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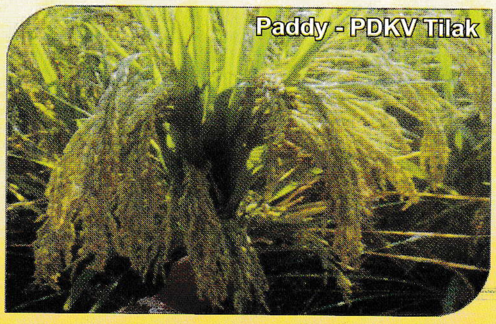
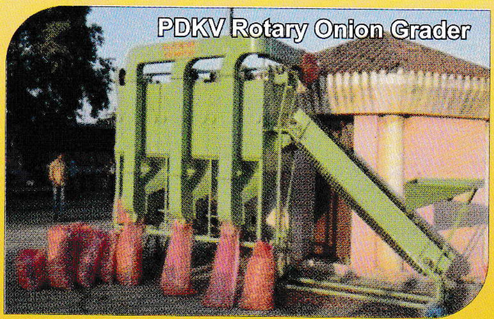
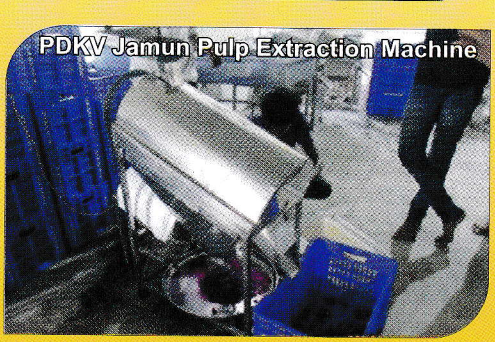
Soybean - PDKV Yellow Gold


Paddy - PDKV Tilak


PDKV Rotary Onion Grader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Genetic Diversity for Yield and Quality Components in Cluster Bean

R. S. Wankhade[1], V. S. Kale[2], P. K. Nagre[3] and H. H. Dikey[4]

ABSTRACT

Fifty five genotypes of cluster bean were evaluated for genetic divergence using Mahalanobis D^2 technique in summer-2014 at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The genetic material exhibited wide range of genetic divergence for all the 28 traits investigated. Among the twenty eight characters studied, dry pod yield ha^{-1} (24.92 %) contributed highest towards genetic divergence followed by gum yield (22.90 %). The inter-cluster D^2 values of 8 clusters revealed that maximum divergence occurred between V and VIII (D^2=12012.73), while closer proximity existed between II and V (D^2=1735.42). Among Intra-cluster distance, maximum divergence was reported for cluster VI (D^2=2503.67) and minimum for solitary cluster, cluster V, VII and VIII (0.00). Maximum divergence indicates genotypes of divergent group where as minimum divergence indicates genotypes of closer nature in the cluster. On the basis of inter-cluster distances and *per se* performance observed, the genotypes with specific characters (protein percentage and gum content in seed, hundred seed weight, ten dry pod weight) was utilized for hybridization programme using cluster mean values.

Cluster bean [*Cyamopsis tetragonoloba* L.) Taub] [2n=14], is an under exploited leguminous crop. It is a drought tolerant, deep rooted, *Kharif* annual legume. The endosperm fraction of cluster bean seed is rich in galactomannan (16.80 to 30.90 %), which is being used in multifarious applications like cosmetics, explosive, mining, oil industries, dairy products, textile, paper, candy products and baking industries. The crop also has medicinal value for curing diabetes and those having cadastral levels.

Considering the importance of cluster bean gum for industrial and medicinal purposes, there is a prime need for its improvement. Six genetic divergence analysis have been conducted in cluster bean, for vegetable and seed purpose by Gipson and Balakrishnan (1992), Henry and Mathur (2005), Girish *et al*. (2012), Shabarish Rai and Dharmatti (2013), Vikas Kumar *et al.* (2014) and Niranjana *et al.*(2015). D^2 statistics developed by Mahalanobis (1936) provides a measure of magnitude for divergence between two genotypes under comparison. Grouping of genotypes based on D^2 analysis will be useful in choosing suitable parental lines for breeding. Therefore, present study was undertaken to know the nature and magnitude of genetic divergence, clustering pattern of 55 genotypes of cluster bean and to identify suitable genotypes having maximum genetic divergence for selection in crossing programme.

MATERIAL AND METHODS

An investigation was carried out at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, during summer- 2014 in Randomised Block Design (RBD) with two replications. It has come out with results on genetic divergence (D^2) (Mahalanobis (1936)) from the evaluation of 55 cluster bean genotypes listed in table 3 which were collected from NBPGR, Jodhpur, Rajasthan. Each plot consisted of two rows of 1 m length with a spacing of 60 cm x 10 cm. All the recommended package of practices for cluster bean was followed. Observations were recorded on five competitive plants in respect of 28 characters *viz.*, plant height (30, 60 and 90 DAS), plant spread (cm^2), number of primary branches per plant, internodes length, days to first flower, days to 50 per cent flowering, number of dry pod cluster $plant^{-1}$, number of dry pod $cluster^{-1}$, number of dry pods $plant^{-1}$, days to first picking of dry pod, length of dry pod, width of dry pod, ten dry pod weight (g), number of seeds dry pod^{-1}, hundred seed weight (g), dry pod yield $plant^{-1}$ (g), dry pod yield $plot^{-1}$ (g), dry pod yield (q ha^{-1}), seed yield $plant^{-1}$ (g), seed yield $plot^{-1}$ (g), seed yield (q ha^{-1}) seed to husk ratio, gum content in seed (%), endosperm percentage in seed, protein percentage in seed and gum yield (Kg ha^{-1}). The data obtained from mean values of five plants for 28 characters were subject to statistical and divergence (Mahalanobis (1936)) analysis. The

1. Assistant Professor, 2. Professor, 3. Head and 4. Assistant Professor, Department of Vegetable Science, Dr. PDKV, Akola

genotypes were grouped into different clusters following Tocher's method as described by Rao (1952).

RESULTS AND DISCUSSION

Analysis of dispersion using Wilk's criterion

Analysis of dispersion has been presented in Table 1. The analysis of dispersion for the test of significance of differences in the mean values based on Wilk's Criterion revealed highly significant differences between the genotypes for the aggregate of 28 characters, justifying thereby, the need to calculate D^2 values. Therefore, D^2 values were estimated for the 55 genotypes in summer 2014 in Akola environment.

Table 1. Analysis of dispersion

S. N.	Source of variation	d.f.	Mean Squares
1	Genotypes	54	2.5034E05**
2	Error	53	4.6792E27
3	Total	107	1.2634E05

** P< 0.01

Contribution of each character towards total divergence

The relative ranking of different character components of D^2 analysis showed that maximum contribution towards total divergence (Table 2) by dry pod yield per hectare (24.92 %). This was followed by gum yield (22.90%), seed to husk ratio (15.15 %), seed yield ha^{-1} (10.91 %), seed gum content (9.56 %), test weight (8.22 %), ten dry pod weight (6.40 %), number of primary branches $plant^{-1}$ (1.21 %), seed yield $plant^{-1}$ (0.54 %), plant spread (0.13 %) and number of dry pods $plant^{-1}$ (0.07%).

The contribution to the total divergence by these attributes indicates their role in maintaining variability in natural population and hence selection of best genotypes for such traits would be helpful in breeding programme.

The results obtained were in confirmation to the findings of Hingane and Navale (2008), Manivannan and Anandakumar (2013), Henry *et al.* (1984) and Gipson and Balakrishnan (1992).

Grouping of genotypes into different clusters

Using the estimated D^2 values as the squares of generalised distance, cluster IV was the largest involving 15 genotypes. Fourteen genotypes were grouped in cluster II followed by 10, 7 and 6 genotypes in I, III and VI cluster respectively, whereas cluster V, VII and VIII contained only one genotype each. It indicated that the clustering pattern is because of the maximum differences in characters contributing towards diversity. Our results are in accordance with the findings of Girish *et al.* (2012). Where as different genotypes in different clusters are suggesting that the breeding lines are selecting for hybridization in breeding programme (Ravi, *et al.*, 2013)

Table 2. Contribution of each character towards genetic divergence

S.N.	Source	Times ranked 1^{st}	Per cent contribution
1	Plant height (30 DAS)	0	0.00
2	Plant height (60 DAS)	0	0.00
3	Plant height (90 DAS)	0	0.00
4	Plant spread cm^2 (90DAS)	2	0.13
5	Number of primary branches $plant^{-1}$ (90DAS)	18	1.21
6	Internodal length (cm)	0	0.00
7	Days to first flower	0	0.00
8	Days to 50per cent flowering	0	0.00
9	Number of dry pod clusters $plant^{-1}$	0	0.00
10	Number of dry pod $cluster^{-1}$	0	0.00
11	Number of dry pods $plant^{-1}$	1	0.07
12	Days to first picking of dry pod	0	0.00
13	Length of dry pod (cm)	0	0.00
14	Width of dry pod (cm)	0	0.00
15	Ten dry pod weight (g)	95	6.40
16	Hundred seed weight (g)	122	8.22
17	Number of seeds dry^{-1} pod	0	0.00
18	Dry pod yield $plant^{-1}$ (g)	0	0.00
19	Dry pod yield $plot^{-1}$ (g)	0	0.00
20	Dry pod yield ha^{-1} (q)	370	24.92
21	Seed yield $plant^{-1}$ (g)	8	0.54
22	Seed yield $plot^{-1}$ (g)	0	0.00
23	Seed yield ha^{-1} (q)	162	10.91
24	Seed to husk ratio	225	15.15
25	Gum content in seed (%)	142	9.56
26	Endosperm (%)	0	0.00
27	Protein (%)	0	0.00
28	Gum yield (Kg ha^{-1})	340	22.90

Table 3. Clustering pattern of cluster bean genotypes

ClusterNo.	Total number of genotypes	Name of genotypes				
I	10	(6) IC-415163	(9) IC-421801	(13) IC-421816	(1) IC-298638	(2) IC-370742
		(3)IC-415102	(11)IC-421806	(14)IC-421820	(30)IC-369789	(15)IC-421821
II	14	(17)IC-421825	(19)IC-421828	(25)IC-421839	(31)IC-329639	(22)IC-421832
		(52)IC-369868	(16)IC-421822	(18)IC-421826	(37)IC-415109	(21)IC-421831
		(55)AVT-GR-11	(49)IC-369861	(26)IC-421840	(34)IC-324032	
III	07	(32)IC-421815	(33)IC-248087	(36)IC-370478	(35)PLG-354	(28)IC-421842
		(23)IC-421834	(40)IC-325811			
IV	15	(10)IC-421803	(27)IC-421841	(45)RGC-936	(5)IC-415160	(7)IC-415165
		(48)IC-373480	(4)IC-415157	(50)IC-421812	(41)IC-373427	(53)RGC-986
		(43)IC-311441	(54)HG-3-100	(12)IC-421811	(20)IC-421830	(42)IC-415159
V	01	(24)IC-421837				
VI	06	(39)IC-329036	(51)IC-421798	(29)IC-421843	(46)RGC-1031	(38)PLG-85
		(8)IC-421797				
VII	01	(44)IC-415140				
VIII	01	(47)IC-402296				

Intra and Inter-Cluster Distance D^2

The average D^2 value within (intra) and between (inter) clusters among twenty eight quantitative characters calculated by Tocher's method are presented in table 4.

The inter-cluster D^2 values of 8 cluster revealed that maximum divergence occurred between V and VIII (D^2=12012.73), while closer proximity existed between II and V (D^2=1735.42). Among Intra-cluster distance, maximum divergence was reported for cluster VI (D^2=2503.67) and minimum for solitary cluster, cluster V, VII and VIII (0.00). It is desirable to select the genotypes from the cluster showing high inter-cluster distance in breeding programme for obtaining desirable segregants (Girish, *et al.*2012 and Singh, *et al.*2005b).

Cluster means

The cluster means of all the characters are presented in table 5. The cluster I had highest mean value for plant height (60DAS) (76.95cm), number of dry pod per cluster (6.16) and endosperm percentage in seed (37.44per cent). Cluster III had highest mean value for number of dry pods per plant (86.67), days to first picking of dry pod (67.21), dry pod yield per plant (21.12g), dry pod yield per plot (373.95g), dry pod yield per hectare (31.15q), seed yield per plant (12.46 g), seed yield per plot (220.59g), seed yield ha^{-1} (18.38 q) and gum yield ha^{-1} (459.67 kg). Cluster IV had maximum mean value for number of primary branches $plant^{-1}$ (3.02). Cluster V had maximum mean value for plant height (30DAS) (28.90cm), plant height (90DAS) (107.15cm), internodes length (4.39cm), days to 50 per cent flowering (34.19) and seed to husk ratio (1.72). Cluster VI had highest mean value for number of dry pod clusters per plant (17.49). Cluster VII had height mean value for days to first flower (31.45), length of dry pod (5.45 cm) and number of seeds per dry pod. Cluster VIII had the maximum mean value for plant spread (46.85 cm^2), width of dry pod (0.65 cm), ten dry pod weight (4.57 g), hundred seed weight (3.63 g), gum content in seed (28.92 %) and protein percentage in seed (28.55 %).

The lowest mean values in clusters III were recorded for days to 50 per cent flowering (31.51), length of dry pod (4.79 cm) and endosperm percentage in seed (34.78 %). While cluster V having minimum mean cluster values with respect to number of primary branches per plant (0.00), width of dry pod (0.55cm) and protein percentage in seed (28.55 %) (Table 5). Cluster VI recorded minimum cluster means with respect to number of primary branches $plant^{-1}$ (2.83), number of dry pod per cluster (5.42) and seed to husk ratio (1.09). Cluster VII had minimum mean values for plant height (30 DAS) (19.95 cm), plant spread (15.65 cm^2), number of dry pods $plant^{-1}$ (41.36), width of dry pod (0.55cm), hundred seed weight (1.89 g), dry pod yield per plant (7.99 g), dry pod yield $plot^{-1}$ (115.10g), dry pod yield ha^{-1} (9.60 q), seed yield $plant^{-1}$ (4.50 g), seed yield $plot^{-1}$ (64.80 g), seed yield ha^{-1} (5.40 q), gum content in seed (24.35 %) and gum yield ha^{-1} (131.26 kg) while cluster VIII having minimum mean cluster values with respect to plant height (60 DAS) (61.25 cm), plant height (90 DAS) (83.60 cm), internodes length (3.30 cm), days to first flower (29.60), number of dry pod cluster $plant^{-1}$ (8.73), days to first picking of dry pod (63.00) and number of seeds dry pod^{-1} (6.50) (Table 5). Similar results were reported by Girish *et al.* (2012), Shabarish Rai and Dharmatti (2013) and Vikas Kumar *et al.* (2014).

On the basis of inter-cluster distances and cluster means, this investigation suggests that the genotypes (IC-421837 and IC-402296) grouped under maximum divergence clusters could be used for crossing if superior

Table 4: Average intra and inter cluster distance in cluster bean by Tocher Method

Cluster	I	II	III	IV	V	VI	VII	VIII
I	777.00	2142.87	3506.33	2579.03	4430.20	4913.77	3379.52	2962.58
II		1102.53	2776.04	2478.40	1735.42	6320.54	3663.04	7394.31
III			1367.71	5498.86	2347.72	3853.49	4903.57	7493.44
IV				2370.58	4296.58	8684.63	3812.93	7369.42
V					0.00	7321.58	4427.80	12012.73
VI						2503.67	5263.16	5466.28
VII							0.000	7788.34
VIII								0.000

Table 5. Cluster mean values for 28 characters in cluster bean by Tocher Method

S.N.	Clusters	Plant height (30 DAS)	Plant height (60 DAS)	Plant height (90 DAS)	Plant spread cm^2 (90DAS)	No. of branches $plant^{-1}$ (90 DAS)	Internodes length (cm)	Days to first flower	Days to 50% flowering
1	I	25.07	76.95	98.37	26.26	1.61	4.38	29.89	32.97
2	II	26.81	73.51	95.15	32.74	2.12	3.95	29.45	32.03
3	III	26.44	73.47	95.21	43.19	2.60	4.12	29.82	31.51
4	IV	25.25	72.88	90.54	33.69	3.02	4.00	30.23	32.69
5	V	28.90	76.88	107.15	17.10	0.00	4.39	29.33	34.19
6	VI	22.74	71.79	90.91	32.14	2.72	3.73	29.95	32.44
7	VII	19.95	69.00	89.40	15.65	0.80	3.85	31.45	32.50
8	VIII	20.45	61.25	83.60	46.85	2.30	3.30	29.60	32.20
S.N.	**Clusters**	**No. of dry podclusters $plant^{-1}$**	**No. of dry pod $cluster^{-1}$**	**No. of dry pods $plant^{-1}$**	**Days to first picking of dry pod**	**Length of dry pod (cm)**	**Width of dry pod (cm)**	**Ten dry Pod weight (g)**	**No. of seeds dry^{-1} pod**
1	I	11.09	6.16	60.26	66.36	5.38	0.63	4.13	7.47
2	II	13.29	6.00	70.76	66.44	5.03	0.61	3.60	7.17
3	III	17.19	5.62	86.67	67.21	4.79	0.60	3.60	6.82
4	IV	10.31	5.96	52.77	66.32	5.16	0.60	3.67	7.53
5	V	17.26	4.97	75.95	66.90	5.08	0.55	3.25	6.70
6	VI	17.49	5.42	84.67	66.08	5.24	0.64	3.40	7.01
7	VII	8.99	5.77	41.36	65.50	5.45	0.55	2.77	8.50
8	VIII	8.73	5.82	42.87	63.00	5.35	0.65	4.57	6.50

Table 5: Continued …

S.N.	Clusters	Hundred seed weight (g)	Dry pod yield $plant^{-1}$ (g)	Dry pod yield $plot^{-1}$ (g)	Dry pod yield ha^{-1} (q)	Seed yield $plant^{-1}$ (g)	Seed yield $plot^{-1}$ (g)
1	I	3.27	16.98	295.72	24.64	9.95	173.26
2	II	3.12	17.64	307.88	25.65	10.89	190.03
3	III	3.11	21.12	373.95	31.15	12.46	220.59
4	IV	3.06	13.00	218.04	18.17	8.08	135.53
5	V	2.99	16.56	286.57	23.88	10.47	181.20
6	VI	2.58	19.49	337.51	28.13	10.16	176.01
7	VII	1.89	7.99	115.10	9.60	4.50	64.80
8	VIII	3.63	13.88	229.98	19.17	7.35	121.80
S.N.	**Clusters**	**Seed yield ha^{-1} (q)**	**Seed to husk ratio**	**Gum content in seed (%)**	**Endosperm (%)**	**Seed protein (%)**	**Gum yield (Kg ha^{-1})**
1	I	14.44	1.41	27.95	37.44	27.17	403.70
2	II	15.83	1.61	28.86	36.86	27.27	454.77
3	III	18.38	1.44	24.99	34.78	27.67	459.67
4	IV	11.62	1.68	27.76	37.03	27.28	316.38
5	V	15.10	1.72	25.90	37.15	26.20	391.09
6	VI	14.67	1.09	27.34	36.07	27.27	397.29
7	VII	5.40	1.29	24.35	36.70	26.25	131.26
8	VIII	10.15	1.13	28.92	37.30	28.55	293.60

varieties are planned in the breeding development programme although cluster bean is a self-pollinated crop.

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Cluster Analysis Among Indigenous and Exotic Germplasm Lines of Yield Traits in Sunflower *(Helianthus animus* L.)

Mohd. Yunus Patel[1], S. S. Lande[2], N. B. Mohod[3] and P. P. Gawande[4]

ABSTRACT

In order to develop improved breeding lines having superior yield and oil content, it is essential to have genetically diverse parental lines. Hence, an attempt was made to find out genetic divergence among fifty four breeding lines for twelve traits in sunflower. To assess the genetic divergence among the 54 genotypes in sunflower, Mahalanobis D^2statistics was applied for twelve traits. The genotypes were grouped into seven clusters where cluster I was the largest containing twenty four genotypes followed by cluster II with twenty genotypes. The highest intra cluster distance was observed for cluster IV (66.77) while highest inter cluster distance was observed between cluster HI and VII (629.70) followed by cluster IV and VII (625.00). Maximum cluster means for seed yield per plant was recorded in cluster VI (58.75) followed by cluster VII (46.60). The study revealed that 50 per cent flowering contributed maximum divergence (61.74 %) which was followed by Chlorophyll content (7.62 %) and 100 seed weight (7.41 %).|On the basis of mean performance and cluster means the genotypes RHA-1-1R afiiTRHA-138-2R found better for seed yield, while 6-D-.IR and, RHA-1-1R found better for oil content.

Sunflower is an important edible oilseed crop of the world. The crop is grown under diverse agro-production situations, crossing climatic and geographic boundaries which necessitated the development of more productive hybrids of diverse duration. Development of hybrid is of much value for increasing the production of sunflower. Selection of parents based on genetic divergence is prerequisite in heterosis breeding programme. The parents need to be selected from diverse groups so as to generate hybrid vigour. Since hybrid vigour essentially depends on genetic divergence of parents, it is necessary to identify a genetically diverse parents for hybridization.

Multivariate analysis by means of Mahalanobis' D^2 statistic has been widely used for assessing the genetic divergence in several crops. It is a powerful tool in quantifying the degree of genetic divergence among parents (Murty and Arunachalam, 1966). Although this technique has been used frequently in many crop species, few reports are available regarding its application for seed yield parameters in sunflower. Therefore, the present study was initiated to determine genetic divergence based on the seed yield parameters in diverse sunflower genotypes. Genetic divergence and grouping of genotypes into different clusters were already reported by Anuradha *et al.*, (2004); Reddy *et al.* (2004); Loganathan et aL (2006) and Mahalaksmi *et al.*, (2006).

MATERIAL AND METHOD

The material for the present study comprised of 54 sunflower genotypes. The experiment was conducted at Oilseed Research Unit, Dr. PDKV, Akola during *rabi* 2014-15. Each genotype was sown in three rows with spacing of 60 cm between rows and 45 cm between plants. The experiment was laid out in a Randomized Block Design with three replications. In each genotype, five plants were randomly selected and used for recording of data on twelve characters *viz.*, days to 50 per cent flowering, days to maturity, plant height (cm), volume weight (g/100ml), hundred seed weight (g), seed yield per plant (g), oil content (%), head diameter (cm), seed filling percentage, hull content (%), chlorophyll content and leaf area index. The data were subjected to statistical analysis using Mahalanobis D^2 statistic (Mahalanobis, 1936) and Toucher's method as described by Rao (1952) for determining group constellation.

RESULTS AND DISCUSSION

Inter crossing of parents from divergent groups would lead to broad genetic base in the base population and greater opportunities for crossing over to occur, which in turn may release hidden variability by breaking close linkage (Thoday, 1960). The progenies derived from such crosses were expected to show wide variability, providing greater scope for isolating transgressive

1.M.Sc.Student, 2.Assistant Professor, 3. Junior Research Assistant and 4. Associate Professor, Department of Agrilcultural Botany Dr. P.D.K.V.Akola.

Table 1. Distribution of 54 sunflower genotypes into seven different clusters

Cluster	No. of genotypes	Name of genotypes
1	24	EC-6023072R, EC-512682R, EC-512687R, EC-6023030R, 3/147R, PKV-105R, RHA138- 2 R, R-856, RHA-1 -1R, EC-601939R, EC-601901R, EC-601961R, EC—6023025R, EC-601812R, 298R, R-272, EC-60220! 1R, EC-60230i5R, EC- 60230 16R, EC-6023031R, MRHA-1R, EC-602302,8R, EC-6023060R
‘I :II	20	EC-601764R, EC-60181 OR, EC-6023621 R, EC- 601725R, AKS-F-12R, EC-6{)1729R, AK-345-2R, EC-601905R, AK1-R, EC-601768R, P-146R, P- 144R, EC-601958R, R-271, EC-601817R, R-I6.P- 141R, 856R, AKSF-6R, EC-6023027R.
l«	1	EC-601820R
IV	6	EC-601951R, EC-6023020R, 6-D-1R, RHA-138-2R, NDR-1R, AKSF-1-HR
V	1	TAS-82
VI	1	1R-1-1-R
VII	1	SS 08 08

Table 2. Average inter and intra (diagonal) cluster distances between sunflower genotypes

Clusters		II	III	IV	V	VI	VII
1	41.33	89.94	70.92	84.77	187.70	97.89	385.22
II		48.75	208.23	213.64	84.98	148.54	197.09
III			0.00	47.38	334.93	98.35	629.70
IV				66.77	362.31	132.51	625.00
V					0.00	189.54	78.19
VI						0.00	368.67
VII							0.00

segregants in the advanced generations. Hence these genotypes may be used repeatedly in the crossing programmes to recover transgressive segregants, which can be either released as variety or can be utilized in the genetic enhancement of sunflower crop.

In the present study, all the fifty four parental lines were grouped into seven clusters (Fig. 1). *Cluster 1* comprised of twenty four genotypes followed by cluster II that had twenty genotypes. The Clusters III, V, VI, VII comprised of only one genotype each and cluster IV having six genotypes (Fig.l) and (Table 1). The average intra and inter cluster D2 values are presented in (Table 2). The inter cluster D^2 value was found to be minimum between cluster III and IV (47.38) indicating the close relationship among the genotypes included in this cluster. Maximum inter cluster distances was noticed between clusters III and VII (629.70) followed by clusters IV and VII (625.00) respectively. Thus, the genotype EC-601820R of cluster III, SS0808 of cluster VII, EC-601951R, EC-6023020R, 6D-1-R, RHA-138-2R, NDR-1R, AKSF-1-HR of cluster VI if involved in crosses may give high heterotic response and wider segregations after hybridization. These results are in conformity with Irene Priyadarshini (1999) and Serene Maragatham Isacs (2002). The study revealed that 50 per cent flowering contributed maximum divergence (61.74 %) which was followed by Chlorophyll content (7.62 %) and 100 seed weight (7.41 %). Cluster I exhibited minimum intra-cluster value (41.33) indicating that the diversity between the genotypes of cluster I was less, while cluster IV had maximum intra cluster value (66.77). The cluster mean

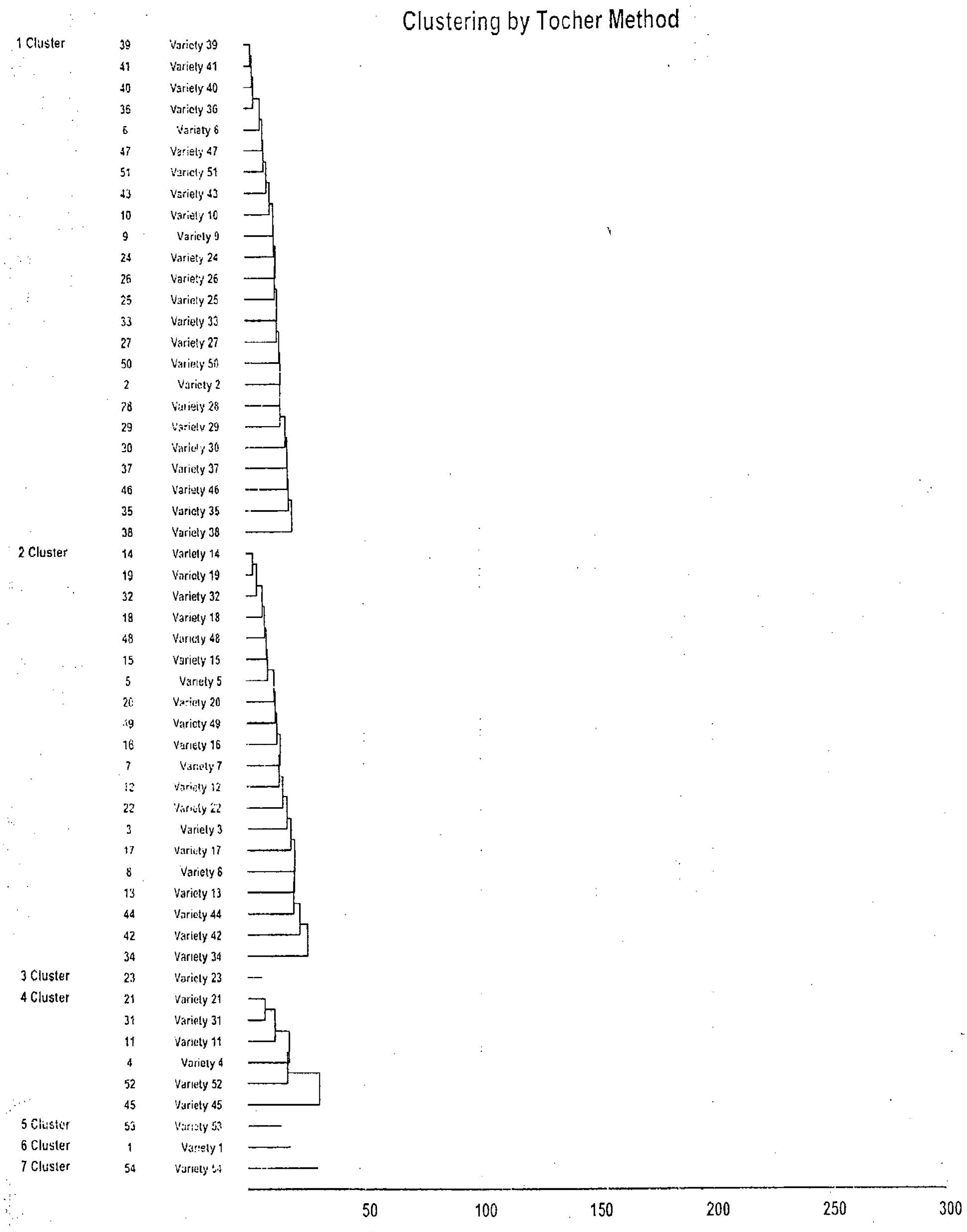

Fig. 1. Cluster Diagram of parental lines

Table 3. Cluster means for twelve characters

Clusters and Genotypes	Volume weight (g/100ml)	Seed filling per cent	Days to maturity	Plant height (cm)	50 % flowering	Head diameter (cm)	Hull content (%)	100 seed weight (g)	Oil content (%t)	Chlorophyll content	Leaf area index	Seed yield plant^{-1}(g)
1 RHA 1-1R	35.04	78.84	93.46	103.51	72.90	11.32	35.11	4.07	33.59	34.25	1.54	39.00
II	34.67	81.26	93.48	102.48	64.73	11.65	33.54	3.84	33.73	34.26	1.71	39.09
IK	35.72	79.03	92.67	108.33	80.67	12.00	36.60	4.13	32.33	38.90	1.53	40.42
IVRHA-138-2 R6-D-1-R	35.24	74.86	94.67	109.33	79.61	11.56	38.56	4.63	33.50	32.50	1.76	41.75
VTAS-82	31.14	79.70	89.00	128.33	59.33	13.83	40.53	3.02	38.60	39.50	1.80	38.88
VIIR-1-1R	29.24	79.20	92.67	125.00	72.00	14.00	35.30	7.27	37.80	39.16	2.25	58.75
VIISS-0808	29.21	67.00	87.33	124.33	50.33	14.00	38.20	5.03	34.67	36.67	1.54	46.60

values for different characters are presented in Table 3. Regarding the cluster mean performance, the genotype IR-l-l-R (cluster VI) had the highest mean 58.75 for seed yield per plant and genotype TAS-82 (cluster V) for oil content percent respectively. It seems that Reddy Vishnuwardhan *et al* (2005) reported the similar result. Hence, the genotypes IR-1-1-R(cluster VI) followed by SS0808(cluster VII) could be used as one of the parents to get higher seed yield.

The present study revealed that the selection of parents must be used on the wider inter cluster distance and superior mean performance for yield and yield parameters. Based on the inter cluster distance and *per se* performance IR-l-l-R and SS0808 as desirable parents could be utilized in hybridization programme to synthesize high yielding hybrids in sunflower.

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PDKV – Pragati : Promising Okra Variety for Vidarbha Region

S. M. Ghawade[1], D. S. Phad[2] and Abhilasha P. Kharkar[3]

ABSTRACT

PDKV Pragati a promising variety of okra has been released by Chilli and Vegetable Research Unit, Dr. PDKV., Akola possesses desirable characters like high yield, moderately resistance to the YVMV and qualities suitable for export. New variety was developed through hybridization followed by mass selection from derivatives of cross between Parbhani Kranti × AKO-75 and back cross with AKO-75, at Chilli and Vegetable Research Unit, Dr. PDKV., Akola. The selection pressure were applied in the direction of earliness, high yielding ability and with at par resistant to released varieties against YVMV i.e. Parbhani Kranti, Pusa A-4 and Arka Anamika and Pusa Sawani. Apart from these characters, PDKV Pragati having horticultural characters like, more in fruit yield by 25.56 per cent over check Parbhani Kranti, earliness in flowering (39.26 days), normal crop duration (100-105 days) , at par resistance with Parbhani Kranti for YVMV, moderately resistant to sucking pests and fruit borer. Considering the superiority for desired parameters over check, the okra genotype AKOV-107 has recommended for commercial cultivation with the name PDKV Pragati in Vidarbha region by varietal release sub-committee.

Okra or Bhendi (*Abelmoschus esculentus* L.) is an important member of Malvaceae family having chromosome number of 2n = 73-132. It is native of India, where its wild forms are met. Okra plants is hairy; erect, annual shrub flowers are 5-6 mm in diameters with 5 petals, fruits is a capsule, Colour vary from white, dark green or red, fruit is ridged, round, 10-45 cm in length, 2-3 cm in diameter, 30-80 seeds are per fruit and the stem contains crude fiber which is used in paper industry. Bhendi is a good source of vitamins A and B. It is rich in protein and mineral elements Singh (2001). It is very popular vegetable crop where irrigation facilities are available. It is one of the most favourite vegetable for growing in kitchen garden. In India, it is grown on 59.18 lakh ha with the production of 828.90 lakh MT. whereas, in the state of Maharashtra okra is grown on 1.06 lakh ha area with the production of 8.45 lakh MT (Anonymous, 2016). Although there are several varieties and hybrids of okra available in the market, but the demand of Vidarbha farmers for okra with medium green colour, a tender fruit with moderately resistant to Yellow Vain Mossaic disease as well as resistant to sucking pest like leaf hopper, white flies and fruit borer to some extent was noticed. Keeping these facts in view, it was, therefore felt necessary to identify and develop high yielding, early flowering and suitable type of okra having at least one special morphological character for Vidarbha region.

MATERIAL AND METHODS

Hybridization followed by mass selection was employed with derivatives developed from the cross Parbhani Kranti × AKO-75 and its back crossed with AKO-75. The selection pressure were applied in the direction of earliness, high yielding ability and with at par resistant to released variety against YVMV i.e. Parbhani Kranti.

On account of the promising performance in comparison with the checks *viz.*, Parbhani Kranti, Pusa A-4 and Arka Anamika and Pusa Sawani, this strain AKOV-107 was promoted to University level multi-location varietal trials at Akola, Katol and Amravati since 2012-13. Each genotype was sown at 45 x 60 cm in randomized block design with three replications. Recommended plant protection measures and fertilizers as well as intercultural operations were applied to raise the normal crop of okra.

The genotype AKOV-107 was also screened for reaction to major pests and diseases. The data from agronomical evaluation were also recorded for different spacing as well as fertility levels. Thus the performance of this genotype was tested along with checks across various experimental trials and data were analyzed as per the statistical methods suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Observation on the vegetative growth and qualitative parameters were recorded at Chilli and Vegetable Research Unit, Dr. PDKV., Akola during 2010-11 to 2016-17.

Vegetative/ancillary characters:

The data recorded during 2010-11 to 2016-17 in respect of days to 50 per cent flowering, plant height (cm),

1. Associate Professor , 2. Assistant Professor and 3. Junior Res. Asstt., Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

average fruit weight (g), number of fruiting nodes per plant, days to first harvest, inter-nodal distance branches and fruits per plant were found promising over check varieties *viz.*, Arka Anamika, Pusa A-4 and Parbhani Kranti. As far as days to 50 flowering (39.26) and inter modal distance (6.63 cm) were concerned, genotype AKOV-107 reflected earliness and more fruit bearing ability over the check varieties (Table 1).

Moreover, yield contributing characters in okra like plant height, fruit length, fruit girth, branches plant^{-1} were exhibited their optimum limit comparable to the check varieties. Furthermore, superior fruit weight (11.57 g), number of fruiting nodes (23.65) plant^{-1} and number of fruits plant^{-1} (39.60) were noticed against the check varieties.

Table: 1 Mean ancillary characters of Okra genotype AKOV-107 during *kharif* seasons of year 2010-11 to 2016-17.

S.N.	Traits	AKOV-107	Checks		
			Arka Anamika	Pusa A-4	Parbhani Kranti
1	Days to 50 per cent flowering	39.26	41.43	40.35	40.14
2	Plant Height (cm)	122.89	124.46	135.79	125.03
3	Fruit length (cm)	10.89	10.98	10.86	10.84
4	Fruit girth (cm)	1.45	1.40	1.34	1.42
5	Avg. fruit wt (gm)	11.57	11.13	11.10	10.98
6	No of fruiting nodes/ plant	23.65	20.45	19.65	19.97
7	Days to first harvest (days)	44.90	45.99	45.67	45.13
8	Inter-nodal distance (cm)	6.63	7.27	7.42	7.39
9	Number of branches / plant	3.48	3.40	3.99	3.07
10	Number of fruits /plant	39.60	30.56	31.60	31.24

Table 2 Summary of fruit yield performance of okra genotype AKOV-107 in University Multilocation trials during *kharif* season (2010-11 to 2016-17)

Year	Fruit yield (q/ha)			
	AKOV-107	Checks		
		Arka Anamika	Pusa A-4	Parbhani Kranti
Overall average of Year 2010-11 to 2016-17	99.30	78.72	78.45	79.08
Overall per cent increase / decrease over check 2010-11 to 2016-17	—	26.14	26.58	25.56

Table 3 : Per cent interaction of YVMV in Multi-location trial during 2015-17

S.N.	Genotypes	Year			Pooled Mean (PDI)	Reaction
		2015-16	2016-17			
		Katol	Amravati	Katol		
1	AKOV-107	11.30	13.33	11.33	11.99	MR
2	Arka Anamika	10.56	10.37	10.67	10.53	MR
3	Pusa A-4	12.04	12.50	11.67	12.07	MR
4	Parbhani Kranti	10.15	10.37	10.33	10.28	MR
5	Pusa Sawani	98.98	97.78	96.67	97.81	HS

I-Immune R- Resistant MR- Moderately Resistant
T- Tolerant MS - Moderately Susceptible S- Susceptible
HS- Highly Susceptible

Table 4 Field reaction of Okra genotype AKOV-107 to powdery mildew (PDI) during year 2011-12 to 2016-17.

S.N.	Genotypes	Pooled Mean	Reaction
1	AKOV-107	30.93(31.76)	MS
2	Pusa A-4	36.94(34.35)	S
3	Arka Anamika	35.75(33.31)	S
4	Parbhani Kranti	34.71(33.13)	S
	'F' test	Sig.	
	S.E (±M)	1.08	
	C.D @ 0.05	3.18	

MS- Moderately Susceptible S- Susceptible

Rating scale for Powdery mildew of okra by Singh and Malhotra (1991)

S.N.	Ranking	Disease Incidence (%)	Reaction/ Category
1	0	0	Immune (I)
2	1	1-5	Resistant (R)
3	2-3	6-10	Moderately Resistant (MR)
4	4-5	11-30	Moderately Susceptibility (MS)
5	6-7	31-50	Susceptibility (S)
6	8-9	51-100	Highly susceptibility (HS)

Table 5. Pest reaction of Okra genotype AKOV-107 recorded during *kharif* season (2014-15 to 2016-17)

S.N.	Variety	Year	Leaf hopper/leaf	White flies	Fruit damage per cent
1	AKOV-107	2014-15	14.67	4.59	4.17
		2015-16	14.1	3.23	43.75
		2016-17	2.63	1.13	45.21
		Average	10.47	2.98	31.04
2	Arka Anamika	2014-15	18.74	4.19	4.17
		2015-16	15.55	4.1	46.37
		2016-17	3.39	1.07	52.68
		Average	12.56	3.12	34.41
3	Pusa A-4	2014-15	21.89	5.56	6.67
		2015-16	15.13	4.22	44.97
		2016-17	2.78	1.2	52.62
		Average	13.27	3.66	34.75
4	Parbhani Kranti	2014-15	20.19	5.41	16.67
		2015-16	13.9	3.12	46.59
		2016-17	5.41	1.17	46.43
		Average	13.17	3.23	36.56

Table 6: Effect of spacing and fertilizers on fruit yield (q/ha) of Okra genotype AKOV-107 during *kharif* season 2016-17

S.N..	Treatments	Fertilizer dose ($N:P_2O:K_2O$) Kg ha^{-1}			Mean (q/ha)
	Spacing	F1: 80 % RDF	F2: 100 % RDF	F3:120 % RDF	
		40:40:00	50:50:00	60:60:00	
1	S1 (45 cm x 45 cm)	140.74	153.09	161.48	**151.77**
2	S2 (60 cm x45 cm)	148.15	164.81	166.30	**159.75**
3	S3 (60 cm x 60 cm)	133.33	147.22	150.28	**143.61**
	Mean	**140.7**	**155.0**	**159.7**	**151.83**

Factors	SE (m)	CD at 5 %
Spacing	4.20	12.49
Fertilizers	4.20	12.49
Spacing x Fertilizers	7.28	NS

Yield

The yield differences due to okra genotype AKOV-107 over the check varieties Arka Anamika, Pusa A-4 and Parbhani Kranti showed significantly superior performance at multi-location trial. The pooled mean of fruit yield ha^{-1} of genotype AKOV-107 was noticed significant increase of 26.14 per cent over Arka Anamika, 26.58 per cent over Pusa A-4 and 25.56 per cent over Parbhani Kranti during *Kharif* seasons of 2010-11 to 2016-17 (Table 2).

Reaction to biotic stresses

Genotype AKOV-107 of okra recorded moderately resistant reaction against the Yellow Vein Mosaic Virus (YVMV) during screening period (2015-16 to 2016-17). From the data, it is opined that, significantly the minimum (11.99 %) pressure of YVMV were recorded by AKOV-107 which showed moderately resistant reaction as against the highly susceptible okra variety Pusa sawani reflected highest (97.81%) PDI of YVMV during the experimentation (Table 3).

As far as the major pest infestation on okra crop is concerned, leaf hopper, white flies and fruit borer damaged the crop severely from the data presented in table 5 during the period of 2014-15 to 2016-17. Significantly the minimum leaf hopper leaf $^{-1}$ (10.47), white flies per leaf (2.98) and percent fruit borer damage (31.04) were observed in AKOV-107. However, these were showed significantly more infestation on okra check varieties *viz*., Arka Anamika, Pusa A-4 and Parbhani Kranti .

Spacing and levels

In agronomical trial (Table 6), the interaction effect of spacing and fertilizer levels were found statistically non-significant. The okra genotype AKOV-107 sown at the spacing 60 x 45 cm along with 60:60:00 NPK kg ha^{-1} application gave maximum (166.30 q/ha) fruit yield and it was at par with spacing 60 x 45 cm along with 50:50:00 NPK kg ha^{-1} application (164.81 q ha^{-1}) however, the fruit yield of okra genotype AKOV-107 reported significantly minimum (133.33 q ha^{-1}) when planted at spacing 60 x 60 cm and fertilized with 40:40:00 NPK kg ha^{-1}.

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Effect of Foliar Applications of Zinc and Iron on Flowering, Fruit Set, Fruit Yield and Quality of Guava

Trupti G. Bhadke[1], S. G. Bharad[2], P. L. Deshmukh[3] and S. V. Gholap[4]

ABSTRACT

A field experiment was carried out to find out the suitable concentrations of Zn and Fe for foliar feeding to guava. A field experiment was laid out in Factorial Randomized Block Design with sixteen treatment combinations replicated thrice during 2017-18 at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Thirteen year old healthy and uniformly grown plants of guava variety L-49 (Sardar) were selected for the study. The investigation revealed that the yield and yield attributing characters *viz.,* No. of flowers per shoot, fruit set, number of fruits per tree, fruit yield tree^{-1} (kg), fruit yield ha^{-1} were found to be maximum with foliar applications of 0.8 per cent $ZnSO_4$. In respect to iron levels, the foliar application of 0.6 per cent $FeSO_4$ showed the better performance in terms of yield and yield attributing characters, while combined foliar application of zinc (0.8 %) and iron (0.6 %) were found to be the best treatments for number of flowers shoot^{-1}, fruit set, fruit yield plot^{-1}, quality of guava and highest yield.

Guava (*Psidium guajava* L.) is one of the important fruit crops of tropical and subtropical regions of India. It is popularly known as "Apple of Tropics" and claims to be the fourth most important fruit in area and production after mango, banana and citrus (Pedapati and Tiwari, 2014). Guava belongs to family Myrtaceae and originated from Tropical America and seems to have been growing from Mexico to Peru. It is cultivated in India, since the seventeenth century due to its wider adaptability in diverse soil and agro-climates. Guava is hardy, drought tolerant, high yield potential and have diverse uses of fruits looking to these qualities this crop has gained an ideal position for scarcity zones where other fruits cannot be grown successfully. This indicate the need for the application of nutrients, specially micronutrient at a specific time by particular method to derive their maximum benefit. The inadequacy of any of these nutrients at a critical stage of fruit development may adversely affects the productivity and fruit quality.

Nutrients like nitrogen, phosphorus, and potash play vital role in promoting the plant vigour and productivity, whereas micronutrients like zinc, iron, boron, copper and molybdenum perform specific role in the growth and development of the plant, quality produce and uptake of major nutrients (Bala *et al.*, 2006). The zinc and iron are needed to achieve not only for the highest total fruit production but also for the greatest percentage of fruit production suitable for marketing.

Micronutrients are essentially as important as macronutrients to have better growth, yield and quality of fruit crops. Zinc is considered to be a very important element for auxin, protein and proper maturity of the fruit. Iron increases the chlorophyll content of leaves, reflecting the colour of leaves. The present research was carried out to study the effect of different concentrations of foliar applications of zinc and iron on flowering, fruit set, fruit yield and quality of guava fruits.

MATERIAL AND METHODS

The experiment was conducted at the Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2017-18. The experiment was laid in Factorial Randomized Block Design with sixteen treatments including control replicated thrice times. Thirteen year old healthy and uniform grown plants of guava variety L-49 (Sardar) were selected and all necessary cultural practices are adopted during experiment. In respect of fertilizer application the half dose of nitrogen and full dose of potassium and phosphorus was applied in last week of June 2017 and remaining half dose of nitrogen at fruit set stage *i.e.* first week of August.

Treatments comprised of four levels of foliar sprayings of zinc sulphate *i.e.*, 0per cent, 0.4per cent, 0.6per cent and 0.8per cent with four levels of spray of ferrous sulphate *i.e.*, 0 per cent, 0.2 per cent, 0.4 per cent and 0.6 per cent, while the control plant received no fertilizer and no spray. The zinc sulphate and ferrous sulphate was

1. & 3. P. G. Student, 2. Head and 4. Assistant Professor, Department of Fruit Science, Dr. PDKV, Akola

applied before flowering and second spray was carried out three weeks after the first spray.

The observations recorded during the investigation were number of flowers per shoot, fruit set percentage, number of fruits tree^{-1}, fruit yield tree^{-1} and fruit yield ha^{-1}. The quality parameters of guava *i.e.*, fruit volume, fruit diameter, fruit weight, Total soluble solids, total sugars, titrable acidity and ascorbic acid were also recorded. Total soluble solids (^{0}Brix), total sugars (%), titrable acidity (%) and ascorbic acid (mg 100 g^{-1} pulp) in the fruits were determined following the procedures (A.O.A.C., 1960).

RESULTS AND DISCUSSION

Yield attributing characters

Number of flowers

The number of flowers per shoot was significantly influenced by zinc sulphate applications (Table 1). The $ZnSO_4$ @ 0.8 per cent recorded maximum number of flowers per shoot (19.58), while lowest (16.08) were recorded in control. Significantly the highest number of flowers shoot^{-1} (20.91) was recorded in the treatment of foliar spray of $FeSO_4$ @ 0.8 per cent, while the lowest (14.91) was recorded in control.

The interaction effect of foliar spray of zinc and iron on a number of flowers per shoot was significantly influenced by the different combinations (Table 3). The highest number of flowers per shoot (26.00) was recorded in treatment combinations Z_3F_3 (0.8 and 0.6 %), while minimum (13.67) was in treatment combinations Z_0F_0 (control). Similar findings have also been reported by Bhoyar and Ramdevpura *et al.,* (2006) in guava and Venu *et al.,* (2014) in kagzi lime.

Fruit set

The treatment of foliar application of $ZnSO_4$ @ 0.8per cent recorded significantly highest fruit set (77.18 %) at par with foliar spray of $ZnSO_4$ @ 0.6 per cent, while the lowest (67.26 %) in control. In case of foliar spray of ferrous sulphate recorded highest fruit set (78.09 %) significantly foliar spray of $FeSO_4$ @0.6 per cent and lowest fruit set (71.29 %) in control.

