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CONTENT

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RESEARCH NOTE

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Genetic Variability in Castor Over Environments

K. K. Dhedhi[1], Y. H. Ghelani[2], H. J. Joshi[3] and C. J. Dangaria[4]

ABSTRACT

Genetic variability, heritability and genetic advance of seed yield and ten component traits for 29 castor genotypes were studied under two environments i.e., *Kharif* 2007-08 and 2008-09 at Pearl Millet Research Station, Jamnagar. The analysis of variance revealed highly significant differences among the genotypes for all the eleven characters studied. The characters, namely, leaf length, days to 50 per cent flowering, number of nodes, internode length, number of lobes leaf^{-1}, petiole length, capsule length, length of primary spike, plant height and 100-seed weight were less affected by environment showing close correspondence between genotypic co-efficient of variation and phenotypic co-efficient of variation. The variability analysis revealed that plant height, length of primary spike, internode length, number of nodes and leaf length depicted higher magnitude of phenotypic range, genotypic co-efficient of variation, phenotypic co-efficient of variation, heritability and genetic advance expressed as percentage of mean thereby suggesting the importance of additive gene action. Hence, these characters can be improved through simple selection process.

Castor (*Ricinus communis* L.) is an important non-edible oilseed crop (Euphorbiaceae family) of the arid and semi-arid region of India. India is the world's principal producer of castor. Gujarat is the leading castor growing state in India having maximum area of about 2.88 lakh ha. with production of 4.90 lakh tones and productivity of 1701 kg ha^{-1} (2006-07). The critical assessment of nature and magnitude of genetic variability, heritability and genetic advance is one of the important prerequisites of plant breeding. The estimates of variability parameters for seed yield and its components in castor could help in planning successful breeding programme. Variability parameters for various characters in castor have been studied by various castor breeders (Muthian *et. al*., 1982; Patel *et. al*., 1985; Patel *et. al*., 1991 and Lakshmamma *et al*., 2005) under single environment. However, it has been well established fact that the yield and its contributing characters are significantly influenced by the environmental fluctuations. Comstock and Moll (1963) have emphasized the importance of the interaction between genotype and environment, and their contribution to "genetic slippage" in selection for quantitative characters. It is, therefore, important to study the variability parameters under varying environmental conditions. Hence, present investigation was undertaken to estimate the genetic variability, heritability and genetic advance for seed yield and ten components in castor under two environments (*Kharif* 2007-08 and 2008-09) under irrigated condition.

MATERIAL AND METHODS

The experimental material consisted of 29 diverse castor genotypes comprising six varieties, 10 hybrids and 13 parental lines of different hybrids. The material was evaluated in randomized block design with three replications at Pearl Millet Research Station, Jamnagar, Gujarat during *Kharif* seasons (2007-08 and 2008-09) under irrigated condition. Each plot consisted of 10 rows of 6 m length accommodating 100 plants. The row-to-row and plant-to-plant spacing was 90 cm and 60 cm, respectively. All the recommended package of practices was adopted including plant protection measures to raise healthy crop. Observations were recorded on 11 characters viz., days to 50 per cent flowering, number of nodes upto primary spike, average internode length (cm), fourth leaf from top was observed for recording observation related to leaf i. e. leaf length (cm), number of lobes leaf^{-1} and petiole length (cm), capsule length (cm), length of primary spike (cm), plant height (cm) upto primary spike, 100-seed weight (g) and seed yield plant^{-1} (g). Average values of two years were subjected to standard statistical analysis of variance (Panse and Sukhatme, 1961), genotypic and phenotypic co-

1. & 2 Assistant Seed Research Officer, 3. Seed Research Officer, and 4. I/C Director of Research, Junagadh Agricultural University, Jamnagar-6 (Gujarat)

efficient of variations (Burton, 1952) and heritability and genetic advance (Johnson *et al*., 1955).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed highly significant differences among the genotypes for all the eleven characters studied; it indicated that vast genetic variability existed among the genotypes for different characters studied. Present findings are in accordance with those of Muthian *et al*., (1982), Patel *et. al*., (1985), Patel *et. al*., (1991) and Lakshmamma *et. al*., (2005). The range of phenotypic variability depicted wide phenotypic variation for plant height, length of primary spike, leaf length, number of nodes and internode length. The under range recorded possibility of effective selection for these traits. On the other hand, capsule length, number of lobes leaf^{-1} and petiole length exhibited narrow range of phenotypic variability. The remaining characters showed moderate magnitude of phenotypic variability. In the present study, the higher estimates of genotypic variance over environmental variance in all the characters except seed yield plant^{-1} revealed that the variation among the genotypes had a genetic basis. The estimates of phenotypic and genotypic variances were higher for plant height, length of primary spike and leaf length. The phenotypic and genotypic variances were moderate for 100-seed weight, days to 50 per cent flowering and number of nodes; while, they were low for the remaining characters. This was in line with the findings of Lakshmamma *et. al*., (2005).

The relative amount of variation expressed by different traits was judged through estimates of phenotypic and genotypic co-efficient of variation. In the present study, phenotypic co-efficient of variation (PCV) was higher than the corresponding genotypic co-efficient of variation (GCV) for most of the characters, which showed prominent effect of environmental factors. The characters like plant height, seed yield, internode length, length of primary spike, number of nodes and leaf length exhibited high magnitude of GCV and PCV indicating the presence of wide genetic variability for these traits and fairly high chances for improvement in these characters. The moderate values of GCV and PCV were observed for 100-seed weight and capsule length. The remaining characters showed low magnitude of GCV and PCV under studiy. These results are in agreement with the results reported by Patel *et. al*., (1985), Patel and Jaimini (1988) and Patel *et. al.*, (1991).

Partitioning of total phenotypic variation into heritable and non-heritable components is very useful because only heritable portion of variation is exploitable through selection. In present investigation, high heritability (Broad senses) estimates were recorded for the traits viz., plant height, internode length, 100-seed weight, leaf length, number of nodes, length of primary spike and days to 50 per cent flowering thereby suggesting the usefulness of making selection based on phenotypic observations. The high heritability observed may be due to additive gene effects hence these traits are likely to respond to direct selection for improvement of these traits. Moderate heritability estimates was observed for the remaining four characters studied. Genotypic coefficient of variability along with heritability estimates provides a better picture for the amount of genetic gain expected to be obtained from phenotypic selection (Burton, 1952). It was interesting to note that high GCV was accompanied with high heritability estimates for plant height, internode length, length of primary spike, number of nodes and leaf length in the present material which further supports the effectiveness of selection for the improvement of these traits.

Heritability in conjunction with genetic gain was more useful than the heritability values alone in the prediction of the resultant effect for selecting the best individual genotypes (Johnson *et. al*., 1955). Genetic gain gives an indication of expected genetic progress for a particular trait under suitable selection pressure. In the present study, the characters like plant height, length of primary spike, internode length, number of nodes and leaf length exhibited high heritability coupled with high genetic advance expressed as percentage of mean indicating the predominance of additive gene action in governing these traits. The yield attributing characters having predominance of additive gene action can easily improved through selection. These results are in accordance with those of Patel *et. al.*, (1991) and Lakshmamma *et. al*., (2005). High to moderate heritability estimates and genetic gain expressed as genetic advance in percentage of mean was observed for seed yield, 100-seed weight and

Table 1: Analysis of variance and variability parameters for different traits in Castor over two years

S.N.	Character	Mean	Mean sum of squares			Range		Pheno-typic variance	Geno-typic variance	Enviro-metal variance	PCV (%)	GCV (%)	Herita-bility (h^2) %	Genetica dvance	Geneticn advanceas % of mean
			Replic-ations (2 df)	Geno-types (28 df)	Error (56 df)	Min.	Max.								
1	Seed yield plant^{-1} (g)	0.367	0.001	0.032**	0.002	0.239	0.579	0.014	0.009	0.005	29.41	27.31	86.30	0.19	52.26
2	Leaflength (cm)	33.83	1.36	58.67**	0.87	24.70	40.27	20.14	19.26	0.87	13.26	12.97	95.70	8.84	26.14
3	Days to 50 %flowering	59.45	0.86	17.23**	0.35	55.33	67.17	5.98	5.63	0.35	4.11	3.99	94.10	4.74	7.97
4	Nodes up toPrimary spike	14.40	0.10	11.17**	0.16	11.57	20.60	3.83	3.67	0.16	13.59	13.31	95.90	3.87	26.85
5	Internode length (cm)	5.42	0.01	5.51**	0.04	2.39	8.29	1.86	1.82	0.04	25.15	24.89	98.00	3.75	50.75
6	No. oflobes/ leaf	9.36	0.14**	0.35**	0.02	9.10	10.17	0.13	0.11	0.02	3.85	3.54	84.20	0.63	6.68
7	Petiolelength (cm)	34.23	0.64	3.91**	0.35	32.40	36.47	1.54	1.19	0.35	3.62	3.18	77.20	1.97	5.76
8	Capsulelength (cm)	2.52	0.03*	0.16**	0.01	2.15	2.90	0.06	0.05	0.01	9.56	8.84	85.50	0.42	16.84
9	Primary spikelength (cm)	47.07	2.44	126.6**	2.04	36.67	55.83	43.58	41.53	2.04	14.02	13.69	95.30	12.96	27.53
10	Plant height up toPrimary spike (cm)	78.67	0.03	1819.8**	3.84	32.67	127.73	609.17	605.33	3.84	31.37	31.27	99.20	50.52	64.22
11	100-seedweight (g)	28.67	0.11	28.44**	0.19	22.73	36.75	9.61	9.42	0.19	10.81	10.70	98.00	6.26	21.83

*, significant at 0.05 % level of probability, ** Significant at 0.01 % level of probability

GCV = Genotypic coefficient of variation; PCV= Phenotypic coefficient of variation capsule length indicating the involvement of both additive and non-additive gene action with more influence of environment. These results are akin to the reports of Patel and Jaimini (1988) and Patel *et al*., (1991). Moderate heritability estimates with low genetic gain was manifested for days to 50 per cent flowering, number of lobes leaf^{-1} and petiole length which might be due to preponderance of non-additive gene effects. It suggested that improvement of these characters might be difficult through selection.

Thus, in the present study, the characters like plant height, length of primary spike, internode length, number of nodes and leaf length had higher magnitude of phenotypic range, heritability, PCV, GCV, genetic advance and genetic advance expressed as percentage of mean. It indicated that selection for these traits could be effective to increase castor seed yield through improvement of yield contributing characters.

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Varietal Identification of Wheat Through Morphological Descriptors

R. S. Shaikh[1], V. R. Shelar[2], V. A. Chavan[3] and M. R. Manjare[4]

ABSTRACT

Twelve varieties of wheat *viz;* HD 2189, LOK 45, NIAW 15, NIAW 34, NIAW 295, NIAW 301, NI 5439, NI 9947, MACS 2446, MACS 3125, MACS 1967 and MACS 2496 were studied for their morphological characteristics, which were found to be important diagnostic characteristics in identification of wheat varieties except, the flag anthocyanin colouration of auricles, flag leaf hairs on auricles and awn presence since these characteristics didn't show any kind of variation among all the varieties. Twenty five to twenty nine days after sowing , the varieties could be differentiated on the basis of their plant growth habit. At early boot stage variation in the foliage colour was observed among the varieties. Varieties *viz*; NIAW 15, NI 5439, MACS 2446 and MACS 1967 had green colur whereas rest of the varieties had dark green colour. The characteristic flag leaf attitude showed variations among the varieties *viz;* HD 2189, LOK 45, NIAW 34, NIAW 295 and NI 9947 had semi-erect attitude whereas rest of the varieties had erect attitude. At anthesis , the varieties could be differentiated on the basis of characteristics *viz;* flag leaf waxiness of sheath, flag leaf waxiness of blade, ear waxiness and culm waxiness of neck. Distinct variations were observed among the varieties at dough and ripening stages. At dough development and ripening stages varieties could be differentiated on the basis of characteristics *viz;* straw pitch in cross section, ear shape profile view, ear density, awn colour, awn attitude and ear colour. The varieties could be very well distinguished at maturity on the basis of grain colour and grain shape. From the results, it is concluded that the morphological characteristics exhibited by the different wheat varieties are similar in respect of three characteristics *viz;* flag leaf antthocyanin colouration of auricles, flag leaf hairs on auricles and awn presence however, can be distinguished from each other on the basis of remaining morphological characteristics.

Number of varieties / hybrids of various crops have been released. It is essential to record the morphological characteristics of most of the released varieties as per DUS Test Guidelines. Documentation of morphological characteristics of any crop is of prime importance, which will be helpful to the seed growers or officers who are engaged in seed production programme to identify off- types from the seed plots. As such it is difficult to identify the off- types in seed production. Identification of off types mostly depends on morphological characteristics, hence, proper documentation of morphological characteristics is very essential. However, the information on descriptors/ characteristics of varieties for characterization of cultivars is meagre. Thus, it is essential to study key characteristics of the crops and utilize these characteristics for distinguishing the varieties from each other. Seed Production system, all over the world, are still based on visual differences and petal spot in cotton can, therefore, be used by the breeders and seed producers as identification marker (Anonymous, 1996). Similarly, Protection of Plant Varieties and Farmer's Rights Act, 2001 have been enacted in India. Distinctness, Uniformity and Stability are the criteria of PPV and FRA for the registration and protection of the varieties. Thus proper documentation and characterization of all the notified / extant varieties of the crops is essential for all the organizations/institutions. In view of this, the present study was undertaken to characterize twelve wheat varieties that are active in seed multiplication chain on the basis of qualitative and quantitative characters (Anonymous, 2003).

MATERIAL AND METHODS

The genetically pure seeds of twelve wheat varieties were obtained from the Agricultural Research Station, Niphad. The seed material was raised at Seed Technology Research Unit farm during 2004 and 2005. The crop was grown in six rows with 4.0 m length in two replications. Row to row and plant to plant spacing were maintained at 30 x 5 cm. The recommended agronomic practice2s were

1. Senior Res. Asstt. 2. Seed Research Officer 3. Asstt. Seed Production Officer and 4. Chief Scientist (Seeds), Seed Cell, MPKV, Rahuri

followed properly to raise the healthy crop. The observations were recorded as per DUS Test Guidelines for wheat during different growth stages. Ten randomly selected plants were examined for each characteristic from each variety in each replication. Plant growth habit was recorded at tillering stage. Foliage colour was observed at early boot stage. Observations *viz;* Flag leaf anthocyanin colouration of auricles, flag leaf hairs on auricles and flag leaf attitude were recorded at first spikelet of inflorescence just visible stage. Observations *viz;*. flag leaf waxiness of sheath, flag leaf waxiness of blade, ear waxiness and culm waxiness of neck, etc., were recorded during the anthesis. Straw pitch was recorded at dough development stage by taking cross section between base of ear and stem node. It was categorized as thin, thick and medium. The panicle characteristics *viz;* ear shape in profile, ear density, awn presence, awn colour, awn attitude and ear colour were recorded from dough development to spike let ripening stages.

RESULTS AND DISCUSSION

In the present investigation, twelve varieties of wheat were explored for sixteen morphological traits and presented in Table 1. Out of sixteen characteristics, thirteen characteristics were found polymorphic and three were monomorphic. Morphological features of seed and plant parts are major components of cultivar identification because they provide dependable data for identification. Joshi *et. al.,(2007)* reported that the polymorphic nature of characteristics indicates their potential for varietal identification.

At tillering stage, varieties could be differentiated on the basis of plant growth habit and categorized as erect, semi-erect and intermediate. Varieties *viz;* LOK 45, NIAW 15 and NIAW 34 had erect growth habit, whereas varieties NIAW 295, NI 5439, NI 9947, MACS 2446 and MACS 3125 had semi-erect growth habit The varieties *viz;* HD 2189, NIAW 301, MACS 1967 and MACS 2496 had intermediate growth habit**.** Singhal and Prakash (1989) also reported early growth habit of Indian bread wheat cultivars for description and identification.

Among the varieties studied, NIAW 15, NI 5439, MACS 2446 and MACS 1967 had green foliage colour while, rest of the varieties had dark green foliage colour. Shiv Kumar *et. al.,* (2000) studied plant morphological characteristics *viz;* leaf shape, intensity of leaf colour, etc., of rapseed and mustard and reported significant differences among the varieties for their morphological characteristics.

The flag leaf attitude of the varieties *viz;* HD 2189, LOK 45. NIAW 34, NIAW 295 and NI 9947 had semi-erect attitude, whereas NIAW 15, NIAW 301, NI 5439, MACS 2446, MACS 3125, MACS 1967 and MACS 2496 had erect attitude. While distinguishing the wheat varieties on the basis of flag leaf waxiness of sheath, varieties were categorized into two sub groups *viz;* strong and very strong. Waxiness of flag leaf sheath was strong in the varieties *viz;* HD 2189, LOK 45, NIAW 34, NIAW 301, NI 5439, NI 9947, MACS 2446, MACS 1967 and MACS 2496 whereas, it was very strong in NIAW 15, NIAW 295 and MACS 3125. The waxiness of flag leaf blade was weak in LOK 45 and MACS 1967, whereas it was strong in varieties HD 2189 and MACS 2496. The waxiness was medium in rest of the varieties.

The wheat varieties could be identified on the basis of ear waxiness and waxiness on neck of the culm at anthesis. The varieties *viz;* LOK 45 and NI 5439 had weak wax on ear whereas, the varieties *viz ;* NIAW 34, NIAW 301, NI 9947, MACS 2446, MACS 3125 and MACS 2496 had medium ear waxiness. The varieties *viz;* HD 2189 ans MACS 1967 had strong ear waxiness, whereas the varieties NIAW 15 and NIAW 295 had very strong ear waxiness. On the basis of waxiness on neck of the culm, the varieties could be differentiated into three categories *viz;* medium, strong and very strong. The waxiness on the neck of culm was medium in NI 5439 and MACS 3125 whereas, it was very strong in NIAW 295, while in remaining varieties it was strong.

