @ 0.5 ml L^{-1} present finding are in conformation with Singh *et al.* (2012) who reported that fenvalerate 20 EC @ 300 g a.i. ha^{-1} recorded maximum grain yield and higher ICBR. As regards the efficacy of emamectin benzoate 5 SG @ 0.3 g L^{-1} with HaNPV present finding are in confirmation with Singh and Kumar (2012) who reported that HaNPV @ 250 LE ha^{-1} + emamectin benzoate 5 SG @ 200g ha^{-1} increased grain yield and ICBR. Results could not be compared with best combination of HaNPV @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1} for want of literature.

LITERATURE CITED

Ali, A., R. A. Choudhury, Z. Ahmad, F. Rahman, F. R. Khan, and S. K. Ahmad, 2009. Some biological characteristics of *Helicoverpa armigera* on chickpea, Tunisian, J. Pl. Prot., 4(1): 99-106.

Treatments	Grain yield (q ha^{-1})	Percent avoidable losses	Increase in yield over control (q ha^{-1})	Cost of increased yield over control@ Rs. 3600 q^{-1}	Cost of insecticides ha^{-1} + labour	Net profit (Rs ha^{-1})	Cost benefit ratio
T_1 HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1}	15.58	33.13	6.03	21708	2140	19568	1:9.14
T_2 Azadirachtin 10,000 ppm @1ml L^{-1}	14.78	36.56	5.23	18828	2100	16728	1:7.96
T_3 Quinalphos 25 EC @ 2 ml L^{-1}	15.65	32.83	6.10	21960	1800	20160	1:11.20
T_4 Emamectin benzoate 5 SG @ 0.3 g L^{-1}	19.80	15.02	10.25	36900	3440	33460	1:9.72
T_5 Flubendiamide 20 WG @ 0.5 g L^{-1}	22.63	2.87	13.08	47088	4140	42948	1:10.37
T_6 Fenvalerate 20 EC @ 0.5 ml L^{-1}	16.18	30.56	6.63	23868	1175	22693	1:19.31
T_7 HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} +Azadirachtin 10,000 ppm @ 0.5 ml L^{-1}	15.83	32.06	6.28	22608	2670	19938	1:7.46
T_8 HaNPV 1x10^9 POB ml^{-1} @ 500 LE $^{-1}$ ha + Quinalphos 25 EC @ 1ml L^{-1}	18.08	22.40	8.53	30708	2520	28188	1:11.18
T_9 HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} +Emamectin benzoate 5 SG @0.15g L^{-1}	20.96	10.04	11.41	41076	3340	37736	1:11.29
T_{10} HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + flubendiamide 20 WG @ 0.25 g L^{-1}	23.30	-	13.75	49500	3690	45810	1:12.41
T_{11} HaNPV 1x10^9 POB ml^{-1} @ 500 LE ha^{-1} + fenvalerate 20 EC @ 0.25 ml L^{-1}	18.13	22.18	8.58	30888	2207	28681	1:12.99
T_{12} Untreated Control	9.55	59.01	-	-			
S.E.(m) ±	0.7						
C.D. at 5%	2.1						
CV %	7.14						

N.B : Cost of HaNPV 500 LE @ Rs.1100/-per lit. Emamectin benzoate 5 SG @ Rs.8000/-per kg. Azadirachtin 10,000 ppm @ Rs.1060/-per lit. Flubendiamide 20 WG @ Rs.6200/-per kg. Quinalphos 25 EC @ Rs. 380/- per lit. Fenvalerate 20 EC @ Rs 270./per lit. price of chickpea Rs. 3600/- per qtl. and labour charges @ Rs. 120/- per day (4 labour/ha) and Rs. 40/spray- (spray pump)charges @ Rs. 20/- pump per day

Baber, K.S., T.M. Bharpoda, K.D. Shah, and R.C. Jhala, 2012. Bio-efficacy of newer molecules of insecticides against chickpea pod borer, *Helicoverpa armigera* (Hubner), Agres – An International e- journal, 1(2): 134-147.

Bhatt, N.J. and R.K. Patel, 2001. Screening of chickpea cultivars for their resistance to gram pod borer *H. armigera*, Indian J. Entomology, 63(2) : 423-430.

Dodia, D.A., B.G. Prajapati and S. Acharya, 2009. Efficacy of insecticides against gram pod borer, infesting pigeonpea, J. Food Legumes, 22 (2): 144-145.

Kambrekar, D.N, G. Somanagouda, M.P. Basavarajappa and S.P Halagalimath, 2012. Effect of different dosages of emamectin benzoate 5 SG and indoxacarb 14.5 SC on pod borer, *Helicoverpa armigera* infesting chickpea, Legume Research, 35 (1): 13- 17.

Shinde Y. A., O. P. Veda and B. R. Patel, 2014. A note on estimation of avoidable losses due to pod borer, *Helicoverpa armigera* (Hubner) in chickpea (*Cicer artetinum*), Indian J. Ent., 76(2): 152-156

Singh S.K. and Kumar Jeewesh, 2012. Management of pod borers in pigeonpea (*Cajanus cajan* L.) through bio and novel insecticides, Trends in Biosciences , 5 :154-156

Sirvi, A. L., H. R. Choudhary, Narendra Jat, V. K. Tiwari and Nahar Singh, 2013. Compatibility of bio-agents with chemical pesticides: An Innovative Approach in Insect-Pest Management, Popular Kheti, 1(1): 62-67

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Influence of Azadirachtin with Chemical Insecticides and *Verticillium lecanii* on Shoot and Fruit Borer of Brinjal

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ABSTRACT

The present investigation was conducted, to find out the cost effective treatment. The experiment was conducted during *Kharif* 2014-15 on the field of Department of Entomology Dr.PDKV, Akola. Total five sprays of the treatments were done at an interval of 15 days commencing first application at 30 days after transplanting. The treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 0.04 per cent (1 ml L^{-1}), (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.023 per cent (0.75 ml L^{-1}), (T5) Triazophos 40 EC @ 0.08 per cent (2 ml L^{-1}), (T6) Fenpropathrin 30 EC @ 0.045 per cent (1.5 ml L^{-1}) were found significantly effective in recording lower shoot damage due to shoot and fruit borer. In case of fruit infestation on number and weight basis, treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 0.04 per cent (1 ml L^{-1}) (9.04% and 10.13%) and (T11) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.023 per cent (0.75 ml L^{-1}) (12.30% and 12.42%) were effective in recording lower fruit infestation. Whereas yield recorded was highest in Treatment T10 and T11.

Brinjal or eggplant (*Solanum melongena* L.) is an important Solanaceous crop of subtropics and tropics. In India, it is one of the most common, popular and principal vegetable crop grown throughout the country except higher altitudes. Brinjal is also called by some as the 'King of Vegetables'. Though brinjal is a summer crop, it is being grown throughout the year under irrigated condition. Hence, it is subjected to attack by number of insect pests right from nursery stage to harvesting (Ragupathy *et al.,* 1997). Among the insect pests infesting brinjal, the major one is shoot and fruit borer, *Leucinodes orbonalis* (Guen.) and considered as the main constraint in brinjal production.

It was revealed that the infestation of shoot and fruit borer commenced from August (21.2 %) and reached first peak during middle of the October (35.3 %) when crop was transplanted in last week of July (Mahesh and Men, 2007). The borer incidence was 1.5 per cent at the shoot stage. However, at fruiting stage, the highest incidence of the borer was recorded in first (60 %) and second (50 %) pickings followed by third and fourth pickings and least (7.7 %) in fifth picking (Singh and Pandita, 2009). The yield loss caused by this pest is to the extent of 70-92 per cent (Eswara Reddy and Srinivas, 2004). Now a days there is a practice amongst farmers to mixed three to four chemical together for management of pest and diseases, without knowing their phytotoxic effects on the crop. Deadly poisonous chemicals are also sprayed on brinjal which is perishable commodity. Due to this reason, farmers have to face many problems for crop growth, nutritive quality and yield deterioration and also improper management of insect. Combining in two or three insecticide or chemical could be more effective if they acted synergistically but more harmful when acted antagonistically.

MATERIAL AND METHODS

The experiment was laid out in randomized block design (RBD) with twelve treatments (Table 1) replicated thrice on the field of Department of Entomology Dr. PDKV, Akola with a view to evaluate the using botanicals, microbial, newer and conventional insecticides in field trial for the management of shoot and fruit borer of brinjal. A one month old brinjal seedlings (variety: Aruna) were transplanted at 60 x 60 cm spacing and each gross plot size was 4.2 m × 3 m. The plants were raised as per the recommended package of practices except plant protection measures. The five rounds of insecticidal sprayings as per treatments were applied at fortnightly intervals commencing first application at 30 days after transplanting and last spraying of the treatments were taken 15 days before the last picking of the fruits. Observations were taken before first spray and 3, 7 and 14 days after application of each treatment for shoot infestation upto two sprays and after each picking for fruit infestations for five sprayings. At each observation infested shoots per net plot were counted and per cent of shoot infestation was worked out. For per cent fruit infestation observations

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were taken on number and weight of infested fruits and healthy fruits per net plot and per cent of fruit infestation was worked out on number basis and weight basis.

Shoot and Fruit borer

a) Per cent Shoot infestation

At each observation, infested shoots per net plot were counted and percent of shoot infestation per treatment was worked out by following operations.

Per cent Shoot infestation = (Number of infested shoot / Number of total shoots) x 100

b) Per cent fruit damage –

From randomly selected five plants observations were taken;

Total number of infested fruits, healthy fruits and Total weight of infested fruits and fruits plucked and Per cent infestation was worked out using the following formula

$$\text{Fruit borer infestation \% (number basis)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits plucked}} \times 100$$

Table 1: Cumulative effect of various treatments against per cent shoot infestation on brinjal after two sprays

Tr. No.	Treatment details	Formulation	Conc.(%), ml L^{-1} / g L^{-1}	Percent shoot infestation		
				3 DAT*	7 DAT*	14 DAT*
T1	Azadirachtin	10000 ppm	2 ml L^{-1}	12.73	13.20	13.62
				(3.56)	(3.63)	(3.68)
T2	*Verticillium lecanii*	1.15% WP	4 g L^{-1}	13.09	13.42	13.96
				(3.62)	(3.66)	(3.74)
T3	Imidacloprid	17.8 SL	0.0045	13.23	13.62	14.34
				(3.64)	(3.69)	(3.79)
T4	Thiamethoxam	25 WG	0.01	13.97	14.29	14.77
				(3.73)	(3.77)	(3.84)
T5	Triazophos	40 EC	0.08	11.17	11.79	12.30
				(3.31)	(3.42)	(3.49)
T6	Fenpropathrin	30 EC	0.045	11.39	11.95	12.58
				(3.36)	(3.45)	(3.54)
T7	Azadirachtin + *Verticillium lecanii*	10000 ppm + 1.15% WP	2 ml/L + 2 g/L	12.51	12.80	13.40
				(3.53)	(3.57)	(3.65)
T8	Azadirachtin + Imidacloprid	10000 ppm + 17.8 SL	2 ml/L + 0.0023	11.77	12.22	12.75
				(3.42)	(3.49)	(3.56)
T9	Azadirachtin + Thiamethoxam	10000 ppm + 25 WG	2 ml/L + 0.005	12.17	12.56	13.04
				(3.48)	(3.54)	(3.60)
T10	Azadirachtin + Triazophos	10000 ppm + 40 EC	2 ml/L + 0.04	10.17	10.51	11.15
				(3.18)	(3.24)	(3.33)
T11	Azadirachtin + Fenpropathrin	10000 ppm + 30 EC	2 ml/L + 0.023	10.59	10.83	11.71
				(3.25)	(3.29)	(3.41)
T12	Untreated control		-	21.44	22.38	23.77
				(4.62)	(4.27)	(4.87)
	SE (M) ±			0.19	0.15	0.17
	CD at 5 %			0.56	0.46	0.50

* Figures in parentheses are arc sin transformations. DAT – Days after treatment

Table 2: Mean per cent fruits infestation by shoot and fruit borer on number and weight basis

Tr.No.	Treatment details	Formulation	Conc. (%)	Cumulative of fruit infestation	
			ml L^{-1} / g L^{-1}	Number basis (%)	Weight basis (%)
T1	Azadirachtin	10000 ppm	2 ml L^{-1}	24.16 (29.44)*	23.67 (29.11)*
T2	*Verticillium lecanii*	1.15% WP	4 g L^{-1}	25.76 (30.42)	24.81 (29.87)
T3	Imidacloprid	17.8 SL	0.0045	27.12 (31.28)	25.57 (30.38)
T4	Thiamethoxam	25 WG	0.01	28.17 (32.05)	27.30 (31.49)
T5	Triazophos	40 EC	0.08	13.39 (21.45)	16.58 (24.03)
T6	Fenpropathrin	30 EC	0.045	16.58 (24.00)	18.24 (25.58)
T7	Azadirachtin + *Verticillium lecanii*	10000 ppm + 1.15% WP	2 ml L^{-1} + 2 g L^{-1}	22.01 (27.96)	22.79 (28.51)
T8	Azadirachtin + Imidacloprid	10000 ppm + 17.8 SL	2 ml L^{-1} + 0.0023	18.81 (25.68)	19.92 (26.49)
T9	Azadirachtin + Thiamethoxam	10000 ppm + 25 WG	2 ml L^{-1} + 0.005	20.30 (26.72)	20.77 (27.11)
T10	Azadirachtin + Triazophos	10000 ppm + 40 EC	2 ml L^{-1} + 0.04	9.04 (17.49)	10.13 (18.56)
T11	Azadirachtin + Fenpropathrin	10000 ppm + 30 EC	2 ml L^{-1} + 0.023	12.30 (20.52)	12.42 (20.63)
T12	Untreated control		-	34.00 (35.59)	(35.76) 33.76
	SE (M) +-			1.37	1.13
	C.D. 0.05			4.02	3.31

*Fig. In parentheses of arc sin transformation

$$\text{Per cent fruit damage (Weight basis)} = \frac{\text{Weight of damaged fruits}}{\text{Total weight of fruits plucked}} \times 100$$

The treatment wise total yield of marketable brinjal fruits were calculated by summation of yield obtained net $plot^{-1}$. Yield data were recorded treatment wise and then converted to hectare basis. The data thus recorded was subjected to statistical analysis after transformations of original value and were analyzed using randomized block design (RBD) for statistical comparison. The incremental cost benefit ratio of each treatment was calculated by taking into account the prevailing market price of input, produce, labour charges etc.

RESULTS AND DISCUSSION

Shoot infestation:

The cumulative percentage of shoot damage 3rd day after spraying in all treated plots were significantly lower (10.17% to 13.97%) and superior over control

Table 3: Effect of various treatments on yields of brinjal fruits

Tr. No.	Treatment details	Formulation	Conc.(%), ml L^{-1}/ g L^{-1}	Fruit yield kg $plot^{-1}$			
				RI	RII	RIII	Mean
T1	Azadirachtin	10000 ppm	2ml L^{-1}	4.82 (89.26)*	5.30 (98.20)	5.83 (108.08)	5.32 (98.51)
T2	*Verticillium lecanii*	1.15% WP	4g L^{-1}	4.85 (89.87)	5.35 (99.20)	5.65 (104.80)	5.29 (97.95)
T3	Imidacloprid	17.8 SL	0.0045	6.28 (116.45)	5.98 (110.79)		5.99 (110.92)
T4	Thiamethoxam	25 WG	0.01	5.34 (98.90)	6.02 (111.51)	5.69 (102.33)	5.63 (104.24)
T5	Triazophos	40 EC	0.08	5.68 (105.22)	6.17 (114.33)	(123.74)	6.18 (114.43)
T6	Fenpropathrin	30 EC	0.045	5.56 (103.07)	5.19 (96.17)	6.68 (110.18)	5.57 (103.14)
T7	*Azadirachtin + Verticillium lecanii*	10000 ppm + 1.15% WP	2ml L^{-1} + 2g L^{-1}	5.46 (101.18)	5.14 (95.30)	5.58 (103.51)	5.40) (100.00)
T8	*Azadirachtin + Imidacloprid*	10000 ppm + 17.8 SL	2ml L^{-1} + 0.0023	6.50 (120.43)	6.16 (114.24)	7.24 (134.21)	6.64 (122.96)
T9	*Azadirachtin + Thiamethoxam*	10000 ppm + 25 WG	2ml L^{-1} + 0.005	*6.26* (116.06)	*6.82* (126.43)	*5.98* (110.82)	*6.36* (117.77)
T10	*Azadirachtin + Triazophos*	0000 ppm + 1 40 EC	2ml L^{-1} + 0.04	6.86 (127.22)	7.21 (133.62)	6.58 (121.93)	6.89 (127.59)
T11	*Azadirachtin + Fenpropathrin*	10000 ppm + 30 EC	2ml L^{-1} + 0.023	6.45 (119.59)	6.60 (122.40)	7.18 (133.01)	6.15 (125.00)
T12	Untreated control		-	4.16 (77.19)	3.97 (73.57)	4.00 (74.22)	4.05 (75.00)
	SE (m) ±						4.00
	CD %						11.75

* values in parentheses are q ha^{-1} of brinjal fruit yield

(21.44%). The minimum per cent shoot damage was recorded in the treatment (T10) i.e. Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} (10.17% shoot damage) and it was statistically at par with rest of treatment. Same trend was recorded after 7th day of spraying. However at 14th day after application of treatments the lowest cumulative average per cent of shoot damage due to shoot and fruit borer (11.15%) was observed in treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} and was at par with rest of the treatments except (T4) Thiamethoxam 25 WG @ 0.4 g L^{-1} (14.77%). Niranjan Das (2014), also reported that soil application of neem cake @ 2.5 q ha^{-1}, removal and destruction of infected shoots and fruits and alternate spraying of triazophos 40 EC @ 1250 ml ha^{-1} and neem oil @ 2.5 lit ha^{-1} at 10 days interval was found to be the most effective for management of shoot and fruit borer on brinjal. Present findings are also in confirmation with Singh *et al.* (2009) who reported efficacy of azadirachtin 0.2 per cent + thiamethoxam 0.0025 per cent, thiamethoxam 0.005 per cent and azadirachtin 0.4 per cent against the shoot infestation of brinjal.

Fruit infestation on number and weight basis

The data presented in Table 2, showed that during all the pickings there was a pronounced difference in case

Table 4: Incremental cost benefits ratio and net monetary return in different treatments.

Treatments	Qty. of insecticide req. ha^{-1}	Cost of treatment (Rs ha^{-1})		Total cost (A)	Yield (q/ha)	Increase yield over control	Value of increased yield	Increment benefit (C) (B-A) (q ha^{-1})	ICBR (C/A) (Rs. ha^{-1}) (B)	Rank
		Cost of insecticide	Labour + sprayer charges							
T1	5000 ml	5300	4750	10050	98.51	23.51	23510	13460	1:1.34	X
T2	10 kg	2000	4750	6750	97.95	22.95	22950	16200	1:2.4	VII
T3	625 ml	2062	4750	6812	110.92	35.92	35920	29108	1:4.27	II
T4	1 kg	5600	4750	10350	104.24	29.24	29240	18890	1:1.83	IX
T5	5000 ml	2620	4750	7370	114.43	39.42	39420	32050	1:4.35	I
T6	750 ml	2280	4750	7030	103.14	28.14	28140	21110	1:3.00	VI
T7	5000 ml + 5 kg	6300	4750	11050	100.00	25.00	25000	13950	1:1.26	XI
T8	5000 ml + 312.5 ml	6331	4750	11081	122.96	47.96	47960	36880	1:3.33	V
T9	5000 ml + 500 gm	8100	4750	12850	117.77	42.77	42770	29920	1:2.33	VIII
T10	5000 ml + 2500 ml	6610	4750	11360	127.59	52.59	52590	41230	1:3.63	III
T11	5000 ml + 375 ml	6440	4750	11190	125.00	50.00	50000	38810	1:3.47	IV
T12	-	-	-	-	75.00	-	-	-		

1) Labour charges:- (For one spray) 5 labour ha^{-1} @ Rs. 180 labour^{-1} day^{-1},

2) Spray pump charge:-Rs. 25 day^{-1}, 3). Sale price of brinjal fruit: Rs. 1000 qtl.$^{-1}$

	Chemical name.	Rate (Rs).
1)	Azadirachtin 10000 ppm	1060 L^{-1}
2)	*Verticillium lecanii* 1 x 10^8 cfu ml^{-1}	200 Kg^{-1}
3)	Imidacloprid (17.8 SL)	3300 L^{-1}
4)	Thiamethoxam (25 WG)	5600 Kg^{-1}
5)	Triazophos (40 EC)	524 L^{-1}
6)	Fenpropathrin (30 EC)	3040 L^{-1}

of fruit infestation on number and weight basis. Among the treatments for their effectiveness against *Leucinodes orbonalis* treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} (9.04% and 10.13%) was found superior and statistically at par with T11, T5, T9, T1, T2, T3, T4, T12.

These results are in confirmation with the findings of the past workers viz., Niranjan Das (2014) who reported that integrated Pest Management module consisting of soil application of neem cake @ 2.5 q ha^{-1}, removal and destruction of infected shoots and fruits and alternate spraying of triazophos 40 EC @ 1250 ml ha^{-1} and neem oil @ 2.5 lit ha^{-1} at 10 days interval was found to be the most effective treatment recording only 7.8 per cent fruit infestation. Nath and Sinha (2011) were also found that the application of triazophos 700g a.i. ha^{-1} on brinjal recorded lower i.e. 14.97 per cent fruit infestation confirms the present results.

Yields of marketable brinjal fruits

The data (Table 3) pertaining to the yield of healthy fruits revealed that all the treatments showed significantly higher fruits yield of brinjal over untreated control. However, highest yield of brinjal fruits (127.59 q ha^{-1}) was obtained from (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} followed by the treatments T11, T8, T9 and T5. However, the data pertaining to ICBR (Table 4) the treatment (T5) Triazophos 40 EC @ 2 ml L^{-1} recorded highest ICBR i.e. 1:4.35 followed by the treatments T3, T10, T11, T8, T6, T2, T9, T4 amd T7. But, in case of net monetary returns, the order of efficacy which gave net monetary differed due to the cost of insecticides. The more net monetary return was gained in treatment (T10) Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} i.e. Rs. 41230.00 followed by the treatments T11, T8, T5 and T9.

CONCLUSION

The treatment Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1}, Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1}, Triazophos 40 EC @ 2 ml L^{-1}, Fenpropathrin 30 EC@ 1.5 ml L^{-1} were found significantly effective in recording lower percentage of shoot damage due to shoot and fruit borer. In case of fruit infestation on number and weight basis, treatment Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1}, Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1} and Triazophos 40 EC @ 2ml L^{-1}, were effective in recording lower fruit infestation on number basis. The lowest percentage of fruit infestation on weight basis was recorded in the treatment Azadirachtin 10000 ppm @ 2 ml L^{-1} + Triazophos 40 EC @ 1 ml L^{-1} and Azadirachtin 10000 ppm @ 2 ml L^{-1} + Fenpropathrin 30 EC @ 0.75 ml L^{-1}. Deleterious effect of treatments either alone or in combination with Azadirachtin were not observed on any predator, throughout the season.

LITERATURE CITED

Eswara Reddy, S. G. and Srinivasa, 2004. Management of shoot and fruit borer (*Leucinodes orbonalis*) in brinjal using botanicals, Pestology, 28:50-52.

Mahesh, P. and U. B. Men, 2007, Seasional incidence of *Leucinodes orbonalis* (Guen) on brinjal, Annals of Pl. Prot. Sci., 15 (2):469-539.

Nath, V. and S.R.Sinha, 2011. Efficacy of insecticide and their mixture for management of insect pest on brinjal, Indian J. Ent., 73(4) : 308-311.

Niranjan Das, 2014. Impact assessmemt of IPM module for management of shoot and fruit borer in Brinjal, Annals of Pl. Prot. Sci., 23 (1) :46-48.

Ragupathy, A.; S. Palaniswami,; N. Chandramohan and K. Gupta, 1997. Guide on Crop Pests, Sooriya Desk Top, Coimbatore.

Singh, D.K., R. Singh; S.D. Datta and S.K. Singh, 2009. Seasonal incidence and insecticidal management of shoot and fruit borer (*Leucinodes orbonalis* Guenee) in brinjal, Annals of Hort., 2(2): 187-190.

Singh, P. B. and V. K. Pandita, 2009. Incidence of brinjal fruit and shoot borer in Haryana, Annals of Pl. Prot. Sci., 17: 225-274.

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Field Evaluation of Different Modules Against Insect Pests and Diseases of Soybean

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ABSTRACT

Four different modules like chemical, adoptive, bio-intensive and control were tested in natural field condition for insect pest and disease management. Chemical module (ST with thiram + carboxin @ 2 g kg^{-1} + spraying with lamda-cyalothrin @ 0.05 per cent + spray hexaconazole @ 0.01 @ 0.1 per cent at 45 DAS followed by second spray at 60 DAS with hexaconazole @ 0.1 per cent and spinosad @ 0.05 per cent followed by spray with carbendazim 0.1 per cent at 70 and 85 DAS was found best as least leaf defoliator population (3.20 mrl^{-1}) and lowest girdle beetle infestation (3.30 %) were observed in field. In respect of disease, minimum charcoal rot (23.26 %) and *Alternaria* leaf spot (10.76 %) were recorded in chemical module followed by Adoptive module (28.08 and 17.17%, respectively). As regards to yield, chemical module proved in yield maximization (1383.70 kg ha^{-1}) as compared to other modules.

Soybean (*Glycine max* (L.) Merrill) is the most significant source of protein and oil. It plays a predominant role in Maharashtra and particularly Vidarbha region farmer's economy. At present with the increased area expansion, constant mono-cropping of soybean in same fields, same variety has led to built up of numerous insect pests and diseases which contributing for rising severity and yield losses year after year. Mono-culturing usually catch the attention of pest and diseases and spread rapidly in entire cultivated area, thereby regular pest and disease outbreaks observed in Vidarbha region causing reduction in the yield and productivity in comparison to state and world level.

In Vidarbha region, habitual incidence of leaf defoliators, girdle beetle, stem fly, charcoal rot and fungal foliar diseases recorded to cause potential loss in soybean production.

Under such circumstances integrated pest and disease management modules need to be developed and test their efficacy under natural field condition. In view of that and for effective management of pests and diseases and to achieve higher production of soybean crop, present investigation was undertaken to identify effective modules for pest and diseases management.

MATERIAL AND METHODS

A field trial was conducted at field of Regional Research Center, Amravati during *Kharif* 2014. The experiment was laid out in Randomized Block Design with four modules *viz.*, Bio-intensive, Chemical control, Adaptive and Control. The details of modules treatments as follows-Module-I:Bio-intensive module-Seed treatment with *T. harzianum* @ 6 g kg^{-1} + spray cow urine @ 10 per cent + neem oil @ 0.5 per cent, *Nomuraea rileyi* @ 5g l^{-1} at 45 DAS followed by sprays of cow urine @10 per cent + neem oil @ 0.5 per cent at 55 DAS and spray with cow urine @10 per cent + neem oil @ 0.5 per cent at 65 DAS. Module-II:Chemical control module-Seed treatment with thiram + carboxin @ 2g kg^{-1} + spray with Lamda-cyhalothrin @ 0.05 per cent + spray Hexaconazole @ 0.1 per cent at 45 DAS followed by second spray at 60 DAS with Hexaconazole @ 0.1 per cent and Spinosad @ 0.05 per cent followed by spray with Carbendazim 0.1 per cent at 70 and 85 DAS. Module-III: Adaptive module-Seed treatment with *T. harzianum* @ 6g kg^{-1} + *Rhizobium* @ 25 g kg^{-1} of seeds + spray neem oil @ 0.1 per cent, *Nomuraea rileyi* @ 5 g ha^{-1} at 45 DAS followed by second spray at 60 DAS with Hexaconazole @ 0.1 per cent. Spinosad @ 0.05 per cent and *Pseudomonas fluorescens* @ 0.5 per cent at 75 DAS. Module-IV: Control- Seed treatment with *Rhizobium* @ 25 g kg^{-1} seed only. The soybean cv. JS-335 was sown and each module had gross plot of 8 x 6 m and replicated five times at a row spacing 45 cm. The crop was raised under recommended fertilizer package of practices. The data on all growth and yield parameters were recorded at maturity stages and analyzed as per design. Bio-efficacy comparisons of modules were based on leaf defoliator's population per meter row length (mrl), girdle beetle and stem fly infestation in per cent and per cent disease index (PDI) were recorded according

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to the uniform method of insect pest and disease rating (Anonymous, 2013).

RESULTS AND DISCUSSION

Growth parameters:

Plant height, plant dry weight, number of pods plant^{-1} and 100 seed weight measured in different modules after crop harvest (Table 1). Maximum plant height (41.26 cm), utmost plant dry weight (21.71 g), highest number of pods plant^{-1} (50.66) and 100 seed weight (12.15 g) were recorded in Chemical module. Next best was Adoptive modules in regards to growth parameter. Control module found less effective in growth parameter characteristics.

Table 1: Effect of different modules on growth parameters of soybean

Modules	Plant height (cm)	Plant Dry Wt. (g)	No. of pods plant^{-1}	100 seed wt.
Bio-intensive	34.18	15.06	33.56	9.79
Chemical	41.26	21.71	50.66	12.15
Adoptive	35.25	16.86	39.76	10.80
Control	30.00	13.18	27.50	8.50
SE (m) ±	1.11	1.14	2.18	0.49
CD (P=0.05)	3.41	3.50	6.71	1.50

Pest management

The data on leaf defoliator population (semilooper and Spodoptera) mrl^{-1} revealed that chemical module showed their efficiency in reducing the leaf defoliators over other modules (Table 2). Significantly less population of leaf defoliators (3.0 mrl^{-1}) was observed in adoptive module. Second superlative low population i.e. 3.20 mrl^{-1} were recorded in chemical module. The data in respect of per cent infestation of girdle beetle revealed that chemical module showed their effectiveness in controlling the girdle beetle over other modules. Least (3.30 %) girdle beetle infestation was recorded in chemical module followed by adoptive module (5.15%). Highest per cent (6.0 %) girdle beetle infestation was observed in control. Lower per cent infestation (1.88 %) of stem fly was observed due to chemical module. Higher per cent stem fly infestation (7.80%) was recorded in control module. The present findings are supported by the results obtained by Suganya Kanna *et al.* (2005) who reported that emamectin 5 SG @ 10 g a.i. ha^{-1} was more effective against tomato fruit borer when compared to profenophos 50 EC and lambda cyhalothrin 5 EC but it was comparable with spinosad 2.5 SC in reducing the larval population and damage which ultimately increased the yield.

Table 2. Effect of different modules on major insect pests of soybean

Modules	Leaf defoliator population mrl^{-1}	Girdle beetle Infestation (%)	Stem fly infestation (%)
Bio-intensive	4.84 (2.19)*	6.16 (2.47)*	4.00 (1.95)*
Chemical	3.20 (1.78)	3.30 (1.81)	1.88 (1.36)
Adoptive	3.00 (1.70)	5.15 (2.25)	3.01 (1.73)
Control	6.00 (2.44)	9.70 (3.10)	7.80 (2.77)
SE (m) ±	0.11	0.13	0.17
CD (P=0.05)	0.35	0.40	0.53

*Figures indicate Square root transformed values

Disease management

During crop growth period, *Alternaria* Leaf Spot (ALS) and Charcoal rot (CR) were observed in field. Least incidence of *Alternaria* Leaf Spot (10.76%) and Charcoal rot disease (23.26%) was recorded in chemical module followed by adoptive module (17.17% and 28.08%, respectively). Maximum disease incidence of *Alternaria* Leaf Spot and Charcoal rot was observed in control module *i.e.* 34.77 and 48.92 per cent, respectively (Table 3). Gupta and Sharma (2009) reported that seed treatment with carboxin + thiram @ 0.2 per cent was best in reducing post emergence mortality and enhancing seed yield.