The interaction effect of foliar spray of zinc and iron on fruit set was significantly influenced by the different combinations. The significantly highest fruit set (84.59 %) was recorded in treatment combinations Z_3F_3 (0.8 and 0.6 %) which is at par with Z2F2. While minimum (63.09 %) was in treatment combinations Z_0F_0 (control). This could be attributed to higher production of auxins, protein by Zn and Fe foliar sprays and this translocated to the fruits. The finding similar with the results reported by Kumar *et al.,* (2013) and Hada *et al.,* (2016) in guava.

Number of fruits per tree

The foliar spraying of $ZnSO_4$ @ 0.8 per cent registered maximum number of fruits per tree (138.25), while the minimum (105.91) were recorded in control. In case of foliar spray of $FeSO_4$ @ 0.6 per cent recorded maximum number of fruits per tree (143.25) and minimum (95.58) in control.

The interaction effect of foliar spraying zinc and iron on a number of fruits per tree was significantly influenced by the different combinations. The significantly highest number of fruits per tree (170) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6 %), followed by Z_2F_2 (0.6 % and 0.4 %), while a minimum (86.67) was in Z_0F_0 (control). The results are in conformity with Gurjar *et al.,* (2015) in mango, Suman *et al.,* (2016) in guava, Kharwade *et al.,* (2018) in guava.

Fruit yield per tree

The foliar spraying of $ZnSO_4$ @ 0.8 per cent registered significantly highest fruit yield per tree (31.88 kg), while minimum (20.52 kg) in control. In case of foliar spray of ferrous sulphate significantly highest fruit yield per tree (35.47 Kg) was recorded in $FeSO_4$ @ 0.6 per cent recorded in foliar spray of $FeSO_4$ @ 0.8 per cent.

The interaction effect of foliar spraying of zinc and iron on fruit yield per tree was significantly influenced by different combinations and significantly highest fruit yield per tree (48.96 kg) was recorded under treatment Z_3F_3 (0.8 and 0.6 %), while the minimum (11.58 kg) in Z_0F_0 control. This may be ascribed to the increase in use efficiency of major nutrients by Zn and Fe Foliar application. Results obtained are in accordance with the finding reported by Kumar *et al.,* (2013), Waskela *et al.,* (2013) and Jatav *et al.,* (2016) in guava.

Fruit yield per hectare

The foliar spraying of $ZnSO_4$ @ 0.8 per cent registered significantly highest fruit yield ha^{-1} (8.85 t ha^{-1}) and lowest (5.69 t ha^{-1}) in control. In case of foliar spray of ferrous sulphate significantly highest fruit yield per hectare (10.40 ts ha^{-1}) was recorded in $FeSO_4$ @ 0.6 per cent, while lowest (4.53 t ha^{-1}) in control.

Table 1. Effect of foliar sprays of zinc and iron on yield and yield attributing characters of Guava.

Treatments	Yield and yield attributing characters				
	Number of flowers per shoot	Fruit set (per cent)	Number of fruits tree^{-1}	Fruit yield kg tree^{-1}	Fruit yield t ha^{-1}
a. $ZnSO_4$ levels					
Z_0 (0.0 %)	16.08	67.26	105.91	20.52	5.69
Z_1 (0.4 %)	17.58	75.14	130.00	28.14	7.78
Z_2 (0.6 %)	18.33	77.10	135.41	30.31	8.41
Z_3 (0.8 %)	19.58	77.18	138.25	31.88	8.85
SE (m) ±	0.28	0.70	0.30	0.08	0.02
CD at 5 %	0.81	2.04	0.87	0.24	0.07
b. $FeSO_4$ levels					
F_0 (0.0 %)	14.91	71.29	95.58	16.34	4.53
F_1 (0.4 %)	17.33	72.60	125.25	25.14	6.97
F_2 (0.6 %)	18.33	74.86	137.25	31.86	8.84
F_3 (0.8 %)	20.91	78.09	143.25	35.47	10.40
SE (m) ±	0.28	0.70	0.30	0.08	0.02
CD at 5 %	0.81	2.04	0.87	0.24	0.07

Table 2. Effect of foliar sprays of zinc and iron on quality parameters of guava fruits.

Treatments	Quality of guava fruits						
	Fruit volume (cm^3)	Fruit diameter (cm)	Fruit weight (g)	Total soluble solids (^{0}Brix)	Total sugars (%)	Titrable acidity (%)	Ascorbic acid (mg 100 g pulp)
a. $ZnSO_4$ levels							
Z_0 (0.0 %)	176.94	4.55	189.00	10.11	6.24	0.36	196.86
Z_1 (0.4 %)	199.25	4.93	212.53	10.67	7.60	0.33	213.09
Z_2 (0.6 %)	199.34	5.05	216.74	10.66	7.74	0.35	219.70
Z_3 (0.8 %)	211.99	5.21	223.83	10.79	7.91	0.30	233.16
SE (m)±	0.24	0.01	0.26	0.01	0.001	0.001	0.007
CD at 5 %	0.71	0.03	0.76	0.03	0.004	0.004	0.022
b. $FeSO_4$ levels							
F_0 (0.0 %)	160.16	4.50	169.74	10.01	6.76	0.38	189.68
F_1 (0.4 %)	193.41	4.77	198.25	10.13	7.24	0.35	178.70
F_2 (0.6 %)	207.86	5.23	228.49	10.87	7.69	0.32	227.87
F_3 (0.8 %)	245.62	5.67	245.62	11.22	7.93	0.27	239.75
SE (m)±	0.24	0.01	0.26	0.01	0.001	0.001	0.007
CD at 5 %	0.71	0.03	0.76	0.03	0.004	0.004	0.022

The interaction effect of foliar spraying of zinc and iron on fruit yield per tree was significantly influenced by different combinations and significantly highest fruit yield per hectare (13.60 t ha^{-1}) was recorded under in Z_3F_3 (0.8 and 0.6 %), while the minimum (3.21 t ha^{-1}) in Z_0F_0 control. The results obtained are in accordance with the finding reported by Balkrishnan (2000), Trivedi *et al.*, (2012) in guava.

Quality parameters of Guava fruits

Fruit volume

The foliar spraying of $ZnSO_4$ @ 0.8 per cent registered maximum fruit volume (211.99 cm^3), while the minimum fruit volume (176.94 cm^3) in control. (Table 2) the foliar spray of ferrous sulphate @ 0.6 per cent recorded highest fruit volume (254.62 cm^3), whereas minimum fruit volume (160.16 cm^3) in control. The interaction effect of foliar spraying of zinc and iron on fruit volume was significantly influenced. The maximum fruit volume (288.00 cm^3) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6 %), while minimum (127.66 cm^3) under Z_0F_0 (control). The results are in conformity with the findings reported by Goswami *et al.*, (2014), Waskela *et al.*, (2013), Jat and Kacha (2014) in guava.

Fruit diameter

The fruit diameter was significantly influenced by the zinc sulphate foliar applications as compared to other levels of zinc. The treatment $ZnSO_4$ @ 0.8per cent foliar spray registered maximum fruit diameter (5.21 cm), while the minimum (4.55 cm) in control. The maximum fruit diameter (5.49 cm) was recorded in F_3 (0.6 % $FeSO_4$), while minimum fruit diameter (4.50 cm) in control.

The interaction effect of foliar sprays of zinc and iron on fruit diameter was significantly influenced and maximum fruit diameter (5.92 cm) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6 %), while minimum (4.32 cm) in treatment combinations Z_0F_0 (control). The result is in conformity Manivannan *et al.*, (2015) in guava, Tanuja *et al.*, (2016) in pomegranate.

Table 3. Interaction effect of foliar spray of zinc and iron on yield and yield attributing characters of Guava

Treatments	Yield and yield attributing characters				
	Number of flowers $shoot^{-1}$	Fruit set (per cent)	Number of fruits $tree^{-1}$	Fruit yield (kg $tree^{-1}$)	Fruit yield (t ha^{-1})
Interaction of Zinc x Iron					
Z_0F_0	13.67	63.09	86.67	11.58	3.21
Z_0F_1	14.67	63.64	95.00	17.58	4.88
Z_0F_2	17.00	68.43	118.00	24.90	6.91
Z_0F_3	18.67	73.90	124.00	28.06	7.79
Z_1F_0	16.00	68.66	100.00	19.10	5.30
Z_1F_1	17.33	74.99	112.00	21.73	6.00
Z_1F_2	18.00	78.03	150.00	32.55	9.03
Z_1F_3	19.00	78.90	158.00	39.22	10.81
Z_2F_0	14.00	76.27	92.67	16.21	4.50
Z_2F_1	15.33	73.88	128.00	25.08	6.97
Z_2F_2	24.00	83.31	167.00	46.08	12.79
Z_2F_3	20.00	74.95	154.00	33.88	9.40
Z_3F_0	16.00	77.15	103.00	18.49	5.12
Z_3F_1	22.00	77.31	166.00	36.18	10.04
Z_3F_2	14.33	69.67	114.00	23.94	6.64
Z_3F_3	26.00	84.59	170.00	48.96	13.60
SE (m)±	0.55	1.41	0.60	0.16	0.05
CD at 5 %	1.62	4.09	1.75	0.48	0.14

Fruit weight (g)

The treatment of foliar sparying of $ZnSO_4$ @ 0.8per cent showed highest fruit weight (233.83 g) as compared to all treatments, while minimum fruit weight (189.00 g) was recorded in control. The maximum fruit weight (245.62 g) was recorded with foliar sprays of $FeSO_4$@ 0.6 and minimum fruit weight (169.74 g) in control.

The interaction effect of foliar spraying of zinc and iron on fruit weight was recorded significantly highest fruit weight (288 g) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6 %), while minimum (133.66 g) in Z_0F_0 (control). These findings are in agreement with the results reported by Bhatt *et al.*, (2012) in mango, Manivannan *et al.*, (2015) in guava.

Total soluble solids

The treatment of foliar sprays of $ZnSO_4$ @0.8per cent recorded maximum total soluble solids (10.79 ^{0}Brix), while the minimum (16.08 ^{0}Brix) was recorded in control. The maximum total soluble solids (20.91 ^{0}Brix) was recorded in F_3 (0.6per cent $FeSO_4$), while minimum total soluble solids (14.91 ^{0}Brix) in control. The interaction effect of foliar sprays of zinc and iron on total soluble solids was significantly influenced and highest total soluble solids (24.00 ^{0}Brix) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6per cent), while minimum (14.67 ^{0}Brix) in combinations Z_0F_0 (control). The results are in conformity with Bakshi *et al.*, (2013) in strawberry and Kumar *et al.*, (2017) in Mandarin.

Total sugars

The treatment of foliar sprays of $ZnSO_4$ @0.8 per cent showed maximum total sugars (7.91%), while minimum (6.24 %) was recorded in control. The maximum total sugars (7.93 %) was recorded by foliar spray of $FeSO_4$@ 0.6 per cent, while minimum total sugars (6.76 %) was in control. The interaction effect of foliar sprays of zinc and iron on total sugars was significantly influenced and maximum total sugars (8.71%) was recorded under treatment

Table 4. Interaction effect of foliar sprays of zinc and iron on quality parameters of Guava fruits.

Treatments	Quality of guava fruits						
	Fruit volume (cm^3)	Fruit diameter (cm)	Fruit weight (g)	Total soluble solids (^{0}Brix)	Total Sugars (%)	Titrable acidity (%)	Ascorbic acid (mg/ 100 g pulp)
Interaction (ZxF)							
Z_0F_0	127.66	4.26	133.66	9.80	5.81	0.41	172.26
Z_0F_1	171.00	4.32	185.00	9.54	6.35	0.38	183.09
Z_0F_2	194.11	5.62	211.00	10.30	6.41	0.36	207.50
Z_0F_3	215.00	5.71	226.34	10.80	6.42	0.29	224.60
Z_1F_0	183.00	4.55	191.00	10.33	7.13	0.38	190.24
Z_1F_1	188.00	4.73	194.00	10.37	7.19	0.35	213.45
Z_1F_2	188.33	4.68	217.00	10.75	7.86	0.32	220.75
Z_1F_3	237.00	5.76	248.14	11.26	8.22	0.28	231.33
Z_2F_0	162.00	4.35	175.00	9.75	6.76	0.40	199.18
Z_2F_1	186.00	4.70	196.00	10.40	7.50	0.37	217.23
Z_2F_2	253.00	5.87	275.99	11.15	8.33	0.34	225.60
Z_2F_3	196.00	5.30	220.00	11.36	8.37	0.27	236.78
Z_3F_0	168.00	4.85	179.33	10.18	6.85	0.33	197.04
Z_3F_1	227.00	5.35	218.00	10.23	7.92	0.32	258.04
Z_3F_2	196.00	4.75	209.99	11.29	8.18	0.28	258.13
Z_3F_3	288.00	5.92	288.00	11.46	8.71	0.25	266.32
SE (m)±	0.49	0.02	0.53	0.02	0.003	0.003	0.015
CD at 5 %	1.42	0.06	1.53	0.07	0.008	0.007	0.044

combinations Z_3F_3 (0.8 and 0.6 %), while minimum (5.81%) in combinations Z_0F_0 (control). The observation results similar in Rawat *et al.,* (2010), Trivedi *et al.,* (2012) and Zagade *et al.,* (2017) in guava.

Titrable acidity

The treatment $ZnSO_4$ @ 0.6 per cent foliar sprays showed minimum titrable acidity (0.28 %), whereas the maximum titrable acidity (0.32 %) was recorded in control. The spray of ferrous sulphate @ 0.8per cent recorded minimum titrable acidity (0.27 %) and maximum titrable acidity (0.38 %) in control.

In case of the interaction effect of foliar sprays of zinc and iron on titrable acidity was significantly influenced and minimum titrable acidity (0.25 %) was recorded under treatment combinations Z_3F_3 (0.8 and 0.6 %) while maximum titrable acidity (0.41%) in combinations Z_0F_0 (control). Similar results are obtained by Goswami *et al.,* (2012), Gaur *et al.,* (2014) and Manivannan *et al.,* (2015) in guava.

Ascorbic acid

The treatment of foliar sprays of $ZnSO_4$ @0.8 per cent recorded maximum ascorbic acid (233.16 mg 100 g^{-1} pulp), while the minimum ascorbic acid (182.09 mg100 g^{-1} pulp) in control. The ascorbic acid (239.75 mg 100 g^{-1} pulp) was recorded by foliar sprays of $FeSO_4$ @ 0.6 per cent, while minimum ascorbic acid (189.68 mg 100 g^{-1} pulp) under control.

The interaction effect of foliar sprays of zinc and iron on ascorbic acid was significantly influenced and Ascorbic acid (225.60 mg100 g^{-1} pulp) significantly higher under treatment combinations Z_3F_3 (0.8 and 0.6 %), while minimum (183.09 mg100 g pulp%) in the treatment combinations Z_0F_0 (control). The result of the present investigation is in similar finding obtained by Nehete (2011) and Bakshi *et al.,* (2013) in Guava.

CONCLUSION

Thus, it can be inferred that, highest fruit setting, number of fruits, fruit yield and improvement in quality parameters of guava fruits with the combined foliar spraying of Zinc sulphate and ferrous sulphate @ 0.8 and 0.6 percent, respectively.

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Effect of Micro-irrigation and Fertigation on Fruit Yield of Acid Lime (*Citrus aurantifolia*)

H. B. Goramnagar[1], P. K. Nagre[2], S. R. Munnarwar[3] and V. A. Tiwari[4]

ABSTRACT

To study the effect of micro-irrigation and fertigation on fruit yield of *ambia bahar* in acid lime crop an investigation was carried out in factorial randomized block design comprised of three levels of irrigation *i.e.* 100, 90 and 80 per cent micro-irrigation of Evp and three levels of fertigation i.e. 100, 80 and 60 per cent RDF with nine treatment combinations. It is evident from the data that, the interaction effect of irrigation and fertigation levels was non-significant on fruit yield per tree in *ambia bahar* during both the years of study. However, in case of pooled yield, significantly maximum fruits yield (29.80 kg plant^{-1}) were produced in interaction of irrigation and fertigation levels I_1F_1 (i.e. 100 % irrigation + 100 % RDF) which were followed by an interaction of the irrigation and fertigation levels I_1F_2 (28.04 kg plant^{-1}) and I_2F_1 (27.44 kg plant^{-1}) which were found to be at par with each other.

Acid lime commonly known as Kagzi lime (*Citrus aurantifolia* Swingle) has various kinds of uses and nutritional as well as medicinal values. Due to various uses and the increasing consumer awareness, the demand for lime fruits is constantly increasing. To accomplish this demand, large scale plantations are coming up in Maharashtra state particularly in Vidarbha region. Similar to mandarin and sweet orange, the acid lime is also responsive to moisture deficit. Water and nutrition management is also one of the significant aspect for improving the productivity and quality of fruit crops. The knowledge of precise nutrient and water requirement is prerequisite for improved fertilizer and water use efficiency for avoiding unnecessary use of excess fertilizer and water. Hence present investigation was carried out to find out the optimum level of micro-irrigation and fertigation for obtaining higher production and quality of acid lime fruits in ambia bahar.

MATERIAL AND METHODS

The experiment was laid out in factorial randomized block design comprised of three levels of irrigation *i.e.* 100, 90 and 80 per cent micro-irrigation of Evp and three levels of fertigation i.e. 100, 80 and 60 per cent RDF with nine treatment combinations replicated thrice at experimental farm of Dr. PDKV, Akola during the year 2012-13 and 2013-14.

Treatment details

A. Irrigation levels

1. I_1 : 100 per cent Irrigation of evaporation (Evp) through micro-irrigation
2. I_2 : 90 per cent Irrigation of evaporation (Evp) through micro-irrigation
3. I_3 : 80 per cent Irrigation of evaporation (Evp) through micro-irrigation

B. Fertigation levels

1. F_1: 100 per cent RDF through fertigation
2. F_2: 80 per cent RDF through fertigation
3. F_3: 60 per cent RDF through fertigation

Split doses of fertilizer applied with micro irrigation

Split	Quantity of fertilizer through fertigation at each stage								
	F1 (100%)			F2 (80 %)			F3 (60%)		
	N (g)	P (g)	K (g)	N (g)	P (g)	K (g)	N (g)	P (g)	K(g)
1st October	150	75	60	120	60	48	90	45	36
2nd November	150	75	60	120	60	48	90	45	36
3rd December	120	60	60	96	48	48	72	36	36
4th January	120	60	60	96	48	48	72	36	36
5th February	60	30	60	48	24	48	36	18	36
Total (g)	600	300	300	480	240	240	360	180	180

1. Assistant Professor, 2. Associate Dean, PGI, 3 & 4. Senior Research Assistant, Dr. PDKV,Akola

The recommended dose of fertilizer (RDF) 600 g N, 300 g P_2O_5 and 300 g K_2O per tree per year was applied with water soluble fertilizers in range for urea (46 % N), 19:19:19, phosphoric acid (27 % P), sulphate of potash (50 % K).

A ring of drip lateral with suitable number of drippers of equal discharge rate (8 lph) was installed around each tree. For treatment I1- 10 drippers, for treatment I2- 9 drippers and for treatment I3- 8 drippers were installed at equal distance in the ring so that, the irrigation regimes of 100, 90 and 80 per cent of evaporation replenishment would have been achieved within single operation. For drip irrigation quantity of water to be applied was calculated by the following formula (FAO, 1998 and Palve, 2012).

Water requirement (Q) = A x Epan x Kp x Kc

Where,

Q is the water requirement of plant (liters day-1plant-1), A is area of each plant (6 m x 6 m), Epan is pan evaporation (mm day-1) Kp is pan coefficient i.e. 0.8 (Deshmukh and Wadatkar, 2011), Kc is crop coefficient i.e. 0.7 for citrus crop (Allen *et al.*, 1998).

The quantity of water in liters day^{-1} plant^{-1} was computed by the formula which was applied to irrigate the plant as per the treatment. The irrigation water was applied at alternate day considering the total evaporation during the interval gap. During the rainy days, the watering was done taking into account the amount of rainfall (mm) received. But, during the heavy rainfall and continuous rainy days, the irrigation was withheld for 72 hours so as to bring down the excess water in the soil to the field capacity level. Further, again the irrigation water was applied by considering the evaporation rate. The fruits harvested from an observational plant were counted at each harvest. The total number of fruits of all pickings were counted together and recorded in numbers as of fruits per plant and total fruit yield in kilogram per plant was calculated and recorded accordingly.

RESULTS AND DISCUSSION

The data in respect of fruits plant^{-1} in *Ambia bahar* were significantly influenced due to the irrigation and fertigation levels individually during both the years of experiment and under pooled analysis (Table 1). The results indicated that, the irrigation level I_1 (i.e. 100 % irrigation) had produced significantly higher fruits per plant (876.2) which were at par with the irrigation level I_2 (i.1. 50 % irrigation) (812.1) during the year 2012-13. The irrigation level I_1 had recorded significantly the maximum fruits plant^{-1} (825.1) during the year 2013-14 and (850.7) in pooled result, all these values were at par with the values recorded by the irrigation level I_2 (777.9 and 795.0, respectively).

On perusal of the data, it revealed that, significantly the maximum *Ambia bahar* fruits were harvested from the fertigation level F_1 (864.8, 862.2 and 863.5, respectively) which were followed by the fertigation level F_2 (849.8, 807.6 and 828.7, respectively) in the years 2012-13, 2013-14 and when the data was pooled analysis and these values were also statistically at par with each other in respective years. It is evident from the data (Table 1) that, the fruits in *ambia bahar* had shown non-significant response to the irrigation and fertigation levels in combination during both the years of study and in pooled result also.

The higher fruit yield of acid lime was observed with 100 per cent irrigation in *Ambia bahar*. This might be due to the fact that during *Ambia bahar* high temperature from the month of March to June increases the evapo-transpiration of crop which resulted in higher requirement of irrigation water for growth and other metabolic activity. Further, the more vegetative growth and development at higher levels of irrigation and fertigation in the earlier season i.e. *Hasta bahar* might have help in formation of more number of flowers and fruit in the consecutive season i.e. *Ambia bahar*. Thus, the higher fruit yield was noted at higher levels of irrigation and fertigation in *Ambia bahar*.

Significantly higher fruit yield tree^{-1} from *Ambia bahar* was harvested (26.72 kg tree^{-1} in 2012-13 and 26.82 kg tree^{-1} in 2013-14) under the irrigation level I_1 which was at par with the irrigation level I_2 (24.77 kg plant^{-1} in 2012-13 and 25.28 kg tree^{-1} in 2013-14). It is evident from the pooled data that, the irrigation level I_1 had produced significantly higher fruit yield (26.77 kg tree^{-1}) followed by the irrigation level I_2 (25.03 kg tree^{-1}). Result also revealed that, significantly the higher fruit yield per tree (26.38, 28.02 and 27.20 kg tree^{-1}, respectively in 2012-13, 2013-14 and in pooled result) was obtained from the fertigation level F_1 which was statistically at par with the fertigation level F_2 (25.92, 26.25 and 26.08 kg tree^{-1}, respectively in the years 2012-13, 2013-14 and in pooled result).

Table 1. Effect of micro-irrigation and fertigation on no. of fruits and fruit yield tree^{-1} of *Ambia bahar* in acid lime

TreatmentS	Fruits plant^{-1}			Fruit Yirlf (kg plant^{-1})		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Irrigation						
I_1 : 100 % Evp	876.2	825.1	850.7	26.72	26.82	26.77
I_2 : 90 % Evp	812.1	777.9	795.0	24.77	25.28	25.03
I_3 : 80 % Evp	742.6	700.3	721.4	22.65	22.76	22.70
SE (m) $\pm$	21.01	23.05	15.21	0.64	0.75	0.48
CD @ 5 %	63.00	69.11	44.61	1.92	2.25	1.41
Fertigation						
F_1 :100 % RDF	864.8	862.2	863.5	26.38	28.02	27.20
F_2 : 80 % RDF	849.8	807.6	828.7	25.92	26.25	26.08
F_3 : 60 % RDF	716.3	633.6	674.9	21.85	20.59	21.22
SE (m) $\pm$	21.01	23.05	15.21	0.64	0.75	0.48
CD @ 5 %	63.00	69.11	44.61	1.92	2.25	1.41
Irrigation X Fertigation						
I_1F_1	960.0	933.0	946.5	29.28	30.32	29.80
I_1F_2	922.0	860.3	891.2	28.12	27.96	28.04
I_1F_3	746.7	682.0	714.3	22.77	22.17	22.47
I_2F_1	880.0	862.7	871.3	26.84	28.04	27.44
I_2F_2	840.7	860.7	850.7	25.64	27.97	26.81
I_2F_3	715.7	610.3	663.0	21.83	19.84	20.83
I_3F_1	754.3	791.0	772.7	23.01	25.71	24.36
I_3F_2	786.7	701.7	744.2	23.99	22.80	23.40
I_3F_3	686.7	608.3	647.5	20.94	19.77	20.36
SE (m) $\pm$ 3	6.40	39.93	26.35	1.11	1.30	0.83
CD @ 5 %	-	-	-	-	-	2.44

It is evident from the data that, the interaction effect of irrigation and fertigation levels was non-significant on fruit yield tree^{-1} in *ambia bahar* during both the years of study. However, in case of pooled yield, significantly maximum fruits yield (29.80 kg plant^{-1}) were produced in interaction of irrigation and fertigation levels I_1F_1 which were followed by an interaction of the irrigation and fertigation levels I_1F_2 (28.04 kg plant^{-1}) and I_2F_1 (27.44 kg plant^{-1}) which were found to be at par with each other.

The result pertaining to effect of the irrigation and fertigation levels individually and in combination on fruit yield ha^{-1} during both the years of experimentation with pooled data is presented in Table 2. Significantly higher fruit yield (7.40, 7.43 and 7.42 t ha^{-1}, respectively in 2012-13, 2013-14 and in pooled result) was harvested from the irrigation level I_1 and it was statistically at par with the irrigation level I_2 (7.00 t ha^{-1} during the year 2013-14).

Table 2. Effect of micro-irrigation and fertigation on fruit yield per hectare *Ambia bahar* in acid lime

TreatmentS	Fruit (t ha^{-1})		
	2012-13	2013-14	Pooled
Irrigation			
I_1 : 100 % Evp	7.40	7.43	7.42
I_2 : 90 % Evp	6.86	7.00	6.93
I_3 : 80 % Evp	6.27	6.30	6.29
SE (m) ±	0.18	0.21	0.13
CD @ 5 %	0.53	0.62	0.39
Fertigation			
F_1 : 100 % RDF	7.31	7.76	7.53
F_2 : 80 % RDF	7.18	7.27	7.22
F_3 : 60 % RDF	6.05	5.70	5.88
SE (m) ±	0.18	0.21	0.13
CD @ 5 %	0.53	0.62	0.39
Irrigation x Fertigation			
I_1F_1	8.11	8.40	8.25
I_1F_2	7.79	7.75	7.77
I_1F_3	6.31	6.14	6.22
I_2F_1	7.43	7.77	7.60
I_2F_2	7.10	7.75	7.43
I_2F_3	6.05	5.49	5.77
I_3F_1	6.37	7.12	6.75
I_3F_2	6.65	6.32	6.48
I_3F_3	5.80	5.48	5.64
SE (m) ±	0.31	0.36	0.23
CD @ 5 %	-	-	-

The fertigation level F_1 had produced significantly the higher fruit yield (7.31, 7.76 and 7.53 t ha^{-1}, respectively in 2012-13, 2013-14 and in pooled result) from *Ambia bahar*. However, this treatment F_1 was found to be at par with the fertigation level F_2 (7.18, 7.27 and 7.22 t ha^{-1}, respectively in 2012-13, 2013-14 and in pooled result). The data pertaining interaction of the irrigation and fertigation levels in combination during both the years of study and in pooled analysis in respect of fruit yield per hectare in *Ambia bahar* found to be non-significant. The application of fertigation during December to February boosted the flowering and fruit setting of *Ambia bahar*. Similarly, the residual effect of unutilized nutrient and continuous supply of irrigation in different levels of fertigation might have provided the higher uptake of nutrients. This might have resulted in the significant increase in number of fruits per plant; fruit yield per plant and also yield per hectare in *ambia bahar*.

Increase in fruit number with nutrient application was ascribed to improved fruit retention (Syamal and Mishra, 1989, Satpathy and Banik, 2002 and Singh and Singh, 2002). Increase in yield with optimum irrigation level through drip has also advocated by Barua *et al.* (2000) in Assam lemon. These results are in close agreement with the finding reported by Panigrahi and Srivastava (2011) in Nagpur mandarin, Kumar *et al.* (2013) in sweet orange and Shirgure *et al.* (2014) in Nagpur mandarin.

Panigrahi and Srivastava (2011) had recorded the maximum yield with 75 per cent EP + 75 per cent RDF. Similar increase in fruit yield per hectare due to 75 per cent irrigation + 45:20:20 g NPK tree^{-1} was observed by Ramniwas *et al.* (2012).

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Effect of Nitrogen, Phosphorus and Potassium Levels on Yield and Quality of Onion Seed cv. Akola Safed

V. G. Lajurkar[1], S. M. Ghawade[2], A. P. Kharkar[3] and B. J. Patle[4]

ABSTRACT

The research work was carried out at Main Garden, Department of Horticulture, Dr. PDKV, Akola, Maharashtra in 2015-16 and 2016-17 to study the effect of nitrogen, phosphorus and potassium on quality of onion seed cv. Akola Safed. Three different factors were considered, in which first factor nitrogen (N) with levels (0, 100, 150 kg ha^{-1}), phosphorus (P) with levels (0, 50, 75 kg ha^{-1}) and potassium (K) with levels (0, 50, 75 kg ha^{-1}). The experiment consisting of 27 treatments combination was laid out in factorial randomized block design (FRBD) with three replications. The results showed that, the quality of onion seed in respect to test weight(g), germination (%) and graded seed yield were significantly influenced by different treatment combinations. The quality of onion seed was improved with increased levels (i.e. NPK at 150:75:75 kg ha^{-1}) of different treatment combinations under study.

Onion *(Allium cepa* L.) is one of the most important vegetable crop commercially grown in Maharashtra. It contains an essential volatile oil chiefly constituting "Allyl-propyl-disulphide" which imparts characteristic pungency (Simandi *et al.,* 2000). In India, area under onion is 12.03 lakh ha with the production of 194.02 lakh MT and productivity of 16.13 metric tonnes ha^{-1}. Maharashtra, Tamil Nadu, Andhra Pradesh, Bihar, Karnataka, Rajasthan and Punjab are the most important onion producing states in India. In Maharashtra, districts in onion production include Nashik, Jalgaon, Buldhana and Pune. Onion being extensively cultivated crop, there is a heavy demand for fresh seeds every year. Seed is the most important input component for productive agriculture. The success of green revolution has been mainly due to the availability of high yielding varieties of seed only. The annual onion seed requirement of the India is about 9600 tonnes, beside 20 per cent additional stock required to cover poor germination, storage losses and as buffer stock. In this, 8 per cent is supplied by the public sector organizations, 9 per cent by the private seed companies, 13 per cent by private traders and rest 70 per cent by the farmers from their own saved seed. In case of onion viability of seed is less therefore, every year it is highly essential to produce seed as per requirement. Most commonly used method of seed production is bulb to seed method which permits a grower to easily discard off types, diseased or otherwise undesirable bulbs.

Plant nutrition play an important role in quality seed production in which nitrogen is one of the most important determinant in seed yield of onion which favour greater synthesis of carbohydrate in plants resulting in higher flower and fruit set and ultimately higher seed yield. Phosphorus is a component of nucleic acids (DNA and RNA) and essential for energy transfer within the plant, thus it has a direct effect on yield and quality of onion seed. While, potassium regulates water condition within the plant cell and water loss from the plant by maintain the balance between anabolism, respiration and transpiration. Similarly it improves keeping quality of seed. 'Akola Safed' onion variety released by Dr. PDKV Akola. In view to know and study the primary nutrient requirement for the quality seed production of released variety of white onion. The said experiment was conducted on the quality parameters of onion seed cv. Akola Safed along with seed yield.

MATERIAL AND METHODS

The research work was conducted at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* seasons 2015-16 and 2016-17. The experiment was conducted in factorial randomized block design with three replication and twenty seven treatment combinations. The treatments consisted of factorial combinations of three levels of each, nitrogen (0, 100, 150 kg ha^{-1}), phosphorus (0, 50, 75 kg ha^{-1}) and potassium (0, 50, 75 kg ha^{-1}). The half dose of nitrogen in the form of urea and full dose of phosphorus and potassium (Single super phosphate and muraite of potash, respectively) were applied at the time of planting. Remaining half dose of nitrogen was applied 30 DAP. The

1. Ph.D. Scholar, 2. Associate Professor, 3. S.R.A. and 4. P. G. Student, Chilli and Vegetable Research Unit, Dr. PDKV Akola

bulbs of 4-6 cm diameter and having 60-80 g weight were planted along one side of the ridge at a spacing of 60 cm x 30 cm. All the required cultural practices such as irrigation, weeding, etc. were given uniformly as and when necessary. When about 10 per cent of the umbels were exposed black seed, harvesting was undertaken by cutting or snapping of them with a quick turn of the hand, leaving a short piece of stem attached. For graded seed, 1000 seeds were taken out and pass through 12 x 12 BSS (British Standard Sieve) sieve. The seeds those passed through mesh were rejected and bold seeds which remains in sieve were counted and considered as graded seed. On the basis of counted graded number of seeds out of 1000 seeds the per cent graded seed yield was calculated and recorded accordingly in per cent (Geetharani *et al.,* 2008). The data were statistically analyzed as per the methods suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Test weight (g) and germination per cent

Effect of nitrogen levels

The data presented in Table 1 revealed that, the different levels of nitrogen on test weight and germination per cent of onion seed were found to be significant, during both the years of experiments. In the year 2015-16, the treatment N_2 recorded significantly the maximum test weight and germination per cent (3.80 g and 82.02 %, respectively). However, significantly the minimum test weight and germination per cent (3.23 g and 69.35 %, respectively) were observed in treatment N_0.

During the year 2016-17, significantly the maximum test weight and germination per cent (3.86 g and 84.58%, respectively) were found in treatment N_2. Whereas, the treatment N_0 recorded significantly the minimum test weight and germination per cent (3.28 g and 70.59 %, respectively). More dose of nitrogen might favorite enlargement of onion seeds, which could be resulted into maximum test weight of seed and an additional application of nutrients which would be effective in breaking the dormancy and as nitrogen is the integral part of the process like amino acid and protein synthesis, might have enhanced the process of protein synthesis and ultimately would have helped to increase the germination percentage of onion seed. The results of present investigation are in close agreement with the findings of Singh *et al*. (1998), Khewle (2009), Khadse *et al.* (2015) and El-Damarany *et al*. (2016) in onion.

Effect of phosphorus levels

The data furnished in Table 1 revealed that, application of P @ 75 kg ha^{-1} recorded maximum test weight and germination per cent (3.59 g and 78.12%, respectively). Whereas, the treatment P_0 recorded minimum test weight and germination per cent (3.43 g and 74.39 %, respectively), during the year 2015-16.

Similar trend was observed in year 2016-17, the treatment P_2 recorded maximum test weight and germination per cent (3.65 g and 79.46 %, respectively). Whereas, the treatment P_0 recorded significantly the minimum test weight and germination per cent (3.50 g and 75.76 %, respectively). This might be due to the fact that, an application of higher dose of phosphorus would results in the overall development of seed in the umbel and would get more weight than ordinary seed produced without or less phosphorus treated onion plants. This could be the reason of maximum test weight of onion seed in this treatment. Whereas, phosphorus is also an integral part of phosphate compounds, energy obtained from photosynthesis and metabolism of carbohydrates is stored in these compounds, naturally it would be stored in onion seed, and ultimately influenced the germination per cent. Similar results were recorded by Chauhan (1974), Sedera (1999) and Ali *et al*. (2008) in onion.

Effect of potassium levels

During the year 2015-16, maximum test weight and germination per cent (3.58 g and 77.58 %, respectively) were noted in treatment of K @ 75 kg ha^{-1}. Whereas, the treatment K_0 produce significantly the minimum test weight (3.46 g and 75.03 %, respectively).

In the year 2016-17, the treatment K @ 75 kg ha^{-1} was recorded maximum test weight and germination per cent (3.64 g and 78.98 %, respectively). However, significantly the minimum test weight and germination per cent (3.53 g and 76.32 %, respectively) were recorded in treatment K_0(Table 1). An application of potassium might be helpful to accelerate the translocation of photosynthates of onion crop and which in turn reflects into enlargement of onion seed, which might increased the test weight. However, potassium fertilizer accelerate the various enzymes, which might help in more of protein synthesis, and ultimately it would have helped to increase the germination percentage of onion seed. Similar results have been recorded by Singh and Singh (2003), Khewle (2009) and Khadse *et al*. (2015) in onion.

Table 1. Effect of nitrogen, phosphorus and potassium levels on quality and yield characters of onion seed

Treatments	Test weight (g)		Germination (%)		Graded seed yield (%)		Seed yield ($q\ ha^{-1}$)
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	Pooled
Nitrogen (N)							
N_0 - 0 Kg ha^{-1}	3.23	3.28	69.35	70.59	95.77	95.90	
			(56.40)	(57.18)	(78.25)	(78.44)	9.44
N_1 - 100 Kg ha^{-1}	3.57	3.63	77.65	78.99	96.50	96.78	
			(61.81)	(62.74)	(79.23)	(79.68)	12.57
N_2 - 150 Kg ha^{-1}	3.80	3.86	83.02	84.58	96.73	97.20	
			(65.71)	(66.92)	(79.63)	(80.45)	12.94
SE(m) ±	0.01	0.01	0.08	0.10	0.15	0.13	0.03
CD at 5 %	0.03	0.02	0.22	0.27	0.43	0.37	0.08
Phosphorus (P)							
P_0 - 0 Kg ha^{-1}	3.43	3.50	74.39	75.76	96.02	96.27	
			(59.74)	(60.67)	(78.59)	(78.99)	10.68
P_1 - 50 Kg ha^{-1}	3.57	3.63	77.51	78.93	96.39	96.63	
			(61.86)	(62.88)	(79.09)	(79.49)	12.03
P_2 - 75 Kg ha^{-1}	3.59	3.65	78.12	79.46	96.60	96.98	
			(62.31)	(63.29)	(79.43)	(80.09)	12.25
SE(m) ±	0.01	0.01	0.08	0.10	0.15	0.13	0.03
CD at 5 %	0.03	0.02	0.22	0.27	0.43	0.37	0.08
Potassium (K)							
K_0 - 0 Kg ha^{-1}	3.46	3.53	75.03	76.32	95.56	95.88	
			(60.18)	(61.05)	(77.92)	(78.40)	11.04
K_1 - 50 Kg ha^{-1}	3.55	3.62	77.40	78.86	96.60	96.84	
			(61.82)	(62.87)	(79.39)	(79.77)	12.06
K_2 - 75 Kg ha^{-1}	3.58	3.64	77.58	78.98	96.84	97.16	
			(61.91)	(62.91)	(79.80)	(80.39)	11.86
SE(m) ±	0.01	0.01	0.08	0.10	0.15	0.13	0.03
CD at 5 %	0.03	0.02	0.22	0.27	0.43	0.37	0.08
Interaction (N x P)							
SE(m) ±	0.02	0.02	0.13	0.17	0.26	0.23	0.05
CD at 5 %	-	-	-	-	-	-	0.14
Interaction (N x K)							
SE(m) ±	0.02	0.02	0.13	0.17	0.26	0.23	0.05
CD at 5 %	-	-	-	-	0.75	0.65	0.14
Interaction (P x K)							
SE(m) ±	0.02	0.02	0.13	0.17	0.26	0.23	0.05
CD at 5 %	-	-	-	-	-	-	0.14
Interaction (N x P x K)							
SE(m) ±	0.03	0.03	0.23	0.29	0.46	0.40	0.09
CD at 5 %	0.08	0.07	0.65	0.81	-	-	0.25

(Figures in parentheses are arc sin value transformation)

Table 2 (a). Interaction effect between nitrogen, phosphorus and potassium levels on test weight (g), germination (%) and seed yield (q)

N x P x K	Test weight (g)						Germination (%)						Seed yield (q ha^{-1})		
	2015-16			2016-17			2015-16			2016-17			Pooled		
	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	N_2
P_0K_0	3.04	3.43	3.63	3.13	3.49	3.69	65.78	74.22	78.77	66.96	75.68	80.23	7.18	11.32	11.89
							(54.21)	(59.49)	(62.56)	(54.93)	(60.43)	(63.60)			
P_0K_1	3.12	3.55	3.73	3.17	3.63	3.79	66.73	77.69	81.43	67.81	78.98	83.11	8.41	12.26	12.09
							(54.77)	(61.81)	(64.47)	(55.43)	(62.70)	(65.70)			
P_0K_2	3.18	3.46	3.75	3.23	3.52	3.81	68.07	74.99	81.87	69.20	76.37	83.48	8.69	11.77	12.52
							(55.59)	(59.99)	(64.80)	(56.30)	(60.90)	(66.03)			
P_1K_0	3.22	3.53	3.78	3.27	3.59	3.84	69.13	76.59	82.44	70.52	77.40	83.69	9.45	12.44	12.77
							(56.25)	(61.07)	(65.23)	(57.10)	(61.60)	(66.20)			
P_1K_1	3.26	3.65	3.84	3.38	3.71	3.95	71.70	79.46	84.47	72.86	80.92	86.29	9.94	13.42	13.83
							(57.86)	(63.05)	(66.79)	(58.60)	(64.10)	(68.27)			
P_1K_2	3.33	3.63	3.85	3.31	3.73	3.90	70.11	79.81	83.87	71.74	81.45	85.53	10.11	13.12	13.17
							(56.86)	(63.30)	(66.33)	(57.90)	(64.50)	(67.63)			
P_2K_0	3.19	3.55	3.81	3.24	3.60	3.87	68.22	76.95	83.18	69.36	78.29	84.72	8.95	12.43	12.91
							(55.69)	(61.31)	(65.79)	(56.40)	(62.23)	(66.97)			
P_2K_1	3.30	3.60	3.86	3.35	3.66	3.92	73.47	78.18	85.13	74.72	79.53	86.55	11.16	13.36	14.12
							(59.00)	(62.15)	(67.32)	(59.80)	(63.10)	(68.50)			
P_2K_2	3.40	3.71	3.93	3.46	3.77	4.00	70.91	80.94	86.06	72.10	82.26	87.63			
							(57.36)	(64.12)	(68.08)	(58.13)	(65.07)	(69.40)	11.09	13.04	13.20
SE (m) ±		0.03			0.03			0.23			0.29			0.09	
CD at 5 %	0.08			0.07			0.65			0.81			0.25		

(Figures in parentheses are arc sin value transformation)

Interaction effect

Test weight and germination per cent of onion seed during the years 2015-16 and 2016-17 as influenced by nitrogen x phosphorus (N x P), nitrogen x potassium (N x K), phosphorus x potassium (P x K) and nitrogen x phosphorus x potassium (N x P x K) interactions were found to be non-significant except three way interaction between nitrogen, phosphorus and potassium.

Interaction effect between nitrogen, phosphorus and potassium

The data presented in Table 2 (a) exhibited that, the interaction effect due to nitrogen, phosphorus and potassium levels regarding the test weight, during the years 2015-16 and 2016-17 were found to be statistically significant. During the years 2015-16 and 2016-17, the treatment combination $N_2P_2K_2$ recorded significantly the maximum test weight (3.93 g and 4.00 g, respectively) and germination per cent (86.06 % and 87.63 %, respectively). Whereas, the treatment combination $N_0P_0K_0$ recorded minimum test weight (3.04 g and 3.13 g, respectively) and germination per cent (65.78 and 66.96 %, respectively). Similar results have been recorded by Dudhat *et al*. (2010) and Dingre *et al*. (2016) in onion.

Seed yield

Effect of nitrogen levels

The pooled data (Table 1) found that, significantly the maximum (12.94 q) seed yield was obtained in treatment N_2. Whereas, the treatment N_0 recorded significantly the minimum seed yield (9.44 q ha^{-1}). This might be due to the more number of graded seeds per primary and secondary umbel, which would have recorded maximum weight of the seeds per umbel and maximum seed weight per plot. Similar findings were recorded by Chavan (1975), Ahmed and Abdalla (1984) and Khewle (2009) in onion.

Effect of phosphorus levels

The pooled data indicated that, the treatment P @ 75 kg ha^{-1} recorded significantly the maximum seed yield (12.25 q ha^{-1}). Whereas, the treatment P_0 noticed significantly the minimum seed yield (10.68 q ha^{-1}) (Table 1). In bulbous crop like onion, the enhanced vigorous growth and development of reproductive parts of onion plant like umbel number and size, seed number and size might be achieved through higher application of phosphorus, which might be resulted into maximum seed yield. Similar results were recorded by Sedera (1999) and Ali *et al*. (2008) in onion.

Effect of potassium levels

The pooled data indicated that, the treatment K @ 50 kg ha^{-1} recorded significantly the maximum seed yield (12.06 q ha^{-1}). However, the treatment K_0 recorded significantly the minimum (11.04 q ha^{-1}) seed yield (Table 1). An application of optimum dose of potassium might produce large size of umbel, its early emergence and thereby produced large number of seeds per umbel and ultimately maximum seed yield ha^{-1}. The results of present investigation are in close agreement with the findings of Khewle (2009) and El-Damarany *et al.* (2016) in onion.

Interaction effects

Interaction effects between nitrogen and phosphorus

The pooled results in respect of seed yield per hectare was presented in Table 2(b). The treatment combination N_2P_2 produced maximum (13.41 q ha^{-1}) seed yield. Whereas, minimum (8.09 q ha^{-1}) seed yield was recorded in the treatment combination N_0P_0. Production of higher seed yield ha^{-1} with higher level of nitrogen and phosphorus in the present investigation might be justified with the fact that, increased root mass due to application of nitrogen is largely responsible for increased plant uptake of phosphorus. At the same time higher availability of phosphorus might responsible for early root growth and proliferation, which might resulted into desired nitrogen uptake. Hence, application of nitrogen and phosphorus in conjugation might resulted into maximum number of seeds $umbel^{-1}$, seed weight per plant and ultimately the seed yield ha^{-1}. The results of the present investigation are in harmony with findings of Ahmed and Abdalla (1984) in onion.

Interaction effects between nitrogen and potassium

The pooled results in respect of seed yield per plot was exhibited significant influence due to the interaction effect of nitrogen and potassium levels treatment and presented in Table 2(b). whereas, the treatment combination N_2K_1 produced maximum (13.35 q ha^{-1}) seed yield. However, minimum (8.53 q ha^{-1}) seed yield was recorded in the treatment combination N_0K_0.This might be due to the fact that, optimum level of potassium application might increases nitrogen uptake with an assimilation in plant. Hence, combined efficient use of nitrogen and potassium might resulted into better plant

Table 2(b). Effect of different interaction on seed yield of onion

N x P	Seed yield (q ha^{-1})			N x K	Seed yield (q ha^{-1})			P x K	Seed yield (q ha^{-1})		
	Pooled				Pooled				Pooled		
	N_0	N_1	N_2		N_0	N_1	N_2		P_0	P_1	P_2
P_0	8.09	11.78	12.17	K_0	8.53	12.06	12.52	K_0	10.13	11.55	11.43
P_1	9.83	13.00	13.26	K_1	9.83	13.01	13.35	K_1	10.92	12.40	12.88
P_2	10.40	12.94	13.41	K_2	9.96	12.64	12.96	K_2	10.99	12.13	12.44
SE(m) ±		0.05		SE(m) ±		0.05		SE(m) ±		0.05	
CD at 5 %		0.14		CD at 5per cent		0.14		CD at 5per cent		0.14	

Table 3. Interaction effect between nitrogen and potassium levels on graded seed yield

N x K	Graded seed yield (%)					
	2015-16			2016-17		
	N_0	N_1	N_2	N_0	N_1	N_2
K_0	94.53 (76.62)	96.02 (78.50)	96.12 (78.64)	94.66 (76.77)	96.35 (79.00)	96.63 (79.43)
K_1	96.37 (79.04)	96.67 (79.49)	96.76 (79.64)	96.44 (79.12)	96.93 (79.91)	97.15 (80.29)
K_2	96.42 (79.09)	96.80 (79.70)	97.30 (80.60)	96.62 (79.43)	97.06 (80.13)	97.82 (81.62)
SE(m) ±		0.26			0.23	
CD at 5 %		0.75			0.65	

(Figures in parentheses are arc sin value transformation)

growth and ultimately maximum seed yield ha^{-1}. The results obtained in the present investigation are in close agreement with the findings of El-Damarany *et al.* (2016) in onion.