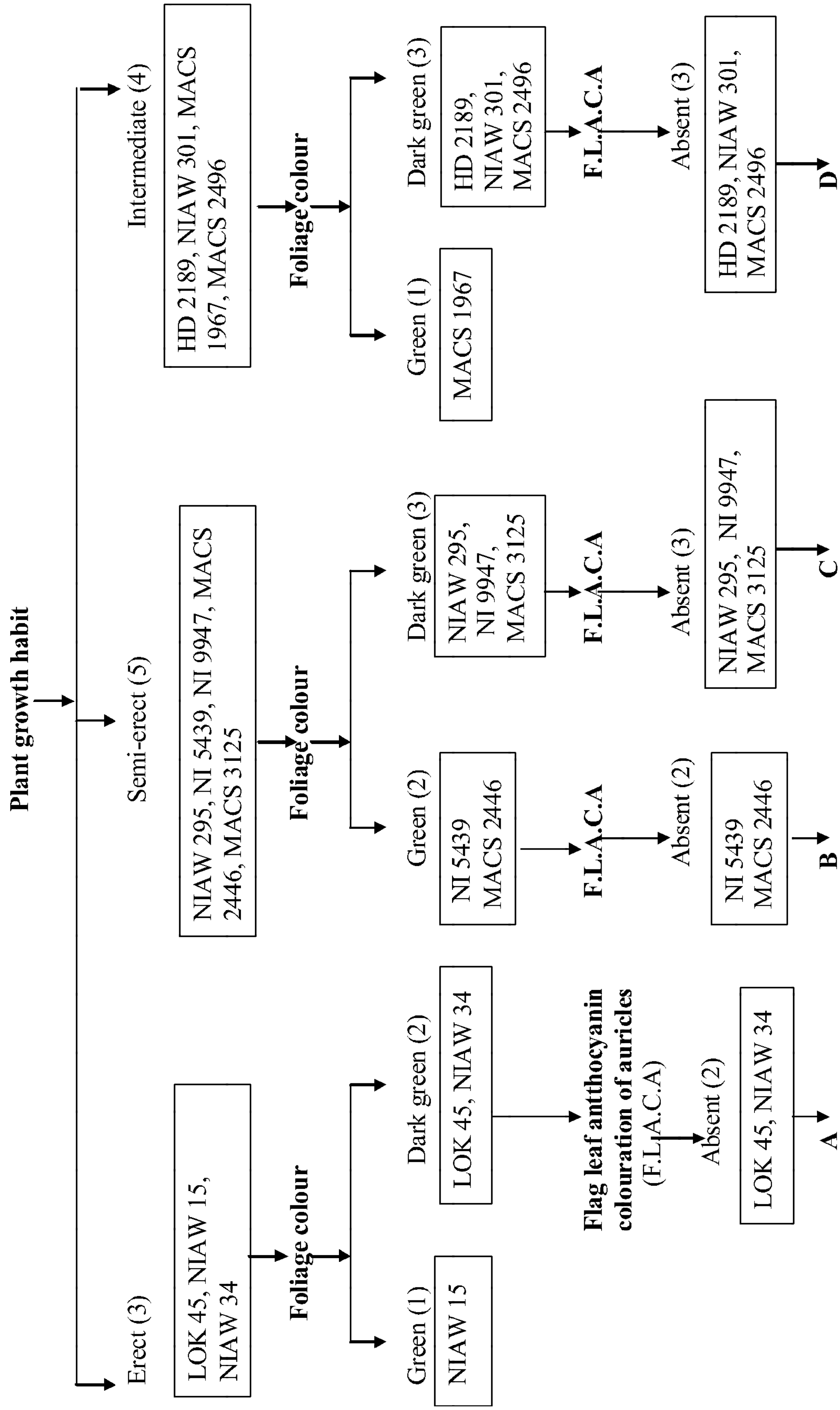
Distinct variation was observed among the varieties at dough development and ripening stages. At dough development stage the varieties could be differentiated on the basis of pithiness in the wheat straw. The varieties *viz;* HD 2189, NIAW 34, NIAW 301, NI 5439, NI 9947 and MACS 2496 had thin pithiness whereas, the rest of the varieties had medium pithiness. At ripening stage, varieties could be differentiated on the basis of characteristics *viz;* ear shape in profile, ear density, awn colour, awn attitude and ear colour. These are the most

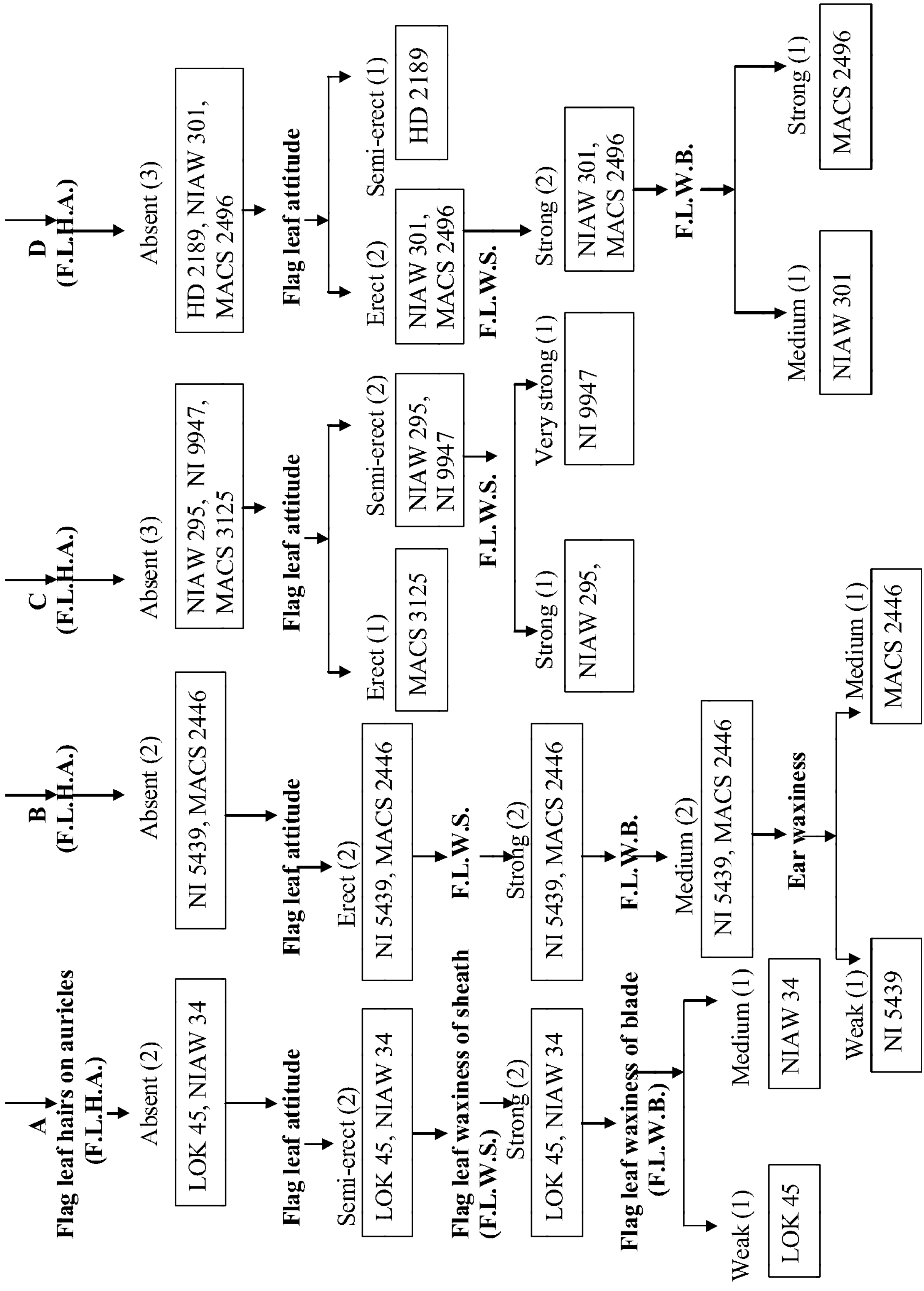
Table 1: Morphological characterization of wheat varieties.

S. N.	Varieties	Plant characteristics							
		Plant: growth habit	**Foliage colour**	**Flag leaf anthocyanin colouration of auricles**	**Flag leaf: hairs on auricles**	**Plant: flag leaf attitude**	**Flag leaf : waxiness of sheath**	**Flag leaf : waxiness of blade**	**Ear : waxiness**
1.	**HD 2189**	Interme-diate	Dark green	Absent	Absent	Semi-erect	Strong	Strong	Strong
2.	**LOK 45**	Erect	Dark green	Absent	Absent	Semi-erect	Strong	Weak	Weak
3.	**NIAW 15**	Erect	Green	Absent	Absent	Erect	Very strong	Medium	Very strong
4.	**NIAW 34**	Erect	Dark green	Absent	Absent	Semi-erect	Strong	Medium	Medium
5.	**NIAW 295**	Semi-erect	Dark green	Absent	Absent	Semi-erect	Very strong	Medium	Very strong
6.	**NIAW 301**	Interme-diate	Dark green	Absent	Absent	Erect	Strong	Medium	Medium
7.	**NI 5439**	Semi-erect	Green	Absent	Absent	Erect	Strong	Medium	Weak
8.	**NI 9947**	Semi-erect	Dark green	Absent	Absent	Semi-erect	Strong	Medium	Medium
9.	**MACS 2446**	Semi-erect	Green	Absent	Absent	Erect	Strong	Medium	Medium
10.	**MACS 3125**	Semi-erect	Dark green	Absent	Absent	Erect	Very strong	Medium	Medium
11.	**MACS 1967**	Interme-diate	Green	Absent	Absent	Erect	Strong	Weak	Strong
12.	**MACS 2496**	Interme-diate	Dark green	Absent	Absent	Erect	Strong	Strong	Medium

S. N.	Varieties	Plant characteristics							
		Culm:waxiness of neck	**Straw :pith in cross section**	**Ear : shape in profile**	**Ear density**	**Awn presence**	**Awn colour**	**Awn: attitude**	**Ear : colour**
1.	**HD 2189**	Strong	Thin	Fusiform	Dense	Present	White	Spreading	Light brown
2.	**LOK 45**	Strong	Medium	Fusiform	Medium	Present	Brown	Spreading	White
3.	**NIAW 15**	Strong	Medium	Tapering	Very dense	Present	Brown	Spreading	Dark brown
4.	**NIAW 34**	Strong	Thin	Parallel sided	Medium	Present	Brown	Spreading	Light brown
5.	**NIAW 295**	Very strong	Medium	Tapering	Very dense	Present	Black	Spreading	Light brown
6.	**NIAW 301**	Strong	Thin	Tapering	Medium	Present	White	Spreading	Light brown
7.	**NI 5439**	Medium	Thin	Tapering	Medium	Present	Brown	Spreading	Light brown
8.	**NI 9947**	Strong	Thin	Parallel sided	Medium	Present	Brown	Spreading	Light brown
9.	**MACS 2446**	Strong	Medium	Tapering	Very dense	Present	Black	Spreading	Light brown
10.	**MACS 3125**	Medium	Medium	Tapering	Very dense	Present	Black	Spreading	Light brown
11.	**MACS 1967**	Strong	Medium	Parallel sided	Dense	Present	White	Appressed	Light brown
12.	**MACS 2496**	Strong	Thin	Tapering	Dense	Present	Brown	Spreading	Dark brown

Fig. 1. : Schematic diagram of plant morphology




A
Flag leaf hairs on auricles
(F.L.H.A.)
Absent (2)
LOK 45, NIAW 34
Flag leaf attitude
Semi-erect (2)
LOK 45, NIAW 34
Flag leaf waxiness of sheath
(F.L.W.S.)
Strong (2)
LOK 45, NIAW 34
Flag leaf waxiness of blade
(F.L.W.B.)
Weak (1)
LOK 45
Medium (1)
NIAW 34
B
(F.L.H.A.)
Absent (2)
NI 5439, MACS 2446
Flag leaf attitude
Erect (2)
NI 5439, MACS 2446
F.L.W.S.
Strong (2)
NI 5439, MACS 2446
F.L.W.B.
Medium (2)
NI 5439, MACS 2446
Ear waxiness
Weak (1)
NI 5439
Medium (1)
MACS 2446
C
(F.L.H.A.)
Absent (3)
NIAW 295, NI 9947, MACS 3125
Flag leaf attitude
Erect (1)
MACS 3125
Semi-erect (2)
NIAW 295, NI 9947
F.L.W.S.
Strong (1)
NIAW 295,
Very strong (1)
NI 9947
D
(F.L.H.A.)
Absent (3)
HD 2189, NIAW 301, MACS 2496
Flag leaf attitude
Erect (2)
NIAW 301, MACS 2496
Semi-erect (1)
HD 2189
F.L.W.S.
Strong (2)
NIAW 301, MACS 2496
F.L.W.B.
Medium (1)
NIAW 301
Strong (1)
MACS 2496

distinguishable characteristics and are helpful in maintaining the identity. Singhal and Prakash (1989) described ear characters of wheat plant i.e. angle of ear, ear colour, ear shape, ear density, ear length and reported which are necessary to ascertain the cultivars characteristics. The varieties *viz;* HD 2189 and LOK 45 had fusiform ear shape. Varieties *viz;* NIAW 15, NIAW 295, NI 5439, MACS 2446, MACS 3125 and MACS 2496 had tapering ear shape and rest of the varieties had parallel sided ear shape. On the basis of ear density the varieties could be grouped in to three groups *viz;* medium, dense and very dense. The varieties *viz;* HD 2189, MACS 1967 and MACS 2496 had dense ear whereas, the varieties *viz;* NIAW 15, NIAW 295, MACS 2446 and MACS 3125 had very dense ear. Rest of the varieties had medium ear density. Based on the variations observed in awn colour, varieties could be classified in to white, black and brown colour. The varieties HD 2189 and MACS 1967 had white awn colour, black awn colour was noticed in the varieties NIAW 295, MACS 2446 and MACS 3125, whereas the rest of the varieties had brown awn colour. The variety MACS 1967 had appressed awn attitude which is the distinct character of this variety. Rest of the varieties classified into spreading type awn attitude. The ear colour of the wheat varieties was categorized into two groups *viz;* white, light brown and dark brown. Variety LOK 45 had white ear colour and NIAW 15 had dark brown ear colour.

Development of key characters

Varieties can be distinguished individually by preparing schematic diagram (Fig. 1). This may facilitate to the seed growers/ seed certification agencies for identification of varieties during the seed production. While preparing the key characteristics of plant morphology, varieties were divided into three groups of plant growth habit i.e. erect, semi-erect and intermediate. Varieties within that group further divided into two groups of foliage colour *i.e.* green and dark green. Varieties within each group further divided into different groups on the basis of flag leaf anthocyanin colouration of auricles, flag leaf hairs on auricles, flag leaf attitude, flag leaf waxiness of sheath, flag leaf waxiness of blade and ear waxiness.

Thus, the wheat varieties under present investigation could be distinguished from each other on the basis of plant morphological characteristics. This documentation of morphological characteristics also helpful in seed production programme as well as registration of cultivars under Plant Variety Protection and Farmers Rights Act, 2001. Similar attempts have also been reported in rice by Joshi *et. al.*, (2007), pea by Surendra Prakash and Singhal (1997), pearl millet by Arunkumar (2004) and forage sorghum by Sangwan *et. al.*, (2005).

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Combining Ability and Heterosis Analysis of Newly Developed Genetic Male Sterile Lines in Safflower

R. L. Bhakre[1] and P.B. Ghorpade[2]

ABSTRACT

Four newly developed genetic male sterile (GMS) lines of safflower were used to evaluate the combining ability, identify the most promising GMS line for its utilization in hybrid breeding and recurrent selection programme and estimate the useful heterosis for economic traits. The forty crosses and two check varieties (Bhima and A1) were grown in a randomized complete block design with two replications and data were recorded and analyzed for eight agronomic characters. HUS-305MS-2 x AKS-152 exhibited significant useful heterosis (46.08 %). Among male parents, AKS-152, PH-39 and AKS-207 were good general combiners for yield and its components. These parents may be utilized in synthesis of random mating population. The GMS lines, HUS-305MS-2 and HUS-305MS-3 were average combiner for seed yield plant^{-1}. Therefore, GMS lines HUS-305MS-2 and HUS-305MS-3 may be utilized in recurrent selection programme for development of superior varieties.

Safflower is an important oilseed crop. Safflower seed oil is rich in polyunsaturated fatty acids (Linoleic acid, 78%) which play an important role in reducing blood cholesterol level and is considered as a healthy cooking medium. Safflower is predominantly self-pollinated crop. Safflower improvement programme in India was started in 1931 and N-630, the first variety was released in 1940. Also N-7 was released for commercial cultivation from Nagpur in 1945. Since then so many varieties and hybrids were released.

These varieties have the genetic potential to give yield of 15 to 20 q ha^{-1} with oil content about 30 per cent under optimal conditions. However, attempts to further improve the yield and oil content were not successful even after release of three safflower hybrid varieties with use of genetic male sterility *viz.*, DSH-129, MKH-11 and NARI-NH-1 which have 20-22 per cent yield advantage over existing national check variety, A1. Infact, these hybrids are not popular for commercial cultivation due to difficulties in seed production and limited extent of useful heterosis. The genetic male-sterility is useful in safflower for development of safflower hybrid varieties and for the development of random-mating population for recurrent selection programme. Several genetic male-sterile lines have been identified and reported in safflower (Ramchandram and Sujatha, 1991; Singh, 1996 and Ghorpade, 1999). Some of these GMS lines have been used directly for the development of safflower hybrid varieties *viz.*, DSH-129, MKH-11 and NARI-NH-1. However, direct utilization of GMS lines will be undesirable. The AKSMS-1 GMS line was poor combiner for number of capitula plant^{-1} resulting reduction in yield of 26 experimental hybrids under study (Naoghare and Ghorpade, 2001). Therefore, it is essential to transfer male sterility into agronomically superior varieties like Bhima, A1 before its utilization in hybrid breeding programme. New GMS lines *viz.*, HUS-MS-1, HUS-MS-2 and HUS-MS-3 were the spontaneous mutants from HUS-305, a national check for high oil content were identified and maintained at College of Agriculture, Nagpur (Ghorpade, 1999). These male-sterile lines are agronomically superior and segregate in the ratio of 3 fertile: 1 sterile (Poornima, 2002).Therfore, it is essential to evaluate different types of male sterile lines for segregation pattern, marker gene association with male sterility, agronomic performance, genetic diversity, combining ability before its utilization in hybrid breeding and recurrent selection programme. The present investigation was, therefore, aimed to evaluation of combining ability of newly developed GMS lines of safflower, to identify the most promising genetic male sterile line for its utilization in hybrid breeding and recurrent selection programme and to estimate the useful heterosis for economic traits.

MATERIAL AND METHODS

The present study was conducted during *Rabi* 2004 at the research farm of Department of Agricultural Botany, College of Agriculture, Nagpur. Four GMS *viz.*, HUS-305MS-1, HUS-305MS-2, HUS-305MS-3 and MS(0)9 were crossed with 10 elite parents of safflower *viz*. Bhima, A1, AKS-152, AKS-207, N-7, BLY- 652, Sharda, JLSF-88, S-25 and PH-39.

1. Ph.D.Scholer and 2. Professor and Head of Section, Section of Agril. Botany, College of Agriculture Nagpur

Resulting 40 crosses alongwith check varieties, Bhima and A1 were grown in randomized complete block design with two replications. The plants were spaced at a distance of 45 cm in a rows and row to row distance was 45 cm. Each row consisted of 20 plants. Border rows were grown on two sides to avoid border effect. Recommended package of practices were followed to raise a good crop. The observations were recorded on plant height (cm), number of primary branches plant^{-1}, number of capitula plant^{-1}, number of seeds capitulum^{-1}, seed yield plant^{-1} (g), 100 seed weight (g) on five randomly selected competitive plants per replication of each genotype. However, data for days to 50 per cent flowering and days to maturity were recorded on plot basis. Combining ability analysis was carried out as per procedure given by Kempthorne (1957) with effect model (Model I) of Eisenhart (1947).

RESULTS AND DISCUSSION

Analysis of variance revealed significant genotypic variances for all the characters studied except for number of seeds capitulum^{-1} indicating substantial genetic variability for these traits except number of seeds capitulum^{-1}. The variation due to crosses was partitioned into different components represented by mean squares due to males, females and male x female interactions. The mean squares due to male were significant for all the characters except plant height. The mean squares due to female was significant only for five characters *viz.*, days to 50 per cent flowering, plant height, days to maturity, number of primary branches plant^{-1} and number of capitula plant^{-1}. However, the mean squares due to male x female interaction were significant for all the characters except plant height (Table 1).

In the present study, the GMS line HUS-305 MS-1 was good general combiner for number of primary branches, HUS-305 MS-2 was good general combiner for days to 50 per cent flowering and days to maturity. HUS-305 MS -3 was good general combiner for number of capitula plant^{-1}. MS (09) was poor combiner for plant height, days to maturity, number of primary branches plant^{-1} and number of

Table 1: Estimates of useful heterosis over Bhima for different characters.

S.N.	Crosses	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches plant^{-1}	No. of capitula plant^{-1}	100 Seed weight (g)	Seed yield plant^{-1} (g)
1	HUS-305 MS-1 X Bhima	-1.87**	-	-	-	-	-	-
2	HUS-305 MS-1 X AKS-152	-	-	-	24.7	-	-	-
3	HUS-305 MS-1X BLY-652	-	-	-0.95	-	-	-	-
4	HUS-305 MS-1X Sharda	-	11.46*	-	-	-	-	-
5	HUS-305 MS-1X JLSF-88	-1.87**	-	-	33.8	-	-	-
6	HUS-305 MS-1X PH-39	-1.0	-	-	-	-	-	-
7	HUS-305 MS-1X A 1	-1.5**	-	-	-	-	-	-
8	HUS-305 MS-2X AKS-152	-	-	-	24.7	61.56*		46.08*
9	HUS-305 MS-2X AKS-207	-	-	-	-	-	19.64	-
10	HUS-305 MS-2X Sharda	-1.31**	-	-	-	-	-	-
11	HUS-305 MS-2X S-251	-1.19**	-	-	-	-	-	-
12	HUS-305 MS-3X N-7	-	-		-	43.64	-	-
13	HUS-305 MS-3X S-251	-0.75	-	-	-	-	-	-
14	HUS-305 MS-3X PH-39	-	6.55	-0.83		70.81*	-	34.80
15	HUS-305 MS (0)9X AKS-207	-0.62	-	-	-	-	-	-
16	HUS-305 MS (0)9X S-251	-0.75	-	-	-	-	-	-
	SE ± (D)	0.25	3.12	0.53	1.52	6.93	0.41	8.27
	CD at 5% level	0.71	8.92	1.51	4.35	19.80	1.17	23.63
	CD at 1% level	0.95	11.92	2.02	5.81	26.49	1.57	31.61

, * Significant at 5 per cent, 1 per cent level, respectively.

capitula plant^{-1} (Table 3). None of the GMS line was good general combiner for seed yield plant^{-1}. Naoghare and Ghorpade, (2001) reported that GMS line AKSMS-1 was poor combiner, resulting reduction in yield of experimental hybrids. However, HUS-305 MS-2 and HUS - 305 MS-3 were average combiner for seed yield plant^{-1}.

Among male parents, AKS-152, PH-39 and AKS-207 were good general combiners for yield and its components. These parents may be utilized in synthesis of random-mating population. The cross combination, HUS-305 MS-2 x AKS-152 exhibited significant useful heterosis (46.08 %) (Table 1) and positive significant SCA effect for seed yield plant^{-1} (17.98) and number of capitula plant^{-1} (10.46) (Table 4) indicating significant contribution of dominance and dominance x dominance component to heterosis. Virmani and Maruyama (1995) indicated that there

Table 2: Analysis of variance for combining ability.