Table 3. Effect of different modules on major disease and yield of soybean

Modules	ALS	CR	Yield (kg ha^{-1})
Bio-intensive	28.04 (31.88)#	36.80 (37.31)#	985.18
Chemical	10.76 (19.08)	23.26 (28.71)	1383.70
Adoptive	17.17 (24.35)	28.08 (31.97)	1100.74
Control	34.77 (36.11)	48.92 (44.38)	669.63
SE (m) ±	1.44	1.66	86.90
CD (P=0.05)	4.42	5.10	266.71

Figures indicate arc sin transformed values

Yield :

The yield of soybean was maximum yield (1383.70 kg ha^{-1}) in chemical module. Second best was adoptive module in respect of yield (1100.74 kg ha^{-1}). Least yield was recorded in control module *i.e.* 669.63 kg ha^{-1}. Chemical module proved effective for yield maximization due to better growth parameter, minimum pest and disease pressure. These findings were supported by Singh and Singh (1990), Ashok Kumar *et al.* (2006). Arbind Kumar *et al.* (2010) who reported that maximum yield was obtained due to chemical insecticides application which gives quick results. No doubt chemical module found better in pest and disease management but the use of chemical pesticides for effective plant protection often promotes selection for pest resurgence, resistant and also leads to environmental contamination. Therefore for long term benefits of environment adoptive module strategies may prove effective.

LITERATURE CITED

Anonymous, 2013. Proceeding and Technical Programme of 43nd Annual Group Meeting of All India Coordinated Research Project on Soybean. Annexure -I

Arbind Kumar, Rai, Mayank Kumar and S. S. Singh, 2010. Efficacy of neem product vis-à-vis triazophos for the management of soybean stem borers, Annals of Plant Prot. Sci., 18(1):133-140.

Ashok Kumar, M. M. Kumawat, and N. K. Meena, 2006. Field evaluation of triazophos against insect pest of soybean and its impact on yield, Pestology,30 (8):14-15.

Gupta, G.K. and S. K. Sharma, 2009. Influence, optimization, energy budgeting and monetary considerations of different time intervals between fungicidal seed treatment and sowing on *Sclertoium* blight of soybean, Crop Protection. 28:854-858

Singh, K. J. and O. P. Singh, 1990. Economics of spray schedule for the control of green semilooper and stem fly on soybean in Madhya Pradesh, Indian J. Pl. Prot., 18 :31-35

Suganya Kanna S., S. Chandrasekaran, A. Regupathy, and D. Lavanya, 2005. Field efficacy of Emamectin 5SG against tomato fruit borer *Helicoverpa armigera*, Pestology. 24 (4):21-24

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Seasonal Incidence of Major Insect Pests of *Suru* Sugarcane and its Correlation with Weather Parameters under Water Stress Conditions

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ABSTRACT

Data on seasonal incidence revealed that the damage due to early shoot borer was initiated during 5th MW i.e. 35 DAP (5.13% dead heart) and it was continued up to 29th MW. The maximum damage due to early shoot borer was observed during 8th MW i.e. 60 DAP (6.77 % dh) during which meteorological parameters were in the range of 14.2 to 35.2° C temperature, 16 to 60 % RH and rainfall 0.0mm. The correlation with weather parameters with early shoot borer incidence has shown negative non-significant correlation with morning relative humidity and max. temperature. It showed negative significant correlation in min. temp. and relative humidity evening at 5per cent level. The incidence of scales was initiated during 37th MW (56 % incidence and 5.82 % intensity) and it was continued up to 52nd MW. The per cent incidence increased at 37th MW and per cent intensity of scales increased during the last met weeks and was maximum on 51th MW (9.92%). The incidence of scales had also negative non-significant correlation with rainfall and min. temp. The negative significant correlation was observed with maximum temperature, relative humidity morning and evening. The incidence of pyrilla was initiated during 30th MW (0.35 per leaf) and it was continued up to 43rd MW. The maximum population of pyrilla per leaf was observed on 35th MW (0.38 no. per leaf). In case of pyrilla it showed non-significant correlation with rainfall, max. and min. temp and negative Non-significant with RH I and RH II.

Sugarcane (*Saccharum officinarium*) is a long duration crop and therefore is liable to be attacked by a number of insect pests which are major constraints in sugarcane production. In India, sugarcane is infested by 288 insects of which nearly two dozen cause heavy losses to the quality as well as quantity of the crop. Due to the diversity in agro-ecological conditions the importance of the insect pests varies and therefore, management strategies should be adopted accordingly. The repeated use of synthetic chemical insecticides as crop protectants has posed serious hazards for the humans and the environment, caused deleterious effects on natural enemies and led to resistance in pests to insecticides (Perry *et al.* 1998). Therefore, in sugarcane, the use of pesticides has to be restricted upto those few occasions when their applications become imperative. The researchers are trying to explore the techniques which must be proficient, eco-friendly and affordable to reduce pest infestation on crops. Host plant resistance to insect pests and forewarning is the key component in the pest management system as it is environmentally friendly, harmless and cost effective methods to pest control. Therefore, a study was planned to assess the seasonal incidence of major borer and sucking pests and peak period of pest infestation and its correlation with the weather parameters under water stress conditions.

MATERIAL AND METHODS

The experiment was laid out in non-replicated design on the field of Department of Entomology Dr. PDKV, Akola during 2015-16 with a view to study the seasonal incidence with peak periods of infestations of major borer and sucking pests and their correlation with the weather parameters under water stress conditions. The sugarcane setts (Variety: Co-86032) were planted at 90 cm row to row spacing with a plot size of 6.00 x 13.50 m^2. The planting was done as per the university recommended package of practices except plant protection measures. Weekly Weather data for the year 2015 were recorded at Meteorological Observatory Department of Agronomy Dr. PDKV.,Akola

Method of Observations

Early Shoot Borer : The observations were initiated after one month of the emergence of the crop then after weekly observations were recorded for the incidence of the early shoot borer. Four middle rows were selected from the plot and total germinated shoots were counted. The shoots affected by early shoot borer showing "dead hearts" were counted to calculate percentage incidence of borer.

Scale insects: Randomly twenty five canes were selected

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from the plot and affected internodes due to scale insect and total internodes in each cane were counted. The per cent incidence and per cent intensity were calculated as per the following formulae.

$$\% \text{ Incidence} = \frac{\text{Number of infested canes}}{\text{Total number of canes}} \times 100$$

$$\% \text{ intensity} = \frac{\text{Number of affected internodes}}{\text{Total number of internodes.}} \times 100$$

Pyrilla: In all twenty leaves, each two from ten canes were selected randomly from the plot and numbers of pyrilla per leaf were counted. (Anonymous,2015)

RESULTS AND DISCUSSION

The insect pests recorded on sugarcane var. Co-86032 during 2015-16 were early shoot borer, scales and pyrilla.

Seasonal incidence of major pests of sugarcane

Early shoot borer

The seasonal incidence data (Table 1) revealed that the damage due to early shoot borer was initiated during 5th meteorological week i.e. 4th Feb 2015 (5.13% dh) and it was continued up to 29 MW. The maximum damage due to early shoot borer was observed during 8th MW i.e.25/02/2015 (6.77% dh) during which meteorological parameters were in the range of 14.2 to 35.2^0 C temperature, 16 to 60 per cent RH and rainfall 0.0mm.

Scales : The incidence of scales was initiated during 37th MW (56% incidence and 5.82 % intensity) and it was continued up to 52nd MW. The per cent incidence increased at 37th MW and per cent intensity of scales increased during the last meteorological weeks and was maximum on 51th MW (9.92%).

Pyrilla : The incidence of pyrilla was initiated during 30th MW (0.35 per leaf) and it was continued up to 43rd MW. The maximum pyrilla per leaf was observed on 35th MW (0.38leaf^{-1}).

Correlation of incidence of insect pests on sugarcane with weather parameters

The data presented in Table 2 revealed that the early shoot borer incidence on Co-86032 has shown negative non-significant correlation with morning relative humidity, rainfall, max. temperature. It showed negative significant in min. temp. and relative humidity evening at 5 per cent level. Similar is the case with scales. However, the incidence of scales has also negative non-significant correlation with rainfall and Min. temp. The negative significant correlation was observed with maximum temp., relative humidity morning and evening. In case of pyrilla it showed non-significant correlation with Rainfall, max. and min. temp. and negative Non-significant with RH I and RH II.

The above findings on the seasonal incidence of insect pests and weather correlation are more or less in confirmation with the studies conducted by Smriti Sharma and Uppal (2015) who reported the seasonal incidence of early shoot borer which was 2.96 per cent and *Pyrilla perpusilla* incidence was low (0.33 insects leaf^{-1}). Regarding the correlation of weather parameters, Early

Table 1: Seasonal incidence of major pests of sugarcane

S.N.	Pests	Infestation period (MW)	Highest infestation period	Meteorological parameters				
				RF (mm)	T max °C	T min °C	RH I (%)	RH II (%)
1	Early Shoot Borer % infestation	5th to 29th MW	(6.77) 8th MW	0.0	35.2	14.2	60	16
2	Pyrilla no. per leaf	30th to 43rd MW	(0.38) 38th MW	78.9	31.3	22.2	87	63
3	Scales % incidence	37th to 52nd MW	(56)37th MW	61.6	34.3	22.7	88	54
4	Scales % intensity	37th to 52nd MW	(9.92)51st MW	0.0	30.7	12.9	67	29

Table 2: Correlation of incidence of insect pests on sugarcane at Akola with the weather parameters

Variety		Rainfall (mm)	Max. Temp	Min. Temp	RH I (%)	RH II (%)
Early shoot borer						
Co-86032	r	0.396* & 0.505**				
	t (cal)	-0.193	-0.286	-0.650	-0.109	-0.483
	n=25	-NS	-NS	-S	-NS	-S-NS
Scales						
Co-86032	r	0.497* & 0.623**				
	t (cal)	-0.399	-0.608	-0.879	-0.681	-0.510
	n=16	-NS	-S-NS	-NS	-S	-S-NS
Pyrilla						
Co-86032	r	0.532* & 0.661*				
	t (cal)	0.069	0.115	0.191	-0.208	-0.100
	n=14	NS	NS	NS	-NS	-NS

Here r= coefficient of correlation, t = calculated t NS = Non-significant S = significant at 0.05%* and 0.01%**

shoot borer numbers were positively correlated with maximum and minimum temperatures but negatively correlated with relative humidity and rainfall.

LITERATURE CITED

Anonymous, 2015. Technical Programme 2015-16: Entomology, All India Coordinated Research Project on Sugarcane (ICAR) Research Methodology for recording observations of sugarcane pests(October 2015): Indian Institute of sugarcane Research Lucknow (U.P.) : 3-14.

Perry, C.D., J.S. Durrence, G. Vellidis, D.L. Thomas, R.W. Hill and C.S. Kvien, 1998. Field Experiences With A Prototype Peanut Yield Monitor, ASAE Paper No. 983095, ASAE, St. Joseph, MI.

Smriti Sharma and S. K. Uppal, 2015. Occurrence of insect pests of sugarcane and their natural enemies in relation with weather parameters and effect on cane quality, International Sugar Journal, 117 (1402) : 744-751

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Knowledge Level of the Soybean Farmers About Pesticides Label Claims

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ABSTRACT

A systematic survey of 150 soybean growers was conducted in Akola, Buldana, Washim, Amravati, and Yavatmal districts of Vidarbha during 2015-16 as University Research Review Committee Project. The main objective was to study the knowledge level of the selected soybean growers, extension functionaries and proprietor of *Krushi Seva Kendras* about the pesticides label claims. The key finding revealed that in selected five district of Vidarbha out of 150 selected soybean farmers 145 (96.67%) farmers were observed in low knowledge level group about the pesticides label claims. Majority of the selected farmers heard the label claim word first time during the interview by the researcher at the time of data collection. This study also brought out that 62.50 per cent selected extension workers were observed in low knowledge level group about the label claim of pesticides. While the study also clears that majority 77.50 per cent proprietors of *Krushi Seva Kendras* have high level knowledge about the label claim of pesticides. But it was noted that they were not using the knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. Hence this study clears that there is a need to create the awareness of knowledge among the farming community and extension functionaries about the pesticide label claims. Similarly it should be made mandatory to all input dealers to sale the pesticides as per the pesticides label claims. It will help to improve the adoption status of pesticides having label claim for specific crop and specific purpose approved by the CIB & RC and it will also help to bring uniformity in the recommendations made by the Central Insecticide Board and other institutions for betterment of farming community. Secondly it will also help to either set the MRLs of a pesticide for appropriate food commodities or to monitor pesticide residues for food safety.

Many of the farmers are recently using the pesticides including herbicides, insecticides, and fungicides in all major field crops in India. Pesticide labels contain detailed information on how to use the product correctly and legally. Pesticide use in India is regulated by the Central Insecticides Board and Registration Committee (CIB & RC) and the Food Safety and Standards Authority of India (FSSAI). The CIB & RC registers pesticides for crops while the FSSAI sets the maximum residue limits (MRL) of pesticides for the crops it has been registered for (Anonymous, 2013). If a food has a higher level of residue than the MRL, it does not automatically mean that the food is not safe to eat. A residue above the MRL may show that the farmer has not used the pesticide properly (Anonymous, 2010). Uses of spurious and non-recommended pesticides by the Central Insecticides Board and Registration Committee i.e. without approved label claims are the reasons of pesticide residues in food commodities (Sharma, 2013).

A one-day workshop on "Approved Uses of Pesticides in Agriculture" was organized on August 30, 2010 by Department of Agriculture & Co-operation (DAC), Ministry of Agriculture at NASC Complex, Pusa, New Delhi under the Chairmanship of Joint Secretary (Plant Protection). Representatives of DAC, Directorate of Plant Protection, Quarantine & Storage, Faridabad, State Departments of Agriculture, State Departments of Horticulture, State Agriculture Universities, ICAR Institutes, NCIPM, Tea Board, Spices Board and Associations of Pesticide Industry participated in the workshop. Secretary, Central Insecticides Board & Registration Committee (CIB&RC) stated that use of pesticides is a hazardous sector and unless pesticides are used as approved by the Registration Committee, the whole environment could be at risk. Assistant Director General (Plant Protection), ICAR emphasized there have been issues country-wide about the inadequate knowledge about the label claims and their utilization. About 90% of usage of pesticides is without approved label claims. These lead to presence of residues of those pesticides, which are not approved for use on particular crops. He made a point that the document on recommended uses of pesticides by States needs a thorough review by a duly constituted group comprising all stakeholders. State Governments should ensure that the molecule

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recommended for use on one commodity and banned on another should not juxtapose each other. Much of problems, which are faced today are due to lack of awareness, lack of sensitivity and lack of seriousness to be implementing what should be actually implemented. He emphasized that if the pesticides are used sensibly, they are the most opportune system for increasing productivity, (Anonymous, 2010).

Recently non availability of labourers coupled with more cost is a very severe problem with the majority of the farmers (Kale, *et.al*, 2011 and Kale, *et.al* 2013). Under such situation post-emergence herbicides remain the only viable option for an effective and economical method of weed control (Kumar *et al*., 2003, Jha *et al*., 2014, Dhaker, *et al*. 2015 and Nandini Devi *et al.,* 2016). Secondly maximum number of farmers are using various insecticides and fungicides in soybean crop in Vidarbha. Pesticide Companies registered its products as per the Insecticide Act 1968 and claimed that the registered products are for management of certain weed/ pest/disease in particular crop(s) only as per the written, printed or graphic label on the container approved by the government regulatory agencies i.e. Central Insecticides Board & Registration Committee (CIB&RC). When the farmers using the pesticides as per the crops specified on label approved by the CIBRC, then we can say that farmers using the pesticides as per the label claim. But it was observed that farmers were unaware about the pesticides label claims and they mostly using the agricultural pesticides as the input dealers recommended them. Hence, this becomes a researchable issue for the researchers. Hence, this research study was planned with the specific objectives to study the Variables related to use of pesticides by the selected soybean growers and to study the knowledge level of the selected soybean growers, extension functionaries and proprietor of *Krushi Seva Kendras* about the pesticides label claims.

MATERIAL AND METHODS

The present investigation was carried out in Akola, Buldana, Washim, Amravati, and Yavatmal districts of Vidarbha region of Maharashtra by using the exploratory design of social research with multistage sampling method. From each district one Tahsil was selected where soybean crop was cultivated by the majority of the farmers during the year 2015-16. From each selected tahsil 3 villages were selected randomly and from each selected village 10 farmers were interviewed with the help of structured interview schedule. Thus, this investigation was confined to a sample of 150 soybean growers. In addation to this researchers have selected the random sample of 40 extension functionaries and 40 proprietors of *Krushi Seva Kendras* from the selected districts for testing their knowledge about pesticides label claims.

Knowledge as a body of understood information by an individual farmer regarding pesticides label claims. A teacher made knowledge test was developed to measure the knowledge of an individual respondents about the pesticides label claims, responses of the respondents were taken on two point continuum i.e. yes/no and numerical score of 1 and 0 was assigned respectively. Obtained knowledge raw score were converted into knowledge index by using following formula.

$$\text{Knowledge index (\%)} = \frac{\text{Knowledge score actually obtained}}{\text{Maximum obtainable knowledge score}} \times 100$$

The respondents were categorized according to obtained knowledge index score with equal interval method as low (Upto 33.33), medium (33.34 to 66.66) and high (Above 66.66) level of knowledge regarding pesticides label claims.

RESULTS AND DISCUSSION

I) Variables related to use of pesticides by the selected farmers.

1. Use of pesticides

Distribution of selected farmers according to use of pesticides during 2015-16 has been presented in Table 1.

Table 1: Distribution of selected farmers according to use pesticides during 2015-2016.

S.N.	Use of pesticides (2015-2016)	No.	%
1	Yes	149	99.33
2	No	01	0.67
	Total	**150**	**100.00**

It was observed from Table 1 that near about sent per cent selected farmers have used the pesticides during 2015-16. The data regarding the mode of purchase of pesticides have been presented in Table 2.

2. Mode of Purchase of pesticides

Table 2: Distribution of selected farmers according to the mode of purchase of pesticides during (2015-2016)

S.N.	Mode of purchase of pesticides (2015-2016) (N=149)	No	%
1	Cash	81	54.36
2	Credit	68	45.64
	Total	**149**	**100.00**

It was observed from Table 2 that 45.64 per cent farmers had purchased the pesticides on credit and remaining purchased in cash (54.36%)

3. Immediate contact regarding selection of pesticides

Distribution of selected farmers according to their immediate contact made by them for selection of pesticides during 2015-16 in study area is presented in Table 3.

Table 3: Distribution of selected farmers according to their immediate contact regarding selection of pesticides

S.N.	To whom contacted	No.	%
1	Own decision	39	26.17
2	Proprietor of *Krushi Seva Kendras*	81	54.36
3	Progressive farmers	25	16.78
4	Neighborers	4	2.69
	Total	**149**	**100**

It was observed from Table 3 that more than half (54.36%) of the selected farmers had made immediate contact with the Proprietor of *Krushi Seva Kendras* for selection of pesticides in study area. While more than one fourth (26.17%) farmers had taken their own decision regarding purchase of pesticides. Whereas, 16.78 per cent farmers had taken decision by contacting with progressive farmers and 2.69 per cent farmers had taken the advice from neighborers regarding selection of pesticides.

4. Use of growth promoters with insecticides

Distribution of the respondents according to use of growth promoters with insecticides during 2015-16 in selected five districts of Vidarbha has been furnished in Table 4.

Table 4: Distribution of selected farmers according to use of growth promoters with insecticides during 2014-15

S.N.	Use of growth promoters	Frequency	Percentage
1.	Yes	124	82.67
2.	No	26	17.33
	Total	**150**	**100.00**

It was noted from Table 4 that majority 82.67 per cent farmers have used the growth promoters with insecticides for soybean crop during 2015-16.

5. Advice taken about the use of growth promoters

The distribution of the selected farmers according to advice taken about the use of growth promoters has been presented in Table 5 as bellow.

Table 5: Distribution of selected farmers according to whom they have taken the advice about the use of growth promoters

S. N.	Advice taken from	Frequency	Percentage
1.	Own Decision	53	42.74
2.	Advice of Shopkeeper (KSKs)	60	48.39
3.	Joint decision	11	8.87
	Total	**124**	**100.00**

The data regarding the advice taken by the farmers about use of growth promoters clears that 48.39 per cent farmers had taken the advice from input dealers. Whereas, 42.74 per cent had taken their own decision and remaining 8.87 per cent had taken decision jointly.

II) Knowledge of selected farmers about the pesticide label claims

Total 8 important statements about the pesticides label claims have been considered for accessing the knowledge of selected farmers about the label claims. The results about the knowledge of the selected respondents regarding pesticides label claims were presented in Table 6.

It was observed from Table 6 that each of the majority (97.00%) selected farmers were found to be unaware about Central Insecticide act 1968, Central

Table 6 : Distribution of the selected farmers according to Knowledge about the pesticides label claims

S.N.	Knowledge test statements about the pesticides label claims	Knowledge (N=150)	
		Yes	No
1	Do you know about insecticide act 1968 ?	5 (3.33)	145 (97.00)
2	Do you know about the central insecticide Board and Registration Committee (CIB&RC)?	5 (3.33)	145 (97.00)
3	Do you know what the pesticides label claims is ?	5 (3.33)	145 (97.00)
4	While purchasing the pesticide do you ensure whether is having label claim for the pest/weed you want to control	5 (3.33)	145 (97.00)
5	Prior to spraying of pesticides do you read the instructions given on the label of pesticides?	5 (3.33)	145 (97.00)
6	While spraying pesticide do you spray as per the label claim dosages and against particular crop pest?	5 (3.33)	145 (97.00)
7	Do you know the pesticides doses should be mixed thoroughly in prescribed quantity of water as per label claim?	9 (6.00)	141 (94.00)
8	Do you know the waiting period of pesticide?	9 (6.00)	141 (94.00)

Insecticide Board and Registration Committee (CIB&RC), what the label claim of pesticides is and whether pesticides having label claim for the particular pest/disease/weed for particular crop. Whereas, 94.00 per cent farmers have no knowledge about the doses of pesticides, quantity of water to be use for mixing the pesticide, waiting period of pesticides is given on the label of the pesticides container and their importance with seriousness.

Overall knowledge level of the selected farmers

Overall knowledge level of selected farmers about selected eight statements about the pesticides label claims has been computed in the form of index and respondents has been distributed in three categories by equal distribution method as given in Table 7.

Table 7. Distribution of the respondents according to their level of knowledge about the pesticides label claims

S. N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	145	96.67
2	Medium (33.34 to 66.66)	0	00.00
3	High (Above 66.67)	05	3.33
	Total	**150**	**100.00**

It was observed from the data depicted in Table 7 that majority 96.67 per cent selected farmers were found in low knowledge level group, this group of farmers have heard the word label claims of pesticides first time during the interview by the researcher and only 3.33 per cent respondents have high level of knowledge about the pesticides label claims. These groups of farmers were having either input shop or close contact with the input dealers. Hence, have knowledge about the pesticides label claims.

Knowledge level of Extension functionaries about the pesticides label claims

In addition to the farmers of study area researchers had taken the representative sample of 40 Extension functionaries from the selected districts and tested their knowledge about the label claims of pesticides. The data regarding the educational level of the selected extension functionaries and their knowledge about the pesticides label claims are presented in Table 8 and 9 as follows.

Table 8: Distribution of the selected Extension functionaries according to educational level

S.N.	Educational level	Frequency	Percentage
1.	Agril. Diploma	23	57.50
2.	B.Sc. (Agri)/ M.Sc. (Agri)	17	42.50
	Total	40	100.00

It was observed from Table 8 that all selected extension functionaries were learned persons, out of the selected 57.50 per cent were agricultural diploma holders and remaining 42.50 per cent were agricultural graduates and post graduates.

Table 9 : Distribution of the selected Extension functionaries according to Knowledge about the pesticides label claims

S.N.	Knowledge test statements about the pesticides label claims	Knowledge (N=40)	
		Yes	No
1	Do you know about the insecticide act 1968?	14	26
		(35.00)	(65.00)
2	Do you know about the Central Insecticide Board and Registration	11	29
	Committee (CIB&RC)?	(27.50)	(72.50)
3	Do you know what the pesticides label claims are?	22	18
		(55.00)	(45.00)
4	Do you know prior to giving advice to the farmers every extension personnel	21	19
	have to read the label of pesticides and give advice as per the label claims?	(52.50)	(47.50)
5.	Do you have knowledge about the waiting period of pesticides?	18	22
		(45.00)	(55.00)

The results regarding the knowledge of the Extension functionaries about the pesticides label claims clears from Table 9 that 72.50 per cent extension workers of the state department of agriculture did not aware about the CIB and RC, followed by 65.00 per cent extension workers did not know about the insecticides act 1968. Whereas 55.00 per cent extension workers have awareness knowledge about the label claims of pesticides, knowledge about to be read the pesticides label before advice to the farmers and 45.00 per cent extension functionaries know about the waiting period of pesticides in study area. The Overall knowledge level of selected extension functionaries about selected five statements about the label claims of pesticides has been computed in the form of index and respondents has been distributed in three categories by equal distribution method as given in Table 10.

Table 10. Distribution of the selected extension functionaries according to their overall knowledge level about pesticides label claims.

S. N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	25	62.50
2	Medium (33.34 to 66.66)	08	20.00
3	High (Above 66.66)	07	17.50
	Total	**40**	**100.00**

It was observed form Table 10 that 62.50 per cent selected extension functionaries were observed in low level of overall knowledge about the selected five statements of pesticides label claims, it was followed by 20.00 per cent falls in medium category and remaining 17.50 per cent observed in high knowledge level about the pesticides label claims. Hence this study clears that awareness knowledge of the extension functionaries should have to be enhanced through the training programmes by the State Department of Agriculture and KVKs.

Knowledge level of Proprietors of Krushi Seva Kendras

In addition to the farmers and Extension functionaries of study area researchers have taken the representative sample of 40 input dealers from the selected districts and tested their knowledge about the label claims of pesticides. The data regarding this have been presented in Table 11 as follows.

Knowledge of Proprietors of *Krushi Seva Kendras* about the label claim of pesticides had studied and the results were depicted in Table 11 clears that majority of the input dealers (Proprietors of Krushi Seva Kendras) had knowledge about the label claims statements constructed by the researchers. The overall knowledge has also computed in the form of knowledge index and results are presented in Table 12 as follows.

Table 11: Distribution of the selected Proprietors of Krushi Seva Kendras according to knowledge about pesticides label claims

S. N.	Knowledge test statements about the Label claims	Knowledge (N=40)	
		Yes	No
1	Do you know about insecticide act 1968 ?	31 (77.50)	09 (22.50)
2	Do you know about the central insecticide Board and Registration Committee ?	27 (67.50)	13 (32.50)
3	Do you know what the pesticides label claims are?	37 (92.50)	03 (07.50)
4	Do you know prior to selling of pesticides you have read the instructions given on the label of pesticides?	37 (92.50)	03 (07.50)
5	Do you know while selling the pesticide you has to ensure whether is having label claim for the specific purpose and for specific crop.	38 (95.00)	02 (05.00)
6	Do you know while recommending pesticide dosages you have to give the advice to the farmers as per the dosages mentioned on label claim?	37 (92.50)	03 (07.50)

Table 12. Distribution of the selected Proprietors of Krushi Seva Kendra according to their level of knowledge about pesticides label claims.

S.N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	02	5.00
2	Medium (33.34 to 66.66)	07	17.50
3	High (Above 66.67)	31	77.50
	Total	**40**	**100.00**

It was clears from the results depicted in Table 12 that majority 77.50 per cent proprietors of *Krushi Seva Kendras* had knowledge about the pesticides label claims, followed by 17.50 per cent had medium level of knowledge and remaining 5.00 per cent falls in low level category of knowledge about the pesticides label claims in study area. But it was noted that they were not using these knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. These may lead to presence of residues of those pesticides, which are not approved for use on particular crops.

CONCLUSION

In selected five district of Vidarbha 96.67 per cent farmers and 62.50 per cent selected extension workers were observed in low knowledge level group about the pesticides label claims. Whereas, majority (77.50%) proprietors of *Krushi Seva Kendras* have high level knowledge about the label claim of pesticides, but they are not using the knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. Hence, this study clears that there is a need to create the awareness among the farming community and extension functionaries about the pesticide label claims. Similarly it should be made mandatory to all input dealers to sale the pesticides as per the pesticides label claims. It will help to improve the adoption status of pesticides having label claim for specific crop and specific purpose approved by the CIB & RC and it will also help to bring uniformity in the recommendations made by the Central Insecticide Board and other institutions for betterment of farming community. Secondly, it will also help to either set the MRLs of a pesticide for appropriate food commodities or to monitor pesticide residues for food safety.

LITERATURE CITED

Anonymous, 2010. Annual report of the Pesticide Residue Committee of UK, page no. 4.

Anonymous, 2013. State of Pesticide Regulations in India. Paper published by Centre for Science and Environment, New Delhi, India.

Dhaker, S.C., S.L. Mundra, R.C. Dhaker and H.K. Sumeriya, 2015. Effect of weed management and sulphur on nutrient content and uptake by weeds and soybean, Legume Research., 38 (3): 411-414.

Jha, B.K., R. Chandra and Rohitashav Singh, 2014. Influence of post emergence herbicides on weeds, nodulation and yields of soybean and soil properties, Legume Res., 37 (1) : 47-54.

Kale, N.M., P.P. Wankhade and Gopal Jadhao, 2011. Factors affecting agrarian distress proneness in Western Vidarbha, J. Agril. Extn. Manag. (MANAGE, Hyderabad),12(2): 61-68.

Kale, N.M., D.M. Mankar and P.P. Wankhade, 2013. Factors affecting agrarian distress proneness in Vidarbha, Research Review Committee Report 2014, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). : 35-75.

Kumar, D., B.L. Chandrasekhar and P.K. Mishra, 2003. Effect of integrated weed management on economics of soybean [*Glycine max* (L.)Merrill] under vertisols of Chhattisgarh, Annals of Agric Res., 24:212-214.

Nandini Devi K, Kh. Lenin Singh, CNJS Arangba Mangang, N. Brajendra Singh, Herojit Singh Athokpam and A. Dorendro Singh, 2016. Effect of weed control practices on weed dynamics, yield and economics of soybean [*Glycine max* (L.) Merrill], Legume Research., 39 (6): 995-998.

Sharma, K.K., 2013. Pesticide Residues in food commodities in India: an Overview available at http:/ /cropcarefed.in/ presentation/2day/K.K.SHARMA. pdf.

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Adoption of Management Practices for Buffalo Keeping in Akola District of Maharashtra

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ABSTRACT

The study was conducted on impact of management practices on quality and quantity of buffalo milk in Akola district during the year 2014-2015. Data collected from 450 buffalo owners of the district. Scientific study in terms of breeding, feeding, housing and milking management practices of buffaloes were studied. However, it was observed that, rearing of good genetic potential animal and deciding their feeding quantity of roughages and concentrates by considering the overall performance of buffalo in terms of breed, BW, age and milk yield to provide required amount of DCP, TDN and DM to buffalo would favors the milk production in them. All these factors exhibited positive direct effect on milk production. It is concluded on the basis of adoption of different existing management practices the management index worked out as 70.60, 72.28, 73.95 in Gp-I, III and IV, representing fare (70 to 80%) and in Gp-II it was 67.78 being satisfactory (Up to 70%).

The farmers has to integrate several operations like breeding, feeding, general management and health care with diversified base to make his animal to produce more and more economically. The output i.e. milk is the function of application of different practices properly so as to create a good management environment. Therefore, one has to pay due attention towards its management in terms of breeding, feeding, housing, milking, general management and health care in order to harvest maximum possible production. Presently information on status of rearing the livestock in various parts of the country is not available and whatever available seems to be inadequate for planning and development. To cope up with these views the present study was planned for collecting the information on management status of buffalo rearing in Akola district of Maharashtra.