Interaction effects between phosphorus and potassium

The pooled results in respect of seed yield was significantly influenced due to the interaction effect of phosphorus and potassium levels (Table 2(b)). Whereas, the treatment combination P_2K_1 produced maximum seed yield (12.88 q ha^{-1}). Whereas, minimum seed yield (10.13 q ha^{-1}) was recorded in the treatment combination P_0K_0. The maximum seed yield of onion with this treatment combination could be ascertained with phosphorus uptake and its full utilization in plant, which was governed by osmatic and water balance maintained by optimum potassium supply. Hence, there would be the possibility of combined use of phosphorus and potassium, which might be responsible for greater physiological activities of plant and thus resulted into maximum seed yield of onion. These findings are in harmony with the results reported by Majumder (2011) and Howlader *et al*. (2012) in onion.

Interaction effects between nitrogen, phosphorus and potassium

The pooled data reported in Table 2(a) revealed that, significantly the maximum seed yield (14.12 q ha^{-1}) in onion was recorded in treatment combination $N_2P_2K_1$. Whereas, the treatment combination $N_0P_0K_0$ had recorded minimum seed yield (7.18 q ha^{-1}). These results are in line with the findings of earlier workers like Dingre *et al*. (2016) in onion.

Graded seed yield

Effect of nitrogen levels

The data in Table 1 revealed that, the treatment N_2 recorded significantly the maximum graded seed yield (96.73 %). However, the treatment N_0 recorded significantly the minimum graded seed yield (95.77 %) in the year 2015-16. In the subsequent year 2016-17, the treatment N_2 recorded significantly the maximum (97.20 %) graded seed yield. Whereas, the treatment N_0 recorded minimum graded seed yield (95.90 %). The nitrogen is an integral part of the process like amino acid and protein synthesis, which would have helped to improve the quality of seed and thereby increasing the per cent graded seed yield of onion. The results of the present investigation are supported by the findings of Khewle (2009) and Khadse *et al.* (2015) in onion.

Effect of phosphorus levels

The treatment P @ 75 kg ha^{-1} recorded significantly, the maximum graded seed yield (96.60 %). Whereas, P_0 recorded minimum graded seed yield (96.02 %), during the year 2015-16. In subsequent year, maximum graded seed yield (96.98 %) was observed in treatment P_2 and treatment P_0 which was recorded minimum graded seed yield (96.27 %) Table 1. The applied phosphorus is an integral part of phosphate compounds, such as Adenosine diphosphate and Adenosine triphosphate, energy obtained from photosynthesis and metabolism of carbohydrates is stored in these compounds, which subsequently used in growth and reproductive process of plant that ultimately positively influenced the quality of seed and might be reflected in higher percentage of graded seed yield of onion. The results of the present investigation are supported by the finding of Naval (2015) in onion.

Effect of potassium levels

During the years 2015-16 and 2016-17, the treatment K @ 75 kg ha^{-1} was recorded maximum graded seed yield (96.84 and 97.16 %, respectively) and it was recorded minimum graded seed yield (95.56 and 95.88 %, respectively) in the treatment K_0 (Table 1). The potassium is an important primary element for many crop quality characteristics, due to its involvement in synthesis and transfer of photosynthates to the reproductive part like umbel and thereby increase the graded seed yield of onion in the present study. The results of the present investigation are supported by the finding of Khadse *et al.* (2015) in onion.

Interaction effect

All interaction effects of nitrogen, phosphorus and potassium on the graded seed yield, during both the years of experimentation 2015-16 and 2016-17 were found to be non-significant, except interaction between nitrogen and potassium.

Interaction effect between nitrogen and potassium

In the year 2015-16, the treatment combination N_2K_2 recorded maximum (97.30 %) graded seed yield. However, significantly the minimum (94.53 %) graded seed yield was found in treatment combination N_0K_0. In the next year 2016-17, significantly the maximum (97.82 %) graded seed yield was observed in treatment combination N_2K_2. Whereas, the treatment combination N_0K_0 recorded significantly the minimum (94.66 %) graded seed yield (Table 3). This might be due to the fact that, maximum utilization and functioning of potassium in plant is governed by optimum nitrogen supply. Hence, combined use of nitrogen and potassium might be resulted into higher seed setting with graded seed yield of seed in crop like onion. The results of the present investigation are supported by the findings of Khewle (2009) and Khadse *et al.* (2015) in onion.

CONCLUSION

It is inferred that, the onion seed quality paratmeters test weight, germination per cent and graded seed yield recorded higher with the application of higher levels of nutrients (150 kg N, 75 kg P_2O_5 and 75 kg K_2O ha^{-1}). However, significantly higher seed yield of onion (14.12 q ha^{-1}) was produced with application of 150 kg N, 75 Kg P_2O_5 and 50 Kg K_2O ha^{-1}.

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Effect of Nutrient Levels on Growth and Yield of Ajwain Crop in Semi Arid Climate of Vidarbha Region of Maharashtra

S. S. Hadole[1], S. M. Ghawade[2], P. A. Sarap[3] , R. N. Katkar[4] and S. R. Lakhe[5]

ABSTRACT

An experiment was conducted during the year 2014-15 to 2016-17 at Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra in RBD with five treatments replicated four times to study the effect of different fertilizer levels on growth and yield of Ajwain (*Trachyspermum ammi* L.). The result of the experimentation indicated that, application of 80 :40 :40 kg ha^{-1} N, P, K recorded significantly highest seed and straw yields 14.28 and 57.41 q ha^{-1}, respectively and also improved essential oil content of ajwain seed 3.01 per cent. with significant improvement in the fertility status of the soil. Thus, 80 kg nitrogen, 40 kg phosphorus and 40 kg potassium ha^{-1} should form the integral part of ajwain for getting a good optimum harvest of ajwain under semi-arid climatic conditions of Vidarbha region of Maharashtra State.

Ajwain (*Trachyspermum ammi L.*) belonging to family Apiaceae is highly valued medicinally important seed spice. Ajwain or Bishop's weed is an annual herbaceous plant, the seeds are used for flavouring foods and as preservatives. The roots are diuretic in nature and the seed possess excellent aphrodisiac properties. The seeds contain 2.4 per cent brown coloured oil is popularly known as ajwain oil. The main component of this oil is thymol, which is used as gastrointestinal ailments, lack of appetite and bronchial problems. It is used in pharmaceutical industry as a diuretic, anti-vomiting, analgesic, antiasthma, antispasmodic and carminative. The essential oil from seeds is used in perfumery, essence and medicinal preparations (Nath *et al.*, 2008). Ajwain is a native of Egypt and is cultivated in India, Iraq, Pakistan and Afganistan. In India, ajwain is cultivated in MP, UP, Gujrat, Rajasthan, Maharashtra, Bihar and WB. Therefore, the present investigation was undertaken to study the different levels of fertilizers on growth and yield of ajwain and application of economically optimum rates of fertilzation results in efficient use of resources, maximum production potential and to ensures crop profitability in semi-arid tropics of Vidarbha region.

MATERIAL AND METHODS

A field experiment was conducted during the year 2014-15 to 2016-17 at Chilli and Vegetable Research Unit, Dr. PDKV, Akola. Characteristics of experimental soil at the start of the experiment are presented in Table 1 showed that the site is medium in organic carbon (5.01 g kg^{-1}), low in available N and P (220 & 17.27 kg ha^{-1}, respectively) and medium high in available K (288 kg ha^{-1}). There were five treatments comprising of control (without fertilizer application), 20:10:10 NPK kg ha^{-1}, 40:20:20 NPK kg ha^{-1}, 60:30:30 NPK kg ha^{-1} and 80:40:40 NPK kg ha^{-1}, replicated four times in randomized block design. Urea, SSP and MOP fertilizers were applied to all the plots to supply N, P and K. Surface soil samples (0-20 cm depth) were taken after harvest of the crop and analysed for pH, EC (Jackson, 1973), organic carbon (Piper, 1966), available N (Subbajah and Asija, 1956), Available phosphorus (Watanabe and Olsen, 1965), Available potassium (Jackson, 1973). Essential oil content (%) of ajwain seed was measured on Clevenger apparatus (Robert Adams, 1995).

Table 1. Initial status of experimental soil

S. N.	Soil properties	Value
1	Mechanical analysis	
	Sand (%)	31.17
	Silt (%)	17.67
	Clay (%)	51.22
2	pH (1:2.5)	8.29
3	EC (d Sm^{-1})	0.56
4	Organic carbon (g kg^{-1})	5.01
5	Available N (kg ha^{-1})	220.0
6	Available P (kg ha^{-1})	17.27
7	Available K (kg ha^{-1})	288

1 & 2. Associate Professor, 3, Assistant Professor, 4. Professor and 5. Senior Res. Fellow, Deepartment of Soil Science and Agril. Chemistry, Dr. PDKV,Akola

RESULTS AND DISCUSSION

Seed and straw yield

The pooled seed yield of ajwain as influenced by different treatments is presented in Table 2. The seed yield of ajwain is ranged between 11.23 to 14.28 q ha^{-1}. The application of fertilizer level 80:40:40 kg ha^{-1} N, P and K recorded significantly highest seed yield (14.28 q ha^{-1}). Superiority of 80 kg N ha^{-1} over rest of nitrogen levels was observed. It was also noted that, lower doses nitrogen is not enough to get a good harvest of ajwain crop. Similar findings were reported by Vahidipour *et al.* (2013), Naruka *et al*. (2012), and Moussavi *et al*. (2011). Results also indicated that, phosphorus dose produced significant improvement in the seed yield, the linear increment in seed yield per hectare was 12.09, 12.73, 13.46, and 14.28 q ha^{-1} under 10, 20, 30, 40 kg ha^{-1} P incremental fertilizer. Thus, data revealed that, with application of 40 kg phosphorus per hectare, increase in seed yield was more pronounced. Similar beneficial effects of increasing levels of phosphorus application to ajwain crop had also been observed by Marks *et al.* (2005). Further, results indicated that potassium dose produced significant improvement in the seed yield as it was highest in 40 kg ha^{-1} potash application treatment.

Quality performance of ajwain

Essential oil and yield

Quality was judged in the present investigation in terms of yield of essential oil in seed. The essential oil content in the form of volatile oil was taken into consideration as a quality parameter. Mean comparison of data showed the highest essential oil 3.01 per cent was recorded by the treatment of 80:40:40 NPK kg ha^{-1} (Table 3) and the lowest 2.51 per cent was recorded in control treatment. Essential oil percentage showed non significant difference between treatments, but the essential oil yield increased significantly with increasing levels of fertilizers. Increasing essential oil in consequence of nitrogen fertilizer consumption can be due to the fact that nitrogen plays an important role in the development and divisions of new cells contain essential oil, essential oil channels, secretary

Table 2. Seed yield and straw yield of ajwain as influenced by various treatments

Treatments	Seed yield (q ha^{-1})				Straw yield (q ha^{-1})			
	2014-15	2015-16	2016-17	Pooled Mean	2014-15	2015-16	2016-17	Pooled Mean
T1- N_O P_O K_O (Control)	10.73	12.83	10.15	11.23	52.52	48.31	47.69	49.57
T2- N_{20} P_{10} K_{10} kg ha^{-1}	11.49	13.32	11.46	12.09	52.79	49.25	50.23	50.76
T3- N_{40} P_{20} K_{20} kg ha^{-1}	12.09	13.70	12.41	12.73	53.28	51.32	51.32	51.97
T4- N_{60} P_{30} K_{30} kg ha^{-1}	13.13	14.08	13.59	13.46	54.81	53.33	55.98	54.94
T5- N_{80} P_{40} K_{40} kg ha^{-1}	14.75	14.67	14.59	14.28	58.52	55.66	58.06	57.41
SE m(±)	0.24	0.09	0.31	0.16	0.49	0.24	0.48	0.24
CD at 5 %	0.74	0.28	0.97	0.49	0.15	0.76	0.15	0.74

Table 3. Oil content of ajwain as influenced by various treatments

Treatments	Oil content (%)			
	2014-15	2015-16	2016-17	Pooled Mean
T1- N_O P_O K_O (Control)	2.83	2.12	2.58	2.51
T2- N_{20} P_{10} K_{10} kg ha^{-1}	2.78	2.33	2.62	2.58
T3- N_{40} P_{20} K_{20} kg ha^{-1}	2.75	2.48	2.70	2.64
T4- N_{60} P_{30} K_{30} kg ha^{-1}	2.96	2.75	2.91	2.87
T5- N_{80} P_{40} K_{40} kg ha^{-1}	3.06	2.93	3.06	3.01
SE m(±)	0.08	0.07	0.10	0.05
CD at 5 %	NS	NS	NS	NS

Table 4. pH and EC and organic carbon of soil as influenced by various treatments after harvest of ajwain

Treatments	pH (1:2.5)			EC (dS m^{-1})			Organic carbon (g kg^{-1})		
	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17
T1- $N_O P_O K_O$(Control)	8.25	8.24	8.25	0.55	0.53	0.51	5.02	5.06	5.03
T2- $N_{20} P_{10} K_{10}$ kg ha^{-1}	8.25	8.24	8.24	0.55	0.51	0.51	5.02	5.01	5.04
T3- $N_{40} P_{20} K_{20}$ kg ha^{-1}	8.23	8.24	8.22	0.52	0.52	0.53	5.01	5.01	5.01
T4- $N_{60} P_{30} K_{30}$ kg ha^{-1}	8.25	8.24	8.24	0.53	0.54	0.52	5.03	5.07	5.03
T5- $N_{80} P_{40} K_{40}$ kg ha^{-1}	8.22	8.26	8.25	0.54	0.52	0.52	5.03	5.05	5.04
SE m(±)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.13	0.01
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Available N, P and K content of soil as influenced by various treatments after harvest of ajwain

Treatments	Available Nitrogen (kg ha^{-1})			Available Phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17
T1- $N_O P_O K_O$(Control)	217.0	191.0	202.3	16.53	18.53	16.66	255	276	278
T2- $N_{20} P_{10} K_{10}$ kg ha^{-1}	225.8	207.8	213.3	17.57	18.57	17.33	275	282	289
T3- $N_{40} P_{20} K_{20}$ kg ha^{-1}	234.0	214.5	223.3	18.07	19.32	18.65	283	288	287
T4- $N_{60} P_{30} K_{30}$ kg ha^{-1}	240.5	216.0	237.3	18.59	19.44	18.87	290	292	300
T5- $N_{80} P_{40} K_{40}$ kg ha^{-1}	246.5	234.0	256.3	19.05	20.55	19.48	297	299	311
SE m(±)	3.12	3.59	4.14	0.12	0.19	0.25	2.90	1.45	2.17
CD at 5 %	10.96	11.07	12.76	0.38	0.59	0.78	8.95	4.48	6.68

Table 6. Effect of different fertilizer levels on monetary returns of ajwain

Treatments	Pooled Grain yield (q ha^{-1})	GMR (Rs)	COC(Rs.)	NMR (Rs.)	B:C Ratio
T1- $N_O P_O K_O$ (Control)	11.23	134810	77690	57120	1.74
T2- $N_{20} P_{10} K_{10}$ kg ha^{-1}	12.09	145060	78537	66523	1.85
T3- $N_{40} P_{20} K_{20}$ kg ha^{-1}	12.73	152782	79583	73199	1.92
T4- $N_{60} P_{30} K_{30}$ kg ha^{-1}	13.46	161510	80230	81280	2.01
T5- $N_{80} P_{40} K_{40}$ kg ha^{-1}	14.28	171330	81076	90254	2.11

ducts and glandular trachoma's (Agena, 1994; Moore, 1979). Another reason can be attributed to better photosynthesis and better breathing, because secondary metabolites engender from plant photosynthesis and better photosynthesis produces more secondary metabolites and more essential oil. A similar result as regards of significant differences in essential oil yield of ajwain and non-significant differences in case of essential oil percentage was also reported by Vahidipour *et al.* (2013).

Soil properties

The data regarding to soil chemical properties (pH, EC and OC) and residual nutritional status for available nitrogen, phosphorus and potassium is presented in Table 4. The data indicated that, there was no considerable change in pH, electrical conductivity and organic carbon status of soil. However, the soil pH ranges from 8.22 to 8.26 and electrical conductivity of the soil was found between 0.51 to 0.55 dS m^{-1}. The organic carbon content of the soil after harvest of ajwain was observed between 5.01 to 5.07 g kg^{-1}. Furthermore, the average mean values of pH, EC and organic carbon revealed that there was slight increase in pH over initial value (8.25) whereas, there was non-significant reduction in soil electrical conductivity over initial value (0.52 dS m^{-1}). Non-significant improvement in mean organic carbon content of soil was also recorded; however, it was increased up to 5.06 g kg^{-1} from 5.01 g kg^{-1} its initial.

Available nutrients in soil

Data as regards of available nitrogen, phosphorus and potassium content in soil after harvest of ajwain was significant (Table 5). Furthermore, it was noted that mean average content of available nitrogen, phosphorus and potash content in soil was highest i.e. 256.3 kg ha^{-1}, 20.55 kg ha^{-1} and 311 kg ha^{-1}, respectively with application of fertilizer level 80:40:40 kg ha^{-1} N, P and K fertilizers. The data revealed that significant increase in available nitrogen, phosphorus and potassium in the soil increase with increase in the doses of the fertilizers.

Monetary returns and B:C ratio

The highest gross monetary returns (Rs. 171330=00) were recorded by the treatment 80:40:40 N,P, K kg ha^{-1} followed by the treatment 60:30:30 N,P and K kg ha^{-1} which was reflected on higest net monetary returns (Rs.90254/-) with 2.11 B:C ratio under the experimentation (Table 6.).

CONCLUSION

Application of 80:40:40 kg ha^{-1} N, P_2O_5 and K_2O to Ajwain showed significant improvement in fertility status of soil and yield of Ajwain crop which ultimately reflected on the highest B:C ratio and net monetary returns.

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Effect of Conjunctive Use of Glyricidia Green Leaf Manure and Chemical Fertilizers on Soil Biological Properties and Yield of Soybean in Vertisols

Usha V. Satpute[1], V. V. Gabhane[2], B. A. Sonune[3], D. V. Mali[4] and N. M. Konde[5]

ABSTRACT

A field experiment was conducted at All India Co-ordinated Research Project for Dryland Agriculture, Dr. PDKV, Akola in Vertisols during kharif 2013-14 on the long term experiment initiated during 2009-10. The soil of the experimental site was moderately alkaline in reaction (pH 8.1). The nine treatments comprised of control, 100 per cent RDF through chemical fertilizers and the combinations of 50per cent N through glyricidia green leaf manure and 50 per cent N through inorganics, 25 kg K ha^{-1} and seed treatment with biofertilizers in randomized block design with three replications. The results indicated that, glyricidia green leaf manuring in combination with inorganic fertilizers enhanced the soil microbial biomass carbon (SMBC), dehydrogenase activity (DHA), CO_2 evolution, alkaline phosphatase and yield of soybean. The application of 50 per cent N through glyricidia +50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1} was found to be beneficial for improvement in SMBC(191.41 µg kg^{-1} soil**)**, CO_2 evolution (48.03 mg 100 g^{-1} soil), alkaline phosphatase (286.18µg p-nitrophenol g^{-1} 24 hr^{-1}) and DHA(51.13µg TPF g^{-1} 24 hr^{-1}) and yield of soybean in Vertisols.

Soybean (*Glycine max* (L) Merill), a grain legume is considered as a wonder crop due to its dual quality *viz.*, high protein (40-43 %) and oil content (20 %). Soybean being a potentially high yielding crop can play a greater role in boosting oil seed production in the country. This legume is making straight way in Indian agriculture to meet protein and oil requirement. In addition to this, soybean protein has five per cent lysine, which is deficit in most of the cereals and enriching the cereal flour with soybean improves the nutritive quality.

The green manures are a valuable potential source of N and organic matter. They play an important role in improving soil physical, chemical and biological properties of soil with increase in the microbial population in soil. Biofertilizers are preparations containing live or latent cell of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for application to seed, soil or composting areas with the objectives of increasing the population of such beneficial microorganisms and accelerate certain microbial processes to augment the extent of the availability of nutrients in a form which can be easily assimilated by the plants.

In view of the above, the experiment was conducted to study the effect of conjunctive use of glyricidia green leaf manure and chemical fertilizers on soil biological properties and yield of soybean in Vertisols.

MATERIAL AND METHODS

A field experiment conducted on Vertisols was initiated on the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola since 2009-10. The present study was conducted during 2012-13 to assess the effect of conjunctive use of glyricidia green leaf manuring and chemical fertilizers on soil biological properties and yield of soybean. The details of various treatments undertaken in the experiment are (T_1) Control, (T_2)100 per cent RDF (30:75:00 NPK kg ha^{-1}), (T_3) 100 per cent RDF + biofertilizers, (T_4)100 per cent N through FYM + biofertilizers, (T_5) 100per cent RDF + 25 kg K ha^{-1} , (T_6) 100 per cent RDF + 25 kg K ha^{-1} + biofertilizes,(T_7) 50 per cent N through green leaf manure + 50 per cent N through inorganics, (T_8) 50 per cent N through green leaf manure + 50 per cent N through inorganics + biofertilizers, (T_9) 50 per cent N through green leaf manure+50 per cent N through inorganics + biofertilizers + 25 kg potassium ha^{-1}. Biofertilizers used were rhizobium and PSB as seed treatment (25 g kg^{-1} seed). Recommended P was applied to all the treatments except control (T_1) & 100 per cent N through FYM + biofertilizers (T_4). N supplied through urea, P through Single super phosphate and K through Muriate of potash.

Treatment wise surface (0-20 cm) soil samples for biological parameter were collected during peak growth stage of soybean and immediately analyzed.

1. P G student, 2. Professor, 3,4,5. Assistant Professors, Dept. of Soil Science and Agril. Chemistry &, Dr. PDKV, Akola.

Microbial biomass carbon (MBC) was determined by chloroform fumigation extraction method (Jenkinson and Powlson, 1976). Enzyme activities were determined by assay method (Tabatabai and Bremnar, 1969; Pancholy and Rice, 1973); CO_2 evolution was determined by alkali trap method (Anderson, 1982).

RESULTS AND DISCUSSION

Soil Biological Properties

The biological activity of a soil is the function of number of organisms present in soil and their physiological efficiency. The rate of respiration can be used as an index of the biological activity of soil as it reflects physiological efficiency of the organisms. All biological reactions in soils are catalyzed by enzymes. Soil enzyme activities are believed to indicate the extent of specific processes in soil and in some cases act as indicators of soil fertility. The data in respect of biological properties of soil at harvest of soybean are presented in Table 1.

Soil Microbial Biomass Carbon (SMBC)

The soil microbial biomass carbon (SMBC) was observed to be significantly increased under integrated nutrient management in comparison with only chemical fertilizers. It was considerably lower in control treatment (Table 1).

The glyricidia green leaf manure as a source of organics under study has recorded on par results in respect of SMBC. However, 50per cent N through glyricidia + 50per cent N through inorganics + biofertilizer + 25 kg K ha^{-1}recorded (191.41 µg kg^{-1} soil) statistically significant improvement in soil microbial biomass carbon over all other treatments and it was found to be on par with the application of 50 per cent N through glyricidia+50per cent N through inorganics + biofertilizers (187.32 µg kg^{-1}soil) and 50per cent N through glyricidia + 50 per cent N through inorganics (178.29 µg kg^{-1}). The soil microbial biomass carbon act as the transformation agent of the organic matter in the soil. As such, the biomass is both source and sink of the carbon, nitrogen, and phosphorus contained in the organic matter. It is the center of majority of biological activity in soil.

It might be 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 results are in conformity with Vineela *et al.* (2008), and Chakraborty *et al.* (2011).

Table 1. Effect of conjunctive use of glyricidia green leaf manure and chemical fertilizers on biological properties of soil

Treatments		SMBC (µg kg^{-1} soil)	CO_2 evolution (mg 100 g^{-1} soil)	Alkaline phosphatase activity (µg p-nitrophenol g^{-1} 24 hr^{-1})	DHA (µg TPF g^{-1} 24 hr^{-1})
T_1	Control	106.59	23.10	208.16	24.42
T_2	100 %RDF (30:75:00 NPK kg ha^{-1})	145.31	29.77	233.13	28.42
T_3	100 % RDF + biofertilizers	147.87	31.70	247.63	29.24
T_4	100 % N through FYM + biofertilizers	152.32	32.47	254.55	31.98
T_5	100 % RDF + 25kg K ha^{-1}	165.45	35.83	257.16	41.52
T_6	100 %RDF + 25kg K ha^{-1} + biofertilizers	172.12	38.30	265.19	49.02
T_7	50 % N through green leaf manure + 50 % N through inorganics	178.29	41.00	271.67	42.53
T_8	50 % N through green leaf manure + 50 % N through inorganics + biofertilizers	187.32	46.17	277.90	47.82
T_9	50 % N through green leaf manure +50 % N through inorganics+ biofertilizers + 25 kg K ha^{-1}	191.41	48.03	286.18	51.13
	SE (m) ±	5.71	2.55	3.20	1.38
	CD at 5 %	17.11	7.66	9.59	4.14

CO_2 evolution

Soil respiration is an evolution of soil biological activity and extent of organic matter decomposition. Profound influence of integrated nutrient management treatments comprising of FYM, glyricidia (green manure) with 50 per cent recommended dose of fertilizers were found on soil respiration over chemical fertilizer treatments (Table 1). The significantly higher CO_2 evolution in soil was observed under the treatment receiving 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizer + 25 kg K ha^{-1} (48.03 mg 100 g^{-1} soil) and it was found to be on par with 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers (46.17 mg 100 g^{-1} soil) and 50 per cent N through glyricidia + 50 per cent N through inorganics (41.00 mg 100 g^{-1} soil). It is indicative of the nutrient turn over at higher carbon expenses met through added organic carbon. Similar results were also reported by Mishra *et al.* (2008) on the basis of long term fertilizer experiment.

All the treatments of only chemical fertilizers recorded comparatively lower values of CO_2 evolution while control (23.10 mg 100 g^{-1} soil) showed lowest values. The INM involving use of various organics however recorded significantly higher values, which thus suggest that very low biological activity under absence of organics renders the soil poor in biological health.

Alkaline Phosphatase Activity

The general name phosphatase has been used to describe a broad group of enzymes that catalyze the hydrolysis of both esters and anhydrides of H_3PO_4 involving five major groups. Due to relative importance of phospho monesterases in soil organic P mineralization and plant nutrition, their assay in soil assumes more importance. The enzymes are classified as acid and alkaline phospho monoesterases because they show optimum activities in acid and alkaline ranges. Alkaline phospho monoesterases activity is derived from microorganisms only.

The alkaline phosphatase activity (Table 1) showed statistically significant improvement under 50 per cent N through glyricidia + 50per cent N through inorganics + biofertilizer + 25 kg K ha^{-1} (286.18 µg p-nitrophenol g^{-1} 24 hr^{-1}) and it was found to be on par with application of 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers (277.90 µg p-nitrophenol g^{-1} 24 hr^{-1}). It was drastically reduced at control (208.16 µg p-nitrophenol g^{-1} 24 hr^{-1}), which improved along with increasing dose of chemical fertilizers. However, it has recorded higher alkaline phosphatase over only NPK fertilizers application indicating necessity of regular application of organics. The significantly higher activities of alkaline phosphatase in the organically treated soils may be due to the enhanced microbial activity and diversity of phosphate solubilizing bacteria due to manure input over the years. These findings are in confirmation with Manna *et al.* (2005) and Mandal *et al.* (2007).

Dehydrogenase Activity (DHA)

Monitoring of dehydrogenases, which are respiratory enzymes and integral part of all soil organisms, express a measure of biological activity of soil at a given time. The dehydrogenase activity showed significant improvement due to 50per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1} (51.13 µg TPF g^{-1}24 hr^{-1}) and it was found to be on par with application of 50per cent N through glyricidia + 50 per cent N through inorganics+ biofertilizers (47.82µg TPF g^{-1}24 hr^{-1}) and 100 per cent RDF + 25 kg K ha^{-1} + biofertilizers (49.02 µg TPF g^{-1}24 hr^{-1}). It was drastically reduced in control (24.42 µg TPF g^{-1}24 hr^{-1}), which improved slightly along with increasing fertilizer dose. However, it was significantly lower in all the treatments of imbalanced fertilization.

The stronger effects of FYM and glyricidia on dehydrogenase activity might be due to the more easily decomposable components of crop residues on the metabolism of soil microorganisms and due to the increase in microbial growth with addition of carbon substrate. The results are in conformity with the findings of Mandal *et al.* (2007).

Grain and Straw Yield

The data on grain and straw yield of soybean (Table 1) was significantly influenced by various treatments. The significantly higher (1255 kg ha^{-1}) grain yield was observed with application of 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1} (T_9) and it was on par (1221 kg ha^{-1}) with the application of 100 per cent RDF + biofertilizers+ 25 kg K ha^{-1} (T_6), 100 per cent RDF + 25 kg K ha^{-1} (T_5), 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers (T_8) and 100 per cent RDF + biofertilizers (T_3). The lowest grain yield (939.6 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Table 2. Effect of conjunctive use of glyricidia green leaf manure and chemical fertilizers on soybean yield

Treatments		Grain (kg ha^{-1})	Straw (kg ha^{-1})
T_1	Control	940	1352
T_2	100 % RDF (30:75:00 NPK kg ha^{-1})	1063	1707
T_3	100 % RDF + biofertilizers	1084	1819
T_4	100 % N through FYM + biofertilizers	1029	1574
T_5	100 % RDF + 25 kg K ha^{-1}	1193	1871
T_6	100 % RDF + 25 kg K ha^{-1} + biofertilizers	1221	1894
T_7	50 % N through green leaf manure + 50 % N through inorganics	1043	1662
T_8	50 % N through green leaf manure + 50 % N through inorganics + biofertilizers	1180	1871
T_9	50 % N through green leaf manure +50 % N through inorganics+ biofertilizers + 25 kg K ha^{-1}	1255	2040
	SE (m) $\pm$	61.6	114.9
	CD at 5 %	184.8	344.6

The application of 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1} (T_9) resulted in 25.13 per cent increase in grain yield over control (T_1) and 15.29 per cent increase over 100 per cent RDF (T_2). The significantly higher (2040 kg ha^{-1}) straw yield was observed with the application of 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1} (T_9) and it was found to be on par with most of the treatments. The lowest (1352 kg ha^{-1}) straw yield was recorded in treatment T_1 *i.e.* control. In general, the higher grain as well as straw yield was recorded with application of 50 per cent N through glyricidia + 50 per cent N through inorganics + biofertilizers + 25 kg K ha^{-1}.

This may be due to beneficial role of potassium which increases nodulation of legumes and biofertilizers also perform better when soil is well supplied with nutrients particularly nitrogen and phosphorus by fixing atmospheric nitrogen. Singh *et al.*, (2009) observed the positive effect of Rhizobium and phosphate solubilizing microorganism in increasing the growth and yield of soybean. Similar results were also reported by Jadhav and Andhale (2009) and Singh *et al.* (2012).

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Long Term Effect of Integrated Nutrient Management on Soil Nutrient Status and Productivity of Cotton+Greengram Intercropping System in Vertisols

Ashwini Chandel[1], V. V. Gabhane[2], K. Rajesh Naik[3], M. B. Nagdeve[4] and B. A. Sonune[5]

ABSTRACT

A long term field experiment to study the effect of integrated nutrient management soil on nutrient status and productivity of cotton + greengram (1:1) intercropping system in Vertisols was initiated during 1987-88. The present study was conducted during kharif 2015-16 at Research farm of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The soil of the experimental site was moderately alkaline in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. The eight treatments comprised of control,100per cent RDF(50:25:00 NPK kg ha^{-1}) through chemical fertilizer, 50per cent RDF through chemical fertilizer, 50per cent N through FYM/gliricidia, 50per cent N through fertilizers + 50 per cent N through FYM/gliricidia + 100per cent P_2O_5 ha^{-1} through chemical fertilizers and 100per cent N ha^{-1} through gliricidia + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers in randomized block design with three replications. The results after 29th cycle indicated that the use of FYM followed by gliricidia green leaf manuring in conjunction with chemical fertilizers recorded higher seed cotton (1180 kg ha^{-1}) and cotton stalk (2207 kg ha^{-1}), grain yield, (448 kg ha^{-1}) and straw yield of green gram (264 kg ha^{-1}) along with improvement in soil fertility status. Hence, it is concluded that long term integrated nutrient management through application of 50per cent N through FYM/gliricidia + 50per cent N through fertilizers+ 100per cent P_2O_5 ha^{-1} to cotton + greengram (1:1) intercropping system resulted in sustaining crop productivity and build up fertility status of Vertisols under rainfed condition.

Cotton (G*ossypium* spp.) is an important cash crop globally known as "King of fiber"and play vital role in the economy of farmers as well as the country and is popularly known as "white gold". India ranks first in area under cotton in the world however, stands third in production. It is a fiber crop originated in India and belong to Malvaceae family. Among different species of cotton, *Gossypium hirsutum* and *Gossypium arborium* are commonly grown in Maharashtra and used in textile industries for manufacture of cloth. Besides this, it is also used for several other purposes like making threads and for mixing in other fibers.

Maharashtra is one of the leading cotton growing states in India having 41.92 lakh ha area under cotton cultivation which is one third of country's area of cotton cultivation with the production of 85 lakh bales. The productivity of cotton in Maharashtra is 345 kg lint per ha (Anonymous, 2015).

Pulses play an important role in Indian agriculture. Unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative changes in soil physical properties make them known as "soil fertility restorers". Pulses are the main source of protein for the bulk of population, which is mostly vegetarian.

Greengram (*Vigna radiata*) is an excellent source of high (25 %) quality protein. The whole or split grains are used as 'dal' or made into flour. The straw and husk are a fodder for cattle. Grains are also used in many Indian dishes. It belongs to leguminosae family and is believed to be native of central Asia. It can be raised on wide array of soil ranging from red lateritic soils of south India to black cotton soils of Maharashtra. It is one of the thirteen food legumes grown in India and third most important pulse crop of India after chickpea and pigeonpea.

In India, the area under greengram is about 3.55 mha with production of 1.80 mtones and productivity of 512 kg ha^{-1} whereas, Maharashtra has about 4.08 lakhs ha area and production is 2.38 lakh tones with productivity of 531 kg ha^{-1}. The area under Vidarbha is 1.30 lakh ha, production 0.38lakh tones with productivity of 344 kg ha^{-1} (Anonymous, 2014). Integrated plant nutrient management is an intelligent use of optimum combination of organic, inorganic and biological nutrient sources in specific crop, cropping system and climatic situation so as to achieve and sustain optimum yield and to improve

1.Ph.D student, 2.Sr.Soil Scientist, 3.PG student 4. Chief Scientist, AICRP for Dryland Agriculture, 5.Assistant Professor, Dept of SSAC, Dr. PDKV, Akola

or maintain soil physical, chemical and biological properties. Integrated plant nutrient management is beneficial to maintain soil fertility, sustainable agricultural production and increase availability of nutrients from all resources and minimizing loss of nutrients.

With the aim of maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from organic plant nutrient sources available at farm level in the region, a fixed frame plot experiment with the combinations of organic and inorganic nutrient sources is being conducted in cotton + greengram intercropping system on Vertisols since 1987-88.The present study was carried out during 2015-16 (29^{th} cycle).

MATERIAL AND METHODS

With a view to study effect of integrated nutrient management on soil nutrient status and productivity of cotton + greengram intercropping system in Vertisols, a field experiment was initiated on the research farm, AICRP for Dryland Agriculture, Dr. PDKV, Akola since 1987-88. The present study was undertaken during 2015-16 with the cotton + greengram intercropping system. The eight treatments comprised of control,100 per cent RDF (50:25:00 NPK kg ha^{-1}) through chemical fertilizer,50 per cent RDF through chemical fertilizer, 50 per cent N through FYM/ gliricidia, 50 per cent N through fertilizers + 50 per cent N through FYM/gliricidia +100 per cent P_2O_5 ha^{-1} through chemical fertilizers and 100per cent N ha^{-1} through gliricidia + 100per cent P_2O_5 ha^{-1} through chemical fertilizers in randomised block design with three replications.

The representative soil samples from 0-30 cm depth were collected by using soil auger after harvest of cotton. These samples were analyzed for soil physical and chemical properties as per standard methods (Jackson, 1973).

RESULTS AND DISCUSSION

Soil nutrient status

The results pertaining to available N status of soil was significantly influenced by different treatments. The available N in soil varied from 209 to 257 kg ha^{-1}. The higher available N (257 kg ha^{-1}) was observed in treatment T_7 receiving 50 per cent N fertilizers + 50 per cent N ha^{-1} FYM + 100 per cent P_2O_5 ha^{-1} fertilizers .The lower value of N was observed in control. The higher value of available N over the initial value might be due to nitrogen fixation by greengram crop.

The increase in available N due to incorporation of FYM/gliricidia green leaf manuring may be due to higher amount of nitrogen content and the favourable soil conditions under green leaf manuring which might have helped the mineralization of soil N leading to build-up of higher available N.

The available N status although showed increase under INM as compared to other treatments, it has not been increased much due to the prevailing climatic condition accelerating oxidation of organic matter as well as the nature of nitrogen forms in soil in the form of its losses through volatilization and leaching. The various research trials on long term fertilizer application also reported higher nitrogen availability with the application of sunhemp and FYM (Badanur *et al.* 1990) and also reported by Katkar *et al.* (2006), over only fertilizer application.

It is evident from the data (Table 1) that available P content of soil varied significantly and it ranged from 10.3 to 15.8 kg ha^{-1} indicating that the soil was medium to high in available phosphorus content. The highest (15.8 kg ha^{-1}) available P was recorded with the application of 50 per cent N through chemical fertilizers + 50per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizer fertilizers and it was found to be at par with the treatments T_6 i.e. 50 per cent N through chemical fertilizers + 50per cent N through gliricidia +100 per cent P_2O_5 ha^{-1} through chemical fertilizers and T_8 i.e. 100per cent N ha^{-1} through gliricidia + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers. The lower value of P was found in treatment T_1 i.e. control.

The increase in available phosphorus status under all INM treatments might be due to residual effect of organics applied as well as inclusion of legume crop in the cropping system, as legume absorb more soil phosphorus from subsurface and a part of which is left in the surface layer and part of which is left in subsurface soil with roots. The results are in conformity with Babhulkar *et al.*(2000), Gabhane *et al. (*2013), Khambalkar *et al.* (2017) and Naik *et al.*(2018).

The data (Table 1) on available K content of soil varied significantly from 280 to 362 kg ha^{-1} indicating that the soil was high to very high in available K content. Data indicated that highest available K content 362 kg ha^{-1} was recorded with the application of 50 per cent N through chemical fertilizers + 50per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers and T_7 was

Table 1: **Long term effect of INM on soil nutrient status**

Treatments		Available Nutrient Status (kg ha^{-1})		
		N	P	K
T_1	Control	209	10.3	280
T_2	100 % N + 100% P_2O_5 ha^{-1} fertilizers	240	13.3	317
T_3	50% N + 50% P_2O_5 ha^{-1} fertilizers	236	12.5	314
T_4	50% N ha^{-1} gliricidia	234	11.3	325
T_5	50% N ha^{-1} FYM	238	12.2	327
T_6	50% N fertilizers + 50% N gliricidia +100% P_2O_5 ha^{-1} fertilizers	251	15.1	358
T_7	50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5 ha^{-1} fertilizers	257	15.8	362
T_8	100% N ha^{-1} gliricidia + 100% P_2O_5 ha^{-1} fertilizers	242	14.9	340
	SE (m) ±	6.4	0.6	11.7
	CD at 5 %	19.0	1.9	34.6
	Initial status	214	12.97	317

found to be at par with the T_6 i.e.50 per cent N fertilizers + 50 per cent N through gliricidia +100 per cent P_2O_5 ha^{-1} though chemical fertilizers and T_8 i.e.100 per cent N ha^{-1} through gliricidia + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers.

The buildup of soil available K by the application of potassium through FYM/ gliricidia green leaf manuring might be due to the fact that FYM and gliricidia leaves contains higher amount of K and it is deposited in the soil and due to applied K through FYM, gliricidia green leaf manure, the solubilizing action of certain organic acids produced during decomposition and it results in greater capacity to hold K in the available form.

Long-term application of chemical fertilizers with organic manures increased the K content of the soil. Similar results were recorded by Malewar and Hasnabade (1995) and Kumar *et al*. (2008), Gabhane *et al*. (2013) and Khambalkar *et al.(*2017) .

DTPA micronutrients

DTPA- Fe

The effect of gliricidia green leaf manuring and FYM on available iron was found to be significant. The higher DTPA-Fe (9.8 mg kg^{-1}) was observed with conjoint use of chemical fertilizers with FYM which was 50 per cent N through chemical fertilizers + 50 per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_7) (Table 2). While the treatments comprising of gliricidia green leaf manuring applied for the substitution of 50 and 100 per cent of N with chemical fertilizers (T_6 & T_8) were found at par with each other and recorded significantly superior values over the treatments of only chemical fertilizers and control after a period of 29 years.

The enhancement in DTPA-Fe due to the addition of organic substances may be ascribed to the presence of appreciable quantity of iron in the organics and residual effect of FYM added to this treatment.

The increase in Fe status under INM might be due to organic acids released with the mineralization of FYM which might have solubilized the precipitated iron minerals in soil. The available iron shows emerging deficiencies in alkaline calcareous soils due to intensive cropping and the INM is therefore imperative to maintain the Fe status of soils. Similar findings were reported by Bellakki *et al.* (1998), Kumar *et al.* (2008) and Kumar and Singh (2010).

DTPA-Mn

The data revealed that after 29th cycle the DTPA-Mn status was significantly influenced with various treatments varying between 9.65 to 17.59 mg kg^{-1}. The effect of gliricidia green leaf manuring and FYM on available manganese was found to be significant.

The higher DTPA-Mn (17.59 mg kg^{-1}) was observed with conjoint use of chemical fertilizers with FYM i.e. application of 50 per cent N fertilizers + 50 per cent N ha^{-1} FYM + 100per cent P_2O_5 ha^{-1} fertilizers (T_7). While the treatments comprising of gliricidia green leaf manuring applied for the substitution of 50 and 100 per cent of N with chemical fertilizers were found at par with each other and recorded significantly superior values over the treatments of only chemical fertilizers and control after a period of 29 years. Thus, the results indicated that beneficial effect of organics in combination with NP over only chemical fertilizers in maintaining the available manganese in soil. Similar findings were reported by Bellakki *et al.* (1998), Kumar *et al.* (2008) and Kumar and Singh (2010).

DTPA- Cu

The data revealed that the DTPA-Cu status was significantly influenced with various treatments during the study after 29th year and it varied between 2.82 to3.93 mg kg^{-1}.

The effect of gliricidia green leaf manuring and FYM on available copper was found to be significant. It was observed that, the significantly higher content of Cu (3.93 mg kg^{-1}) was observed with application with 50 per cent N fertilizers + 50per cent N ha^{-1} FYM + 100 per cent P_2O_5 ha^{-1} fertilizers (T_7). While the treatments comprising of gliricidia green leaf manuring applied for the substitution of 50 and 100 per cent of N with chemical fertilizers were found at par with each other and recorded significantly superior values over the treatments of only chemical fertilizers and control after a period of 29 years. The results thus suggest that the use of FYM and green manure along with chemical fertilizers helps in maintaining available micronutrient status of soil over a long-term cropping period. Addition of organic materials might have enhanced the microbial activity in the soil and consequently the release of complex organic substances like humic and fulvic acids acting as chelating agents during the decomposition of organic manure and crop residue. This could have prevented micronutrients from precipitation, fixation, oxidation, leaching and augmented the solubility, mobility, availability of insoluble micronutrients.

Application of FYM significantly increased availability of micronutrients over rest of the treatments probably due to the decomposition of FYM and consequent release of micronutrients. Similar findings were also reported by Bellakki *et al.* (1998), Kumar *et al.* (2008) Kumar and Singh (2010) and Prasad *et al.* (2010).

DTPA-Zn

The data in respect of available zinc in soil after harvest of cotton influenced by various treatments was found to be significant (Table 2).

The effect of gliricidia green leaf manuring and FYM on available zinc was found to be significant. The higher available zinc (0.73 mg kg^{-1}) was observed with conjoint use of chemical fertilizers with FYM which was 50 per cent N through chemical fertilizers + 50 per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_7) and followed by treatment with application of 50 per cent N through chemical fertilizers + 50 per cent N ha^{-1} through gliricidia + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers(T_6), treatment with 100 per cent N ha^{-1} through gliricidia + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_8) and these treatments were found to be at par with each other. The lowest available zinc status (0.57 mg kg^{-1}) was observed in control treatment after a period of 29 years of experimental study.

The increased zinc content maintained under integrated nutrient management for a long period might be due to the addition of organics. The organic materials

Table 2: Long term effect of INM on soil micronutrients

Treatment		DTPA micronutrients (mg kg^{-1})			
		Fe	Mn	Cu	Zn
T_1	Control	7.04	9.65	2.82	0.57
T_2	100% N + 100%t P_2O_5 ha^{-1} fertilizers	9.14	12.54	3.16	0.62
T_3	50% N + 50% P_2O_5 ha^{-1} fertilizers	8.21	10.73	3.09	0.59
T_4	50% N ha^{-1} gliricidia	8.48	13.93	3.07	0.62
T_5	50% N ha^{-1} FYM	8.41	13.86	3.17	0.62
T_6	50% N fertilizers + 50% N gliricidia +100% P_2O_5 ha^{-1} fertilizers	9.28	16.37	3.53	0.73
T_7	50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5 ha^{-1} fertilizers	9.80	17.59	3.93	0.71
T_8	100% N ha^{-1} gliricidia + 100% P_2O_5 ha^{-1} fertilizers	8.89	16.21	3.59	0.69
	SE (m) ±	0.37	0.57	0.14	0.03
	CD at 5%	1.09	1.71	0.43	0.08

form chelates and increase the availability of zinc. The similar results were reported by Verma *et al.* (2005), Bellakki *et al.* (1998), Kumar and Singh (2010) and Prasad *et al.* (2010).

Crop yield

The yield of cotton and greengram during 2015-16 showed considerable increase due to integrated nutrient management in comparison to only chemical fertilizers (Table 3). The substitution of 50 per cent N by FYM/gliricidia along with chemical fertilizers was found superior among all the treatments. However, inclusion of organics was found beneficial in increasing the yield of both the crops.

Yield of cotton

The significantly highest seed cotton yield (1180 kg ha^{-1}) and highest cotton stalk yield (2207 kg ha^{-1}) were recorded with the application of 50 per cent N through FYM + 50 per cent N through inorganics + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_7) followed by application of 50per cent N through gliricidia + 50per cent N through inorganics+ 100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_6) which were found to be on par with each other. The lower seed cotton yield (648 kg ha^{-1}) and stalk yield (1609 kg ha^{-1}) were recorded in control (T_1) treatment.

The seed cotton and cotton stalk yield under the treatments of integrated nutrient management involving 50 per cent N through organics i.e. FYM/gliricidia and 50 per cent recommended N through fertilizer to cotton showed superior yields as compared to other treatments because of residual effect of organics during long term experiment (Table 3).

Yield of greengram

The significantly highest grain yield (448.4 kg ha^{-1}) of greengram was recorded by the treatment T_7 receiving 50 per cent N through fertilizers + 50 per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers and was found to be on par with application of 50 per cent N through chemical fertilizers + 50 per cent N though gliricidia +100 per cent P_2O_5 ha^{-1} through chemical fertilizers (T_6). The highest straw yield (264 kg ha^{-1}) of greengram was recorded with the application of 50 per cent N through chemical fertilizers + 50 per cent N ha^{-1} through FYM + 100 per cent P_2O_5 ha^{-1} through chemical fertilizers.

This increase in crop productivity may be due to the combined effect of nutrient supply, synergism and improvement in soil physical and biological properties. However, the yields of both the crops in 50 per cent N fertilizer + 50 per cent N through FYM (T_7) and 50 per cent N fertilizers + 50 per cent N ha^{-1} gliricidia + 100 per cent P_2O_5 ha^{-1} fertilizers(T_6) was found to be maintained year after year which can be ascribed to sustenance of soil health. Similar results were recorded by Gabhane *et al.* (2014), Doli *et al.* (2015), Sanjay kumar *et al.*(2015), Khambalkar *et al.*(2017) and Shariff *et al.*(2017).

The results after 29th cycle indicated that the use of FYM followed by gliricidia green leaf manuring in conjunction with chemical fertilizers recorded higher nutrient status with maximum cotton and greengram yields and improvement in soil fertility. Hence, it is concluded

Table 3: Long term effect of INM on productivity of cotton + greengram intercropping system

Treatment		Yield (kg ha^{-1})			
		Cotton		Greengram	
		Seed cotton	Stalk	Grain	Straw
T_1	Control	648	1609	245	179
T_2	100% N + 100% P_2O_5 ha^{-1} fertilizers	969	2132	345	247
T_3	50% N + 50% P_2O_5 ha^{-1} fertilizers	895	1833	326	209
T_4	50% N ha^{-1} gliricidia	811	1684	310	194
T_5	50% N ha^{-1} FYM	828	1646	321	199
T_6	50% N fertilizers + 50% N gliricidia +100% P_2O_5 ha^{-1} fertilizers	1018	2170	413	260
T_7	50% N fertilizers + 50%N ha^{-1} FYM + 100% P_2O_5 ha^{-1} fertilizers	1180	2207	448	264
T_8	100% N ha^{-1} gliricidia + 100per cent P_2O_5 ha^{-1} fertilizers	988	1796	358	231
	SE (m) ±	63.1	112.6	23.4	13.3
	CD at 5%	187.4	334.5	69.6	39.5

that long term integrated application of 50 per cent N through FYM/gliricidia + 50 per cent N through fertilizers + 100 per cent P_2O_5 ha^{-1} to cotton+greengram (1:1) intercropping system resulted in sustaining crop productivity and build up fertility status of Vertisols under rainfed condition.