Source of variation	d.f.	Mean squares						
		Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches plant^{-1}	No. of capitula plant^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Replication	1	0.1053	0.97	8.74	2.66	1070.19	0.80	845.01
Crosses	39	1.17**	70.33**	6.65**	7.26**	101.6**	0.64**	187.40**
Males (M)	9	0.74**	105.76	6.62**	4.49**	102.98*	0.92**	267.03**
Females (F)	3	0.45**	225.51*	7.29**	15.31**	128.02*	0.30	91.77
Males Vs Females (M x F)	27	1.39**	41.29	6.59**	7.29**	98.22	0.58	171.48**
Error	39	0.066	96.11	0.29	2.41	49.66	0.18	69.96

* - P < 0.05, ** - P < 0.01, NS – Non-significant

Table 3: Estimates of general combining ability effects of the parents.

Parents	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches plant^{-1}	No. of capitula plant^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Females							
HUS-305 MS-1	-0.07	1.13	-0.17	1.06**	1.68	0.06	-1.69
HUS-305 MS-2	-0.2**	0.72	-0.76**	0.09	-2.19	-0.18*	2.27
HUS-305 MS-3	0.20**	2.97	0.46**	-0.06	3.68**	0.09	1.51
MS (0)9	0.07	-4.82*	0.46**	-1.09**	-3.17*	0.03	-2.09
(SE gi) ±	0.05	2.19	0.12	0.35	1.57	0.09	1.87
Males							
Bhima	0.29**	-1.7	0.5**	0.04	-0.71	-0.09	2.79
A 1	0.26**	1.68	-0.22	-0.13	-2.31	0.03	-5.46
AKS-152	0.14	1.13	0.78**	1.82**	8.82**	0.32*	8.01**
AKS-207	-0.05	1.31	1.65**	-0.11	-0.63	0.71**	3.04
N-7	0.06	1.57	-0.22	-0.46	1.14	-0.49*	-2.12
BLY-652	0.31**	-1.65	-1.62**	-0.43	-1.69	-0.11	1.24
Sharda	0.2*	2.85	0.24	0.37	-1.43	0.09	-3.59
S-251	-0.55**	-9.14**	-0.77**	-1.03	-5.81*	0.09	-6.66*
JLSF-88	-0.42**	0.28	0.4*	-0.31	2.62	-0.21	-6.31*
PH-39	-0.24**	3.67	-0.065**	0.24	3.75	-0.34*	9.06**
(SE gj) ±	0.09	3.47	0.19	0.55	2.49	0.15	2.96

* - P < 0.05, ** - P < 0.01.

Table 4: Estimates of specific combining ability effects of the crosses for different characters.

S,N.	Crosses	Days to 50 %	Plant height	Days to maturity	No. of primary plant^{-1}	No. of capitula	No. of seed capitulumt^{-1}	100 Seed Weight (g)
1	HUS305 MS-1 X Bhima	-1.78**	-1.78	0.41	-0.63	3.66	0.07	17.26**
2	HUS305 MS-1 XA 1	0.46	-6.75	-1.99**	0.24	-0.85	0.46	4.19
3	HUS305 MS-1 X AKS-152	0.58*	-4.79	-1.36**	-0.01	-2.2	0.37	-7.79*
4	HUS305 MS-1X AKS-207	0.76**	-4.08	1.96**	-0.18	-1.63	-0.63*	-0.41
5	HUS305 MS-1X N-7	-0.15	-0.76	1.58**	-0.13	0.51	-0.56*	0.44
6	HUS305 MS-1X BLY-652	0.2	-0.74	-1.92**	-1.46*	-0.58	0.69*	-2.01
7	HUS305 MS-1X Sharda	0.51*	11.74**	0.68*	-0.56	2.77	0.19	-5.08
8	HUS305 MS-1X S-251	1.05**	6.37	1.68**	-0.06	0.76	0.59*	-3.11
9	HUS305 MS-1X JLSF-88	-1.08**	2.05	-2.59**	3.22**	3.9	-1.11**	3.94
10	HUS305 MS-1X PH-39	-0.55*	-1.26	1.55**	-0.43	-6.33*	-0.08	-7.43*
11	HUS305 MS-2X Bhima	0.85**	2.44	0	0.74	5.72*	-1.22**	1.51
12	HUS305 MS-2X A 1	-1.39**	-0.35	-1.39**	-0.49	-1.39	-0.49	-0.45
13	HUS305 MS-2X AKS-152	-0.4	1.02	0.13	0.96	10.46**	0.51	17.98**
14	HUS305 MS-2X AKS-207	0.38	-0.28	-3.76**	0.29	-1.07	0.71*	8.65**
15	HUS305 MS-2X N-7	0.58*	1.47	-1.39**	1.24*	5.66*	0.31	3.90
16	HUS305 MS-2X BLY-652	-0.17	2.29	1.02**	1.71**	1.08	-0.37	-1.25
17	HUS305 MS-2X Sharda	-1.21**	-0.22	0.17	0.31	1.83	-0.37	4.18
18	HUS305 MS-2X S-251	-0.37	-3.69	0.17	2.41**	6.72*	0.13	-10.05**
19	HUS305 MS-2 X JLSF-88	1.05**	0.96	3.5**	-5.31**	-19.74**	0.63*	-18.20
20	HUS305 MS-2X PH-39	0.68**	-3.64	1.55**	-1.86**	-9.27**	0.16	-6.27*
21	HUS305 MS-3X Bhima	-0.24	-0.53	-1.23**	0.29	-1.95	-0.06	-3.64
22	HUS305 MS-3X A 1	-0.21	1.91	1.07**	-1.04	0.36	-0.26	-3.89
23	HUS305 MS-3X AKS-152	0.32	-1.05	1.88**	-1.09	-9.7	-0.56*	-5.66
24	HUS305 MS-3X AKS-207	-0.51*	1.48	1.9**	1.64**	2.68	0.24	-7.29*
25	HUS305 MS-3X N-7	-0.21	4.21	0.32	1.59**	4.7	0.24	-4.34
26	HUS305 MS-3X BLY-652	0.55*	2.33	0.72*	-1.74**	-4.48	-0.34	-0.59
27	HUS305 MS-3X Sharda	0.86**	-5.07	0.12	-0.54	-7.23**	0.33	7.84*
28	HUS305 MS-3X S-251	-0.31	-3.58	-0.88**	-2.64**	-8.25**	-0.24	5.02
29	HUS305 MS-3X JLSF-88	-0.14	-3.81	-0.38	1.34*	13**	-0.44	0.76
30	HUS305 MS-3X PH-39	-0.11	4.11	-3.7**	2.19**	10.87**	0.99**	11.79**
31	MS(0)9 X Bhima	1.19**	-0.15	1.07**	-0.39	-7.41**	0.6*	-15.36**
32	MS(0)9 X A 1	1.14**	5.2	1.69**	1.28*	1.89	0.3	-0.11
33	MS(0)9 X AKS-152	0.56*	4.85	-0.68*	0.13	1.45	-0.21	-4.78
34	MS(0)9 X AKS-207	0.58*	2.87	0.02	-1.74**	0.01	0	1.29
35	MS(0)9 XN-7	-0.1	-4.9	-0.43	-2.69**	-10.86**	0.2	-0.26
36	MS(0)9 X BLY-652	-0.63*	-3.89	0.19	1.48*	3.96	0.02	3.59
37	MS(0)9 X Sharda	-0.22	-6.48	-0.88**	0.78	2.62	0.02	-7.18*
38	MS(0)9 X S-251	-0.44	0.91	-0.96**	0.28	0.79	-0.39	7.89*
39	MS(0)9 X JLSF-88	0.19	0.79	-0.55	0.76	2.84	0.32	13.24**
40	MS(0)9 X PH-39	0.07	0.8	0.52	0.11	4.71	-0.86**	1.68
	SE ± (sij)	0.24	3.47	0.29	0.59	2.50	0.27	2.96

* - P < 0.05, ** - P < 0.01.

was no evidence in rice that significant dominance effects cause heterosis. Mostly heterosis was due to additive effects and linkage disequilibrium of genes in the parents.

The GMS lines, HUS-305 MS-2 and HUS-305 MS-3 may be utilized in recurrent selection programme for development of superior varieties. The predominance of additive genetic variation in safflower (Janolkar and Ghorpade, 1991) and random-mating population (Panchabhai, 2004) suggest that recurrent selection is effective in utilization of additive genetic variation. Naole (2004) reported 23.87 per cent increase in yield over Bhima by utilizing half-sib recurrent selection scheme in a random-mating population segregating for genetic male sterility.

On the basis of the results obtained in this study, only one cross *viz.*, HUS-305 MS-2 x AKS-152 (46.08%) showed significant increase over Bhima for seed yield plant^{-1} (Table 1). Many workers reported useful heterosis which ranged from 42 to 177 per cent for yield over check variety (Pandya *et. al*., 1990; Deshmukh, 1991; Wandhare, 1997). The release of three GMS based safflower hybrid varieties indicated that genetic male sterility can be exploited successfully for commercial exploitation of hybrid vigour in safflower. However, these hybrids are not cultivated on commercial scale due to inherent seed production problems. The identification and removal of 50 per cent heterozygous fertile plants at flowering stage is tedious and impractical in commercial seed production plots. There is no marker gene available in safflower, which is associated with male sterile gene. Therefore, the use of genetic male sterility for exploitation of heterosis at commercial level in safflower has limited application. The hybrid varieties in safflower will become reality when CMS lines become available. Under such circumstances, potential GMS lines may be utilized for development of random-mating population for recurrent selection programme.

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Studies on Inheritance of Morphological Traits in Chickpea

S. R. Patil[1], Anita Babbar[2] and A. R. Bhuyar [3]

ABSTRACT

Investigation was carried out during Rabi season 2008-09 under All India Coordinated Research Project on Chickpea in the experimental field of Seed Breeding Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, (MP). The F_2 population derived from sixteen crosses of twenty parents. The genetic inheritance of different morphological traits is essential for selection of superior and desirable transgressive segregants for genetic improvement of the crop.

Chickpea (*Cicer arietinum* L.), the world's third most important winter season food legume, is a self pollinated diploid legume. It belongs to family leguminoceae and sub-family papilionoideae Goodwin (2003). It is valued for its nutritive seeds with high protein content (25.3-28.9 %), and vitamin C content after dehulling. Chickpea is currently grown on about 11 m ha area worldwide. India's share in global chickpea production is 67 per cent. In India, chickpea is being grown in 7.10 m ha area, with production 5.65 mt and productivity 795 kg ha^{-1}. Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Gujarat and Andhra Pradesh are the major chickpea growing states sharing 85 per cent area. Madhya Pradesh covers 2.8 m ha area with production 2.6 mt and productivity 931 $kgha^{-1}$, Chickpea use for making 'Chana dal' (milling), *Besan*, parching, table purpose, vegetable, salad bars, vegetable mixes, or ground into humus, etc. (Goodwin, 2003).

Genetic improvement in chickpea though started since its domestication but progress has not been made up to the satisfaction. Breeding efforts for high yield potential have been based on either selection for yield $selection^{-1}$ or indirect selection for yield components in early segregating generation. To improve the production potential of this crop, breeding programme should be aimed at development of high yielding varieties by combining genes from various sources which require precise information on the nature and degree of genetic variability present in the crop. These breeding strategies may be effective if there is adequate information on genetic inheritance and linkage. Breeders have to formulate criteria for isolating superior genotypes from early segregating populations.

MATERIAL AND METHODS

Jabalpur is situated at 23.9°N latitude and 79.58°E longitude at an altitude of 411.87m above the mean sea level. This region has subtropical, semi-arid climate. The main features are hot and dry summer and cold winter with occasional showers in *Rabi* and *Summer* season. The average rainfall is about 1400 mm, which is received mostly during July to September temperature vary from 8°C being minimum into January and 45°C being maximum in May. The crop was grown under normal crop season. The germination was excellent in *Desi* chickpea type in comparison to *Kabuli*.

In the present investigation required seeds were procured from All India Coordinated Research Project on Chickpea, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, (M.P.). Crosses were made during 2006-07 (*Rabi* season) and their F_1 seeds were grown in 2007-08 (*Rabi* season).In 2008-09 all four generations viz. P_1, P_2, F_1 and F_2 Seeds of each crosses were grown in experimental plot in lines with row length of 4m, row to row distance of 30 cm and plant to plant spacing 10 cm. for *Desi* crosses and row to row distance of 45 cm and plant to plant spacing 12-15 cm. for *Kabuli* chickpea crosses. Parents of each cross were grown in single row and F_1 in two rows. Segregating population (F_2) was grown in fifteen rows $plot^{-1}$. To avoid border effect one border row is sown both side of the plot. Standard agronomic practices and plant protection methods were taken up as and when required.

1. & 3. M.Sc. Students and 2. Professoer and Senior Scientist, Deptt. of Plant Breeding and Genetics, JNKVV, Jabalpur (MP)

The objectives to study inheritance of morphological traits in chickpea *viz.* growth vigour, days to flowering, foliage colour, leaf type, leaflet size, flower colour, pods peduncle^{-1}, branching habit, seed surface, seed size, seed colour and seed shape. The F_2 population derived from sixteen crosses of twenty parents involving ten *Desi*, five *Kabuli*, one *Gulabi*, two mutant and two wild parents with eight *Desi* x *Desi*, three *Kabuli* x *Desi*, one *Desi* x *Gulabi*, one *Kabuli* x *Kabuli*, one *Desi* x mutant, one mutant x *Kabuli* and one wild x wild. Here investigate twelve contrasting characters as growth vigour early - late, days to initial flowering early - late, foliage colour light green - dark green, leaf type imperipinnate leaf - simple leaf, pod peduncle^{-1} single - double, flower colour pink - white - purple, growth habit erect - spreading, seed surface rough - smooth, seed size large - small, seed colour orange – yellow - beige, leaf size broad - small, seed shape angular - round.

The F_2 segregation analysis was performed using the computer programme linkage–1 developed by Suiter *et al.* (1983). This programme tested monogenic inheritance using goodness of fit χ^2 (Chi^2) tests and calculate its standard error (SE) using the maximum likelihood formulae suggested by Allard (1956). The χ^2 (Chi^2) test for homogeneity of data for different F_2 families was calculated according to Mather (1951).

RESULTS AND DISCUSSION

Among pulses, chickpea (*Cicer arietinum* L.) is the crop on which detail research work with respect to some important qualitative characters has been carried out. However, its production is less per unit area as compared to cereals and millets. Therefore, considerable attention should be given for its genetic improvement. The P_1, P_2, F_1 and F_2 populations of sixteen crosses including twenty parents were used for inheritance study.

Growth Vigour

The slow growth vigour character is recessive over normal and controlled by duplicate gene action. The F_2 segregation ratio of 15 normal : 1 slow growth was in agreement with the finding of Sabaghpour *et. al.*, (2003). On the other hand, Dahiya *et al.* (1994) observed a monogenic segregation for 3 normal : 1 slow growth vigour in F_2 and 1 normal : 1 slow growth vigour in back cross. But, Waldia *et al.* (1992) reported the inheritance of root length and speed of radical emergence was additive and additive x additive gene effects were important for the expression of these characters.

Leaf type

Simple leaf mutant has been the trait of common interest, the earlier studies revealed that it is governed by single recessive gene (Rao *et. al.*, 1980, Gowda 1981, Pandey and Tiwari 1981, Pundir and reddy, 1998 and Jain, 2003). The result of this study also supports the previous findings in the cross between simple leaf and imperipinnate-leaf. The F_1 of this cross showed imperipinnate leaf and in F_2 segregating ratio was 3:1 (3 imperipinnate leaf : 1 simple leaf).

Srinivasan *et. al.*, (2006) concluded the results of their study and stated another negative effect of simple leaf trait, the reduction in seed yield plant^{-1}. Thus it is recommended that selections should be practiced for imperipinnate leaves plants in crosses involving simple leaves and imperipinnate leaves type.

Leaf Foliage Colour

Light green colour was found to be recessive to dark green foliage. The F_2 segregation ratio of 3 green : 1 light green foliage was in agreement with the finding of Jain (2003), also found that other colours were found to be recessive to normal green foliage.

In other case cross between purple flower *Desi* mutant with white flower *kabuli* shows all purple flower plants in F_1 and its F_2 segregating population shows the inhibitory gene action, which is supported by Sandhu *et. al.*, (1993) in a cross between purple pigment of whole plant and normal foliage colour plant**.** On the other hand Rao *et. al.*, (1980) revealed that the purple and light green foliage colours were found to be recessive to normal green foliage; inheritance of purple foliage colour is reported first time, *i.e.* the purple green foliage colour is monogenic recessive in nature over light green foliage.

Days to Initial Flowering

In the crosses between *Desi* x *Desi*, *Desi* x *Gulabi* and *Desi* x mutant lines and their pooled data suggesting that the early flowering was recessive over late and early flowering was controlled by

Table 1: Characteristics showing dominant and recessive inheritance in Chickpea

S.N.	Characters	Inheritance	Dominant	Recessive
1.	Growth Vigour	Duplicate	High	Low
2.	Days to Initial Flowering			
	2a. *Desi* x *desi*, *gulabi* x *desi* and mutant x *desi* crosses	Duplicate	Late	Early
	2b. *Kabuli* x *desi* cross	Monogenic	Late	Early
3.	Foliage Colour			
	3a. *Desi* x *Desi* crosses	Monogenic	Dull Green	Light Green
	3b. Mutant x mutant cross	Inhibitory	Purple Green	Normal Green
4.	Leaf Type	Monogenic	Imperipinnate leaf	Simple
5.	Pod per Peduncle	Monogenic	Single Pod	Double Pod
6.	Flower Colour			
	6a. *Gulabi* x *Desi* cross	Monogenic	Pink	White
	6b. *Kabuli* x *Desi* cross	Supplementary	9 (Pink) : 3 (Blue) : 4 (White)	
7.	Growth Habit	Monogenic	Spreading	Erect
8.	Seed Surface	Monogenic	Rough	Smooth
9.	Seed Size	Monogenic	Large	Small
10.	Seed Colour			
	10a. *Gulabi* x *Desi* Crosses	Monogenic	Orange	Brown
	10b. *Kabuli* x *Desi* Crosses	Monogenic	Brown	White
11.	Seed Shape	Monogenic	Angular	Pea shape

duplicate gene action. This data are supported by the result of Anbessa *et. al.,* (2006). In other three *Desi* x *Kabuli* crosses for days to initial flowering gave a good fit to 3 late flowering : 1 early flowering suggesting that the early flowering time characters was recessive and monogenic in nature. Similarly Or *et. al.*, (1999) also suggested that F_2 populations derived from crosses between an early-flowering breeding line (*Desi*) with weak photoperiodic response and a late-flowering high yielding (*kabuli*) cultivar with a strong photoperiod response, a 3 : 1 ratio of late flowering : early flowering types was observed. Here in *Desi* x *Kabuli* crosses are differing from suggestion of Gumber *et. al.*, (1996) and Anbessa *et. al.,* (2006) in chickpea.

Flower Colour

Inheritance of flower colour in three type of crosses *i.e. Desi* x *Gulabi*, *Desi* x *Kabuli* and mutant x *Kabuli* exhibited that in *desi* x *gulabi* crosses, white flower colour trait was recessive over pink and governed monogenically. On the other hand *Desi* x *Kabuli* and mutant x *Kabuli* (Pink x White) crosses show supplementary gene action, give a good fit to 9:3:4 (9 Pink : 3 Purple : 4 White). This trait has been widely used. Many workers have observed a monogenic segregation for pink vs. white petal colour. (Ghatge, 1994 and Jain, 2003). This data also support the revelation of Kumar *et. al.,* (2000) *i.e.* Pink x White crosses show supplementary gene action. However, the basic idea behind using known traits was to search linkage if any between the new traits involved in the study.

Pods Peduncle^{-1}

The inheritance of pods peduncle^{-1} trait was studied in ten crosses between single podded and double podded parents revealed that all of these crosses gave a good fit to 3:1 (Single pod : double pod) ratio in a χ^2 contingency table. This data also support to the revelation of Maesen *et. al.,* (1980), Pawar and Patil (1983), Rao and Pundir (1983), Singh and Van Rheenen (1994), Babbar *et. al.,* (2005) and Srinivasan *et. al.*, (2006) *i.e.* single recessive gene has been reported to govern double flowered double podded^{-1} trait over single flower-1single podded trait.

The results of this study will help in development of breeding strategies for exploitation of these flowering and podding traits in chickpea improvement.

Growth Habit

The genetic inheritance of growth habit was studied in F_2 generation of three crosses, in which two crosses gave a good fit to 3 erect : 1 spreading and one cross was distorted to 3 spreading : 1 erect type suggesting that spreading growth habit characters was recessive and controlled monogenically. Similarly Ghatge (1994) also showed 3 erect : 1 spreading.

Seed Size

Seven crosses were made for the study of seed size (mm), small seed size was found to be recessive to large seed size. The F_2 segregation ratio of 3 large : 1 small seed size was found. This data borrow support from the finding of Upadhyaya *et. al.,* (2006). On the other hand this data fails with the suggestion of Kumar and Singh (1995) and Malhotra, *et. al.,* (1997) both suggested that small seed size was partially dominant over large seed size.