Management has long been recognized as a factor of production both in industry and agriculture. However, few studies are on record with regards to role of management in milk production. Perhaps the first scientific approach on the development of management indices in agriculture was suggested by Kahlon and Acharya (1957) which was further supported through the work of Raut (1982a) where he tried to construct housing management indices to evaluate its effect on milk production.

In view of this each qualitative practice was assign the score in the context of scientific recommendations so as to estimate the management index of each practice by such estimation one can know the management status of the guidelines for future management improvement programme as management would lie within the control of dairy farming.

MATERIAL AND METHODS

The present study entitled "Impact of management practices on quality and quantity of Buffalo milk in Akola district (Maharashtra)" was undertaken to study the technological changes in terms of breeding, feeding, housing and milking management practices followed by buffalo owners from three tahsils namely Akola, Patur and Barshitakali of the district. Ten villages in each tahasil were selected randomly making a sample of total 30 villages for the collection of data and 150 buffalo owners were studied from each tahasil. Thus a data on total of 450 buffalo owners (150 x 3) was collected. The information collected was classified according to herd size of four categories i.e. group Gp-I (1 buffalo), Gp-II (2 buffalo), Gp-III (3 to 5 buffalo) and Gp-IV (Above 5 buffalo), respectively.

Collection and Compilation of Data

A detailed interview schedule was prepared and pretested before the actual collection of data.

Tabulation and Analysis of Data

Besides this following statistical test were used for the analysis of collected data.

1, 3,4 & 5 Asstt. Profesor and 2. Assoc. Professor, Dept. of Animal Husbandary and Dairy Science, Dr. PDKV, Akola

C.V.% their measures necessity mean value of variabiltiy.

$$X = \frac{1}{N}(x_1 + x_2 + x_3 + \ldots\ldots\ldots\ldots x_n) = \frac{\Sigma X}{N}$$

Where,

ΣX = represents the sum of all the observations

Standard Deviation :

$$\text{Standard déviation (S.D.)} = \sqrt{\frac{\Sigma (X - \bar{X})^2}{N}}$$

Where,

X = An observation of variate value

$\bar{X}$ = Arithmetic mean

N = Number of given observations

Coefficient of Correlation

To study the extent of relationship amongst the selected variables correlation was worked out by the following formula (Amble (1975).

$$r = \frac{\text{Cov}(x, y)}{\text{SD}(x)\ \text{SD}(y)}$$

The significance of correlation coefficient was tested by 't' test as.

$$t\ cal = \frac{|r|}{\text{SE}(r)}$$

The table value of 't' is noted at (n-2) df for significance.

The following variables were used for calculation of correlation coefficient of different management practices with daily milk yield of buffaloes, on herd size and overall basis.

1. Breeding management
2. Feeding management
   a) Dry Fodder
   b) Green Fodder
   c) Concentrate Fodder
3. Housing management
4. Milking management
5. Fat content of milk
6. SNF content of milk
7. Overall management index

The following variables were used for calculation of correlation coefficient of nutrient intake with daily milk yield.

1. Dry matter intake
2. DCP intake
3. TDN intake

The following variables were used for calculation of correlation coefficient of feeding attributes amongst themselves.

1. Dry roughage
2. Green roughage
3. DM intake
4. Concentrate

RESULTS AND DISCUSSION

The clearly demonstrated that different aspects of management did influence the milk yield and quality of buffalo milk. However to pinpoint the impact of different management practices, the correlation studies are necessary which further extended to regression analysis for assessing the contribution of individual factor in total variation.

The association of ten different management attributes with daily milk yield in buffalo under different herd size were worked out and are shown in Table 1.

It was observed from Table 1 that, except green feeding different management practices irrespective of herd size established positive significant association with that of daily milk yield of buffaloes. Perhaps, feeding of occasionally greens by the buffalo owner could be the reason for non-significant association as 84 to 93% buffalo owners fed it as per the availability. The overall correlation values were 0.701, 0.494, 0.296, 0.279, 0.453, 0.692, 0.232 and 0.701 between breeding, feeding, housing, milking, dry, concentrate feeding, SNF content and overall management index with daily milk yield in buffalo respectively, indicating moderate to strong impact of these existing practices on milk yield of buffaloes. In contrast, Fat content of milk showed moderate negative significant ($r = -0407$) relationship with milk yield in buffalo. This means, there was decrease in fat content of milk with the increase in milk yield. The findings are collaborative to Raut (1982 a), Raut (1982 b), Goodger *et al.* (1985), Yadav and Yadav (1985), Sharma and Patel (1988). Where they noticed positive significant association between housing, feeding, feeding practices, breeding and feeding

Table 1. Correlation coefficient of various attributes with daily milk yield of buffalo in different herd size

S.N.	Variable	Gp-I (1-Buffalo)	Gp-II (2-Buffalo)	Gp-III (3 to 5-Buffalo)	Gp-IV (Above 5-Buffalo)	Overall
1	Breeding management	0.845**	0.883**	0.763**	0.479**	0.701**
2	Feeding management	0.689**	0.867**	0.340**	-0.038 NS	0.494**
3	Housing management	0.271*	0.777**	0.236*	0.229 NS	0.296**
4	Milking management	0.529**	0.549**	0.169 NS	0.403**	0.279**
5	Dry feeding	0.053 NS	0.848**	0.701**	0.527**	0.453**
6	Green feeding	-0.106 NS	-0.095 NS	0.367**	-0.091 NS	-0.005 NS
7	Conc. Feeding	0.639**	0.778**	0.715*	0.688**	0.692**
8	Fat content	-0.232*	-0.574**	-0.479**	-0.789**	-0.407**
9	SNF content	0.112 NS	0.270*	0.317**	0.527**	0.232*
10	Overall management index (Composite index)	0.507**	0.427**	0.870**	0.247*	0.701**

* - Significant at 5% , ** - Significant at 1%

composite management index, breeding and feeding with that of milk yield in buffaloes respectively.

It was observed that in all the herd size amongst different variables existing breeding practices index had greater positive significant influence on milk yield as the correlation values were of high degree, being r = 0.845, 0.883, 0.763 in Gp-I, II and III, respectively and moderate order (r = 0.479) in Gp-IV. The existing feeding practices index had also shown high degree positive significant association with that of daily milk yield in Gp-I (0.689) and Gp-II (0.867) while it was of moderate magnitude in Gp-III (r = 0.340) and low order negative non-significant in Gp-IV (r = -0.038).

Similar trend was noticed in respect of housing management index on milk yield, being positive significant in Gp-I, II, III and non-significant in Gp-IV. The existing housing management practices did exhibit positive significant association with milk yield but the magnitude of association was lower, being r = 0.271 and 0.236 in Gp-I and Gp-III, respectively and was of higher order (r = 0.777) in Gp-III while, positive non-significant in Gp-IV. On the other hand, the impact of milking management practices was of moderate order, with daily milk yield in buffaloes, being r = 0.529, 0.549 and 0.403 in Gp-I, II and IV, respectively, but non-significant (0.169) Gp-III. These findings appear to be good sign for clean milk production in the study area. Thus, the ranking order of impact on the basis of magnitude of association, it comes to breeding management followed by feeding management, milking management and housing management.

In reference to rate of feeding roughages and concentrates to buffalo, it was noticed that dry roughages feeding showed high degree positive significant association with milk yield in all herd size except Gp-I. The correlation co-efficients were 0.848, 0.701 and 0.527 in Gp-II, III and IV respectively while it was non-significant in Gp-I . Adequate dry roughages feeding are essential to fulfill the appetite of buffalo on one hand and supply of energy on the other hand. The rate concentrate feeding exhibited positive significant relationship of high order with that of milk yield in buffalo in all herd size. The co-efficient values being r = 0.639, 0.778, 0.715 and 0.688 in Gp-I, II, III and IV respectively. While feeding greens did not establish significant association with daily milk yield in buffaloes except GP-III where it was positive significant (r= 0.367). Thus, increase in feeding rate of dry roughages and concentrates were associated with increase of production in buffaloes Raut (1982 b) reported significant relationship between feed and milk yield. While Ganesh Kumar (2001) and Nalwade *et al.* (2002) reported positive significant association between milk yield and feeding of roughages and concentrates which are supportive to present study.

Thus, the results clearly postulated that increase of management index was associated with the increase in milk production of buffalo. The co-efficient values were 0.507, 0.427, 0.870 and 0.247 in Gp-I, II, III and IV, respectively, indicating approximate contribution in

Table 2. Correlation co-efficient of nutrient intake with daily milk yield in different herd size

S.N.	Variable	Gp-I	Gp-II	Gp-III	Gp-IV	Overall
1	Milk yield X DM Intake	0.082 NS	0.763**	0.700**	0.441**	0.389**
2	Milk yield X DCP Intake	0.404**	0.863**	0.790**	0.683**	0.512**
3	Milk yield X TDN Intake	0.145 NS	0.825**	0.720**	0.503**	0.394**

*-Significant at 5%, **-Significant at 1%

variation of milk yield to the level of 25.70, 18.23, 75.69 and 6.10 per cent in Gp-I, II, III and IV, respectively. Sharma and Patel (1988) also reported that Composite Management Index had significant positive influence on milk production which supports the present results.

The DM and TDN intakes did not establish significant relationship with that of milk yield in Gp-I, though DCP intake exhibited positive significant (r = 0.404) association with milk yield, indicating that there was increase in milk yield of buffalo with the increase of DCP intake in buffalo. In contrast, in rest of herd size, intake of DM, DCP and TDN established high order positive significant relationship with milk yield. Moreover, the magnitude of association between milk yield and nutrient intake was more in Gp-II as compared to Gp-III and IV. The co-efficient values in Gp-II were 0.863, 0.825 and 0.763 for DCP, TDN and DM respectively against the corresponding correlation values 0.683 and 0.790, 0.503 and 0.720 and 0.441 and 0.700 in Gp-IV and III

LITERATURE CITED

Balakrishnan, B., 1997. Evaluation of diary production practices in selected farming system of Karnataka State, Ph.D. thesis (unpub), Submitted to NDRI, Karnal.

Dhiman, P.C., Narendra Singh and B.L. Yadav, 1990. A study of cattle and buffalo feeding and breeding practices adopted in non-adopted villages of Hissar district, Indian J. Anim.Prod.Mgmt.6(2):84-89.

Dube, S.K., V.K. Sawarankar and K.M. Naik, 1989. Constraints in adoption of improved animal husbandry practices, Maharashtra J. Extn. Edu. 8 : 139-144.

Goodger, W.J., R. Ruppanner, B.D. Slenning and J.E. Kushman, 1984. An approach to scoring management on large scale dairies, J. Dairy Sci. 67(3):675-685.

Kahlon, A.S. and S.S. Acharya, 1957. A study on management input in farming, Zvi Grilinchs, "Specification Bias in Estimate of Production Function", J. Farm. Econ.39(1):18-20.

Kundu, A.K. and S.B. Basu, 1987. Analysis and measurement of management in dairy farms, Indian J. Anim. Prod. Mgmt. 3(2) : 60-66.

Mattigatti, R.H. & Jayram, 1993. Direct and indirect effects of factors of milk production, Indian Dairyman 45(8):357-360.

Nalawade, T.H., D.K. Pawar and D.Z. Jagtap, 2002. Study on feeding and breeding practices of Bovine in tribal area of Pune district, J. Maharashtra Agril. Univ.27(2):215-216.

Pandey, A.K., 1996. A comparative study livestock rearing system amongst tribal and non-tribal in Chota Nagpur region of Bihar, Ph. D. Thesis (Unpub.) NDRI., Karnal.

Raut, K.C., 1982. Management indicators in respect of housing of buffaloes for milk production, Indian J. Anim. Sci. 52(11):1012-1018.

Varma, O.P. and K.C. Tyagi, 1990. Adoption behavior of dairy farmers, Indian Dairyman, 52(12):125-126.

Sharma, K.N.S., and R.K. Patel 1988. Quantification of management input in milk production, Indian J. Anim. Sci. 58(2):253-259.

Srivastava, P.L. and Promila, 1985. Adoption of feeding practices in dairy management in farm women of selected villages, Indian J. Dairy Sci. 38(1):59-61.

Tanwar, P.S., Y. Kumar and G. Sankhala, 2012. Study on breeding and feeding management practices followed by members and non-members of dairy co-operatives in Jaipur district of Rajasthan, Indian J. Dairy Sci. 65(6):508-513.

Yadav, B.L. and M.C. Yadav, 1996. Buffalo breeding practices followed by farmers in the home tract of Murrah, Indian J. Anim. Prod. Mgmt. 12(2):73-76.

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Effect of Different levels of Orange *(Citrus reticulate)* juice on Chemical and Sensory Characteristics of Paneer Whey Beverage

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ABSTRACT

The present investigation was undertaken during 2015-16 at the Department of Animal Husbandry and Dairy Science and Department of Plant Pathology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. Whey is a nutritious by product obtained from paneer, channa, cheese containing valuable nutrients like lactose, proteins, minerals and vitamins etc., which have indispensable value as human food. The orange flavoured paneer whey beverage was prepared with the addition of different level of whey, sugar and orange juice. The paneer whey beverage was prepared by using different levels of orange juice@ 10, 15, 20, 25 and 30 per cent with 8 per cent sugar. Also formulations were prepared was studied for the sensory analysis on an average, the orange flavoured paneer whey beverage of treatment T_1, T_2, T_3, T_4 and T_5 scored flavor 8.06, 8.28, 8.51, 8.75 and 7.88, colour and appearance 8.04, 8.33, 8.62, 8.91 and 7.70, consistency 8.21, 8.35, 8.66, 8.84, 7.98 and overall acceptability were 8.10, 8.31, 8.59, 8.85 and 7.85, respectively. The overall acceptability of paneer whey beverage prepared with 25 per cent orange juice level was significantly superior and more acceptable than other levels of orange juice.

Whey is the largest and highly nutritious important by product of the dairy industry, it is obtained during the manufacture of casein, cheese, paneer, channa and shrikhand. Whey protein comprises of four major protein fractions and six minor protein fractions. Major protein fractions include beta-lactoglobulin (65%), alpha-lactalbumin (25%), bovine serum albumin (8%) and immunoglobulins (2%) (Walzem *et al.*, 2002 and Marshall, 2004).The current world production of whey is estimated at about 165 million tonnes, of which cheese whey contributes about 95 per cent. In the absence of systematic surveys/statistics, the predicted value of whey production in India is estimated at 5 million tonnes per annum. Whey contains 45-50 per cent of total milk solids, 70 per cent of milk sugars, and 20 per cent of milk proteins, 70-90 per cent of milk minerals and almost all water soluble vitamins present in milk. It is one of the major problematic disposals for dairy industry because of high Biological Oxygen Demand (BOD) value ranging from 39,000 to 48,000 ppm (Divya and Kumari, 2009) and chemical oxygen demand of 60,000-80,000 mg l^{-1} (Macwan *et. al.*, 2016) and its stringent environmental regulatory acts. Pollution due to whey is a big problem thus utilization of whey for the production of beverages, soft drinks and wines are some of the solutions to minimize the intensity of pollution problem (Parekh, 2006).

Nutritive benefits of whey can be utilized with fruit juice, pulp or concentrate in the development of a value added beverage. This would be the most logical and economical way of utilization of whey nutrients in human food chain (Goyal and Gandhi, 2009). Beverages based on fruits and milk products are currently receiving considerable attention as their market potential is growing. Besides being delicious, these beverages are highly nutritious. At present fruit beverages are generally synthetic flavoured, bottled and sold in the market. If this could be substituted with fruit juice and dairy whey, it will be more beneficial to the consumers, dairy industries and beverage manufacturers as well as fruit growers (Sakhale *et al.* 2012). The pulp of orange fruit is considered cool and diuretic. Oranges constitute a significant source of antioxidants (mainly vitamin C), polyphenol compounds (hydroxyl cinnamic acid and flavanones), phyto-chemicals (hesperidins and narigenin) and various vitamins and minerals. These components exhibit therapeutic properties such as anti-inflammatory, antihypertensive, diuretic, analgesic and hypolipidemic activities (Klimczak *et al.*, 2007). Therefore, keeping in view of the nutritional and functional attributes of orange juice, potential of whey to be used in nutritious and health promoting beverages, the present study was undertaken with an objective to develop a value added orange based whey beverage.

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MATERIAL AND METHODS

Good quality fresh buffalo milk was procured and then strained through muslin cloth. The fat content in milk was standardized at 6 per cent fat and 9 per cent SNF. The milk was transferred to stainless steel vessel and heated to about 90°C. The vessel was then removed from the fire and cooled to 72°C. The coagulant *i.e.* citric acid solution @ 1.5 per cent was added slowly till complete coagulation of milk. Then the mass was poured over stretched piece of clean muslin cloth over another vessel to drain the whey. The clear drained whey was collected in the vessel. The yellowish green whey was then used for the preparation of whey beverage. After getting whey 8% sugar and Orange juice were added. The products were filled in sterilized bottles and then cooled and stored in refrigerator at 5-7°C.

Preparation of paneer whey beverage

Paneer Whey
↓
Addition of sugar (8%)
↓
Addition of orange juice (as per treatments)
↓
Addition of stabilizer (0.1%)
(Sodium citrate)
↓
Mixing
↓
Bottling
↓
Refrigerated cooling and storage(7±1°C)

(Reddy *et al.*, 1987)

Treatment details:

T_1 : 90% paneer whey + 10% orange juice,

T_2 : 85% paneer whey + 15% orange juice,

T_3 : 80% paneerwhey + 20% orange juice

T_4 : 75% paneer whey + 25% orange juice.

T_5 : 70% paneerwhey + 30% orange juice.

(Sugar level kept constant *i.e.* @ 8% (w/v) of final product in all the treatments).

The product so obtained was subjected to sensory evaluation by the 5 member's panel of judges, for various attributes of sensory evaluation like flavour, colour and appearance, consistency and overall acceptability on 9-point hedonic scale (Gupta, 1976 and BIS, 1971). The results obtained were statistically analyzed by Randomized Block Design as per the method prescribed by Panse and Sukhatme (1967) with five treatments and four replications.

RESULTS AND DISCUSSION

The result obtained from the present investigation in respect to chemical composition of paneer whey is presented in Table 1 and orange juice is presented in table 2, respectively.

Table 1. Chemical composition of paneer whey.

Constituent per cent				
Fat	**Protein**	**Reducing Sugar**	**Acidity**	**pH**
0.48	0.47	4.43	0.18	5.32

The average chemical composition of paneer whey utilized for whey beverage preparation contain fat 0.48 per cent, protein 0.47 per cent, reducing sugar 4.43 per cent, 0.18 per cent acidity and pH 5.32.(Table 1).The values for different paneer whey were nearer to the results reported by Saravankumar and Manimegalai (2002[a]) who reported the chemical composition for paneer whey as 7 per cent total solids, 0.17 per cent acidity, 5.27 pH and 5.18 per cent total sugars. Gaikwad *et al.* (2010) studied on preparation of *chhana* whey beverages using sapota pulp. The beverage was prepared by using 0, 5, 10 and 15 per cent of sapota pulp. They observed an average composition i.e. the moisture content of sapota whey beverage was found to be 93.50, 92.51, 91.52 and 90.50 per cent, fat 0.48, 0.51, 0.54 and 0.57 per cent, protein 0.38, 0.40, 0.41 and 0.42 per cent, ash 0.48, 0.51, 0.53 and 0.57 per cent, total solids 6.50, 7.49, 8.48 and 9.47 per cent and carbohydrate 5.16, 6.07, 7.00 and 7.91 per cent for treatment T_0, T_1, T_2 and T_3, respectively. Shukla *et al.* (2013) reported that the total solids in whey, pineapple juice and probiotic whey based pine apple beverage were 6.40, 12.79 and 12.80per cent, respectively whereas titratable acidity was 0.18, 0.87 and 0.546 per cent lactic acid. Probiotic beverage containing pineapple juice and whey in the ratio of 35:65 had 0.546 per cent acidity, protein (0.23%), ash (0.51%), total soluble solids (12.2), reducing sugars (1.48%) and non reducing sugars (9.96%), respectively.

Table 2.Chemical composition of orange juice.

Constituent per cent				
TSS	**Reducing Sugar**	**Total sugar**	**Acidity**	**pH**
9.13	2.24	6.46	0.69	4.35

The orange juice contains TSS (°Brix) 9.13, reducing sugar 2.24 per cent, total sugar 6.46 per cent, acidity 0.69 and pH 4.35. (Table 2).These contention was supportive to the results as reported by Chatterjee*et al.* (2015), which reported physico-chemical characteristics of orange juice and obtained that it is reach in vitmain C content. The total soluble solids in fruit 9.13± 0.21 per cent, Moisture 85.31±0.36 per cent, total sugar 6.46±0.07, ash 0.38±0.035 per cent, titrable acidity 0.69 ± 0.023, pH 3.92 ± 0.04.

Sensory evaluation:

Final product obtained was evaluated by a panel of sensory evaluation by using 9 point hedonic scale and the data obtained in respect to various attributes of sensory evaluation are presented in Table3.

Table.3 Sensory evaluation of paneer whey beverage with orange juice

Treat.	Sensory attribute Score			
	Flavour	**Colour and appearance**	**Consistency**	**overall acceptability**
T1	8.06	8.04	8.21	8.10
T2	8.28	8.33	8.35	8.31
T3	8.51	8.62	8.66	8.59
T4	8.75	8.91	8.84	8.85
T5	7.88	7.70	7.98	7.85
Result	Sig	Sig	Sig	Sig
SE(±)	0.07	0.09	0.05	0.04
C.D. at (5%)	0.21	0.28	0.16	0.13

* $p<0.05$

Flavour :

The mean score of flavour for fresh paneer whey beverage were 8.06, 8.28, 8.51, 8.75 and 7.88 for treatment T_1, T_2, T_3, T_4 and T_5, respectively. The different levels of orange juice had significant ($p<0.05$) effect on flavour of paneer whey beverage product. The maximum scores were allotted to the treatment T_4 (8.75), whereas the lowest treatment (7.88) was observed for treatment T_5. Treatment T_1 was at par with treatment T_5. Similar observations were made by Bhat and Singh (2014) observed that the ratio of 67.5 per cent (whey): 20 per cent (guava juice) was found best for the formulation of whey guava beverage.

Colour and Appearance:

The mean score of colour and appearance for fresh paneer whey beverage were 8.04, 8.33, 8.62, 8.91 and 7.70 for treatment T_1, T_2, T_3, T_4, and T_5, respectively. The highest score (8.91) was obtained for treatment T_4, while the lowest score (7.70) was obtained for treatment T_5. Present results were closely agreement with Babar *et al.* (2008) that the average sensory score of *Chakka* whey beverage for colour were 8.71, 8.65, 8.81 and 8.35 for treatment T_1, T_2, T_3 and T_4, respectively in *Chakka* whey based pomegranate juice beverage.

Consistency:

The mean scores for consistency of whey beverage were 8.21, 8.35, 8.66, 8.84 and 7.98 under treatment T_1, T_2, T_3, T_4 and T_5, respectively. The highest score (8.84) was recorded in treatment T_4, while the lowest score (7.98) was obtained by T_5 treatment. Treatment T_1 was at par with T_2. The observations clearly indicated that, the highest liking was toward T_4. These results of consistency are closely agreement with the results reported by Babar *et al.* (2008) observed that, the mean score of the product for consistency were 8.47, 8.65, 8.82 and 8.36 for treatment T_1, T_2, T_3 and T_4, respectively.

Overall acceptability

It is observed from Table 3 that, the mean score for overall acceptability for treatments T_1, T_2, T_3, T_4 and T_5 were 8.10, 8.31, 8.59, 8.85 and 7.85, respectively. The average score for treatments T_1, T_2, T_3 and T_4 were more than T_5. The overall acceptability of paneerwhey beverage was significantly affected by addition of orange juice in whey beverage preparation. Paneer whey beverage with 25 per cent orange juice in treatment T_4 was significantly superior in respect of acceptability of overall treatments. It indicates that blending of beverage with orange juice more than 25 per cent (T_4) level decreases the score of overall acceptability which might be due to high intensity of flavour, dark colour and consistency. Similar results were reported by Deepa *et al.* (2014) The highest score for overall acceptability was given to the V_2 with 40 per

cent addition of whey water and 60 per cent addition of musk melon juice as 7.6±1.224.

Gaikwad (2010) studied on preparation of chhana whey beverages using sapota pulp. The beverage was prepared by using 0, 5, 10 and 15 per cent of sapota pulp. They observed that overall acceptability score for treatment T_0, T_1, T_2 and T_3 was 7.53, 8.03, 7.87 and 7.65, respectively.

Yadav *et al.* (2010) studied the development and storage of whey-based banana herbal (WBBH) beverage with the incorporation of Menthaarvensis extract (0 to 4 per cent). The amount of banana juice and sugar were fixed at 10 ml and 8 g, respectively per 100 ml of the beverage. Whey quantity varied from 72 to 84 ml for each 10 mL of the beverage depending upon the concentration of Mentha extract. The organoleptic scores and overall acceptability of the beverage improved with increase in Mentha extract from 0 to 2 per cent. Addition of 3 and 4 per cent Mentha extract decreased the beverage quality as beverage scored lower organoleptic scores.

Darade *et al.* (2011) studied the sensory quality of pineapple based channa whey beverage. The overall acceptability of channa whey beverage prepared with 20 per cent pineapple juice level was significantly superior and more acceptable than other levels of pineapple juice.

Pandiyan *et al.* (2011) studied the development of mango flavoured sweetened whey drink. The treatments were divided into control, T_1 using 4 per cent, T_2 using 5 per cent and T_3 using 6 per cent mango pulp. The sensory analysis of the treatments showed in table 3. Sensory analysis of the treatments showed a significant difference ($P>0.01$) among the treatments for colour, taste, flavor, texture and overall acceptability. Mango pulp added treatments scored a high by the sensory panel.

Revathi and Vinita (2012) studied on sensory evaluation of whey based pineapple beverage. Nine formulations were prepared with different level of whey, sugar and pineapple flavour. The different levels of sugar and pineapple flavour had a definite effect on improving the sensory quality of the beverage. The beverage prepared by utilizing *Paneer* whey with 12 per cent sugar and 0.2ml of flavour (T_5), had secured the highest sensory score (8.37) and ranked as most acceptable product followed by T_4 with 8.15 points sensory score. The overall organoleptic quality was observed in case of fresh beverage made from 12 per cent sugar with 0.2ml of pineapple flavour.

Cost of production of paneer whey beverage

In order to popularize this beverage, it is necessary that the product should be inexpensive as compared to other soft drinks available in the market. The cost of product was reduced under investigation, whey was utilized for product preparation. The whey is the waste disposal obtained during manufacture of coagulated dairy products. It contains valuable milk components, having high nutritional values. While, considering the prevailing rates of ingredients available in the local market and the rate of paneer whey as a byproduct during preparation of paneer, the cost is very less due to sale of major product paneer. Generally whey is not utilized in market for future product preparation and it is just a waste during paneer preparation. So, whey was made available at only Rs. 0.50 l^{-1}. Thus, all the values were considered for calculating the cost of production of whey beverage. The cost of paneer whey beverage with different levels of orange juice ranged between Rs. 11.57 to Rs. 21.47 per 1000 ml for treatment T_1 to T_5, respectively. The cost of treatment T_2, T_3 and T_4 was 14.04, 16.52 and 18.99 per 1000 ml, respectively. The highest cost was recorded for treatment T_5 i.e. Rs. 21.47 where in 30 per cent orange juice was incorporated. The lowest cost was recorded for treatment T_1 i.e. Rs. 11.57. Increased level of orange juice showed the increasing trend in cost of production of paneer whey beverage. The present investigation of whey beverage is comparable with those reported by Babar *et al.* (2008), Rupnar *et al.* (2009) and Darade *et al.* (2011) as they reported the levels of fruit juice were increased the cost of production. These view are supportive to present result.

The cost of production of paneer whey beverage for superior treatment, i.e. treatment T_4 with 25 per cent blending of orange juice in paneer whey was Rs 18.99 per litre. Based on 200 ml beverage bottle, the cost of production of treatment T_4 was only Rs. 3.59, which seems to be very cheaper as compared to different soft drinks or beverages sold in market. On an average the cost of orange juice as Rs. 5 per 100 ml was considered for the calculation of cost of the production. The cost of sugar Rs. 39 kg^{-1}, sodium citrate Rs. 1000 kg^{-1} was taken for calculation, while other charges cost viz., labour, fuel and other miscellaneous was taken approximately. The cost of production of the present product is shown that the cost

of 200 ml of beverage having 10 per cent orange juice is Rs. 2.42 at 15 per cent profit margin. The cost of beverages having 15, 20, 25 and 30 per cent orange juice increased to Rs. 2.99, 3.56, 4.12 and 4.70 for 200 ml of product taking 23 per cent, 47 per cent, 70 per cent and 94 per cent profit margin, respectively.

Present investigation result were justified with result as reported by Raut (2007) and Bothe (2013) opined that the cost of production of chhana whey orange based beverage and whey based mango herbal beverage increase with increased in level of blending of orange and lemongrass extract in the beverage. This observation agreement with our present results. Sahu *et al.* (2005) reported that, the preparation of whey based mango (lemon grass) beverage the volume of mango pulp (12 %), sugar (8 %), water (48 %) and *paneer* whey (32 %) were kept constant while the volume of lemongrass distillate was varied from 0 to 2.5 per cent (v/v). The value added soft lemon grass beverage had cost of Rs. 5.75 per 250 ml of mango lemon grass beverage.

CONCLUSION

The incorporation of orange juice in blends of paneer whey up to 25 per cent proportion was found acceptable without affecting the sensory characteristics significantly. Whey a byproduct generated during manufacturing of paneer can be efficiently utilized for the preparation of whey beverage products. Based on 200 ml beverage bottle, the cost of production of treatment T_4 was only Rs. 3.79, which seems to be very cheaper as compared to different soft drinks or beverages sold in market. The technology standardized by this study provides pace for household and commercialization at industrial level.

LITERATURE CITED

Babar, R.B., D.D. Salunkhe, K.D. Chavan and V.M. Thakare, 2008. Utilization of pomegranate juice for the preparation of chakka whey beverage,. J. Dairying, Foods & H.S. 27(2) : 87-93.

Bhat, F.M., and R. Singh, 2014. Preparation, quality evaluation and shelf life studies of whey-guave beverage, World J. of Agri. Sci. 10(3) : 141-145.

BIS, 1971. IS: 6273, Part-II: Guide for sensory evaluation of foods. Methods and Evaluation Cards, Bureau of Indian Standards, ManakBhavan, Delhi.

Bothe, M.S., 2013. Studies on preparation of whey based mango herbal (lemongrass) beverage, M.Sc. (Agri.) thesis (Unpub), M.P.K.V., Rahuri (M.S.).

Chatterjee, G., J. De Neve, A. Dutta and S. Das, 2015. Formulation and statistical evaluation of a ready-to-drink whey based orange beverage and its storage stability, Revista Mexicana de IngenieriaQuimica, 14(2): 253-264.

Darade, V.R., R.J. Desale, S.S. Ghodke and D.M. Choudhari, 2011. Sensory quality and cost of production of pineapple chhana whey beverage, Res. J. Animal Hus. & Dairy Sci., 2(1&2) : 56-59.

Deepa, C.K and V. Krishnaprabha, 2014. Development and nutrient, antioxidant and microbial analysis of muskmelon and whey water and probiotic incorporated squash, Int. J. Curr. Microbiol. App. Sci. 3(5) : 267-271.