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Effect of Presowing Treatments on Seed Germination of Woodapple *(Feronia limonia* Swingle)

S. R. Wahurwagh[1], S. W. Choudhari[2], V. P. Mane[3], U. A. Raut[4], V. B. Shambharkar[5], T. S. Chopade[6] and Y. B. Taide[7]

ABSTRACT

A nursery based experiment was conducted to study the effect of varied presowing treatments on seed germination of wood apple (*Feronia limonia* L.) Swingle. Seeds of Wood apple were subjected to nine different presowing treatments. Results revealed that, the highest germination percentage was observed 66.67 per cent seed soaking in GA_3 40 ppm for 10 min., followed by 56.67 per cent seed soaking in IBA (20 ppm for 10 min.) and 48.33 per cent seed soaking in cow dung slurry for (12 hrs). Seed soaking in GA_3 40 ppm for (10 min.), seed soaking in IBA 20 ppm for (10 min.) and seed soaking in cow dung slurry for (12 hrs) are highly recommended for maximum germination within the shortest period of time. These findings of the research will be helpful to take effective decision regarding the raising of large scale production of Wood apple seedling in a cost effective way with ensuring their earlier germination.

Wood apple (*Feronia limonia)* belongs to family Rutaceae is commonly known as Kawatha or Wood Apple and is widely distributed in deciduous and arid landscape of several countries in South Asia. In India, it is found throughout the plains. The original home of Wood Apple is South India and Sri Lanka (Lande *et al.*, 2010). Wood Apple has got high medicinal value. Every part of the fruit i.e. pulp, seed and oil has got its medicinal property. The seed composition and fatty acid profile were reported as 28 per cent protein and 34 per cent oil (Ramakrishna *et al.*, 1979). It is grown in the wild and is also cultivated along roads in the edges of fields and occasionally in orchards. It is apparently drought tolerant and best adapted to light soils (Vijayvargia, 2014).

The Wood apple can grow in almost every type of soil. It easily withstands long periods of drought. It requires little care once established. Saplings begin to bear fruit within seven years. It reproduces naturally from seeds. The dispersal is aided by human beings and animals seeking the edible fruits.

Germination of the seeds is very low (15-30 per cent) and a part of the cause may be dormancy (Troup, 1952). Treatments to the seed covering structures and Gibberellins can promote germination (Ellis *et al.*, 1985). Physiological dormancy is the most common type of dormancy in temperate species of Rutaceae (Baskin and Baskin, 1998). The embryo has low growth potential. In some cases of physiological dormancy, germination is stimulated by Gibberellic Acid (Baskin and Baskin, 2004).

The purpose of the present research is to explore the best presowing treatment to find out their germination period and germination percentage.

MATERIAL AND METHODS

Plant material

The fresh, unripe seeds of *Feronia limonia* were collected from healthy well growing tree of very hygiene and polluted free area in the month of April- May from the Main Garden Department of Horticulture, Dr. PDKV, Akola. The seeds and plant were identified and authenticated from the Department of Horticulture.

Seed was treated with the eight different treatments and one control. The seeds were sown in poly bags. For filling polythene bags, potting mixture of soil, FYM, and sand in the ratio of 2:1:1 was used. The poly bag size is 6×9 cm were arranged in the nursery. The good and healthy seed was sown in each polythene bag after applying presowing treatment. The germination of the seeds and seedlings performance was observed.

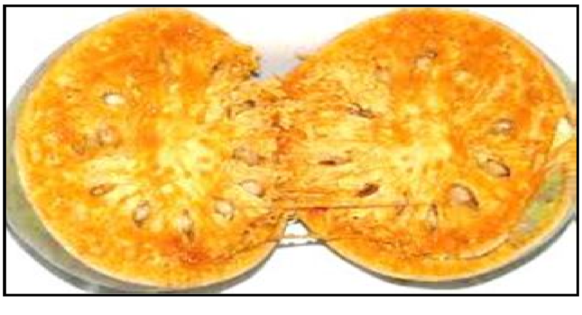

Fig. 1: Fruits of *Feronia limonia* and its cross section.

1 & 6 P. G. Student, 2,4 & 5 Assistant Professor, 3. Associate Professor and 7 Associate Dean, College of Forestry, Dr. PDKV, Akola

A completely randomized design with three replicates was used for the experiment. Seeds were subjected to nine presowing treatments including control.

T_1 - GA_3 treatment (Immersion in 20 ppm for 10 min.)
T_2 - GA_3 treatment (Immersion in 40 ppm for 10 min.)
T_3 - IBA treatment (Immersion in 20 ppm for 10 min.)
T_4 - IBA treatment (Immersion in 40 ppm for 10 min.)
T_5 - Seed soaking in cow dung slurry for (6 hrs.)
T_6 - Seed soaking in cow dung slurry for (12 hrs.)
T_7 - Seed soaking in tap water for (6 hrs.)
T_8 - Seed soaking in tap water for (12 hrs.)
T_9 - Control

The data on effect of pre-sowing treatments was assessed periodically through germination and initial growth performance of the seedlings in the nursery. The germination was recorded every day from the date of sowing seeds and continued till the last germination (36 days after seed sown). In this period the number of seeds that germinate and the time required for germination for each treatment were recorded.

The data collected on various observations during the course of investigation were statistically analyzed using computer software Microsoft Excel to explore the possible treatment variation. The analysis of Variance (ANOVA) and OPSTAT software were used for the analysis.

RESULTS AND DISCUSSION

Seed germination and initial growth performance of seedlings

Presowing treatment influenced the germination period and germination percentage of Weed apple seeds. Germination for all the treatments started after five days of sowing (DAS) and continued up to 30 DAS, except control in which germination was started after 10 days of sowing and continued up to 37 days. (Fig.1)

The seed soaking in GA_3 for 40 ppm (for 10 minutes), showed highest germination (66.67per cent) however it was at par with seeds soaked in IBA for 20 ppm for 10 minutes (56.67 %). Seeds soaking in cow dung slurry for 12 hours showed 48.33 per cent germination, respectively. The lowest 23.33 per cent germination was recorded in control (Fig. 2).

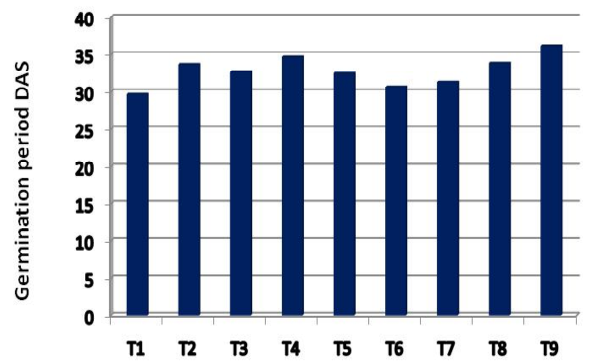

Fig. 2. Effect of seed treatment on germination period

Days required for seed germination

Data recorded in Table 1 revealed that seed treatment significantly influenced days required for seed germination of Wood apple.

The minimum days required for initial seed germination was observed in T_2 (4.83 days) i.e. treated with GA_3 (immersion in 40 ppm for 10 min.) followed by treatments T_1 (5.5 days) i.e. treated with GA_3 (immersion in ppm 20 for 10 min.) and T_6 (5.17 days) i.e. seed soaked in cow dung slurry for 12 hrs. However, the maximum days required for initial seed germination (10.67 days) is in control.

Days required for early recruits

The minimum days required for early recruits after the day required for seed germination were observed in treatment T_1 (5.5 days) which is followed by treatments T_6 (7.8 days). However, maximum days required for early recruits of *Feronia limonia* were recorded in control (11.17 days).

Germination period

The minimum germination period was observed in treatment T_1 (29.66 days) which is followed by treatments T_6 (30.66 days) and T_7 (31.33 days) However, maximum germination period was recorded in control (36.17 days) .

Germination percentage

The maximum germination percentage was observed in treatment T_2. (66.67 %) followed by treatments T_3 (56.67 %) and T_6 (48.33 %) However, minimum germination percentage were recorded control (23.33 %).

Table 1. Effect of seed treatment on days required for seed germination, days required for early recruits, germination period and germination percentage

Seed Treatment	Days required for seed germination	Days required for early recruits	Germination period (DAS)	Germination percent
T_1 - GA_3 20 ppm for 10 min.	5.50	5.50	29.67	35.00 (36.14)*
T_2 - GA_3 40 ppm for 10 min.	4.83	8.00	33.67	66.67 (54.72)*
T_3 - IBA 20 ppm for 10 min.	7.00	9.00	32.67	56.67 (48.82)*
T_4 - IBA 40 ppm for 10 min.	7.67	9.67	34.67	30.00 (32.98)*
T_5 - Cow-dung slurry for 6 hrs.	9.33	8.83	32.50	36.67 (37.18)*
T_6 - Cow-dung slurry for 12 hrs.	5.17	7.83	30.67	48.33 (44.01)*
T_7 - Tap water for 6 hrs.	6.33	8.50	31.33	40.00 (39.10)*
T_8 - Tap water for 12 hrs.	7.67	10.00	33.83	40.00 (39.19)*
T_9 - Control	10.67	11.17	36.17	23.33 (28.76)*
SE(m)±	0.42	0.56	0.98	4.58
C.D at 5 %	1.27	1.68	2.93	13.72

*The values in parenthesis are angular transformation value

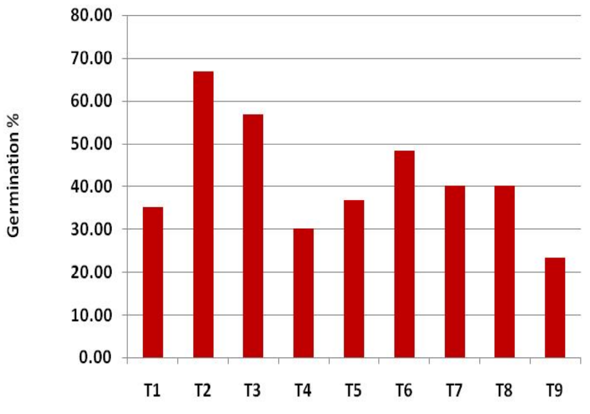

Fig. 3. Effect of seed treatment on germination per cent

CONCLUSION

The present findings revealed that pre-sowing seed treatment significantly enhances the germination process. However, effective pre-sowing treatments can ensure their successful germination. Among the treatments applied in the experiment, the best effective treatment was found for Wood apple was GA_3 (40 ppm for 10 min.) in respect to faster germination and higher germination percentage. Since seed germination under soaking in cow dung slurry for 12 hrs is quite simple and inexpensive, it is also recommended for on a broad scale.

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Effect of Growth Hormones on Clonal Propagation of Guggul (*Commiphora wightii)* (Arn.) Bhandari

A. S. Sure[1], A. U. Nimkar[2], S. M. Khachane[3], S. P. Pawar[4] and S. B. Jumnake[5]

ABSTRACT

Commiphora wightii is an important plant, which is being specially tapped for gum for its medicinal purposes and considered as endangered medicinal plant. An experimental trial was conducted to find out the effective auxin through semi-hardwood cuttings propagation of *Commiphora wightii* (Arn.) Bhandari. In the present investigation, relationship of growth parameter i.e. sprouting and rooting percentage, length of root, number of roots, diameter of root number of sprouts, number of leaves and diameter of shoot were measured. Results showed that maximum sprouting and rooting percentage, number of roots, root length and diameter of root were observed in IBA 500 ppm (85.00%, 76.67%, 7.36 cm,13.87cm and 1.22 mm, respectively). Number of sprouts and leaves, length and diameter of shoot were reported in 500 ppm for NAA (7.17, 25.17, 12.58cm and 3.977mm, respectively). The correlation studies revealed that there was strong positive correlation between diameter of shoot and length of shoot.

Guggul or Indian Myrrh or Indian Bdellium is one of the most important medicinal plant of herbal heritage of India (Atal *et al.,* 1975) and botanically known as *Commiphora wightii (*Arn.) belonging to the family Burseraceae. It is native to India, Bangladesh and Pakistan (Deng 2007; Urizar and Moore, 2003) and distributed in Rajputana and Bednor (Rajastan), Khandesh and Berar (Maharashtra), Mysor and Bellary (Karnataka) and Gujarat states of India. It is much-branched, dioecious, up to 2.5-3 m tall with brown colored, spine scented knotty, crooked and spirally ascending branches ending in sharp spines (Kumar and Shankar, 1982).

Guggul is a source of oleo-gum resin and secreted form the bark as a result of wound or incision on the bark (Krishnamurthy and Shiva, 1977). Guggul has been used extensively by Ayurvedic physicians to treat a variety of afflictions, including arthritis, inflammation, bone-fractures, obesity and disorders of lipid metabolism. *Commiphora wightii* is the most important species of this genus and has been used extensively in pharmaceutical and perfumery industry (Urizar and Moore, 2003).

The guggulsterone is the bioactive principle in gum Guggul responsible for its pharmacological action (Kimura *et al*, 2001). Increasing demands of oleo gum resin in India are believed to be met by importing large quantities of gum Guggul from other countries (Kulhari *et al.,* 2014). For the medicinal preparation Guggul resin (*Niryasa*) is collected by tapping the bark of 7-8 years plant in winter season, if the process does not do properly then the plant may die (Thosar and Yende, 2009). In order to obtain more and more oleo gum resin, its ruthless and indiscriminate tapping in the last 50 years has leads to its extermination over large areas in Rajasthan (Kulloli and Kumar, 2013).

This plant has become endangered and reported in data deficient category of IUCN's Red Data list due to its slow growth, poor seed setting and lower germination rate, and unscientifically exploiting of its gum tapping method by pharmaceutical industries and religious prophets (Tajuddin *et al.*, 1997). Over exploitation and slow growth of the tree which is associated with poor seed set make this plant an endangered species (Kumar and Shankar 1982; Kumar *et al.,* 2004). Very low germination i.e. 1.4 per cent (Yadav *et al.*,1999) in the nursery is a serious constraint on the efficiency of nursery management. Hence, there is need for alternative sources of planting materials. Vegetative propagation through stem cutting is most common and successful method (Kumar *et al*., 2006; Thosar and Yande 2009). The clonal multiplication reproduces clones, which contain all the genetic traits of the parent tree, (Surendran, 2000). However, it plays an important role in tree improvement programmee for mass multiplication of superior genotype and quick productivity gain.

Vegetative propagation is extensively used in agriculture, horticulture and forestry for multiplying elite plants selected from natural populations or obtained in

2. Assistant Professor, 3. Associate Professor 1,4, & 5 M.Sc. Student, College of Forestry, Dr. PDKV, Akola.

breeding programs. The formation of adventitious roots is an essential step in vegetative propagation and therefore if cuttings do not form roots, losses occur. The formation of adventitious roots is a process induced and regulated by environmental and endogenous factors, such as temperature, light, hormones (especially auxin), sugars, mineral salts and other molecules. (Pop *et al*., 2011). Auxins play an essential role in coordination of many growth and behavioral processes in the plant life cycle and the behavior they played in plant growth. Auxin enters cuttings mostly via the cut surface. Role of some auxins IAA, IBA and NAA has been examined for their stimulatory effects on adventitious root formation in stem cuttings as well as on subsequent growth and survival of cuttings. It induces shoot apical dominance; the axillary buds are inhibited by auxin. When the apex of the plant is removed, the inhibitory effect is removed and the growth of lateral buds is enhanced. (Kenney *et al.*, 1969, Pop, *et al.*, 2011 and Gehlot *et al*., 2014).

The present investigation was undertaken to standardization vegetative propagation techniques in Guggul plant *(Commiphora wightii)* in order to fulfill the requirement for domestication and conservation of this species.

MATERIAL AND METHODS

The experiment was conducted at forest nursery of Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during the year 2016-17. The healthy planting material for experiment was collected from Nagarjun Medicinal Plant Garden, Dr. P.D.K.V., Akola. Semi-hard wood portion of the branches of vigorously growing and disease-pest free plant selected for vegetative propagation. The cuttings size of 8-10 mm diameter and 15-20 cm length were prepared by giving a slant cut at the bottom. The basal portion (2-3 cm) of the softwood cuttings were dipped for 24 hrs in freshly prepared solution of growth hormones and treatment details are as given below. Immediately after treatment of the growth hormones cuttings were planted into root trainers of size 80x60x45 mm which were properly filled with potting media comprising of soil + sand + vermicompost. The cuttings were placed in green shade house to reduce direct desiccating effect of sunlight and watered regularly. The experiment was laid out in a Completely Randomized Design (CRD) with three replications having 20 cuttings per replication. Data were recorded daily for days for sprouting, number for sprouts and sprouting percentage up to 30 days after planting. The other various shoot and root parameters were recorded when five observational cuttings were finally uprooted at 90 days after planting. The diameter of the root and shoot in rooted cutting was measured by using digital caliper and their mean was calculated.

The experimental data recorded on various parameters during the investigation were statistically analyzed as per the method suggested by Panse and Sukhatme (1967). Correlation coefficient analysis conducted among the different growth parameters *viz.* sprouting percentage, rooting percentage, numbers of roots, length of root, diameter of root, number sprouts, number of leaves, length shoot and diameter of shoot, as per the method suggested by Panse and Sukhatme (1978) and Gupta (1984). The significance at 5 per cent level of probability was tested as per the formula given by Gosset (1908).

RESULTS AND DISCUSSION

The statistical analysis of data evident that, different treatments of growth hormones had a significant effect on growth parameters of Guggul. Influence of different growth hormones on growth parameters of Guggul stem cuttings are presented in Table 1. Results indicated that stem cutting treated with 500 ppm of IBA and NAA observed higher percentage of sprouting (85.00 %). Rooting percentage was recorded highest i.e. 76.67 per cent when cutting treated with 500 ppm concentration of IBA followed by NAA and IAA 500 ppm (63.33 and 60.00 %, respectively). The minimum sprouting percentage (63.48 %) and rooting percentage (37.45 %) was recorded in control. The formation of adventitious roots is a high energy requiring process, which involves cell division, in which predetermined cells switch from their morphogenetic path to act as mother cells for the root primordia; hence need more reserve food material for root initiation (Aeschabacher *et al*., 1994). Similar results were found by Singh *et al.* (2003), who obtained the highest survival percentage with IBA at 500 ppm in *Piper longum* cuttings. Devarnavadagi *et al*. (2005) studied on effect of growth regulator on induction of adventitious rooting in stem cutting of neem. 1000 ppm IBA treatment for 10 minutes recorded higher percent of sprouting and rooting.

Number of sprouts developed in Guggul varied from range 3.00-7.17. The higher concentration 500 ppm of NAA, IBA and IAA showed maximum number of sprouts (7.17, 6.50 and 6.27, respectively) and minimum was recorded in control (3.00), whereas; both maximum number of leaves, length of shoot and diameter of shoot were observed in NAA 500 ppm (25.17, 12.58cm and 3.977mm, respectively) and was at par with IBA 500 ppm i.e. (22.37, 11.44cm and 3.624mm, respectively) and minimum was recorded in control (10.67, 4.18cm and 1.833mm, respectively). These findings may be due to effect of growth auxins, which would have triggered the activity of specific enzymes that promoted early sprouting. Early sprouting of cuttings will make the cuttings less dependent on stored food (Sen and Bose, 1967). The results are in conformity with Chandramouli (2001) in Bursera, wherein cuttings treated with growth regulators have recorded early sprouting, and maximum number of sprouts, higher length and thickness of longest sprout as compared to control.

Significant differences were noted in number of roots, length of root and diameter of root. The maximum number of roots (7.36) was recorded in IBA 500 ppm and minimum was in control (2.84). The highest length of 13.84 cm of root was recorded in 500 ppm of IBA and was at par with 250 ppm of IBA (11.58 cm) and shortest length of root was recorded in control 3.97 cm. The maximum diameter of root was recorded in IBA 500 ppm (1.228mm) and minimum was in control (0.743mm). The combination of growth hormones at 500 ppm concentrations was not so effective in respect of growth parameters studied. But as compared with control, the maximum percentage of sprouting, number of sprouts, number of roots and length of root was recorded in IAA+IBA 500 ppm i.e. (80.00 %, 5.50, 5.23 and 8.76 cm), maximum rooting percent was observed in NAA+IBA 500 ppm i.e. 60.19per cent and maximum number of leaves and shoot length was recorded in IAA+NAA 500 ppm i.e. (19.97 and 8.17 cm, respectively). Different portion of a single branch vary in their rooting and sprouting response depending on the seasonal, physiological conditions and age factor, thus their response will differ under same environmental conditions. The increase in number of roots in the cuttings treated with IBA, at 500 ppm can be attributed to the action of auxin activity which might have caused hydrolysis and translocation of carbohydrate and nitrogenous substances at the base of cuttings and resulted in accelerated cell elongation and cell division in suitable environment (Singh *et al.*, 2003). Similar inference was made by Mishra and Kumar (2014) in Guggul and Shwetha (2005) in Bursera. Tripathi *et al.*, (2014), reported that the percentage of rooting and length of root was higher and increased in IBA treatment as compared to similar concentration of IAA in *Commiphora wightii*.

The values for correlation coefficients between growth parameters of *Commiphora wightii* in semi-hardwood cutting propagation are presented in Table 2. Out of 36 combination of simple correlation, 29 combinations were found to be positive and significant and 6 combinations were non-significant. Out of this 30 positive and significant correlations, 5 combinations were significant at 1 per cent level of significance and 25 combinations were significant at 5 per cent level of significance.

The highly significant and positive correlation coefficients at 1 per cent level of significance were obtained between diameter of root and sprouting percentage (0.460), number of leaves and length of root (0.425), number of sprouts and sprouting percentage (0.423), number of leaves and number of roots (0.412), sprouting percentage and length of root (0.374).

Highly significant and positive correlation coefficients at 5 per cent level of significance were obtained between diameter of shoot and length of shoot (0.930), diameter of root and length of root (8.30), length of shoot and number of leaves (0.769), diameter of shoot and number of leaves (0.726), length of root and rooting percentage (0.717), diameter of root and number of roots (0.712), diameter of root and rooting percentage (0.710), length of root and number of roots (0.704), number of leaves and number of sprouts (0.671), number of roots and rooting percentage (0.645), length of shoot and number of sprouts (0.601), diameter of shoot and number of sprouts (0.598), rooting percentage and sprouting percentage (0.588), number of sprouts and length of root (0.580), number of leaves and rooting percentage (0.568), number of sprouts and diameter of root (0.543), spouting percentage and diameter of shoot (0.539), number of sprouts and number of roots (0.539), number of sprouts and rooting percentage (0.536), length of shoot and rooting percentage (0.511), sprouting percentage and length of shoot (0.486), rooting percentage and diameter of shoot (0.486), number of leaves and diameter of root (0.475), sprouting percentage and number of leaves (0.472), length of shoot and length of root (0.316).

Table 1: Influence of different growth hormones on growth parameters of Guggul stem cuttings

Treatment		Sprouting percentage %)	Rooting percentage (%)	Number of roots	Length of root (cm)	Diameter of root (mm)	Number of sprouts	Number lof leaves	Length of shoot (cm)	Diameter of shoot (mm)
T1	IAA 250 ppm	71.71 (57.98)**	49.07 (44.44)**	3.84	7.70	0.803	4.33	13.07	5.43	2.183
T2	IAA 500 ppm	63.33 (52.75)	55.91 (48.43)	5.08	8.75	0.861	6.27	16.65	7.70	2.493
T3	IBA 250 ppm	83.33 (65.93)	60.00 (50.83)	4.22	11.58	1.089	5.33	16.50	7.08	2.370
T4	IBA 500 ppm	85.00 (67.38)	76.67 (61.19)	7.36	13.87	1.228	6.50	22.37	11.44	3.624
T5	NAA 250 ppm	81.67 (64.97)	51.67 (45.94)	2.91	5.56	0.767	4.50	14.33	10.03	3.193
T6	NAA 500 ppm	85.00 (67.38)	63.33 (52.72)	3.72	8.90	0.904	7.17	25.17	12.58	3.977
T7	IAA+IBA 500 ppm	80.00 (63.90)	58.33 (49.78)	5.23	8.76	0.865	5.50	16.50	5.38	2.093
T8	IAA+NAA 500 ppm	79.00 (62.75)	50.00 (44.98)	3.58	5.93	0.784	4.67	19.67	8.17	2.757
T9	NAA+IBA 500 ppm	75.07 (60.09)	60.19 (50.86)	4.34	7.87	0.825	4.00	18.00	6.63	2.213
T10	Control	63.48 (52.84)	37.45 (37.67)	2.84	3.97	0.743	3.00	10.67	4.18	1.833
Mean		76.76	61.60	4.31	8.29	0.887	5.13	17.29	7.86	2.674
SE(m)±		2.54	2.58	0.41	0.97	0.009	0.42	1.22	0.56	0.122
C.D. at 5 %		7.54*	7.66*	1.21*	2.89*	0.027*	1.26*	3.63*	1.66*	0.432*

*values are significant at 5 per cent, ** Figures in parenthesis are arc sign value

Table 2. Correlation coefficient between growth parameters of *Commiphora wightii* in stem cutting propagation

Parameters	Sprouting percentage	Rooting percentage	Number of roots	Length of root	Diameter of root	Number of sprouts	Number of leaves	Length of Shoot	Diameter of Shoot
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1.000	0.588**	0.184NS	0.374*	0.460*	0.423*	0.472**	0.486**	0.539**
2		1.000	0.645**	0.717**	0.710**	0.536**	0.568**	0.511**	0.486**
3			1.000	0.704**	0.712**	0.539**	0.412*	0.172NS	0.149NS
4				1.000	0.830**	0.580**	0.425*	0.316**	0.293NS
5					1.000	0.543**	0.475**	0.359NS	0.340NS
6						1.000	0.671**	0.601**	0.598**
7							1.000	0.769**	0.726**
8								1.000	0.930**
9									1.000

Parameters

1. Sprouting percentage
2. Rooting percentage
3. Number of roots
4. Length of root
5. Diameter of root
6. Number of sprouts
7. Number of leaves
8. Length of Shoot
9. Diameter of Shoot

*Significant at 5per cent level of significance

**Significant at 1per cent level of significance

NS- Non-Significant

The non-significant correlations were obtained between length of shoot and diameter of root (0.359), diameter of shoot and diameter of root (0.340), diameter of shoot and diameter of root (0.293), sprouting percentage and number of roots (0.184), length of shoot and number of roots (0.172), diameter of shoot and number of roots (0.149).

In the present studies, the results obtained for the different auxins with regard to growth parameters indicate that IBA 500 ppm have a better performance in terms of growth parameters of Guggul under green shade condition. The correlation studies observed that there was strong positive correlation between diameter of shoot and length of shoot.

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Impact of Joint Forest Management Programme on Livelihood of the Rural People of Akola District of Maharashtra

M. B. Thigale[1], H. K. Deshmukh[2], Y. B. Taide[3] , U. R. Chinchmalatpure[4], S. S. Harne[5]
R. D. Walke[6], A. J. Deshmukh[7] and A. S. Khandagale[8]

ABSTRACT

Indian forest is under pressure of meeting growing demand of increasing population. The denudation of forest is common phenomenon all over the country. All the efforts made to check the denudation of the forest have not yielded the desired results. Hence it has been accepted that the forest can not be protected and developed without the involvement of the local people. The present study was carried out in Malrajura village of Akola district and found that positive and highly significant impact of JFM on availability of non-timber forest produces, the employment and annual income of respondent were increased.

Indian forest is under pressure of meeting growing demand of increasing population. The majority of population depends on forest for meeting their basic needs of fuel wood, fodder, small timber and non-timber forest produce.

National Forestry Action Programme – India note that forest provides 50 per cent of fuel wood, 33 per centof fodder and 30 per cent of diet of the forest dwellers in the form of fruits, tubers and other minor forest produce. It is estimated that about 270 million tones of fuel wood, 280 million tones of fodder, over 12 cubic million of timber and large quantities of non-timber forest products are harvested from forest annually. About 400 million people living in the vicinity of forest depends on non-timber forest produce for their subsistence and earn up to 50 per cent of their income from the sale of the produce (MOEF 1999).

Joint Forest Management is the concept of developing the partnership between fringe village communities and forest department on the basis of mutual trust and jointly defines role and responsibilities with regard to forest protection and development (Jha, 2006).

The Joint Forest Management Programme in India has its origin in the National Forest Policy 1988, which envisage creating massive peoples involvement for achieving the objectives and minimize the pressure on existing forest. Government of Maharashtra issued an ordered on Joint Forest Management on dated 16th March, 1992 on the basis of past experiment, Government of Maharashtra revised the resolution on dated 25th April, 2003 taking in to account various guidelines issued by the Government of India (Jha 2006).

MATERIAL AND METHODS

The present study was carried out at Malrajura village of Akola district and exploratory design of social research was used to find out the impact of Joint Forest Management Programme on livelihood of rural people. Sixty respondents were selected randomly on the basis of land holding i.e. landless, up to 1.00 ha, 1.01 ha to 2.00 ha, 2.01 to 4.00 ha and above 4.00 ha. The data were collected through face to face contact method by contacting the randomly selected respondents. The secondary data were collected from Joint Forest Management Committee record, Grampanchayat Office record, Forest Department Record, Gazetteer, Library, etc.

The independent variables such as age, education, land holding, livestock, family size, sources of information and attitude with the dependent variables such as annual income, employment, and availability of non-timber forest produce was used to find out the impact of JFM programme on livelihood of rural people. The following formula was used to calculate the percent change in availability of non-timber forest produce.

$$DP = \frac{Pa - Pb}{Pb} \times 100$$

Where,

DP = Percent change in availability of non-timber forest produce.

Pa = Mean score availability of non-timber forest produce after participation in Joint Forest Management Programme.

Pb = Mean score availability of non-timber forest produce before participation in Joint Forest Management Programme.

1& 8. Post Graduate Student, 2, 4 &6. Asstt. Prof. 3. Associate Dean, 5. Professor and 7. S.R.A., College of Forestry, De. PDKV, Akola

The statistical techniques namely, arithmetic mean, standard deviation, coefficient of correlation and Z-test were used to find out the impact of JFM programme on livelihood of rural people.

RESULTS AND DISCUSSION

Correlation of independents variables with quantity of non-timber forest produces

It is observed from the data (Table 1) that the variable education (0.313), land holding (0.354) and source of information (0.266) had positive and highly significant impact on collection of quantity of non-timber forest produce due to JFM programme. However livestock also having positive and significant relationship with collection of quantity of non-timber forest produce.

Gupta and Singh (2003) also found that some positive and negative impact of Joint Forest Management Programme on non-timber forest produce and socio-economic development in Uttaranchal. Wherever, Mishra (2008) revealed that NTFP based activities such as production, procurement, processing and marketing of NTFP are to be supported to the livelihood of tribals under JFM programme in Chhattisgarh.

Table 1. Coefficient of correlation of characteristics of the respondents with quantity of non-timber forest produce

S.N.	Variables	'r' value
1	Age	0.105
2	Education	0.313**
3	Land holding	0.354**
4	Livestock	0.237*
5	Family size	0.159
6	Sources of information	0.266**
7	Attitude	0.195

*Significant at 0.05 level of probability

** Significant at 0.01 level of probability

Testing the significance of the difference in the means

The overall impact of Joint Forest Management Programme on dependent variables were determined and results on the testing the significance of the difference of means in change in annual income, employment and availability of non-timber forest produce are presented in Table 2.

The mean of the dependent variables of the respondents after participation in Joint Forest Management Programme found higher than before participation in Joint Forest Management Programme. The respondents differed significantly in annual income, employment and availability of non timber forest produce. It could be inferred that the respondents differed significantly after participation in Joint Forest Management Programme. Therefore it is stated that there was definite increase in availability as result of participating in JFM programme.

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Table 2. Testing the significance of difference of the means in change in annual income, employment and availability of non-timber forest produce

Dependent variables	Before participation in JFM	After participation in JFM	Impact	Per cent impact	Z value
Annual income	24258.33	29495.33	5237.33	21.58	2388**
Employment	208.78	233.28	24.50	11.73	11.73**
Availability of NTFPs	48.65	58.77	17.12	22.85	05.07**

*****Significant at 0.05 level of probability ** Significant at 0.01 level of probability

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Allelopathic Effects of A*cacia nilotica* (L.) Leaf Leachate with Emphasis on *Beta Vulgaris var. b*engalensis Hort.

S. W. Choudhari[1], Tejaswinee Chopde[2], V. P. Mane[3], V. B. Shambharkar[4], N. M. Konde[5], R. D. Walke[6] and Y. B. Taide[7]

ABSTRACT

This nursery-based investigation was carried out to study the allelopathic effects of *Acacia nilotica* (L.) on vegetable crop (*Beta vulgaris var.* bengalensis Hort.) *Acacia nilotica* (L.) leaf leachate was prepared by soaking the dry leaves in tap water for 24hours in a ratio of 1:10 weight by volume. The prepared leachate was diluted to three different concentrations *i.e.* 25, 50 and 75 per cent by adding tap water accordingly, thus there were five treatments of leachates (control, 25, 50, 75 and 100 %t concentration). On germination paper, germination trial results revealed that the increasing concentration of the leaf leachates had inhibitory effect on germination parameters, plumule and radicle length in test crop. In green house condition, similar results were observed with respect to germination parameters. The leaf leachates had both stimulatory and inhibitory effect on growth (shoot and root height) though significantly and non significantly in spinach respectively.The yield (fresh and dry weight) was affected by different concentration of leaf leachate. As compared to control, stimulatory effect was observed for fresh weight and dry weight. However, the analysis of soil i.e. pH, EC, N, P, K, OC reported that *Acacia nilotica* (L.) leaf leachate had improved the status of soil. From this we can predict that *Acacia nilotica* (L.) might possess allelochemicals that causes both suppressive and stimulatory ability where in spinach was positively affected by higher concentration giving the at par result. The nursery study indicated that the effect was proportional to the concentrations of the extracts so that higher concentration has a stronger inhibitory or stimulatory effect.

Based on the Molisch's concept, Rice (1984) defined Allelopathy as any direct or indirect positive or negative effect of one plant on the other (including the microbes) through the release of chemicals into the environment. However, the term is today generally accepted to cover both inhibitory and stimulatory effects of one plant on another plant.

Agroforestry is the major safeguard for lean periods by providing agriculture crops in association with trees which are very much useful for fuel, fodder and timber. Therefore, the choice of species combinations may profoundly affect the productivity and ultimate success of some agroforestry system.

Acacia nilotica (L.) commonly known as babul, kikar or Indian gum Arabic tree, has been recognized worldwide as a multipurpose tree (National Academy of Sciences 1980). *Acacia nilotica* (family Leguminosae, subfamily Mimosoideae). *Acacia nilotica* (L.) established as very important economic plants since early times as source of tannins, gums, timber, fuel, fodder, medicine, apiculture. So *Acacia nilotica* (L.) is selected as trees species to check allelopathic effect on *Beta vulgaris var.* bengalensis Hort. (Spinach).

MATERIAL AND METHODS

For this experiment controlled condition in greenhouse size of each bed 2 × 4 ft. was selected. The matured leaves of *Acacia nilotica* (L.) were collected from the campus of Dr. PDKV, Akola. As for the vegetable seeds, it's procured from the local market.The matured leaves of *Acacia nilotica* (L.) were sun dried for 48 hours. Its leaf leachate was prepared by soaking the dried leaves in tap water for 24 hours at 1:10 proportion on weight by volume. The leaf leachate filtered with the help of cheese cloth and the leaf leachate of different concentrations i.e. 25, 50, 75 per cent was prepared by adding water to it, accordingly.Thus, there was five treatments including control as follows: T_1 - Control (Tap Water), T_2 - Leachate of 25 per cent concentration, T_3 - Leachate of 50 per cent concentration, T_4 - Leachate of 75 per cent concentration, T_5 - Leachate of 100 per cent concentration (Chupitho, 2016).

Freshly prepared leaf leachate was used to irrigate the crops under control condition in green house, for the study, using the seeds of *Beta vulgaris var.* bengalensis Hort. (Spinach). The seeds were sown in plot of nursery at the rate of 50 seeds $plot^{-1}$. The leaf leachate of different

1, 4 & 5. Assistant Professor, 2. PG Student, 3, 6 . Associate Professor and 7. Professor, College of Forestry, Dr.PDKV, Akola

concentrations was used to irrigate the nursery bed. The crop were grown up to 45 days after which 5 seedlings of spinach for every treatment was randomly selected and marked with tag for taking for regular observation after which tagged plants were harvested to record the observation.

The soil samples from the nursery bed, which were used as a medium for the raising of the test crops, were collected in polythene bags for each treatment replicationwise and were analyzed for pH, OC, ECas per methods out lined by Deshmukh (2013). For the analysis of data the statistical analysis of Variance (ANOVA) and OPSTAT software were used for the analysis as described by Sheoran Programmer, Computer Section, CCS HAU, Hisar.

RESULTS AND DISCUSSION

Seed germination

The inhibitory effect of leaf leachates was observed on germination percentage. The highest percentage of germination was found at control concentration i.e. treatment T1 (90 %) and lowest germination percentage of 71 per cent was recorded in T3 (Table 1).

Germination period

The least germination period of seeds started after two days of sowing and continued up to 5 days. The fastest germination i.e. least germination period (2 days) was recorded with leachate of 100 per cent concentration.

Germination value

The highest germination value of 11.36 was observed for T5 (100 % concentration), and lowest germination value of 7.21was found fort reatment T3 (50 % Concentration).

Length of plumule

The inhibitory effect of leaf leachates was observed on plumule length of seedling. The maximum plumule length of seedling was observed in T1 (8.46 cm) minimum plumule length recorded in T4 (5.36 cm).

Length of radicle

The stimulatory effect of leaf leachates was observed on radical length of seedling except in treatment T4 and T5. The maximum radical length of seedling was observed in T3 (4.21 cm) while the minimum length of radical was recorded in T5 (2.89 cm).

GREENHOUSE CONDITION

Germination Percentage

The stimulatory effect of leaf leachates was observed on germination percentage. The highest percentage of germination was found at (100 % concentration i.e. treatment T5 (78.5 %) and lowest in T2 (71.00).

Germination period

The germination of seeds started 3 days after sowing and continued up to 4 days. The fastest germination i.e. least germination period (3 days) was recorded the same in all, irrespective of the different treatments

Germination Value

The germination value under the different treatment the highest germination value of 9.68 was found at T3 and lowest germination value of 7.06 was found in T2.

Shoot Height

From initial stage of growth of seedling the height was notably varied with respect to the treatments. On 15th

Table 1. Effect of *Acacia nilotica* (L.) leaf leachate on germination percentage, least germination period, germination value, length of plumule, length of radical of spinach (germinator)

Treatment	Germination per cent	Least germination period	Germination value	Length of plumule (cm)	Length of radical (cm)
T1-Control	90	5	9.74	8.46	3.42
T2-25 %	74.5	4	7.98	5.69	3.96
T3-50 %	71	4	7.21	5.85	4.21
T4-75 %	76	4	7.56	5.36	3.55
T5-100 %	80.5	2	11.36	5.52	2.89
CD @ 1 %	9.36	3.28	6.19	0.19	0.62

day from sowing, the maximum height was found in T5 (6.52 cm) and lowest i.e. 5.12 cm was found in T2. Similar result was found on 30th day. The maximum height (17.73 cm) was found in T5 and the lowest i.e. 11.27 cm was found in T2. On 45th day, the observation showed that the maximum height (25.25 cm) was found in T5 and the lowest i.e. 22.02 cm was found in T2.

Root height

The root height was non significantly varied with respect to the treatments. As compared to control treatment, stimulatory effect was found in T5 on root length. The maximum length (17.46 cm) was found in T5 and the lowest i.e.15.95 cm was found in T2.

Shoot fresh weight

The shoot fresh weight was increased as the increase concentration of leaf leachate except T2 and T3. The maximum shoot fresh weight was observed in T5 (12.56 gm) and the minimum shoot fresh weight was recorded in T2 (8.2605 gm).

Root fresh weight

The shows that, the root fresh weight was increased as the increase concentration of leaf leachate except T2 and T3. The maximum root fresh weight was observed in T5 (0.8015 gm) and the minimum root fresh weight was recorded in T2 (0.5575 gm).

Shoot dry weight

The shoot dry weight was progressively increased as increased in the concentration of leachate except T2 and T3. The maximum shoot dry weight was observed in T5 (0.97 gm) and the minimum shoot dry weight was recorded in T2 (0.58 gm).

Root dry weight

The root dry weight was notably varied due to the treatments. The root dry weight was progressively increased as increased in the concentration of leachate except T2 and T3. The maximum root dry weight was observed in T5 (0.13 gm) while the minimum root dry weight was recorded in T2 (0.08 gm).

Soil Status

The root pH and EC was not significantly intended by the leachete treatments, results shows result non significant.

Organic carbon in soil

The OC of the soil was analyzed in the soil testing laboratory. The data presented in Table 3 showed that, result significant in spinach lowest OC observed in 0-15 cm depth in T1 (5.1) and highest in T5 (5.3). Highest OC in 15-30 cm depth T5 (5.00), T4 (5.00) and lowest in T1 (4.8). It shows that increasing concentration the OC also increases.

Available nitrogen

N of the soil was analyzed in the soil testing laboratory. The data given Table 3 showed that, result significant in spinach lowest N observed in 0-15 cm depth in T1 (155.50) and highest in T4 (188.09). Highest N in 15-30 cm depth T4 (183.01) and lowest in T1 (148.23). It shows that increasing concentration the N also increases except T5.

Available phosphorus in soil (P) (kg ha^{-1})

P of the soil was analyzed in the soil testing laboratory. The data given Table 3 showed that, result is significant in spinach lowest P observed in 0-15 cm depth in T1 (20.01) and highest in T4 (25.3). Highest P in 15-30 cm depth T4 (22.3) and lowest in T1 (19.3). It shows that increasing concentration the P also increases except T5.

Available potassium in soil (K) (kg ha^{-1})

K of the soil was analyzed in the soil testing laboratory. The data given Table 3 showed that, result significant in spinach lowest K observed in 0-15 cm depth in T1 (281.2) and highest in T4 (299.56). Highest K in 15-30 cm depth T4 (289.68) and lowest in T1 (278.48). It shows that increasing concentration the K also increases except T5.

CONCLUSION

`Maximum inhibition in germination percentage had recorded at higher concentration i.e. 75 per cent and 100 per cent concentration. The germination period and germination value for test crop was not affected notably by different concentration of leaf leachate. Plumule length and radical length showed that, the higher concentration of *Acacia nilotaca* (L.) leaf leachate had inhibitory effect on this test crop.The observation recorded for shoot and root height parameter revealed that the treatment in this case the maximum positive effect was observed as the concentration increase shoot and root height of spinach also increases but it gives at par results. This showed increase in shoot and root fresh weight with increasing concentration by showing at par result for different concentration of leaf leachates. With respect to shoot and

Table 2. Effect of *Acacia nilotica* (L.) leaf leachate on germination percentage, least germination period, germination value, shootand root height, Shoot and root fresh weight, shoot and root dry weight of spinach (greenhouse condition)

Treatment	Germination per cent	Least germination period	Germination value	Shoot height (cm)			Root height 45 DAS (cm)	Shoot fresh wt (gm)	Root fresh wt (gm)	Shoot dry wt (gm)	Root dry wt (gm)
				15 DAS	30 DAS	45 DAS					
T1-Control	76	4	8.05	5.93	14.83	22.94	16.86	10.03	0.72	0.83	0.10
T2-25 %	71	4	7.06	5.12	11.27	22.02	15.95	8.26	0.55	0.58	0.08
T3-50 %	77.5	3	9.68	5.64	12.72	22.04	16.01	9.22	0.62	0.79	0.10
T4-75 %	72.5	4	7.08	6.30	16.51	24.99	17.16	11.97	0.76	0.88	0.12
T5-100 %	78.5	3	8.53	6.52	17.73	25.25	17.46	12.56	0.80	0.97	0.13
CD @5 %	2.55	1.55	1.80	1.15	3.27	4.76	2.27	4.41	0.31	0.37	0.053

Table 3.Effect of *Acacia nilotica* (L.) leaf leachate on pH, EC, N, P, K, OC in soil of spinach

Treatment	pH		EC (ds/m)		N (kg/ha)		P (kg/ha)		K (kg/ha)		OC(tones/ha)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1-Control	8.02	8.12	0.47	0.49	155.50	148.23	20.01	19.3	281.2	278.48	5.1	4.7
T2-25 %	8.05	8.14	0.52	0.54	170.03	168.03	22.3	20.1	286.08	280.16	5.12	4.9
T3-50 %	8.09	8.2	0.52	0.54	186.82	180.03	24.6	21.0	294.78	284.72	5.2	4.9
T4-75 %	8.12	8.23	0.53	0.55	188.09	183.01	25.3	22.3	299.56	289.68	5.26	5.0
T5-100 %	8.16	8.29	0.53	0.55	185.23	178.38	24.8	20.9	295.48	286.84	5.30	5.0
CD @5 %	0.217	0.301	0.016	0.019	4.68	5.60	0.88	1.34	8.05	4.68	0.14	0.20

root dry weight, stimulatory effect was marked for this crop. Positive effect has been recorded for spinach was found mostly benefited by different concentration of *Acacia nilotica* leaf leachate. The improvement in soil fertility parameters was observed in soil used to grow this test crops.

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Pyrolytic Reactor for Fuel Oil Recovery from Plastic Waste

A. K. Kamble[1], Nishigandha S. Patil[2], S. H. Thakare[3] and M. B. Nagdeve[4]

ABSTRACT

A pyrolytic reactor for fuel oil recovery from plastic waste was developedand evaluated its performance.Waste plastic have created a serious concern because of its non-biodegradable. The pyrolytic reactor of 3 kg waste plastics holding capacity was designed for pyrolysis of HDPE, LDPE and PP for product yield. The performance of pyrolytic reactor was evaluated at varying reactor temperature of 350, 450, 550 and 650 for pyrolysis of HDPE, LDPE and PP. The highest fuel oil recovery was found to be 450 ml kg^{-1} using polypropylene followed by 420 ml kg^{-1} for HDPE and 358 ml kg^{-1} for LDPE waste plastics. The highest waste reduction efficiency of pyrolytic reactor was observed to be 90per cent for PP waste plastics and it was observed to be 89 per cent and 85 per cent for HDPE and LDPE waste plastics, respectively. The properties of oil obtained from the waste plastics were compared with the conventional fuel diesel and almost all the properties of the pyrolytic oil obtained from PP waste were found similar to that of the diesel oil.The colour of pyrolytic oil of PP waste plastic oil was observed to be light brown and light transparent, whereas, it was light brownish and greenish of diesel oil.

Plastic waste management is a common problem for both developed and developing countries, because of the fact that as the population increases, the quantity of waste generation also increases. Plastic waste collection, segregation and disposal have been a longstanding unresolved problem and will remain a problem in the future if there is no initiative made to solve it. Mismanagement of plastic waste will result to serious environmental problems such as surface and ground water contamination, flooding, air pollution and climate change. Plastic debris, laced with chemicals and often in the ingested by marine animals, can injure or poison wild life. Floating plastic wastes, which can survive for thousands of years in water, serve as mini transportation devices for invasive species, disturbing habitats. Plastic buried deep in landfills can leach harmful chemicals that spread into ground water.

Plastics are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Due to their light weight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, the plastics are employed in entire gamut of industrial and domestic area. Every year humans produce nearly 280 million tons of plastic, and much of that plastic ends up in the environment, harming marine life and other ecosystems.

The chemical bonds that makes plastic so durable makes it equally resistant to natural processes of degradation. Since plastics are non-biodegradable in nature, it is very difficult to eliminate the waste plastics fromnature. The majority of the plastic waste ends up in landfills, and becomes a carbon sink where it may take up to 1000 years to decompose and potentially leak pollutants into the soil and water. Also the plastic wastes are dumped in the oceans threatening the health and safety of marine life. The uncontrolled incineration of plastic produces polychlorinated dibenzo-p-dioxins, a carcinogen. So, converting the waste plastic into crude oil will have two benefits. First of all, the hazards caused due to plastic waste can be reduced and secondly, production of oil from it, which can be further, purified to be used as a fuel in different areas *viz.*, as domestic fuel, fuel for automobiles and industries etc. Thereby, our dependency on fossil fuels will reduce to a certain extent (Vijaykumar *et al.*, 2015).Among different types of plastic polymer, low-density polyethylene (LDPE) demonstrates maximum growth in consumption in India closely followed by HDPE and PP. On an average, the commodity plastics *viz.*, PE, PP, PVC, and polystyrene (PS) accounts 80 per cent of the total plastic consumption in India. Plastic waste is a major concern in urban areas, with repeated efforts, over the years, to ban or limit its use.