Seed Surface

The rough seed surface revealed monogenic dominant behaviour over smooth seed surface. Jain (2003) and Meena *et. al.*, (2005) reported that the rough seed surface was controlled by single dominant gene.

Seed Colour

The four crosses were made of contrasting trait for the study of seed colour. In *Gulabi* (orange colour) x *Desi* (yellow colour) orange colour was found to be dominant over yellow colour. The F_2 segregation ratio of 3:1 (3 Orange : 1 brown) seed colour was found. In second cross, cross between *Desi* mutant (yellow seed colour) and *Kabuli* mutant (beige seed colour), beige seed colour was found to be monogenic recessive to yellow and in case of brown verses beige seed coat colour, beige seed coat colour controlled by monogenic inheritance.

Ghatge and Kolhe (2008) also concluded that seed colour was controlled by single gene. Meena *et. al.,* (2004) studied inheritance of seed colour in chickpea and concluded that different seed colour combination were governed by different genes *i.e.* simple dihybrid, supplementary gene action.

Seed Shape

The genetic inheritance of seed shape was studied in F_2 generation of two crosses. In these crosses and their pooled data gave a good fit to 3 angular : 1 round suggesting that the round seed shape trait character was recessive over angular seed shape and controlled monogenically. Ghatge and Kolhe (2008) also supported to round seed shape trait character recessive over angular seed shape and controlled monogenically. On the other hand Meena *et. al.,* (2004) reported inheritance of seed shape in chickpea show segregation in F_2. Their studies revealed that *Desi* types are dominant over both *Kabuli* and pea types while pea types are dominant over *Kabuli* type indicated the digenic control of seed shape in chickpea.

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Correlation and Path Analysis in Durum Wheat

S. B. Sakhare[1] and N. P. Ghawat[2]

ABSTRACT

The present investigation was conducted with a view to determine association between yield and yield components and thereby to assess the direct and indirect effects of yield components on yield. The genotypic correlations between yield plot^{-1} and grain weight ear^{-1}, number of ears meter^{-1}, seed index, number of grains ear^{-1}, plant height at maturity and days to 50 per cent flowering indicated the direct contribution of these characters for improvement of yield. The character grain weight ear^{-1} (0.405) had the largest direct effect on yield plot^{-1}, followed by number of ears meter^{-1} (0.285), seed index (0.253), number of grains ear^{-1} (0.189), plant height at maturity (0.174), days to 50 per cent flowering (0.138) and length of ear (0.019). This indicated the direct contribution of these characters for improvement of yield. Indirect effect via grain weight ear^{-1} was found to be maximum for most of the traits like seed index, length of ear, plant height at maturity and number of ears meter^{-1}. Thus, grain weight ear^{-1} was found to be promising character for enhancing yield.

India is one of the largest growers of durum wheat in the world. Since the Indian durum is of very high standards and meets the export standards, it will be possible for the country to export it on a large scale. So it seems essential to develop quality durum wheat varieties with improved yield potential in order to get more returns to the farmers . The improvement in yield potential is the basic criterion, which a plant breeder has always to keep in view in his attempts to evolve a new variety. However, yield itself as is well known, is not a unitary character but is the result of interactions of number of factors inherent both in plant as well as in the environment in which the plant grows.

Therefore, selection for such characters based on phenotypic expression is likely to be less efficient. Under such condition knowledge of interrelationship among its different components is necessary for effective selection and for simultaneous improvement of yield components. Such information can be obtained by studying the correlation between yield and its components. Though correlation studies provide information on nature, extent and direction of selection, but still it becomes difficult to understand the exact cause and effect relationship between two characters. Path coefficient analysis at this juncture helps in understanding the direct and indirect contribution of each character on yield. Hence, correlation studies aided by path coefficient analysis will be a powerful tool in selecting the plants for desired characters. Upon these considerations, the present investigation was aimed to study the correlation and path analysis for various yield and yield attributes in durum wheat.

MATERIAL AND METHODS

The present investigation was carried out with fifty genotypes of durum wheat (*Triticum durum* L.) in the field of Regional Research Centre, Amravati of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Randomized Block Design with three replications. Observations were recorded in each replication for each genotype on eleven different characters namely, days to 50 per cent flowering, length of ear, plant height at maturity, days to maturity, number of ears meter^{-1}, number of grains ear^{-1}, seed index, grain weight ear^{-1}, grain yield meter^{-1} row, β-carotene content and yield plot^{-1}. The data obtained in respect of all the characters have been subjected to statistical analysis. The simple genotypic, phenotypic and environmental correlation coefficients were worked out as per the formulae suggested by Hayes, *et. al.*, (1955) and there by the path coefficients were calculated by the method of Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation studies

In order to find out the degree of association of yield with yield contributing traits and among themselves, genotypic and phenotypic correlation coefficients were worked out and are presented in Table 1. It is revealed that the genotypic

1. Associate Prof. and 2. M.Sc., Department of Agril. Botany, Dr. PDKV, Akola

correlations between yield plot^{-1} and grain weight ear^{-1}, number of ears meter^{-1}, seed index and plant height at maturity were positive and significant. This indicated a strong association of these traits with yield which could be fruitfully exploited for enhancing yield potential. Similar findings were reported by Waldron (1928), Lebsock and Arnoldo (1969) for seed index and grain weight ear^{-1}, Bhullar and Nijjar (1984), Bangarwa *et. al.*, (1987), Bakhet *et. al.*, (1989) and Dechev (1990) for number of ears meter^{-1} and Kaltsikes and Larter (1970), Quick (1980) for plant height at maturity. The character days to maturity showed negative and significant association with yield plot^{-1} indicated the fact that increase in one trait in general may result corresponding decrease in the other. This result is also in agreement with the findings of Barriga (1974).

Among yield components, length of ear showed positive and significant association with plant height at maturity. Similar result was obtained by Hirachand *et. al.*, (1978). Positive and significant association of length of ear with grain weight ear^{-1} was recorded. Similar result was obtained by Huang *et. al.*, (1989). Thus, selection for length of ear might help in simultaneous improvement of plant height at maturity and grain weight ear^{-1}. Number of ears meter^{-1} and grain weight ear^{-1} showed positive and significant association with each other. Similarly, grain weight ear^{-1} found positively and significantly correlated with seed index, so selection for grain weight ear^{-1} might be helpful for improvement of seed index and number of ears meter^{-1}.

The character, days to 50 per cent flowering showed negative and significant association with plant height at maturity and grain weight ear^{-1}, indicated direct selection for days to 50 per cent flowering may result in decrease in height of plant and grain weight ear^{-1} and may ultimately affect yield. Negative and significant association of days to maturity with grain weight ear^{-1} and number of ears meter^{-1} was observed. Similarly, the negative and significant correlation between seed index and number of grains ear^{-1} will not have any advantage in selection programme.

Path analysis

The over all correlation observed between two attributes is a function of a series of direct and indirect relationship between those attributes. In order to know the specific forces in building up the total correlation, it is essential to resort to path coefficient analysis developed by Wright (1921). It measures the direct influence of one component upon the other and permits the partitioning of the total correlation coefficients in to its components of direct and indirect effects.

The Table 2 revealed that the character grain weight ear^{-1} (0.405) had the largest direct effect on yield plot^{-1}, followed by number of ears meter^{-1} (0.285), seed index (0.253), number of grains ear^{-1} (0.189), plant height at maturity (0.174), days to 50per cent flowering (0.138) and length of ear (0.019). This indicated the direct contribution of these characters for improvement of yield. Similar results were recorded by Lungu *et. al.*, (1990), Sheroran *et. al.*, (1986) for grain weight ear^{-1} and Peterson (1984), Shrivastava and Singh (1971), Shrivastava *et. al.*, (1980) for number of ears meter^{-1}, Ram *et al.* (1974), Barriga (1974), for seed index, Sarkar *et al.* (1988), Thakur *et al.* (1989) for number of grains ear^{-1} and Bangarwa *et. al.*, (1987) for length of ear. Negative direct effect on yield plot^{-1} was observed for character days to maturity (-0.242).

The maximum indirect effect of the trait seed index was via grain weight ear^{-1} (0.310), followed by grain weight ear^{-1} via seed index (0.193), length of ear via grain weight ear^{-1} (0.189), plant height at maturity via grain weight ear^{-1} (0.137), number of ears meter^{-1} via grain weight ear^{-1} (0.124), number of ears meter^{-1} via plant height at maturity (0.059), days to 50 per cent flowering via number of ears meter^{-1} (0.043) and days to maturity via days to 50 per cent flowering (0.034). These characters can be exploited for enhancing the yield.

From the present study, it can be concluded that the character grain weight ear^{-1} can be fruitfully exploited for the improvement of yield since it had highest direct effect on yield plot^{-1}. Similarly, it exhibited a positive and significant association with yield plot^{-1}. Besides, indirect effect via grain weight ear^{-1} was also found to be maximum for most of the traits namely seed index, length of ear, plant height at maturity and number of ears meter^{-1}. Thus, grain weight ear^{-1} was found to be a promising character for enhancing yield.

Table 1 : Genotypic and phenotypic correlation coefficient for different characters

Characters		Days to 50 per cent flowering	Length of ear	Plant height at maturity	Days to maturity	No. of ears meter^{-1}	No. of grains ear^{-1}	Seed index	Grain weight ear^{-1}	β - carotene content	Yield plot^{-1}
Days to 50 % flowering	G	1.000	-0.014	-0.318*	0.249	0.151	-0.049	-0.173	-0.487**	0.164	-0.185
	P	1.000	-0.009	-0.290*	0.170	0.062	-0.049	-0.154	-0.249	0.150	-0.161
Length of ear	G		1.000	0.353*	0.160	-0.303*	0.168	-0.112	0.466**	-0.154	0.146
	P		1.000	0.302*	0.127	0.174	0.305*	-0.086	0.238	-0.084	0.120
Plant height at maturity	G			1.000	-0.092	-0.014	0.147	0.053	0.338*	-0.081	0.333**
	P			1.000	-0.061	0.126	0.273	0.004	0.285*	-0.068	0.311*
Days to maturity	G				1.000	-0.489	-0.065	-0.280*	-0.505**	0.005	-0.648**
	P				1.000	-0.308*	-0.088	-0.163	-0.355**	7×10^{-4}	-0.445**
No. of ears meter^{-1}	G					1.000	0.207	0.149	0.306*	0.024	0.617**
	P					1.000	0.225	-0.029	0.170	0.006	0.427**
No. of grains ear^{-1}	G						1.000	-0.440**	0.062	0.353	0.200
	P						1.000	-0.246	0.398**	0.177	0.158
Seed index	G							1.000	0.764**	-0.159	0.572**
	P							1.000	0.367**	-0.125	0.453**
Grain weight ear^{-1}	G								1.000	-0.038	0.820**
	P								1.000	-0.016	0.444**
b - carotene content	G									1.000	0.028
	P									1.000	0.028
Yield plot^{-1}	G										1.000
	P										1.000

G – Genotypic correlation coefficient
P – Phenotypic correlation coefficient
* Significant at 5 % level of probability
** Significant at 1 % level of probability

Table 2 : Direct and Indirect effects of different characters on yield in durum wheat

Characters	Days to 50 per cent flowering	Length of ear	Plant height at maturity	Days to maturity	No. of ears meter^{-1}	No. of grains ear^{-1}	Seed index	Grain weight ear^{-1}
Days to 50 % flowering	0.138	0.001	-0.055	-0.060	0.043	-0.009	-0.044	-0.197
Length of ear	-0.002	0.019	0.061	-0.039	-0.086	0.032	-0.028	0.189
Plant height at maturity	-0.044	0.007	0.174	0.022	-0.004	0.028	0.013	0.137
Days to maturity	0.034	0.003	-0.016	-0.242	-0.139	-0.012	-0.071	-0.205
No. of ears meter^{-1}	0.021	-0.006	-0.002	0.118	0.285	0.039	0.038	0.124
No. of grains ear^{-1}	-0.007	0.003	0.025	0.016	0.059	0.189	-0.111	0.025
Seed index	-0.024	-0.002	0.009	0.068	0.043	-0.083	0.253	0.310
Grain weight ear^{-1}	-0.067	0.009	0.059	0.122	0.087	0.012	0.193	0.405

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Stability Parameter Analysis and Heterosis Estimation for Yield and Yield Attributes in Safflower

R. A. Satpute[1], A.N. Nimbalkar[2], R.R. Mishra[3] and C.B. Chaporkar[4]

ABSTRACT

Twelve Safflower hybrids were evaluated for yield and other traits along with six checks (three varieties and three hybrids) to know the stability and standard heterosis over the best checks (MRSA-521 and PBNS-12). Two hybrids, SA07003 and SA07008 exhibited significant standard heterosis over the best varietal and hybrid check for seed yield. One hybrid (SA07011) for dwarfness, two hybrids (SA07008 and SA07010) for primary branches, six hybrids for seeds capitula^{-1} and five hybrids for oil content were significantly heterotic over both the best checks; while for no. of effective capitula 11 hybrids showed significant heterosis over the best varietal check PBNS-12 and three hybrids showed significant superiority for test weight over the best hybrid check MRSA-521. Significant Genotype × Environment (G × E) interaction for days to 50 per cent flowering, days to maturity, seed yield and oil content and that to G × E (Linear) and pooled deviation (Non-linear) revealed significance of both components accounted for G × E interaction for the traits effective capitula plant^{-1}, oil content and seed yield. The genotypes SA07001 and SA07005 for days to 50 per cent flowering, SA07003 and SA07001 for days to maturity, three hybrids and two checks for plant height found more stable than other entries. For yield and yield contributing traits different hybrids or checks viz. A-1 and SA07001 for primary branches plant^{-1}, SA07006 and MKH-9 for effective capitula plant^{-1}, SA07007, SA07009 and A-1 for seeds capitula^{-1}, SA07011 for 100 seed weight, SA07003, SA07008 and MRSA-521 for seed yield and SA07008, SA07009, SA07011 and MRSA-521 found more stable than other entries and checks for the trait oil content (%).

Safflower (*Carthamus tinctorus* L.) is an often cross pollinated crop and getting considerable importance in recent past as it performs better under limited moisture condition in different parts of the country. The total area under safflower in the country is around 3.2 Lakh ha with a production of about 2.4 lakh tonnes with a productivity of 637 kg ha^{-1} (Anonymous, 2008). The crop cultivated primarily for its seeds, which yields oil. It is very necessary to develop genotypes capable of high degree of adaptability combined with superior productivity levels over wide range of ecogeographical conditions for successfully exploiting its inherent potential. Genotype × Environment (G × E) interaction is supposed to be one of the genetic parameters responsible for phenotypic stability and adaptation. In the present investigation, attempts were made to estimate standard heterosis of newly developed hybrids and also to identify stable hybrids for yield and its components in safflower.

MATERIAL AND METHODS

Present investigation was carried out in Mahyco research farms at Jalna (Maharashtra) and Gulbarga (Karnataka) during *Rabi* 2007-08 and 2008-09. Experimental material consisted of 18 entries (12 test hybrids, 3 hybrid checks and 3 varietal checks). Experiment was laid out in Randomized Complete Block Design in three replications with protective irrigation (2 irrigations, one at 30 days after sowing (DAS) and another at 75 DAS). Each plot comprised of six rows with 45 x 20 cm spacing. Five randomly selected plants were tagged to record observations for days to flower, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of effective capitula plant^{-1}, number of seeds capitulam^{-1}, 100 seed weight (g), oil content (%), seed yield plant^{-1} (g), seed yield ha^{-1} (kg) . The data were analyzed for stability parameters using the model proposed by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Heterosis

Analysis of variance showed highly significant difference among the entries including checks for all the characters under study (Table 1). Results of standard heterosis are presented in Table 2, including per se performance of the entries and

1. Lecturer, Govt. Institute of Science, Aurangabad, 2. Assistant Res. Scientist, 3. Land Regulator Affairs and 4. Head, Cotton, Okra and Oilseed Research, Mahyco, Jalna.

Table 1. Analysis of variance for different characters in safflower hybrids/varieties.

Source	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Primary branches plant^{-1}	Effective capitula plant^{-1}	Seeds capitulam^{-1}	100 seed weight (g)	Oil content (%)	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (Kg)
Entry	148.84**	55.48**	455.15**	6.85**	332.81**	1126.73**	7.49**	23.93**	235.45**	1842634.68**
Locations	5.78**	57.37**	2758.70**	0.97**	2106.38**	610.38**	15.05**	51.90**	943.61**	7038774.94**
Locations by Entry	3.57**	7.80**	24.71**	1.21**	39.99**	47.93**	0.18**	1.96**	48.00**	244959.15**
Blocks in location	5.73**	11.39**	17.98	0.18	9.46	8.80	0.03	0.87**	44.15**	147816.32**
Error	1.29	3.46	12.79	0.31	5.37	6.51	0.03	0.35	10.28	37061.21

** Significant at 1% level of probability checks. Standard heterosis values were calculated over best hybrid check (MRSA-521) and best varietal check (PBNS-12), as they were best among all the checks for most of the characters.

The range for days to 50 per cent flowering was recorded from 72.67 to 81.00 days; while it was 71.83 and 81.75 days for MRSA-521 and PBNS-12, respectively. None of the entry was early than the check MRSA-521 but on the other side except SA07006 all the other entries were significantly earlier than the varietal check PBNS-12. For days to maturity the range was between 113.08 to 118.83 days for checks and it was 113.33 and 118.00 days for MRSA-521 and PBNS-12, respectively. None of the entry was significantly early than MRSA-521, on the other hand SA07002, SA07011 and SA07012 were significantly early than PBNS-12.

Entries attained the plant height between 79.96 to 97.83 cm; while that of 85.00 and 86.50 for checks MRSA-521 and PBNS-12, respectively. SA07011 reflected standard heterosis for dwarfness over both the checks. For number of primary branches plant^{-1} trait only two entries SA07008 and SA07010 had significant superiority over both the checks.

Effective capitula for entries ranged between 32.16 to 47.22 and that to checks 42.32 and 31.96 for MRSA-521 and PBNS-12, respectively. Four entries had positive significant superiority over MRSA-521 for effective capitula plant^{-1} trait and that to all the entries except SA07001 had positive significant superiority over PBNS 12. For seeds capitulam^{-1} the entries ranged between 33.04 to 54.17 and six out of twelve entries had significant superiority over both checks. For 100 seed weight only three entries viz. SA07008, SA07009 and SA07012 had positive significant superiority over MRSA-521 but none of the entry showed positive significant superiority over the check PBNS-12. In terms of oil content, five entries showed superiority over MRSA-521 and all the twelve entries showed significance over the check PBNS-12.

Seed yield plant^{-1} is most important trait and the range for this trait was 33.12 g to 47.14 g and the value for checks MRSA-521 and PBNS-12 were 43.94 g and 41.92 g, respectively. Entry SA07003 was significantly superior over both checks while the entries SA07008, SA07009 and SA07012 had significant superiority over PBNS-12. For seed yield ha^{-1} trait the entries ranged between 2412.82 to 3600.96 kg and for checks it was 3371.00 and 3002.53 kg, respectively. Entry SA07003 and SA07008 were significantly superior over both checks. Hill (1989) mentioned the superiority of CMS hybrids over the best varieties in California (USA). GMS based hybrids MKH-11 and DSH-129 had superiority for seed yield over the best varieties (Anonymous, 1998).

Stability

The analysis of variance for stability (Table 3) showed highly significant mean sum of squares for genotypes and environments for all traits studied except number of primary branches for environment. This revealed significant difference among genotypes and diversity of environments. Significant G × E interaction for days to 50 per cent flowering, days to maturity, seed yield and oil content (%) showed that the genotype responded differently relative to each other to change in environment for the above mentioned traits. Further partitioning of G × E interaction into G × E (Linear) and pooled deviation (Non-linear) revealed significance of both components accounted for G × E interaction for the traits effective capitula plant^{-1}, oil content (%) and seed yield. This indicated presence of both predictable and non predictable components. The importance of both linear and non-linear sensitivity for the expression of these traits was also evident; however linear component was significantly higher than the non linear portion of the G × E interaction.

Among all the genotypes SA07001 had above average stability and SA07005 had below average stability for days to 50 per cent flowering. For days to maturity character the hybrids SA07003 (bi=1.04) and SA07001 (bi=1.2) possessed high mean value and non significant regression coefficient approaching unity with non significant deviation from regression and hence were most stable across the environment for this trait.

Out of all the test entries SA07004 (bi=1.03), SA07008(bi=0.94) and SA07009 (bi=0.93) were more stable for plant height trait, among the checks MRSA-521 (bi=0.93) and Bhima (bi=0.94) were more stable for plant height.

For number of primary branches plant^{-1}, the genotype A-1 was more stable among all entries, followed by SA07001 with non significant regression

Table 2. Mean performance and standard heterosis of safflower hybrids over best hybrid and varietal check.