Divya and ArchanaKumari 2009. Effect of different temperatures, timings and storage periods on the physico-chemical and nutritional characteristics of whey-guava beverage,World J. of Dairy & Food Sci. 4 (2): 118-122.

Gaikwad, S.V. 2010. Studies on preparation of chhana whey beverage using sapota pulp, M.Sc.(Agri.) thesis (Unpub) submitted to VMKV, Parbhani. (MS)

Goyal Nupur and D. N. Gandhi, 2009. Comparative analysis of Indian paneer and cheese whey for electrolyte whey drink,World J. Dairy & Food Sci. 4 (1): 70-72.

Gupta, S. K. 1976. Sensory evaluation in food, Indian Dairyman, 28(8): 2931.

Klimczak, M., M. Malecka, A. Szlachta and A. Gliszczy´nska- ´Swiglo, 2007. Effect of storage on then content of polyphenols, vitamin C and the antioxidant activity of orange juices, J. Food Composition and Analysis, 20 : 313-322.

Macwan S. R., Bhumika K. Dabhi, S.C. Parmar and K.D. Aparnathi. 2016. Whey and its utilization, International J. Curr. Microbiol. App. Sci. 5(8): 134-155.

Marshall, K., 2004. Therapeutic applications of whey protein, Alternative Medicine Review, 9, 136-156.

Naik, Y. K., A. Khare., P. L. Choudhary., B. K. Goel and A. Shrivastava, 2009. Studies on physico-chemical and sensory characteristics of whey based watermelon beverage, Asian J. Research Chem., 2 (1): 57-59.

Panse, V.G. and P.V. Sukhatme, 1967. Statistical methods for Agriculture Workers. 2nd Edn. ICAR, New Delhi.

Pandiyan, C., R. Villi, Annal and V. Chandirasekaran, 2011. Development of mango flavoured sweetened whey drink, JIVA. 9(3) : 35-37.

Parekh, J. V. 2006. Emerging new technologies in dairy industry in India.

Raut, H.K., 2007. Utilization of orange juice for the preparation of chhana whey beverage, M.Sc. (Agri.) thesis (Unpub) submitted to Dr. PDKV, Akola (MS).

Reddy, G.J., B.V.R. Rao, K.S.R. Reddy and D. Venkayya, 1987. Development of whey beverage, Indian J. Dairy Sci., 40(4) : 445-450.

Revathi D. and Vinita Singh, 2012. Sensory evaluation of whey based pineapple beverage, Food Science Res. J., 3(2) : 229-231.

Rupnar, P.S., K.D. Chavan, B. K. Pawar and D.N. Bhosale, 2009. Sensory quality of paneer whey beverage prepared with kokum juice, J. Dairying, Foods & H.S. 28(2) : 111-114.

Sakhale B. K., V. N. Pawar.and R. C. Ranveer. 2012. Studies on the development and storage of whey based RTS beverage from Mango cv. Kesar, J Food Process Technol., 3 (3): 148-152.

Saravanakumar, R. and G. Manimegalai, 2002[a]. A delicious soymilk, whey blended papaya RTS beverage, Beverage and Food World, 29(1) : 57: 58.

Shukla, M., Y.K. Jha and S. Admassu, 2013. Development of Probiotic Beverage from Whey and Pineapple Juice, J. Food Process Technol., 4 : 206.

Walzem, R. L., C. J. Dillard and J.B. German, 2002. Whey components: millennia of evolution create functionalities for mammalian nutrition: what we know and what we may be overlooking, Critical Reviews in Food Science and Nutrition 42, 353-375.

Yadav, R.B., S. Baljeet and N. Kalia, 2010. Development and storage studies on whey-based banana herbal (*Menthe arvensis*) beverage, American J. Food Technol. : 1-9.

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Path Coefficient Analysis of Management Practices of Buffalos in Akola District of Maharashtra

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ABSTRACT

In this study, it was aimed to study impact of management practices on quality and quantity of buffalo milk in Akola district during the year 2014-2015. Data were collected from 450 buffalo owners of the district. Technological changes in terms of breeding, feeding, housing and milking management practices of buffaloes were studied. The Path co-efficient analysis postulated that, daily milk yield in buffalo was not influenced by a single factor of management practices. However, it was observed that, rearing of good genetic potential animal and deciding their feeding quantity of roughages and concentrates by considering the overall performance of buffalo in terms of breed, BW, age and milk yield to provide required amount of DCP, TDN and DM to buffalo would favor the milk production in them. All these factors exhibited positive direct effect on milk production. On the basis of adoption of different existing management practices the management index was worked out as 70.60, 72.28, 73.95 in Gp-I, III and IV, representing fare (70 to 80%) and in Gp-II it was 67.78 being satisfactory (Up to 70%).

Management has long been recognized as a factor of production both in industry and agriculture. However, few studies are on record with regards to role of management in milk production. Perhaps the first scientific approach on the development of management indices in agriculture was suggested by Kahlon and Acharya (1957) which was further supported through the work of Raut (1982a) where he tried to construct housing management indices to evaluate its effect on milk production.

The farmer has to integrate several operations like breeding, feeding, general management and health care with diversified base to make his animal to produce more and more economically. The output i.e. milk is the function of application of different practices properly so as to create a good management environment. Therefore, one has to pay due attention towards its management in terms of breeding, feeding, housing, milking, general management and health care in order to harvest maximum possible production. Presently information on status of rearing the livestock in various parts of the country is not available and whatever available seems to be inadequate for planning and development. To cope up with these views the present study was planned for collecting the information on management status of buffalo rearing in Akola district of Maharashtra.

The path coefficient analysis provides an effective mean for finding out direct and indirect causes, association and permits a critical examination of the specific forces acting to produce a given co-relation. Majority of these practices have qualitative nature and were difficult to quantify them.

In view of this each qualitative practice was assign the score in the context of scientific recommendations so as to estimate the management index of each practice by such estimation one can know the management status of the guidelines for future management improvement programme as management would lie within the control of dairy farming.

MATERIAL AND METHODS

The present study entitled "Impact of management practices on quality and quantity of Buffalo milk in Akola district (Maharashtra)" was undertaken to study the technological changes in terms of breeding, feeding, housing and milking management practices followed by buffalo owners from three tahsils of the district. Ten villages in each tahasil were selected randomly making a sample of total 30 villages for the collection of data and 150 buffalo owners were studied from each tahasil. Thus a data on total of 450 buffalo owners (150 x 3) were collected. The information

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collected was classified according to herd size of four categories i.e. group Gp-I (1 buffalo), Gp-II (2 buffalo), Gp-III (3 to 5 buffalo) and Gp-IV (Above 5 buffalo) respectively.

Collection and Compilation of Data

A detailed interview schedule was prepared and pretested before the actual collection of data.

Tabulation and Analysis of Data

Besides this following statistical test were used for the analysis of collected data.

C.V.% their measures necessity mean value of variabiltiy.

$$X = \frac{1}{N}(x_1 + x_2 + x_3 + \ldots\ldots\ldots\ldots x_n) = \frac{\Sigma X}{N}$$

Where,

ΣX = represents the sum of all the observations

Standard Deviation:

$$\text{Standard déviation (S.D.)} = \sqrt{\frac{\Sigma (X - X)^2}{N}}$$

Where,

X = An observation of variate value

X- = Arithmetic mean

N = Number of given observations

RESULTS AND DISCUSSION

Path Analysis:

The results obtained on Path analysis are tabulated in Table 1,2 , 3, & 4

It was observed from Table 2 that, breeding management practices had positive direct effect on daily milk yield of buffalo in Gp-I. The degree of contribution was of high order (0.630) while, amongst the indirect

Table 1. Path analysis of selected management practices and their mode of effect on Gp-I daily milk yield of buffalo.

S.N	Particulars	Total effect	Direct effect	indirect effect	Indirect contributors
1.	**Management Practices**				
	X1-Breeding	0.845	0.630	0.215	X1 X3
	X2-Feeding	0.689	0.108	0.581	X1
	X3-Milking	0.529	0.209	0.320	X1
2.	**Nutrient Intake**				
	X4-DCP	0.406	0.130	0.276	X1 X5
	X5-TDN	0.145	0.214	-0.069	X4 X6
	X6-DM	0.082	-0.293	0.375	X4 X5

Table 2. Path analysis of selected management practices and their mode of effect on Gp-II daily milk yield of buffalo.

S.N	Particulars	Total effect	Direct effect	indirect effect	Indirect contributors
1.	**Management Practices**				
	X1-Breeding	0.883	0.313	0.570	X2 X5
	X2-Feeding	0.867	0.256	0.611	X1 X5
	X3-Milking	0.549	-0.024	0.573	X1 X2 X5
2.	**Nutrient Intake**				
	X4-DCP	0.863	-0.484	1.347	X1 X2 X5
	X5-TDN	0.828	2.185	-0.1.357	X1 X2 -X6
	X6-DM	0.763	-1.957	2.721	X1 X5

effects maximum positive contribution was due to feeding and milking management practices (0.215), resulting into positive significant correlation (0.845) with milk. Moreover feeding and milking management practices had also positive direct effect on milk yield. The magnitude of contribution was of low order being 0.108 and 0.209 respectively. Moderate degree positive indirect contribution from breeding management resulted in to moderate order positive and significant correlation of feeding and milking management practices (0.689 and 0.529) with milk yield.

In respect of Gp-II it is noticed from Table 3 that, breeding management showed positive direct effect (0.313) on milk yield of buffalo. Its indirect effects through feeding and TDN intake were in positive direction, though milking management and DM intake contributed in negative direction. The higher magnitude of direct and indirect effects resulted to high order (0.883) positive significant correlation with milk yield. In contrast, the positive direct effect of feeding management was low degree (0.256) on milk yield. But its indirect effects via breeding and TDN intake were positive and higher which nullified the negative direction effects of DCP and DM intake. As a result the correlation with daily milk yield was of high order positive significant (0.887). While the direct effect of milking management was negative (-0.024) and was of very low order, but higher positive contribution of indirect effects via breeding, feeding and TDN intake resulted into positive moderate order correlation, (0.549) with milk yield.

In reference to Table 4 of Gp-III, breeding management had higher positive direct effect (0.458) on milk yield. Its indirect effects through other practices were also positive with moderate order (0.305). This resulted to positive significant high degree correlation with milk yield (0.763).

With regards to Gp-IV, it was observed from Table 5 that, breeding management exhibited positive direct effect on milk yield (0.327). Its indirect effect through DCP intake in positive direction contributed to moderate order positive significant correlation between breeding management and milk yield (r = 0.479). In contrast, feeding management had negative direct effect (-0.218) on milk yield, but its higher indirect effect contribution via DCP intake in positive direction resulted in to low

Table 3. Path analysis of selected management practices and their mode of effect on Gp-III daily milk yield of buffalo.

S.N	Particulars	Total effect	Direct effect	indirect effect	Indirect contributors
1.	**Management Practices**				
	X1-Breeding	0.763	0.458	0.305	X1 X4
	X2-Feeding	0.340	-0.083	0.423	X1 X4
	X3-Milking	0.169	0.103	0.066	X1 X4 X5
2.	**Nutrient Intake**				
	X4-DCP	0.790	0.428	0.362	X1 X5
	X5-TDN	0.720	0.212	0.508	X1 X4

Table 4. Path analysis of selected management practices and their mode of effect on Gp-IV daily milk yield of buffalo.

S.N	Particulars	Total effect	Direct effect	indirect effect	Indirect contributors
1.	**Management Practices**				
	X1-Breeding	0.479	0.327	0.152	X4 - X6
	X2-Feeding	-0.038	-0.218	0.180	X1 X4
	X3-Milking	0.403	0.256	0.147	X4 - X5
2.	**Nutrient Intake**				
	X4-DCP	0.683	0.623	0.060	X1 X3
	X5-TDN	0.505	-0.049	0.554	X1 X4
	X6-DM	0.441	-0.051	0.492	X1 X4

degree negative non-significant relationship with milk yield (r=-0.038). Thus, the Path co-efficient analysis postulated that daily milk yield in buffalo was not influenced by a single factor of management practices. However, rearing of good genetic potential of animal and deciding their feeding quantity of roughages and concentrates by considering the overall performance of buffalo in terms of breed, BW, age and milk yield to provide required amount of DCP, TDN and DM to buffalo would favor the milk production in them. Similar views were expressed by Tanwar *et al.* (2012). Moreover, Mattigatti and Jayram (1993) observed that the direct contribution of herd size was 68.70 per cent and indirectly contributed by dry fodder and concentrates to the tune of 26.95 and 19.30 per cent, respectively and the milk production in buffaloes could respond more favorably to feeding as compared to other management practices. These views support the contention that enhanced milk production in buffalo is a result of combination of breeding management and nutrient intake (DCP).

LITERATURE CITED

Bidwe, K.U., 2009. Path coefficient analysis of buffalo production in Buldana district of Maharashtra, Veterninary World, Vol.2(3):103-104.

Balakrishnan, B., 1997. Evaluation of diary production practices in selected farming system of Karnataka State, Ph.D. thesis (Unpub), Submitted to NDRI, Karnal.

Dhiman, P.C., Narendra Singh and B.L. Yadav, 1990. A study of cattle and buffalo feeding and breeding practices adopted in non-adopted villages of Hissar district, Indian J. Anim.Prod.Mgmt., 6(2) : 84-89.

Dube, S.K., V.K. Sawarankar and K.M. Naik, 1989. Constraints in adoption of improved animal husbandry practices, Maharashtra J. Extn. Edu. 8 : 139-144.

Goodger, W.J., R. Ruppanner, B.D. Slenning and J.E. Kushman 1984. An approach to scoring management on large scale dairies, J. Dairy Sci. 67(3) : 675-685.

Kahlon, A.S. and S.S. Acharya, 1957. A study on management input in farming, Zvi Grilinchs, "Specification Bias in Estimate of Production Function"., J. Farm. Econ., 39(1):18-20.

Kundu, A.K. and S.B. Basu, 1987. Analysis and measurement of management in dairy farms, Indian J. Anim. Prod. Mgmt., 3(2):60-66.

Mattigatti, R.H. and Jayram, 1993. Direct and indirect effects of factors of milk production, Indian Dairyman, 45(8):357-360.

Pandey, A.K., 1996. A comparative study livestock rearing system amongst tribal and non-tribal in Chota Nagpur region of Bihar, Ph. D. Thesis (Unpub.) NDRI., Karnal.

Raut, K.C., 1982. Management indicators in respect of housing of buffaloes for milk production, Indian J. Anim. Sci. 52(11):1012-1018.

Varma, O.P. and K.C. Tyagi, 1990. Adoption behavior of dairy farmers, Indian Dairyman. 52(12):125-126.

Srivastava, P.L. and Promila, 1985. Adoption of feeding practices in dairy management in farm women of selected villages, Indian J. Dairy Sci. 38(1):59-61.

Tanwar, P.S., Y. Kumar and G. Sankhala, 2012. Study on breeding and feeding management practices followed by members and non members of dairy co-operatives in Jaipur district of Rajasthan, Indian J. Dairy Sci. 65(6):508-513.

Yadav, B.L. and M.C. Yadav, 1996. Buffalo breeding practices followed by farmers in the home tract of Murrah, Indian J. Anim. Prod. Mgmt. 12(2):73-76.

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Effect of Pre-sowing Seed Treatment on Seed Germination and It's Vigour on *Acacia concinna* (willd.) DC. Under Rainfed Agroclimatic Condition

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ABSTRACT

The major problems associated with Shikakai seeds are poor, uneven and delay in germination. The present investigation has been undertaken for knowing suitability of best pre-sowing seed treatments to enhance seed germination in *Acacia concinna*. This study was carried out in randomized block design with three replication at the nursery of Department of Forestry, Dr.PDKV, Akola during the year 2011-12. Seeds were treated with ten various treatments of Thiourea, KNO_3, H_2SO_4, soaking in tap water, soaking in hot water, soaking in cow urine, at different concentrations and duration with control (untreated seed). The study revealed that maximum seed germination and highly significant effect on seedling vigour were observed in treatment T_6 (seeds soaked in 20% conc. H_2SO_4 for 10 min.) followed by T_5 (seeds soaked in 20% conc. H_2SO_4 for 5 min.) and T_8 (seeds soaked in Hot water at 60°c for 10 min.).

The World Health Organization (WHO) reported that the worldwide demand for medicinal plant-based raw materials is climbing at the rate of 15 to 25 per cent per annum. In response to this growing demand for medicinal plants, commercial cultivation of medicinal plants is beginning to gain prominence amongst the grower and farmers, in large numbers. Sokakai *(Acacia concinna* (Willd.) DC). belongs to the family-Fabaceae is a neglected useful multipurpose medicinal, tree and also native indigenous species in India. This tropical plant grows from mean sea level up to 400-1500 m in loam and clay loam soil. It has also established in regions with 1500-2000 mm annual rainfall. It occurs in stream banks of less rainfall areas also with tropical or subtropical temperature. *Acacia concinna* plants are medium fast growing and which is bushy cum creeper, with curvy thorns (Troup 1921).

The species stands chance of being one of the potential sources of herbal product and medicine. The decoction of pods when used as hair wash removes dandruff kills lice and promotes hair growth. Cream made using extract of pod and coconut oil can cure skin disease. Decoction of pods used in skin diseases. The pods are bitter, astringent, dinsetic, emetic, deodorant, detergent, depurative and anthelinimitic. The powered pods are the best alternative to soaps in all cases of skin diseases Reddy and Nagaarjuna (1998).

The *Acacia concinna* plant has got the potential of plantation in waste land development in arid and semi-arid region as it requires very less water and does not require any high quality supervision. It will be a better substitute for medicinal purpose and herbal purpose crises. The major problems associate with *Acacia concinna* seed is poor germination, uneven and delay in germination. The main aim of the study is to find out the suitable seed treatment to enhance the germination *of Acacia concinna* seed.

MATERIAL AND METHODS

The seed of *Acacia concinna* was treated with various pre-sowing treatment due to its hard seed coat to improve germination rate in a short period of time through the artificial regeneration.

Hence, the present study was undertaken to evaluate the effect of pre-sowing treatments on *Acacia concinna* carried out at nursery of Department of Forestry, Post Graduate Institute, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola during year 2011-12.

Sowing Beds : The raised bed was prepared by giving a crosswise harrowing followed by stubble picking. Well-decomposed farmyard manure was spread up and mixed up with the soil. Raised bed of size 2.45 x 1.45 m^2 was prepared which consists of 30 plots of size 45 x 20 cm. In between two plots 5 x 5 cm distance was

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kept to separate out the plots. After preparing the beds BHC 10 per cent dust was applied to the bed to check the damage from termites to the seed.

Selection of seed : The fresh seeds were collected from the mother tree of *Acacia concinna* located near the Nagarjuna Medicinal garden Dr. P.D.K.V. campus, Akola. The mother tree was selected based on observations viz., Tree height (m), Age (yrs), Girth (D.B.H. in cm), Canopy (m), Estimated seed yield tree^{-1} (kg), Month of flowering, Time of fruiting, Average no. of pods/bunch, 100 seed weight (g), Number of branches, Seed size etc.

Experimental layout : An experiment was conducted in Randomized Block Design with ten treatments and replicated thrice having a total of 30 plots. Total numbers of fifty seeds were sown in each treatment per plot.

Treatment details

The following treatments were given for the present study- T1 :Thiourea (Treatment-5% time require 12 hours); T2 :Thiourea (Treatment-10% time required 2 hours); T3 :KNO_3 (Treatment -1% time required 12 hours); T4 :KNO_3 (Treatment 2% time required 12 hours); T5 :Conc. H_2 $S0_4$ for 5 Min. (Dipping in 20% H_2S0_4 for 5 min.); T6 :Conc. H_2 $S0_4$ for 10 Min. (Dipping in 20% H_2S0_4 for 10 min.); T7 :Seed soaking in tap Water (12 hours); T8 :Seed soaking in hot water (60^{0}c for10 min); T9 :Seed soaking in cow urine (12 hours); T10 :Control (untreated seeds)

The Observations were recorded up to 60 DAS from the day of sowing and average was computed and analyzed. Germination percentage (%), randomly five seedlings of each replication were selected and Shoot length (cm),Root length (cm) from the collar region was recorded, Seedling vigour index was calculated by adopting the method suggested by Abdul-Baki and Anderson (1973), Collar diameter (mm) measured with the help of vernier caliper, Seedling dry matter content (g) was calculated with subtraction of dry weight from fresh weight of leaves, shoots and roots by electronic balance, Days require for germination, Number of leaves per seedling, Fresh wt. of shoot (g) and Dry wt. of shoot (g) was recorded by electronic balance, The data obtained in the present investigation were statistically analysed by the method suggested by Panse and Sukhatme (1976) and means were taken for the comparison and interpretation of results.

Sowing of seeds : After completion of treatments, the treated as well as untreated seed were sown immediately on raised bed. The seeds were sown in lines by keeping uniform spacing (about 5 cm) between two rows and between two seeds. After sowing, the seeds were lightly covered with thin layer of soil. The bed was watered on alternate day with the help of watering can till germination takes place.

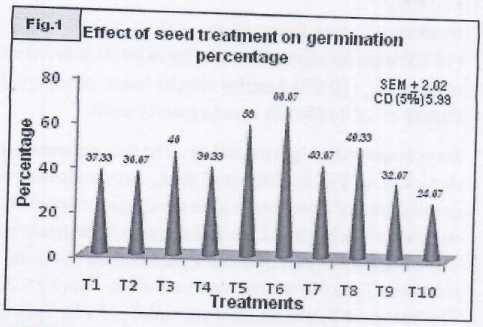
RESULTS AND DISCUSSION

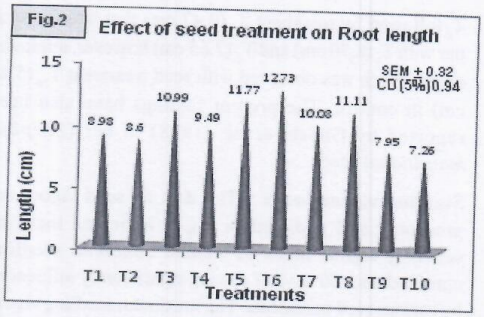
The present study was on suitable pre-sowing treatment on seed germination and it's vigour in *Acacia concinna* under rainfed agroclimatic condition. The results are observed and recorded on the various physiological and morphological characters. The effect of various seed treatments are discussed as below-

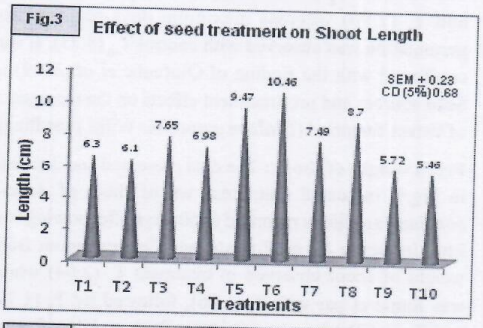
Germination percentage : The data presented and showed in Fig.1, indicated that, seed treatment significantly influenced the germination percentage of *Acacia concinna.* Significantly highest germination percentage (66.67%) was observed, when seed treated with concentrated. H_2SO_4 (Dipping in 20% for 10 min.) in (T_6) followed by (T_5) seed treated with concentrated. H_2SO_4 (Dipping in 20% for 5 min.) and (T_8) seed treated with hot water treatment for 10 min at 60^0 C (49.33%) where as minimum germination percentage was recorded in (T_{10}) control (24.67%). The present findings have conformity with the findings of Randhava *et al.* (1986) in *Cassia fistula* seeds, Patel and Kakadia (1996) in *Delonix regia* seeds, Sharma and Wadhera (2000) in Acacia seeds, Agboola *et al.*(2005) in *Albezia lebbeck* and *Cassia siamia* seeds.

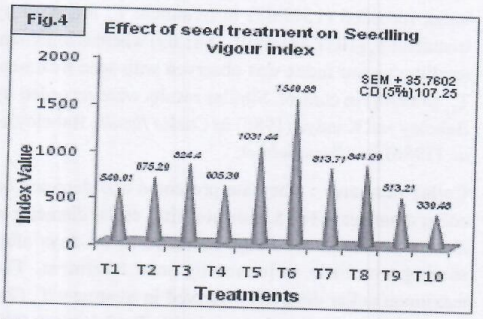
Root length : The data on root length presented and depicted in Fig.2, indicated that, the maximum root length recorded (12.73 cm) in treatment T_6 (dipping of seed in 20% H_2SO_4 for 10 min.) followed by (11.77 cm) in treatment T_5 (dipping of seed in 20% H_2SO_4 for 5 min.) that was found at par with (11.11 cm) T_8 (hot water treatment for 10 min at 60^{0}C) whereas minimum root length was observed with seed treatment (control) T_{10} (7.26 cm).Similar findings have confirmed with the finding of Ghosh, *et al.* (1988) in ber (*Ziziphus mauritiana*) seeds.

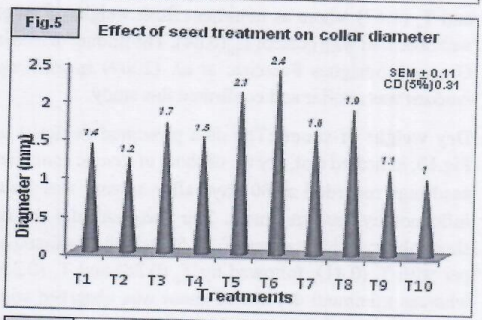
Shoot length : The data on shoot length presented and depicted in Fig.3, indicated that, the shoot length of *Acacia concinna* seedling uprooted after 60 days of sowing significantly influenced by various seed treatment. The maximum shoot length recorded (10.46 cm) in treatment

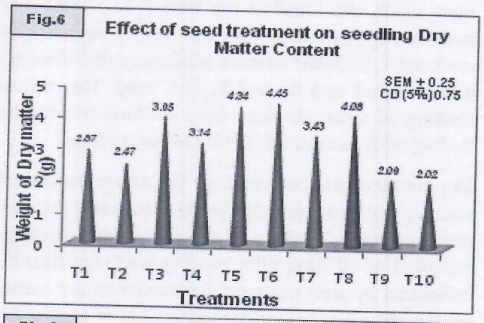


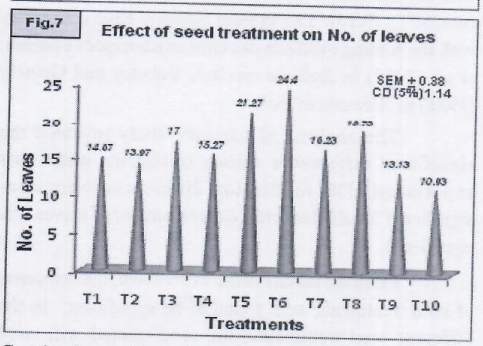


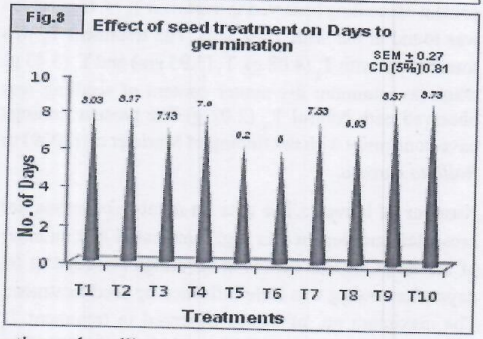












Graphs shows effect of pre-sowing treatments on seed germination and seedling vigour of Shikakai *(Acacia concinna)*

T_6 followed by treatment T_5 (9.47 cm) that was found at par with T_8 (8.70 cm) and T_3 (7.65 cm) however, minimum shoot length was observed with seed treatment T_{10} (5.46 cm) in control. The present findings have also been reported by Ghosh, *et al.* (1988) in ber (*Ziziphus mauritiana*) seeds.

Seedling vigour index : The data on seed vigour are presented and depicted in Fig.4, indicated that, the seedling vigour index of *Acacia concinna* seedling uprooted after 60 days of sowing significantly influenced by various seed treatments. The maximum seedling vigour index recorded (1549.88) in treatment T_6 followed by treatment T_5 (1031.44) and T_8 (841.09) whereas minimum seedling vigour index was observed with seed treatment T_{10} (339.48) in control. Similar results were recorded by Babeley and Kandya (1988) in *Cassia fistula,* Babeley, *et al.* (1986) in *Albizia lebbek.*

Collar diameter : The data presented and depicted on collar diameter in Fig.5, indicated that, collar diameter of *Acacia concinna* seedlings recorded at 60 days after sowing was little influence by seed treatment. The maximum collar diameter observed in treatment T_6 (2.4 mm) which was found at par with T_5 (2.1 mm). The treatment T_8 was found at par with T_3 (1.7 mm), T_7 (1.6 mm) and T_4 (1.5mm) whereas minimum collar diameter was observed with control T_{10} (1.0 mm). The present findings of collar diameter have conformity with the finding of Ghosh and Sen (1988) in ber seedling.

Dry matter content of seedling : The data presented and seedling dry matter depicted in Fig.6, indicated that, dry matter content of seedling of *Acacia concinna* seedlings recorded at 60 days after sowing was significantly influenced by seed treatment the maximum dry matter content of seedling observed in treatment T_6 (4.45 g) which was found at par with T_5 (4.34g). The treatment T_5 was found at par with T_8 (4.08 g), T_3 (3.95 gm) and T_7 (3.43 g) where as minimum dry matter content of seedling was observed with control T_{10} (2.02 g).The present findings have confirmity with the finding of Maria *et.al.* (2009) in *Rollinia mucosa.*

Number of leaves : The data on number of leaves are presented and depicted in Fig.7, indicated that, number of leaves of *Acacia concinna* seedlings recorded at 60 days after sowing was little influence by seed treatment. The maximum no. of leaves observed in treatment T_6 (24.40) which was found at par with T_5 (21.27). The treatment T_8 was found at par with T_3 (17.00), and T_7 (16.23) whereas minimum no. of leaves was observed with control T_{10} (10.93).Similar results were observed by Pathak *et. al.* (1980) in *Acacia tortilis* seeds.

Days required for germination : The data presented and depicted in Fig.8, indicated that, days required for germination of *Acacia concinna* seedlings recorded at 60 days after sowing was little influence by seed treatment. The minimum days required for germination observed in treatment T_6 (6.00) which was found at par with T_5(6.20). The treatment T_8 was found at par with T_3 (7.13), T_7 (7.53) and T_4 (7.90) whereas maximum days required for germination was observed with control T_{10} (8.73). It was confirmed with the finding of Olufunke *et al.*(2009) in Seed sources and pre-treatment effects on the emergence of Velvet Tamarind (*Dialium guineense* Willd.) seedlings.

Fresh weight of shoot : The data presented and depicted in Fig.9, indicated that, fresh wt. of shoot of *Acacia concinna* seedlings recorded at 60 days after sowing was little influence by seed treatment. The maximum fresh weight of shoot observed in treatment T_6 (2.04) which was found at par with T_5 (1.96), followed by T_8 (1.79) and T_3 (1.67) where as minimum fresh weight of shoot was observed with control T_{10} (0.64). The finding of Maria Gracas Rodrigues Ferreira; *et al.* (2009) in *Rollinia mucosa* was similar and confirmed this study.

Dry weight of shoot : The data presented depicted in Fig.10, indicated that, dry wt. of shoot of *Acacia concinna* seedlings recorded at 60 days after sowing was little influence by seed treatment. The maximum dry wt. of shoot observed in treatment T_6 (0.50) which was found at par with T_5 (0.41), followed by T_8 (0.38) and T_3 (0.35) whereas minimum dry wt. of shoot was observed with control T_{10} (0.16). The present findings have confirmity with the finding of Maria das Gracas Rodrigues Ferreira, *et al.* (2009) in *Rollinia mucosa,* Babeley and Gautam (1986) in *Albezzia lebbek.*

The analysis of variance study revealed the significant differences among treatments under this experiment. The replication differences were non-significant for all characters except number of leaves was significant.