Pyrolysis is a thermo-chemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis has the potential of transforming solid wastes into useful recyclable products, but

1.Assistant Professor, 2. M. Tech. Student, 3. Head and 4. Dean, Department of Farm Power and Machinery, Faculty of Agricultural Engineering, Dr. PDKV, Akola (M.S.), INDIA

conventionally leads to a wide spectrum of pyrolysis products, which are difficult to be separated and utilized. In the pyrolysis of plastics, the macromolecular structures of polymers are broken down into smaller molecules or oligomers and sometimes monomer units. Further degradation of these subsequent molecules depends on a number of different conditions including temperature, residence time, and other process conditions. The Pyrolysis reaction can be carried out with or without the presence of catalyst. Plastic is fed into a cylindrical chamber. The pyrolytic gases are condensed in a specially designed condenser system, to yield a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic, and aromatic hydrocarbons, and liquid is separated using fractional distillation to produce the liquid fuel products. Since incineration is less accepted and the cost of state-of-the-art landfill facility is unaffordable, finding economically not feasible and environment friendly means of waste recycling and reduction is challenging. The pyrolytic reactor employs the pyrolysis method of converting waste plastic into oil. The advantage of pyrolysis over landfill and incineration is in terms of environmental protection because it reduces the risk of air, water and soil pollution. In pyrolysis, the possibility of recycling is improved, because the resulting product such as gas and liquid can be used as fuel to substitute fossil fuels.

Pyrolysis of plastic is a thermal degradation at temperatures between 400 to 600°C in an inert atmosphere. As mentioned previously, one of the plastics that are present in large quantities in municipal solid waste is polypropylene. During the pyrolysis, plastics were heated at a high temperature when their macromolecular structures were broken, which gives rise to smaller molecules yielding a broad range of hydrocarbons that could be used as fuels or chemicals. In this study an effort has been taken to develop pyrolytic reactor for fuel oil recovery.

MATERIAL AND METHODS

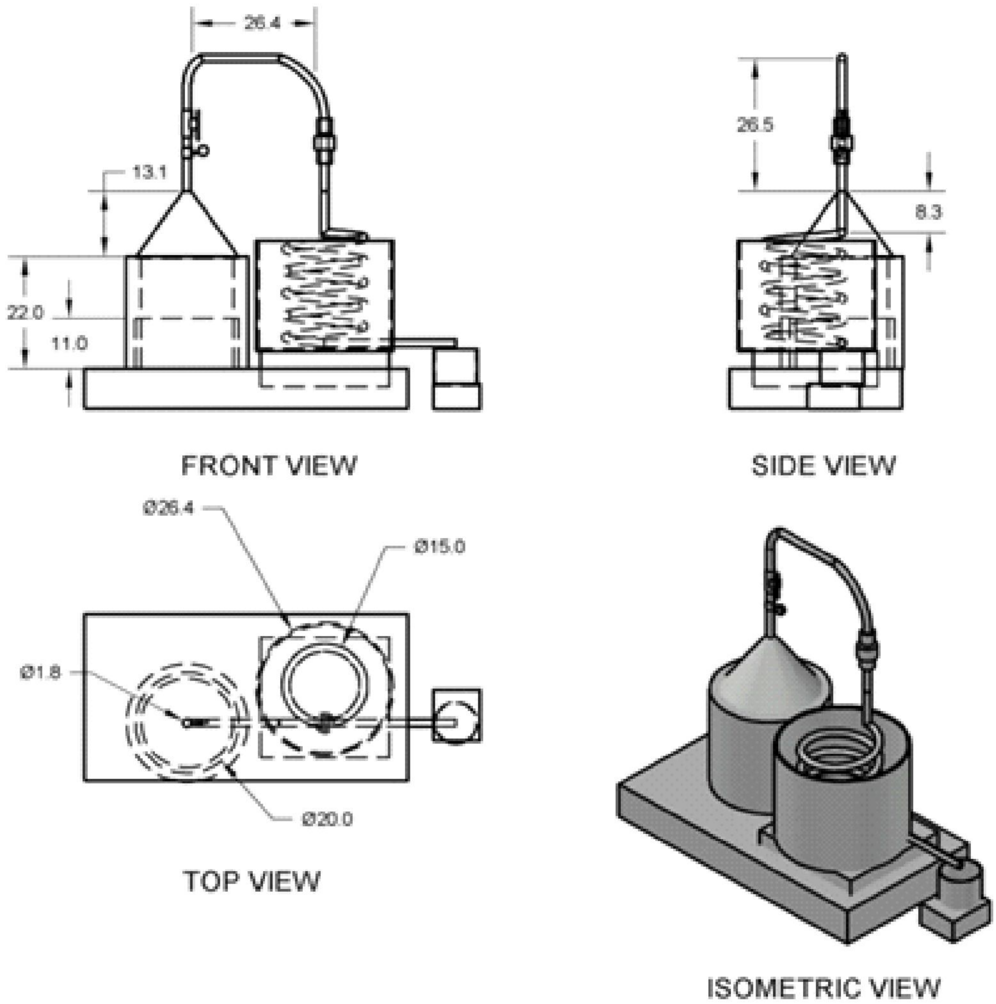
A batch type pyrolytic reactor was designed by considering waste plastic holding capacity of 3kg. The reactor was designed for pyrolysis of waste plastics, *viz.*, high density polyethylene (HDPE), low density polyethylene (LDPE) and polypropylene (PP).The average densities of HDPE, LDPE and PP, i.e. 0.94 g cm^{-3}, 0.910 g cm^{-3} and 0.895 gcm^{-3}, respectively were taken into consideration for design of reactor. The design specifications of the pyrolytic reactor are given in Table1 and the schematic views of pyrolytic reactor system is shown in Fig.1.

Experimental setup for evaluation of pyrolytic reactor system

The experiments were carried out in the Department of Unconventional Energy Sources and Electrical Engineering, Dr. PDKV, Akola. The degradation of waste plastics *viz.*, HDPE, LDPE and PP was investigated in batch type pyrolytic reactor. Pyrolytic reactor, electric heaters with glass wool insulation, condensing unit were

Table 1. Design specifications of pyrolytic reactor

S.N.	Particulars	Specifications	Materials
1.	Pyrolytic reactor		
	Height, cm	22	MS Sheet of 22 gauge
	Diameter, cm	20	
2.	Heaters (2 Nos.)	2 kW of each	Ceramic heaters
3.	Insulation	-	Glass wool
4.	Condensing unit		Copper coil
	Copper tube diameter, cm	1.5	Copper
	Copper coil diameter, cm	15.8	Copper
	Condenser tank diameter, cm	30	MS Sheet of 24 gauge
5.	Temperature controller, °C	0-1200	-
6.	Thermocouple, °C	0-1200	Stainless steel
7.	Pressure gauge, kg cm^{-2}	0-7	-
8.	Regulating valve size (f), cm	2.5	Brass



All Demension in cm

Fig. 1. Schematic views of pyrolytic reactor system for fuel oil recovery from waste plastics

the main components of the pyrolytic reactor system. Temperature controller, thermocouple, pressure gauge and regulating valve were provided on the system for performance evaluation of the system.

The experimental set-up of the pyrolytic reactor system for fuel oil recovery from plastic waste is shown in Fig. 2. Pyrolytic reactor consists of two heaters 2 KW capacity of each were wrapped on the surface of reactor to obtain the required temperature inside the reactor for heating of waste plastics. As the required temperature attained the waste plastic get heated to form vapours. These vapours then passed through the condenser coil where they get condensed to obtain fuel oil. The thermocouples were provided in the reactor as well as on the surface of the reactor to measure the temperature of pyrolytic reactor. The digital temperature indicator was provided to observe the readings. Pressure gauge and regulating valve were mounted on the outlet of reactor. The effect of pyrolytic temperatures *viz.*, 350, 450, 550 and 650 °C on the product yields of fuel oil, solid residue, pyrolysed gas and residual time of waste plastics were studied.Condensing coil was fully immerged in the water tank of capacity 100 liter. Electric power was supplied to the heaters through temperature controller unit. The temperature controller unit activated when the temperature of reactor reach to the pre-decided temperature. Automatically the power supply cut down and again power supply get on when the temperature of reactor goes down. The exact temperature was maintained by controller unit while experimentation.

Fig2. Pyrolytic reactor system for fuel oil recovery from wasteplastics

Waste plastic were collected from local scrap market and it was being sorted based on the types like HDPE, LDPE & PP and were used for experiment. Size reduction was carried out using shredder and graded to uniform size of 2cm × 2 cm (Hariram, 2014).The reactor was made up of MS and had cylindricalshape and conical at upper end.The cone was fitted on the cylinder by nut bolts after feeding waste plastics in the reactor. Champion heavy duty gasket was provided to control the leakage of gas from the joining section of cylinder and cone of the reactor.

To increase the temperature of reactor, the waste plastic placed in a reactor was heated by heater wrapped on the surface of reactor and maintained the temperature levels of 350, 450, 550 and 650^{o}C (Kumar *et al.*, 2011).Additional packing of mica sheet was also providedto avoid leakage of gas. Mica sheet was used for electrical insulation where high temperatures are encountered. The plastic get evaporated at high temperature, these vapors werepassed to the condensing unit of spiral shape copper pipe of 6 m in length 12.5 mm in diameter, where it gets condensed to atmospheric temperature. The other end of copper tube was used for collection of condensed oil, obtained from reactor and collected in measuring jar.

Performance evaluation of pyrolytic reactor system

Waste plastic were characterized by proximate analysis and it involved the determination of moisture content, volatile matter, ash content and fixed carbon.Waste plastics sample were weighed in a silica crucible. The crucible was placed inside an electric hot air-oven and maintaining temperature at 105°C. The crucible was allowed to remain in oven for two hour and then it was taken out, cooled in dessicator and was weighted. Loss in weight was the moisture content on percent basis.

$$\text{Moisture Content, (\%)} = \frac{W_w - W_d}{W_w} \times 100 \qquad \ldots\ldots \text{Eq. (1)}$$

Where,

W_w- Weight of the plastic waste sample (g)

W_d- Weight of the oven dried sample (g)

Volatile matter content

The dried sample of waste plastic was taken in crucible andcovered with a lid and was placed in an electric muffle furnace, maintaining temperature at 925$\pm$20°C. The crucible taken out of the oven after seven minute of heating and the crucible was cooled first in air, then was cooled inside dessicator and was weighted again. Loss in weight was the volatile matter on percentage basis.

$$\text{Volatile Matter, (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad \ldots\ldots.. \text{Eq. (2)}$$

Where,

W_1 - Weight ofemptysilica crucible, (g)

W_2 - Weight of thecrucible and sample, (g)

W_3 - Constantweight ofcrucible and sample afterheating, (g)

Ash content

The residual plastic waste in the crucible then was heated without lid in a muffle furnace at temperature 700 50°C for half an hour. The crucible then was taken out andwas cooled first in air, then in dessicator and was weighed. Heating, cooling and weighing was repeated, till a constant weight obtained. The residue was ash on percentage basis.

$$\text{Ash Content, (\%)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad \ldots\ldots\ldots. \text{Eq. (3)}$$

Where,

W_1 - Weight of emptysilica crucible, (g)

W_2 - Weightofthe crucible and sample, (g)

W_3 - Constantweight ofcrucibleand sample after combustion, (g)

Fixed carbon

Fixed carbon was estimated using following equation

Fixed Carbon, (%) = 100 - [per cent of moisture content + per cent volatilematter + per cent ash content]

The performance of the pyrolytic reactor was evaluated for fuel oil recovery, solid residue and pyrolysed gas percentage. The performance of the reactor was evaluated by the conversion efficiency, waste reduction efficiency andoil recovery by the following formulae.

Conversion efficiency (%)

Conversion efficiency is the ability of the equipment to convert waste plastic into oil in terms of weight and it is given by following equation.

$$CE\ (\%) = \frac{W_o}{W_{sm}} \times 100 \qquad \ldots\ldots..Eq.(4)$$

Where,

CE - Conversion Efficiency

W_o - Weight of oil converted (g)

W_{sm} - Weight of the sample material (g)

Waste reduction efficiency (%)

Waste reduction efficiency is the measure of how efficient the reactor in reducing waste in terms of weight and it is given by following equation.

$$WRE\ (\%) = \frac{W_{pw} - W_c}{W_{pw}} \times 100 \quad \ldots\ldots\ldots Eq.(5)$$

Where,

WRE - Waste Reduction Efficiency

W_c - Weight of char inside the reactor (g)

W_{pw} - Weight of plastic waste material (g)

Oil recovery (%)

Oil recovery is the amount of oil recovered from per kilogram of plastic waste and is given by following equation.

$$OR = \frac{V}{Wsm} \times 100 \qquad \ldots\ldots. \quad Eq.(6)$$

Where,

OR - Oil Recovery (ml/kg)

V - Volume of oil recovered (ml)

W_{sm} - Weight of sample material (kg)

RESULTS AND DISCUSSION

From proximate analysis it was observed that the volatile matter was 100 per cent in the PP, due to the absence of ash in waste PP (Table 1). Kumar and Singh, (2011) analysed HDPE plastic waste and found almost same results.

Table 2. Proximate analysis of waste plastics

S.N.	Particulars	HDPE	LDPE	PP
1.	Volatile matter (%)	99.40	99.20	100.00
2.	Fixed Carbon (%)	0.00	0.30	0.00
3.	Ash content (%)	0.60	0.50	0.00

Effect of temperature of pyrolytic reactor in fuel oil recovery

The effect of temperature of pyrolytic reactor and HDPE, LDPE and PP of the feedstock was studies for product yield of oil recovery. Many scientists have worked on the concept of fuel oil production from waste plastics. From the reviews of literature it has been observed that the temperature was maintained in the reactor in the range of 350 to 650 °C, for pyrolysis of waste plastics. Santaweesuk and Janyalertadun, (2017) reported temperature range of 350 to 450 °C, maintained in the reactor at atmospheric pressure. Kumar, 2016 has also reported temperature of closed chamber in the range of 300 to 450 °C.

Effect of temperature using HDPE waste plastic on product yield

The product yield from HDPE plastics waste in the form of fuel oil recovery, solid residue and uncondensed gas at various temperature level of rector is shown in Fig. 3. The highest oil recovery of 42.0per cent was obtained from HDPE waste plastics at 550 °C, whereas lowest of 35.0 per cent was obtained at 350 °C. Kumar and Singh, (2013) studied thermolysis of high density polyethylene to petroleum product and obtained oil recovery of 31.3, 52.46, 44.32 and 8.83per cent at 400, 450, 500 and 550°C. The variation of 10.46per cent oil recovery might be due to the feed stocks i.e. HDPE pellets of 2.5 mm in size used by Kumar and Singh(2013). The solid residue percentage was observed to be 18.0 per cent, 15.0per cent, 11.0 per cent and11.0 per cent, respectively at 350, 450, 550 and 650°C temperature. Similarly, uncondensed gas percentage was found 47.0, 52.8, 45 and 45per cent at 350, 450, 550 and 650 °C, respectively. Two percent of unmeasurable product was estimated in pyrolysis of HDPE waste plastics. At 650 °C temperature the same oil recovery, solid residue and uncondensed gas was obtained. It is seen from the table that 550 °C

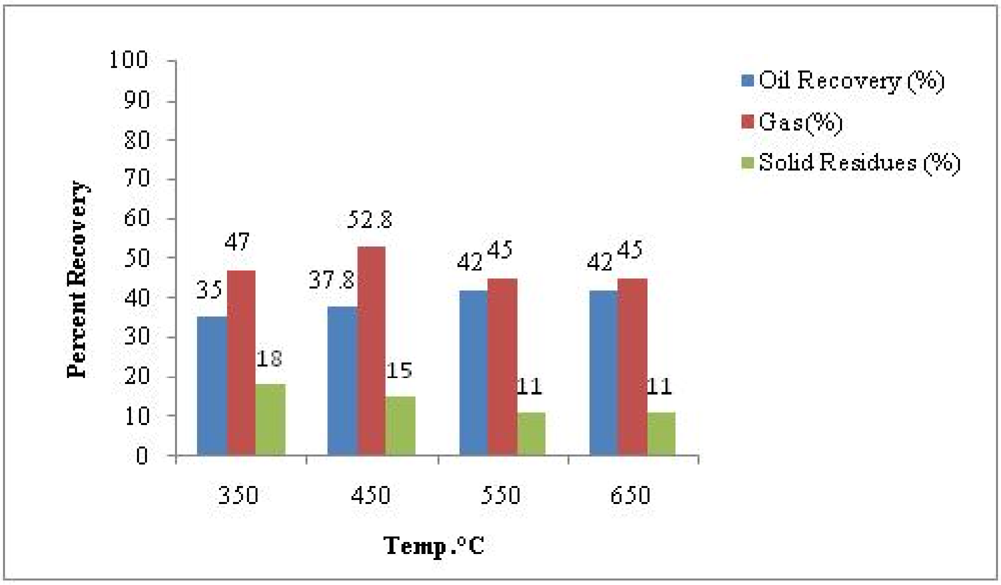


Fig. 3. Effect of HDPE waste plastics on product yield

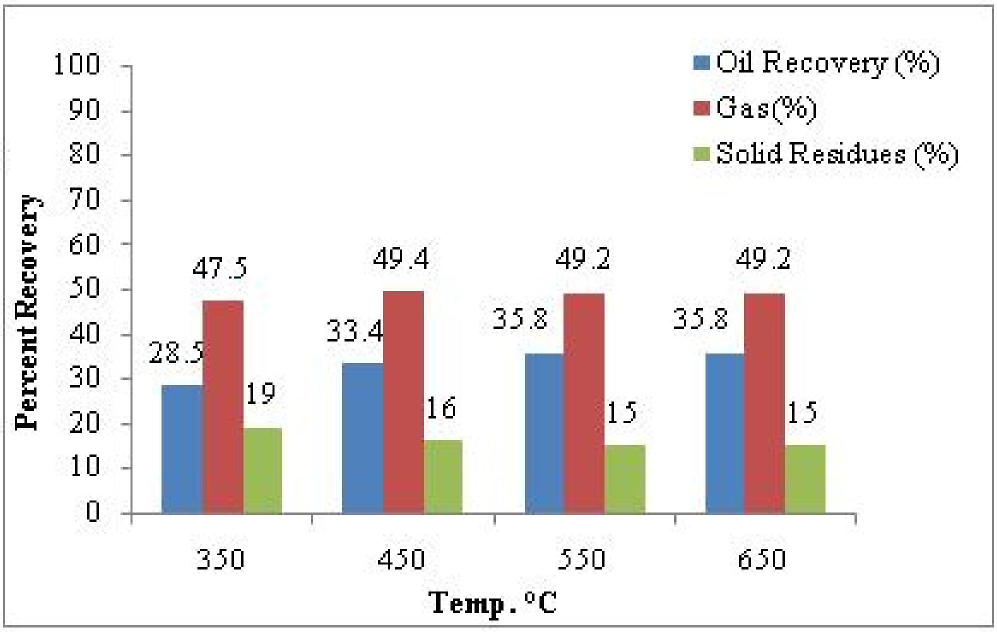


Fig. 4. Effect of temperature on product yield using LDPE waste plastics

temperature was found to be best for optimum oil recovery from HDPE waste plastics.

Effect of temperature using LDPE waste plastics on product yield

The product yield as the effect of LDPE waste plastic feedstock and temperature is shown in Fig.4. The highest oil recovery of 35.8 per cent was obtained from LDPE plastics at 550 °C, whereas, lowest of 28.5 per cent was obtained at 350 °C. The solid residue percentage was observed to be 19.0 per cent, 16.0 per cent, 15.0 per cent and 15.0 per cent, respectively at 350, 450, 550 and 650°C temperature. Similarly, uncondensed gas percentage was found to be 47.5, 49.4, 49.2 and 49.2 per cent at 350, 450, 550 and 650 °C, respectively.

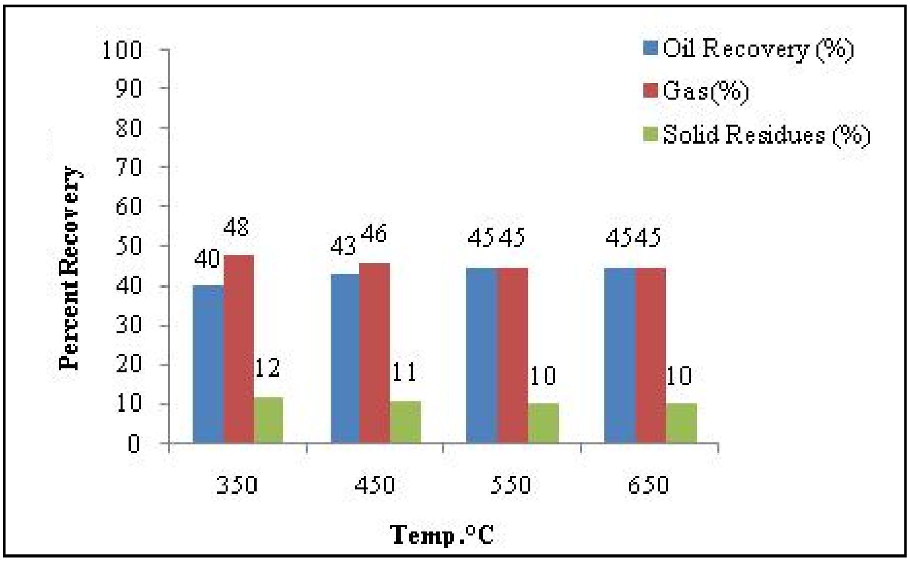


Fig. 5. Effect of temperature on product yield using PP plastic waste

Table 3. Optimized condition for product yield fom pyrolytic reactor

S.N.	Waste plastics	Temp. °C	Oil Recovery (%)	Solid Residue (%)	Uncondensed Gas (%)	Residual Time (min)
1.	HDPE	550	42.0	11.0	47.0	45
2.	LDPE	550	35.8	15.0	49.2	45
3.	PP	550	45.0	10.0	45.0	45

Effect of temperature using PP waste plastics on product yield

The product yield as the effect of PP waste plastic feedstock is shown in Fig. 5. The highest oil recovery of 45.0 per cent was obtained from PP was plastics at 550 °C and 650°C also, whereas, lowest of 40.0 per cent was obtained at 350 °C. The solid residue percentage was observed to be 12.0 per cent, 11.0 per cent, 10 per cent and 10.0 per cent, respectively at 350, 450, 550 and 650 °C temperature. Similarly, uncondensed gas percentage was found to be 48.0, 46.0, 45.0 and 45.0 per cent at 350, 450, 550 and 650 °C, respectively. Similarly no changes were observed at 650°C on product yield.

Optimized condition for different waste plastics

The Data (Table 3) revealed the effect of HDPE, LDPE and PP waste plastics on product yield. It was observed that the fuel oil recovery was maximum at 550°C temperature of 42.0 per cent, 35.8 per cent and 45.0 per cent for HDPE, LDPE and PP, respectively. The corresponding residue and gas obtained 11.0 per cent, 15.0 per cent and10.0 per cent and 45.0 per cent, 49.2 per cent and 45.0 per cent for HDPE, LDPE and PP waste plastics, respectively.

The performance of the pyrolytic reactor was measured in terms of conversion efficiency, waste reduction efficiency and oil recovery.The conversion efficiency of pyrolytic reactor for HDPE, LDPE and PP waste plastic was found to be 42 per cent, 35.8 per cent and 45 per cent, respectively. Waste reduction efficiency of pyrolytic reactor for HDPE, LDPE and PP waste plastics was found to be 89 per cent, 85 per cent and 90 per cent,

Table 4. Performance parameters of pyrolytic reactor using HDPE, LDPE and PP plastic waste

S.N	Parameters	HDPE	LDPE	PP
1.	Conversion Efficiency (%)	42.0	35.8	45.0
2.	Waste Reduction Efficiency (%)	89.0	85.0	90.0
3.	Oil Recovery (ml kg^{-1})	420	358	450

PP Oil **LDPE Oil** **HDPE Oil**

Fig. 6. Pyrolytic oil from waste plastics

respectively. Oil recovery from unit amount of HDPE, LDPE and PP in pyrolytic reactor was found to be 420 ml kg^{-1}, 358 ml kg^{-1} and 450 ml kg^{-1}, respectively. From Table 4 the conversion efficiency, waste reduction efficiency and oil recovery of PP waste plastic was found higher as compare to HDPE and LDPE. Similar results of waste reduction efficiency of 90 per cent was reported by Rapsing (2017) for PP waste plastics, Rapsing (2017) also reported more conversion efficiency of 60.90 per cent which might be due to the feed material of plates and food boxes. The oil obtained from pyrolysis of HDPE, LDPE and PP waste plastics are shown Fig. 6.

CONCLUSION

The polypropyleneplastic waste registered maximum oil recovery of 45 per cent whereas, it was found to be 42 per cent and 35.8 per cent using HDPE and LDPE plastic waste, respectively at 550 ^{o}C in pyrolytic reactor. The pyrolytic reactor for fuel oil recovery from plastic waste was capable of converting plastic waste to fuel oil.

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Effect of Machine and Process Parameters on Peeling Efficiency of Potatoes

P. A. Borkar[1], R. P. Murumkar[2], S. N. Gunjkar[3] and M. R. Rajput[4]

ABSTRACT

A potato peeling machine (batch type) was developed to peel the potatoes during 2016-17 in All India Coordinated Research Project on Post Harvest Engineering and Technology, Dr. PDKV, Akola. The overall dimensions of the developed machine are 1665 × 580 × 40 mm which is operated by 1 hp single-phase electric motor. The peeling machine consist of peeling unit, drive mechanism, water spray pipe, frame and waste water outlet. Performance of the developed machine was evaluated and the effect of various machine and process parameters viz. emery size, roller speed and retention time on the different response parameters such as peeling efficiency, peeling loss and damage percentage was studied. The working capacity of the machine was found to be 100 kg h^{-1} of potatoes. The maximum peeling efficiency was found to be 98.07 per cent for the emery size No. 80, roller speed of 100 rpm and retention time of 4 minutes.

Potato (*Solanum tuberosum* L.), is the third most important staple crop in the world, and is a widely consumed vegetable in India. The production of potatoes in India was 40,476.30 thousand metric tonnes in 2010-2011 from a total area of 1893.90 thousand hectare (Anonymous, 2011). Uttar Pradesh was the largest producer of potatoes for India with 108.09 lakh tonnes production from an area of 5.27 lakh hectares. Production of potatoes in Uttarakhand was 5.12 lakh tonnes from an area 2.51 lakh hectares (Anonymous, 2008). The other major producers were West Bengal, Bihar, Punjab, Madhya Pradesh, Gujarat and Assam.

Potato is a major food crop, grown in more than 100 countries in world. It is cultivated in 23 states in India. Country has achieved a tremendous growth in potato production during last four to five decades. The annual compound growth rate of potato is higher than other major food crops in respect of area, production and productivity. In the year 2002-2003, the production was 25 million tonnes whereas it was 5 million tonnes during 1970. Hence, owing its significant growth in production, bumper yields have been observed almost in every year. Potato is an important crop not only of the developed countries but also of the developing countries. For table purpose about 68per cent of potato production is consumed, while for processing operations share is 7.5 per cent. Chips, dehydrated items are gaining importance due to changing lifestyles and urbanisation. Potato processing is gaining importance in our country in view of the rising employment of women in cities leading to growing demand for processed products and the general increase in demand for processed foods in urban areas due to liking of people particularly youngsters for such products. The increase in number of fast food outlets in the metros and even smaller cities is also contributing towards this. Processing helps in reducing demand for storage space and also provides better returns to the growers. Potatoes can be processed into a number of value added products like chips, French fries, flakes, granules, dice and canned potatoes on a commercial scale. In addition industrially useful products like potato flour and potato starch can also be produced on a large scale. Village level processing of potatoes can also be done to prepare dehydrated products like dehydrated chips, *papads*, etc. Products from potatoes are quite popular in our country. Many ready to eat products can be prepared by utilizing potatoes. Units based on potato products can easily be established in potato growing areas and the market for these products can be exploited in urban and semi-urban areas. The potato chip is a very popular snack food in India. For making chips, the important preparatory operations are washing and peeling. Hand peeling is traditional in India and is tedious and time consuming. Moreover, the loss of flesh is very high. However, the potato processing industry uses lye peeling. In the lye peeling process, a heat ring is formed below the surface of the potato due to tissue damage and polyphone enzyme activity that deteriorates the quality of the chips.

Keeping in view the above, low cost potato peeling machine was developed in AICRP on PHET, Dr. PDKV, Akola. The evaluation of developed peeling machine was carried out to study the effect of various

1. Research Engineer, 2. Assistant Professor, 3. P.G.Student and 4. Senior Research Assistant, Post Harvest Engineering and Technology, Dr. PDKV, Akola

machine and process parameters on the peeling efficiency, peeling loss and damage percentage.

MATERIAL AND METHODS

The power operated low cost potato peeler developed using locally available materials as shown in Fig. 1 was evaluated. The peeler consists of the peeling unit, power transmission mechanism, water spray pipe, frame and waste water outlet. The effect of water spray and rubbing action of potatoes on emery rollers peel and clean the potatoes passed over the emery rollers in the peeling unit. Emery rollers (Emery size, No. 60, 80, 100) of 100 mm diameter and 1300 mm length were fabricated using galvanized iron pipe (GI) and fixed on mild steel (MS) angle frame using pedestals. Five emery rollers were used in order to form a U shaped trough to retain the potatoes over the rollers so as to expose the maximum surface area of potatoes to the rotating emery rollers. All the five emery rollers rotate in one direction. When the peeler is operated, the peeling can be achieved by adjusting the emery rollers speed and the retention time of potatoes passed over the emery rollers. The optimum retention time for maximum peeling of potatoes was determined by conducting the trials.

Peeling unit consists of Emery rollers of 100 mm diameter and 1300 mm length were fabricated using galvanized iron pipe (GI) and fixed on mild steel (MS) angle frame using pedestals as shown in Fig 1. Five emery rollers were used in order to form a U shaped trough to retain the potatoes over the rollers so as to expose the maximum surface area of potatoes to the rotating emery rollers. All the five emery rollers rotate in one direction. When the peeler is operated, the peeling can be achieved by adjusting the emery rollers speed and the retention time of potatoes passed over the emery rollers. The effect of water spray and rubbing action of potatoes on emery rollers peel and clean the potatoes passed over the emery rollers in the peeling unit.

Potatoes were procured from local market of

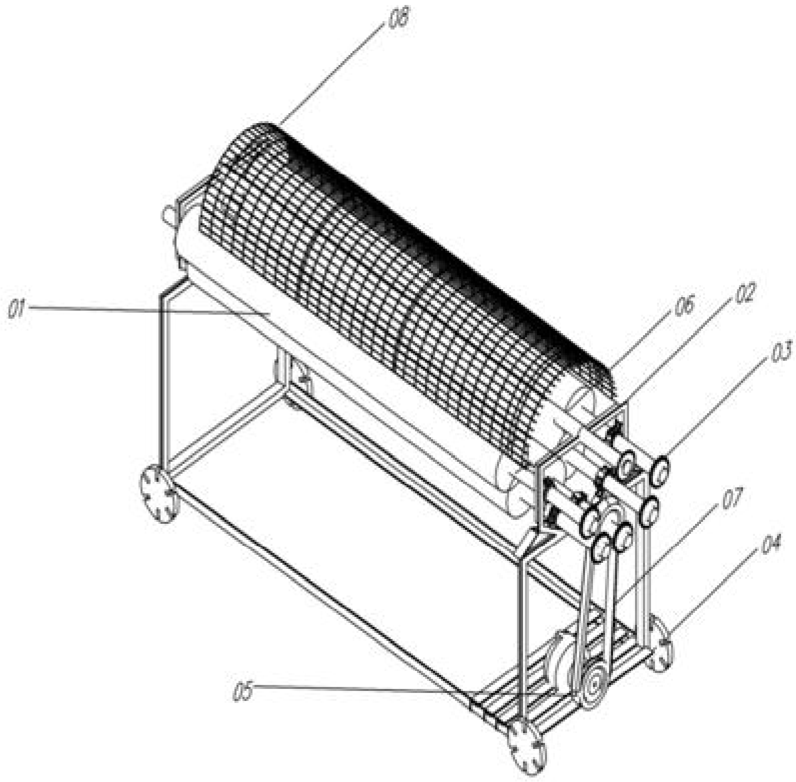

Fig. 1. Potato peeler with cover

1.	Emery Roller	2.	Main Frame	3.	Sprocket mechanism
4.	Wheels	5.	Driving Mechanism	6.	Water Spray Pipe
7.	V – Belt	8.	Wire Mesh Cover		

Akola and were used for the experimental purpose. The moisture content of potatoes was in the range of 24.95 (wb) to 33.21 per cent (db). The weighed 1000 g sample of potatoes was used for each experiment. The potatoes were fed to the peeling unit manually. After completion of peeling operation, the machine was stopped and different fractions of potatoes sample like peeled potatoes, unpeeled potatoes, damaged potatoes were collected carefully. The performance of the developed potato peeler was evaluated for its suitability for peeling of potatoes was tested with following parameters.

Independent parameters

Following parameters were decided after conducting some filler trials.

1. ***Machine Parameters***

1. Emery size (No) - 60, 80,100

Process Parameters

1. Roller speed (rpm) - 75, 100, 125
2. Retention time (min) - 2, 4, 6

Dependent parameters

1. Peeling Efficiency (%)
2. Peeling Loss %)
3. Damage Percentage (%)
4. Bruise Index

The peeling efficiency was assumed to be affected by emery size, roller speed and retention time. The levels of independent variables for peeling of potatoes are shown in Table 1. The table shows the coded and uncoded variables and their levels.

Table 2. Levels of independent variables for peeling of potatoes

Independent variables	Symbols		Levels	
	Coded	Un-coded	Coded	Un-coded
Emery size (No)	x_1	X_1	10-1	1008060
Roller Speed (rpm)	x_2	X_2	10-1	12510075
Retention time (min)	x_3	X_3	10-1	642

As per 3 variable 3 level Box Behnken model, 17 trials were performed for obtaining the peeling efficiency and peeling loss responses for each treatment. All these trials were conducted with 1 kg sample size and data for peeling efficiency and peeling loss was reported. To avoid bias, 17 runs were performed in a random order. The decision for the range and centre points of the variables were taken through preliminary trials. The performance evaluation was carried out using the following equations (Jayashree and Visvanathan, 2013.)

Peeling efficiency

Peeling Efficiency,

$$h = [(W_1 - W_2)/W_1] \text{ X } 100$$

Where,

W_1 – Quantity of peel in potato, g (unpeeled)
W_2 – Quantity of peel remained on potato after peeling, g

Peeling loss percentage

Peeling loss was calculated by following expression,

Peeling Loss,

$$= \frac{\text{Weight of potato mass removed with peel}}{\text{Weight of potato mass before peeling}} \times 100$$

Damage percentage

Damage percentage was calculated by following expression,

Damage percentage,

$$\text{Damage percentage} = (W_D / W) \times 100$$

Where,

W_D – wt. of potato after peeling, g (peeled)

W – wt. of potato before peeling, g (unpeeled)

RESULTS AND DISCUSSION

The experiments were conducted with various treatment combinations as given in Table 1. Fig. 1 to Fig. 3 shows effect of various levels of peeling parameters on peeling efficiency. The peeling efficiency was observed to be ranging between 93.2 to 98.07 per cent. The maximum peeling efficiency of 98.07 per cent was observed at 100 No. emery size, 75 rpm roller speed and 4 min retention time. The minimum peeling efficiency of 93.2 per cent was observed at 80 No. emery size, 75 rpm roller speed and 2 min retention time.

The analysis of variance (ANOVA) was carried out for the experimental data and the significance of emery size, roller speed and retention time as well as their interactions on peeling 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 peeling efficiency response (Table 3). It revealed that the model was highly significant at 1 per cent level of significance and lack of fit was non significant indicating that the model was quite adequate for predicting the response.

The results showed that among linear effects retention time had significant effect on peeling efficiency ($P<0.01$) at 1 per cent level of significance followed by roller speed followed by emery size. The existence of quadratic terms indicates the curvy linear nature of response. 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 quadratic response surface model data indicated the results as significant. The lack of fit was found to be non significant which indicates that the developed model was adequate for predicting the response. The coefficient of determination (R^2) was 0.9575 for peeling treatment which indicated that the model could fit the data for peeling activity very well for all the three variables, i.e. emery size, roller speed and retention time.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Final Equation in Terms of Coded Factors:

$$\text{Peeling efficiency} = +97.08 + 0.47 X_1 + 0.65 X_2 + 1.53 X_3 - 1.30 X_1X_2 - 0.48 X_1X_3\ 0.010 X_2X_3 - 0.064 X_1^2 - 0.27X_2^2 - 1.27X_3^2 \quad ....1$$

Where,

X_1= emery size (No)
X_2= roller speed (rpm)
X_3= retention time (min)

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients. The response surface equation was obtained for the model of second degree in terms of actual factors as under.

Table 3. ANOVA for effect of peeling variables on peeling efficiency

Source	Df	Sum of Square	Mean sum of square	F Value	p-value	Prob>F
Model	9	38.92	4.32	17.51	0.0005	Significant
A-Emery Size	1	1.77	1.77	7.16	0.0318	
B-Roller Speed	1	3.37	3.37	13.63	0.0077	
C-Retention time	1	18.76	18.76	75.95	< 0.0001	
AB	1	6.79	6.79	27.48	0.0012	
AC	1	0.93	0.93	3.77	0.0933	
BC	1	4.000E-004	4.000E-004	1.620E-003	0.9690	
A^2	1	0.017	0.017	0.069	0.8007	
B^2	1	0.30	0.30	1.21	0.3084	
C^2	1	6.75	6.75	27.33	0.0012	
Residual	7	1.73	0.25			
Lack of Fit	3	0.40	0.13	0.41	0.7576	Not significant

Std. Dev.	0.50	R-Squared	0.9575
Mean	96.33	Adj R-Squared	0.9028
C.V. per cent	5.52	Pred R-Squared	0.7902
PRESS	8.53	Adeq Precision	13.026

$$\text{Peeling efficiency} = +54.42850 + 0.35765x_1 + 0.32027x_2 + 4.28263x_3 - 2.60500E-003x_1x_2 - 0.012063x_1x_3\ 2.00000E-004x_2x_3 - 1.58750E-004x_1^2 - 4.25600E-004x_2^2 - 0.31650x_3^2 \quad \text{.........2}$$

Where,

x_1 = emery size, No

x_2 = roller speed, rpm

x_3 = retention time, min

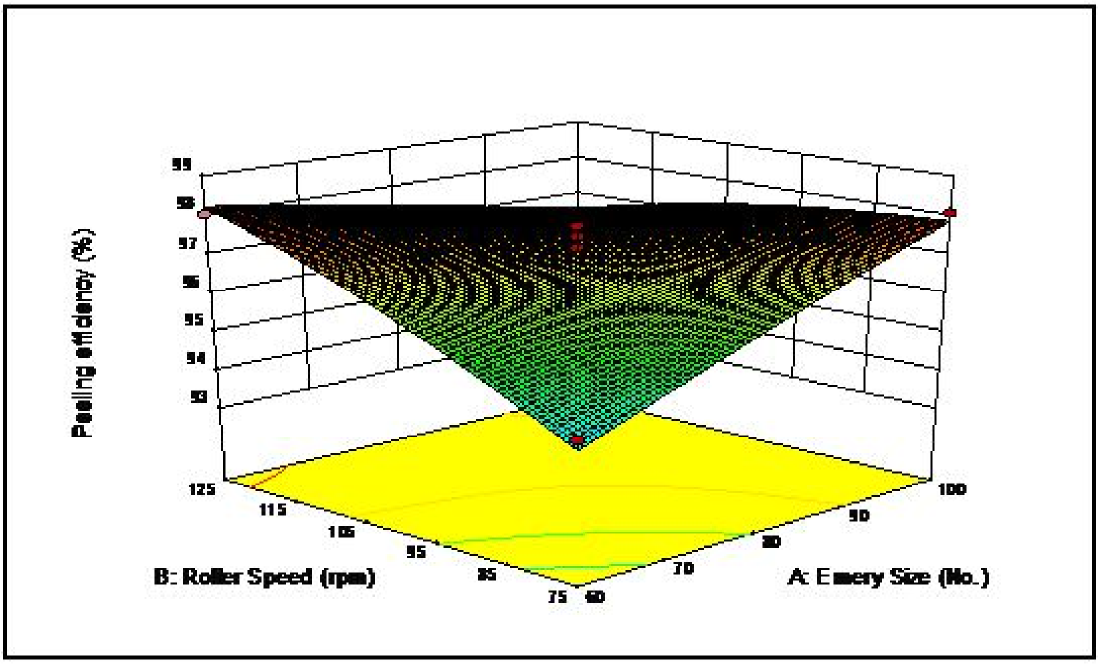

Fig. 1. Effect of emery size and roller speed on peeling efficiency

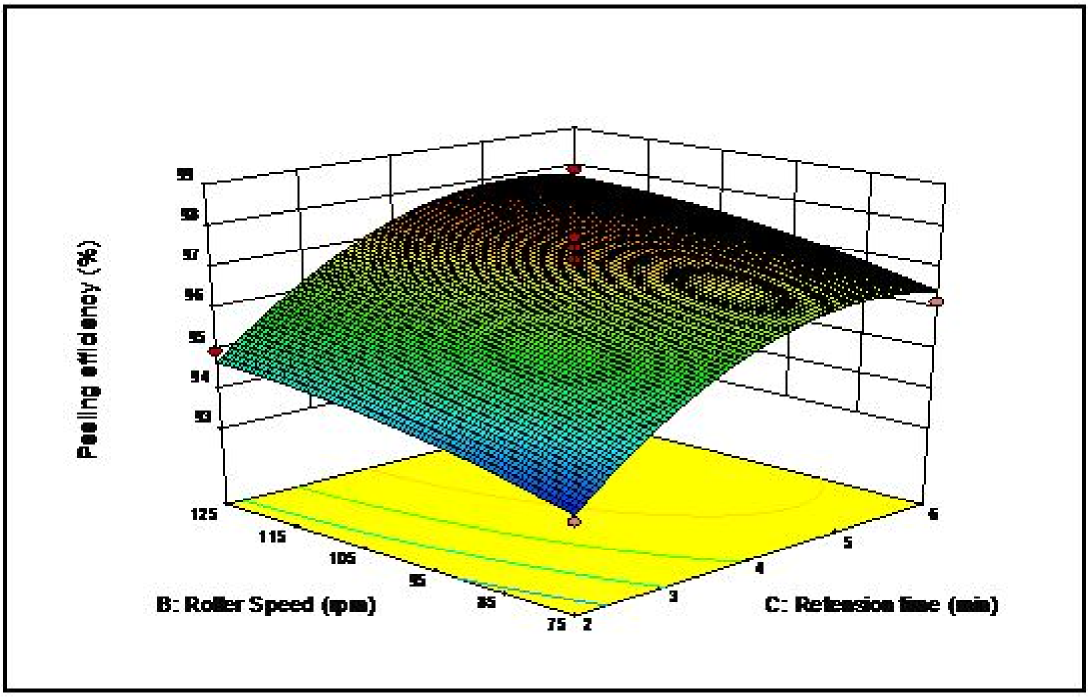

Fig 2. Effect of roller speed and retention time on peeling efficiency

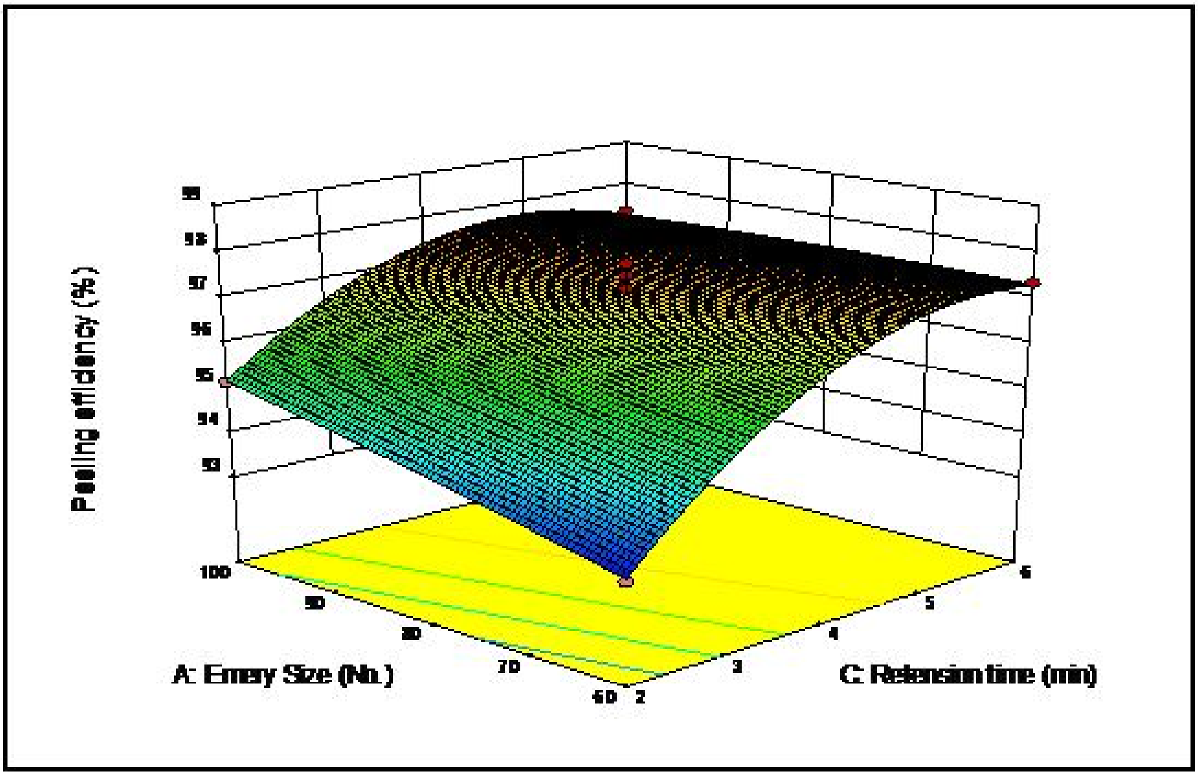

Fig. 3.. Effect of emery size and retention time on peeling efficiency

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor.

Effect of emery size and roller speed on peeling efficiency

The effect of emery size and roller speed on peeling efficiency was determined keeping retention time constant at 4 min which is shown in Fig. 1. Three dimensional responses for peeling efficiency of samples were generated. From these surfaces, it could be evident that peeling efficiency increased with increase in emery size. As roller speed was increased, peeling efficiency was found to be increased.

Effect of roller speed and retention time on peeling efficiency

The effect of roller speed and retention time on peeling efficiency was determined keeping emery size constant at 80 No. which is shown in Fig. 2. Three dimensional responses for peeling efficiency of samples were generated. Peeling efficiency was found to be increased with increasing in retention time and further was found to be be decreased (Fig. 2 and 3).

Response 2: Peeling Loss (per cent)

The experiment was conducted with various treatment combinations as given in Table 2. It revealed that the peeling loss was observed to be ranging from 8.72 to 25.34 per cent depending upon the peeling treatments. The maximum peeling loss was observed in case of treatment having the combination of emery size No 60, roller speed 125 rpm and retention time 4 min. The minimum peeling loss was found for treatment having the combination of emery size No. 100, roller speed 100 rpm and retention time of 2 min.

The ANOVA in Table 5 revealed that the

Table 5. ANOVA for effect of peeling treatment variables on peeling loss

Source	Df	Sum of Square	Mean sum of square	F Value	p-value	Prob>F
Model	8	440.30	55.04	74.20	< 0.0001	Significant
A-Emery Size	1	*1.09*	*1.09*	*1.47*	*0.2604*	
B-Roller Speed	1	*196.91*	*196.91*	*265.48*	*< 0.0001*	
C-Retention time	1	*24.15*	*24.15*	*32.56*	*0.0005*	
AB	1	*31.53*	*31.53*	*42.51*	*0.0002*	
BC	1	*10.56*	*10.56*	*14.24*	*0.0054*	
A^2	1	*27.30*	*27.30*	*36.80*	*0.0003*	
B^2	1	*139.27*	*139.27*	*187.77*	*< 0.0001*	
C^2	1	*6.38*	*6.38*	*8.61*	*0.0189*	
Residual	8	5.93	0.74			
Lack of Fit	4	*2.56*	*0.64*	*0.76*	*0.6023*	not significant
Pure Error	4	*3.37*	*0.84*			
Cor Total	16	446.23				

Std. Dev.	0.86	Squared	0.9867	Mean	12.90
Adj R-Squared	0.9734	C.V. per cent	6.68	Pred R-Squared	0.9327
PRESS	30.05	Adeq Precision	27.490		

model was highly significant at 1per cent level of significance. The results showed that among linear effects, roller speed was more effective on peeling loss followed by retention time and emery size. All the interaction and quadratic effects were found significant for peeling loss.