Entries	Days to 50% Flowering			Days to Maturity			Plant Height (cm)			Primary Branches Plant^{-1}			Effective Capitula Plant^{-1}		
	Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over	
		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12
SA07001	77.83	8.36**	-4.89**	118.25	4.34**	0.21	97.83	15.09**	13.06**	11.35	-8.80**	-8.80**	32.16	-24.01**	0.63
SA07002	75.25	4.87**	-7.95**	114.83	1.32*	-2.69**	83.83	-1.38	-3.12	12.36	-0.8	-0.8	40.82	-3.54	27.50**
SA07003	79.33	10.45**	-3.06**	118.67	4.71**	0.57	89.08	4.80**	3.01	12.93	3.20	3.20	44.85	5.98**	40.31**
SA07004	78.92	9.89**	-3.55**	118.00	4.12**	0.00	88.83	4.51**	2.66	12.05	-3.2	-3.2	37.49	-11.41**	17.19**
SA07005	80.00	11.42**	-2.2**	117.83	3.97**	-0.14	91.67	7.85**	6.01**	12.11	-3.2	-3.2	37.61	-11.13**	17.50**
SA07006	81.00	12.81**	-0.98	118.83	4.85**	0.70	94.58	11.27**	9.36**	12.17	-2.4	-2.4	38.15	-9.85**	19.38**
SA07007	79.00	10.03**	-3.42**	117.67	3.83**	-0.28	93.13	9.56**	7.63**	11.20	-10.40**	-10.40**	35.95	-15.05**	12.50**
SA07008	76.00	5.85**	-7.09**	116.67	2.95**	-1.13	89.17	4.91**	3.12	13.65	9.60**	9.60**	47.03	11.13**	46.88**
SA07009	77.42	7.80**	-5.38**	117.08	3.31**	-0.78	91.54	7.69**	5.78**	12.87	3.20	3.20	42.28	-0.09**	32.19**
SA07010	77.67	8.22**	-5.01**	116.83	3.09**	-0.99	91.54	7.69**	5.78**	13.13	4.80**	4.80**	47.22	11.58**	47.50**
SA07011	72.67	1.25	-11.12**	113.08	-0.22	-4.17**	79.96	-5.93**	-7.51**	12.86	3.20	3.20	41.64	-1.61	30.00**
SA07012	73.17	1.95**	-10.51**	113.08	-0.22	-4.17**	81.54	-4.07	-5.78**	12.56	0.80	0.80	46.44	9.74**	45.00**
MRSA-521 I	71.83	0.00	-12.22**	113.33	0.00	-3.96**	83.33	-1.96	-3.70*	12.53	0.00	0.00	45.61	7.77**	42.50**
MRSA-521	71.83	0.00	-12.22**	113.33	0.00	-3.96**	85.00	0.00	-1.73	12.53	0.00	0.00	42.32	0.00	32.19**
MKH-9	80.00	11.42**	-2.2**	118.83	4.85**	0.70	104.50	22.94**	20.81**	10.42	-16.80**	-16.80**	33.47	-20.91**	4.69
Bhima	83.50	16.30**	2.08**	118.50	4.56**	0.42	85.04	0.05	-1.73	12.22	-2.4	-2.4	35.45	-16.23**	10.94**
A-1	80.83	12.53**	-1.22	118.08	4.19**	0.07	84.08	-1.08	-2.77	11.87	-4.80**	-4.80**	33.66	-20.46**	5.31
PBNS-12	81.75	13.93**	0.00	118.00	4.12**	0.00	86.50	1.76	0.00	12.45	0.00	0.00	31.96	-24.48**	0.00
Mean	**77.67**			**116.72**			**88.95**			**12.29**			**39.67**		
LSD at 5%	**0.92**			**1.50**			**2.89**			**0.45**			**1.87**		
LSD at 1%	**1.21**			**1.98**			**3.81**			**0.59**			**2.47**		

Entries	Seeds capitulam^{-1}			100 seed weight (g)			Oil content (%)			Seed yield plant^{-1} (g)			Seed yield ha^{-1} (Kg)		
	Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over		Mean	Standard Heterosis over	
		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12		MRSA -521	PBNS -12
SA07001	54.17	31.70**	73.16**	3.41	-20.70**	-41.38**	32.12	2.16**	9.18**	37.32	-15.07**	-10.98**	2846.22	-15.57**	-5.21*
SA07002	33.04	-19.67**	5.43	4.16	-3.26*	-27.59**	31.41	-0.10	6.80**	41.95	-4.53	0.24	3194.16	-5.25*	6.38*
SA07003	39.33	-4.38	25.56**	4.09	-4.88**	-29.31**	30.37	-3.40**	3.40**	47.14	7.28*	12.41**	3600.96	6.82**	19.93**
SA07004	44.63	8.51**	42.49**	3.68	-14.42**	-36.21**	33.40	6.23**	13.61**	38.17	-13.13**	-8.83**	2650.01	-21.39**	-11.74**
SA07005	47.80	16.22**	52.72**	3.52	-18.14**	-39.66**	33.18	5.53**	12.93**	36.29	-17.41**	-13.37**	2597.33	-22.95**	-13.50**
SA07006	45.42	10.43**	45.05**	3.67	-14.65**	-36.21**	33.08	5.22**	12.59**	34.77	-20.87**	-16.95**	2541.68	-24.60**	-15.35**
SA07007	52.22	26.96**	66.77**	3.65	-15.12**	-36.21**	33.79	7.47**	14.97**	33.12	-24.62**	-21.00**	2412.82	-28.42**	-19.64**
SA07008	41.42	0.71	32.27**	4.69	9.07**	-18.97**	31.26	-0.57	6.46**	45.13	2.71	7.64*	3551.77	5.36*	18.29**
SA07009	44.09	7.20**	40.89**	4.71	9.53**	-18.97**	30.97	-1.49	5.44**	45.02	2.46	7.40*	3492.18	3.59	16.31**
SA07010	38.97	-5.25*	24.60**	4.10	-4.65**	-29.31**	30.25	-3.78**	3.06**	35.63	-18.91**	-15.04**	2574.14	-23.64**	-14.27**
SA07011	33.94	-17.48**	8.31	4.32	0.47	-25.86**	31.51	0.22	7.14**	35.31	-19.64**	-15.75**	2815.98	-16.46**	-6.21*
SA07012	37.48	-8.87**	19.81**	4.63	7.67**	-20.69**	31.22	-0.70	6.12**	45.68	3.96	9.07**	3493.05	3.62	16.34**
MRSA-521 I	40.35	-1.90	29.07**	4.38	1.86	-24.14**	31.34	-0.32	6.46**	43.33	-1.39	4.77	3358.71	-0.36	11.86**
MRSA-521	41.13	0.00	31.31**	4.30	0.00	-25.86**	31.44	0.00	6.8**	43.94	0.00	3.34	3371.00	0.00	12.27**
MKH-9	66.24	61.05**	111.50**	3.47	-19.30**	-39.66**	32.88	4.58**	11.90**	43.05	-2.03	2.86	3261.34	-3.25	8.62**
Bhima	28.82	-29.93**	-7.99*	5.57	29.53**	-3.45**	30.83	-1.94*	4.76**	41.40	-5.78	-1.19	3085.71	-8.46**	2.77
A-1	26.88	-34.65**	-14.06**	6.06	40.93**	5.17**	28.47	-9.45**	-3.06**	36.16	-17.71**	-13.60**	2834.33	-15.92**	-5.60*
PBNS-12	31.26	-24.00**	0.00	5.76	33.95**	0.00	29.38	-6.55**	0.00	41.92	-4.60	0.00	3002.53	-10.93**	0.00
Mean	41.51			4.34			31.49			40.29			3037.99		
LSD at 5%	**2.06**			**0.14**			**0.48**			**2.59**			**155.42**		
LSD at 1%	**2.72**			**0.18**			**0.63**			**3.42**			**205.32**		

** Significant at 1% level of probability, * Significant at 5% level of probability

Table 3. Analysis of variance for different characters in safflower.

Source	D.F.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Primary branches $plant^{-1}$	Effective capitula $plant^{-1}$	Seeds $capitulam^{-1}$	100 seed weight (g)	Oil content (%)	Seed yield $plant^{-1}$ (g)	Seed yield ha^{-1} (Kg)
Genotype	17	49.61**	18.49**	151.72**	2.28**	110.94**	375.58**	2.50**	7.98**	78.48**	614211.56**
Environment	3	1.93*	19.13**	919.57**	0.32	702.13**	203.46**	5.02**	17.30**	314.54**	2346258.25**
G x E	51	1.19**	2.60**	8.24*	0.40	13.33	15.98	0.06	0.65**	16.00**	81653.05**
E + (G x E)	54	1.23**	3.52**	58.87**	0.40	51.60**	26.39	0.34**	1.58**	32.59**	207464.45**
Environment (L)	1	5.78**	57.38**	2758.70**	0.97	2106.39**	610.38**	15.06**	51.91**	943.61**	7038775.00**
G x E (L)	17	2.49**	6.72**	15.22**	0.33	22.70**	6.30	0.05	1.35**	37.32**	200841.95**
Pooled deviation	36	0.51	0.51	4.48	0.41**	8.17**	19.66**	0.06**	0.29**	5.04	20833.12*
Pooled error	136	0.43	1.16	4.27	0.10	1.79	2.17	0.01	0.12	3.43	12353.66

** Significance at 1% level of probability, * Significance at 5% level of probability

Table 4. Estimation of stability parameters for different characters in safflower.

Hybrids/	Days to 50% flowering			Days to maturity			Plant height (cm)			Primary branches $plant^{-1}$			Effective capitula $plant^{-1}$		
Varieties	Mean	Bi	S^2di	Mean	bi	S^2di	Mean	Bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
SA07001	77.83	0.77	-0.44	118.25	1.20	-0.54	97.83	1.17	18.82**	11.35	1.33	-0.07	32.16	0.34*	0.13
SA07002	75.25	6.58*	-0.08	114.83	-0.07	-0.37	83.83	1.31	-1.03	12.36	1.79	0.10	40.82	0.62	0.72
SA07003	79.33	3.23	-0.41	118.67	1.04	-0.46	89.08	1.61*	-4.32	12.93	-0.25	2.20**	44.85	0.94	5.47*
SA07004	78.92	2.88	0.30	118.00	-0.11	-0.43	88.83	1.03	-2.14	12.05	1.21	0.46**	37.49	1.56	1.38
SA07005	80.00	1.62	-0.49	117.83	1.44	-0.46	91.67	1.21	-2.37	12.11	0.71	-0.03	37.61	0.74	-0.83
SA07006	81.00	2.62*	-0.50	118.83	2.24	-0.69	94.58	0.87	-0.87	12.17	1.61	0.32*	38.15	1.08	-1.33
SA07007	79.00	2.23	-0.20	117.67	-0.06	-1.09	93.13	1.18	1.02	11.20	2.26	0.03	35.95	0.78	10.80**
SA07008	76.00	1.96	0.31	116.67	0.41	-0.79	89.17	0.94	-4.05	13.65	-1.45	0.47**	47.03	1.69	5.80*
SA07009	77.42	-0.65	-0.32	117.08	0.70	-0.27	91.54	0.93	-2.29	12.87	-0.88	0.29*	42.28	1.21	10.80**
SA07010	77.67	-2.77	0.26	116.83	1.70	-1.19	91.54	1.21	3.06	13.13	9.54	0.52**	47.22	1.96	29.24**
SA07011	72.67	-0.31	0.80	113.08	-0.87*	-1.26	79.96	0.80	-1.06	12.86	3.20	0.03	41.64	1.37	15.03**
SA07012	73.17	2.23	0.19	113.08	-1.18*	-1.15	81.54	1.20*	-4.30	12.56	0.15	0.61**	46.44	0.41	4.82*
MRSA-521 I	71.83	3.85	-0.05	113.33	-0.23	-0.72	83.33	1.21*	-4.28	12.53	-1.29	-0.07	45.61	1.19	22.96**
MRSA-521	71.83	3.15	0.72	113.33	-0.49*	-1.02	85.00	0.93	-2.49	12.53	-0.64	-0.02	42.32	0.55	12.39**
MKH-9	80.00	0.00*	0.00	118.83	3.27*	-1.29	104.50	0.71	0.56	10.42	-0.40	0.65**	33.47	1.11	-1.60
Bhima	83.50	-3.50	0.24	118.50	3.04*	-0.71	85.04	0.94	1.22	12.22	0.10	-0.05	35.45	0.86	-0.15
A-1	80.83	-2.04	-0.24	118.08	2.53	-0.55	84.08	0.53	-0.94	11.87	1.16	0.11	33.66	0.79*	-1.66
PBNS-12	81.75	-3.85	0.38	118.00	3.45*	-1.28	86.50	0.22	7.62	12.45	-0.16	0.02	31.96	0.80	-0.51
Mean	77.67			116.72			88.95			12.29			39.67		
SE (m) ±	0.41	1.26		0.40	0.40		1.22	0.17		0.37	2.77		1.65	0.26	

Contd....

Table 4. contd.

Hybrids/	Seeds capitulam^{-1}			100 seed weight (g)			Oil content (%)			Seed yield plant^{-1}(g)			Seed yield ha^{-1} (Kg)		
Varieties	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
SA07001	54.17	1.35	60.85**	3.41	0.68	0.01	32.12	0.57	-0.07	37.32	-0.11*	-1.79	2846.22	0.54	7343.73
SA07002	33.04	0.81	29.63**	4.16	1.37	0.07**	31.41	0.54	0.00	41.95	2.56*	-2.87	3194.16	2.51*	-5211.81
SA07003	39.33	1.06	21.68**	4.09	1.20	0.18**	30.37	0.13*	-0.05	47.14	1.21	-2.82	3600.96	1.24	-8079.57
SA07004	44.63	1.54	8.78**	3.68	1.23	0.09**	33.40	0.33	0.47*	38.17	1.22	-1.58	2650.01	1.37	12171.46
SA07005	47.80	1.38	32.28**	3.52	1.04	0.22**	33.18	0.69	0.09	36.29	0.93	23.71**	2597.33	1.25	75355.31**
SA07006	45.42	0.82	1.26	3.67	1.37	0.18**	33.08	0.69	-0.03	34.77	1.59	-0.56	2541.68	1.33	-6586.33
SA07007	52.22	1.14	0.12	3.65	1.01	0.11**	33.79	1.04	1.44**	33.12	1.19	-1.78	2412.82	1.32	2302.37
SA07008	41.42	0.70	21.83**	4.69	0.83	0.00	31.26	1.20	0.09	45.13	0.97	-0.12	3551.77	0.69	-3833.94
SA07009	44.09	1.28	0.01	4.71	0.58	0.00	30.97	1.03	-0.02	45.02	0.15*	-3.98	3492.18	0.65	-11527.12
SA07010	38.97	1.24	45.71**	4.10	1.07	0.05**	30.25	1.43*	-0.12	35.63	0.88	0.37	2574.14	1.04	-4465.87
SA07011	33.94	0.73	4.44	4.32	0.94	0.00	31.51	1.06	-0.12	35.31	-0.12*	-4.05	2815.98	0.13*	-13219.72
SA07012	37.48	0.10	2.92	4.63	0.78	-0.01	31.22	1.46	0.03	45.68	2.57*	-3.50	3493.05	2.33*	8993.69
MRSA-521 I	40.35	1.26	5.87*	4.38	0.88	0.00	31.34	0.56	-0.09	43.33	1.37	17.18**	3358.71	1.14	64448.75**
MRSA-521	41.13	1.49	10.50**	4.30	0.69	0.01	31.44	1.04	0.13	43.94	1.62	0.18	3371.00	1.01	-13571.78
MKH-9	66.24	1.52	25.14**	3.47	1.26*	-0.01	32.88	-0.13*	-0.09	43.05	1.38	-2.23	3261.34	1.27	-6719.90
Bhima	28.82	0.43	21.79**	5.57	0.72	0.00	30.83	1.59	0.27	41.40	0.93	1.53	3085.71	0.50	8995.38
A-1	26.88	0.82	3.13	6.06	1.22	0.03*	28.47	2.58	0.85**	36.16	-0.38*	-2.41	2834.33	-0.21*	-13779.09
PBNS-12	31.26	0.33	18.18**	5.76	1.12	0.00	29.38	2.18	0.13	41.92	0.05	2.52	3002.53	-0.11	23095.03
Mean	41.51			4.34			31.49			40.29			3037.99		
S.E. +-	2.56	0.76		0.14	0.27		0.31	0.32		1.29	0.31		83.30	0.20	

** Significant at 1% level of probability, * Significant at 5% level of probability, bi: Regression coefficient, S^2di: Standard deviation coefficient approaching unity with non significant deviation from regression. The genotypes SA07006 (bi=1.08) and MKH-9 (bi=1.11) having non significant regression coefficient approaching unity with non significant deviation from regression and hence were most stable across the environment for the trait effective capitula plant^{-1}.

The genotype SA07007 and SA07009 among test entries and A-1 amongst check were more stable than others for seeds per capitula trait, they had high mean for hybrids and low mean value for checks with non significant regression coefficient approaching unity with non significant deviation from regression. For 100 seed weight (g) only one entry SA07011 was most stable among all entries and checks possessing average mean value and non significant regression coefficient approaching unity with non significant deviation from regression.

For seed yield plant^{-1} SA07003, SA07008, Bhima and MRSA-521 possessed high mean value and non significant regression coefficient approaching unity with non significant deviation from regression and hence were most stable across the environments for this trait. Similar genotypes showed stability for seed yield ha^{-1} trait. These findings resemble to that of Patil *et. al.,* (1992), Patil and Zope (1997) for the cultivar Bhima. Rudra Naik *et. al.,* (2005) reported stable genotypes for seed yield in safflower.

The genotypes SA07008 (bi=1.19), SA07009 (bi=1.03), SA07011 (bi=1.06) and MRSA-521 (bi=1.04) having average mean values and non significant regression coefficient approaching unity with non significant deviation from regression and hence were most stable across the environments for the trait oil content (%).

On the basis of standard heterosis and stability analysis the test hybrids SA07003 and SA07008 were found promising for seed yield and majority of traits with high mean performance across the environments.

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Drainage Requirement of Agricultural Lands for Nagpur and Akola

S. B.Wadatkar[1] and M. M.Deshmukh[2]

ABSTRACT

Drainage requirement of agricultural land was estimated through rainfall analysis for Nagpur and Akola. For this purpose, the daily rainfall data of 35 years for Nagpur and 25 years for Akola were used for analysis to find one to four consecutive days rainfall values for 2, 5, 10 and 20 years return period. Drainage coefficients for agricultural land of Nagpur for vegetable crops are 106.03, 82.03, 58.03, 34.03 and 10.03 mm day^{-1} for soils having basic infiltration rate 1, 2, 3, 4 and 5 mm h^{-1}, respectively. In case of oil seed crops drainage coefficients are 67.76, 43.76 and 19.76 mm day^{-1} for soils having basic infiltration rate 1, 2 and 3 mm hr^{-1}, respectively. For crops like Cotton, Sorghum, Maize, Bajra and other similar crops drainage coefficients are 45.04 and 21.04 mm day^{-1} for soils having basic infiltration rate between 1 and 2 mm hr^{-1}, respectively. Drainage coefficients for agricultural land of Akola for vegetable crops are 112.14, 88.14, 64.14, 40.14 and 16.14 mm day^{-1} for soils having basic infiltration rate 1, 2, 3, 4 and 5 mm hr^{-1}, respectively. In case of oil seed crops drainage coefficients are 55.81, 31.81 and 7.81 mm day^{-1} for soils having basic infiltration rate 1, 2 and 3 mm hr^{-1}, respectively. For crops like Cotton, Sorghum, Maize, Bajra and other similar crops drainage coefficients are 32.55 and 8.55 mm day^{-1} for soils having basic infiltration rate between 1 and 2 mm hr^{-1}, respectively.

A major target before the planner of the country is to increase the agricultural production per unit area for meeting the day to day needs of population. The main purpose of drainage is to provide a root environment that is suitable for the maximum growth of plants. Drainage discharge is a key factor for deciding the design capacity of a drainage system. If the rate of drainage is not assessable by direct measurement, indirect method of its estimation, such as, analysis of rainfall is used. Kesslar and De Radd (1974) described the design rainfall as a function of return period, duration and area under the study for different kinds of drainage problems. Bhattacharya and Sarkar (1982) stated that for estimating drainage rate for agricultural crops one needs to know the total rainfall over duration of crop tolerance period.

Rainfall analysis for the purpose of design of drainage systems is different from the conventional method of analysis such as the intensity duration frequency analysis. Rainfall is a stochastic variable and large number of years rainfall data are needed for its depth-duration-frequency analysis. Particularly, for flat lands with slopes ranging between 0 – 0.05 per cent the design rate of removal of excess surface water is decided by the interaction of the chances of crop loss due to water logging. The design drainage rate for surface drainage is commonly taken as approximately 10 mm/ day for agricultural watersheds of various command areas of the country, irrespective of the agrometeorological conditions such as type of crops grown, type of soil or rainfall pattern. Keeping in view above facts, study was planned to evaluate drainage coefficient through rainfall analysis.