From the results of the experiment, the responses of seed treatments were found to be significant. In the different seed treatments, the seed treated with acid treatment (dipping in 20% conc. H_2SO_4 for 10min.) prior

to sowing gave the maximum germination percentage, followed by acid treatment (dipping in 20% H_2SO_4 for 5 min.) and hot water treatment (at 60°c for 10 minutes).

LITERATURE CITED

Abdul-Baki, A. A. and J. D.Anderson, 1973. Vigour determination in soybean seed by multiple criteria, Crop Sci., Vol. 13: 630-633.

Agboola, D. A., A. O. Ebotin, A. M. Aduradul and A. A. Ajiboye, 2005. The effect of pre-sowing treatment on the germination of seeds of two savannah tree legumes, Indian Forester, Vol. 131(5): 701-710.

Babeley, G. S and A. K. Kandya, 1985.Effect of various pretreatments on germination and vigour of *Leucaena leucocephala* (Lam.) de Wit. Seeds, J. Trop. Forestry. 1(1): 85-90.

Babeley, G. S. and S. P. Gautam and A. K. Kandya, 1986. Pre-treatment of *Albizzia lebbeck* Benth. Seeds to obtain better germination and vigour, J. Tropical Forestry, Vol. 2(11): 105-113.

Ghosh, S. N. and S. K. Sen, 1988. Effect of seed treatment on germination, seedling growth and longevity of ber (*Ziziphus mauritiana* Lank) seeds, South Indian Hort., 36(5):260-261.

Krishnan, B. M. and M. Kulasekaran, 1984. Studies on seed germination in wild ber (*Zizyphus rotundifolia*), South Indian Hort. :153-154.

Laurie, M.V., 1974. Tree planting practices in African Savannas.FAO For. Dev. Paper No. 19. FAO Rome, Madras Agri. Journal, 97 : 1/3 21.

Maria, D., G. R. Ferreira, A. D. Santos, E. D. O. Silva, E. P. Goncalves, E. U. Alves and R. D. L. A. Bruno, 2009. Overcoming dormancy in seeds of *Rollinia mucosa* (Jacq.) Baill, Rev. Bras. Sementes, Vol. 31(4).

Olufunke, Olayodeand E., Alaba Ghadamosi, 2009. Seed sources and pre-treatment effects on the emergence of Velvet Tamarind (*Dialium guineense* Willd.) seedlings, J. Sust. Forestry, 28: 895-903.

Panse, V.G. and P.V. Sukhatme, 1976. Statistical method for Agricultural Workers, New Delhi, ICAR, 123-159.

Patel , V. S. and M. U. Kakadia, 1996. Effect of pre-sowing treatments for *Delonix regia* (Boj) Rafin. seeds, J. Tropical Forestry, vol. 2 (ii): 101-103.

Pathak, P. S., S. K. Gupta and R. Deb Roy, 1980. Studies on seed polymorphism, germination and seedling growth of *Acacia tortilis* Hayne, Indian J. Forestry, Vol. 3(1):64-67.

Randhawa, H. S., H. L. Sharma, Jagmeet Kaur and G. S. Rattan, 1986. The acceleration of germination of *Cassia fistula*: fungi associated with rotting seeds and abnormal seedlings, Indian Forester; 524-527.

Reddy and Nagaarjuna, 1998. Inhibition of inflorescence in *Acacia concinna* D.C. by gall formation, Indian Forester, 267-269.

Sharma A. and S. L. Wadhera, 2000. Pre-treatments for hastening seed germination and seedling growth in *Acacia catechu* Willd., Vaniki Sandesh; 24: 4, 11-13. 7.

Troup R.S 1921. The Silviculture of Indian Trees, Clarendon Press. Volume I, 178-183.

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Solar Cabinet Dryer Coupled with Thermal Storage System for Drying Ginger Slices

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ABSTRACT

A solar cabinet dryer coupled with heat storage system has been developed in the Department of Unconventional Energy Sources & Electrical Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for drying ginger slices. The loading capacity of the dryer was about 10 kg slices per batch. The drying characteristics of the dryer were studied and compared with open sun drying method. The maximum temperature attained in solar cabinet dryer was 53.0, 54.3, 54.8, 55.00 and 55.8 °C in T_1, T_2, T_3, T_4 and T_5 drying trays, respectively. The average ambient temperature, solar intensity, relative humidity and wind velocity was obsereved to be 35.91°C, 472.53 W/m^2, 16.32 per cent and 0.76 m/s, respectively. The maximum temperature developed in heat storage system was recorded to be 67.46°C whereas, the average ambient temperature was varied from 28 to 39.9°C. Drying time for drying ginger slices for reducing its moisture content from 79.51 per cent to 9.67per cent (wb) was found to be 15 h in solar cabinet dryer whereas, 17.25 h was observed in the open sun drying method. The heat storage system containing gravel with iron scrap extended the drying hours by 3 h after sunset also. The colour of solar dried ginger slices was found better as compared to open sun dried ginger slices. The powder of ginger slices dried in dryer was prepared and had good quality, colour, appearance, taste, smell and overall acceptability than open sun dried ginger powder. The content of fats 2.06 per cent and 1.86 per cent was observed in ginger powder prepared from the slices dried in solar cabinet dryer and in open sun drying, respectively.

India has a daily solar potential of 4 to 7 kWh/m^2 with about 1500–2000 sunshine hours annually. This available solar potential of 600 TW (5 x 10^{12} kWh year^{-1}) is much more than the current energy consumption (Salam *et al.*, 2012). Drying of fruit and vegetables is one of the oldest methods of food preservation. In addition, drying enhances the storability, transportability, nutritional value retention, flavour and texture of food products reducing moisture content of foodstuff down to a certain level slows down the action of enzymes, bacteria, yeasts and molds. Thus food can be stored and preserved for long time without spoilage (Jithinraj and Karim, 2014). Solar energy is by far the most attractive alternative energy sources for the future. But the main problem of solar energy is its intermittent nature. However, solar drying is in practice since long time for preservation of food and agricultural crops.

This was done particularly by open sun drying under the open to sky. This process has several disadvantages like spoilage of product due to adverse climatic conditions like rain, wind, moist, dust, loss of material due to birds and animals. Solar cabinet dryer with heat storage system become popular due to considerable reduction in drying time and significant improvement of product. Solar dryer for domestic as well as industrial usage could be an effective alternative of saving conventional energy. The provision of heat storage material in solar cabinet dryer such as gravels, sand, iron scraps, etc. which can store the heat energy during sunshine hours and provide the heat during off sunshine hours. By the introduction of heat storage system in solar dryer, additional drying hours could be made available (Bal *et al.*, 2010; Chauhan *et al.*, 1996, Mohanraj and Chandrasekar, 2009).

Thermal storage system enable drying to continue after sunset provided there is enough sunshine during the day. However, the intensity of solar radiation is sometimes so low that the temperature of the thermal mass rises by a very small (or no) margin above the ambient level. So, this still limits the continuity of the drying process in a solar dryer with a thermal mass (Madhlopa *et al.*, 2002; Anuradha and Oommen, 2013 and Ayyappan and Mayilsamy, 2012).

In many cases continuous drying is preferred. However, solar cabinet dryer is operated only during day time for 8 to 9 h. The conventional source of energy is to be used to continue the drying after sun set. Thermal

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storage system could be coupled with the solar dryer to improve its efficiency, operating hours of solar dryers (Kamble *et al.*, 2013). This could also save conventional source of energy. In view of the above, there was need to study solar dryer with heat storage system for drying vegetable. Therefore the study was undertaken on solar cabinet dryer with heat storage system for drying ginger slices. Ginger is an important spice cash crop of the world. It is one of the earliest known oriental spices and is being cultivated in India for both as fresh vegetable and as a dried spice. Ginger and its products have varied applications in culinary preparation, bakery products, toiletry products, perfume industries, meat products, wine, and soft drinks making. Dried ginger is used both as a spice and medicine (Deshmukh *et al.*, 2014). Dry ginger contains essential oil 1-3 per cent, oleoresin 5-10 per cent, starch 50-55 per cent, moisture 7-12 per cent with small quantities of protein, fiber, fat and ash (Eze and Agbo, 2011 and Jayashree *et al.*, 2012).

MATERIAL AND METHODS

The solar cabinet dryer integrated with heat storage system was developed in the Department of Unconventional Energy Sources & Electrical Engineering, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Dr. PDKV) and it is shown in Fig.1.

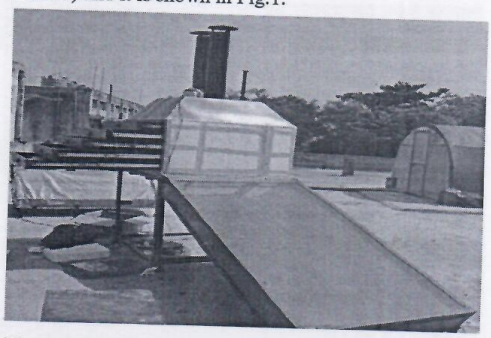

Fig. 1 Solar cabinet dryer coupled with heat storage system

The performance of solar cabinet dryer with heat storage system was evaluated at full load condition. Under the full load condition (10 kg batch^{-1}) the ginger slices were spread over the stainless steel wire mesh drying trays. The experiment was conducted in the month of April 2015. The initial weight of the samples was recorded. The sample of 100 gm of fresh ginger slices were placed in all five trays of the dryer. The weight loss was recorded at an interval of one hour and simultaneously the temperature, relative humidity, solar radiation and air velocity inside the solar cabinet dryer were also recorded. Drying was carried out between 8:30 to 20:30 h with heat storage system.

The freshly harvested gingers were properly washed in fresh running water and then they were cut into slices of 4-6 mm thickness. The initial moisture content of the sliced ginger was determined by hot air oven. The ginger slices of were spread uniformly with a thin layer in the five trays of the solar cabinet dryer containing 2000 g each (Fig. 2 and 3). The temperature attended in the drying chamber, weight loss of ginger slices, relative humidity, air velocity and ambient condition and temperature developed in the heat storage system were observed. The sample of ginger slices were also kept for open sun drying for comparing the data obtained from the solar cabinet dryer.

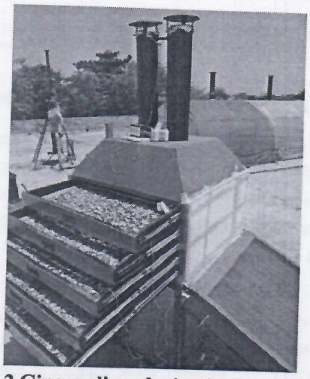

Fig.2 Ginger slices drying in day time

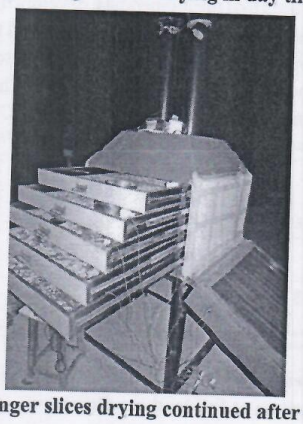

Fig.3 Ginger slices drying continued after sunset

RESULTS AND DISCUSSION

Drying kinetics of ginger (*Zingiber officinale*) slices

The solar cabinet dryer with heat storage system was evaluated for drying of ginger slices. The maximum temperature attained in solar cabinet dryer was 53.0, 54.3, 54.8, 55.0 and 55.8 °C in T_1, T_2, T_3, T_4 and T_5 drying trays, respectively (Fig 4). The average ambient temperature, solar intensity, relative humidity and wind velocity was observed to be 35.91°C, 472.53 W/m², 16.32 per cent and 0.76 m/s, respectively.

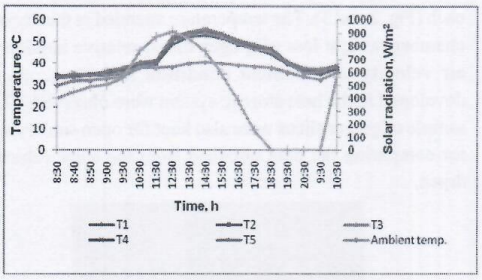

Fig. 4 Temperature variation in solar cabinet dryer

From Fig. 4 it is seen that the heat storage system supplied the heat to the drying chamber during off sunshine hour and remarkable difference in temperature of drying chamber and ambient temperature was obsereved upto 20:30 h .

The temperature developed in the heat storage system of solar cabinet dryer during day time and after sunset was measured at upper and lower layer of heat storage bed viz., bottom, middle and top positions. From Fig. 5 it is seen that the temperature developed in the heat storage system at its upper layer was observed to be 36.81 to 55, 38.94 to 68.23, 38.80 to 67.46°C at bottom, middle and top position, respectively (Fig. 5). The ambient temperature was varied from 28 to 39.9°C and solar intensity was varied from 98.90 to 933.80 W/m².

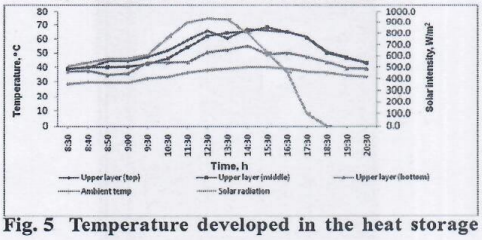

Fig. 5 Temperature developed in the heat storage system at full load condition

The variation in moisture content of ginger slices dried in solar cabinet dryer and open sun drying (OSD) are given in Fig 6. The moisture content of ginger slices samples dried in solar cabinet dryer reduced from 79.51 to 9.67 per cent (wb) in 15 h, in solar cabinet dyer whereas, it was found to be 17.25 h in open sun drying in the month of April 2015 (Fig. 6).

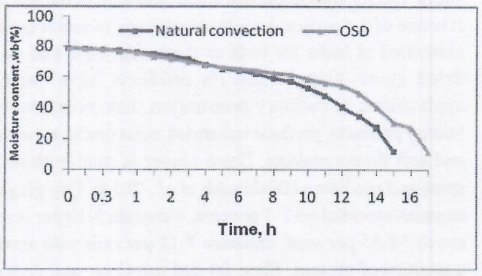

Fig. 6 Variation in moisture content of ginger slices in solar cabinet dryer and open sun drying

The solar dried and open sun dried ginger slices are shown in Fig 7 and 8, respectively. From Fig 7 and 8 it is clearly seen that the remarkable difference is clearly in dark green colour of the dried ginger slices which fetch as good market value.

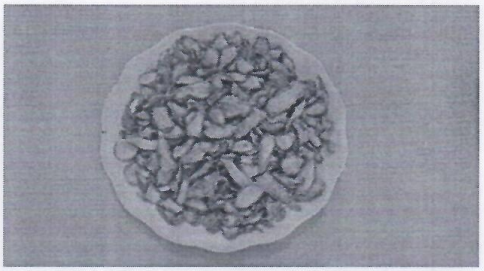

Fig. 7 Solar dried ginger slices

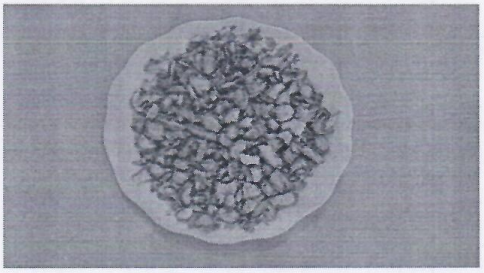

Fig. 8 Open sun dried ginger slices

The ginger powder was prepared from the ginger slices dried in solar cabinet dryer and in open sun drying method and its composition is given in Table 2. The composition of market ginger powder was also found out for the comparison point of view. It is seen from Table 1 that higher percentage of fat was retained in the ginger slices dried in solar cabinet than that of the open sun dried and market ginger powder.

Table 1. Composition of ginger powder

Composition (%)	Ginger powder samples		
	S_1	S_2	S_3
Moisture content (per cent)	11.43	8.91	7.72
Ash content, per cent	4.27	4.08	4.03
Fat, per cent	1.863	2.060	1.137

S_1 - Powder prepared from sun dried ginger slices
S_2 - Powder prepared from solar cabinet dryer
S_3 - Market ginger powder

Sensory evaluation of ginger powder

The samples of ginger powder were subjected to sensory evaluation testing using 1-9 hedonic scale (Rahman, 2013). The samples of ginger powder viz., sun dried ginger powder (S_1), cabinet dryer dried ginger powder (S_2) and market ginger powder (S_3) was given to the ten panelists for sensory evaluation. The mean scores of color, pungency, smell and overall acceptability of different samples are presented in Table 2. The mean values of sun dried ginger powder (S_1) and market ginger powder (S_3) was found at par with each other whereas, the mean value of the sample of cabinet dryer dried ginger powder had significant difference. The quality attributes i.e. colour had a significant difference whereas, other three attributes viz., pungency, smell and overall acceptability were at par with each other.

Table 2. Sensory evaluation of ginger powder samples

Factor	Means				CD (5%)	CV, %
Samples	6.450^a (S_1)	7.325^b (S_2)	6.500^a (S_3)		0.359	11.97
Quality Attributes	7.367^a (Color and appearance)	6.67^b (Taste/pungency)	6.567^b (Smell)	6.433^b (Overall acceptability)	0.415	

Note: The row-wise values superscripted by similar letter were at par with each other
S_1 - Powder prepared from sun dried ginger slices
S_2 - Powder prepared from solar cabinet dryer
S_3 - Market ginger powder

CONCLUSION

The drying time required for drying 10 kg of ginger slices from 79.51 to 9.67 per cent (wb) was found to be 15 h in solar cabinet dryer whereas, 17.25 h in open sun drying method. It was observed that the heat storage system supplied heat for about 3 h after sunset also. The ginger powder obtained from solar cabinet dryer was found to be in dark green colour, better in smell and taste as compared to open sun dried ginger powder sample.

LITERATURE CITED

Anuradha and R. Oommen, 2013. Analysis and study of solar dryer for cauliflower and ladies finger drying with pebble bed storage system, International J. Recent Scien. Res., 4(10): 1571-1574.

Ayyappan, S. and K. Mayilsamy, 2012. Solar tunnel dryer with thermal storage for drying of copra. International, J. Energy Techno.y and Policy. 8(1): 3-12.

Bal, L. M., S. Satya and S. N. Naik, 2010. Solar dryer with thermal energy storage systems for drying agricultural food products, Renewable and Sustainable Energy Reviews,14 (8):2298–2314.

Chauhan, P.M., C. Choudhury and H.P. Garg, 1996. Comparative performance of coriander dryer coupled to solar air heater and solar air-heater-cum-rockbed storage, Applied Thermal Engineering. 16(6): 475-486.

Deshmukh, A. W., M. N. Varma, K.Y. Chang and K. L. Wasewar, 2014. Investigation of solar drying of ginger (*zingiber officinale*): Empirical modeling, drying characteristics and quality study, Chinese J. Engg.,1-7.

Eze, J.I. and K.E. Agbo, 2011. Comparative studies of sun and solar drying of peeled and unpeeled ginger, American J. Scien. and Indus. Res., 2(2): 136-143.

Jayashree, E. and R. Visvanathan and J. T. Zachariah, 2012. Quality of dry ginger (*Zingiber officinale*) by different drying methods, J. Food Sci. and Tech.

Jithinraj, T. and A. A. Karim, 2014. Experimental analysis on multi pass flat plate collector solar air dryer, International J. Emerging Engg. Res. and Tech., 2:1-11.

Kamble, A.K., I. L. Pardeshi., P. L. Singh and G. S. Ade, 2013. Drying of chilli using solar cabinet dryer coupled with gravel bed heat storage system, J. Food Res. and Tech. 1(2): 87-94.

Madhlopa, A., S. A. Jones and J.D.K. Saka, 2002. A solar air heater with composite-absorber systems for food dehydration, Renewable Energy 27:27-37.

Mohanraj, M. and P. Chandrasekar 2009. Performance of a forced convection solar dryer integrated with Gravel as heat storage material for chilli drying, J, Engg, Sci, and Tech., Vol. 4(3) : 305-314.

Rahman, M.J., M.A.I. Talukder, L. Rani, K. C. Saha and M. S. I. Nahid, 2013. The effect of processing techniques on the shelf life, nutritional and sensory quality of ginger (*Zingiber officinale*) powder and paste, J. Innovation & Develop. Strategy.7(3):60-66.

Salam, A. A., R. Anjan, B. Srivatsa and R. Senthil, 2012. Thermal performance analysis on solar integrated collector storage, Academic Res. Journal (UARJ). 1(2) : 111-114.

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Development and Evaluation of Turmeric Slicing Machine

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ABSTRACT

Turmeric Cutting cum slicing machine is developed to meet the requirement of small scale entrepreneurs and also the farmers who are interested to set up their own rural level low capacity turmeric processing plant with low initial investment for preparation of turmeric powder. Turmeric cutting cum slicing machine has centrifugal action and consists of hollow drum with beaters, stationary blade and a rotor plate. The performance of the developed turmeric slicer was found satisfactory and the machine was found to be techno-economically feasible for the entrepreneur. The slicing efficiency, damage percentage and capacity of the machine for slicing of turmeric rhizomes were found to be 74.74 per cent, 24.85 per cent and 383 kg h^{-1}, respectively.

India ranks first with 90 per cent production of turmeric. India produced 1189.89 thousand tonnes turmeric from 232.67 thousand ha area during the year 2013-14 whereas Maharashtra produced 11.00 thousand tones turmeric from 11.00 thousand ha area for the year 2013-14. (Horticultural Statistics at a Glance 2015). Because of increasing demand of turmeric in the market with good market returns and fluctuations in the market of other cash crops, turmeric is emerging as an assured cash crop in Maharashtra. The whole turmeric is a unique, colorful and versatile plant product combining properties of a spice or flavoring with added features being a colourant, a cosmetic and a drug useful in a number of diseases.

Turmeric processing involves cleaning / washing, boiling of turmeric rhizomes, drying and polishing. Cutting / slicing of turmeric rhizomes is necessary in order to achieve fast drying for preparation of turmeric powder since drying of boiled turmeric rhizomes consumes much time (8 to 10 days) to reduce the moisture up to 8 to 10% (Gunasekar *et. al.*, 2009). Although the mechanical slicers are available in market but these are very costly and are beyond the limit of small entrepreneur. After washing, slicing and drying the turmeric rhizomes are valued for aroma, flavor and pungency. Therefore, post harvest equipments for turmeric cutting/slicing machine for farmers/entrepreneurs are being developed to mechanize primary processing activities of turmeric (such as cutting/ slicing) after harvest, thereby reducing drudgery involved and labor cost.

MATERIAL AND METHODS

Development of turmeric cutting cum slicing machine

The power operated turmeric cutting cum slicing machine (Plate 1) has been developed using locally available materials. The machine consists of the feeding unit, slicing mechanism, driving mechanism, frame and the housing. The principle of centrifugal action is adopted. The washed turmeric rhizomes fed through hopper are subjected to centrifugal force and strikes on the stationary SS blade fixed on the casing. The machine cuts the turmeric rhizomes into slices of desired thickness from (2 to 5 mm). The slices are collected through outlet provided below the blade.

Plate 1: PDKV Turmeric slicer

1 & 5. Assistant Professor, 2. Research Engineer, 3. Assoicate Professor and 4. Research Fellow, AICRP on PHET, Dr. PDKV,Akola

Performance evaluation of turmeric slicing/cutting machine

The performance of the developed turmeric slicer was studied. Fully matured turmeric rhizomes were procured from the farmers field. The thoroughly washed and cleaned turmeric rhizomes were fed into the hopper of the slicer. After slicing, complete slices and damaged slices were separated and weighed.

The performance of the machine was evaluated using the following formulae (Aniyi, 2006).

1. **Cutting Efficiency (CE)**

$$\text{Cutting efficiency (CE)} = \frac{W - WD}{W} \times 100$$

Where W = Weight of all slices

W_D = Weight of damaged slices

2. **Per cent Damage (PD)**

$$\text{Per cent damage} = \frac{WD}{W} \times 100$$

3. **Capacity of the turmeric slicer**

The throughput of the machine was determined by calculating the time of operation and weight of the raw material sliced.

Capacity (kg/h) = [Quantity (wt)of sliced turmeric(kg) / Operating time (s)] × 3600

RESULTS AND DISCUSSION

Physical Properties of turmeric rhizomes

The physical properties of turmeric rhizomes were studied for development of the turmeric slicer (Table 1).

Table 1: Physical properties of turmeric

Physical property	Primary finger, raw	
	Range	Average value
Length, cm	6.88-9.90	9.14
Diameter, cm	1.82-2.50	2.13
Bulk density, kg/m^3	305-322	311
Angle of repose, °	32.29-34	33.15

Fabrication of turmeric cutting cum slicing machine

1. **Hopper/Feeding unit** – The feed hopper of size 280 x 305 x 242 mm with slope of 35° is fabricated using 24 gauge SS sheet with bottom opening of 75 mm length.
2. **Rotor plate** – A rotor plate (152 mm diameter, thickness 6 mm) is provided inside the housing to which a hollow rotating drum is coupled.
3. **Rotating hollow drum/Striking unit**– It comprises of 3 stainless steel (SS) flat plates which are coupled at the periphery of two circular SS plates at 120° included angle. One circular plate is provided with the hole at the centre (30 mm dia.) for coupling shaft of rotor plate with nut. The material fed to machine through hopper is thrown towards the stationary cutting blade by centrifugal action due to high speed (300-500 rpm) of rotating drum with flat plates.
4. **Casing/housing unit** – The casing is a cylindrical structure with SS sheet (3 mm thick) rounded and welded to cover the hollow drum to receive the material from the hopper.
5. **Cutting/Slicing unit** – It consists of the stationary SS cutting blade fixed on the casing having bevel angle of 22°.
6. **Thickness controlling unit** – It consists of control knob/screw and spring mechanism for controlling slice thickness by pressing the plate above SS cutting blade and varying the clearence.
7. **Outlet/ Discharge unit** – The outlet is trapezoidal shape of 204 x 204 x 102 mm size. Output of slicing unit is guided on discharge chute.
8. **Drive mechanism** – Single phase one horse power electric motor, pulleys and V-belts are used to drive rotor.
9. **Supporting Frame** – The supporting frame of 610 (L) x 458 (W) x 900 mm (H) mm size is fabricated using MS angle (40 x 5 mm) for mounting the rotor assembly, feeding unit and motor components of turmeric slicing machine.

Performance evaluation

As per 3 variable 3 level Box Behnken model, 17 trials were performed as enumerated in Table 2 for obtaining the slicing efficiency, per cent damage and capacity responses for each treatment. To avoid bias, 17 runs were performed in a random order. The decision for the range and centre points of the variables was taken through preliminary trials. The independent variables i.e. rotor speed, slice thickness and duration, the coded

Table 2. Experimental layout for three variables and three levels response surface analysis

Tr. No.	Rotor speed, rpm x_1	Slice thickness, mm x_2	Duration, days x_3	Rotor speed, rpm X_1	Slice thickness, mm X_2	Duration, after harvesting days X_3
1	0	1	-1	400	4.5	00
2	0	0	0	400	3.5	15
3	-1	0	1	300	3.5	30
4	1	0	-1	500	3.5	00
5	0	1	1	400	4.5	30
6	1	0	1	500	3.5	30
7	0	0	0	400	3.5	15
8	0	-1	-1	400	2.5	00
9	-1	-1	0	300	2.5	15
10	-1	0	-1	300	3.5	00
11	1	-1	0	500	2.5	15
12	1	1	0	500	4.5	15
13	-1	1	0	300	4.5	15
14	0	0	0	400	3.5	15
15	0	0	0	400	3.5	15
16	0	-1	1	400	2.5	30
17	0	0	0	400	3.5	15

Table 3:ANOVA for effect of slicing variables on slicing efficiency

Source	Df	Sum of Square	Mean sum of square	F Value	p-value Prob>Fig	
Model	4	76.10	19.02	75.96	< 0.0001	Significant
A-Rotor speed	1	9.42	9.42	37.60	< 0.0001	
B-Slice thickness	1	50.95	50.95	203.45	< 0.0001	
C-Duration	1	4.34	4.34	17.31	0.0013	
A^2	1	11.39	11.39	45.47	< 0.0001	
Residual	12	3.01	0.25			
Lack of Fit	8	2.04	0.25	1.05	0.5175	Non significant
Pure Error	4	0.97	0.24			
Cor Total	16	79.10				

variables (X_1), decoded variables and their levels are presented in Table 2, as described by Pokharkar (1994), Chowdhury *et al.* (2000), Ravindra and Chattopadhyay (2000), Jain (2007), Singh *et al.* (2008), Ranmode (2009) and Borkar (2011).

1. Effect of input parameters on slicing efficiency

The slicing efficiency was observed to be ranging from 66.66 to 75.08 % depending upon the slicing treatments. The minimum slicing efficiency was found for treatment having the combination of rotor speed of 500 rpm, slice thickness of 3.5 mm and duration 30 days. The maximum slicing efficiency was observed in case of treatment having the combination of rotor speed of 400 rpm, slice thickness of 2.5 mm and duration zero days i.e. fresh sample.

The analysis of variance (ANOVA) was carried out for the experimental data and the significance of rotor speed, slice thickness and duration as well as their

interactions on slicing efficiency was analyzed. The response surface quadratic model was fitted to the experimental data and statistical significance of linear, interaction and quadratic effects were analyzed for slicing efficiency response (Table 3). It revealed that the model was highly significant at 1 per cent level of significance.

The results showed that among linear effects, slice thickness had significant effect on dehulling efficiency ($P<0.01$) at 1 per cent level of significance followed by rotor speed and the effect of duration was found least. Quadratic effect of rotor speed had significant effect on slicing efficiency ($P<0.01$) at 1 per cent level of significance. The existence of quadratic terms indicates the curvy linear nature. It indicates that increasing the value of variable initially increases the response up to certain level of variable however further increase in the level of variable decreases the value of response.

The data regarding weight of different fractions, weight of whole slices, weight of damaged slices and weight of total slices, slicing efficiency, damage percent and capacity obtained with different combination of variables were calculated. The minimum slicing efficiency was found in treatment having the combination of rotor speed 500 rpm, slice thickness 3.5 mm and duration 30 days while the maximum slicing efficiency found in treatment having the combination of rotor speed 400 rpm, slice thickness 2.5 mm and duration zero days i.e. fresh. The quadratic response surface model data indicated the results as significant. The lack of fit was found to be non significant and hence the model was significant. The coefficient of determination (R^2) was 0.9620 for slicing treatment and thus indicated that the model could fit the data for slicing activity very well for all the three variables, i.e. of rotor speed, slice thickness and duration (days) after harvesting. The linear terms of all the three parameters showed effect on slicing efficiency however the interaction terms were about showing nonsignificant effect. The quadratic terms of rotor speed only showed significant effect.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

$$\text{Slicing efficiency, \%} = 71.30 - 1.08X_1 - 2.52X_2 - 0.74X_3 - 1.64X_1^2 \quad \ldots\ldots\ldots 1$$

Where,

X_1 = rotor speed, rpm
X_2 = slice thickness, mm
X_3 = duration after harvesting, days

1.1 Effect of rotor speed and duration on slicing efficiency

The effect of rotor speed and duration on slicing efficiency was determined keeping slice thickness constant at 2.5 mm which is shown in Fig. 1. Three dimensional responses for slicing efficiency of samples were generated. From these surfaces, it could be evident that slicing efficiency initially increased with increase in rotor speed and then started decreasing, thereby indicating the existence of optimum levels of parameter within the selected range. Since as rotor speed increased the amount of slices increased with less damaged slices upto certain speed, and further increase in rotor speed resulted in more damaged slice because of which the slicing efficiency decreased. Duration after harvesting was found to have very less effect on slicing efficiency as compared to other parameters.

1.2 Effect of rotor speed and slice thickness on slicing efficiency

The effect of rotor speed and slice thickness on slicing efficiency was determined keeping duration after harvesting constant at 15 days (Fig. 2). It could be observed that with increase in rotor speed, the slicing efficiency increased at a particular rotor speed and then decreased. It was observed that the slicing efficiency was found maximum at 2.5 mm slice thickness and as the slice thickness increased the slicing the slicing efficiency decreased.