The lack of fit was non significant and hence the model can be considered as quite adequate for predicting the response. The coefficient of determination (R^2) was 0.98 for peeling loss which indicated that the model could fit the data for activity very well for all the three variables, i.e. emery size, roller speed and retention time.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

$$\text{Peeling loss} = +9.57 - 0.37 X_1 + 4.96 X_2 + 1.74 X_3 - 2.81 X_1 X_2 + 1.63 X_2 X_3 + 2.5 X_1^2 + 5.75 X_2^2 - 1.23 X_3^2 \quad \text{..........3}$$

Where,

X_1 = emery size

X_2 = roller speed

X_3 = retention time

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients. The response surface equation was obtained for the model of second degree in terms of actual factors as under.

$$\text{Peeling loss} = +83.6400 - 0.47544 x_1 - 1.32275 x_2 + 0.081250 x_3 - 5.61500E\text{-}003 x_1 x_2 + 0.032500 x_2 x_3 + 6.36562E\text{-}003 x_1^2 + 9.20200E\text{-}003 x_2^2 - 0.30781 x_3^2 \quad \text{.........4}$$

Where,

x_1 = emery size

x_2 = roller speed

x_3 = retention time

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the centre of the design space.

Effect of roller speed and retention time on peeling loss

The effect of roller speed and retention time on peeling loss was determined keeping the emery size No. 80. which is shown in Fig. 4. Three dimensional responses for peeling loss of samples were generated. From these surfaces, it could be evident that peeling loss was increased with increasing retention time to some extent and then started decreasing with increase in roller speed within the selected range. As the roller speed increased, peeling loss slightly decreased and then increased.

The effect of roller speed and emery size on peeling loss was determined by keeping retention time 4 min. Fig. 5 and Fig. 6, the peeling loss was found to be increased as the roller speed increased. As emery size was increased, the peeling loss was found to be decreased slightly and then increased slightly.

Optimization of peeling efficiency and peeling loss

Numerical optimization

The main criteria for optimization were minimum peeling loss and all the input parameters in range.

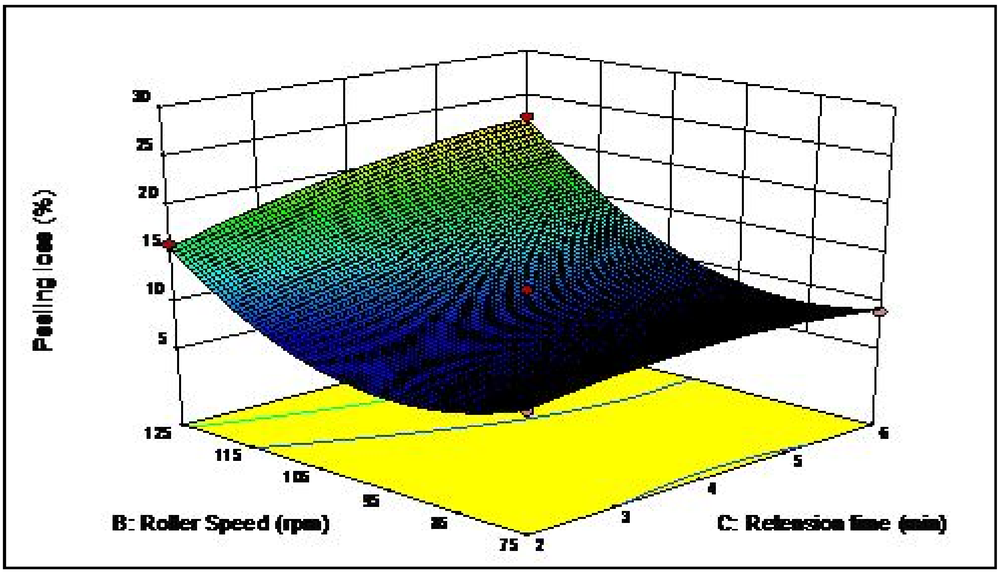

Fig. 4. Effect of roller speed and retention time on peeling loss

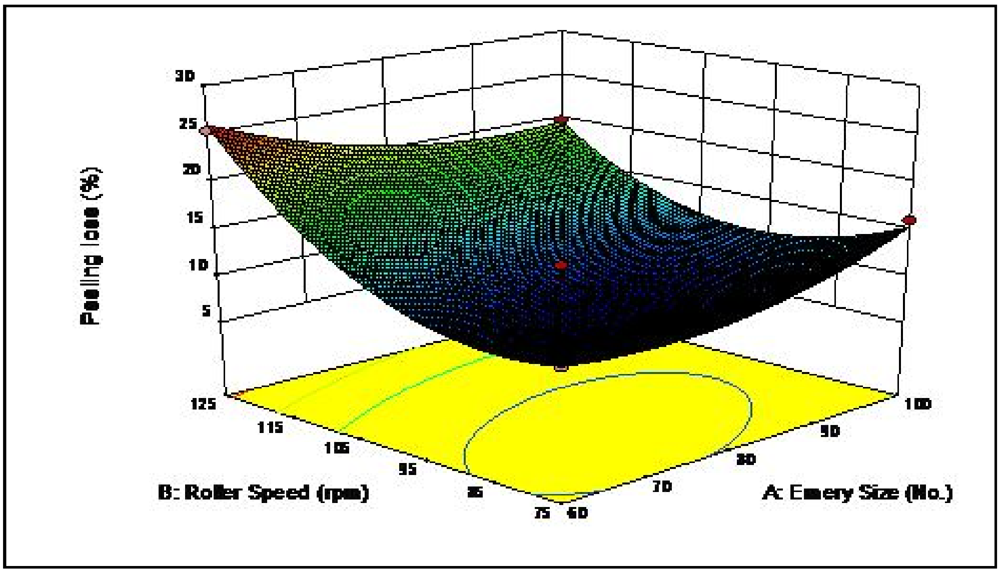

Fig. 5. Effect of roller speed and emery size on peeling loss

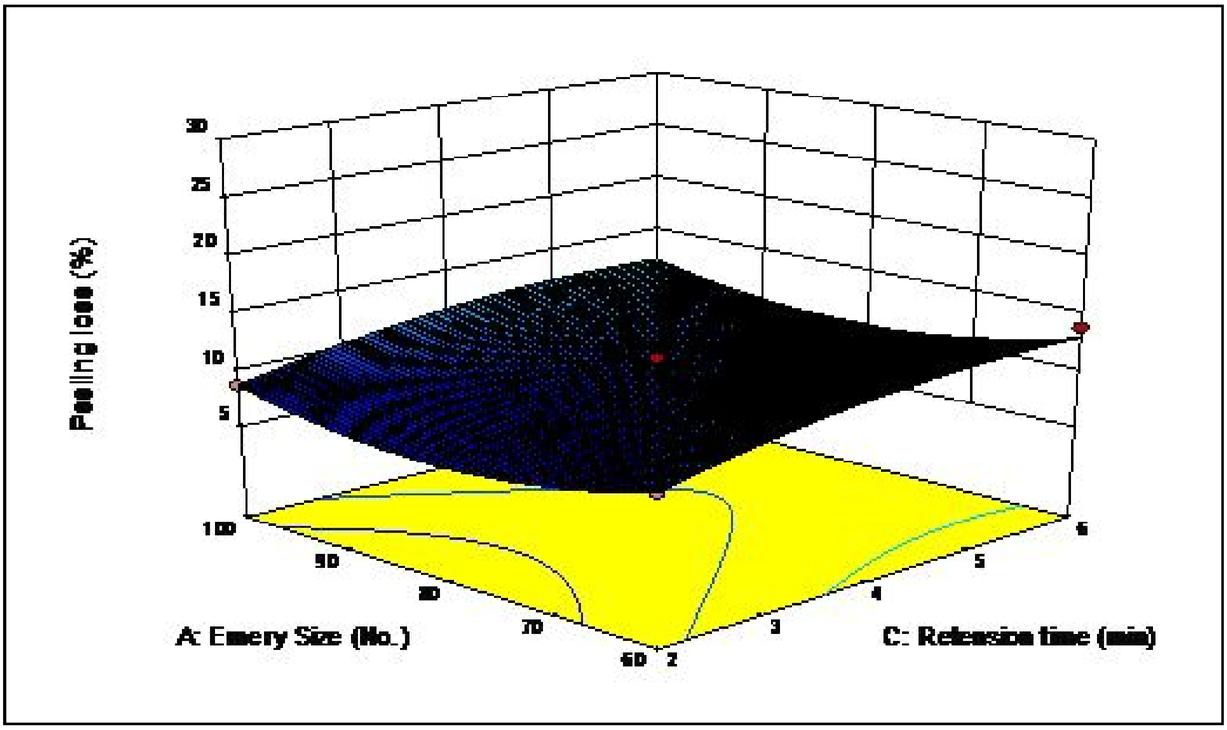

Fig. 6. Effect of emery size and retention time on peeling loss

Software Design Expert version 9.0.6.1 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 for different variables and their predicted responses thus obtained are given in Table 4.

The optimum values of different variables for peeling were found within the range considered in the study.

Graphical optimization

The superimposed contours for response and their intersection for maximum peeling efficiency (Fig. 8) indicated the range of optimum values of process variables. The superimposed contours of all the responses for emery size (No.), roller speed (rpm) and retention time (min) along with their intersection zones for maximum peeling efficiency (per cent), minimum peeling loss (per cent), indicated the range of optimum values of process variables. The optimum values obtained from superimposed contours in the ranges are given below:

1. Peeling efficiency (per cent): 75-95
2. Peeling loss (per cent): 62-90

Table 4. Optimized variables and their predicted responses for peeling of potato

Variable	Optimized values	Responses	Predicted values
Emery Size, No	86.20	Peeling efficiency, per cent	97.50
Roller Speed, rpm	92.37	Peeling Loss, per cent	9.29
Retention Time, min	5.12		
R^2	0.9327		

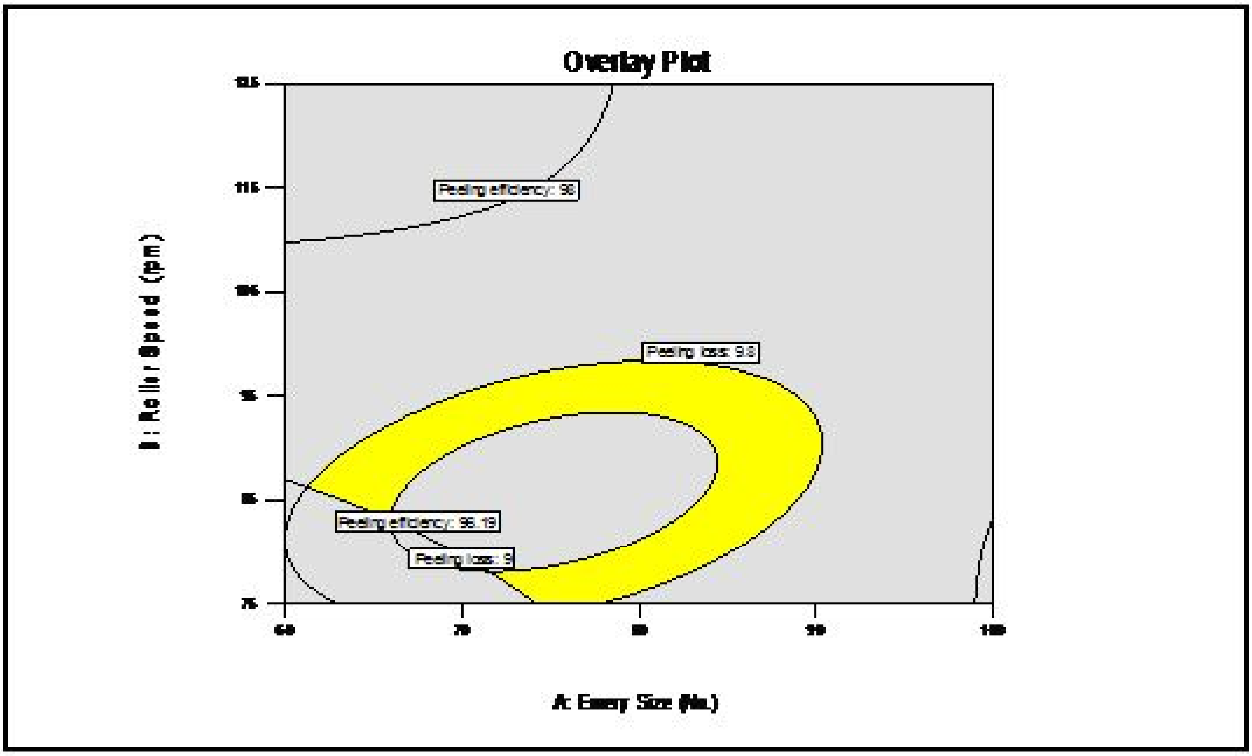

Fig. 7. Superimposed contours for peeling efficiency and peeling loss

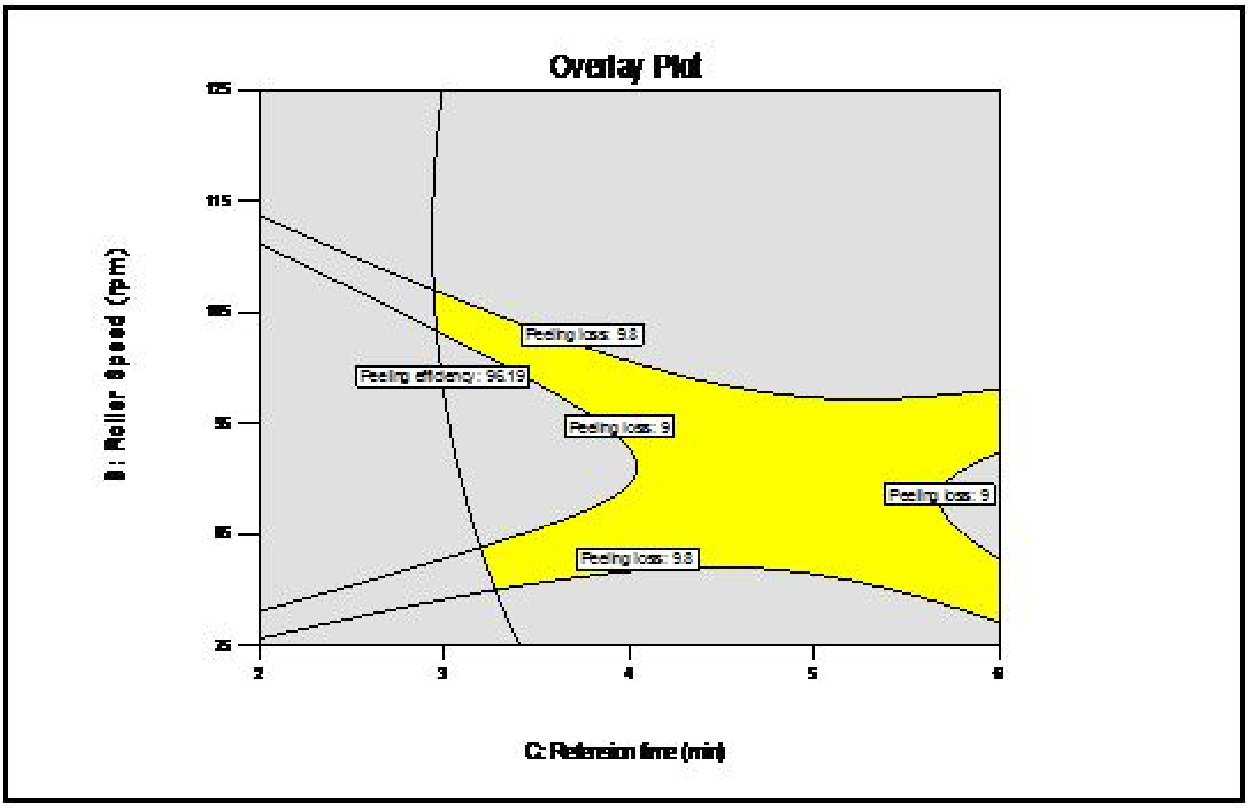

Fig. 8. Superimposed contours for peeling efficiency and peeling loss

Table 5. Predicted and experimental values of responses at optimum level of different variables

S.N.	Responses	Predicted values	*Experimental values (± SD)	C.V.
1	Peeling efficiency, per cent	97.500	94.69 (±0.86)	0.23
2	Peeling loss, per cent	9.297	4.58 (± 0.23)	6.68

* Figures in parenthesis represent standard deviation

Table 9. Practically available variables and their predicted responses for peeling of potato

Variable	Practically available variables	Responses	Predicted values
Emery size, No	80	Peeling efficiency, per cent	97.54
Roller speed, rpm	100	Peeling Loss, per cent	10.15
Retention time, min	5.12		

Verification of the model for peeling of potato

The performance of this model was also verified by conducting an experiment for the validation. In order to validate the optimum conditions of peeling treatment variables, the experiments were conducted at optimum input parameters derived conditions. The average values of three experiments are given in Table 7. The observed values of peeling efficiency and peeling loss were found to be 94.69 per cent and 4.58 per cent. It could reveal that the experimental values were very close to the predicted values which confirmed that the model was quite adequate to predict response. (Table 5).

The Practically available variables, values of different variables for peeling were found within the range considered in the study.

The optimized values of different variable emery size No. 86.20, roller speed 92.37 rpm, and retention time of 5.12 min have found to be practically less acceptable. Hence, considering the practically available variable are as emery size No 80, roller speed 100 rpm and retention time of 5.12 min, the responses obtained werer peeling efficiency 97.54 per cent and peeling loss 10.15 per cent. From Table 6, experimental values are very close to practically available variable. Hence, the combination of variable for optimized condition of machine can be considered.

Response 3: Damage Percentage (per cent)

Effect of peeling parameters on damage percentage

It revealed that the damage percentage was observed to be ranging between 0.19 to 0.49 per cent depending upon the peeling treatments. The minimum damage percentage was found for treatment having the combination of emery size No 80, roller speed 125 rpm and retention time of 2 min. The maximum damage percentage was observed in case of treatment having the combination of emery size No 60, roller speed 125 rpm and retention time of 4 min.

Table 6. Practically available variables and experimental values of responses at optimum level of different variables

S. N.	Responses	Predicted values	*Experimental values (± SD)	C.V.
1	Peeling efficiency, per cent	97.54	94.69 (±0.86)	0.02
2	Peeling loss, per cent	10.15	4.58 (± 0.23)	0.53

* Figures in parenthesis represent standard deviation

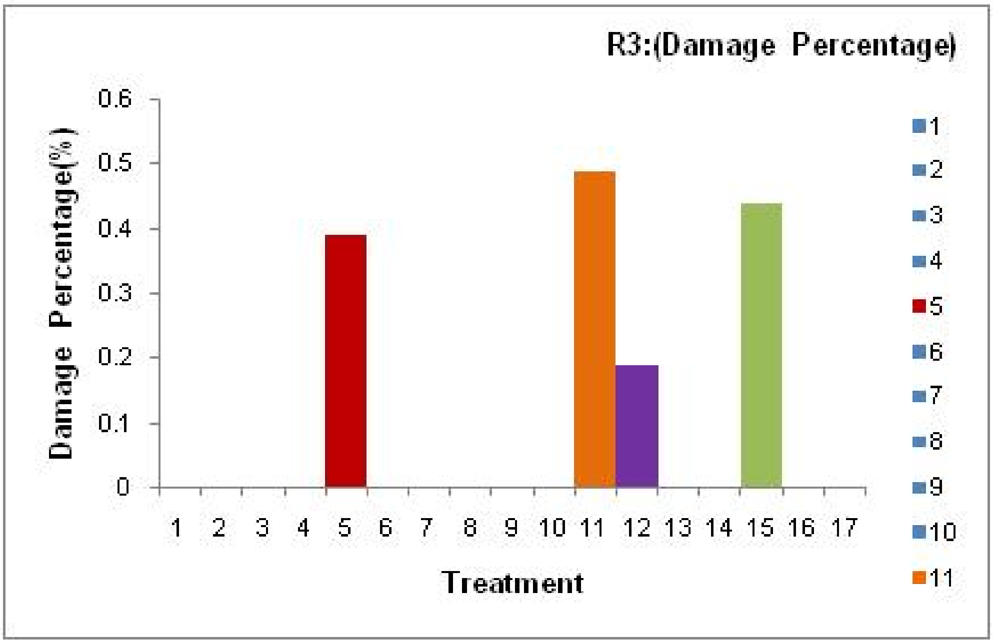

Fig. 9. Effect of emery size, roller speed and retention time on damage percentage

CONCLUSION

The developed low cost potato peeler costing Rs 30,000/- was found to work satisfactorily having 60 kg/h capacity, 98.07 per cent peeling efficiency, 25.34 per cent peeling loss and 0.49 per cent damage.

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Development of Sprouted Grains Composite Flour and It's Product

Pooja S. Ledaskar[1], I. L. Pardeshi[2], Shilpa D. Deshmukh[3] and Sejal Shedani[4]

ABSTRACT

The development of food product using composite flour has increased as per consumers demand increased for nutritional food. For sprouted grains composite flour based *chappati*, wheat and soybean were used as raw materials. The wheat grains were optimally sprouted by soaking it in clean tap water for 6 hrs, followed by six numbers of rinsing at an interval of six hours at room temperature of 32 (±2^{0}C). The soybean seeds also sprouted by soaking for 6 h followed by 6 to 7 rinsing at an interval of 6 hrs. The sprouted grains dried using laboratory tray dryer at 60 ^{0}C and 1.6 m/sec air velocity. The composition made by mixing the sprouted soy flour in sprouted wheat flour in 0 per cent, 5 per cent, 10 per cent, 15 per cent, 20 per cent, 25 per cent, 30 per cent proportion of the total composition. The level of addition of sprouted soy flour is optimized by sensory evaluation based on nine point hedonic scale where 15 per cent - 20 per cent addition was accepted. The shelf life of sprouted wheat flour is found 21 days (about 3 weeks) and that of sprouted soy flour was 36 days (about 5 weeks), if stored at 45^{0}C temperature and 95 per cent RH (Accelerated storage condition) and packed in HDPE (High density polythene) size of 100 Microns.

The critical period where children develop malnutrition coincides with the introduction of complementary foods, which are nutritionally inadequate in many developing countries (Khanam *et al*., 2011). There is a need for nutritionally balanced, energy- dense, easily digestible foods with functional benefits to be formulated. A cost- effective, nutritious and functional multi-nutrient food mix prepared using locally available raw materials, which is easily assimilated by the body and promotes growth is a good option. To achieve this objectives, use of seasonal, local, low-cost and abundantly available raw food ingredients having high nutrition and functional properties like cereals, coarse cereals and millets, soybean, dairy ingredients and horticultural produce should be advocated (Murugkar *et al.*, 2013). Wheat (*Triticum aesitivum*) is considered good source of proteins, minerals, B-group vitamins and dietary fiber, i.e., an excellent health-building food. Thus, it became the principal cereal, being more widely used for the making of bread than any other cereal because of the quality and quantity of its characteristic protein called gluten. Wheat is the most important staple food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crops (Kumar *et al.*, 2011).

Wheat provides nearly 55 per cent of carbohydrates and 20 per cent of the food calories. It contains 78.10 per cent carbohydrate, 14.70 per cent protein, 2.10 per cent fat, 2.10 per cent of minerals and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron) (Kumar *et.al.* 2011). Most common use of wheat is that its flour is used in the preparation of cakes, biscuits, breads, pizza etc and Indian traditional foods such as *poori, paratha, roti,* and *chapati*.

In the endosperm of the wheat, about 72 per cent of the protein is stored, which forms 8-15 per cent of total protein per grain weight. The wheat grain is a storehouse of nutrients essential to the human diet. Endosperm is about 83per cent of the grain weight; it is the source of white flour (Kumar *et.al,*. 2011).

Bran is about 14.5 per cent of the grain weight. Bran is included in whole-wheat flour and is available separately. Of the nutrients in whole wheat, the bran contains a small amount of protein, larger quantities of the B-complex vitamins listed above, trace minerals, and indigestible cellulose material called dietary flour. (Kumar *et al.*,2011). Wheat is the best nourishing food that can be easily given to patients and even babies.

In India, on one hand, nutritional deficiency due to limited availability of pulses is prevailing while on another hand, soybean, the major source of vegetable proteins, is having its utilization limited for oil purpose only. After appropriate processing like sprouting and converting into consumer friendly and health friendly sprouted soybean products, it would help to incorporate

1 & 4. M. Tech. Student, 2. Associate Professor and 3. Junior Research Fellow, Department of Agricultural Process Engineering, Dr. PDKV, Akola

soybean in daily diet of Indian population. For this purpose, there is a need to establish an appropriate and full proof process. This will help to ensure and adapt its routine use in the high soybean producing regions where malnutrition is still widely prevalent.

Soybean (*Glycine max* L.) described as “golden bean” has ensured its widespread consumption by strong evidence of low incident rate of breast, colon and prostate cancer or coronary diseases in the eastern countries (Plaza *et al.*, 2002). Soybean is widely used in variety of food preparation. The Food and Drug Administration (FDA) of United State confirms that soy protein, as part of a diet, low in saturated fat and cholesterol may significantly reduce the risk of coronary heart disease.The FDA recommends incorporating 25 g of soy protein in your daily meals (Anonymous, 2009a). It is rich in minerals (calcium, phosphorus and iron) and vitamins (vitamin “A”, “D”, “E” and “K”) (Prasad *et al.*,2001).

Sprouting is the practice of soaking, draining and then rinsing seeds at regular intervals until they germinate, or sprout (Anonymous, 2009). Sprouted soybean prevent the disease like cancer, lowering the level of blood cholesterol and reducing the risk of coronary heart disease, modulating the immune response and stimulating the minerals absorption. It also works as an antihypertensive and anti-diabetic agent and prevents the diseases like hypertension and diabetes (MaCue *et al.*, 2005). Therefore, the aim of the study is to use soybean and wheat in sprouted form and make a composite flour based nutritious *chapatti*. The process for sprouting of soybeans is used according to previous research (Pardeshi and Tayade, 2013) and prepared sprouted soybean are dried and stored appropriately for further usage.

MATERIAL AND METHODS

Selection of Materials

The normal wheat and soybean were the raw materials for preparation of sprouted grains composite flour.

Preparation of sprouted soybean grain

For preparation of sprouted soybean, 2 to 3 times as much cool (30-32°C) water was added in weighed sample of soybean grains and mixed up to assure even water contact for all. The grain was allowed to soak for requisite time of 4 h. The soaked soybean grains were covered into the wet cloth and soaked water was drained off. The soaked sample were set anywhere out of direct sunlight at a room temperature (32°C is optimal) between rinses for optimal sprouting. The sprouted soybeans were cleaned with running tap water, known as rinsing. The rinsing of soybeans needs to be done at an interval of 4 to 6 h and repeat it again till the sprouting is better (Soy sprouts founds better with more frequent rinses). While rinsing, the sprouts should not be disturbed. The rinsing at regular interval was done until desired sprouting was achieved (Pardeshi and Tayade, 2013).

Preparation of sprouted wheat grains

For preparation of sprouted wheat, cool water (28-30 °C) was added in weighed sample of wheat grains and mixed up to assure even water contact for all. The grain was allowed to soaked for requisite time of 6 hr. For sprouting of the soaked wheat grains, experimental setup was used which comprised of a plastic tray (30 × 36 cm), and perforated container (7 × 10 cm) of SS material. The containers were filled with soaked wheat grains. The containers arranged in the plastic tray just above the water level so as to maintain humidity. Then each container allowed to be rinsed at interval of 4 h. The tray was covered with plate and set anywhere out of direct sunlight at room temperature (32 ± 2°C).

Drying of sprouted material

The sprouted grains were dried in tray dryer in thin layer at 60 °C for 170 minutes at an air velocity 1.67 m/s (Chakraverty, 1988).

Preparation of sprouted wheat flour and sprouted soybean flour

The sprouted grains flour was obtained by grinding the sprouted dried grains using flour mill and the flour was sieved through sieve of 30 mesh (Kerr *et al.*, 2000).

Biochemical profile of sprouted wheat flour

Proximate compositions and nutritional properties of sprouted grains flour namely, protein, fat, ash and moisture content, carbohydrate + fibres, etc., required for the present investigation, were determined by following method.

The moisture content (MC) of the sample was determined by using hot air oven method. The weighed samples were subjected to remove moisture at 105 ± 2 °C for 24 hr.

$$MC\ (\%\ wb) = \frac{W_1 - W_2}{W_1 - W_3} \times 100$$

Where,

W_1 = Initial weight of the test sample and petridish (g)
W_2 = Final weight of the test sample and petridish(g)
W_3 = Weight of petridish (g)

Ash content was determined as per the method given by AOAC (1984) and Thimmaiah (2006).

$$\text{Ash Content (per cent)} = \frac{\text{Final Weight}}{\text{Initial Weight}} \times 100$$

The crude fat was determined using Soxhlet apparatus (Thimmaiah, 2006) using following equation.

$$\text{Crude fat or oil content in sample (per cent dry weight, basis)} = \frac{(a-b) \times 100}{\text{Weight of sample (g)}}$$

Where,

a - dry pre-weighed solvent flask,g
b - Final weight of cooled solvent flask,g.

Protein Content was determined by AOAC (1984).

$$\text{N per cent in sample} = (X-Y) \times 0.014 \times \frac{100}{\text{Weight of sample (g)}}$$

Where,

X - ml of H_2SO_4 for sample
Y - ml of H_2SO_4 for blank

Protein content (per cent) = Nper cent x 5.7 (Tkachuk, 1969)

Soybean grains were germinated under controlled condition and its soaking and germination time was finalized for the best results.

It was found that the germination of soybean reduced the carbohydrate content from 22.1 to 17.9 (%), ash content from 4.95 to 4.59 (%), fat 24 to 10 (%). The germination of grains increased the moisture content from 10 to 11 (%), protein content 29.09 to 34.99 (%). (Warle *et al.*, 2015)

Preparation of sprouted composite flour

The composition of sprouted wheat flour and sprouted soybean flour was made by uniformly mixing the soy flour in sprouted wheat flour in 0 per cent, 5 per cent,10 per cent, 15 per cent, 20 per cent, 25 per cent, 30 per cent proportion of the total composition. These seven levels of composition used to make final product *(chapati)* and the level of addition of sprouted soy flour was optimized by sensory evaluation.

Preparation of *chapati* from sprouted wheat grains composite flour

The *Chapatis,* which are thin, unleavened breads often made from wheat flour, represent a major portion of the diet for Indian people. *Chapatis*are typically, made from *atta,* whole wheat flour, mixed with water to form a dough. The dough is rolled thin and cooked on hot surface *(tawa)* to produce a puffed ball. The *chapati* should be uniform in diameter, well puffed on both sides, and well baked inside (Kadam *et al.*, 2012).

The final product of sprouted composite flour is *chapati* made by culinary process as given below and shown in plate 1.

1. Take 100 g of sprouted composite flour, add salt in it. Mix with 70 - 90 ml of water to make dough of it.
2. Cover the dough cover in bowl and let it rest for 15 minutes.
3. After 15 minutes, add the salt, gently mix the dough for 2 minutes, just enough to gather the dough into one piece.
4. The dough divided into a small balls and then rolled out by rolling pin on a floured surface to an approximate thickness of 1.5 - 1.6 mm. The diameter of it ranges from 80 to 100 mm.
5. Then allowed it to be cooked on hot flat cast-iron pan for 2-3 minutes until puffed (turned every 30 s).The temperature of the cast iron pan was controlled manually. Temperature was tried to maintain in range of 200-250 °C.
6. Gently press on top of the chapatti to make the *chapati* fluff up.

The *chapatis* of seven combination of composite flours were made as above and subjected to sensory evaluation. The best composition decided from the scoring sheet of sensory test. *Chapatis* of seven composite flour are shown in Plate 2, in which sprouted soy flour was mixed in sprouted wheat flour in 0 per cent, 5 per cent, 10 per cent, 15 per cent, 20 per cent, 25 per cent, 30 per cent proportion of a total composition.

Sensory Evaluation

The sensory evaluation of *chapati* of sprouted wheat grains flour as compared to *chapati* of unsprouted grains flour was carried out by a panel of seven members of untrained judges consisting of students and staff of the Department of Agricultural Process Engineering, Dr. PDKV, Akola.

The panellists were asked to indicate their preference for each sample based on the quality attributes of colour, flavour, texture, and overall acceptability (OAA) using a nine point hedonic scale (BIS, 1997).

Storage Study

The storability of sprouted grains' flour in packaging materials of HDPE (100 microns) and at 45 ± 1 ^{0}C and 95 ± 2 per cent RH was determined. The equilibrium moisture content of the product at the given set of storage condition is known, the time (days) required to attain critical moisture content was calculated using fallowing equation, (Mukherjee, 1997),

$$\frac{M - M_e}{M_0 - M_e} = Ae^{-K_H \theta}$$

where, M, M_0 and M_e are moisture contents (kg/kgdm) at time θ, at time 0 and at equilibrium, respectively; θ is the storage time in days and K_H is rate constant (days^{-1}).

RESULTS AND DISCUSSION

Biochemical profile of sprouted and unsprouted wheat flour

The fat, protein, ash, moisture contents, carbohydrate + fibres of both sprouted and unsprouted wheat flour were determined and given in Table 1.

Table 1. Biochemical profile of sprouted and unsprouted wheat flour

Particulars (per centdb)	Unsprouted wheat flour	Sprouted wheat flour
Ash (per cent db)	1.05	1.04
Protein (per cent db)	8.8	11.6
Fat (per cent db)	3.58	1.49
Moisture content (per cent db)	6.5	5.3
Carbohydrate + Fibre	81.02	80.57

Protein content increases after sprouting of wheat flour whereas fat content decreases. There is slight change in moisture content, carbohydrate and fiber content in sprouted and unsprouted wheat flour. These shows that sprouted wheat flour is rich source of protein than unsprouted wheat flour.

Sensory evaluation

The result on sensory evaluation of prepared *chapattis* showed that sprouted wheat flour mixed with upto 20per cent sprouted soy flour was considered at par with sprouted wheat flour. This composition is good in flavour, texture and colour. However with further increased percentage of sprouted soy flour in sprouted wheat flour, the values of sensory scores were found to decrease Ndife *et al.*, (2011) found the similar results for bread. The supplementation of sprouted soy flour at the level of 10 and 15 per cent has same score in the sensory attributes. The scores decreased as the supplementation of sprouted soy flour increased (Table 3). Thus the incorporation of 15 to 20 per cent sprouted soy flour could be considered for this purpose. The sample with 100 per cent (01) un-sprouted wheat flour was liked significantly higher than those samples of sprouted wheat flour and sprouted composite flour. The sample of 100 per cent (02) sprouted wheat flour have high sensory scores followed by that for sprouted wheat flour of 5 per cent (03), 10 per cent (04), 15 per cent (05) and 20 per cent (06) and were at par. The sensory scores of sample 25per cent (07) and 30per cent (08), were having the sensory scores significantly less than other samples.

Table 2. Encoding of the product considered for sensory evaluation

Product Code	Name of product
01	Chapati of 100per cent unsprouted wheat flour.
02	Chapati of 100per cent sprouted wheat flour.
03	Chapati having composition of sprouted wheat and soy flour (95:5)
04	Chapati having composition of sprouted wheat and soy flour (90:10)
05	Chapati having composition of sprouted wheat and soy flour (85:15)
06	Chapati having composition of sprouted wheat and soy flour (80:20)
07	Chapati having composition of sprouted wheat and soy flour (75:25)
08	Chapati having composition of sprouted wheat and soy flour (70:30)

Step 1: Sprouted wheat flour

Step 2: Adding salt

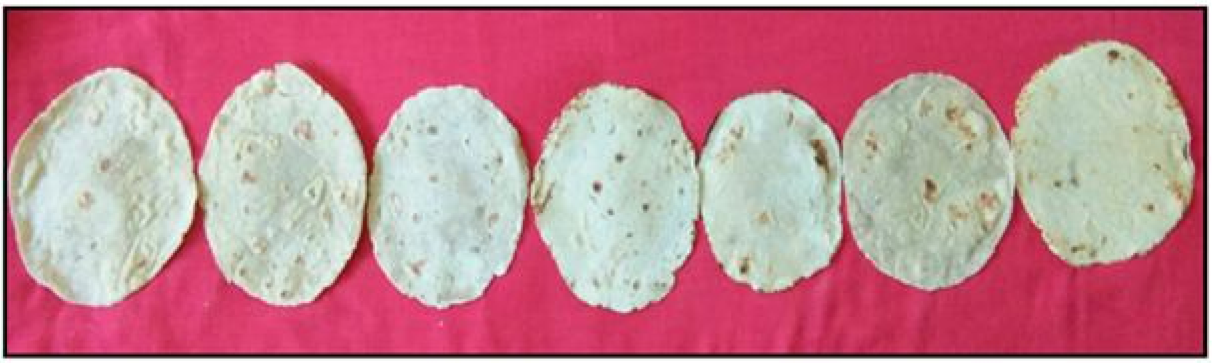
Step 3: Mixing with water

Step 4: Dough

Step 5: Roll with rolling pin

Step 6: Baked on hot flat cast iron pan

Plate 1 : Steps in preparation of un-leavened bread (*Chapati*) by culinary process



a(0 %) b(5 %) c(10 %) d(15 %) e(20 %) f(25 %) g(30%)

Plate 2 : *Chapatis* of composite flour by adding varied proportion of sprouted soy flour in sprouted wheat flour

Table 3. ANOVA (Analysis of variance) of sensory evaluation

FACTOR	MEANS								CD (5per cent)
Sample	7.964[a]	**7.357[b]**	**7.214[b]**	**7.107[b]**	**7.107[b]**	**6.928[bc]**	6.785[c]	6.535[c]	0.463
	(01)	**(02)**	**(03)**	**(04)**	**(05)**	**(06)**	(07)	(08)	
Quality Attribute	7.071	7.2321	7.0535	7.1428					NS
	(Colour)	(Flavour)	(Texture)	(OAA)					

Table 4. Properties of packaging material

S.N.	Packaging Material	Thickness (microns)	WVTR (kg water/day m^2)	Permeability (kg water/day m^2 Pa)
1	HDPE	100	0.00264	3.63 E-06

The sensory scores of sample 2, 3, 4, 5 and 6 were atpar hence incorporation of sprouted soy flour upto 20 per cent in sprouted wheat flour could be acceptable. Composite flour having high nutritional quality can be prepared from wheat flour with 10 per cent soy flour for making good quality of *chapaties*(Kadam *et al.*, 2012).

Storage of sprouted wheat and soybean flour

Storage studies was conducted on the final products (sprouted grains flour) prepared by optimized process conditions at 45 ± 1 °C temperature and 95 ± 2 per cent relative humidity and packaging materials, HDPE (Table 4) used for storage studies, as these materials are known to be fairly good moisture and oxygen resistant and are being used commercially for packaging of foods (Dhumal, 2010).

The storage studies were conducted for a period of 28 days at above given condition. One packet at each condition was taken out from the desiccators, at an interval of 7 days. The quality of the stored product was determined in terms of change in moisture content and water activity.

The critical moisture content of sprouted wheat and soybean flour was found to be 10 per cent and 11 and water activity was found out to be 0.65 and 0.72 per cent, respectively.

CONCLUSION

On the basis of the obtained results, the conclusions drown are wheat grains optimally sprouted by soaking it in water for 6 h, followed by 6-7 numbers of rinsings at an interval of 4 hr at room temperature (32 ± 2 °C). The sensory qualities of *chapati* of *sprouted* composite flour having 15 per cent to 20 per cent sprouted soybean flour were better acceptable.The addition of sprouted soy flour beyond 20 per cent in sprouted wheat flour, the values of sensory scores found to be significantly decreased further.The shelf life of sprouted wheat flour and sprouted soybean flour was 21 days (3 weeks) and 36 days (5 weeks), respectively if stored at 45 ± 1 ^{0}C temperature and 95 ± 1 per cent RH and packed in HDPE (100 microns).

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Biogas Production from Cotton Straw Substrate

A. K. Kamble[1], S. B. Kirjat[2] and M. B. Nagdeve[3]

ABSTRACT

Studies on biogas production from cotton crop residue inoculated with cattle dung was undertaken for utilization of biomass as bio-energy generation. The five plastic bottles i.e. digesters of 2 liter capacity was arranged in such a way that the first digester contained ratio of 25:75 (Cotton straw : Cattle dung), the second digester contained ratio of 50:50, third bottle contained ratio of 75:25 and fourth and fifth digesters content cattle dung and cotton straws alone. In proximate analysis of cotton straw the average moisture content, volatile matter, ash content and fixed carbon was found to be 7.43, 67.60, 4.50 and 20.47 per cent, respectively. The calorific value of cotton straw was found to be 3342.56 kcal kg^{-1}. The optimum biogas production of 32,445 ml was observed in the proportion of 25:75 substrate of cotton straw mixed with cattle dung. The highest percentage of methane was observed to be 65.05 per cent using cotton straw mixed with cattle dung in the ratio of 25:75.

Biogas is a gaseous mixture generated during anaerobic digestion processes using waste water, solid waste (landfills) and organic waste, e.g. animal manure and other sources of biomass. Anaerobic digestion is the biological degradation of biomass in oxygen-free conditions. In the absence of oxygen, anaerobic bacteria will ferment biodegradable matter into methane (40-70 %), carbon dioxide (30-60 %), hydrogen (0-1%) and hydrogen sulfide (0-3 %), a mixture called biogas. Biogas is formed solely through the activity of bacteria. Although the process itself generates heat, additional heat is required to maintain the ideal process temperature of at least 35°C. Mainly cattle dung has been used as the major feed material for anaerobic digestion, which is not likely to have significant impact globally. The scope of this technology could widen by tapping other organic materials like plant waste, industrial waste, municipal waste and water hyacinth (Maduand Sodeinde, 2001; Tsunatu e*t al*., 2014).Cotton is the major crop of Maharashtra grown in kharif season. Cotton straw is left as a residue after its pickings in India which is often get rid of by open burning in the field.

Open burning causes many problems such as influence on soil nutrition, soil moisture, pollution and being flammable to nearby structures. Cotton waste (cotton plant straws, cotton leaves and cotton seed hulls) is one of the agricultural wastes that is considered as ‘‘energy source’’ especially in countries where the cotton is being cultivated on a large scale. The area under cultivation of cotton was found to be 105 lakh ha and 38.06 lakh ha in India and Maharashtra, respectively. The production of cotton was 351 lakh bales and 89 lakh bales in India and Maharashtra respectively. The production of cotton straws in 2015-16 in India, Maharashtra and Vidarbh is 37.95 MT, 12.57 MT and 3.72 MT, respectively. It is estimated that about 25 million tons of cotton straw is generated in India every year (Anonymous, 2016). Most of the straw produced is treated as waste though a part of it is used as fuel by rural masses. On average cotton plant straw contains about 68 per cent hemi-cellulose, 26 per cent lignin and 6 per cent ash. Availability of LPG gas as a fuel is one of the major challenges faced by our modern society. Alternative energy sources have recently become more and more attractive due to the increasing demand for energy, the limited resource for buying fossil fuel, the environmental concerns, and the strategies to survive post-fossil fuel economy era and one of the alternative sources of energy is biogas (Isciand Demirer, 2006). As cotton is the major crop of Vidarbh region and has major biomass source as renewable energy.In this study attempt has been made to develop experimental set up of biogas digesters and to evaluate their performance using cotton strawas substrate.

MATERIAL AND METHODS

The experimental set up of biogas production from cotton straws substratewas developed in the workshop of College of Agriculture Engineering and Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and the experiment conducted in the Department of Unconventional Energy Sources and Electrical Engineering, Dr. PDKV, Akola. The agricultural crop residue of cotton was collected from Dr. PDKV farm and store in the Department of UCES & EE. The residue was chopped and dried in sunlight for a week before being grinded to reduce its particle size.The required size of particles were

1. Assistant Professor, 2. M. Tech. Student and 3. Dean, Faculty of Agricultural Engineering, Dr. PDKV, Akola

prepared to fulfill the requirements of biogas production and to achieve high biogas yields. Feed stock materials pecifications range was less than 2 mm for biogas production. The size reduction of agricultural crop residues was made by grinding machine and sieve shaker (Mmabyalwa *et al.*, 2015).

Characterization of cotton straws

In order to assess the quality of cotton straw, it was characterized for its proximate and ultimate analysis. In a proximate analysis of cotton straw it was characterized for determination of moisture content, volatile matter, ash content and fixed carbon. In ultimate analysis of cotton straw it was characterized fordetermination of carbon, hydrogen, nitrogen, and sulphur based on the American Society of Testing and Materials (ASTM) standards. The oxygen was obtained by subtracting the percentage of ash, carbon, hydrogen, nitrogen and sulphur from 100 per cent (Patel and Gami, 2012).

Determination of calorific value

Calorific value of any biomass is the amount of the heat liberated by the combustion of biomass under specific conditions. The heat value in a given biomass is mostly a function of the biomass chemical composition. The higher heating value (HHV) is the total amount of heat energy that is available in the biomass, including the energy contained in the water vapor in the exhaust gases. The lower heating value (LHV) does not include the energy embodied in the water vapor. The calorific value was calculated using Dulong's formula.

$$HCV = \frac{1}{100}\left[8080\,(C) + 34500\left(H - \frac{O}{8}\right) + 2240\,(S)\right] \ldots 1$$

Where,

C - Carbon

H - Hydrogen

O - Oxygen

S – Sulphur

$$LCV = HCV - 0.009\,(\%\,of\,H)\,x\,587 \qquad \ldots 2$$

Experimental setup for performance evaluation of biogas digesters

The five plastic bottles (digesters) of 2 liter capacity were arranged in such a way that the first digester contained ratio of 25:75 of cotton straw (CS) and cattle dung (CD), the second digester contained ratio of 50:50 (CS:CD), third bottle contained ratio of 75:25(CS:CD)and fourth and fifth contain cattle dung and cotton straw alone. All the containers were connected with plastic tubes of 10 mm in diameter. One end of the tube was connected to the digester and another end was inserted in the gas measuring jars. The lids of all digester were sealed tightly in order to control the entry of air and loss of biogas. Measuring cylinders filled with water were inverted and placed in the plastic containers immersed in water.The amount of biogas produced replaced the amount of water from measuring cylinders and easily measured the quantity of biogas produced by every digester. The decreased in level of water column in the measuring cylinders was the biogas produced. The complete experimental set up is shown in Fig. 1.

(1) (2) (3) (4) (5)

(1) 25:75 ratio of cotton straw (CS) and cattle dung (CD)
(2) 50:50 ratio of cotton straw (CS) and cattle dung (CD)
(3) 75:25 ratio of cotton straw (CS) and cattle dung (CD)
(4) 0:100 Cattle dung alone
(5) 100:0 Cotton straw alone

Fig. 1. Experimental setup for performance evaluation of biogas digesters

The proportions of substrates of cotton straw and cattle dung added in the digesters is given in Table 1.

Table 1. Experimental proportion of cotton straw mixed with cattle dung

Particulars	25:75	50:50	75:25	0:100	100:0
Cotton straw (g)	187.5	375	562.5	0	750
Cattle dung (g)	562.5	375	187.5	750	0
Water (ml)	750	750	750	750	750
Total sample (g)	1500	1500	1500	1500	1500

Determination of available N:P:K contents in substrates and digested slurry

The nitrogen content in substrates and digested slurry was determined by Kjeldahl's method.The phosphorus content in substrates and digested slurry was determined by Olsen's method. One milliliter extract was used in test tube and according to Olsen's method, reagent (R1) was prepared by adding 42 ml H_2SO_4 in 100 ml chilled distilled water in volumetric flask of 250 ml. Then, the mixture was shaken after the addition of 4.3g ammonium heptamolybedate. Reagent (R2) was prepared by taking 1.75 g polyvinyl alcohol (PVA) in 1 liter beaker, and heated with 200 ml of de-ionized water at 80 °C and stirred with a glass rod. After cooling this mixture, 0.175 g malachite green was added. Reagent 1 (R1) was added and kept for 10 minutes. Then, Reagent 2 (R2) was added and left for 30 minutes. Bluish green color was appeared in the extract as phosphorus was present in it. Spectrophotometer (HITACHI U-2000) at 610 nm wavelength was used to detect the phosphorus content present in the extract raw mixture substrates and digested slurry. After the wet digestion of samples according to the method of Wolf, potassium was determined after the extraction by ammonium acetate (1 N of pH 7.0). Potassium content in raw mixture substrates and digested slurry samples were determined by using 7 flame photometer.

RESULTS AND DISCUSSION

The proximate analysis of cotton straw was carried out to determine moisture content, volatile matter, ash content and fixed carbon (Table 2).