MATERIAL AND METHODS

The present study was confined to agricultural area located at Nagpur and Akola of Vidarbha region. Nagpur comes under medium high rainfall zone at an attitude of 310.0 m above mean sea level having $21^0 06^1$ N latitude and 79^0 03^1 E longitude. Akola is located at $20^0 40^/$ North latitude and $77^0 2^/$ East longitude. The annual precipitation of Nagpur and Akola is about 1147.5 mm and 750 mm, respectively. Most of soils in the said region are clayey.

Daily rainfall data of 35 years (1971-2005) for Nagpur and 25 years (1974-1998) for Akola, collected from the observatory situated within the respective research farm of the university were analyzed to work out one to four consecutive days rainfall. The expected values were found out by well known probability distributions viz., Normal, Log Normal, Log-Pearson type III, Gumbel and Weibull distributions. Among these distribution methods the best fit distribution was decided by chi-square test for goodness of fit. If the calculated value was found less than table value, that distribution was

1. Head, and 2. Associate Professor, Department of Irrigation and Drainage Engineering, Dr.PDKV, Akola

considered as non-significant i.e., fit at related level of significance. If more than one distribution was found fit for particular rainfall data, then distribution with lowest chi-square value was selected as the best fit distribution for respective consecutive days maximum rainfall. The drainage coefficient for different return period of 2, 5, 10 and 20 years were determined by subtracting basic infiltration rate from estimated consecutive days rainfall. On the basis of the basic infiltration rate of the soil and tolerance period of different crops grown in Nagpur and Akola, drainage coefficient was calculated considering the fact that soils were saturated and evapotranspiration, surface retention and raindrop interception were negligible as far as land drainage was concerned.

RESULTS AND DISCUSSION

Maximum rainfall in one, two, three and four consecutive days were obtained from daily rainfall. At Nagpur the annual one day maximum rainfall varied from 52.1 mm to 287.3 mm. Annual two consecutive days maximum rainfall was found within the range of 60.6 mm to 337.7 mm. Similarly, it was found that lowest value of annual three consecutive days maximum rainfall was 77.4 mm in and highest value of annual three consecutive days maximum rainfall was 363.7 mm. Annual four consecutive days maximum rainfall was found within the range of 90.6 mm to 367.9 mm.

While, at Akola the annual one day maximum rainfall varied from 18.5 mm to 217.2 mm. Annual two consecutive days maximum rainfall was found within the range of 36.5 mm to 247.0 mm. Similarly, it was found that lowest value of annual three consecutive days maximum rainfall was 53.7 mm and highest value of annual three consecutive days maximum rainfall was 249.8 mm. Annual four consecutive days maximum rainfall was found within the range of 71.5 mm to 250.8 mm.

Rainfall analysis using above said distributions was carried out and chi-square values for selected best fit distribution for respective consecutive days maximum rainfall are presented in Table 1.

Using selected best fit distribution, expected values of one, two, three and four consecutive days maximum rainfall were determined

Table 1: Selected bet fit distribution functions for one, two, three and four consecutive days maximum rainfall.

S. N.	Parameters	Selected Best fit distribution	
		Nagpur	Akola
1	One day maximum rainfall	Gumbel (4.8)	Log Normal(6.52)
2	Two consecutive days maximum rainfall	Log normal(8.0)	Log Normal(2.29)
3	Three consecutive days maximum rainfall	Normal(3.2)	Log Normal(7.50)
4	Four consecutive days maximum rainfall	Gumbel(4.8)	Log Normal(3.01)

Note: Figures in the parenthesis indicates the Chi-square values.

Table 2: Consecutive days maximum rainfall values for different return periods (years)

S. N.	Return Period (years)	Rainfall for consecutive days (mm)			
		1	2	3	4
Nagpur					
1	2	96.61	133.47	157.98	159.33
2	5	130.03	183.52	207.12	211.99
3	10	152.17	216.76	232.81	246.87
4	20	173.4	248.71	254.02	280.32
Akola					
1	2	90.75	113.78	125.90	131.68
2	5	134.14	159.62	169.66	173.41
3	10	174.06	189.16	195.33	206.28
4	20	199.94	220.73	225.41	225.71

at probability levels of 50, 20, 10 and 5 per cent i.e. at the return periods of 2, 5, 10 and 20 years. The values are given in Table 2.

It is observed from Table 2 that annual maximum rainfall values increased with increase in consecutive days and return periods. At Nagpur, it varied from 96.61 mm for one day maximum rainfall for 2 years return period to 280. 32 mm for four consecutive days maximum rainfall for 20 years return period. Similarly, at Akola it varied from 90.75 mm for one day maximum rainfall for 2 years return period to 225.71 mm for four consecutive days maximum rainfall for 20 years return period.

The drainage coefficients (DC) were calculated by subtracting basic infiltration rate (Ib) from consecutive days rainfall for return period of 2, 5, 10 and 20 years and presented in Table 3.

It is observed from Table 3 that at Nagpur, soils having basic infiltration rate above 4, 5, 6 and 7 mm h^{-1} might not need drainage for one day maximum rainfall for return period of 2, 5, 10 and 20 years, respectively. The corresponding values for two consecutive days maximum rainfall were 2, 3, 4 and 5 mm h^{-1} For three consecutive days maximum rainfall these values were 2, 2, 3 and 3 mm h^{-1}. For four consecutive days maximum rainfall these values were 1, 2, 2 and 2 mm h^{-1}. While, at Akola, soils having basic infiltration rate above 3, 5, 7 and 8 mm h^{-1} might not need drainage for one day maximum rainfall for return period of 2, 5, 10 and 20 years, respectively. The corresponding values for two consecutive days maximum rainfall were 2, 3, 3 and 4 mmh^{-1}. For three consecutive days maximum rainfall these values were 1, 2, 2 and 3 mm h^{-1}. For four consecutive days maximum rainfall these values were 1, 1, 2 and 2 mm h^{-1}. When one day period was considered as permissible crop tolerance, the one day maximum rainfall of different return periods was considered for estimation of drainage coefficient and similarly in case of two, three and four days period of crop tolerance two, three and four consecutive days maximum rainfall was used.

Soils of Nagpur having basic infiltration rate 1 to 5 mm h^{-1} drainage coefficient varied between 10.03 to 106.03 mm day^{-1} for 5 years return period for one day maximum rainfall and in case of two consecutive days maximum rainfall drainage coefficients were 19.76 to 67.76 mm day^{-1} for 5 years return period having 1 to 3 mm h^{-1} basic infiltration rate. For three consecutive days maximum rainfall drainage coefficients were 21.04 to 45.04 mm day^{-1} for 5 years return period having basic infiltration rate 1 to 2 mm h^{-1}. Similarly for four consecutive days maximum rainfall drainage coefficients were 5.00 to 29.00 mm day^{-1} for 5 years return period having 1 to 2 mm h^{-1} basic infiltration rate.

Soils of Akola having basic infiltration rate 1 to 5 mm h^{-1} drainage coefficient varied between 16.14 to 112.14 mm day^{-1} for 5 years return period for one day maximum rainfall and in case of two consecutive days maximum rainfall corresponding drainage coefficients were 7.81 to 55.81 mm day^{-1} for 5 year return period and soils having basic infiltration rate 1 to 3 mm day^{-1}. For three consecutive days maximum rainfall drainage coefficients were 8.55 to 32.55 mm day^{-1} for 5 years return period having basic infiltration rate 1 to 2 mm h^{-1}. Similarly for four consecutive days maximum rainfall drainage coefficients was 19.35 mm day^{-1} for 5 years return period having 1 mm h^{-1} basic infiltration rate. It can be seen from results that drainage coefficient values decreased with increase in basic infiltration rate of soil. However, drainage need increases with increase in return periods in every consecutive days rainfall. Considering the tolerance to waterlogging for different crops and rainfall at return period of 5 years, the drainage coefficients for different crops may be suggested as given in Table 4.

Drainage coefficients for agricultural lands of Nagpur for vegetable crops were 106.03, 82.03, 58.03, 34.03 and 10.03 mm day^{1} for soils having basic infiltration rate 1, 2, 3, 4 and 5 mm h^{-1}, respectively. In case of oil seed crops drainage coefficients were 67.76, 43.76 and 19.76 mm day^{1} for soils having basic infiltration rate 1, 2 and 3 mm h^{-1}, respectively. For crops like Cotton, Sorghum, Maize, Bajra and other similar crops drainage coefficients were 45.04 and 21.04 mm/day for soils having basic infiltration rate between 1 and 2 mm h^{-1}, respectively. Drainage coefficients for agricultural lands of Akola for vegetable crops were 112.14, 88.14, 64.14, 40.14 and 16.14 mm day^{-1} for soils having basic infiltration rate 1, 2, 3, 4 and 5 mm h^{-1}, respectively. In case of oil seed crops drainage coefficients were 55.81, 31.81 and 7.81 mm day^{-1} for soils having basic infiltration rate 1, 2 and 3 mm h^{-1}, respectively. For crops like Cotton, Sorghum, Maize, Bajra and other similar crops drainage coefficients were 32.55 and 8.55 mm day^{-1} for soils having basic infiltration rate between 1 and 2 mm h^{-1}, respectively.

Table 3. Estimated drainage coefficient, DC (mm day^{-1})

S.N.	Ib mm/hr	DC for one day rainfall (mm) for return periods (years)				DC for two consecutive days rainfall (mm) for return periods (years)				DC for three consecutive days rainfall (mm) for return periods (years)				DC for four consecutive days rainfall (mm) for return periods (years)			
		2	*5*	*10*	*20*	*2*	*5*	*10*	*20*	*2*	*5*	*10*	*20*	*2*	*5*	*10*	*20*
Nagpur																	
1.	1	72.61	106.03	128.17	149.4	42.74	67.76	84.38	100.36	28.66	45.04	53.60	60.67	15.83	29.00	37.72	46.08
2.	2	48.61	82.03	104.17	125.4	18.74	43.76	60.38	76.36	4.66	21.04	29.60	36.67	—	5.00	13.72	22.08
3.	3	24.61	58.03	80.17	101.4	—	19.76	36.38	52.36	—	—	5.60	12.67				
4.	4	0.61	34.03	56.17	77.4	—	—	12.38	28.36								
5.	5	—	10.03	32.17	53.4	—	—	—	4.36								
6.	6	—	—	8.17	29.4												
7.	7	—	—	—	5.4												
Akola																	
1.	1	66.75	112.14	150.06	175.94	32.89	55.81	70.58	86.36	17.67	32.55	41.11	51.24	8.92	19.35	27.52	32.35
2.	2	42.75	88.14	126.06	151.94	8.89	31.81	46.58	62.36	—	8.55	17.11	27.24	—	—	3.57	8.35
3.	3	18.75	64.14	102.06	127.94	—	7.81	22.58	38.36	—	—	—	3.24				
4.	4	—	40.14	78.06	103.94	—	—	—	14.36								
5.	5	—	16.14	54.06	79.94												
6.	6	—	—	30.06	55.94												
7.	7	—	—	6.06	31.94												
8.	8	—	—	—	7.94												

— *Indicate there is no necessity to provide drainage*

Table 4: Suggested drainage coefficient for agricultural drainage system under different crops

Name of crop	Tolerance to water logging (days)	Return period (Years)	Basic infiltration rate(mm/hr)	Drainage coefficient (mm/day)	
				Nagpur	Akola
Vegetables	1	5	12345	106.03	112.14
				82.03	88.14
				58.03	64.14
				34.03	40.14
				10.03	16.14
Oil seed crops	2	5	123	67.76	55.81
				43.76	31.81
				19.76	7.81
Cotton, Sorghum, Maize,	3	5	12	45.04	32.55
Bajra and other similar crops				21.04	8.55

CONCLUSION

It is concluded that for 5 years return period, the agricultural land drainage coefficients for the corresponding basic infiltration rates need to be adopted for fulfilling the drainage requirement of different crops. Estimated drainage coefficients can be used for designing drainage system for agricultural lands at Nagpur and Akola.

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Determination of Pan Coefficients for Akola

M. M. Deshmukh[1] and S. B. Wadatkar[2]

ABSTRACT

The study has been undertaken to determine and evaluate weekly, monthly, seasonal and annual pan coefficients for Akola in Vidarbha region. Data on climatic parameters for 23 years (1980 to 2002) were collected from agricultural meteorological observatory of Akola. Data of 20 years (1980 to 1999) on weekly, monthly, seasonal and annual basis were used to determine reference evapotranspiration (ETo) by FAO-56 Penman Monteith method (ETopm) accepted as standard method for estimation of ETo. From reference evapotranspiration respective pan coefficients were estimated by using Doorenbos and Pruitt equation. Estimated pan coefficients were evaluated and compared with FAO-56 PM method for next three years i.e. 2000, 2001 and 2002.It is found that there was very good correlation between ETopc and ETopm with low standard errors for weekly, monthly, seasonal and annual analysis. Mean absolute error (MAE), mean absolute relative error (MARE) and root mean square error (RMSE) were also found minimum for all time step analysis. Therefore, it was concluded that, estimated weekly, monthly, seasonal and annual pan coefficients for Akola were found suitable to determine ETo.

The concept of reference evapotranspiration was introduced to study evaporative demand of the atmosphere independently of crop type, crop development and management practices and soil factors. Consequently, ETo is climatic parameter. Evapotranspiration is immediate tool for irrigation planners, researchers to design water storage reservoirs and select crops / cropping pattern. Reference evapotranspiration is not easy to measure. Hence numerous scientists and specialists worldwide have developed large number of empirical methods to estimate evapotranspiration from different climatic variables over the last 50 years. However, large number of data requirement limits the application of many of these methods. Keeping in view the complexity, accuracy and data requirements of prediction methods, pan evaporation method of estimation may be the comparatively less expensive and easy.

Pans have proved their practical value and have been used successfully to estimate ETo by observing the water loss from pan and using empirical coefficient to relate pan evaporation to ETo. These coefficients are called as pan coefficients, which depend on pan types and environment. In selecting appropriate pan coefficient, not only pan type but also ground cover in station, its surrounding as well as general wind and humidity conditions should be checked. The sitting of the pan and pan environment also influence the values of pan coefficients. It is therefore, proposed to establish the values of Class ‘A’ pan coefficients for estimating reference evapotranspiration under climatic conditions of Akola for weekly, monthly, seasonal and annual reference evapotranspiration estimation.

MATERIAL AND METHODS

Akola is located in the Western Vidarbha and characterized by five distinct seasons viz., summer (from 10^{th} to 21^{st}SMW), pre-monsoon (22^{nd} to 23^{rd} SMW), monsoon (24^{th} to 39^{th} SMW) and post monsoon (40^{th} to 48^{th} SMW) and winter (49^{th} to 9^{th} SMW).

Meteorological data viz., maximum temperature (Tmax), minimum temperature (Tmin), maximum relative humidity (RH-I), minimum relative humidity (RH-II), wind speed (WS), bright sunshine hours (BSH) and pan evaporation (OPE) were collected from Agricultural Meteorological Observatory of Dr. PDKV, Akola for period 1980-2002 (23 years). Pan evaporation observations were taken with standard US Weather Bureau Class ‘A’ open pan.

Determination of Reference Evapotranspiration

Weekly, monthly, seasonal and annual reference evapotranspiration were calculated using FAO-56 Penman-Monteith model which is

1. Associate Professor, and 2. Head, Department of Irrigation and Drainage Engineering, Dr.PDKV, Akola

recommended by FAO as sole standard method for estimation of ETo and calibration of other ETo estimation models.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where, ETo = Reference evapotranspiration (mm day^{-1}), Rn = Net radiation at crop surface (MJm^{-2} day^{-1}), G = Soil heat flux density (MJ m^{-2} day^{-1}), T = Main daily air temp. at 2 m height (^0C), u_2 = Wind speed at 2 m height (ms^{-1}), e_s = Saturation vapour pressure (Kpa), e_a = actual vapour pressure (Kpa), (e_s- e_a) = Saturation vapour pressure deficient (Kpa), D = Slope of vapour pressure curve (Kpa $^0C^{-1}$), ã = Psychometric content (Kpa $^0C^{-1}$)

Determination of Pan Coefficient

The computed weekly, monthly, seasonal and annual ETo values were used to compute the pan coefficients by using Doorenbos and Pruitt (1997) equation.

$$K_p = \frac{ET_o}{E_p}$$

Where, K_p = Pan coefficient, ETo = Reference ET (mm day^{-1}), E_p = Pan evaporation (mm day^{-1}),

The computed pan coefficients were employed to estimate reference ET for next three years (2000, 2001, 2002). The estimated reference ET values using computed pan coefficient (ET_{oPC}) were compared with values of ETo estimated using FAO- 56 Penman Monteith equation (ET_{OPM}).

The performance of estimated pan coefficients were evaluated by determining the mean absolute error (MAE), mean absolute relative error (MARE) and root mean square error (RMSE).

RESULTS AND DISCUSSION

Weekly Analysis

Weekly data for the period of 1980-1999 (20 years) were used to determine weekly pan coefficients and are presented in Table 1.

From Table 1, it is seen that weekly pan coefficients for Akola varies from 0.7 to 0.9 during winter season (49^{th} to 9^{th} SMW). Whereas, pan coefficients were found in the range of 0.6 to 0.7 during summer season (10^{th} to 21^{st} SMW). However, during monsoon it was above 0.8.

Estimated weekly pan coefficients were evaluated by determining ETo using FAO –56 Penman Monteith method and estimated pan coefficients for the years 2000, 2001 and 2002. The performance indices are presented in Table 2. Similarly results are depicted in Fig.1 to 2.

It is seen from Fig. 1 to 2 and Table 2 that weekly ETopc was found closer to weekly ETopm for all the three years. Regression line between ETopc and ETopm almost coincided on 1:1 line, representing high correlation for all the three years. Significant correlation was observed between ETopc and ETopm (0.9153, 0.9561, 0.9346 for 2000, 2001 and 2002, respectively) with very low standard errors (0.8200, 0.6606 and 0.9294 mm/day). It is also found that MAE, MARE and RMSE between ETopc and ETopm were minimum.

It is, therefore, concluded from results that determination of weekly ETo using estimated weekly pan coefficients gave closer values throughout the year with standard determination procedure of FAO – 56 Penman Monteinth method. However, the determination of reference ETo using estimated pan coefficients require only pan evaporation data.

Monthly Analysis

Monthly data for the period of 1980-1999 (20 years) were used to determine monthly pan coefficients for Akola and presented in Table 3.

From Table 3, it is seen that monthly pan coefficients for Akola varied from 0.8 to 0.7 during winter months. Whereas it ranged between 0.7 to 0.6 during summer months. However, pan coefficients were found from 0.8 to 1.0 during monsoon months.

Estimated monthly pan coefficients were evaluated by estimating ETo using FAO-56 Penman Monteith method and estimated pan coefficients for the year 2000, 2001 and 2002 and their performance indices are presented in Table 4. Similarly results are depicted in Fig 3 to 4.