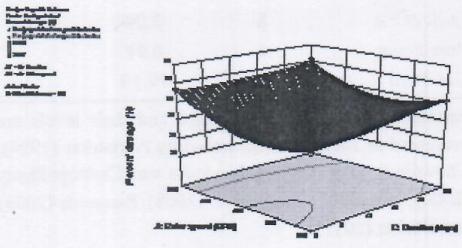

Fig. 1: Effect of rotor speed and duration after harvest on slicing efficiency

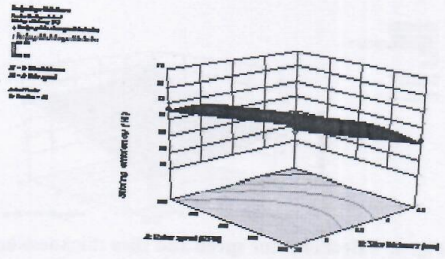

Fig 2: Effect of rotor speed and slice thickness on slicing efficiency

1.3 Effect of slicing treatments on percent damage

The percent damage was observed to be ranging from 24.91 to 33.33 per cent depending upon the slicing treatments. The minimum percent damage was found for treatment having the combination of rotor speed 400 rpm, slice thickness 2.5 mm and duration zero days i.e. fresh sample. The maximum percent damage was observed in case of treatment having the combination of rotor speed 500 rpm, slice thickness 4.5 mm and duration after harvest15 days.

The ANOVA in Table 4 revealed that the model was highly significant at 5 per cent level of significance. The results showed that among linear effects, slice thickness had significant effect on percent damage ($P<0.05$) at 5 % level of significance followed by rotor speed and duration after harvest. All the interaction and quadratic effects were found significant for percent damage.

The lack of fit was non significant and hence the model was significant. The coefficient of determination (R^2) was 0.9774 for slicing which indicated that the model could fit the data for activity very well for all the three variables, i.e. rotor speed, slice thickness and duration.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

$$\text{Percent damage, \%} = 28.46 + 1.09\,X_1 + 2.52X_2 + 0.74\,X_3 + 0.067X_1\,X_2 - 0.36\,X_1X_3 - 0.23\,X_2X_3 + 1.80\,X_1^2 - 0.18X_2^2 + 0.31\,X_3^2 \quad \ldots\ldots 2$$

Where,

X_1 = rotor speed (rpm)
X_2 = slice thickness, mm
X_3 = duration, days

1.4 Effect of rotor speed and duration on percent damage

The effect of rotor speed and duration after harvesting on percent damage was determined keeping the slice thickness constant at 3.5 mm which is shown in Fig. 3. Three dimensional responses for percent damage

Table 4: ANOVA for effect of slicing treatment variables on percent damage

Source	Df	Sum of Square	Mean sum of square	FValue	p-valueProb>F	
Model	9	79.78	8.86	29.57	< 0.0001	Significant
A-Rotor speed	1	9.42	9.42	31.42	0.0008	
B-Slice thickness	1	50.95	50.95	169.99	< 0.0001	
C-Duration	1	4.34	4.34	14.47	0.0067	
AB	1	0.018	0.018	0.061	0.8123	
AC	1	0.53	0.53	1.75	0.2270	
BC	1	0.20	0.20	0.68	0.4382	
A^2	1	13.61	13.61	45.41	0.0003	
B^2	1	0.14	0.14	0.45	0.5227	
C^2	1	0.41	0.41	1.35	0.2827	
Residual	7	2.10	0.30			
Lack of Fit	3	0.75	0.25	0.74	0.5819	Non significant
Pure Error	4	1.35	0.34			
Cor Total	16	81.87				

NS= Non significant S= Significant

of samples were generated. From these surfaces, it could be evident that percent damage was initially high and decreased with increasing rotor speed to some extent and then started increasing with increase in rotor speed within the selected range. As the duration increased, percent damage increased. This was due to reduced moisture content as duration after harvest increased.

1.5 Effect of rotor speed and slice thickness on percent damage

The effect of rotor speed and slice thickness on percent damage was determined keeping duration after harvest constant at 15 days (Fig. 4). The percent damage was found decreasing as the rotor speed increased to some extent and then the damage was found increasing at higher rotor speed. The percent damage was found increased significantly as the thickness of slice increased.

1.6 Effect of duration and slice thickness on percent damage

The effect of duration and slice thickness on percent damage is shown in Fig. 5. Three dimensional responses for percent damage during slicing were generated. From these surfaces, it could be evident that percent damage increased with increase in duration and slice thickness but effect of slice thickness on percent damage was more as compared to the effect of duration after harvest.

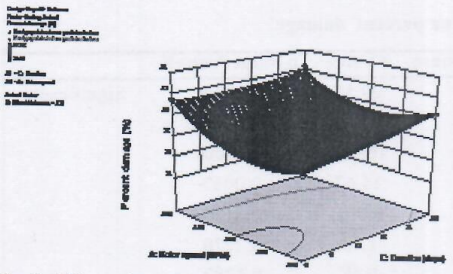

Fig. 3. Effect of rotor speed and duration after harvest on percent damage

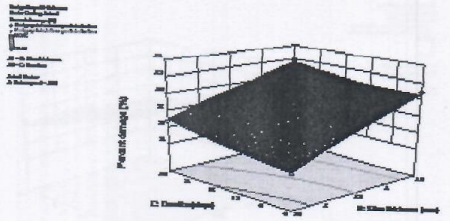

Fig. 4. Effect of rotor speed and slice thickness on percent damage

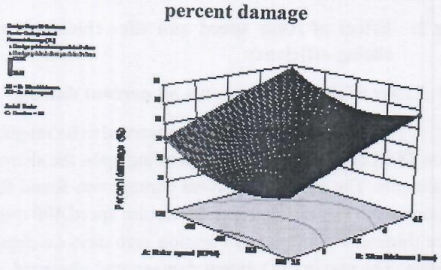

Fig. 5. Effect of duration and slice thickness on percent damage

Optimization of slicing treatment variables

Trial version of software Design Expert version 9.0.3.1 was used for the optimization of responses. A stationary point at which the slope of the response surface was zero in all the direction was calculated by partially differentiating the model with respect to each variable, equating these derivatives to zero and simultaneously solving the resulting equations. The optimum values of slicing with various treatments were evaluated using equation 1 and 2 the multiple regression package was used for purpose. The response surface quadratic model optimized parameters as rotor speed 400 rpm, slice thickness 2.5 mm and duration after harvest zero days i.e. fresh sample gave predicted value of slicing efficiency 74.74 % and percent damage 24.85%. The optimum values for different variables and their predicted responses thus obtained are given in Table 5 as well as Fig. 6 and Fig. 7.

Table 5: Optimized variables and their responses for slicing of turmeric rhizomes

Variable	Optimized values	Responses	Predicted values
Rotor speed, rpm	400	Slicing efficiency, %	74.74
Slice thickness, mm	2.5	Percent damage, %	24.85
Duration, days	0	Capacity, kg h^{-1}	383.94
R^2	0.975		

The optimum values of different variables for slicing were found within the range considered in the study.

Validity of the Model

The performance of this model was also verified by conducting an experiment for the validation. In order to validate the optimum conditions of slicing treatment variables, the experiment was conducted at derived conditions. The data regarding slicing efficiency, percent damage and capacity obtained of optimized condition of variable is given in Table 6. The predicted values of slicing efficiency, percent damage and capacity were 74.74 per cent and 24.85 per cent, respectively. These were experimentally verified and observed values of slicing efficiency, percent damage and capacity were found to be 73.95 per cent and 23.28 per cent, respectively, It revealed that the experimental values were very close to the predicted values which confirmed the optimum conditions.

Table 6: Predicted and experimental values of responses at optimum level of different variables

S. N.	Responses	Predicted values	Experimental values
1	Slicing efficiency, %	74.74	73.95 (± 1.09)
2	Percent damage, %	24.85	23.28 (± 0.67)
3	Capacity, kg h^{-1}	383.94	378.52 (± 5.27)

* Figures in paranthesis represent standard deviation

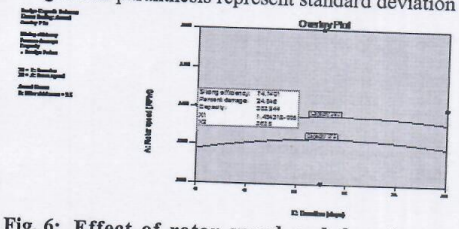

Fig. 6: Effect of rotor speed and duration after harvesting on slicing efficiency and percent damage

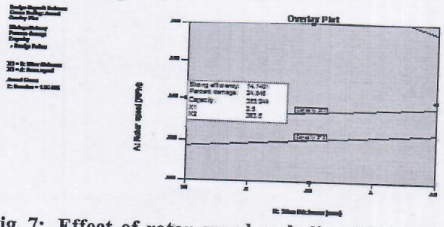

Fig. 7: Effect of rotor speed and slice thickness on slicing efficiency and percent damage

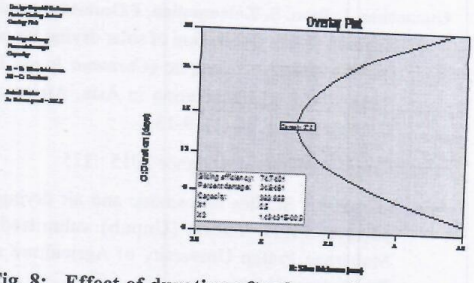

Fig. 8: Effect of duration after harvesting and slice thickness on slicing efficiency and percent damage

Techno-economic feasiblility

The cost economics of the turmeric slicer was calculated and given in Table 7. It revealed that the machine was techno-economically feasible for the entrepreneur.

Table 7: Cost economics of turmeric slicer

Particulars	Values
BEP	25.82%
Pay back period for equipment	0.80 year
Return on investment	97.41
Employment generation	120 mandays/year
Cost of processing	Rs. 22/q or Rs. 220/ton

Conclusion

The developed turmeric slicer was found to work satisfactorily with 74.74% slicing efficiency and 24.85% damage percentage. It was found techno economically feasible for an entrepreneur/farmer.

LITERATURE CITED

Aniyi, S.O., 2006. Design, construction and evaluation of a ginger slicing machine, J. Agril. Engg. and Techn., (JAET). 14: 12-17.

Borkar, P.A. 2011. Studies on osmotic and convective drying of aloe vera gel, Unpublished Ph.D. Thesis (Unpub)Submitted to Maharana Pratap University of Agriculture and Technology, Udaipur.

Chaudhary, A.P., B. K. Kumbhar and M. Narain, 2000. Effect of some process parameters on osmotic dehydration of papaya, J. Insti. of Engg. (Agricultural Engineering division), 81:59-63.

Gunasekar, J. Jhon, S. Kaleemullah, P.Doraisamy and S. Kamraj, 2006. Evaluation of solar drying for post harvest curing of turmeric (*Curcuma longa* L.), Agricultural Mechanization in Asia, Africa and Latin America. 37 (1): 9-13.

Horticultural Statistics at a Glance 2015 : 225

Jain, S.K., 2007. Studies on osmotic and air drying of papaya, Ph.D. Thesis (Unpub) submitted to Maharana Pratap University of Agriculture and Technology, Udaipur.

Pokharkar, S.M., 1994. Studies on osmotic concentration and air drying of pineapple slices, Unpublished Ph. D. Thesis (Unpub) Indian Institute of Technology, Kharagpur.

Ranmode, S. B., 2009. Enhancement of juice recovery from carrot using two stage pressing with ohmic heating, M. Tech Thesis (Unpub) submitted to G. B. Pant University of Agriculture and Technology, Pantnagar

Ravindra, M.R. and P.K.Chattopadhyay, 2000. Optimization of osmotic pre-concentration and fluidized bed drying to produce dehydrated quick cooking potato cubes, J. Food Engineering, 44 : 5-11.

Singh, C., H.K. Sharma and B.C. Sarkar, 2008, Optimization of process conditions during osmotic dehydration of fresh pineapple, J. Food Sci. Technol, 45(4):312-316

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Thermal Analysis of Natural Draft Biomass Cook Stove

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ABSTRACT

A natural draft biomass cook stove was developed in the Department of Unconventional Energy Sources & Electrical Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and its thermal analysis was made for finding heat losses and thermal efficiency of the cook stove. The Bureau of Indian Standards (BIS) and IS-13152 test code were used for its development and its laboratory and field evaluation. The average thermal efficiency of natural draft biomass cook stove was worked out to be 27.20 per cent and which was 16.42 per cent higher than that of the traditional single pot mud stove. The average fuel consumption rate of 1.027 kg h^{-1} was found in developed cook stove and which was less than traditional stove (1.284 kg h^{-1}) and the power rating of developed cook stove was worked out to be 1.30 kW. Emission of CO, CO_2, SO_x and NO_x of the cook stove were observed to be 324.26 ppm, 1.4 to 1.6 per cent, 20.53 and 1.5 ppm, respectively. The total particulate matters concentration was found to be 254.44 mg/MJ. According, to the Ministry of Renewable Energy (MNRE) standards, developed cook stove is suitable for rural household for domestic cooking. The heat loss by flue gases, heat gain by hood, thermal inertia and radiation was observed to be 30.09, 4.97, 6.53, and 24.33 per cent, respectively, however, 6.88 per cent heat loss was non-recordable.

India is vast country, 7th largest in the world with an area of 3166414 sq. km. Also it is the most populous country of the world. Hence the energy requirements are indeed high. India is the fourth largest consumer of energy in the world after US, China and Russia (Anonymous, 2011). Biomass can be classified as woody and non-woody. Non-woody biomass comprises agro-crop and agro-industrial processing residue. Municipal solid wastes, animal and poultry wastes are also referred to as biomass as they are biodegradable in nature. The main biomass sources available from forest wood, wood from energy plantations, saw dust, tree branches and leaves etc. are comprises under wood and wood waste category whereas, rice husk, bagasse, groundnut shells, coffee husk, straws, coconut shells, coconut husk, arhar stalks, cotton stalks and jute sticks etc. comprises under agricultural residue category. There exists a number of improved cook stove able to reduce emissions by 40–75per cent, increase fuel efficiency by almost 30per cent (Kshirsagar and Kalamkar, 2014). Several improvement works have been done on design of biomass cook stoves. Apart from economic and environmental conditions, the other main issue which motivates the various developmental efforts of cook stove is the health factor. Cooking stoves using biomass fuel are the most common combustion devices in the world and is used by over 2.4 million people. Traditional cooking stoves are inefficient and are linked to 1.6 million deaths per year from indoor pollution (Anonymous, 2012). There was an urgent need to speed up the dissemination of cleaner, more efficient and better ventilated stoves technology, and could be easily operated with wide variety of biomass.

In developing countries, rural populations are heavily relied on the biomass to satisfy their daily needs. Due to higher energy content and abundant availability, agricultural solid biomass waste offer great potential as a fuel, which is used in traditional biomass cook stoves as an alternate for fossil fuels. The improved cook stove is a cook stove designed using certain scientific principles, to assist better combustion and heat transfer, for improving emissions and efficiency performance. The goal of an improved cook stove design is to improve upon the shortcomings of the traditional stoves, while still ensuring lower cost and ease of use.

The objective of present research was to study a detailed scientific understanding of heat transfer as it relates to the design of biomass cook stoves.

MATERIAL AND METHODS

The standard design procedure was adapted for development of a natural draft biomass cook considering per capita energy consumption of 524 kcal (Himanshu, 2015; Panwar, 2009). The points were taken into consideration for development of natural draft biomass

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cook stove viz., enhancing combustion process by providing for means of introducing sufficient air for combustion, further reducing amount of heat loss from the combustion chamber by insulation. Reducing the amount of heat loss by careful of the pot seat, reducing the level of pollution of the kitchen environment with smoke emission and enhancing thermal efficiency of the biomass cook stove. The physical dimensions and material requirement for fabrication of cook stove are given in the following Table 1.

Table 1 Physical dimensions and material requirement for fabrication of cook stove

S. N.	Particulars	Values/Quantity
1	Reactor diameter, D, cm	15
2	Reactor height, H, cm	28
3	Area for primary air requirement, A, cm^2	5.81
4	Number of holes for secondary air	18
5	M.S sheet of 18 gauge, kg	2.5
6	M.S sheet of 20 gauge, kg	1.5
7	Bakelite handle, No.	2
8	Grate, No.	1
9	Glass wool, kg	0.5
10	Colour, liter	0.5

During combustion process in the stove, flue gas, thermal inertia of stove and radiations were responsible for the major heat losses. Steady state assumed for the heat transfer study to account energy losses. The complete stove with pot was placed inside the closed designed hood with inlet port for air and fuel. During combustion of fuel inside combustion chamber, heat energy loss was took place through various modes. One thermocouple was fixed such way that it should touch to the inner wall of cook stove and similarly second thermocouple was also fixed to the outer wall of cook stove. Third and fourth thermocouple was fixed in such way that to measure flue gas and flame temperature. Fifth thermocouple was touch to the outer wall of test hood used for thermal analysis of cook stove. Infra red thermometer was also used to measure temperature of surface and handles of cook stove. The isometric view of the cook stove is shown in Fig. 1. The hood used for thermal analysis of the cook stove and the complete experimental setup is shown in Fig. 2.

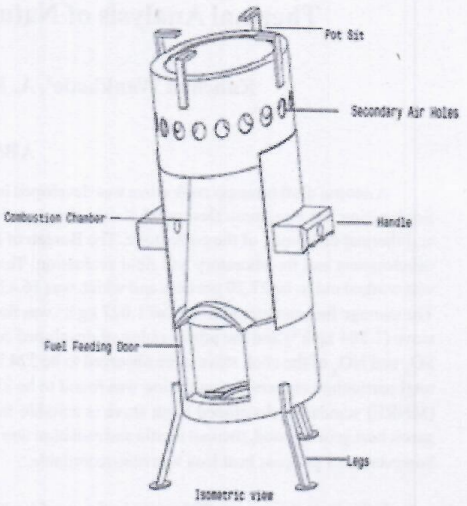

Fig. 1: Isometric view of biomass cook stove

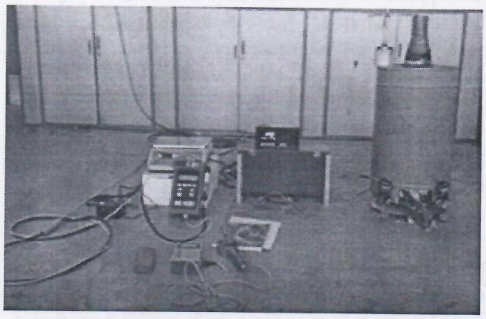

Fig. 2 : Experimental set up for thermal evaluation of natural draft cook stove

The following energy balance equations were used for heat transfer study of cook stove (Motghare *et al.,* 2015). Heat energy supplied by the combustion of fuel is the source energy and it is calculated using the following Eq. 1.

$$E = M \times CV \quad \text{..... (Eq. 1)}$$

Where,

E - Heat energy input, kcal
M - Mass of fuel consumed, kg
CV - Calorific value of fuel, kcal kg^{-1}

Flue gases formed as a result of combustion and which carry a fraction of the heat supplied. Heat energy

supplied by the combustion of fuel was the source energy and it was calculated using fuel energy losses by flue gases and was calculated by Eq. 2.

$$Q_f = M_f \times C_f \times (T_f - T) \ldots\ldots\ldots (Eq. 2)$$

Where,

Q_f - Heat loss by flue gases, kcal
M_f - Mass flow rate of flue gas, kg/sec
C_f - Specific heat of flue gas, kcal/kgR"C
T_f - Flue gas temperature, R"C
T - Atmospheric temperature, R"C

Combustion process was carried out for particular duration time (t) and therefore heat loss by flue gases was calculated by Eq. 3.

$$Q_f = M_f \text{ x } C_f \text{ x } (T_f - T) \text{ x t x } 60 \ldots\ldots\ldots (Eq. 3)$$

The entire cook-stove was enclosed inside the hood and heat energy was transferred to the wall of the metallic hood, and it heated the hood, so energy gained by the hood was due to heat of the flue gasses and was calculated by Eq. 4.

$$Q_h = M_h \text{ x } C_h \text{ x } (T_h - T) \ldots\ldots\ldots (Eq. 4)$$

Where,

Q_h -Heat gained by hood, kcal
M_h -Mass of hood, kg
C_h - Specific heat of MS hood, kcal/kg°C
T_h - Flue gas temperature, °C
T - Atmospheric temperature, °C

Total heat loss (Qt) by flue gases was calculated by addition of heat loss by flue gases and heat gained by metallic hood using Eq. 5.

$$Q_f = Q_f + Q_h \ldots\ldots\ldots (Eq. 5)$$

The percentage heat loss by flue gases was calculated by Eq.6.

$$\% \text{ heat loss} = \frac{Q_t}{E} \text{x } 100 \ldots\ldots\ldots (Eq. 6)$$

Where,

E - Heat energy input, kcal
Q_t - Total heat loss, kcal

Thermal inertial of the cook stove

The fraction of the source heat, which was utilized by the stove to heat itself, is known as thermal inertia of stove and the energy used the by thermal inertia was calculated by the Eq. 7.

$$Q_i = M_s \times C_s \times ? T_{LMTD} \ldots\ldots\ldots (Eq. 7)$$

Where,

Q_i - Thermal inertia of stove, kcal
M_s - Mass of stove, kg
C_s - Specific heat of stove material, kcal/kg°C
"T_{LMTD} - logarithmic mean temperature difference, °C

$$\Delta T_{LMTD} = \frac{T_i - T_o}{\ln \frac{T_i}{T_o}}$$

Where,

T_i - Temperature of inner wall of cook stove, °C
T_o - Temperature of outer wall of cook stove, °C

Radiation heat loss

The radiation heat loss occurs through the cook stove opening for the fuel feed and gab between gas wick and cooking pot. This loss was considered to be the major radiation loss encountered in the operation of stove. Heat loss by radiation was calculated by the Eq. 8.

$$Q_r = e \times \sigma \times (T_{fl}^4 - T^4) \times A_1 + e \times \sigma \times (T_{fl}^4 - T^4) \times A_2 \ldots (Eq. 8)$$

Where,

Q_r - Heat loss by radiation, kcal
e - Emissivity
ó - Stefan Boltzmann constant, W/m²
T_{fl} - Flame temperature, °C
T - Atmospheric temperature, °C
A_1 - Cross sectional area of fuel supply opening, m²
A_2 - Cross sectional area of top opening of the cook stove, m²

Smoke emission measurement from cook stove

The developed cook stove was examined for its emissions of CO, CO_2, SO_x and NO_x using stack monitoring system, multi component portable gas analyzer, model A-114 of HNL system (Fig. 3). The procedure of BIS standard was adopted for smoke emission estimation.

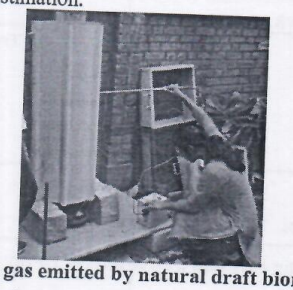

Fig 3. Flue gas emitted by natural draft biomass cook stove

RESULTS AND DISCUSSION

Characterization of cotton stalk

The proximate analysis of cotton stalk was carried out to determine moisture content, volatile matter, ash content and fixed carbon. The results are presents in Table 1. The average moisture content was found to be 9.4 per cent and average volatile matter, ash content and fixed carbon was found to be 69.93, 5.6 and 15.07 per cent, respectively. The calorific value of cotton stalk was also determined by using digital bomb calorimeter and it was observed to be 3757.50 kcal kg^{-1}.

Table 1 Characteristics of cotton stalk

S. N.	Content	Values
1	Moisture, per cent	9.40
2	Volatile matter, per cent	69.93
3	Ash,per cent	5.60
4	Fixed carbon, per cent	15.07
5	Calorific value, kcal/kg	3757.50

Thermal efficiency of natural draft biomass cook stove

The thermal efficiency test of natural draft biomass cook stove was carried out thrice by standard water boiling test using cotton stalk as fuel. The thermal efficiency of cook stove was worked out to be 26.98, 27.47 and 27.16per cent. An average thermal efficiency of cook stove was worked out to be 16.42 per cent. The thermal efficiency of existing cook stove viz., Panjabrao Deshmukh Krishi Vidyapeeth (PDKV) developed cook stove, Sardar Patel Renewable Energy Research Institute (SPRERI) developed cook stove and traditional cook stove was also determined and compared with natural draft cook stove and the results are shown in Table 2.

Table 2 Comparison of thermal efficiency of existing and traditional cook stove with natural draft cook stove.

Particulars	Natural draft biomass cook stove	PDKV cook stove	SPRERI cook stove	Traditional cook stove
Thermal efficiency, %	27.20	20.02	25.56	10.78

Fuel burning rate and power output rating

An average fuel consumption rate of cook stove was found to be 1.027 kg h^{-1}. However, the fuel consumption rate of PDKV stove, SPRERI cook stove and traditional single pot cook stove was found to be 1.172, 1.138 and 1.264 kg h^{-1}, respectively. The fuel consumption rate of the natural draft biomass cook stove was comparatively less than that of the PDKV, SPRERI and traditional single pot cook stove. The power output rating of cook stove was found to be 1.30 kW. Whereas, it was found to be 1.024, 1.23 and 0.683 kW of PDKV cook stove, SPRERI cook stove and traditional cook stove, respectively. The higher output rating of cook stove might be due to proper combustion of fuel in combustion zone.

Energy balance of cook stove

The heat loss by flue gases, heat gain by hood, thermal inertia and radiation was observed to be 30.09, 4.97, 6.53, 24.33 per cent, respectively. However, 6.88 per cent heat loss was non-recordable. From the Fig. 4 it is seen that maximum heat loss was due to flue gases and followed by radiation, thermal inertia and heat loss by hood.

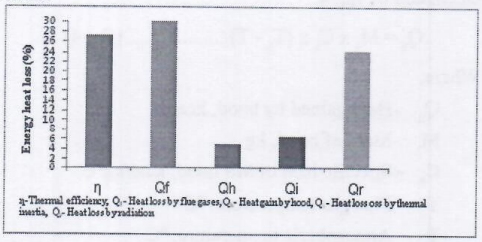

Fig. 4 Energy heat losses of natural draft biomass cook stove

Heat loss by flue gas and by radiation was observed higher than that of heat loss by thermal inertia and that might be due to some incomplete combustion of fuel. However, radiation losses are higher and that might be due to heat loss from side fuel feeding hole and gap between cooking pot and pot rest.

Total particulate matter of natural draft biomass cook stove

The total particulate matters available in flue gas emitted by the natural draft biomass cook stove due to incomplete combustion was collected on Whatman filter papers. One kilogram of cotton stalks was burned during the test and collected the particulate matter on Whatman paper after every 15 minute and it was observed to be 76.33 mg MJ^{-1}, 50.89 mg MJ^{-1} and 76.33 mg MJ^{-1}. The

total particulate matters concentration was found to be 254.44 mg MJ^{-1}.

Emission from natural draft biomass cook stove

The flue gas emitted by natural draft biomass cook stove using cotton stalks as fuel was analyzed for determination of the contents of CO, CO_2, SO_x and NO_x by flue gas analyzer. The CO concentration in flue gas with respect to time is shown in Fig.5. It is seen from the Fig. 5 that the average CO concentration was observed to be 324.26 ppm. Oxygen is made available in the combustion zone of natural draft cook stove by replacement of existing, hot exhaust gases with an induced draft of air. At ignition, the flow rate of exhaust gases was low resulting in low induced airflow into the stove, fuel-rich combustion and production of large quantities of CO.

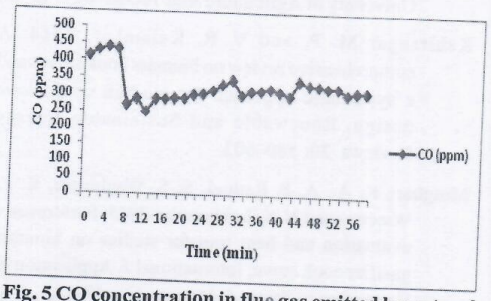

Fig. 5 CO concentration in flue gas emitted by natural draft biomass cook stove

From Fig. 6 it is evident that CO_2 was found to be in the range of 1.4 to 1.6 per cent through the test of CO_2 analysis.

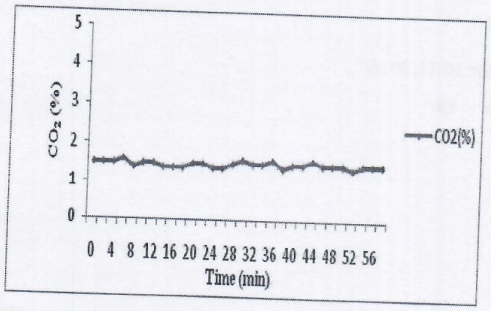

Fig. 6. CO_2 concentration in flue gas emitted by natural draft biomass cook stove

During stove ignition, the fuel burn rate and stove heat output was relatively low resulting in slow initial water temperature ramp. The CO_2 emission was found relatively low. The SO_x and NO_x emission of the cook stove using cotton stalk as fuel and data is represented in Fig 7. It is seen from Fig.7 that on average value SO_x and NO_x was observed in flue gas were 20.53 and 1.5 ppm, respectively.

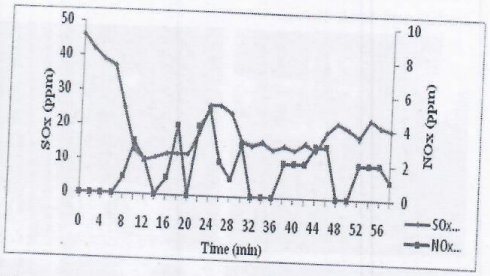

Fig. 7. SO_x and NO_x emission in natural draft biomass cook stove using cotton stalk

The small amount of fuel-bound elemental sulfur is oxidized to produce SO_2 early in the burn process due to the relatively low boiling point of sulfur (440°C) and NO_x is formed at high temperature conditions (>1600°C) from oxidation of fuel bound elemental nitrogen and dissociation of oxygen and nitrogen in combustion of air and therefore, NO_x production was low during the ignition phase.

Cooking test of biomass cook stove

The cooking test of the biomass cook stove was carried out by cooking food required for six family members (Fig. 8). Cooking tests was carried out at rural households for preparation of meal and was compared with the traditional cook stove. The natural draft biomass cook stove was evaluated at user's site at Naigaon, Tq. Nandura, Dist. Buldana for preparation of meal items viz., Tea, curry, roti and rice.

Table 3. Comparative study of cooking test of traditional cook stove and natural draft biomass cook stove

S.N.	Particulars	Natural draft biomass cook stove	Traditional cook stove
1	Fuel consumption, kg	1.68	2.60
2	Time required, kg	82.2	114.2

From Table 3 it is seen that fuel consumption of natural draft biomass cook stove was worked out to be

1.68 kg h^{-1} whereas it was found to be 2.60 kg h^{-1} for traditional single pot cook stove. Similarly, time required for cooking was observed to be 82.2 min and 114.2 min for natural draft biomass cook stove and traditional cook stove, respectively. By the use of natural draft biomass cook stove 35 per cent fuel saving was observed over the traditional cook stove.