Table 2. Proximate analysis of cotton straw

S.N.	Particulars	Cotton straw
1	Moisture content (%)	7.43
2	Volatile matter (%)	67.60
3	Ash content (%)	4.50
4	Fixed carbon (%)	20.47

The average moisture content, volatile matter, ash content and fixed carbon in cottonstraw was found to be 7.43, 67.60, 4.50 and 20.47 per cent, respectively.

Ultimate analysis of cotton straws

The carbon, hydrogen, nitrogen, sulphur and oxygen content was determined by using ultimate analysis of cotton straw and it was found to be 43.63, 5.56, 1.63, 0.55 and 44.36 per cent, respectively (Table 3).

Carbon is the most important element in the fuel as it has direct influence on the heating value according to same; higher the carbon content i.e. 43.63 per cent in cotton crop residue represents higher heating value of fuel and the C:N ratio of cotton straw was found to be 26.77.

Table 3.Ultimate analysis of cotton straw

S.N.	Particulars	Cotton straw
1	Carbon, (%)	43.63
2	Hydrogen, (%)	5.56
3	Nitrogen, (%)	1.63
4	Sulphur, (%)	0.55
5	Oxygen, (%)	44.36

Calorific value of cotton straw

The higher calorific value (HCV) for cotton straw was observed to be 3342.56 kcal/kg, and the lower calorific value (LCV) of cotton straw was worked out to be 3249.06 kcal/kg (Table 4).

Table 4. Calorific value of cotton crop residues

S.N.	Calorific Value	HCV (kcal kg^{-1})	LCV (kcal kg^{-1})
1	Cotton straw	3542.80	3249.06

Average daily biogas production in each digester

The quantity of biogas produced from the cotton straw and cattle dung feed stock of 1500 ml quantity over a period of 50 days at an average ambient temperature of 38ºC are summarized in Fig.2.

The cumulative biogas produced from each digester was measured until it stopped to produce any more gas. In the course of measurement, all ratios of feed stocks appeared to yield more biogas than cattle dung alone. It means that, biogas production is a function of the feedstock's organic content and its biodegradability. The digester containing 25:75 ratio of cottonstraw and cattle dung, and other two ratios of 50:50 and 75:25 started biogas production from 6th, 7th and 9th day, respectively after loading feed stock, while biogas production commenced on 4th day after loading feed stock in the digester containing 100per cent cattle dung. Highest biogas production observed in the digester containing substrate mixture of 25:75 and no biogas was produced in digester containing cotton straw alone mixed with water. The biogas production started early in the digester containing 100 percent cattle dung. This could be due to its partial fermentation that usually takes place in digestive tract of ruminant animal.

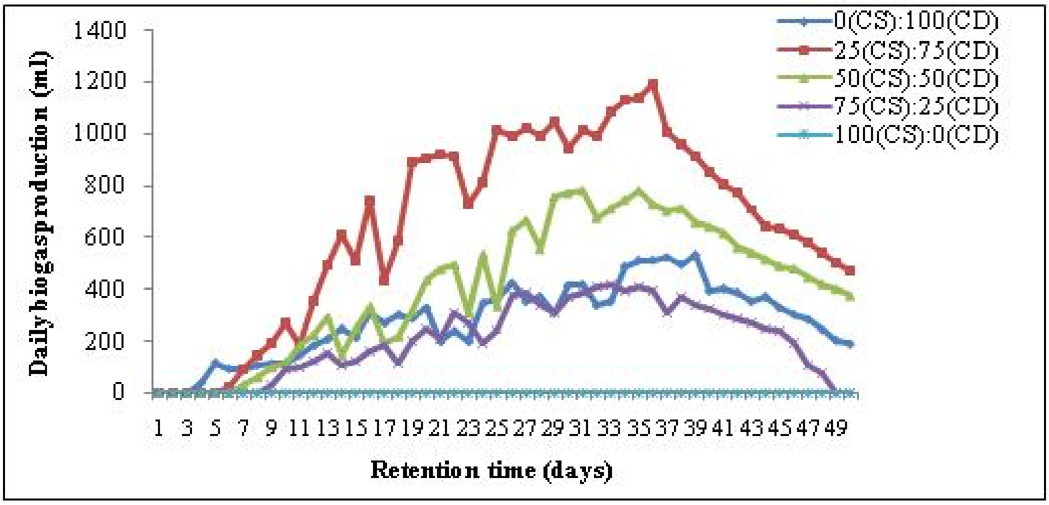

Fig. 2. Daily biogas production from various ratios of cotton straw with cattle dung

Cumulative biogas production from various ratios of cotton straw with cattle dung

The cumulative biogas production was estimated by adding daily biogas production yield. The maximum biogas produced 32445 ml from 1500 ml of slurry in the ratio of 25:75 of cotton straw and cattle dung followed by 20375 ml in 50:50 ratio, 14115 ml in cattle dung alone. i.e. 0:100 and 10200 ml in 75:25 ratios whereas, no gas was produced in the substrate used as cotton straw alone (Table 5).

Table 5. Cumulative biogas production from cotton straw with cattle dung substrates

Retention period (day)	Biogas production from cotton straw and cattle dung (ml)				
	0:100	75:25	25:75	50:50	100:0
50	14115	10200	32445	20375	0

It was observed that biogas production was actually slow initially and at the end of observations. This is predicted because biogas production rate in batch condition is directly equal to specific growth of methanogenic bacteria. During the first week of observation, there was less biogas production, this may be due to the lag phase of microbial growth. Whereas, in second week of observations, biogas production increased substantially and this might be due to more growth of methanogens.The maximum biogas obtained in the ratio of 25:75 proportion of crop residue inoculated with cattle dung. Cotton straws content higher percentage of hemi-cellulose (75.1 %) and the amount of hemi-cellulose reduced the biodegradation rate in the digester and ultimately reduced the biogas production.

Analysis of the biogas produced from cotton straw substrate

Methane yield is an important economic factor in anaerobic digestion. The highest CH_4 was produced in the ratio of 25:75 using cottonstraw and cattle dung. It was found that the co-digestion enhanced methane yields. The composition of biogas produced from various ratios of cotton straw inoculated with cattle dung was analyzed by gas chromatographs at National Environmental Engineering Research Institute(NEERI) Nagpur and is shown in Table 6.

Table 6. Composition analysis of the biogas produced from various ratioscotton strawinoculated with cattle dung

S.N.	Proportions (Straw: Cattle dung)	In cotton straw and cattle dung	
		CH_4 (%)	CO_2 (%)
1	0:100	60.40	32.62
2	25:75	65.05	34.02
3	50:50	61.46	32.33
4	75:25	58.49	29.85
5	100:0	No Gas Found	

Compositional analysis of biogas produced from cotton straw and cattle dung maintaining various proportions is shown in Table 6. The percentage of methane observed in the biogas sample produced from cotton straw mixed with cattle dung in the proportion of substratewas varied from 58.49 to 65.05 per cent. The highest percentage of methane was observed in case of 25:75 ratio of cotton straw and cattle dung and in other ratios of 0:100, 50:50 and 75:25, methane percentage was found to be 60.40, 61.46 and 58.49 per cent, respectively (Table 6). The CO2 percentage was observed to be 32.62, 34.02, 32.33 and 29.85 per cent in 0:100, 25:75, 50:50 and 75:25 ratios, respectively.

Determination of NPK content analysis of cattle dung and digested slurry

Cattle dung is the major source of biogas production. Cattle dung and digested slurry both are being used as organic manure for agriculture. Nitrogen contents in cattle dung and digested slurry was determined by Kjeldahl nitrogen assembly apparatus. The concentration of phosphorus and potassium was determined by using spectrophotometer and flame photometer, respectively.The nitrogen, phosphorus and potassium contents in cattle dung and digested slurry were determine in the laboratory at the Department of Soil Science and Agricultural Chemistry Dr. PDKV, Akola and the results are presented in Table 7.

Table 7. N:P:K content in cattle dung and digested slurry of various proportions of cotton strawmixed with cattle dung

S. N.	Proportions (Cotton Straw: Cattle dung)	Cotton straw inoculated with cattle dung		
		N (%)	P (%)	K (%)
1	0:100	1.17	1.09	0.32
2	25:75	1.36	1.12	0.58
3	50:50	1.25	1.01	0.43
4	75:25	1.22	0.84	0.40
5	100:0	1.10	0.53	0.16

From Table 7 it is seen that, the fresh cattle dung content 1.17, 1.09 and 0.32 per cent, N:P:K, respectively and after digestion of substrate in the biogas digester N:P:K content increased up to 1.36, 1.12 and 0.58 per cent, respectively and which was higher than that of any proportion of cotton straws inoculated with cattle dung (Kamble, 2016).

The nitrogen concentration in cattle dung was lower than that of digested slurry samples. The reason is that slurry being the thermopile bacteria broken down the organic wastes and fixed the amount of nitrogen in it during the anaerobic fermentation of cattle dung in biogas production. The digested slurry contains higher amount of nitrogen than that of the cattle dung mixed with water. However, in cattle dung the nitrogen concentration may be lost because of different reasons. As during sun-drying operation, the manure lost nitrogen roughly equivalent to the whole of free ammonia present. The results revealed that a concentration of nitrogen and potassium was high in digested slurry whereas, the concentration of phosphorus was high in cattle dung. The study suggests that slurry is effective and rich manure as compared to cattle dung.

CONCLUSION

The optimum biogas production of 32, 445 ml was observed in the proportion of substrate of cottonstraw mixed with cattle dung in the proportion of 25:75.The highest percentage of methanewas observed to be 65.05 per cent in case of cotton straw inoculated with cattle dung maintaining the ratio of 25:75 of cotton straw and cattle dung.

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Performace Evaluation of Mini Green Pea Pod Shelling Machine

H. M. Khobragade[1], P. A. Borkar[2] and M. K. Dhote[3]

ABSTRACT

Pea is a grain legume commonly used throughout the world in human cereal grain diets. India is the world's second largest producer of food next to China, and has a great potential in the food and agriculture sector. Pea contains approximately 21-25 per cent protein. Fresh peas are used in various dishes. The use of fresh green pea kernels is increasing day by day. At present green pea pods are shelled manually which are laborious, energy and time consuming. There is need to develop small green pea pod shelling machine. In view of above, mini green pea pod machine was developed and performance was evaluated for shelling green pea pod. The physicalproperties of green pea (variety-*Arkel*) were determined before testing. RSM was used to determine the effect of roller speed and roller clearance on shelling efficiency of mini green pea pod shelling machine. The developed mini green pea pod shelling machine has 61.01per cent shelling efficiency with 2 mm roller clearance and roller speed of 1650 rpm.

Green Pea is a grain legume commonly used throughout the world in human cereal grain diets. Pea has high levels of amino acids, lysine and tryptophan, which are relatively low in cereal grains. Pea contains approximately 21-25 per cent protein. Peas contain high levels of carbohydrates, are low in fiber and contain 86-87 per cent total digestible nutrients, which makes them an excellent livestock feed. Pea contains 5 to 20 per cent less of the trypsin inhibitors than soybean. This allows it to be directly fed to livestock without having to go through the extrusion heating process. It is used as fresh or canned peas in many parts of India, China, Africa, Central America and the Caribbean. The fresh seeds can also be frozen and canned for commercialization and export.

In India, fresh peas are used in various dishes such as aloo matar (curried potatoes with peas) or matar paneer (paneer cheese with peas), though they can be substituted with frozen peas as well. Peas are also eaten raw, as they are sweet when fresh off the bush. Split peas are also used to make dhal, particularly in Guyana, and Trinidad, where there is a significant population of Indians. Green peas are one of the most nutritious leguminous vegetables rich in health benefiting phyto-nutrients, minerals, vitamins and anti-oxidants. Fresh green peas are very good in ascorbic acid (vitamin C). 100 g of fresh pods carry 40 mg or 67per cent of daily requirement of vitamin C.

Mechanization implies the use of agricultural machinery in performing the farm operations speedily and efficiently. There is a large scope of vegetable processing as green vegetables are very essential item of daily food. In previous years, not much emphasis was given on green pea pod shelling. At present green pea pods are shelled manually which are laborious, time consuming and hence its use is limited up to kitchen level in various forms like curry, chutney, paste, roasted nuts, salted and boiled pods, etc.

One person can shell about 3-3.5 kg of green pea pods in one hour (Sharma and Singh, 1989). Therefore, it was felt necessary to develop a small power operated green pea pod shelling machine in order to save time, energy, labour and provide maximum benefits to the consumer at domestic level.

Mitchell *et al.* (1969) has developed a commercial machine for shelling peas after numerous tests of methods for removing peas from pods. A standardized feed gap between the conveyor and the rollers separates shelled peas from unshelled pods. Pods which fail to be gripped by the roller pass to a second slightly modified shelling section. Extensive tests showed that a greater yield of peas was obtained from the sheller operated on hand picked peas, than from conventional stationary or mobile viners operated on vines. Yield for the combination of a mechanical pea pod picker which would be necessary for commercial operations and the pea sheller was not determined. Peas from the sheller were virtually undamaged in contrast to vined peas and were consequently superior in flavor.

The depoding machine not only helps to reduce the time for depoding of pea pods, but can alsobe used as

1. Senior Research Scientist, 2. Head and 3. M.Tech. Student, Department of Agricultural Process Engineering, Dr. PDKV, Akola

a good opportunity for small farmers. By packing the depoded green pea grain, they are able to get more income on investment. Some attempts were madeto make a machine for shelling the peas and similar leguminous crops on commercial and large scale as wellas on small scale. But various types of functional problems were observed during their operation. The observed efficiency of peas shelling was also not recorded. Hence there is an immense need of making anew model of pea depoding machine which could beeasily used on farmer level as per Indian conditions.

Keeping in view the facts placed above, a research study was undertaken at Department of Agricultural Process Engineering, Dr. PDKV, Akola with following objectives

* To study some physical properties of Green pea.
* To evaluate the performance of a mini green pea pod shelling machine.

MATERIAL AND METHODS

The machine was developed and evaluated at the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. PDKV, Akola. The physical and engineering properties of green pea pods and kernels were determined in the laboratory of Department of Agricultural Process Engineering, Dr. PDKV, Akola.

Physical and engineering properties of green pea pods and kernels

Green Pea was procured from local market of Akola. The samples of pea were cleaned manually to remove all foreign materials such as dust, dirt, immature peas etc.Samples of 100 green peas were randomly picked and used for the determination of moisture content(Rangana, 2000). The procedure described in IS: 4333 (Part IV) – 1968 was adopted. Average of five replications has been considered and reported in this study.

The knowledge of engineering properties of any biomaterial is fundamental. It facilitates the design and development of agricultural equipment for different agricultural operations including separation and processing of agricultural products. Some engineering properties of green pea pod and kernel were studied for proper development of a machine. To measure the true density, bulk density of the seed, the method is given in IS : 4333 (Part III) was used. The degree of sphericity was calculated using the procedure given by Mohsenin, 1986.

On the basis of literature, various parameters which can affect the shelling of peas were selected and analyzed inorder to make a good design and described as follow:

Details of developed mini green pea pod shelling machine

A developed mini green pea pod shelling machine was easy to fabricate for removing green pea pods from kernels. It consist of main frame, feeding hopper, shelling unit, power transmission unit, safety guard, pea pod outlet and kernel outlet (Fig.1).

Main frame was supported body, made of cast iron, on which all the parts of the sheller were fastened together. A feed hopper has a horizontal plate supported with two side plates. The function of these side plates is to support the hopper for smooth feeding of green pea pods into the shelling unit. Horizontal plate helps to provide slope for sliding green pea pods manually into the shelling unit. A shelling unit consist of pair of plain rubber roller on shaft with gear assembly and provision for adjustable roller clearance. The adjustable angle block was provided to achieve the different roller clearance. It varies from 0 to 10 mm. Surface of roller made up of some hard material with corrugated surface, it would bring the shearing and friction action which was seen that shelling roller works or increase the grip of pea pod in between the rollers and also reduce to mashed pea kernels.

A high quality India made, 220 volt $\frac{1}{12}$ hp motor was used to transmit the power through belt and pulley mechanism. There are discharge outlets for shelled green pea pod behind the roller assembly and other for kernels.During operation to reduce the sliding and vibration of machine, rubber buffers were provided at the bottom of the main frame to reduce the vibrations and for absorbing shock during operation. The different parts of the machine is shown in figure 1.

Initial trial and parameter checking

Fresh mature green pea pods were procured from local market of Akola city. The variety selected for testing of green pea pods shelling machine was *Arkel*.

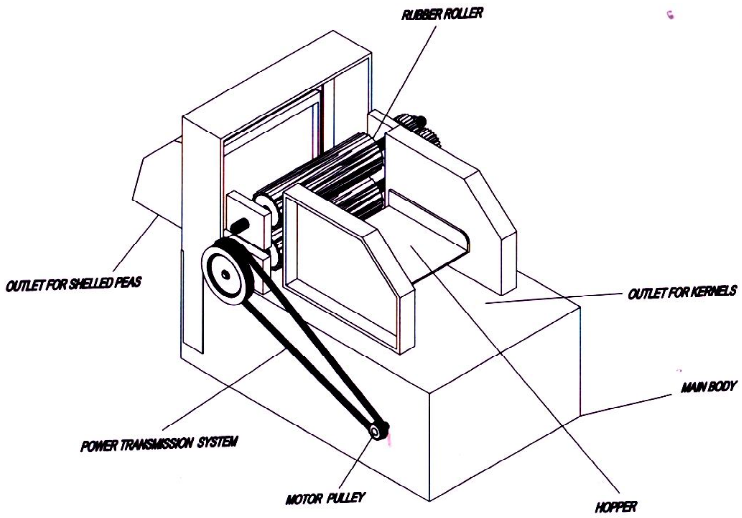

Fig. 1 Isometric view of mini green pea pod shelling machine

Table 1. Technical Specifications of developed mini green pea pod shelling machine

S.N.	Items	Parameters	Dimensions
1.	Type of machine	Portable	
2.	Machine parameters	Length	420 mm
		Width	285 mm
		Height	280 mm
3.	Wt. of machine		8.4 Kg
4.	Roller Parameters	Shaft diameter	10 mm
		Shaft length	250.5 mm
		Roller surface	Corrugated
5.	Power transmission unit	Motor, HP	1/12 hp
		Belt & Pulley	220 volt
6.	Roller clearance adjustment		0 to 10 mm
7.	Rubber buffer		04 Nos.

Table 2. Levels of independent variables for green pea pod shelling.

Independent variables	Symbols	Levels		
	Coded	Un-coded	Coded	Un-coded
Roller Speed, rpm	**X**	R	2	2000
			1	1800
			0	1600
			-1	1400
			-2	1200
Clearance, mm	**X,**	C	2	2.4
			1	2.2
			0	2
			-1	1.8
			-2	1.6

Performance evaluation of mini green pea pod machine

The physical properties of green pea pods and kernels were measured before testing.

The weight of 6 kg sample of green pea pod was taken. Before starting the actual experiment, preliminary trials were conducted and mini pea pod shelling machine was cleaned thoroughly. The motor was started and then the pods were fed to the feeding unit for shelling operation. Green pea pod were shelled by uniform feeding at constant speed. The feed rate was controlled by clearance adjusted less than the average pod size. As the green pea pod feed in between the rollers with suitable clearance and rpm, it offers compression and consequently holds the pod and develops shearing force on it. Due to which shearing action takes place which shear off the husk from the backside of shelling unit through the outlet and kernel were gets collected in seed outlet beneath the horizontal plate from another outlet. After completion of shelling operation, the machine was stopped and different samples of shelled sample like whole kernels, damage kernels, and unshelled pods were collect cautiously. Same procedure was repeated on different roller speed and clearance between rubber rollers to get better shelling efficiency.

The performance of the developed mini green pea pod shelling machine was evaluated for its suitability for shelling of green pea pods with following parameters.

Factor studied and experimental design

The optimize shelling parameters of Mini Green Pea shelling machine that affected shelling efficiency of machine were considered for analysis Independent parameters after conducting some filler trials.

Following parameters were decided after conducting some filler trials.

1. Speed of rubber roller (R) -1200, 1400, 1600, 1800, 2000) rpm
2. Clearance between rubber roller (C) - 1.6, 1.8, 2, 2.2, 2.4) mm

The important design factors that affected shelling efficiency of mini green pea shelling machine were compared roller speed and clearance between rollers. The experimental design of independent parameters is shown in Table 2.

Dependent parameters i.e. Shelling efficiency was calculated by following expressions,

Shelling efficiency, per cent = $(1-\frac{Mup}{M1})\,(1-\frac{Mdk}{M1})$

Where,

Mup = Mass of unshelled pods, g.
MdK = Mass of damaged kernels, g.
M1 = Total mass of green pea pods before shelling, g. (Singh, 2000)

Statistical Analysis

Response surface methodology (RSM) is a collection of statistical and mathematical techniques, which consist of experimental design for defining the range of the independent input variables, empirical mathematical model to explore an appropriate approximating relationship between the output responces and the input variable and optimization methods for achieving the optimum values of the process parameters that produce the desirable responses (Montgomery, 2001).

Response surface methodology (RSM) was applied to the experimental data using Software Design expert version 9 (Statarse Inc, Minneapolis, USA, Trial Version 2015). In order to test the adequacy of the developed mathematical models and to indicate wheather the model developed is meaningful the analysis of variance (ANOVA) method were used. The ANOVA table for the model concludes the analysis of response and the significant model terms. The significance test of regression model and lack of fit test are carried out by software Software Design expert version 9. The lack of fit value of the mathematical model implies that it is not significant. The other adequacy measures such as R^2 illustrates adequacy of the model.

Sixteen trials were performed as enumerated in Table 3 for obtaining of shelling efficiency.

RESULTS AND DISCUSSION

Determination of Physical and Engineering Properties of green pea pod

In order to develop a machine, various parameters which affect the machine performance need to be studied carefully. In this research some physical and engineering properties of green pea pods and kernels were collected such as axial dimensions, geometric mean

Table 3. Experimental layout for 2 variable 5 levels response surface analysis

Experiment No.	Roller speed, (RPM)	Clearance, (mm)	Roller speed (RPM)	Clearance (mm)
	Coded independent variable		Un-coded independent variable	
	X	X,	R	C
1	-2	2	1200	2.4
2	1	-1	1800	1.8
3	-1	0	1400	2
4	-2	-2	1200	1.6
5	0	1	1600	2.2
6	0	1	1600	2.2
7	0	-2	1600	1.6
8	2	2	2000	2.4
9	2	0	2000	2
10	-2	1	1200	2.2
11	-2	-1	1200	1.8
12	2	0	2000	2
13	2	-2	2000	1.6
14	2	2	2000	2.4
15	0	-2	1600	1.6
16	0	1	1600	2.2

Table 4. Some physical and engineering properties of green pea pods and kernels

	Green pea pods			Green pea kernels	
Particular	Range	Average (SD)	Particular	Range	Average
Length, mm	47.01-86.01	70.73 ±8.50	Length, mm	8.56-11.28	9.98
Width, mm	8.24-16.75	12.88 ± 2.28	Width, mm	7.23-10.25	8.66
Thickness, mm	8.23-12.61	9.65± 2.03	Thickness, mm	7.25-10.41	7.88
Geometric mean diameter, mm	14.16-24.37	20.42±2.51	Geometric mean diameter, mm	6.87-9.59	8.25
			Sphericity (per cent)	83-94	87.98
			Surface area, mm2	62.98-186.53	132.92
Bulk density, g/cc	0.273-0.329	0.295±0.23	Bulk density, g/cc	0.60-0.66	0.633 ±0.023
True density, g/cc	0.688-0.873	0.783±0.078	True density, g/cc	0.012-1.67	1.01
Porosity, per cent	59.62-66.93	63.78 ±3.066	Porosity, per cent	17.13-42.85	35.53
Angle of repose, degree	27.55-33.69	29.15 ±2.56	Angle of repose, degree	24.5-33.69	28.10
Thousand pod weight, g	4526.25-4856.3	4701.19 ± 126.04	Thousand kernel weight, g	378.15-423.95	391.91 ±18.91

diameter, thousand grain mass, true and bulk density and moisture content. Shelled peas were investigated at the moisture content of green pea kernel 76.27- 85.95 per cent (wb).

Physical properties

Some physical and engineering properties of green pea pods and kernels were measured at 78.81 to 85.78 per cent (w b) and moisture content of green pea kernel was found to be 76.27-85.95 per cent (wb). Major, minor and perpendicular axis of green pea pods and kernels were measured. The observation was replicated fifty times and average was calculated (Table 4). The fresh green pea pods and kernels weight (1000 unit mass), size, bulk density, true density, porosity and angle of reposed were varied in the range of 4526.25 to 4856.30 g, 14.16 to 24.37 mm, 0.271 to 0.3292 g cm^{-3}, 0.6881 to 08737 g cm^{-3}, 59.62 to 66.93 per cent , 27.55 to 33.69^0 and 378.15 to 423.95 g, 6.87

to 9.59 mm, 0.60 to 0.66 g cm^{-3}, 0.0127 to 1.674 g cm^{-3}, 17.13 to 42.85 per cent, 24.5 to 33.69^{0} respectively. The surface area and sphericity of green pea kernels varied from 62.98 to 186.53 mm^{2} and 83 to 94 per cent, respectively. This study showed considerable variation in some physical properties of green pea (variety *Arkel*).

Effect of roller speed and roller clearance on shelling efficiency

The effect of the roller speed (A) and clearance between rollers (B) were evaluated during experimentation and are shown in Table 3. Data which are shown in Table 3 were tested with 16 number of experiments in order to find the best relationship between independent and variables. The maximum value of shelling efficiency was 65.68 per cent observed in case of experiment having combination of roller speed of 1600 rpm and clearance between rollers of 2.2 mm.

Optimization of input parameters for shelling of green pea pods

Optimization of process parameters such as roller speed (rpm) and clearance (mm) is necessary for maximum shelling efficiency. The coded and un-coded levels of independent variables viz. roller speed and roller clearance are shown in Table 2. The Sixteen trials were performed as enumerated in table 3 for obtaining shelling efficiency for each treatment were measured.

Fitting the model

The analysis of variance (ANOVA) was made for the experimental data and the significance of roller speed and roller clearance was analyzed. The ANOVA was performed for different model in order to find the best model with highest significant. The result indicated that the response surface quadratic model was fitted to the experimental data and statistical significance of linear and other terms were analysed for shelling efficiency (Table 5). The result of lack–of–fit sum of squares are shown in Table 4. The lack-of-fit test was done in order to find the model adequacy.

The model F value of 13.20 implies that the model was significant at 1per cent level of significance ($P<0.05$). The R^2 value was found to be 0.868 showing good fit of model to the data. The lack of fit F value was non-significant which indicates that the developed model was adequate for predicting the response. “Adequate precision” measures the signal to noise ratio. The ratio greater than 4 is desirable. Ratio of 10.614 indicates an adequate signal. This model can be used to navigate the design space.

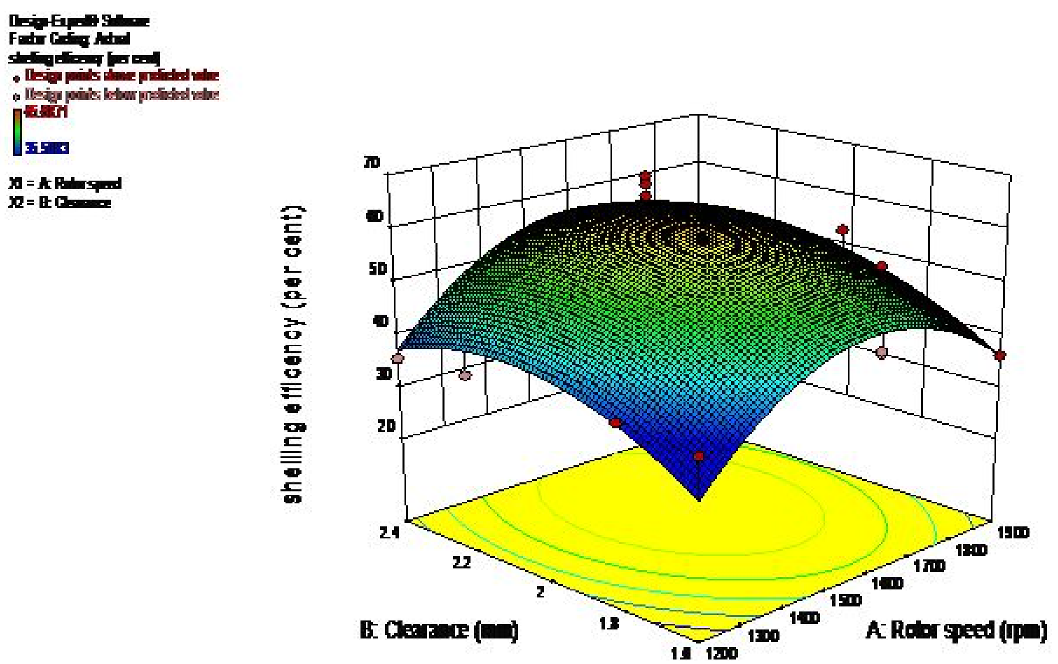

Fig. 2. Effect of roller speed and clearance on shelling efficiency

Table 5. Analysis of variance for shelling efficiency during shelling of green pea pods

Source	Sum of Squares	df	Mean Square	FValue	p-value Prob> F	
Model	1348.31	5	269.66	13.20	0.0004	Significant
A-Roller speed	387.46	1	387.46	18.96	0.0014	
B-Clearance	125.89	1	125.89	6.16	0.0324	
AB	27.47	1	27.47	1.34	0.2732	
A2	777.10	1	777.10	38.04	0.0001	
B2	188.66	1	188.66	9.23	0.0125	
Residual	204.31	10	20.43			
Lack of Fit	141.89	5	28.38	2.27	0.1942	not significant
Pure Error	62.42	5	12.48			
Correlation Total	1552.62	15				
R-Squared	0.8684					
Adj R-Squared	0.8026					
Pred R-Squared	0.6055					
C.V. per cent	9.65					
Adeq Precision	10.614					

Table 6. Optimization criteria for different process variables and responses for shelling of green pea pods

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A:Roller speed	Is in range	1200	2000	1	1	3
B:Clearance	Is in range	1.6	2.4	1	1	3
Shelling efficiency	maximize	35.51	65.68	1	1	3

Table 7. Predicted and experimental values of response of optimum process parameters for shelling of green pea pods

Responses	Predicted value	*Experimental value (± SD)	C.V., %	C.C.(r)	C.D.(r^2)
Shelling efficiency,per cent	61.01	58.73±0.7505	1.28	0.41	0.17

*Average of three replications

The regression equation describing the effects of the input parameters on shelling efficiency in terms of coded values of variables is given as

$$\text{Shelling efficiency} = +59.55 + 6.25A + 4.10B + 2.00AB - 11.85A^2 - 8.45B^2 \quad \ldots\ldots\ldots 1$$

Where,

A= Roller speed, rpm

B= Clearance, mm

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficient.

The regression equation describing the effects of input parameters on shelling efficiency in terms of actual value of variable is given as

$$\text{Shelling efficiency} = -388.12382 + 0.28918A + 199.47476B + 0.014264AB - 9.67259EA^2 - 52.83623B^2 \quad \ldots\ldots\ldots 2$$

Where,

A = Roller speed, rpm

B = Clearance, mm

The equation in terms of actual factors can be used to make predictions about the response for given levels of each others. Here, the levels should be specified in the original units for each other. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at all center of the design space.

To visualize the combined effect of two variables on the shelling efficiency, the response surface and contour plots (Fig. 2) for the fitted model as a function of two variables. It is observed that as the roller speed increased initially the shelling efficiency increased upto certain limit and then decreased. Also as the clearance between rollers increased initially the shelling efficiency increased and then decreased gradually.

The main criteria for constraints optimization were roller speed, clearance in range and for maximum possible shelling efficiency (Table 6).

The software generated optimum conditions of independent variables with the predicted values of responses were found to be 1650 rpm roller speed, 2 mm roller clearance, shelling efficiency of 61 per cent with desirability of 84 per cent and selected for testing the model.

The observed experimental values (mean of three experiments) and values predicted by the equation of the model are presented in table 7. The experimental values were found to be close to the predicted values for shelling efficiency, with C.V. as 1.28 per cent. Therefore it could be concluded from above discussion that model equations 1 and 2 are quite adequate to assess the behavior of shelling of green pea.

CONCLUSION

The developed mini green pea pod shelling machine have 61.01 per cent shelling efficiency with 2 mm roller clearance and roller speed of 1650 rpm.

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Energy Analysis of Cotton Crop Production System

A. K. Kamble[1] and M. B. Nagdeve[2]

ABSTRACT

Energy analysis of cotton crop production system was undertaken to estimate energy input and output involved in cotton crop production in cotton growing areas of Vidarbha region (M.S.). Three types of energies were considered for quantification of requirement of energy for performing various agricultural operations in cotton viz., mechanical energy used by mechanical devices in field operation, animal energy and human energy. The consumption of fuel was collected for the various field operations. The total estimated energy was determined in MJ/ha by multiplying with standard energy equivalent of the particular parameters. The important farm operations like land preparation, sowing, intercultural operations, irrigation, fertilizer application, picking etc. were considered in the cotton crop production. Similarly, human energy used in the field operations was determined by considering the number of labours requirement for field operations. Field operation wise and source wise energy input utilization for cotton crop production and output energy from cotton was worked out. Total energy input was workout to be 12577.76 MJ ha^{-1} and output energy was worked out to be 17275 MJ ha^{-1} and net energy was worked out to be 4697.24 MJ ha^{-1}. The highest energy consumption of 7253 MJ ha^{-1} was observed in fertilizer application followed by ploughing (1562 MJ ha^{-1}), cotton stalk uprooting (893.28 MJ ha^{-1}),harrowing (703.88 MJ ha^{-1}) and picking (628.32 MJ ha^{-1}). The energy output-input ratio, specific energy, energy productivity and net energy for cotton crop production was worked out to be 1.37, 8.59 MJ kg^{-1}, 0.12 kg MJ^{-1} and 4697.24 MJ ha^{-1}, respectively.

Energy consumption per unit area in agriculture is directly related with the development of technological level and production. The inputs such as fuel, electricity, machinery, seed, fertilizer and chemical takes significant share of the energy supplies to the production system in modern agriculture. Efficient use of the energy resources is vital in terms of increasing production, productivity, competitiveness of agriculture as well as sustainability to rural living. Energy auditing is one of the most common approaches to examine energy efficiency and environmental impact of the production system. It enables researchers to calculate input-output ratio, other relevant indicators and energy use pattern in agricultural activity. Moreover, the energy audit provides sufficient data to establish functional forms to investigate the relationship between energy inputs and outputs.

Energy use pattern and contribution of energy inputs vary depending on farming systems, crop season and farming conditions. Energy input-output analysis is usually used to evaluate the efficiency and environmental impacts of production systems. This analysis is important to perform necessary improvements that will lead to a more efficient and environment-friendly production system. The Maharashtra has a significant share in the total agricultural production in India. Cotton is the main crop grown in the Maharashtra in Kharif season with 42 lakh ha area under cotton cultivation. Therefore, considering a major crop of the Maharashtra, energy input and output in cotton crop production was examined in the present study. The main objective of this study was to evaluate the energy input and output for cotton production system. Questionnaire for data collection for energy requirement for cotton cultivation system is finalized by concerning with social scientist of Extension Education and Economist of Agricultural Economics and Statistical Department of Dr. Panjabrao Deshmukh KrishiV idyapeeth, Akola (Dr. PDKV). Data for the cultivation of cotton crop system were collected from 60 farmers by using a face-to-face questionnaire method. This study seeks to analyze the effect of indirect and direct energy on yield using functional form. In addition to these parameters, it was also aimed to calculate energy output and input, energy productivity and specific energy used in the field crop production. In Vidarbha region of Maharashtra, human, animal energy, tractor, oil engines, electric motors and power tiller are the source of energy being used to perform various farm operations. Large quantities of the energy inputs are used in the form of physical inputs like fertilizers, chemical, seed, farm yard manure etc.

1. Assistant Professor and 2. Dean, AICRP on Energy in Agriculture & Agro-based Industries, Faculty of Agricultural Engineering, Dr. PDKV, Akola (M.S.), INDIA

Information pertaining to requirement of energy with its respective source together with cost of production is of immense utility and importance to agriculture. Investigation on the use of energy per unit area for different crops are very important particularly at times, when the country is facing energy crisis and undertaking investigation, which forecasted requisite data on the energy crises issues. It becomes necessary to study energy use pattern and also to study the possibility of optimizing the returns by re-allocation of energy input resources. After careful consideration and in light of above present investigation was undertaken to know the requirement of energy for performing various farm operation in cultivation of cotton crop production.

MATERIAL AND METHODS

The present study was undertaken in Akola, Amravati and Yavatmal districts. The districts were selected purposely because these districts are contributing major cotton growing area. The climate of the area is semi-arid. The majority crops grown in Vidarbha are dependent on rainfall. Cotton, soybean, sorghum, green gram are the major crops cultivated in *Kharif* season. The study was mainly designed to collect pertinent facts about energy requirement in cotton crop cultivation. The emphasis was given on the studies of energy requirement in cotton crop cultivation system.The focus of the present study is centered on the computation of energy requirement for performing different agricultural operations. Therefore, it becomes an inevitable to discuss and describe the procedure followed for computation of energy required for performing different agricultural operations. Three types of energies were considered for quantification of requirement of energy for performing various agricultural operations in cotton. The first one is mechanical energy used by mechanical devices in field operation. The consumption of fuel was collected for the various field operations. The total estimated quantity of energy was determined in MJ ha^{-1} (multiplied by diesel equivalent energy (MJ/l). The important farm operations like land preparation, sowing, intercultural operations, irrigation, fertilizer application, picking etc. were considered in the cotton crop production. Similarly, human energy used in the field operations was determined by considering the number of labours required for field operations. The consumption of bullock energy for field operation was determined in cotton production. The basic input required for the cotton production of seed, fertilizer, organic manure, irrigation were considered to show the outlet of stated parameters in terms of energy for the input energy required for cotton crop production. In order to workout total requirement of energy i.e. summation of mechanical energy, human energy and bullock energy and the primary input were considered together and thus total energy required for crop under study was estimated (Alipou*et al.*, 2012).

Parameters of the study

Following parameters were studies for energy analysis of cotton cultivation system.

Table 1: Parameters and their measures

SN.	Parameters	Empirical measures
1	Area under cultivation	Hectares of land actual put under cultivation
2	Power sources	Bullock power, tractor power, both bullock & tractor power and human energy used
3	FYM application	Quantity of FYM applied for cotton cultivation
4	Irrigation sources	It refers to the irrigation sources used by farmers
5	Hoeing	Number of hoeing applied for cotton cultivation
6	Input energy	It refers to actual energy obtained from direct and indirect energy resources.
7	Yield	It refers to the quantity of yield obtained from each farmer.
8	Output energy	It includes actual energy from cotton, fiber and cotton stalk.

Energy analysis of cotton cultivation system

Energy analysis attempts to take in to account all forms of energy inputs to system and energy output from the system, to establish their energy relationship for understanding the energy requirement of the various operations. The total energy input include direct and indirect energy requirement. The total output energy was calculated from cotton fiber and stalk and their energy equivalent. Input output analysis was primarily made to examine the quantity of energy produced by the system against expending a certain quantity of energy. The ratio of output energy to input is called as energy ratio. The input output ratio of energy was estimated by the following formula. (Kalbande*et.al*., 2011; Oren and Ozturk, 2006).

$$\text{Energy use efficiency \%} = \frac{\text{Output energy, MJ}}{\text{Input energy, MJ}}$$

Specific energy or energy intensity has been widely used in energy analysis to express quantity of energy invested to produce unit quantity of product. The unit of specific energy is MJ/kg.

$$\text{Specific energy, MJ/kg} = \frac{\text{Energy input (MJ/ha)}}{\text{Crop output (kg/ha)}}$$

Energy productivity which measures the quantity of production per unit of input energy (kg/MJ) i.e. inverse of specific energy was term used in energy analysis.

$$\text{Energy Productivity, kg/MJ} = \frac{\text{Crop output (kg/ha)}}{\text{Energy input (MJ/ha)}}$$

The net energy of the cotton crop production was determined using following formula.

$$\text{Net energy MJ/ha} = \text{Energy output (MJ/ha)} - \text{Energy input (MJ/ha)}$$

Where energy input represents the energy use in the form of direct and indirect mode for cotton crop production. The input energy for various operations and the input deployed for growing of cotton crop was determined. The energy equivalents were used for estimation of energy required for cotton crop production is given in Table 2 (Dagistan *et al*., 2009).

Table 2. Energy equivalents for estimation of inputs and outputs energy of cotton production

Input	Energy equivalent, MJ/unit
Human labour (h)	1.96
Diesel	47.8
Chemical fertilizers (kg)	
Nitrogen	60.6
Phosphorus	11.1
Potassium	6.7
Chemicals (kg)	
Herbicides	238
Insecticides	199
Cotton seed(kg)	25
Irrigation (m^3)	0.63
Yield (kg)	11.8

RESULTS AND DISCUSSION

The distribution of respondent on selected characteristics have been presented and described in this part. The characteristics namely, land holding, power sources, farm yard manure, fertilizer application, hoeing, irrigation, input energy have considered exploiting the effect on output energy and cotton yield. The actual area of land in hectares possessed by farmer for cotton cultivation is given in Table 3.

Table 3 Distribution of respondents according to area under cotton crop and power sources used

S.N.	Category	Frequency (N=60)	Percentage %
	Area under cotton crop cultivation		
1.	Marginal Farmer (< 1 ha)	21	35
2.	Small Farmer (1 to 2 ha)	24	40
3.	Semi medium farmer (2 to 4 ha)	11	17.5
4.	Medium farmer (4 to 10 ha)	5	7.5
5.	Large farmer (> 10 ha)	0	0
	Power sources		
1.	Manual power	0	0
2.	Bullock power	0	0
3.	Tractor power	0	0
4.	Bullock+ tractor power	0	0
5.	Manual +Bullock+ tractor power	60	100

The data presented in Table 3 indicates that, the marginal farmer, small farmer, semi medium farmer, medium farmer and large farmer having actual area under cotton cultivation was 35 per cent,40per cent, 17.5 per cent and 7.5 per cent, respectively and it has been also noticed that there was no sample found in the category of large farmer. The actual power sources used by the farmers includes manual power, bullock power, tractor power, both bullock and tractor and all three sources together and the power sources wise distribution of respondents is given in Table 3. Further it is revealed that 100 per cent respondents were found to use all the above three sources together. The above findings are in conformity with the observation that majority respondents prefer both bullock and tractor for cultivation of cotton crop.

Operation wise energy requirement for cotton crop production

Actual energy utilized for various farm operations viz., ploughing, harrowing, FYM application, sowing, fertilizer application, irrigation, hoeing, weeding, spraying, picking, stalk uprooting, stalk collection and transportation of cotton crop production are discussed below in following sections.

Energy requirement for land preparation

The farmers prepared the land by ploughing followed by harrowing and planking and some farmers prepared the land by ploughing followed by rotavator operation. Generally, farmers ploughed their land after every three year and around 61.67 per cent farmers had ploughed their land by tractor drawn MB plough (Table 4). The average energy required for ploughing by MB plough was worked out and found to be 1562 MJ ha^{-1} and 703 MJ ha^{-1} for tilling soil by rotavator. The total energy required for land preparation was worked out 2265 MJ ha^{-1}. However, 38.33 per cent farmers had not ploughed their land and preferred to used five tines cultivator followed by harrowing or tilling by rotavator and the energy requirement was worked out to be 1243.19 MJ ha^{-1}.

Table 4. Energy requirement for land preparation

S.N.	Particulars	Frequency (N=60)	Percentage, %	Av. energy, MJ/ha
1.	Ploughing	37	61.67	1562.00
2.	Rotavator	48	80.00	703.88
			Total energy	**2265.88**
1.	Five tine cultivator (Panji)	23	38.33	539.31
2.	Harrowing/rotavator	23	38.33	703.88
			Total energy	**1243.19**

Energy requirement for sowing cotton

Almost all farmers had used bullock drawn seed drill and manual dibbling for sowing delinted cotton seeds as seen in Table 5. The local bullock drawn seed drill (Tifan) was used by the 81.67 per cent farmers. The average energy utilized for sowing a unit hectare of land of cotton seeds was found to be 316.95 MJ ha^{-1} and energy of seed input was used 26.75 MJ ha^{-1}. The 18.33per cent farmers sown cotton seed by dibbling method and the energy required was worked out to be 144.30 MJ/ha.

Table 5. Energy requirement for sowing cotton seeds

S.N.	Particulars	Frequency (N=60)	Percentage, %	Av. energy, MJ ha^{-1}
1.	Sowing by bullock drawn seed drill (Tifan)	49	81.67	290.20
2.	Seed input	-	-	26.75
			Total energy	316.95
1.	Dibbling	11	18.33	47.10
2.	Cross marks by marker	11	18.33	97.20
			Total energy	144.30

FYM application and irrigation facilities

FYM application refers to FYM used by respondents for production of cotton. It is apparent from the data (Tables 6) that 53.33per cent of respondents used FYM in the farm and 46.67 per cent farmers have not used FYM. Similarly, 46.67 per cent farmer's did not had irrigation facility and only 46.67 per cent of respondents had the irrigation facility for cotton crop production. The average energy utilized for irrigation of cotton crop was worked out to be 99.0 MJ ha^{-1}.

Table 6. Distribution of respondent according to FYM application and irrigation

S.N.	Particulars	Frequency (N=60)	Percentage, %	Av. energy, MJ ha^{-1}
1.	No FYM used	28	46.67	-
2.	FYM used	32	53.33	142.50
	Irrigation			
1.	Non Irrigation	28	46.67	-
2.	Irrigation	32	53.33	99.0

Energy requirement for hoeing

It is evident from the data (Table 7) that maximum percentage (56.67%) respondent had done four times hoeing for cotton cultivation. As much as 28.33 per cent of respondents done hoeing up to three times, a remaining 15 per cent of the respondents had done hoeing up to five times, respectively. The average energy used by the farmers for hoeing was found to be 438.81MJ ha^{-1}.

Table 7. Distribution of respondent according to hoeing number and energy requirement

S.N.	Particulars	Frequency (N=60)	Percentage, %	Av. energy, MJ ha^{-1}
1.	3 times hoeing	17	28.33	438.81
2.	4 times hoeing	34	56.67	
3.	5 times hoeing	9	15.00	

Energy requirement for weeding in cotton crop

It is revealed from the data (Table 8) that maximum percentage (70 %) respondents had done three times weeding in cotton crop. As much as 25 per cent of respondents done weeding up to two times, and remaining 5per cent of the respondents had done weeding up to four times. The average energy used by the farmers in weeding operation was found to be 270.48 MJ ha^{-1}.

Table 8. Distribution of respondent according to weeding numbers

S.N.	Particulars	Frequency (N=60)	Percentage, %	Av. energy, MJ ha^{-1}
1.	2 times weeding	15	25.0	270.48
2.	3 times weeding	42	70.0	
3.	4 times weeding	03	5.0	

Fertilizer application

The farmers gave first fertilizer dose at the time of sowing called as basal dose of N:P:K amounting to 40:50:50 kg ha^{-1}. On an average farmers used to apply three fertilizer doses including basal dose. The average energy utilized for total N:P:Kfertilizer application was estimated to be 7253 MJ ha^{-1} (Table 9).

Table 9. Fertilizer application and energy used in cotton crop production

S.N.	Particulars	Av. Energy, MJ ha^{-1}			Total Energy, MJ ha^{-1}
		N	P	K	
1.	First Basal dose (July) basal (N:P:K) 40:50:50	2424	555	335	7253
2.	Second dose (August) only N= 35 kg/ha	2121	-	-	
3.	Third dose (Sept.) N= 30 kg/ha	1818	-	-	
	Total	6363	555	335	

Energy requirement for spraying in cotton crop

That maximum percentage (60 %) respondents had sprayed pesticides three times on cotton crop(Table 10). As much as 31.67 per cent of respondents had sprayed pesticides two times and remaining 8.33 per cent of the respondents had sprayed pesticides four times. The average energy used by the farmers in spraying pesticides was found to be 269.54 MJ ha^{-1}.

Table 10. Distribution of respondents according to spraying numbers

S.N.	Category	Frequency N=60	Percentage, per cent	Av. Energy, MJ ha^{-1}
1.	2 times spraying	19	31.67	269.54
2.	3 times spraying	36	60.00	
3.	4 times spraying	5	8.33	

Energy requirement for picking of cotton

It is evident from the data in Table 11 that around 51 women labours were used for picking cotton and the average energy required for picking cotton was worked out 628.32 MJ ha^{-1}.

Table 11. Energy requirement for picking of cotton

S.N.	Operation	Labours required, Nos.	Av. Energy, MJ ha^{-1}
1.	First picking	10	628.32
2.	Second picking	11	(Energy equivalent
3.	Third picking	14	of women labour
4.	Fourth Picking	13	1.54 MJ ha^{-1})
5.	Fifth picking	3	
	Total women labours	51	

Cotton stalks uprooting

The cotton stalks were uprooted by tractor drawn v-blade and were collected by women labours. The energy required for uprooting was estimated 893.28MJ ha^{-1} (Table 12).