It is seen from Fig. 3 to 4 and Table 4 that monthly ETopc was found closer to monthly ETopm throughout the year for all the three years. Regression line between ETopc and ETopm almost coincided on 1:1 line, representing very high

Table 1: Weekly pan coefficients estimated for Akola

Standard meteorological week	Pan coefficient	Standard meteorological week	Pan coefficient
1	0.9	27	0.9
2	0.9	28	0.9
3	0.8	29	1.0
4	0.8	30	1.0
5	0.8	31	1.1
6	0.8	32	1.0
7	0.8	33	1.0
8	0.7	34	1.1
9	0.7	35	1.0
10	0.7	36	1.0
11	0.7	37	1.0
12	0.7	38	1.0
13	0.7	39	1.0
14	0.7	40	0.9
15	0.6	41	0.9
16	0.6	42	0.9
17	0.6	43	0.8
18	0.6	44	0.8
19	0.6	45	0.8
20	0.6	46	0.8
21	0.7	47	0.8
22	0.7	48	0.8
23	0.7	49	0.8
24	0.8	50	0.8
25	0.8	51	0.8
26	0.9	52	0.8

Table 2: Performance indices of weekly pan coefficients for Akola

S. N.	Year	Mean absolute error (MAE), mm/day	Mean absolute relative error (MARE)	Root mean square error (RMSE), mm day^{-1}
1	2000	0.6382	0.1156	0.8934
2	2001	0.5322	0.0971	0.7205
3	2002	0.6753	0.1144	1.0020

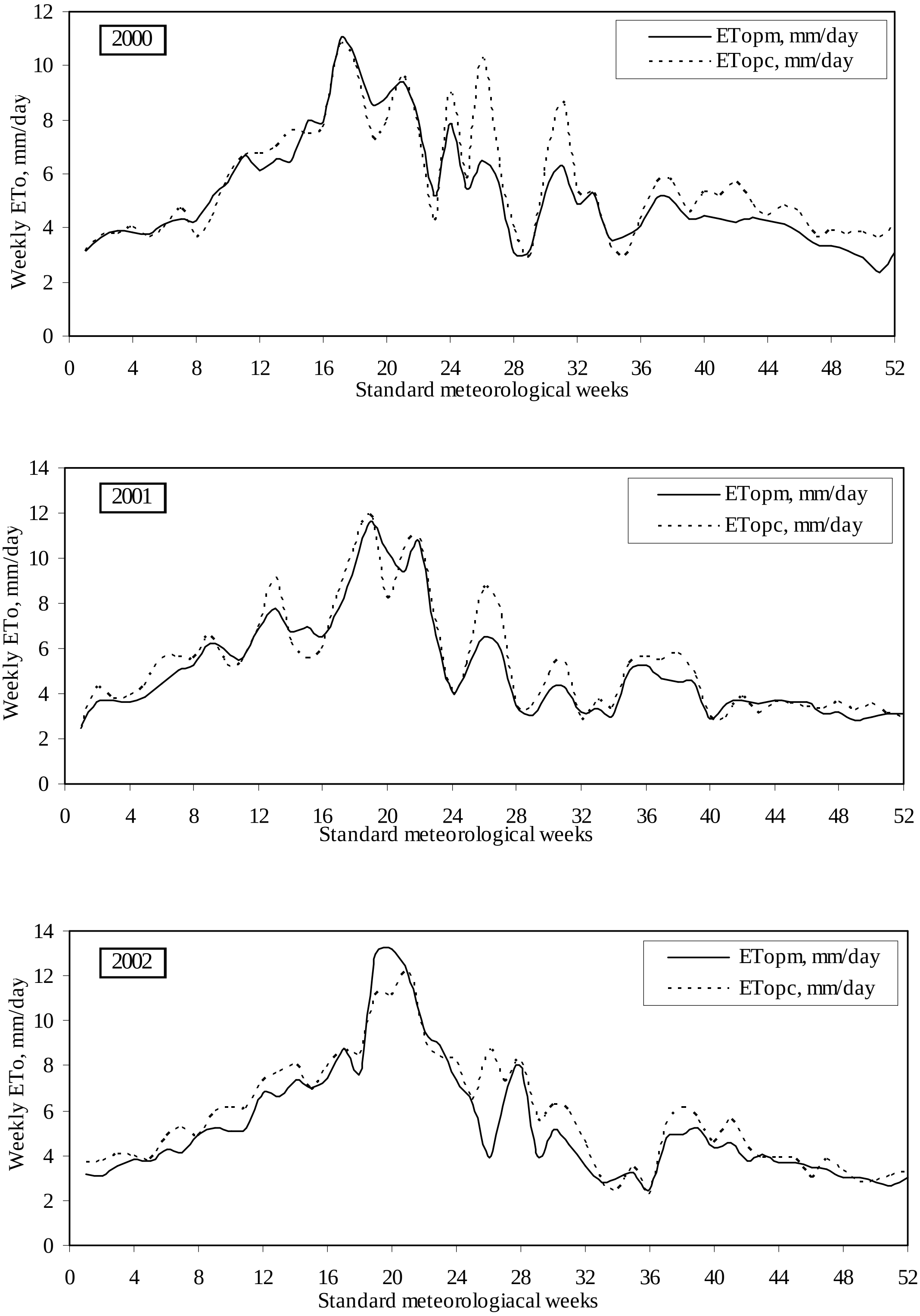

Fig.1: Variation of weekly ETopm and ETopc

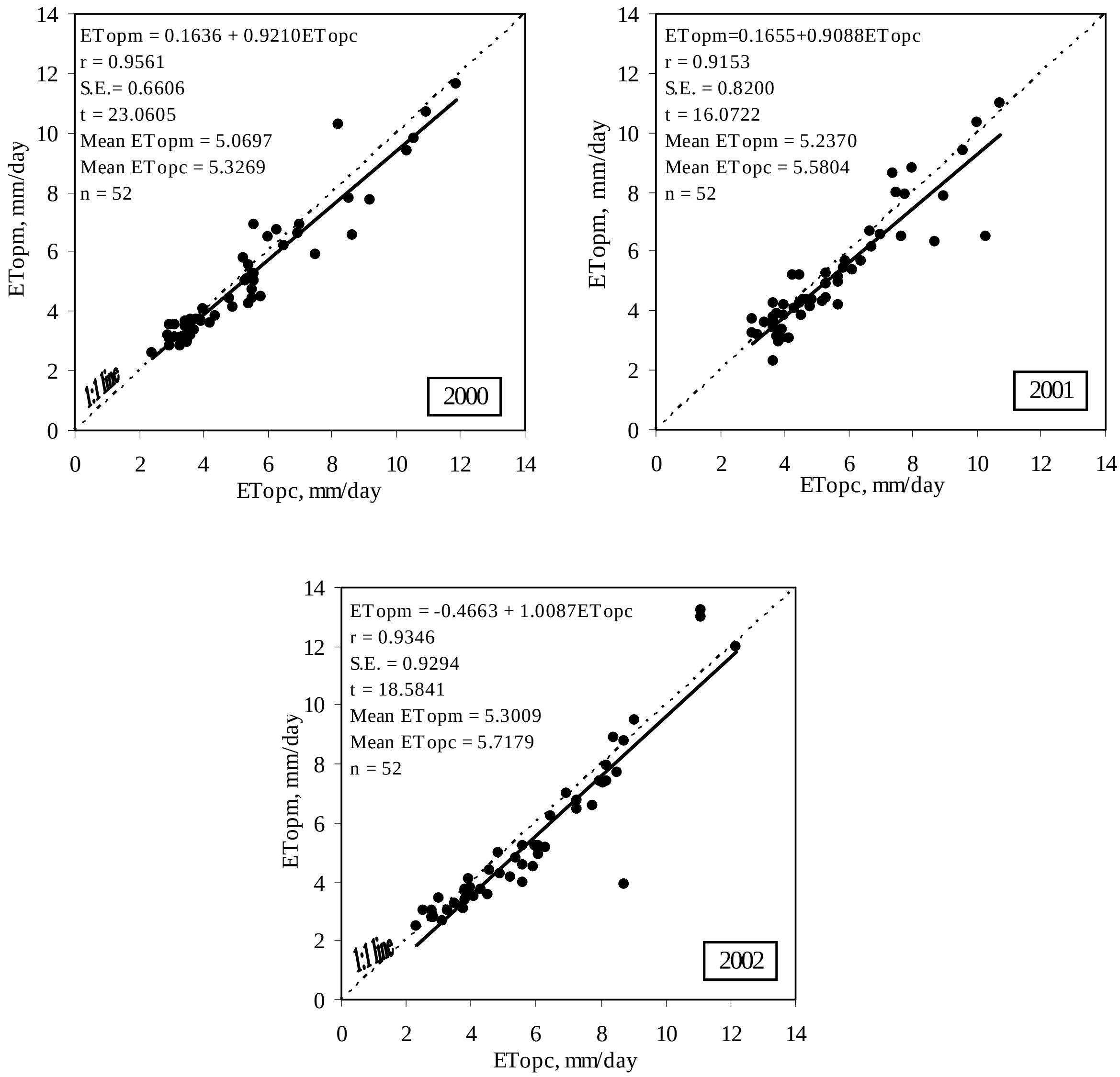

Fig. 2: Scatter plot between weekly ETopm and ETopc

correlation for all the three years. Significant correlation observed between ETopc and ETopm (0.9392, 0.9825, 0.9578 for 2000, 2001 and 2002, respectively) with very low standard errors (0.6820, 0.4236, 0.9578 mm day^{-1}). MAE, MARE & RMSE between ETopc and ETopm were found very low for all the three years.

The estimated monthly pan coefficients may be suitable for determination of monthly ETo instead of FAO-56 PM, because of its simplicity in calculation and requirement of only one parameter i.e. pan evaporation.

Seasonal Analysis

In this analysis, meteorological data were used on seasonal basis calculated by taking means of standard meteorological weeks of respective season. According to the climatic conditions of Vidarbha, five seasons were defined for both stations viz, summer (SUM), pre monsoon (PRM), monsoon (MON), post monsoon (POM) and winter (WIN). Seasonal data for the period of 1980-1999 (20 years) were used to estimate pan coefficients and are presented in the Table 5.

Table 3: Monthly pan coefficients estimated for Akola

Month	Pan coefficient	Month	Pan coefficient
January	0.8	July	0.9
February	0.7	August	1.0
March	0.7	September	1.0
April	0.6	October	0.9
May	0.6	November	0.8
June	0.8	December	0.8

Table 4: Performance indices of monthly pan coefficients for Akola

S. N.	Year	Mean absolute error (MAE), mm/day	Mean absolute relative error (MARE)	Root mean square error (RMSE), mm/day
1	2000	0.5453	0.1011	0.6552
2	2001	0.3709	0.0678	0.4533
3	2002	0.5691	0.0868	0.7756

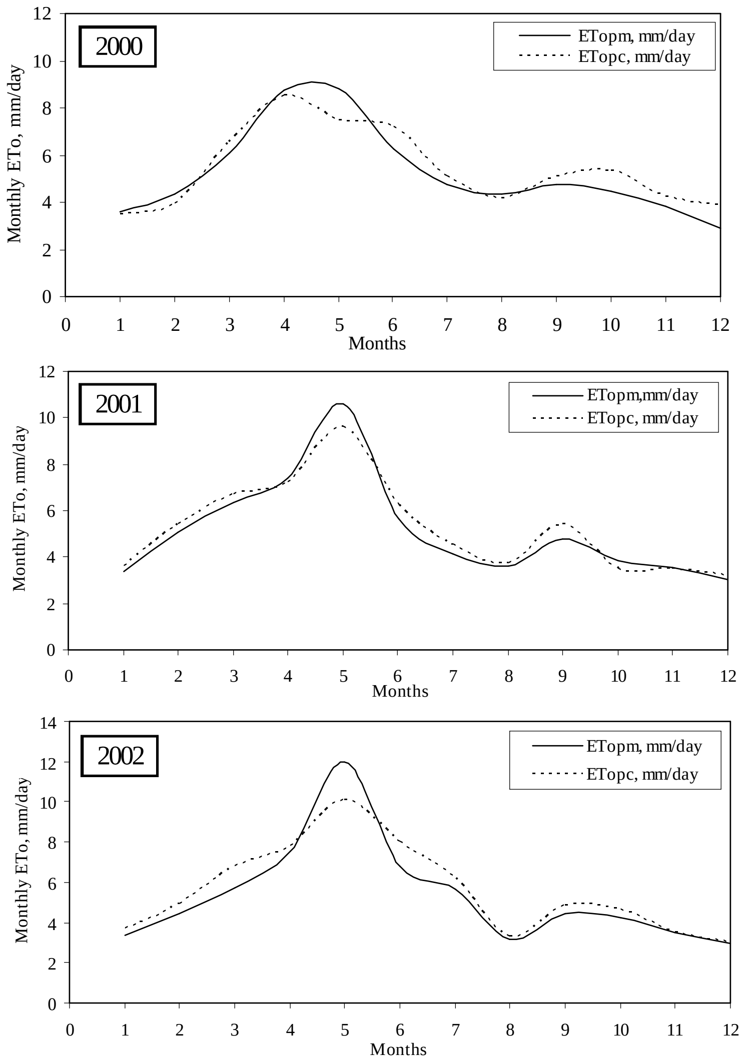

Fig. 3. Variation of monthly ET opm and Et ope

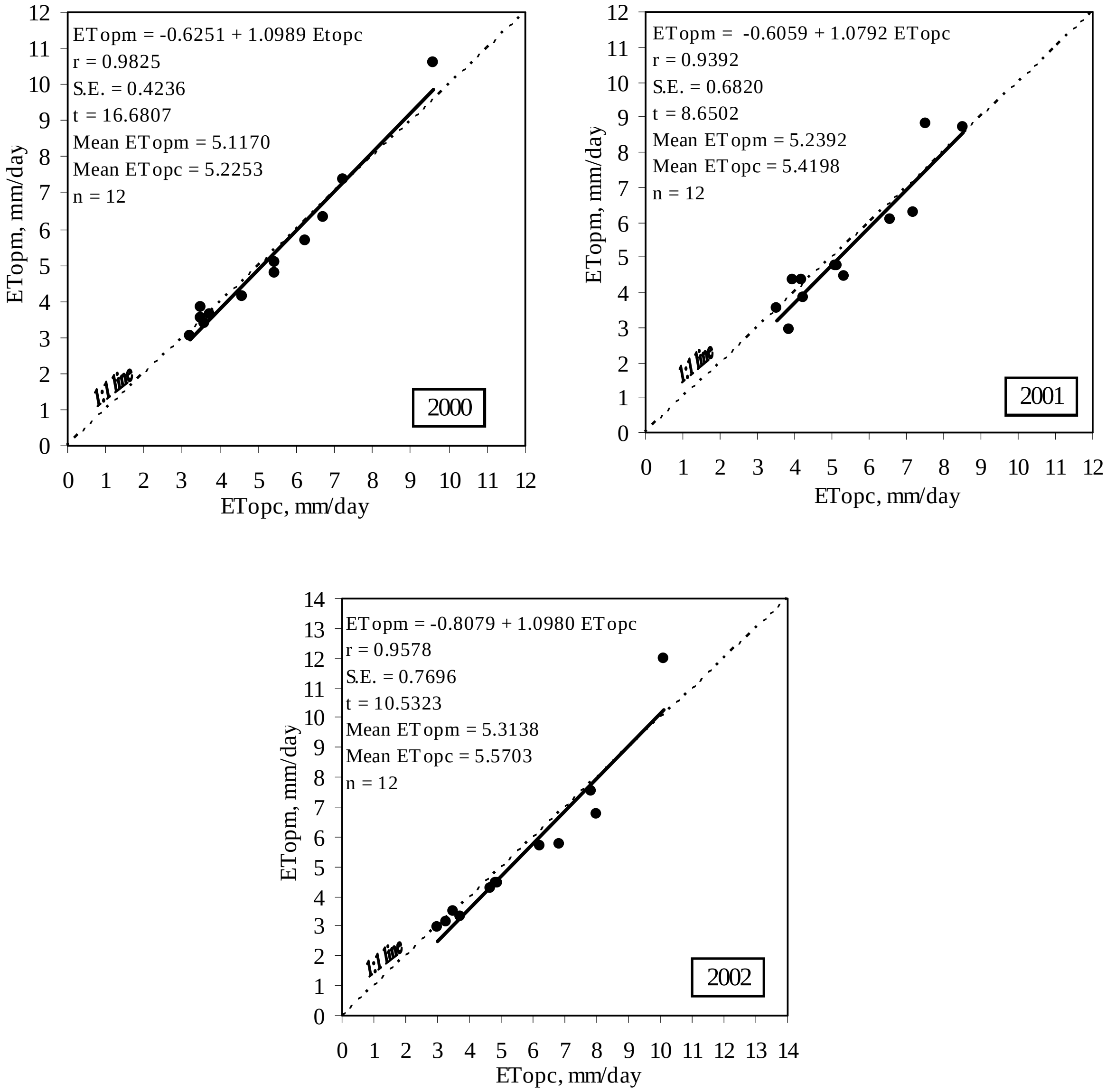

Fig. 4. Scatter plot between monthly ET opm and ET ope

From Table 5 it is seen that seasonal pan coefficients for Akola were minimum (0.6) for summer and maximum (1.0) for monsoon season. Lowest pan coefficient in summer may be due to high temperature effect on pan, which accumulates in higher rate of evaporation as compared to ET from reference crop.

Estimated seasonal pan coefficients were evaluated by determining ETo for the years 2000, 2001 and 2002 and results are shown in Fig 5 to 6 and Table 6.

It is seen from Fig 5 to 6 and Table 6 that seasonal ETopc was found very close to seasonal ETopm for 2001 and 2002 with slight variation for the year 2000. Regression line between ETopc and ETopm almost coincided on 1:1 line for 2001 and 2002. While for 2000 there was little deviation of regression line from 1:1 line. Overall seasonal pan coefficients gave closer estimates of ETo. Significant correlation was observed between ETopc and ETopm (0.9392, 0.9842, 0.9849 for 2000, 2001 and 2002 , respectively) with very low standard errors (0.7337, 0.4880 and 0.5268 mm day^{-1}). It is also seen that MAE, MARE and RMSE between ETopc and ETopm were found considerably low for all the three years. It is, therefore, concluded that estimated seasonal pan

Table 5: Seasonal pan coefficients estimated for Akola

S.N.	Seasons	Pan coefficient
1	Summer (10-21 SMW)	0.6
2	Pre monsoon (22-23 SMW)	0.7
3	Monsoon (24-39 SMW)	1.0
4	Post monsoon (40-48 SMW)	0.9
5	Winter (49-9 SMW)	0.8

Table 6: Performance indices of seasonal pan coefficients for Akola

S. N.	Year	Mean absolute error (MAE), mm/day	Mean absolute relative error (MARE)	Root mean square error (RMSE), mm/day
1	2000	0.7465	0.1364	0.7585
2	2001	0.3934	0.0713	0.4462
3	2002	0.5358	0.0927	0.5967

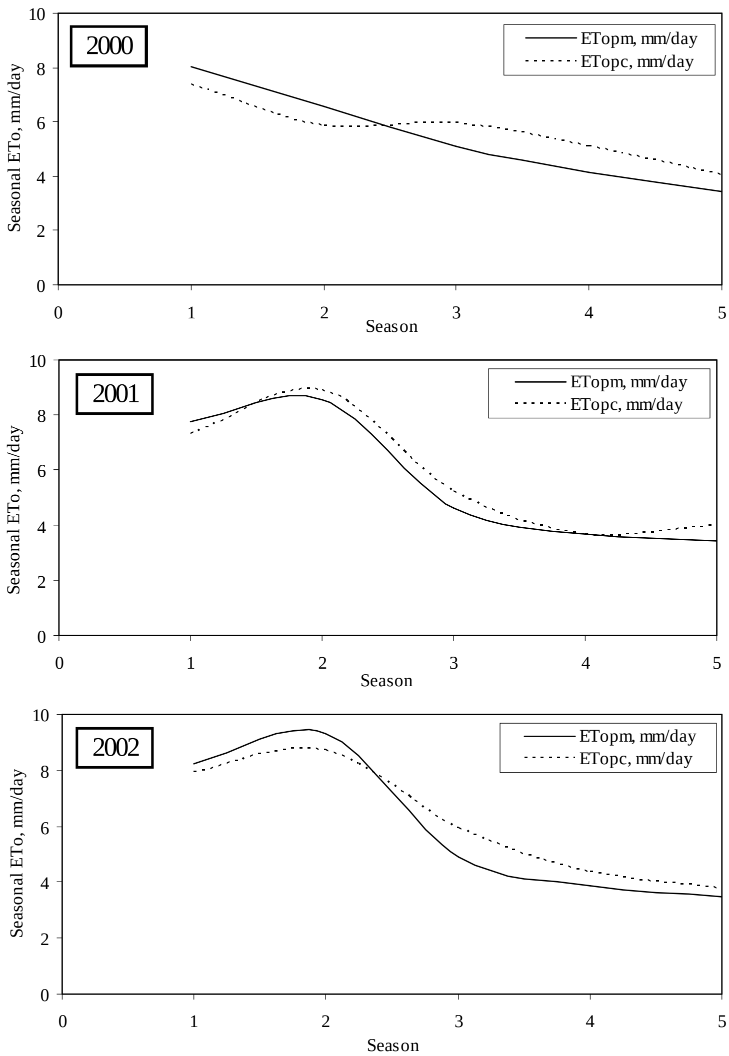

Fig. 5. Variation of seasonal ET opm and ET ope

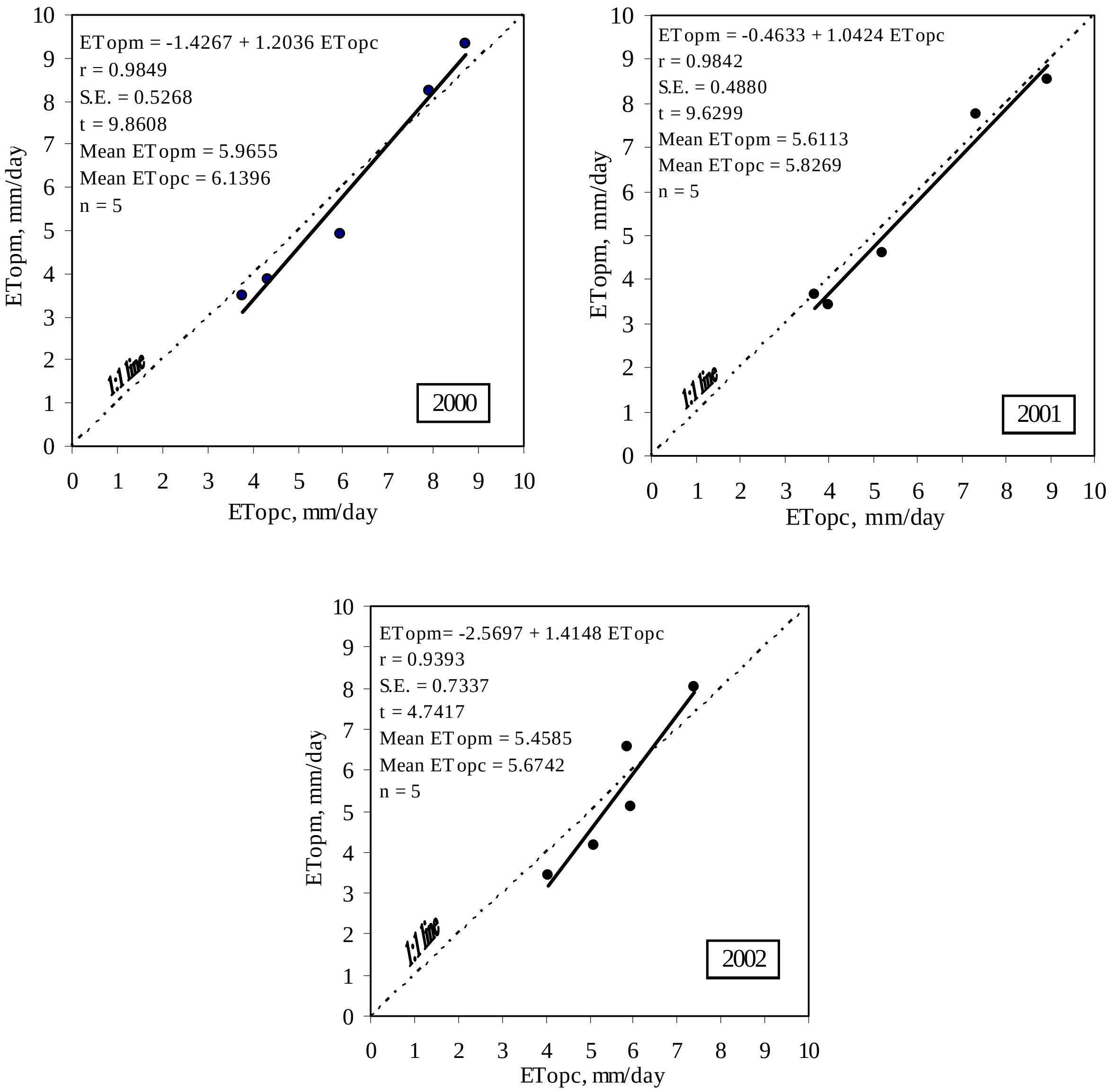

Fig. 6. Scatter plot between seasonal ET opm and ET ope

coefficients may be used for determination of seasonal ETo with better degree of accuracy.