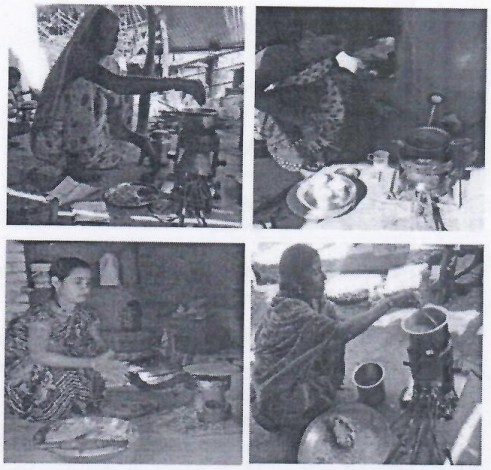

Fig. 8 Field cooking test of biomass cook stove

CONCLUSIONS

The thermal efficiency of natural draft biomass cook stove using cotton stalk as fuel was found 27.25 per cent which was 16.42 per cent higher than that of the traditional cook stove. Saving in fuel consumption of 35 per cent and time saving of 28 per cent was observed over traditional single pot cook stove. The natural draft biomass cook stove is portable, user friendly useful for domestic cooking in rural households.

LITERATURE CITED

Anonymous, 2011. Future potential of biomass energy in India. Bioenergy India, Ministry of New and Renewable Energy, Government of India: 6-11.

Anonymous, 2012. Energy Sources of Indian Households for Cooking and Lighting, 2011-12 Ministry of Statistics and Programme Implementation :12-22.

Himanshu K., 2015. Design, development, and performance evaluation of a wood gas stove with thermoelectric power generation system, M.Tech Thesis (Unpub) submitted to Maharana Pratap University of Agriculture And Technology: 42-43.

Kshirsagar M. P. and V. R. Kalamkar, 2014. A comprehensive review on biomass cook stoves and a systematic approach for modern cook stove design, Renewable and Sustainable Energy Reviews. 30: 580–603.

Motghare K. A., A. P. Rathod, S. S. Waghmare, K. L. Wasewar and N. K. Labhsetwar, 2015. Performance evaluation and heat transfer studies on biomass gasifier cook stove, International J. Application or Innovation in Engg. & Manag., (4): 47-63.

Panwar N. L., 2009. Design and performance evaluation of energy efficient biomass gasifier based Cook stove on multi-fuel, Mitigation Adaptation Strategies Global Change; 14: 627-633.

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RESEARCH NOTES

Evaluation of Pigeonpea [*Cajanus cajan* (L.) Millspaugh] Genotypes Against Sterility Mosaic Disease

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is a short lived legume belonging to Cajaninae sub tribe of the economically most important leguminous tribe Phaseoleae. It plays an important role in food and nutritional security because it is a rich source of proteins, minerals and vitamins. In India, pigeonpea is cultivated in an area of about 36.3 lakh ha with an annual production of 27.6 lakh tonnes averaging a productivity of 760.33 kg ha^{-1} (Annon., 2014). The biotic stresses are considered as one of the main reasons for limiting the yields in pigeonpea. Among them the major biotic stresses causing economic concerns in yield are the *Fusarium* wilt, Sterility Mosaic Disease (SMD) and *Phytopthora* blight (Reddy *et al.*, 1998).

SMD is one among the most destructive disease of pigeonpea (Kannaiyan *et al.*, 1984) causing yield losses up to 95 per cent (Ganapathy *et al.*, 2011). Presently disease is very severe in major pigeonpea growing regions of Northern Karnataka.

The task of developing resistant varieties is complicated in view of the genetic plasticity of the pathogen. Despite several attempts especially during the past 20 years, the agents of SMD remain uncharacterized and posed a big challenge to the scientific community. Effective method of managing virus diseases of crop plants is by using resistant varieties which is most economical, inexpensive and eco-friendly for resource poor farmers in comparison to chemicals. The cost of cultivation with disease/pest resistant varieties was found to be less in comparison to other methods.

A field experiment was conducted during *Kharif* 2015-16 at ARS, farm Bidar. Initially susceptible variety of pigeonpea was sown as a hedge crop for the source of inoculum before two months according to the wind direction and one side crop was surrounded by sugarcane as it cause humidity and congenial condition for the multiplication of vector population and also leaf stapling method was followed for screening to identify the resistant source for pigeonpea sterility mosaic disease. The infected leaf sample was stapeled to the healthy pigeonpea seedlings at 10-15 days after sowing in such a way that the undersurface of the infected leaf should come in contact with the healthy pigeonpea leaf surface of test genotype. The pigeonpea genotypes were collected from AICRP on pigeonpea from Kalaburgi. Each genotype was sown in single row of 3 m length with a spacing of 60 x 30 cm. The initial disease plant count was recorded in all genotypes starting from 60, 90 and 120 DAS till harvest. The infected plants were marked with different colour tags for different recordings, to avoid missing of early infected plants. The disease incidence (%) pigeonpea sterility mosaic disease was calculated by using the formula given below.

$$\text{Disease incidence (\%)} = \frac{\text{Number of SMD infected plants}}{\text{Total number of plants}} \times 100$$

The genotypes were categorised into different categories in the following manner (Lava Kumar, 2002)

S. N.	Reaction	Disease incidence (%)
1	Resistant	0 -10 %
2	Moderately resistant	11 -30 %
3	Susceptible	> 30 %

Thirty seven genotypes were screened for their reaction to SMD disease during the season *kharif,* 2015 at ARS, Bidar with ICP-8863 as susceptible check. Based on the performance of genotypes over the season, they were categorised into following manner. Resistant (0-10%), moderately resistant (11-30%) and susceptible (>30%) incidence of SMD. The results are presented in Table 1 and 2.

Out of 37 genotypes screened, one of the genotype Bahar showed resistant, while 18 genotypes viz. GRG-177, GRG-152, NTL-900, ICP-16264, GRG-2013, GRG-140, GRG -811, GRPH-1, GRPH-2, GRPH-3, GRG-444, GRG-820, AGL-1666, AGL-1919, AGL-2013, PRK-B 136, AGL-1603, AGL-2249 genotypes were moderately resistant and rest of the genotypes (18) nemaly GRG-151, ICPL-14001, AKT-9913, GRG-222, BDN-2008-1, GRG-111, TS-3R, Maruti, ICP-722, ICP-13673, ICP-13101, ICP-88039, ICP-14832, BDN-2008-8, TDRG-33, ICP-11320, ICP-8793, ICPL-99050 and GRG-829 were susceptible. The incidence of 100 per cent was recorded in susceptible check ICP-8863 (Maruti). Considering the overall performance of pigeonpea genotypes over the season, most of the genotypes exhibited moderately resistant and susceptible reaction. The results are in agreement with the earlier research findings of Muniyappa *et al.* (2005) they screen the susceptible check ICP 8863 and also recorded 100 per cent disease incidence which concordant with the present observations.

Table 1. Reaction of pigeonpea genotypes against SMD during *kharif* 2015 at ARS farm, Bidar

S. N.	Pigeonpea genotypes	Disease incidence (%)			
		At 60 DAS	At 90 DAS	At 120 DAS	Reaction
1.	AGL-1603	22.50	25.75	28.50	MR
2.	AGL-1666	18.60	24.50	24.50	MR
3.	AGL-1919	16.60	22.70	25.60	MR
4.	AGL-2249	20.50	28.00	28.00	MR
5.	AGL-2013	21.50	26.75	26.75	MR
6.	AKT-9913	51.00	53.50	54.50	S
7.	Bahar	4.70	4.80	4.70	R
8.	BDN-2008 - 1	15.50	42.50	50.00	S
9.	BDN-2008- 8	35.20	52.90	64.70	S
10.	GRG-111	33.30	33.30	40.00	S
11.	GRG-140	15.42	18.50	20.75	MR
12.	GRG-151	26.60	26.60	33.5	S
13.	GRG-152	10.50	12.40	15.50	MR
14.	GRG-177	12.50	15.00	15.00	MR
15.	GRG-222	33.33	44.40	44.40	S
16.	GRG-444	14.50	25.00	28.50	MR
17.	GRG-811	12.50	15.40	18.75	MR
18.	GRG-820	12.50	25.50	35.50	MR
19.	GRG-829	37.50	55.50	60.50	S
20.	GRG-2013	13.33	20.00	25.60	MR
21.	GRPH-1	9.00	18.50	18.50	MR
22.	GRPH-2	10.50	21.5	21.5	MR
23.	GRPH-3	9.50	20.50	20.50	MR
24.	ICP-7223	62.50	82.5	89.5	S
25.	ICP-8793	70.00	89.50	100	S
26.	ICP-11320	65.50	88.50	96.50	S
27.	ICP-13101	23.00	30.70	46.50	S
28.	ICP-13673	29.50	35.50	42.50	S
29.	ICP-14832	28.50	35.70	42.80	S
30.	ICP-16264	13.50	16.50	16.50	MR
31.	ICP-88039	39.00	72.00	72.00	S
32.	ICPL-14001	28.50	35.70	42.80	S
33.	ICPL-99050	40.50	63.50	63.50	S
34.	PRK-B-136	18.50	26.50	27.00	MR
35.	NTL- 900	16.00	22.50	24.50	MR
36.	TDRG-33	26.60	46.60	62.60	S
37.	TS-3R	29.50	36.50	45.86	S
	Maruti (ICP 8863)	88.20	100	100	Susceptible check

(R) - Resistant, (MR) - Moderately resistant, (S) – Susceptible, DAS – Days after sowing

LITERATURE CITED

Anonymous, 2014, Annual Report, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India.

Ganapathy, K. N., Gnanesh, B. N., Byregowda, M., Venkatesha, S. C., Sunil, S., Gomashe and Channamallikarjuna, V., 2011, AFLP analysis in pigeonpea (*Cajanus cajan* (L.) Millsp.) revealed close relationship of cultivated genotypes with some of its wild relatives, Genet. Res. Crop Evol., 58 : 837–847.

Kannaiyan, J., Nene, Y. L., Reddy, M. V., Ryan, J. G. and Raju, T. N., 1984, Prevalence of pigeonpea diseases and associated crop losses in Asia, Africa and America, Trop. Pest Manage., 30 : 62-71.

Lava Kumar, P., 2002, Studies on pigeonpea sterility mosaic disease isolation and characterisation of the causal agent and assessment of genetic variation within and between populations of the mite vector, *Aceria cajani* ICRISAT, India, 12: 13-45.

Muniyappa, V., P. Lavakumar, K. T. Rangaswamy, 2005, A sterility mosaic resistant vegetable and grain purpose pigeonpea variety, ICRISAT Org., 1: 23-24.

Reddy, M. V., T. N. Raju and J. M. Lenne, 1998. Diseases of pigeonpea. In : The Pathology of Food and Pasture Legumes, CAB *Int.* ICRISAT : 517-558.

Saifulla, M., M. Mahesh, and M. Byre Gowda, 2006, Reaction of pigeonpea genotypes for sterility mosaic disease, In National seminar on new frontiers in Plant Pathology, Shimoga, India : 43-45.

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Levelsof Detoxifying Enzymes in *Spodoptera litura*(Fab.)as Influenced by Feeding on Different Hosts

Resistancein insects is influenced primarily by genetic factors but environmental effect can also influence to some extent, which in case of phytophagous diseases is partially represented by the chemicals found in the host plants. Species with an evolutionary history of feeding on heavily chemically defended plant structures should have elevated levels of enzymes that detoxify defensive chemicals, and therefore an enhanced ability to evolve resistance to synthetic toxins. The role of host plant chemistry on the expression and evolution of pesticide resistance is vital from the perspective of understanding non-genetic factors influencing pesticide resistance, since environmental factors may have relatively important effects influencing the activity of detoxification enzymes in insects and hence, their susceptibility to xenobiotics. Physiological response of herbivores to host plants may lead to enhanced metabolism of pesticides because mechanisms that function in detoxification of plant allelochemicals in their diets may also be effective in detoxifying pesticides. General esterases, glutathione-*S*-transferases (GST) and cytochrome P_{450}-dependent monooxygenases (MFO) are common detoxification enzymes that metabolize pesticides in arthropods. *S. litura* (Fab.) being the polyphagous pest with high reproductive and damage potential, its suppression has become difficult over past decade due to development of resistance to commonly used chemical insecticides. As a result, many field populations of *S. litura* have developed multiple resistances and field control failure has been observed very frequently (Armes *et al.*, 1997, Ahmad *et al.*, 2007). Research done to date indicates cross-resistance with current products including conventionally used insecticides indicating the involvement of detoxifying enzymes in resistance development Therefore, a research

experiment on influence of feeding on different host plants on induction of detoxifying enzymes in *S. litura* was planned.

The present investigation was undertaken during 2014-2015 in the Toxicology Laboratory, Department of Entomology, Post Graduate Institute, Dr. PDKV, Akola.

***Spodoptera* culture**

Spodoptera larvae were collected from castor and soybean fields in and around Dr. PDKV Campus, which served as an initial culture for its mass rearing under laboratory conditions, the larvae were reared for 3 generations on different hosts to determine the levels of detoxifying enzymes in Spodoptera larvae after feeding on different hosts.

Enzyme assays

Midgut of *Spodoptera* was isolated first by dissecting the third instar larvae. The isolated midgut of *S. litura* was crushed with the help of mortar and pestle to which 3 ml homogenization buffer (Phosphate buffer 10mM pH 7.0, 0.1 mM EDTA: 9.3 mg, 0.1 mM PMSF: 4.4 mg, 0.1 mM PTU: 3.8 mg 250 ml^{-1}) was added. The homogenate thus obtained were centrifuged at 10,000 rpm for 10 min at 4^0 C in high speed refrigerated centrifuge. The resultant supernatant was stored at -20°C and used as enzyme source

Carboxylesterase Assay

10µl of enzyme solution from untreated control (water) and larvae were added to the tubes containing 100µl 0.3 mM α- napthyl acetate as a substrate, 990 µl of 40mM PB (pH 6.8) and incubated in dark for 20 minutes at room temperature. After gentle shaking, 1ml of staining solution (1% fast blue BB salt in phosphate buffer [40mM pH 6.8] with 5% sodium dodecyl sulphate (SDS) was added to each tube and incubated at 20°C for 30 minutes the absorbance was recorded at 590 nm. The enzyme activity was calculated from α- napthol standard curve. Each sample was measured in triplicate (Kranthi, 2005).

Protein estimation

Protein concentration of insect mid gut homogenate was determined by Bradford method (1976) by using Bovine Serum Albumin (BSA) as a standard protein to construct the standard curve. A_{595} nm was determined using 1 ml microcuvette to generate a standard curve by plotting absorbance at 595 nm versus protein concentration.

Glutathione S-transferase Assay

Activity of Glutathione-S-transferase (GST) was carried using the method of Kranthi, (2005) in which50 micro liters of 50 mM 1,2-dichloro-4-nitrobenzene (DCNB) and 150 µl of reduced glutathione (GSH) were added to 2.77 ml phosphate buffer (40 mM pH 6.5). Thirty microliters of enzyme stock was then added. The mixture were gently shaken and incubated for 2-3 minutes at 20°C and then transferred in the sample cuvette slot of a UV spectrophotometer. The change in absorbance was measured at 340 nm up to 5 min and the enzyme activity in terms of µ mol of DCNB conjugated min^{-1}mg of enzyme $protein^{-1}$ was calculated using the extinction coefficient of 9.6 mM^{-1} cm^{-1}.

Monooxygenase assay

A stock of 10 µg ml^{-1} of the cytochrome C from Bovine heart was prepared in sodium acetate buffer (0.25 M, pH-5.0). Serial dilutions of 5µg ml^{-1}, 2.5 µg ml^{-1}, 1.25µg ml^{-1}, 0.625µg ml^{-1}, 0.312µg ml^{-1}, 0.156µg ml^{-1} and 0.078µg ml^{-1} were prepared from this stock. A solution of 10 mg Tetramethyl Benzidine (TMBZ) was prepared in 10 ml methanol and this was added to 37.5 ml sodium acetate buffer pH 5.0. 3 per cent hydrogen peroxide was prepared 200 µl of each of the serial dilutions of cytochrome C, 2ml TMBZ, 250 µl of hydrogen peroxide and cuvettes were placed with enzyme sample and absorbance was recorded at 620 nm (Kranthi, 2005).

The enzyme activity in midgut of *S.litura* was quantified and presented host wise in Table 1. The biochemical assays revealed that maximum levels of Glutathion-S-transferase (GSTs), Carboxylesterase (CarE) and Monooxygenase Cytochrome-P_{450} (Cyt-P_{450}) were observed in the field collected population indicating tolerance in field collected *Spodoptera* population which might have been due to the exposure to insecticides in the field condition. The data from F_1 to F_3 generation showed decreasing trend of all the three detoxifying enzymes in *S. litura* fed on all the three host plants. The comparative studies among the host plants after rearing *Spodoptera* for three successive generations indicated higher levels of Carboxylesterasaes and Monooxygenase Cyt-P_{450} in *S. litura* population reared on cotton as compared to castor and soybean. However, relatively higher levels of GSTs were observed in castor fed *Spodoptera* population. The variation in levels of detoxifying enzymes in *Spodoptera* fed on three different host plants is probably due to variation in plant structure and allelochemicals and

Table 1: Levels of different enzymes in *Spodoptera* larvae fed on different hosts

Host plant	Generations	Enzyme activity		
		GSTμM mg protein^{-1}min^{-1}	Carboxylesterase mol/min/mg protein	Monooxygenase mOD min^{-1} mg^{-1} protein
Castor	*F_0	1.78	0.0145	7.50
	F_1	0.75	0.0136	5.18
	F_2	0.74	0.0113	2.49
	F_3	0.62	0.0075	1.85
Cotton	*F_0	1.78	0.0145	7.50
	F_1	1.05	0.0109	5.54
	F_2	0.66	0.0104	3.95
	F_3	0.58	0.0090	3.84
Soybean	*F_0	1.78	0.0145	7.50
	F_1	0.79	0.0038	4.49
	F_2	0.73	0.0037	3.49
	F_3	0.52	0.0037	0.59

*The values are from field collected population irrespective of host plant effect.

therefore, the insects feeding on different host plants showed different levels of detoxifying enzymes.

This study can help in planning the use of insecticides on the basis of resistance mechanisms as well as different doses on different host plants studies. Present investigation are in agreement with the findings of Karuppaiah *et al.*, (2016) who reported that the host plants had a significant influence on levels of detoxification enzymes in *S. litura*.Muthusamy and Karthi (2011) reported 3 fold high CarE activity at 10 ppm where as GSH and GST activity were low (0.2 ± 0.4, 1.5 μM mg protein^{-1} min^{-1}) concluding that esterase and acetylcholine esterase may play a role in detoxification of synthetic pyrethroids and organophosphates in *Spodoptera litura* from South India, which supports the present findings.

LITERATURE CITED

Ahmad M, Arif M I and Ahmad M. 2007. Occurrence of insecticide resistance in field populations of Spodoptera litura (Lepidoptera: Noctuidae) in Pakistan, Crop Prot 26: 809-17

Armes, N.J., J.A. Wightman, D.R. Jadhav and G.V.Ranga Rao, 1997.Status of insecticide resistance in *Spodoptera litura* in Andhra Pradesh, India, Pest. Sci. 50: 240-248.

Bradford, M. M., 1976. A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principle of protein-dye binding, Anal. Biochem.72: 284-254.

Karuppaiah, V., Chitra Srivastava and S. Subramanian, 2016. Effect of host plants on insecticide susceptibility and detoxification enzymes activity in *Spodoptera litura* Fabricius (Noctuidae: Lepidoptera), Proceedings of the National Academy of Sciences, India, Section B : Biological Sci., 86 (3) : 715-721

Kranthi K. R., 2005. Insecticide Resistance- Monitoring Mechanism and Manegement Manual, CICR, PB No.2, Shankarnagar, Nagpur.

Muthusamy, S. and R. Karthi, 2011. Pesticide detoxifying mechanism in field population of *Spodoptera litura* (Lepidoptera: Noctuidae) from South India, Egypt. Acad. J. Biolog. Sci.,3(1):51- 57.

Muliin, C.A. and B. A.Croft,1983. Host- related alterations of detoxification enzymes in *Tetranychus urticcw* (Activityari: Tetranycnidae), Environ Entomol. 12(4): 1278-1282.

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Diversity and Abundance of Scarab Beetles From Akola (M.S.)

Beetles belong to the largest and diverse order of class insecta (Phylum: Arthropoda) have record of 3, 50,000 species of which 15,088 species are from Indian region (Parvez and Srivastava, 2010). Superfamily Scarabaeoidea is the largest superfamily in order Coleoptera which includes approximately 31,000 species worldwide, of which the family Scarabaeidae composed of about 91per cent of all scarabaeoids. Family Scarabaeidae is second largest and omnipresent family within the order Coleoptera and possesses both beneficial (dung beetles) and harmful beetles (chafers) (Ratcliffe and Jameson, 2002).Within Scarabaeidae, two subfamilies; Aphodiinae and Scarabaeinae are represented by approximately 6,850 species and the subfamilies; Orphninae, Melolonthinae, Dynastinae, Rutelinae, Cetoniinae, Troginae and Valginae include approximately 20,950 species (Chandra and Gupta, 2012[a]). Dung beetle is a common name applied to beetles in the subfamilies Scarabaeinae and Aphodiinae while most species in the subfamilies Melolonthinae, Dynastinae, Rutelinae and Cetoniinae feed on plant products and are agricultural pests of various commercial crops.

Insect identification is a fundamental part of recognizing and describing biodiversity. The information regarding the biodiversity of scarabs, that too in agriculture sector is scanty. Therefore, it is essential to have correct identification of pests up to family, sub family, species level and taxonomy play an important role in this regards. Information on the activity of particular fauna in particular agro-ecosystem is essential to generate the information on level of active fauna and its predominance in that crop ecosystem. Knowledge on species diversity, abundance, richness and dominance through survey is helpful in planning strategies for conservation of natural enemies, habitat management, design and developing pest management strategies.

Scarabs were collected through light traps installed at various locations of Dr. Panjabrao Deshmukh Krishi Vidhyapeeth campus, Akola by using net and hand picking. The collected fauna sorted out and categorized under different families and subfamilies with the help of taxonomic key given by Ratcliffe and Jameson, (2002).

A nylon mesh was fixed below the light trap for the collection of the trapped insects. Light trapped insects in the nylon mesh were collected each day, beetles were killed by ethyl acetate in a killing jar; pinned and dried in hot air oven, labeled appropriately and stored in the insect collection wooden showcases. For studying the distinguishing morphological characters of different specimens, stereo zoom microscope (Nikon SMZ 800) with attached Nikon camera was used.

Shannon biodiversity index was calculated to analyze the abundance and diversity richness of Scarabaeids fauna. Shannon biodiversity index was worked out by the formula as below.

$$Pi = ni/N \quad \text{—— (equation-1)}$$

$$H = -\Sigma pi \, Ln \, pi \quad \text{————(equation-2)}$$

ni= number of individuals of species "i"

N = total number of individuals of all species

pi= relative abundance of species "i"

S = total number of species

H' = The Shannon Diversity Index

1. Collection of scarabaeid fauna

Specimens of scarabaeid fauna were collected from Dr. P.D.K.V. campus, Akola during *Kharif* 2014 and categorized into families and different sub families as below.

2. Family wise composition of scarabaeoid fauna collected from Akola Scarabaeidae:

Scarabaeidae emerged as largest family of superfamily Scarabaeoidea contributing 84.58 per cent of the total scarabaeid fauna. Similar results have also been reported earlier by Scarabaeidae as a dominant family in Akola vicinity contributed 72.85 per cent reported by Mohod *et. al.*, (2015). Pawara *et. al.*, (2014) recorded family Scarabaeidae as a dominant family in Jalgaon district of Maharashtra. Chandra and Gupta (2012[b]) reported five species of genus *Onthophagus* Latreille of subfamily Scarabaeidae from Madhya Pradesh, India. Aland *et. al.*, (2012) surveyed 152 species under 101 genera belonging to 25 families of beetles, and concluded family Scarabaeidae to be dominant with 65 species from Amba Reserve Forest, Western ghat, Kolhapur. Thakare *et. al.*, (2012[a]) from Melghat Tiger Reserve, Amravati supporting the present findings.

Table 1: Subfamily and Family wise per cent composition of scarabaeoid fauna in Akola

S.N.	Superfamily	Family	Percentage (%)	Subfamily	Percentage (%)
1.	Scarabaeoidae	Scarabaeidae	84.58	Scarabaeinae	36.56
				Cetoniinae	18.97
				Rutelinae	16.40
				Melolonthinae	12.64
2.		Hybosoridae	7.31	Hybosorinae	7.31
3.		Geotrupidae	4.74	Geotrupinae	4.74
4.		Trogidae	3.35	Troginae	3.35
		Total			**100**

Hybosoridae

With 7.31 per cent of the total Scarabaeid fauna this family found to be the second largest family of superfamily Scarabaeoidea in Akola. Mohod *et. al.*, (2015) recorded Hybosoridae as largest family contributed 20.24 per cent in Akola vicinity during 2013. Chandra *et. al.*, (2012) also studied new 29 species of two families viz. Scarabaeidae and Hybosoridae from Jabalpur, Madhya Pradesh (India) confirmed the availability of Hybosoridae fauna in Central India condition.

Geotrupidae

Geotrupidae family contributed about 4.74% of total scarabaeid fauna in study area. Earlier Chandra and Gupta (2012[c]) studied taxonomic account of subfamily Geotrupidae from central India. Mohod *et. al.*, (2015) recorded Geotrupidae as smallest family (2.45%) from Akola vicinity.

Trogidae

3.35 per cent of the total Scarabaeid fauna was represented by this family. It was reported to be the smallest family of superfamily scarabaeoidea in Akola. Similar, results were reported by Ziani and Sama (2013) from Turkey and Mohod *et. al.*, (2015) who recorded members of Trogidae family (4.44%) in Akola vicinity.

Family : Scarabaeidae

Subfamily : Scarabaeinae

Maximum number of insects collected during the present study belongs to Scarabaeinae subfamily contributing to 36.56 per cent of the total Scarabaeid fauna emerged as the largest subfamily of family Scarabaeidae. Similar results have been reported by Thakare *et. al.*, (2011) with 26 species of scarab beetles belonging to 14 genera and 8 subfamilies from Melghat area of Amravati district of Vidarbha. Scarabaeinae was the dominant subfamily with respect to species diversity (15 species). Mohod *et. al.*, (2015) also recorded dominance of Scarabaeinae from Akola vicinity during 2013.

Subfamily : Cetoniinae

Subfamily Cetoniinae contributed to 18.97 per cent of the total Scarabaeid fauna. Cetoniinae ranked as second largest subfamily of family Scarabaeidae. Mohod *et. al.*, (2015) also recorded members of subfamily Cetoniinae (4.75%) from Akola vicinity. Taggar *et. al.*, (2012) stated that the occurrence of chafer *beetle Oxycetonia versicolor* (Scarabaeidae, Coleoptera) damaging important grain legumes such as pigeonpea (*Cajanus cajan*) and mung bean (*Vigna radiata*) from Punjab, India.

Subfamily : Rutelinae

Rutelinae subfamily contributes about 16.40 per cent of total scarabaeid fauna. These beetles were hand picked on okra and cotton crops being typically diurnal. Kumar *et. al.*, (2006) also recorded thirteen species of scarabaeids on rose from different parts of Bangalore. They reported four genera under subfamily Melolonthinae, three under Rutelinae and three under Cetoniinae. Chandra and Gupta (2012[e]) recorded highest number of beetles from subfamily Rutelinae followed by Melolonthinae, Cetoniinae and Dynastinae from Achanakmar-Amarkantak Biospere Reserve, Chhattisgarh.

Subfamily: Melolonthinae

Of the total Scarabaeid fauna 12.64 per cent was represented by subfamily Melolonthinae. Similar results were reported by Theurkar *et. al.*, (2013) from Khed *taluka* (Pune) a part of Northern Western Ghats of Maharashtra,

India with five major species of white grubs namely *Holotrichia consaguinea*, *H. serrata*, *H. fissa*, *Leucopholis lepidophora* (Melolonthinae) and *Anomola* sp. (Rutelinae). Dadmal *et. al.*, (2013) reported five species of Melolonthinae from Maharashtra.

Family: Hybosoridae

Subfamily: Hybosorinae

Of the total Scarabaeid fauna 7.31per cent was represented by this subfamily and represents the third largest subfamily in Akola. Similar results reported by Thakare *et. al.*, (2012[b]). They collected thirty two species of scarab beetles belonging to twenty genera, eight subfamilies including Hybosorinae and three families under superfamily Scarabaeoidea from Melghat Tiger Reserve, Vidarbha, Maharashtra (India). Chandra *et. al.*, (2012) also recorded Hybosorinae from Jabalpur. Mohod *et. al.*, (2015) reported 20.24 per cent contribution of Hyposorinae from Akola vicinity which supports the present finding.

Family: Geotrupidae

Subfamily: Geotrupinae

4.74 per cent of the total scarabaeid fauna was represented by this subfamily. Similar result were reported by Nuria and Fransisco (2010) who described Geotrupinae species from North and Central America (NCA), representing an average of 0.41 species year^{-1}.

Family: Trogidae

Subfamily: Troginae

Troginae subfamily contributing about 3.35 per cent of total scarabaeid fauna in Akola found to be the least dominant group. Grebennikov and Scholtz (2004) studied families and subfamilies of Scarabaeoidea including Troginae and carried out morphological characterization. Mohod *et. al.*, (2015) reported (4.44%) members of Troginae from Akola vicinity.

3. Shannon Biodiversity Index

Shannon biodiversity index was worked out for the total collection. Calculated diversity index supports the quantitative data collection. Moderate to rich Shannon biodiversity index (H$^{=}$1.6903) was noticed in terms of subfamilies of scarabs in Akola as below.

Table 2: Subfamily wise Shannon Biodiversity Index of Scarabaeid fauna in Akola

Subfamily	pi(ln(pi))
Scarabaeinae	-0.3678
Cetoniinae	-0.3153
Rutelinae	-0.2964
Melolonthinae	-0.2614
Hybosorinae	-0.1912
Geotrupinae	-0.1445
Troginae	-0.1137
H'	1.6903

The data (Table 2) indicates that Scarabaeinae subfamily fauna showed abundance in population (0.3678), followed by Cetoniinae (0.3153), Rutelinae (0.2964) and Melolonthinae (0.2614). Whereas subfamily Hybosorinae (0.1912), Geotrupinae (0.1445) had moderate abundance of Scarabaeids fauna. Troginae subfamily showed lower population of scarabaeid fauna. However, moderate to rich Shannon biodiversity index (H$^{=}$1.6903) was noticed in terms of subfamilies of scarabs in Akola. Gite *et. al.*, (2014) calculated the biodiversity of white grub species by diversity indices in western Maharashtra, India. Mohod *et.al.*, (2015) reported diversity index (H'=1.5738) for different subfamilies of family Scarabaeidae in Akola vicinity of Maharashtra.

LITERATURE CITED

Aland, S. R., A. B. Mamlayya and G. P. Bhawane, 2012. Diversity of beetles (Insecta: Coleoptera) in and around Amba reserve forest, western ghat, Kolhapur Avishkar Solapur Univ. Res. J. 2: 31-41.

Chandra, K. and D. Gupta, 2012[a]. Bolboceratine scarabs of Genera *Bolbohamatum* Krikken, 1980 and *Bolbogonium* Boucomont, 1911 (Coleoptera: Geotrupidae) from Central India, Taprobanica 4(2): 69-76.

Chandra, K. and D. Gupta, 2012[b]. First report on five species of *Onthophagus* Latreille, 1802 (Coleoptera, Scarabaeidae) from Madhya Pradesh, India and their description of external male genitalia, Biodiversity Journal 3(2): 99-106.

Chandra, K. and D. Gupta, 2012[c]. An Inventory of scarab beetles (Coleoptera : Scarabaeidae) of Achanakmar - Amarkantak Biosphere Reserve, Chhattisgarh, India, I.J.S.N. 3(4): 886-891.

Chandra, K., S. Khan and D. Gupta, 2012. New Records to the Species Diversity of Family Scarabaeidae and Hybosoridae (Coleoptera: Scarabaeoidea) of Jabalpur, Madhya Pradesh (India), Academic J. Ent., 5 (1): 28-36, ISSN 1995-8994.