Table 12. Energy requirement for cotton stalks uprooting

S.N.	Operation	Av. Energy, MJ ha^{-1}
1.	Cotton stalk uprooting by V Blade (844 MJ/ha) and labours required for stalks collection (49.28 MJ ha^{-1})	893.28

Output energy assessment

The assessment of energy from cotton yield was workout and presented in Table 13. On an average five picking were made by the farmers and yield of cotton is shown against each picking in Table 13. The total energy from yield of cotton was estimated 17275 MJ ha^{-1}.

Table 13. Output energy from yield of cotton

S.N.	Particulars	Yield, q	Av. Energy, MJ ha^{-1}
1.	First picking	2.17	17275 (Energy equivalent of cotton 11.8MJ kg^{-1})
2.	Second picking	2.55	
3.	Third picking	4.60	
4.	Fourth Picking	4.40	
5.	Fifth picking	0.92	
	Total yield	14.64	

Operation wise and source wise energy input utilization for cotton crop production and output energy is summarized in Table 14. Energy input-output and efficiency calculation in cotton crop production is given in Table 15.

Table 14. Operation wise average energy input coefficient (MJ/ha) required for cotton crop production

S.N.	Operations	Energy, MJ ha^{-1}
	Input Energy	
1	Ploughing	1562.00
2	Harrowing /rotavator	703.88
3	Sowing	316.95
4	FYM application	142.50
5	Irrigation	99.0
6	Hoeing	438.81
7	Weeding	270.48
8	Spraying	269.54
9	Fertilizer application	7253.00
10	Picking	628.32
11	Cotton stalk uprooting	893.28
	Total input energy	**12577.76**
	Output energy	**17275.00**

Table15. Energy input-output and efficiency calculation in cotton crop production

S.N.	Particulars	Value
1.	Total energy input, MJ ha^{-1}	12577.76
2.	Output energy, MJ ha^{-1}	17275.00
3.	Energy output input ratio	1.37
4.	Specific energy, MJ kg^{-1}	8.59
5.	Energy productivity, kg MJ^{-1}	0.12
6.	Net energy, MJ ha^{-1}	4697.24

CONCLUSION

Operation wise and source wise energy input utilization for cotton crop production was worked out to be 12577.76 MJ ha^{-1} and output energy from cotton was workout to be 17275 MJ ha^{-1} and net energy was estimated to be 4697.24 MJ ha^{-1}.

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Development and Performance Evaluation of Hand Operated Vegetable Root Crop Washer

H. M. Khobragade[1], P. A. Borkar[2], P. H. Bakane[3] and B. V. More[4]

ABSTRACT

The root crops like potato, carrot, radish, beetroot, etc. after harvesting from the field need to be cleaned off the soil and foreign particles before processing and transporting to market. Presently, the farmers followed a traditional method of cleaning the root crops by washing manually with hands and feet. Large size washers are available in the big industries and they are very costly and cannot be used in the field. At present there is no low cost equipment available for washing root crops for small farmers. Therefore, a low cost vegetable root crop washer was developed and tested to give the solution to this problem. It consists of main frame, cylindrical wash drum with washing matt, adjustable water spraying assembly, handle, feeding inlet, outlet chute with holding capacity of 10 kg batch^{-1}. The overall dimensions of the vegetable root crop washer are 1520x1690x795 mm and the fabrication cost of the machine was found to be Rs. 8620/. Potato was used for performance evaluation of washer. The result indicated that the capacity of lost cost vegetable root crop washer was found to be 340 kg ha^{-1} for potato tubers. The maximum washing efficiency was found to be 98 per cent with loading capacity of 10 kg per batch of potato tubers with 10 to 12 rpm of handle to reduce minimum skinning damage.

Root and Tuber Crops are the most important food crops after cereals. Many root crop like potato, turnip, carrot, radish and beet root are major root crops grown in the India. Potato is fourth major crop after rice, wheat and maize in the world. Potato is also a cash crop of great importance. Potatoes are underground tubers that grow on the roots of a plant. India ranks second in the world in the production of potatoes (45,343,600 t). The production of potatoes is the largest among all other root crops and also the demand for the potato is more in processing industries. In India Potato is cultivated on of about 1973000 ha and the production is about 415.55 lakh tonns with productivity of 21.1 MT ha^{-1} during 2013-14 (Indian Horticulture Database, 2014).

In Maharashtra state, potato is one of the major cash crops, grown in Pune and Satara districts and accounts for 87 per cent of area and 72 per cent of production. Total area under potato in Maharashtra was 0.18 lakh hectares, with production 3.60 lakh MT. Total area under potato in Maharashtra was 15800 lakh hectares with 70800 tonnes production with average yield of 4.48 t ha^{-1} (Nikam *et. al*. 2008). According to Onwualu *et. al.* (2006), process of agricultural product increase in the amount of finished product, the number of finished product or both and to improve the total economic value of a product. In agricultural processing, product has to undergo various unit operations such as cleaning, sorting, grading, size reduction etc. Cleaning of agricultural product is one of the most important unit operation among various unit operation in processing.

Washing is a process of cleaning and sensitization of product by dripping, rinsing, rubbing or scrabbling. Washing is one of the primary unit operations for value addition of horticultural produce at farm level. It plays an important role in processing of crop produce by adding value and also improving on the quality and safety of the produce in the post harvest operation.

The traditional approach that is being used by the farmers involves using of big perforated crates or tubs. The crops have to be regularly shuffled with hand for proper cleaning. This has been proved to be a very time consuming process and requires a lot of labour (Especially in farms having area >3 ha).The operation requires more labour and the labourers are constantly exposed to chill water during the washing operation. There is no primary processing equipment like washers for these root / tuber crops for small/marginal farmers in this region. High capacity commercial washers are available, although very useful, is cumbersome and expensive which makes it difficult for most farmers to purchase and unsuitable for small farmers to use due to their large capacity.

1. Assistant Professor, 2. Head, 3. Associate Professor and 4. B. Tech. Student, Department of Agriculture Process Engineering, Dr. PDKV, Akola.

The aim of this study was to develop a vegetable root crop washer using locally available material and to evaluate the performance of a low cost batch type vegetable root crop washer. The Root Crop Washer provides a solution to the problem of the farmers reducing the labour requirement, time and cost of operation of operation of the farmers.

MATERIAL AND METHODS

Materials Selection

The cost, availability, properties and weight of materials were some of the major factors considered for the selection of material for each of the machine component. Table1 shows the summary of the material selected for each machine component.

Cost Analysis

Estimation of Cost of Material

It is the overall amount needed to acquire the raw material which has to used for fabrication to desired size and functioning of the components. These materials can be divided into two categories.

Material for Fabrication

Here, the material is obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.

Standard parts purchased from market

These are the materials that are readily available in the local market and need not to be fabricated. Examples are the ball bearing, matting, PVC pipe, pulley, perforated sheet, bolt and nuts.

Machine Cost Estimation

This cost estimation is an attempt to careful forecast the total expenses that may include manufacturing, labor, materials, etc.

Calculation for Cost of Materials

The general procedure for calculation of cost of material and estimation after designing a project bill of material was prepared and that divided into two categories.

1. Fabricated components.
2. Standard components purchased.

The cost of the items used in the fabrication of the design is based on price at Akola in 2017. Components generally available from local hardware or retailers.

Design consideration

Various factors were considered in the development process of the root crop washer, some of which are:

1. The relevant physical and mechanical properties of potato were determined.

Table1. Summery of the materials selected.

Machine Component	Material used	Size/type	Reasons for selecting the materials
Frame	M.S. pipe	30 x 30 mm , 1.5 mm thickness	Low cost and readily available
Cylindrical washing drum	M. S. sheet Matting strips M.S. rings	18 gauge Perforated G.I. sheetplastic matting of 1.5 mm thickness 02 Nos.	Low cost, readily available
Spraying pipe	CPVC pipe	20 mm diameter and 1900 mm long	Low cost, excellent corrosive resistance
	Adjustable height hitching assembly	02 Nos. M. S. sheet	
Handle	M. S. rod	01 No.	Readily available
Pillow block Bearing	NA	02 No.	Resist corrosive environment
Pulley	M.S. material and Plastic	04 Nos. 21 mm Diameter	Readily available

2. The machine was designed to wash potato tubers of different sizes at a capacity higher than that of the manual practice of washing potatoes.
3. To make the design simple and affordable, the materials used were locally available in the market.
4. The machine was design to be relatively cheap and be within the buying capacity of small scale farmers.
5. Simplicity of the design.
6. Region specific anthropometric data of agricultural workers were considered.
7. The maintenance and repair of the machine can be easily carried out.
8. The dimensions, speed, capacity and efficiency of the machine were considered.

Some Physical properties of potato tubers

Some physical properties size, surface area, sphericity, volume, bulk density and true density were determined for root crop i.e. potato tubers were studied to arrive at the design parameters of the washer. The procedure described in IS: 4333 (Part IV) – 1968 was adopted. The requisite methods to measure the true density and bulk density of the seed, as given in IS:4333 (Part III) was used. Measurements of the three major perpendicular dimensions of the tubers, namely, the length (L), width (W) and thickness (T), were carried out with a digital Vernier caliper with an accuracy of 0.01 mm (Mohsenin, 1986). Fifty pieces of whole tubers were randomly selected and their dimensions were measured with the help of a digital Vernier calliper (Sterling Manufacturing Co., Ambala Cantt, Haryana, India) having an accuracy of 0.01 mm. The surface area of potato tuber were calculated by formula given by Topuz (2004). The increase in liquid volume due to sample was noted astrue volume of sample (Mohsenin, 1986).

Development of manually operated vegetable washer

A hand operated root crop vegetable washer was developed at Department of Agricultural Process Engineering, CAET, Dr. PDKV, Akola and based on anthropometric data for agricultural workers of Maharashtra (More and Vyavahare, 2014) for easy operation of the washer and tested for washing of potato. The performance of the machine was tested for washing efficiency and the capacity.

The AutoCAD software was used to produce the drawings. The Auto CAD software was adopted to create new set of CAD drawings to elaborate the progress of the design process and enable documenting detailed specifications. The final version of the CAD drawings of manually operated root crop washer are illustrated in Figure 1.

The root crop washing machine mainly consisted of cylindrical drum with outlet lid, feeding unit, main frame, water spaying system with height adjustment assembly, plastic washing mat, drive mechanism with handle. The overall dimension of the machine was 1520 x 1690 x 795 mm.

The height of the drum was fixed at 90 cm from ground level. The elbow height was fixed at 85 cm for easy rotation of hand wheel. The washer drum being cylindrical, the height of the drum was found to be 45 cm for holding 10 kg of the produce. The mat type washer consisted of a stainless steel drum of 47 cm length and 39 cm diameter. One third of the drum is provided with perforated holes of 0.65 mm diameter. Two third of the surface area is being provided with matting. The center CPVC hallow pipe is provided with fine holes for spraying water. The pipe is connected with a coupling to a hose through which water could be sprayed to the drum.

Principle of operation of root crop washer

The root crop washer was developed to operate in batches of about 10 kg batch^{-1}. Before feeding the samples in cylindrical washing drum, the discharge chute was closed and locked with help of locking arrangement. The muddy samples of 10 kg batch^{-1} were dumped gently through feeding chute into the cylindrical washing drum. The discharge chute was kept closed while washing operation was conducted. A valve which was provided to regulate the pressure of water was opened to allow water to be sprayed onto the potatoes. The cylindrical washing drum was manually operated with the help of handle through power transmission unit. The washing cylinder moves in rotary motion during the operation. Pressurised water is sprinkled on the tubers kept in the rotating drum. Due to the rotation of the drum, mat strips and sprinkling of pressurised water, the soil and foreign materials are separated from the tubers, thus proper cleaning were done. Small pebbles and contaminated water falls down through perforated cylindrical washing drum. Operator keeps the drum rotating until the tubers were washed properly. This

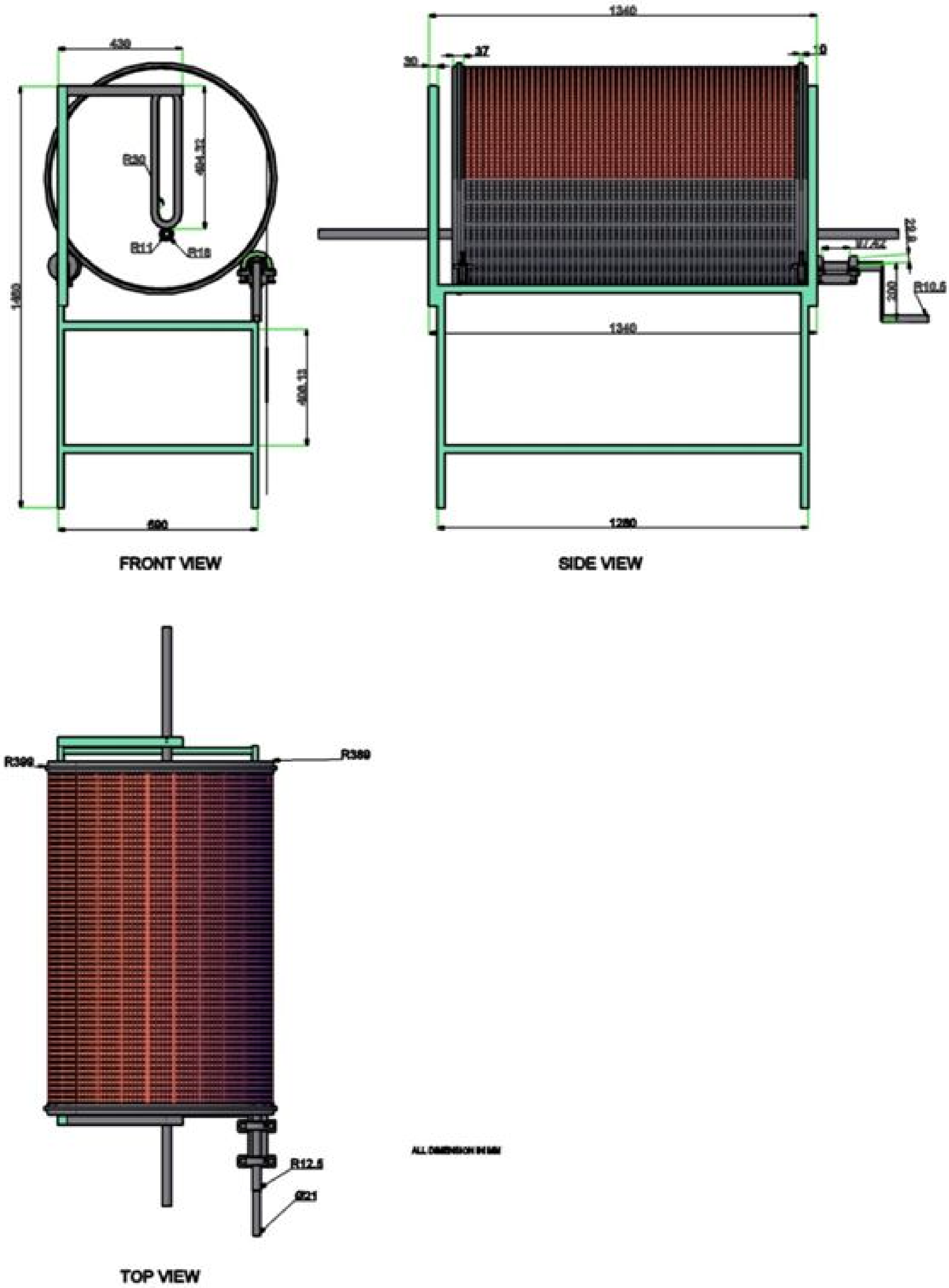

Figure 1 – Three dimensional view in Auto CAD drawing.

time of rotation depended on the quantity of tubers kept in the drum. The rotation of the drum and matt strips which causes tuber to move and fro within the cylindrical drum, mat strips also acts as brush to rub the tubers and water spraying assembly spray water supply clean the tubers from soil and foreign materials. After completed the properly washing by visual observation, pump was switch off during first batch. Then cleaned tubers were collected from cylindrical washing drum from discharge chute in the basket. The discharge chute was remain open while loading the second batch. After loading the batch, switch on the pump to run the water spraying system and handle of washing drum was rotated manually. Same procedure was repeated for washing of vegetable root crops.

Preliminary testing of root crop washer

Preliminary testing by operating the machine was carried out to check all the components were functioning properly or not. The revolution per minute of washing drum, water consumption, spraying pattern, pulley slippage and other necessary data were gathered in running condition of machine without load the tubers. The level of factors considered in operating speed (10-12 rpm) was based on the study of Moos, *et.al*, (2002). For the testing of the prototype different shapes of potatoes were washed using the developed machine. It was observed that machine could not run satisfactory with loading batch of above 10 kg. Therefore, for the final testing, two levels of loading weight i.e., 5 kg batch^{-1} and 10 kg batch^{-1} of potato tubers were used as samples. Performance of the machine in terms of capacity, washing efficiency and skinning damages were evaluated and recorded. For the comparison between manual washing and mechanical washing, basic data was recorded. Simple comparison on the washing capacity, volume of tuber washed per day and labour requirement are the parameters considered. Skinning damage caused by manual washing was not evaluated because there was a minimal bruising caused during manual washing.

Performance parameters of vegetable root crop washer

The Machine

After fabrication of the component parts, the machine was assembled as shown in Plate 1. Testing was carried out to determine the suitable capacity, washing efficiency, damage (skinning damage), time of operation, labour requirement and volume of water required to wash fruits.

The water pump or overhead tank was connected to water spraying system through CPVC pipe. The machine was set to maintain smooth operation, after that potatoes were loaded into the washing cylindrical drum through the feeding chute. The washing operation continued.

The performance of the developed washer were evaluated and recorded based on following parameters;

1. Capacity, kg
2. Washing efficiency, %
3. Skinning damage, per cent
4. Time of operation

Table 2.Variation in weight, axial dimensions, size and surface area of potato tubers.

Particular	Weight, g	Axial dimensions, mm			Size, mm	Surface area, mm^2	Sphericity	True density, g/cm^3
		l	b	t				
No. of observation	25	50	50	50	50	25	25	5
Max	91	92.73	71.22	59.55	69.61	140.12	88.16	1.09
Min	67	38.12	33.56	29.22	44.08	48.63	56.6	1.05
Avg	87.66	72.81	49.60	39.52	53.51	77.55	72.34	1.072
SD	4.93	12.06	7.82	6.20	6.798	21.35	8.270	0.016
Var	24.32	145.45	61.19	38.49	46.20	456.00	68.39	0.000
SEM	0.97	1.71	1.11	0.88	1.36	3.02	1.654	0.007
CV,per cent	5.626	16.56	15.77	15.70	12.70	27.53	11.43	1.53

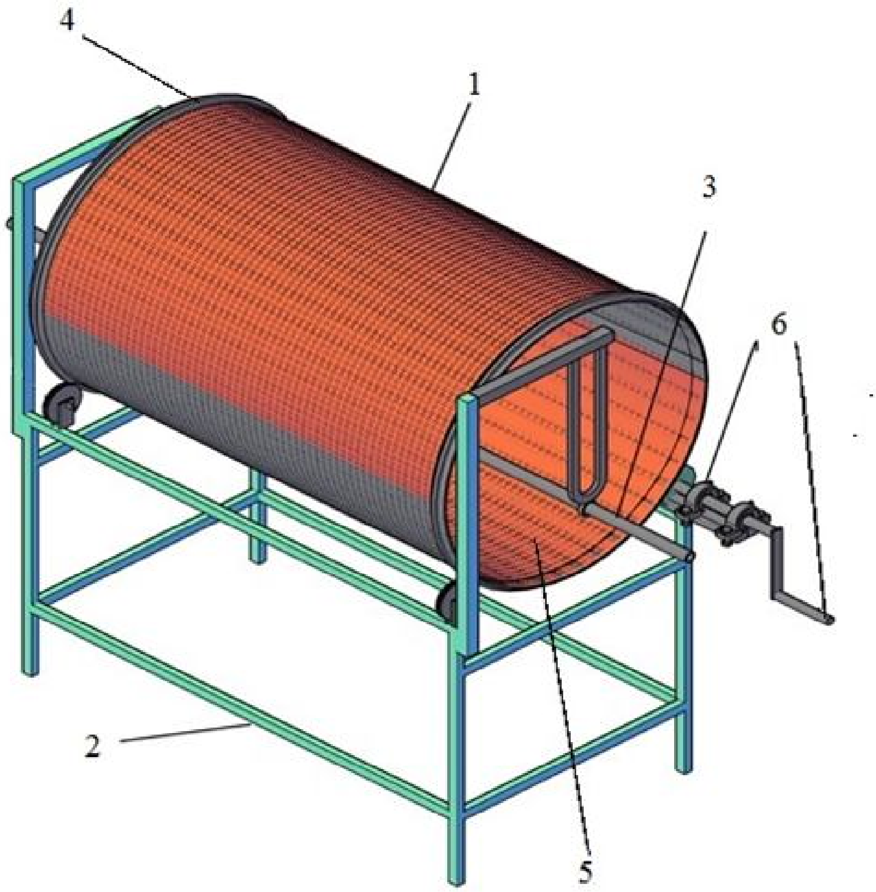

Figure 2 – Isometric view in Auto CAD drawing

1. Cylindrical washing drum,	2. Main frame,	3.Water spraying assembly,
4. Feeding chute,	5. Discharge chute,	6. Drive mechanism with Handle

Plate 1: Final design of the hand operated root crop washer

Measurement of different parameters was followed as per the procedure mentioned below; Each experiment was replicated thrice.

Capacity

The washing capacity of the machine and level of factors i. e. Operating speed of washing drum were considered between 10 to 12 rpm which was based on the study of Moos *et.al,* (2002). Loading weight was set to 5kg, 10 kg, 15 kg batch^{-1} of potato tubers were used as sample and the treatment factor in determining the washing capacity of the machine.

Washing Efficiency of the Machine

For calculating washing efficiency known quantity of foreign material was added to sample and then effect of washing was studied. Washing efficiency of the machine was calculated by the expression given by Scott *et al* (1981) and shown as follows;

$$WE = \frac{SR}{SA} x\ 100$$

Where,

WE = Washing efficiency, per cent

SR = Mass of sample before washing, g kg^{-1}

SA = Mass of sample after washing, g kg^{-1}

Skinning damage

For calculating skinning damage, observation was noted visually by counting the damaged potatoes after washing.

$$\textbf{Skinning damage} = \frac{\textbf{No. of potatoes damaged}}{\textbf{Total no. of potatoes}} \textbf{ x 100}$$

RESULT AND DISCUSSION

Physical properties

A summary of the physical properties i.e. weight, axial dimensions, size, area, sphericity and true density etc. of potato tubers (cv. Analytic) of Chipsona-2 variety were measured and as shown in Table1. These properties were found at a specific tuber moisture level (80 %, w.b.). The average weight of 1000 potato were found to be 87.66 kg with standard deviation of 4.93 kg (Table 2).

Economic Feasibility

The cost of fabricating the machine was calculated and details of each parts and workmanship is given in Table 3. Components of developed root crop washer were used locally available and low cost. The cost of developed machine was Rs. 8620/- only.

Evaluation of performance of vegetable root crop washer

The overall performance of the machine was determined by measuring the different parameters considered in the study. Quality of washing by root crop washer and manual washing were recorded for in same quantity and time for potatoes tubers.

The washing capacity, washing efficiency, washing time and skinning damage of the device were measured and calculated. Table 3 shows the summary of the results on the performance evaluation of the device.

Washing Capacity

It was observed that the machine was working satisfactory with the loading weight of 5 to 10 kg/batch of potatoes. The highest washing capacity was achieved when the machine was operated at loading weight and no. of revolution of washing drum per min of the machine at 10 kg and 10-12 rpm, respectively, with a value of 340 kg hr^{-1}. The washing capacity was directly proportional to the operating speed and loading weight. This result supports the study of Olukunle, *et.al*, (2012) on the evaluation of cassava peeling machine that the throughput capacity increases gradually as machine speed increases.

Effect of Machine Parameter on Washing Efficiency

Washing efficiency of potato was recorded by keeping the machine variable constant i. e. speed of washing drum (10-12 rpm). The washing efficiency of the machine varied between 97.00 to 98.20 per cent with 5 and 10 kg loading weight of potato respectively for 10-12 rpm of cylindrical wash drum (Table 4). It was also observed that there was no significant increase in efficiency for different rotor speeds in case of potato washing. Similar results were reported by Kenghe *et.al.* (2015) for washing of carrot in a rotary vegetable washing machine.

Skinning damage

Skinning damage, per cent with loading weight of 5 kg and 10 kg potatoes were calculated and is given in Table 4.4. Minimum and maximum skinning damage were found to be 0.91 per cent and 3.77 per cent with loading weight of 5 and 10 kg potatoes with 10-12 rpm of cylindrical wash drum. It was observed that skinning efficiency of the machine varied with respect to quantity of material to be washed.

Table 3.Fabrication cost of developed machine

S.N.	Components	Material	Quantity Cost
1	Machine frame	20 kg iron angle @ Rs.50 /kg	1000/-
2	Cylindrical Wash drum	30 sq. ft. @ Rs. 60/sq. ft.	1800/-
3	Mating strips	8 sq. ft. @ RS.70/sq. ft.	560/-
4	CPVC Pipe	2m @ Rs. 100/m	200/-
5	Nut and bolts	2 kg @ Rs.80/kg	160/-
6	Pillow block Bearing P-204	2 pieces @ Rs.200/piece	400/-
7	Feeding and discharge unit	Plain G.I. sheets	300/-
8	Painting		700/-
9	Miscellaneous	End cap, pulley, wheels etc.	500/-
10	Labour cost		3000/-
	Total cost		8620/-

Table 4. Specifications of components of the Root Crop Washer

S.N.	Components	Specification
1.	Type of machine	Root crop hand operated washer
2.	Type of operation	Manually
3.	Crop to be washed	Potato, Beet root, raddish, carrot, cassava,
4.	Overall dimensions of Machine	Length, mm : 1880 Width, mm : 690 Height, mm : 1540
5.	Feeding unit	Length, mm : 630 Height, mm : 295
6.	Cylindrical Wash drum	Type: Perforated type Length, mm :1220 Diameter, mm : 770 Hole size: 10 mm
7.	Matt strips	Size: 1200 (L) x 150 (W) x 3.5 (T)
8.	Main frame	Length, mm : 1280 Width, mm : 690 Height, mm : 1460
9.	Water spraying assembly	Required Source : Overhead tank or small size pumpMaterial : CPVC pipe for sprayingLength, mm : 1900 Diameter, mm : 20 Holes on pipe : 2.5 mm Adjustable height assembly
10.	Discharge Chute	Length, mm : 630 Height, mm : 295 Locking and Unlocking rrangement for un-loading the washed product.
11.	Power source	Manually operated one men
12.	Labour requirement for feeding and for unloading	One
13.	Power transmission mechanism	Manual Handle through shaft and two block bearings through idler pulley
14.	Weight of machine, Kg	55
15.	Output capacity, Kg/hr	340

Skinning damage caused by manual washing was not evaluated since there was a minimal bruises acquired during manual washing.

Simple comparison between manual and mechanical washing

The comparison study of manual washing and mechanical washing revealed the need of farmers / labourers for a fast washing machine that would help them shorten the length of time in washing potatoes and also increasing the quantity of potato tubers washed per unit time (Table 5).

Conclusion

The capacity of vegetable root crop washer was found to be 340 kg h^{-1} for potato tubers. The minimum and maximum skinning damage was found to be 0.91 per cent and 3. 77 per cent with loading weight of 10 and 5 kg $batch^{-1}$ of potatoes respectively. A vegetable root crop washer was easy to handle, operate and light weight. The fabrication cost of the machine was found to be Rs. 8620/- .

A portable type vegetable root crop washer was developed to operate at the seed 10 - 12 rpm of cylindrical washing drum with loading weight of 10 kg $batch^{-1}$ to achieve maximum washing efficiency of 98.20 per cent with minimum skinning damage.

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Table 5. Performance of the root crop washer.

Wt. before washing kg	RPM of handle	Wt. after washing, kg	No. of Potatoes	No. of Potato damage	Required time, min	Washing Efficiency, %	Skinning Damage, %
5	10-12	4.88	55	2	1.20	97.60	3.64
		4.85	53	2	1.15	97.00	3.77
		4.87	54	1	1.25	97.40	1.85
		4.89	55	2	1.10	97.80	3.64
		4.86	54	1	1.18	97.20	1.85
10	10-12	9.78	110	0	1.20	97.80	1.82
		9.8	109	1	1.15	98.00	0.92
		9.81	111	0	1.25	98.10	1.80
		9.82	110	1	1.10	98.20	0.91
		9.79	108	2	1.18	97.90	-

Table 6. Comparison of manual washing and mechanical washing

S. N.	Parameters	Manual washing	Mechanical washing
1	Washing capacity kg hr^{-1} $person^{-1}$	30-40	340
2	Labour requirement	5	2
3	Time required, hrs. min. $person^{-1}$ (100 kg)	1 Hrs. 40 min	12 min
4	Water required, litres (10 kg)	25	14
5	Hours of operation per day, hours	5	5
6	Average volume that can be washed per day, kg day^{-1}	390	1700

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SHORT NOTES

Association of Fungi with Various Parts of Marketed Chilli Fruits

Chilli (*Capsicum annuum* L.) is an indispensable condiment in India and is cultivated as one of the important cash crop in India. Its pungency capsaicin and colouring matter capsinoides are gaining importance in processed foods. The green and red (dry) chilli fruits are valuable on account of their richness in ascorbic acid, carotene, protein, carbohydrates, mineral matters etc (CSIR, 1950). Association of fungi with red chilli fruit causes severe losses in storage and affect quality of fruits as well as seed and its germination. Chaudhary (1957) observed 12 % to 32 % losses of ripe chillies due to *Colletotrichum capsici*. Mathur and Agnihotri (1961) reported 5 % - 85 % losses of marketed chilli fruit in Udaipur market (Rajasthan) due to fruit rotting fungus *Alternaria tenius*. They opined that mechanical injury was responsible for infection. Thind and Jhooty (1985) reported *A. alternata* responsible for black rot of chilli in Punjab and quite serious in all the area surveyed. In earlier work carried out on the fruit rot of chilli, different fungi were found associated. Hence studies on symptomology of rotted fruits and association of fungi with various locations in Yavatmal district were under taken.

Chilli fruit samples were collected from different market of Yavatmal, Digras, Darwha and Pusad tahsils of Yavatmal district. A total 12 samples, 3 from each tahsils were collected. The dried collected samples were stored in cloth bag at room temperature (28 ± 2^{o}C) until further use. Napthallin bolls were placed in each bag to avoid insect damage. To detect fungi associated with various parts of the fruit i.e. pedicel, pericarp, placenta and seed, agar plate method was used. Fifteen samples were tested for each part of each lot. Potato dextrose agar was used for isolation. For isolation of fungi sterilized petri dishes of 9 cm diameter were used. The inoculated plates were incubated at room temperature (28 ± 2^{o}C) for 3 to 5 days. The colony around each bit was examined. Research microscope was used to confirm the identification of fungi.

Collected infected fruits showed black circular to irregular spots of varying sizes. Severely infected red fruits turned straw to pale white colour and adversely affected the quality of fruits and caused severe losses in storage.In some fruits, acervuli were scattered all over the infected parts in concentric manner and internal parts showed black masses of fungi. Infected seeds turned black and/or rusty in colour and adversely affected the seed quality and germination.

Singh *et. al.* (1977) isolated *Colletotrichum capsici* from rotting fruits of chilli. On affected fruits, the fungus form lesions which later enlarged in concentric ring form. Sreekantiah *et. al.* (1977) observed *Alterneria alternata* as causal agent of fruit rot and leaf spot of chilli in Karnataka. The spots on leaves were circular and upto 1 cm in diameter which later enlarged turned brown and showed irregularity sunken patches and concentric zonation. The spots were common towards the margin of leaves and fruits.

In vitro study revealed that the association of mixture of fungi or often a single species. So far, fungi belonging to 17 genera *Alterneria, Aspergillus, Chaetomium, Choanephora, Cladosporium, Colletotrichum, Curvularia, Drechslera, Fusarium, Nigrospora, Peneicillium, Phoma, Rhizoctonia, Rhizopus, Stemphylium and Verticillium* have been found associated with chilli fruit and/or seeds by various workers. (Deena and Basuchaudhary, 1984; Deshmukh, 1985; Thind and Jhooty, 1985; Verma, 1973; Raut , 1990; Asalmol , 2001; Hemallavar *et. al.* , 2009).

In the present study fungi isolated from the various parts of chilli fruits viz., pedicel (fruit stalk), pericarp (fruit coat), placenta and seed, nine fruit rotting fungi viz., *Alterneria alternata*, *Aspergillus niger*, *Cladosporium oxysporum*, *Colletotrichum dematium*, *C. gloeosporioides*, *Curvularia lunata*, *Drechsler atetramera*, *Fusarium moniliforme*, *Phoma spp.* were isolated (Table 1). The fungi were identified on their morphological characters.

From the mean of isolation from pedicel, pericarp, placenta and seed of all the samples, it was evident that *A.alternata* was the most predominant fungus of pedicel (3.89 %), pericarp (10.56 %) and seed (11.11 %). However *C.dematium* was found predominant on placenta (7.22 %) (Table 1). *A. alternata*, *A. niger*, *C. dematium*, *C. lunata*, *F. moniliforme* infected all the parts of fruits viz., pedicel,

Table 1.Percentage of fungi associated with various parts of chilli fruits collected from market of different locations (mean of 15 isolations of each part).

Fungi	Digras Samples				Darwha Samples				Yavatmal Samples				Pusad Samples				Average			
	Pedi-cel	Peri-carp	Plac-enta	Seed	Pedi-cel	Peri-carp	Plac-enta	Seed	Pedi-cel	Peri-carp	Plac-enta	Seed	Pedi-cel	Peri-carp	Plac-enta	Seed	Pedi-cel	Peri-carp	Plac-enta	Seed
Alterneria alternata	4.44	11.11	4.44	6.66	-	8.89	2.22	11.11	8.89	8.89	11.11	8.89	2.22	13.33	4.44	17.78	3.89	10.56	5.55	11.11
Aspergillus niger	-	2.22	-	-	2.22	4.44	-	2.22	2.22	2.22	4.44	-	-	4.44	4.44	2.22	1.11	3.33	2.22	1.11
Cladosporium oxysporum	2.22	-	-	-	-	-	2.22	2.22	-	-	-	2.22	2.22	-	-	-	1.11	-	0.56	0.56
Colletotrichum dematium	-	6.66	6.66	4.44	4.44	2.22	2.22	4.44	-	8.88	4.44	4.44	4.44	11.11	6.66	8.88	2.22	7.22	5.00	5.55
C. gloeosporioides	-	2.22	2.22	-	-	-	2.22	-	-	2.22	-	2.22	-	4.44	2.22	2.22	-	2.22	1.67	1.11
Curvularia lunata	2.22	-	-	2.22	-	4.44	-	-	2.22	-	2.22	2.22	2.22	-	2.22	-	1.67	1.11	1.67	1.11
Drechslera tetramera	-	2.22	2.22	2.22	-	2.22	-	2.22	-	2.22	-	2.22	-	2.22	-	2.22	-	2.22	0.56	2.22
Fusarium moniliforme	4.44	2.22	6.66	2.22	2.22	4.44	2.22	-	-	6.66	4.44	4.44	-	-	-	8.88	1.67	3.33	3.33	3.89
Phoma spp.	-	2.22	-	2.22	2.22	-	-	-	-	2.22	-	-	-	-	-	-	0.56	1.11	-	0.56

pericarp, placenta and seed. *Cladosporiumoxy sporum*was associated with pedicel, placenta and seed. *C. gloeosporioides* infected pericarp, placenta and seed but not pedicel. *Phoma sp*. was detected from pedicel, pericarp and seed. Infection of *Drechslerate tramera* was restricted to pericarp and seed.

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Department of Plant Pathology,
Dr. PDKV, Akola.

S. W. Khodke
V. A. Tiwari
V. R. Gupta

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Growth , Yield and Economics of *Kharif* Fodder Maize as Influenced by the Sowing Dates and Nitrogen Management

Among the various fodder crops, maize (*Zea mays L.*) is one of the most important dual crop grown widely in *Kharif* season for grain as well as for fodder in India. Maize *(Zea mays L.)* with its large number of cultivars and different maturity period have wider range of tolerance to different environmental conditions.

Sowing date is a very important parameter in crop production. The optimum sowing date paves the way for better use of time, light, temperature, precipitation and other factors. Planting date is an important factor in farming which has significant impact on crop growth and development and its yield and yield components.

Nitrogen fertilization is one of the most important agronomic practices and therefore many studies are conducted with nitrogen fertilizer management. Optimum rate of nitrogen fertilizer for forage maize depends on numerous variable factors such as environmental conditions, management systems and genotypes. Nitrogen fertilization of maize influences dry matter yield by influencing leaf area index, leaf area duration and photosynthetic efficiency. Therefore research was planned with the objectives to find out optimum sowing date for maximum green fodder yield and to quantify fertilizer requirement for higher green fodder yield of maize.

A experiment was carried out at College of Agriculture, Nagpur during *Kharif* season 2015-2016 in split plot design with four sowing dates in main plot (D_1-First sowing- At onset of monsoon i.e. Normal, D_2-Second sowing- 10 days after first sowing, D_3-Third sowing- 20 days after first sowing and D_4-Fourth sowing - 30 days after first sowing) and four nitrogen management practices in subplot (N_1-100 % RDN with one split at 30 DAS, N_2-100 % RDN with two split at 20 and 40 DAS, N_3-125 % RDN with one split at 30 DAS and N_4-125% RDN with two split at 20 and 40 DAS) replicated thrice. The soil of the experimental field was clayey in texture, medium in available nitrogen (187.60 kg N ha^{-1}) and available phosphorus (20.32 kg P_2O_5 ha^{-1}) and rich in potash (369.6kg K_2O ha^{-1}). Organic carbon content (0.52 %) was medium and soil reaction (pH 7.7) was slightly alkaline in nature. The soil of the experimental plot was vertisol. The fodder variety of African Tall was used with spacing of 30 cm x 10 cm. The recommended dose of fertilizer was 80:30:20 kg NPK ha^{-1}. The total rainfall during cropping season was 1164.3 as against the average 848.2 mm.

The observation on growth contributing character viz., mean plant height, mean number of functional leaves $plant^{-1}$, mean leaf area $plant^{-1}$ (dm^2), mean green fodder yield (fresh weight) $plant^{-1}$ (g), mean dry matter accumulation $plant^{-1}$, leaf stem ratio, green as well as dry fodder yield (q) ha^{-1} and quality parameter such as protein content and economics were recorded. The data regarding growth, yield and economics are presented in the table 1.

Growth attributes of kharif fodder maize

Effect of sowing dates

The normal sowing at onset of monsoon showed maximum and significantly more plant height, more number of functional leaves at harvest over delayed sowing at 20 and 30 days after first sowing but the second sowing showed at par plant height. This might be due to sufficient amount of moisture available and inherent capacity of maize like photo-insensitivity and thermo-insensitivity and better growth conditions due to earlier sowing.
The leaf area $plant^{-1}$ at harvest was maximum and significantly higher due to normal sowing at onset of monsoon. The second date of sowing 10 days after first and third sowing 20 days after first were at par with normal sowing. This might be due to more number of leaves as well as larger size of leaves. Mashreghi *et al.* (2014) reported that, early June planting date significantly increased leaf area $plant^{-1}$. This supports the present findings.

The green fodder yield $plant^{-1}$ and dry matter accumulation $plant^{-1}$(g) was maximum and significantly more due to normal sowing at onset of monsoon (D_1). This might be due to availability of water for longer period and better climatic conditions leading to higher growth parameters i.e. height, leaf area and number of leaves.

Effect of nitrogen management

Application of 125 % RDN (100 Kg N ha^{-1}) with two split at 20 and 40 DAS (N_4) recorded significantly maximum plant height and number of functional leaves plant^{-1} at harvest over 100 % RDN with one split. This might be due to availability of nutrients through 125 % RDN in two split continuously throughout the crop growth period. Maqsood and Shehazad (2013) also reported significant increase in height due to application of 100 kg N ha^{-1} which resembles the present findings. Application of 100 % RDN with two spilt also recorded significantly higher plant height over 100 % RDN (80 Kg N ha^{-1}) with one spilt. Hani *et al.* (2006) also reported the maximum and significantly higher plant height due to application of 80 kg N ha^{-1}. These results support the present findings.

The application of 125 % (100 kg N ha^{-1}) recommended dose of nitrogen with two spilt (N_4) recorded maximum and significantly higher leaf area plant^{-1}. Application of 100 % (80 kg N ha^{-1}) recommended dose of nitrogen with two spilt (N_2) recorded at par leaf area plant^{-1} with it compared to 100 % RDN with one spilt (N_1). This might due be due to higher number of leaves and bigger size of leaves due to spilt application as this might have supplied nitrogen continuously without any leaching losses. The results obtained during the investigation are similar to finding of Mahmud *et al.* (2003), who also found that, application of 100 kg N ha^{-1} significantly increased leaf area plant^{-1}.

Application of 125 % recommended dose of nitrogen (i.e 100 kg N ha^{-1}) in two splits (N_4) recorded significantly maximum green fodder yield plant^{-1} (g) and dry matter accumulation plant^{-1}(g) among all the nitrogen management practices. This might be due to proper nitrogen management with split doses which might be helpful for the proper growth of plant. Afzal *et al.* (2012) found green fodder (fresh weight) plant^{-1} significantly higher due to the application of 100 kg N ha^{-1} which support present findings.

Interaction effect

The growth attributes were not influenced significantly by the interaction of sowing dates and nitrogen management.

Yield, leaf stem ratio and protein content of green fodder

Effect of sowing date

Sowing at onset of monsoon recorded maximum and significantly higher green fodder yield (299.8 q ha^{-1}) and dry fodder yield (66 q ha^{-1}) over rest of sowing date except 10 days late sowing (D_2) which was at par. This might be due to sufficient amount of rainfall, temperature and relative humidity during crop growth. This might be also the cumulative effect of higher growth parameters like more height, more number of leaves, more leaf area and higher green fodder yield plant^{-1}. Ali *et al.* (2012) recorded maximum and significantly higher green fodder yield by earliest sowing date (20 June) which resembles the present findings. Behrozi *et al.* (2015) also found similar results. The data shows that, the leaf stem ratio was maximum due to normal sowing at onset of monsoon (D_1) sowing fallowed by 10 days after first sowing (D_2). The protein content in green fodder was not influenced significantly by sowing date

Effect of nitrogen management

The maximum and significantly higher green fodder yield (328.7 q ha^{-1}) and dry fodder yield (72.3 q ha^{-1}) was found due to application of 125 % RDN i.e 100 kg N ha^{-1} in two spilt over all other practices. This might be due to cumulative effect of improvement in the growth attributes because of more availability of moisture and applied urea through split which might have resulted in increased growth parameters which increased green fodder. Aslam *et al.* (2011) and Maqsood and Shehazad (2013) also reported significant increase in green fodder yield and dry fodder yield due to application of 100 kg N ha^{-1}. These results are in conformity with the present findings.

The maximum leaf stem ratio was found due to application of 125 % RDN i.e 100 kg N ha^{-1} in two spilt over all other practices. This might be due to cumulative effect of improvement in the growth attributes because of more availability of moisture and applied urea through split which might have resulted increase in growth parameters which increased leaf stem ratio.

The maximum and significantly higher protein content (8.2%) was found due to 125 % RDN i.e 100 kg N in two splits. This might be due to availability of nitrogen. Afzal *et al. (*2012*)* also reported maximum and significantly more crude protein due to application of 100 kg N ha^{-1}. These results supports the present findings.

Interaction effect

The interaction effect of sowing dates and nitrogen management on green fodder yield (q ha^{-1}) and dry fodder yield (q ha^{-1}) was not significant.

Table 1. Growth , yield and economics of *Kharif* fodder maize as influenced by the sowing dates and nitrogen management

Treatments	Growth attributes at harvest				Yield				Economics				
	Plant height (cm)	**Number of functional leaves plant^{-1}**	**Leaf area plant^{-1} (dm^2)**	**Green fodder yield (plant^{-1} (g)**	**Dry matter plant^{-1} (g)**	**Green fodder yield (qha^{-1})**	**Dry Fodder yield (qha^{-1})**	**Leaf stem ratio**	**Protein in green fodder (%)**	**COC (Rs ha^{-1})**	**GMR (Rs ha^{-1})**	**NMR (Rs ha^{-1})**	**B:C ratio**
Main – Sowing dates													
D_1 - At onset of monsoon (Normal)	151.5	13.7	437.2	196.4	51.7	299.8	66.0	0.43	6.7	21332	59959	38628	2.80
D_2 - 10 days after first sowing	142.4	13.3	419.5	173.2	39.3	270.9	59.6	0.40	6.8	21332	54174	32842	2.53
D_3 - 20 days after first sowing	133.9	12.0	390.1	166.4	37.7	255.1	56.1	0.36	6.7	21332	51017	29685	2.39
D_4 - 30 days after first sowing	132.8	11.8	357.8	172.3	36.0	243.3	53.5	0.36	6.5	21332	48650	27319	2.27
SE(m) ±	3.6	0.41	13.81	6.14	1.59	9.5	2.1	-	0.2	-	1902	1902	-
CD at 5%	12.3	1.42	47.80	21.24	5.49	32.9	7.2	-	NS	-	6580	6580	-
Sub – Nitrogen management													
N_1 - 100 % RDN with one split at 30 DAS and 40 DAS	116.7	11.3	342.6	161.0	34.5	205.1	45.1	0.33	5.3	20565	41024	20459	1.99
N_2 - 100 % RDN with two split at 20	148.8	12.6	420.6	171.8	39.7	278.8	61.3	0.42	6.7	21485	55751	34266	2.59
N_3 - 125 % RDN with one split at 30 DAS	130.1	13.4	390.2	165.7	38.8	256.4	56.4	0.38	6.6	21533	51280	29747	2.38
N_4 - 125 % RDN with two split at 20 and 40 DAS	165.0	13.5	451.2	209.8	51.7	328.7	72.3	0.43	8.2	21743	65745	44002	3.02
SE(m) ±	4.4	0.38	12.54	5.23	1.26	8.3	1.8	-	0.2	-	1663	1663	-
CD at 5%	12.9	1.10	36.60	15.3	3.70	24.3	5.3	-	0.6	-	4852	4852	-
Interactions													
SE(m) ±	8.8	0.75	25.07	10.46	2.52	16.6	3.7	-	0.40	-	3325	3325	-
CD at 5%	NS	NS	NS	NS	NS	NS	NS	-	NS	-	NS	NS	-

Maize Green fodder rate Rs 200/q

Economics of kharif fodder maize

Effect of sowing dates

Sowing the crop at onset of monsoon showed maximum and significantly higher gross monetary returns (Rs 59959 ha^{-1}) and net monetary returns (Rs 38628 ha^{-1}) over all other delayed sowing dates, but the second sowing date i.e 10 days after first sowing showed at par gross and net monetary returns. This might be due higher green fodder yield in the same treatments as evidenced from the data. Sowing the crop at onset of monsoon showed maximum and higher B:C ratio (2.80) over all other delayed sowing dates followed by second sowing date i.e 10 days after first sowing (2.53). This might be due to higher gross return and higher yield.

Effect of nitrogen management

The nitrogen management practice application of 125 % RDN with two split at 20 and 40 DAS given maximum and significantly higher gross monetary return (Rs 65745 ha^{-1}) and net monetary return (Rs 44002 ha^{-1}) over all other nitrogen management practices. The probable reason for increase in GMR may be attributed to the increase in yield due to better availability of nitrogen. The application of 125 % RDN with two split at 20 and 40 DAS given maximum B:C ratio (3.02) over all other nitrogen management practices. This can be attributed to the higher grass return per unit of incremental cost.

Interaction effect

The interaction effect of sowing dates and nitrogen management on gross and net monetary return was not significant.

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All India Coordinated Research Project on Mustard ,
College of Agriculture (Dr P. D. K. V. Akola),
Nagpur

A.B. Inzalkar
D.D. Mankar
Beena M. Nair

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Abstract : Concise summation of findings not exceeding 200 words should be written at the beginning of the papers. The abstract should start with the objective. It should be intelligible without reference to the original paper. It should be written in such a way that will facilitate abstracting of the paper in the world of abstracts.

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Nomenclature : The latin binomial or trinomial and authority must be should for all plants, insects and pathogens at first listing either in the title or when first mentioned in the text. Crop varieties (not experimental lines and strains) should be identified by a single quotation mark at first listing only. Generic and specific names should be in italic e.g. *Lycopersium esculentum* Mil Morgtobe.

Reference : They should be double space throughout and arranged alphabetically according to author's names and should be placed under the heading "**LITERATURE CITED**" at the end of the article. Each reference should contain the name of author with initials, the year of publication, title of article, the abbreviated title of publication, volume and page e.g.

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