Dadmal, S. M., S. S. Khadakkar and P. A. Ghuge, 2013. Occurrence of fiveHolotrichia species (coleoptera: Scarabaeidae : melolonthinae) in maharashtra and their male genitalia characterization, The Bioscan 8(1) : 349-35.

Grebennikov, V. V. and C. H. Scholtz, 2004. The basal phylogeny of Scarabaeoidea (Insecta: Coleoptera) inferred from larval morphology, Invertebrate Systematics, 2004, 18, 321–348.

Gite, R.B., P. B. Mohite and B. Rathour, 2014. Distribution and diversity of White grub species in Western Maharashtra, India, International J. Sci. and Res. 4(12):1270-1272.

Kumar, S., T. M. Ali and N. A. Reddy, 2006. Studies on faunal composition of scarabaeids on rose around Banglore, Agric. Sci. Digest, 26 (4): 257-260.

Mohod, D. N., S. M. Dadmal, D. B. Undirwade, V. Bajad and S. Khadakkar, 2015. Diversity and abundance of scarab beetles from Akola Vicinity, PKV Res. J. 39(1,2): 101-105

Nuria, T. M. and J. C. S. Francisco, 2010. The species description process of North and Central American Geotrupinae (Coleoptera: Scarabaeoidea: Geotrupidae), Revista Mexicana de Biodiversidad 81: 299- 308.

Parvez, A. and M. Srivastava, 2010. A short-term surveillance of coleopteran fauna in an agro-ecosystem near Bikaner (Western Rajasthan), India Biological Forum—An International Journal. 2(1): 23-29.

Pawara, R. H., N. G. Patel, J. V. Pawara, P. J. Gavit and S .S. Ishi, 2014. Beetles of Jalgaon district of Maharashtra, India, Biolife, An international Quartly J. Life Sci., 2(3): 970-973.

Ratcliffe, B. and M. Jameson, 2002. Key to Families and Subfamilies of Scarabaeoidea of the New World.

Taggar, G. K., R Singh, R. Kumar and P.C. Pathania, 2012. First report of Flower beetle, *Oxycetonia versicolor* on Pigeon pea & Mungbean from Punjab, India. Phytoparasitica, 40(3):207-211

Thakare, V.G., V.S. Zade and K. Chandra, 2012[a]. New Records of Scarabaeid Beetles (Coleoptera: Scarabaeidae) from Melghat Tiger Reserve, Maharashtra, India, Biological Forum — An International Journal, 4(1): 6-10

Thakare, V., V. Zade, K. Chandra and D. Gupta, 2012[b]. Scarab Beetles (Coleoptera: Scarabaeoidea) of Melghat Tiger Reserve, Central India, Academic Journal of Entomology 5 (2): 73-80.

Thakare, V.G., V.S. Zade and K. Chandra, 2011. Diversity and Abundance of Scarab Beetles (Coleoptera: Scarabaeidae) in Kolkas Region of Melghat Tiger Reserve (MTR), District Amravati, Maharashtra, India, World J. Zoology 6 (1): 73-79.

Ziani, S. and G. Sama, 2013. Chorological data on some Geotrupidae, Aphodiidae and Scarabaeidae (Coleoptera, Scarabaeoidea) species collected during some field-trips in Turkey, Munis Entomology & Zoology, 8 (1): 458-465

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Characteristics of Suicide Farmers in Yavatmal district of Vidarbha

"On average, one farmer commits suicide every 30 minutes in India," (Sainath, 2007 and Center for Human Rights and Global Justice, 2011). Government of India had declared 31 districts as distressed district where the Prime Minister's special rehabilitation package was implemented. In these 31 districts there are six districts from Vidarbha region of Maharashtra. (Anonymous, 2006). "To be, or not to be." (Shakespeare, Hamlet) has been an important question among thinkers (Rauscher 2000). As suicide is a complex social and psychological phenomenon, which factors are mostly responsible for suicides in Vidarbha region and which factors should have been taken for study is big question among researchers. However, Madan (1980), Singh (2005) and Kale (2008) pointed out that the causes of suicide are complex, as are the causes of any social phenomenon. Many factors combine to cause, one particular individual (and not another) to divert his aggression upon himself in the form of suicide. Phal (2000) stated that suicide is both a psychological and social phenomenon. Durkheim (2002) also pointed out that the neurobiological and socio-economic dimensions of risk factors are responsible for committing suicide, but the intersection of these two sets, where the relative risk of committing suicide is higher. In recent review of the neurobiological literature, Mann (2002) cleared that the neurobiological risk factors are predisposing in nature and they internally existing with the individual.

The Vidarbha region of the Maharashtra state is the epicenter of the farmers' suicide in the country. As per the government record in Vidarbha particularly in six districts namely Yavatmal, Amravati, Buldana, Washim, Akola and Wardha since 01, January 2001 to 15, December 2016, total 13,425 farmers committed suicide. This is what we have been hearing from Vidarbha and other part of the country over the last sixteen years. This is now the researchable issue. This research paper deals with the specific objectives to study the personal, socio-economic, situational and socio-psychological characteristic of the farmers and families of the farmers who committed suicide in suicide hit Yavatmal district.

Present research investigation was carried out in Yavatmal district of Maharashtra where percentage of farmer's suicide was found relatively more than other districts. The present study was based on Exploratory Design of Social Research. In this study, respondents were the households of the selected victim who committed suicide, during 1, January 2012 to 31, December 2012 and had declared as a legal victims by district level committee headed by collector of Yavatmal district, for allotting compensation of Rs. 1 lakh and had got Rs. 1 compensation. The time period 1st January to 31st December 2012 was selected purposively so as to match the similar farming condition with all victims.

Before sampling, researchers had contacted personally to the collector office of Yavatmal district and obtained the complete list of farmers who committed suicide during 1, January 2012 to 31, December 2012. In all there were 175 total suicide cases in Yavatmal district, out of which 98 cases were declared as illegal and 77 cases were declared as legal victims. From the list of 77 legal suicide cases, researcher had selected 60 victims by proportionate method of random sampling. It covers 58 villages and 16 *talukas* of Yavatmal district. The detail *taluka* wise list of the selected victims has been given in following Table A. Data were collected by personal interview method with the help of structural interview schedule. Interview was conducted at residence of respondent so as to review overall situation of the family by researcher. In addition to personal interview, RRA (Rapid Rural Appraisal) technique, time line study for historical perspectives, observations, discussion with family members and discussion with key informants (*Police Patil, Sarpanch*, local leaders, other farmers of the village), reviewing victims actual record of institutional debts etc. were some important methods used for data collection.

Distribution of victims according to the personal, socio-economic, situational and socio-psychological characteristics had been presented in Table 1 as below.

It is observed from Table 1 that 36.67 per cent victims were found in young age category followed by 33.33 per cent found in middle age group and 30.00 per cent were found in old age category. The data revealed that from all age group more than one third victims were observed. In case of educational level more than one third (35.00 %) respondents were illiterate and remaining 65.00 per cent were literates. Within the literates 26.67 per cent victims were having education up to middle school level and 16.67 per cent were educated up to high school level.

Table: Characteristics of Suicide Farmers in Yavatmal district of Vidarbha

S.N.	Characteristics	Frequency N=60	Percentage
A	Age		
1	Young (up to 35)	22	36.67
2	Middle (36-50)	20	33.33
3	Old (Above 50)	18	30.00
B	Educational level		
1	Illiterate (no schooling)	21	35.00
2	Primary school(1-4)	08	13.33
3	Middle school(5-7)	16	26.67
4	High school (8-10)	10	16.67
5	Higher Secondary school (11-12)	02	03.33
6	College (Above 12)	03	05.00
C	Caste category		
1	Schedule caste(SC)1	04	06.67
2	Schedule Tribe(ST)2	08	13.33
3	Vimukta Jati (VJ-A)3	16	26.67
4	Nomatic Tribe (NT-B)4	05	08.33
5	Nomatic Tribe(NT-C)5	05	08.33
6	Nomatic Tribe (NT-D)6	03	05.00
7	OBC(7)	18	30.00
8	Open(9)	01	01.67
D	Family Size		
1	Small (up to 3)	16	26.67
2	Medium (4-6)	32	53.33
3	Large (7-9)	12	20.00
E	Land holding		
1	Marginal (up to 1 ha)	06	10.00
2	Small (1.01-2.00 ha)	33	55.00
3	Semi medium (2.01-4.00 ha)	15	25.00
4	Medium (4.01-10.00 ha)	06	10.00
F	Livelihood sources		
1	Agriculture + Labour	17	28.33
2	Agriculture (Farming)	43	71.67
G	Annual Income		
1	Up to 25000	00	00.00
2	25001-50000	15	25.00
3	50001-75000	17	28.33
4	75001-100000	18	30.00
5	Above 100000	10	16.67
H	Socio-economic status		
1	Very low (up to 05.21)	16	26.67

2	Low (05.22-08.37)	36	60.00
3	Medium (08.38-11.52)	05	08.33
4	Medium high (11.53-14.67)	03	05.00
I	Irrigation facilities		
1	No source	24	40.00
2	River	03	05.00
3	Well/tube well	19	31.67
4	Canal	06	10.00
5	Well + Canal	08	13.33
J	Credit source availed		
1	Only Formal/ Institutional	31	51.67
2	Only Informal/ Non-Institutional	12	20.00
3	Both	17	28.33
K	Amount of debts		
1	Up to 25000	04	06.67
2	25001-50000	12	20.00
3	50001-100000	41	68.33
4	Above 100000	03	05.00
L	Crop grown		
1	*Kharif* crops	50	83.34
2	*Kharif* + *Rabi* crops	08	13.33
3	*Kharif* + *Rabi* + Summer crops	02	03.33
M	Cropping intensity		
1	Up to 100%	50	83.33
2	Above 101 to 121.03 %	10	16.67
N	No. of times crop fail		
1	No failure	18	30.00
2	1 time	13	21.67
3	2 time	28	46.67
4	3 time	01	01.66
O	Victims health		
1	Victim free from health problem	44	73.33
2	Victim having health problem	16	26.67
P	Family health		
1	Family members were free from health problem	55	91.67
2	Family members having health problem	05	08.33
Q	Family dispute		
1	Free from dispute/quarrel	53	88.33
2	Having dispute/quarrel with family members	07	11.67
R	Victims according to alcoholism		
1	Regular	22	36.67
2	Occasional	21	35.00
3	Not like	17	28.33

While 13.33 per cent had primary school level education and 05.00 per cent victims had college level education. Only 03.00 per cent possessed higher secondary school education. Caste wise distribution from Table 1 revealed that majority 30.00 per cent suicide cases were belongs to OBC category and mostly the Kunbi's from all the victims in Yavatmal district. This was followed by Vimukta Jati 26.67 per cent.The victims belonging to Schedule Tribe (ST) category were 13.33 per cent, next to this Nomatic Tribe (VJ-A) and Nomatic Tribe (NT-C) were found in 8.33 per cent and 8.33 per cent respectively, whereas 06.67 per cent victims were found in Schedule caste (SC) followed by 05.00 per cent found in Nomatic Tribe (NT-D). Only 1.67 per cent victims were found in open class category whereas no one was from SBC category.

The data in Table 1 revealed that majority 53.33 per cent suicides were concentrated in medium size family having 4 to 6 family members. While more than one forth 26.67 per cent victims having small family size (up to 3 members) followed by 20.00 per cent victims having large family size (7 to 9 members). Thus, it is inferred that majority of the suicides were concentrated between medium and small family size. Similar results were reported by Kale (2013). From Table 1 it is observed that maximum 61.67 per cent, victims were from joint type of family and 38.33 per cent victims belonged to nuclear family.

The distribution of the victims according to land holding is presented in Table 1 shows that more than half (55.00%) of the victims were small farmers having land holding between 1.01 to 2.00 hectares, followed by 25.00 per cent victims were semi medium farmers possessing land up to 1.00 hectares. Whereas, 10.00 per cent each of the victims had marginal (up to 1 hectare) and medium (4.01 to 10.00 hectare) land holding. Regarding livelihood it is clear that majority of the victims (71.67%) were engaged in only Agriculture (farming) and remaining 28.33 per cent victims were farm labour for wage earning as a supportive endeavor to farming. The annual income of the selected households revealed that 30.00 per cent of victims had annual income in the range of Rs. 75001 to 100000. Followed by 28.33 per cent of victims had annual income between Rs. 50001 to 75000, one forth (25.00%) victims had annual income in the range of Rs. 25001 to 50000. Only 16.67 per cent deceased farmers had annual income above Rs. 100000.

Operationally, socio-economic status was defined as position, the victim and his family members occupied, with reference to prevailing average standard of cultural position, effective income, material possession and participation in the group activities of the community. Scale developed and standardized by Thakare (2004) and Thakare and Ingale (2007) was used for measurement of socio-economics status. According to Jacob (2006) decline in socio-economic status was one of the psychological factor associated with an increased risk for suicide, hence this variable was considered for the study.The result pertaining to socio-economic status of the victims has been presented in Table 1. It could be noted from Table 1 that more than half of the victims 60.00 per cent were found in low level of socio-economic status. Most (26.67%) of the deceased farmers were categorized in very low socio-economic status. Only 08.33 and 05.00 per cent victims were observed in medium and medium high level of socio-economic status. Similar results were reported by Kale (2013).

Availability of irrigation facilities and their irrigation potential significantly affect the cropping pattern, production, productivity and ultimately income level of farmers by many folds (Shivappa 2006). Hence irrigation facilities available with the selected victims were ascertained and data in this regard are presented in Table 1. It is observed from Table 1 that 40.00 per cent most of the victims were not having any source to access the irrigation. They solely depended on monsoon rains. Nearly one third 31.67per cent deceased farmers were having only open well as irrigation source, whereas, 13.33 per cent victims had both canal and well as irrigation source. It is observed that the 10.00 per cent victims were having only canal and only 5.00 per cent victims were having river as a irrigation source. Table 1 indicates the source wise indebtedness position of all selected victims. It is observed from Table 1that over half (51.67%) of the victims had outstanding debt of only institutional credit sources whereas 28.00 per cent victims had outstanding debt of both institutional and non-institutional credit sources. Only 20.00 per cent victims had outstanding debt of only non-institutional credit sources. Distribution of the victim's according to their amount of debt is presented in Table 1. From Table 1, out of 60 victims, 41 (68.33%) had the debt in the range of Rs. 50001 to 100000. This was followed by 20.00 per cent victims in class of Rs. 25001 to 50000. It was also revealed that out of 60 victims,

only 6.67 per cent victims had debt up to Rs. 25000 and only 5.00 per cent victims were having debt Rs. above 100000. Distribution of victims according to their crops grown in various season are shown in Table 1. From Table 1, it was observed that majority of the victims were possessed *Kharif* cropping pattern, followed by 13.33 per cent victims were possessed both *Kharif and Rabi* cropping pattern. Only 3.33 per cent victims were taking *Kharif, Rabi* and summer crops. It can be seen from Table 1 that, majority 83.33 per cent of the victims having cropping intensity up to 100 per cent and only 16.67 per cent victims were found which having cropping intensity in the range of 101 to 186.1 per cent. It may be due to the lack of irrigation sources with them. Hence they have taken only *Kharif* crope hence their cropping intensity was observed upto 100 per cent only. It is found that, 46.67 per cent victims had been suffered from two times crop failure during last two years. There were no failure had been seen in 30.00 per cent victims. 21.67 per cent victims were suffering from one times crop failure and only 1.66 per cent of victims were suffering from three times crop failure. According to past research studies on suicide by various social scientists self illness has been proved an important contributing risk factor of suicide in 10 to 51 per cent cases (Kale, 2008). Hence, this was also an important aspect of the present study. Here, health status of suicide farmers during the last two years before the incidence had been considered. The information on health status of the victims were collected and the same is presented in Table 1. From Table 1, it could be seen that the personal health problem was noted in 26.67 per cent deceased farmers, who committed suicide in Yavatmal district, while majority 73.33 per cent were free from health problem. A perusal of Table 1 revealed that in majority 91.67 per cent deceased farmers, family health was not the problem and in 8.33 per cent deceased farmers, ill health of their family members were observed. Regarding family dispute it is seen that in 11.67 per cent victims, dispute /quarrel was noticed with their family members due to domestic reasons, whereas, majority 88.33 per cent victims were free from any domestic dispute / quarrel with their family members. From Table 1, it is observed that, 36.67 per cent of the victims has addicted to alcoholism regularly, whereas, 35.00 per cent of the victims has taken occasionally. It was also observed that 28.33 per cent victims were free from alcoholism.

CONCLUSION

This study concludes that small rainfed land holding with lack of subsidiary occupations, low educational level, subsequent crop failures, very low to low socio-economic status were the important causes were observed with the selected households. Hence their livelihood was unsustainable. Hence this study implied that policy maker's have to provide the social security to the farmers and think about for raising the economic condition of the farmers in study area. Involve them in SHGs and provide financial assistance for subsidiary occupations for sustaining their livelihood.

LITERATURE CITED

Anonymous, 2006. Report of the Expert Group on Agricultural Indebtedness *("Radhakrishna report")*, Ministry of Finance, New Delhi : 15-17.

Center for Human Rights and Global Justice: NYU School of Law. 2011. Every Thirty Minutes: Farmer Suicides, Human Rights, and the Agrarian Crisis in India, New York: CHR & GJ. http://www.chrgi. Org/publications/ docs /every30min.pdf.

Durkheim, E. 2002. (first published in French in 1897). Suicide, London and New Tork, Routledge Classics.

Jocob, D.G. 2006. Assessment and assignment of suicide risk resource materials, http://www.thrani.com/pdf/ suic1. pdt

Kale, N.M. 2008. Socio-economic, psychological and situational causes of suicides of farmers in Vidarbha region. Ph.D. Thesis (Unpub.), Dr. PDKV, Akola. Jawaharlal Nehru Award of ICAR, New Delhi.

Kale, N.M. 2013. Socio-economic, Psychological and Situational Causes of Suicides of Farmers in Vidarbha Region of Maharashtra, Indian J. Extn. Educ., Vol. 49, No. 3 & 4, 2013 (12-18) .

Mann, J. 2002. A current perspective of suicide and attempted suicide, Annals of Internal Medicine. Vol. 136. : 302-311.

Madan, G.R. 1980. Indian Social Problems, Volume-I. New Delhi, Allied Publishers Private Limited.

Phal, S.R. 2000. Theories of suicide: Types of suicide, causes and management. The Problem in India. In.Jogan, Shankar. (eds.), Social Problems and Welfare in India, New Delhi, Ashish Publishing House.pp.101-111.

Rauscher, W.V. 2000. To be or not to be: A pastoral view of suicide in today's world, Xlibris Corporation.

Singh, K. A. 2005. Suicide by farmers in Andhra Pradesh - An analysis. Agricultural Extension Review, May-June. Vol. 17(3):pp 21-23.

Shivappa, H. 2006. Role of irrigation in agricultural development. A study with special reference to Kernataka, Ind. J. of Agril. Econ. Vol. 61. No.3. July-Sept. : 509-510.

Sainath, P. 2007. One farmer's suicide every 30 minutes, The Hindu, November, 15.

Thakare, U.G. 2004. Impact of Centrally Sponsored Crop Development Programmes on the Beneficiaries, Ph.D. Thesis (Unpub.), Dr.PDKV,Akola.

Thakare, U.G. and P.O.Ingle, 2007. Development and standardization of Socio-economic Status Scale, Indian J. Extn. Educ. XXXXIII, 8-16.

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Soil Testing Status of Orange Orchards in Amravati District of *Vidarbha*

Mandarin orange (*Citrus reticulata*) is most common among citrus fruits grown in India. It occupies nearly 40 per cent of the total area under citrus cultivation in India. The most important commercial citrus species in India are the mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*) sharing 41, 23 and 23 per cent, respectively of all citrus fruits produced in the country. In India, citrus is grown in 0.62 million ha. area with the total production of 4.79 million tonnes. The area under orange cultivation in India increased by 67 per cent, from 1.19 lakh ha. in 1991-92 to 1.99 lakh ha. in 2001-02 and the production increased by 57 per cent, (i.e. from 10.58 to 16.60 lakh tonnes). Oranges are mostly grown in the states of Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa, West Bengal, Rajasthan, Nagaland, Mizoram, Arunachal Pradesh (Anonymous, 2002).

Orange occupies the second position among all fruits cultivated in Maharashtra, which has 2.47 lack hectares area under orange cultivation with production of 1761 metric tons with the productivity of 6.4 MT ha^{-1} (Anonymous, 2015). The Nagpur mandarin orange (Citrus reticulate Blanco) is one of the most important fruit crops of Maharashtra state. It is a glorious natural gift to the Vidarbha region and is famous for its exceptional quality of fruits in the world. Hence, Nagpur has created its own status as 'Orange City' in the globe. In Maharashtra, orange is cultivated in many districts like Amravati, Nagpur, Akola, Wardha and Yavatmal. The Amravati and Nagpur districts contribute about 80 per cent of the total area under orange orchards in Maharashtra State sharing 48.88 per cent and 31.45 per cent respectively. In case of production of Orange in Vidarbha, larger production in Amravati district i.e. 37.36 per cent while that in Nagpur district is 23.87 per cent, thus it is seen that Amravati district possessed the largest share of oranges in the Vidarbha orange market. The largest orange cultivation and production is in Warud, Morshi, Chandur Bazar, Achalpur and Anjangaon talukas of Amravati district.

Oranges require deep, uniform and well drained soil because number of feeder roots is less in citrus with pH 5.5 to 7.5. It should be free from hard pans and salty layers (salt content less than 0.1%). The highest global citrus production comes from the soils represented by the order Alfisol, Ultisol, Entisol and Inceptisol (Kohli and Srivastava, 1997; Srivastava and Singh, 2002). Balanced nutritional programme play a dominant role in producing healthy trees with maximum yield and good fruit quality. The cultivation of free lime, excessive salt, defective drainage, and presence of hard pan in the subsurface, soil texture, citrus is dependent on several factors like presence of mineralogy composition of soil, cation exchange

capacity, soil fertility, etc. (Srivastava, *et. al.*, 1999). The free $CaCO_3$, powdery lime, and massive structure in soils limit the water and nutrient absorption (Jagdish, *et. al.*, 2001). Among the various factors which affect the crop production of citrus, $CaCO_3$ (not more than10.00%) plays a very important role. The basic objective of soil testing programme is to give farmers a service leading to better and more economic use of fertilizers, and soil management practices for increasing agricultural production.

Orange is the one of the important fruit crop in Amravati district. In Amravati 70589.4 hectare area is under orange cultivation and out of that 55003.60 hectare is productive orchard. Productivity of orange orchards is 9-10MT/ha and if irrigation facilities are available then it is 12-14MT/ha (S.A.O data 2015). Now a day consumption of fertilizer by farmer is higher than actually requirement. The orange growers are not follows the soil testing technique. The present study was undertaken with the specific objectives to study the knowledge of the selected orange growers about soil testing techniques and adoption status of the soil testing recommendation report.

The study was conducted in Warud and Morshi *talukas* of Amravati district (Vidarbha region) of Maharashtra with exploratory design of the social research. Multistage sampling method was used for the study. From each *taluqa* 10 villages were selected on the basis of large area under orange orchards and from each selected village five farmers were selected having productive orange orchard. Thus total 100 respondents were the sample for the study.

Knowledge of soil testing techniques

The knowledge possessed by the orange growers about soil testing techniques and its recommendation was ascertained and results were depicted in Table 1 as follows. The data regarding practice wise knowledge of the respondents about soil testing techniques and its recommendations in Table 1, revealed that cent per cent (100.00%) of the respondents had knowledge about depth of soil sample, followed by 95.00 per cent of the respondents having knowledge about recommended dose of N for orange per plant, 94.00 per cent of respondent had knowledge about time of soil sampling (before and after planting of orange orchards), 93.00 per cent respondents have knowledge about recommended dose of P_2O_5 and about 77.00 per cent respondents have knowledge about pH, EC, organic carbon, $CaCO_3$, N, P, K testing, whereas 72.00 per cent each respondents possessed knowledge about micronutrients testing and benefits of soil testing. The 65.00 per cent of the respondents having knowledge about procedure of soil sampling, 64.00 per cent respondents have knowledge about recommended dose of FYM, 56.00 per cent respondents possess knowledge about preparation of soil sample and 52.00 per cent respondents have knowledge about objective of soil testing. The 45.00 per cent respondents possessed knowledge about selection of sites for soil sampling and 46.00 per cent respondents possess knowledge about meaning of soil testing.

The 29.00 per cent each of the respondents having knowledge about recommended dose of K_2O for orange orchards, 28.00 per cent respondents have knowledge about information to be attached with soil sample. Only 16.00 per cent respondents possessed complete knowledge about soil testing report and 14.00 per cent respondents possessed knowledge about water quality testing.

The overall knowledge of respondents about the soil testing techniques and its recommendation report was ascertained on the basis of knowledge level of the respondents about all selected practices. It was observed that majority of the respondents (64.00%) had medium level of knowledge about soil testing techniques and its recommendation. Where as 30.00 per cent and 06.00 per cent of the respondent farmers were having high and low level of knowledge about the soil testing techniques and its recommendation, respectively. Thus, study concluded that majority of the respondent had medium level of knowledge about soil testing techniques and its recommendation. Similar finding were reported Poonia (2002), Ingle (2011), Dhotare (2014) and Mankar (2015).

Adoption status of soil test technique

The data regarding the soil testing done by the selected farmers have been collected from the selected orange orchards. It was observed that 58.00 per cent of the orange growers have tested their soil and remaining 42.00 per cent have not tested the soil. The practice wise adoption of soil testing techniques and its recommendations as per the soil test report given by the soil testing laboratory has also been studied and the results in this regards revealed that 63.79 per cent orange growers have applied nitrogen doses as per the recommendation i.e. full adoption, followed by 36.21 per cent applied

nitrogen doses partially as per the soil test report. As regarding to the application of phosphorus fertilizer 91.38 per cent of orange growers applied partially the doses of phosphorus as per the recommendation of soil test report, followed by 8.62 per cent of the orange growers have applied the doses of phosphorus as per the soil test report recommendation i.e. full adoption. As the black cotton is rich in potash therefore it was observed that there is no need of potassium as per the soil test report.

It was observed from Table 2 that all respondent (58.00%) who have tested their soil applied FYM partially as per the soil test report. The results regarding to the application of micronutrients 46.55 per cent orange growers have applied micronutrients as per the soil test report i.e. full adoption, followed by 39.66 per cent orange growers never applied micronutrients. Whereas, 13.79 per cent applied micronutrients partially as per the soil test report. It was observed that 58.00 per cent orange growers have tested their soil. Out of them 72.42 per cent of the respondents had medium level of adoption of soil testing recommendations. The percentage of respondents having low level of adoption was 18.96 per cent, whereas 08.62 percent respondents were having high level of adoption. Thus, study concluded that majority of the respondent had medium level of adoption about soil testing recommendations. Similar finding were reported by Meshram (2010), Patil (2013), Dhotare (2014) and Mankar (2015).

CONCLUSION

The study revealed that 58.00 per cent orange growers have tested their orchard soil and 64.00 per cent of the respondents had medium level of knowledge about soil testing techniques and its recommendation. Out of the 58.00 per cent orchard owners who have tested soil, out of them 72.42 per cent had adopted soil test report recommendations at medium level. That means they have not applied the fertilizer doses as per the report of soil test. Hence this study implied that there is a need to convince and motivate the farmers by all extension functionaries to test the orchard soil in soil health card programme of the Government and adopt the fertilizer doses as per the soil test report for good yield and maintaining the soil health of the orchard.

Table 1: Distribution of respondents according to their knowledge about the soil testing techniques and its recommendation by the orange growers

S. N.	Particulars of soil test	% of the orange growers have knowledge
A) Soil Sampling		
1	Depth of soil sample in cm. (0-30),(30-60), (60-90)	100.00
2	Selection of sites	45.00
3	Procedure of Soil Sampling	65.00
4	Preparation of Soil Sample	56.00
5	Information to be attached	28.00
6	Time of soil sampling (Before and after planting of orange orchards)	94.00
7	Water quality testing	14.00
8	pH ,EC, organic carbon $CaCO_3$,N,P,K testing	77.00
9	Micronutrients testing (Zn, Fe, Mn, Cu)	72.00
B) Soil Testing		
1	Meaning of Soil Testing	46.00
2	Objective of Soil Testing	52.00
3	Benefits of Soil Testing	72.00
C) Knowledge about Recommended doses N,P,K and FYM		
1	Recommended dose of N for orange 800gm/plant	95.00
2	Recommended dose of P_2O_5 for Orange 400gm/plant	93.00
3	Recommended dose of K_2O for orange 600gm/plant	29.00
4	Recommended dose of FYM for orange 50 Kg/plant	64.00
5	Complete Knowledge about soil testing report	16.00

Table 2: Distribution of the respondents according to practice wise adoption as per the soil test report.

S.N.	Adoption as per soil test report	Adoption (n=58)		
		FA(2)	PA(1)	NA(0)
1	Application of Nitrogen Fertilizer	37	21	00
		(63.79)	(36.21)	(00.00)
2	Application of Phosphorus Fertilizer	05	53	00
		(08.62)	(91.38)	(00.00)
3	Application of Potash Fertilizer	58	00	00
		(100.00)	(00.00)	(00.00)
4	Application of FYM	00	58	00
		(00.00)	(100.00)	(00.00)
5	Application of micronutrients	27	08	23
		(46.55)	(13.79)	(39.66)

FA = Full Adoption, PA = Partial Adoption, NA = No Adoption

LITERATURE CITED

Anonymous, 2002. Database of National Horticulture Board, Ministry of Agriculture, Govt. of India, Available at http://nhb.gov.in/report_files/orange/ORANGE.htm.

Anonymous, 2015. National Horticultural Database.www.nhm.nic.in

Dohtare, P. N., 2014. Adoption of Soil Test Recommendations by the Paddy Farmers, M.Sc. Thesis (Unpub) Dr. PDKV Akola.

Kohli, R. R. and A. K. Srivastava, 1997. Nutritional requirement of Nagpur mandarin in clay soils of Central India, Indian Farm., 47:25-27.

Ingle, S. M., 2011. Knowledge and adoption of land care technique in salt affected track of Puma Valley, M.Sc. (Agri) Thesis (Unpub) Dr.PDKV, Akola.

Jagdish, P. N., S. Rajeev, S. K. Ray and P. Chandran , 2001. Characteristics and classification of some orange growing soils in Nagpur district of Maharashtra, J. Indian Soc. Soil Sci. 49(4):735-739.

Mankar D. M., N. M. Kale, P. P. Wankhade, P. P. Bhople, R.S.Waghmare and R. N. Katkar, 2015. Soil Testing Status of the farmers in Distress Prone District of Vidarbha. Research review committee report, Department of Extension Education,Dr. PDKV,Akola.

Meshram, P.P., 2010. Follow up study of recommendation of soil testing by the Farmers M.Sc. (Agri.) Thesis (Unpub), Dr. PDKV Akola.

Patil, A .S., 2013. Adoption of soil test recommendations by the Farmers, M.Sc. (Agri.) Thesis (Unpub) Dr. PDKV, Akola.

Poonia, A 2002. "Technological gap among the Kinnow (*Citrus deliciosa)* orchard owners in Sriganganagar district of Rajasthan", M.Sc. (Agri) thesis (Unpub) MPUAT, Udaipur.

Srivastava, A. K. and S. Singh, 2002. Soil analysis based diagnostic norms for Indian citrus cultivar, Comm. Soil Sci. Plant Analy., 33:1689-1706.

Srivastava, A. K., R. R. Kohli ,H.C. Dass ,A.D. Huchche and R. Lallan 1999. Evaluation of the nutritional status of Nagpur mandarin (Citrus reticulata Blanco) by foliar sampling, Trop. Agric., 72(6):93-98.

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