Annual analysis

Annual pan coefficient was determined using mean annual meteorological data of 20 years (1980 to 1999). Annual pan coefficient of 0.8 was obtained from analysis. Estimated annual pan coefficient was evaluated by determining annual ETo and compaired with annual ETopm for the years 2000, 2001 and 2002. Variation between annual ETopc and ETopm is shown in Fig. 7. The performance indices obtained are presented in Table 7.

It is seen from Fig. 7 and Table 7 that annual ETopc obtained was closer to annual ETopm. It is also found that MAE, MARE and RMSE were found to be good enough. Therefore, it may be concluded that estimated annual pan coefficient for Akola may be suitable for determining annual ETo.

CONCLUSION

Estimated weekly, monthly, seasonal and annual pan coefficients may be used for determination of ETo of respective time step instead of FAO –56 Penman Monteith method, because of

Table 7: Performance indices of annual pan coefficient for Akola

S. N.	Performance indices	Value
1	Mean absolute error (MAE), mm/day	0.1525
2	Mean absolute relative error (MARE)	0.0267
3	Root mean square error (RMSE), mm/day	0.1790

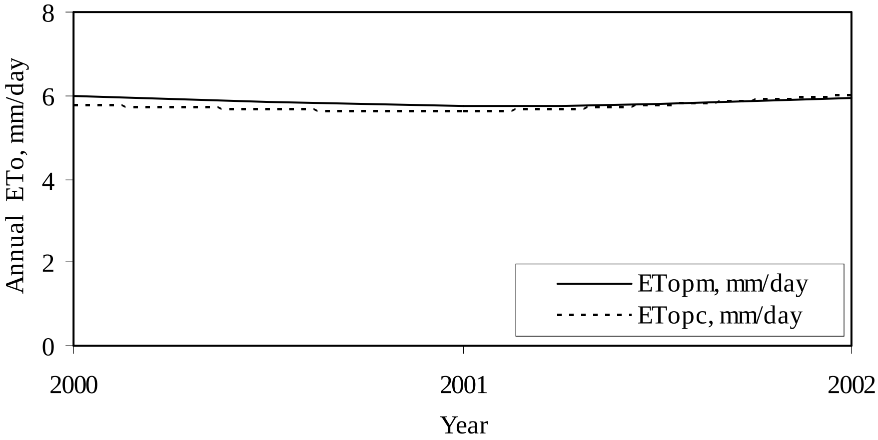

Fig.7: Variation of annual ETopm and ETopc

its simplicity in calculation and requirement of one parameter only i.e. pan evaporation.

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Optimization Study of Lateral Line Length for Flat Surfaces

G.U. Satpute[1], P.R. Chaudhary[2] and R.C. Bhuyar[3]

ABSTRACT

The optimization study of lateral line length on flat surfaces was conducted at Dr. Panjabrao Deshmukhk Krishi Vidyapeeth, Akola with 20 treatments of two lateral diameters 10 and 13.5 mm ID, two emitter discharge rates 4 and 8 lph and five emitter spacing 0.6, 0.9, 1.2, 1.5 and 1.8 m. Linear regression equation was fitted for four independent variables as lateral diameter, emitter discharge rate, emitter spacing and lateral length with discharge variation. Also for 20 treatments separate regression equations were worked out. The optimal lengths of 10 mm lateral laid on flat surface for desired flow variation (10%) were found as 23.0, 31.2, 37.5, 50.0 and 61.0 m for 4 lph emitters and 18.0, 19.5, 26.0, 28.5 and 33.2 m for 8 lph emitters with spacing 0.6, 0.9, 1.2, 1.5 and lateral for desired flow variation (10 %) were found as 42.5, 58.0, 69.0, 90.0 and 108.0 m for 4 lph emitters and 20.0, 33.5, 42.0, 47.4 and 54.2 m for 8 lph emitters with spacing of 0.6, 0.9, 1.2, 1.5 and 1.8 m respectively. The information generated will be useful to field workers for deciding the layout of drip systems according to field boundaries without much hydraulic calculations.

The lateral line design is a primary and important step in the design of drip irrigation system. Different formulae and design chart are available for predicting head losses or allowable pressure/flow variations for different lateral sizes and lengths[1-3]. For optimum design of lateral line further hydraulic calculations are required in relation to emitter discharge rate, emitter spacing, lateral size, field slope and allowable flow variation. This job of hydraulic calculation every time for lateral line design in different layouts is tedious and hence generally minor losses are either neglected or roughly added in major frictional losses which ultimately affects the system uniformity. In view of this, the present study was undertaken to determine optimum lateral line lengths for different flow conditions on flat surfaces.

MATERIAL AND METHODS

The laboratory experiments were conducted in the Department of Soil and Water conservation Engg., Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola. The optimization study of 10 mm and 13.5 mm (ID) lateral was conducted by laying the laterals of various lengths upto 100 m on flat surface (zero slope) with 4 and 8 lph emitters fixed at various spacing. The 4 and 8 lph non-pressure compensating emitters of type 'Turbo key' (Jain Irrigation System Ltd.) were selected for the study. Five emitters spacing viz. 0.6, 0.9, 1.2, 1.5 and 1.8 m were selected as third variable. In all, there were 20 treatments of two lateral diameters, two emitter discharge rate and five emitter spacing.

The 100 m long lateral line of each treatment was laid on the horizontal surface. The inlet pressure of 10 m of water was maintained at the head of the lateral. The maximum and minimum discharge rate of emitters at the head and tail end of the lateral were recorded. Then the lateral length was reduced to 90 m by folding 10m lateral section from the tail end and constant operating pressure was maintained by controlling flow through bypass arrangement near the pump. Then the flow rates of emitters at both end points of the lateral were recorded. Likewise lateral lengths were reduced by 10m intervals upto last section of 10 m in each treatment and observations of emitter discharges were recorded.

From the emitter flow rates recorded at both ends of the lateral, per cent flow variation was determined for each lateral length section in every treatment by using the equation suggested by Bralts *et. al.*, (1982).

$$q_{var} = \{(q_{max} - q_{min}) / q_{min}\} \times 100 \qquad \text{- - - - - (1)}$$

Where,

q_{var} = emitter flow variation expressed in percentage,
q_{max} = maximum emitter discharge, lph and
q_{min} = minimum emitter discharge, lph

1. Associate Prof., 2. Assistant Prof. and 3. Head, Department of SWCE, Dr. P.D.K.V. Akola

RESULTS AND DISCUSSION

From the observations of per cent discharge variation in different treatments of 10 mm and 13.5 mm lateral for different emitter spacing, it was observed that with the increase in length of lateral in each treatment the flow variation increased. For 10 mm or 13.5 mm lateral with 4 or 8 lph dripper, the flow variation reduced with increase in dripper spacing from 0.6 to 1.8 m for different lateral lengths on flat surfaces which was due to reducing outflows from laterals for respective segments.

The flow variation ranged from 24.73 to 72.53 per cent and 9.82 to 39.13 per cent, respectively in 100 m long laterals of 10 mm and 13.5 mm with 4 lph drippers fixed at different spacings (1.8 m to 0.6 m). The flow variation in 50 m long 10 mm lateral and 100 m long 13.5 mm lateral with 8 lph drippers fixed at different spacings (1.8 m to 0.6 m) ranged from 15.18 to 49.38 per cent and 26.88 to 80.63 per cent, respectively.

The optimum length range of 10 mm lateral for 4 lph drippers fixed at 0.6, 0.9, 1.2, 1.5 and 1.8 m

Table 1. Regression equations for per cent discharge variation in drip laterals

S..N.	Lateral diameter, mm	Emitter discharge, lph	Emitter spacing, (Se), m	Regression equation (L : Lateral length, m)	R-Square**
1	10	4	-	Qv = 19.45 – 23.99 Se + 0.55 L	0.869
2	10	8	-	Qv = 13.88 – 19.69 Se + 0.82 L	0.944
3	13.5	4	-	Qv = 6.05– 9.04 Se + 0.24 L	0.765
4	13.5	8	-	Qv = 22.24 – 25.62 Se + 0.54L	0.820
5	10	4	0.6	Qv = - 9.08 + 0.83 L	0.966
6	10	4	0.9	Qv = - 12.75 + 0.735 L	0.972
7	10	4	1.2	Qv = - 11.02 + 0.56 L	0.953
8	10	4	1.5	Qv = - 8.08 + 0.363 L	0.899
9	10	4	1.8	Qv = - 5.8 + 0.26 L	0.885
10	10	8	0.6	Qv = - 7.62 + 0.975 L	0.964
11	10	8	0.9	Qv = - 8.23 + 0.954 L	0.972
12	10	8	1.2	Qv = - 11.16 + 0.813 L	0.966
13	10	8	1.5	Qv = - 10.35 + 0.715 L	0.961
14	10	8	1.8	Qv = - 11.39 + 0.645 L	0.953
15	13.5	4	0.6	Qv = - 9.49 + 0.459 L	0.956
16	13.5	4	0.9	Qv = - 5.52 + 0.268 L	0.893
17	13.5	4	1.2	Qv = - 4.77 + 0.214 L	0.906
18	13.5	4	1.5	Qv = - 2.83 + 0.142 L	0.953
19	13.5	4	1.8	Qv = - 1.78 + 0.109 L	0.941
20	13.5	8	0.6	Qv = - 8.91 + 0.946 L	0.968
21	13.5	8	0.9	Qv = - 11.54 + 0.644 L	0.955
22	13.5	8	1.2	Qv = - 9.45 + 0.464 L	0.974
23	13.5	8	1.5	Qv = - 6.68 + 0.353 L	0.966
24	13.5	8	1.8	Qv = - 5.91 + 0.294 L	0.955

** Significant at one per cent level of significance.

Table 2. Maximum lateral length (m) on flat surfaces for 10 and 13.5 mm (ID) laterals for different flow conditions

Lateral Diameter (mm)	Emitter discharge rate, lph	Per cent flow variation, (%)	Emitter spacing, m				
			0.6	0.9	1.2	1.5	1.8
10	4	5	17.00	24.00	28.60	36.00	41.50
		10	23.00	31.20	37.50	50.00	61.00
		15	29.00	38.00	46.40	63.60	80.00
		20	35.00	44.50	55.40	77.40	99.00
	8	5	13.00	14.00	20.00	21.50	24.40
		10	18.00	19.50	26.00	28.50	33.20
		15	23.00	24.40	32.00	35.50	41.00
		20	28.00	29.60	38.00	42.50	48.60
13.5	4	5	31.60	39.00	45.70	55.00	62.00
		10	42.50	58.00	69.00	90.00	108.00
		15	53.40	76.60	92.40	*	*
		20	64.00	95.00	*	*	*
	8	5	15.00	25.70	31.00	33.00	37.00
		10	20.00	33.50	42.00	47.40	54.20
		15	25.30	41.20	52.70	61.40	71.00
		20	30.60	49.00	63.50	75.60	88.20

* lateral lengths are greater than 100 m

spacing were 30 to 40 m, 40 to 50 m, 50 to 60 m, 70 to 80 m and 80 to 95 m, respectively. The similar range for 10 mm lateral with 8 lph dripper were found as 20 to 25 m, 30 to 35 m, 35 to 45 m, 45 to 50 m and 50 to 60 m, respectively. The optimum range of 13.5 mm lateral for 4 lph dripper fixed at 0.6, 0.9 and 1.2 m spacing were found as 55 to 65 m, 80 to 90 m and 90 to 100 m, respectively and for 1.5 and 1.8 m spacing the length of lateral could be more than 100 m. Similarly for 8 lph drippers fixed at 0.6, 0.9, 1.2, 1.5 and 1.8 m spacing on 13.5 mm lateral, the optimum range of length were found as 25 to 35 m, 40 to 50 m, 50 to 60 m, 60 to 80 m and 70 to 90 m, respectively.

For the observations of all the 20 treatments, a multiple linear regression equation was fitted for four independent variables i.e. lateral diameter, emitter discharge, emitter spacing and lateral length with flow variation and developed relationship as given below.

$$Qv = 39.79 - 3.83\,D + 3.43\,q - 19.53\,Se + 0.54\,L \quad (R^2 = 0.816) \qquad ---(2)$$

Where,

Qv - discharge variation along the lateral length in per cent.
D - lateral diameter, mm.
q - emitter discharge, lph.
Se - emitter spacing, m.
L - lateral length, m.

Separate regression equations were fitted for 10 mm and 13.5 mm laterals which are as given below.

For 10 mm lateral

$Qv = -5.15 + 3.64\ q - 21.84\ Se + 0.68\ L$

($R^2 = 0.896^{**}$) - - - (3)

For 13.5 mm lateral

$Qv = -5.229 + 3.23\ q - 17.28\ Se + 0.387\ L$

($R^2 = 0.733^{**}$) - - - (4)

Limits for equation 2 , 3 and 4 are

10 d” D d” 13.5 ; 4 d” q d” 8 ; 0.6 d” Se d” 1.8 and 10 d” L d” 100

Regression equations were also developed for two lateral diameters and two emitter discharge rates combinely and for all the 20 treatments separately, which are tabulated in Table 1 with limits: 0.6 d” Se d” 1.8, and 10 d” L d” 100.

Considering the equations developed in the study for different treatments, the maximum permissible length of 10 mm and 13.5 mm lateral line for 5, 10, 15 and 20 per cent flow variation with 4 and 8 lph drippers were calculated and are presented in Table 2.

The maximum lateral length for required flow variation (in desired or accepted range) can readily be selected if emitter spacing and its discharge rate is known. This type of information will be helpful to field workers for selection of optimum length of lateral depending upon the field conditions. In case of sloppy field, the optimum lateral lengths will increase or decrease depending upon whether the lateral goes down slope or up slope, respectively.

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Effect of Integrated Nutrient Management on Yield and Yield Contributing Characters of Mustard – Cowpea – Rice Cropping Sequence in Lateritic Soils

Shilpa Babar[1] and J. H. Dongale[2]

ABSTRACT

The field experiment was conducted to study the effect of "Integrated Nutrient Management on Yield and Yield Contributing Characters of Mustard – Cowpea – Rice Cropping Sequence in Lateritic Soils of Konkan". The recommended dose of N, P_2O_5 and K_2O (kg ha^{-1}) for mustard, cowpea and rice crops were 90: 45: 45, 25: 50: 50 and 150: 50: 75, respectively. It is revealed from the study that the performance of mustard and cowpea crops in terms of their yield attributes and grain yield productivity was highest under the treatment T_3 i.e. application of 100 per cent recommended dose of NPK through chemical fertilizers, however in general its effects were statistically at par with those of integrated nutrient management treatment i.e. T_7 (50 % NPK, IF + 50 % N, FYM). The said effects due to above two treatments *viz.*, T_3 and T_7 were much superior over to those of alone organic manure treatment (T_2) i.e. 100 per cent N applied through FYM to both the crops. The performance of rice in terms of grain yield productivity, and yield attributes was highest with integrated nutrient management treatment i.e. T_7 where 50 per cent recommended dose of NPK was applied through chemical fertilizers plus 50 per cent dose of N was applied through glyricidia green leaf manuring to rice and its effects were significantly superior over to those of application of chemical fertilizer alone (T_3) i.e. 100 per cent NPK (IF) and also over application of organic manure alone (T_2) i.e. application of glyricidia green leaf manure @ 50 per cent recommended dose of N.

MATERIAL AND METHODS

The field experiment *viz.*, "Integrated Nutrient Management on Yield and Yield Contributing Characters of Mustard – Cowpea – Rice Cropping Sequence in Lateritic Soils of Konkan" was conducted on Research Farm, Department of Agronomy, College of Agriculture, Dapoli, during *Rabi, Summer* and *Kharif* seasons 2005-06. The field experiment was carried out in randomized block design comprising three replications and eight treatments as follows.

Treatment details

Treat No.	Treatment details		
	Mustard (*Rabi*)	**Cowpea (*Summer*)**	**Rice (*Kharif*)**
T_1	125% N (M)	Residual	Residual
T_2	100% N (M)	100% N (M)	50% N (M)
T_3	100% NPK (IF)	100% NPK (IF)	100% NPK (IF)
T_4	100%NPK(IF)+25%EN(M)	50% NPK (IF)	100%NPK(IF)+25%EN(M)
T_5	75%NPK (IF)	75% NPK (IF)	75% NPK (IF)
T_6	75%NPK (IF)+25% N (M)	75%NPK (IF)+25% N (M)	75% NPK (IF) +25 %N (M)
T_7	50% NPK (IF)+50% N (M)	50%NPK (IF)+50% N (M)	50%NPK (IF) +50 %N (M)
T_8	Control	Control	Control

RESULTS AND DISCUSSION

Yield contributing characters of mustard and cowpea

Number of pods

It was seen from the data (Table 1) that in mustard crop treatments T_3 to T_7 were significantly superior over control at both the stages except T_6 (61.57) at flowering stage. At harvest, the highest pod number was contributed by T_4 (100 IF +25 FYM) treatment (235.3) and its effect was significantly

1. Senior Res. Fellow, Central Institute for Cotton Research, Nagpur and 2. Ex. Director of Research, ARS, Karjat, Dr.B.S.K.K.V., Dapoli

Table 1: Effect of integrated nutrient management on yield contributing characters of mustard and cowpea in lateritic soil

Treatments	Treatments		Mustard			Cowpea		
	Mustard *Rabi*	CowpeaSummer	No. of pods(Plant^{-1})		Seed Weight	No. of pods(Plant^{-1})		Grain
			60 DAS	At harvest	plant-1	60 DAS	Total pods at harvest	Weight(g)
T1	125% N (M)	Residual	58.57	97.35	4.22	8.00	17.08	5.43
T2	100% N (M)	100% N (M)	51.33	94.90	3.41	9.15	19.63	6.03
T3	100%NPK (IF)	100%NPK(IF)	122.00	221.38	11.38	13.80	22.67	6.43
T4	100%NPK (IF) + 25% EN (M)	50%NPK (IF)	110.57	235.30	8.91	13.83	20.60	5.89
T5	75% NPK (IF)	75% NPK (IF)	70.00	218.53	9.81	12.67	19.74	6.01
T6	75% NPK (IF) + 25% N (M)	75% NPK (IF) + 25% N (M)	61.57	196.92	7.07	11.07	17.98	6.25
T7	50% NPK (IF) + 50% N (M)	50% NPK (IF) + 50% N (M)	88.23	190.82	7.23	10.80	21.87	6.33
T8	Control.	Control.	35.60	86.18	3.67	6.70	12.48	4.20
		Mean	74.73	167.67	6.96	10.87	19.01	5.82
		SE (m) ±	10.86	12.19	0.99	0.72	1.35	0.25
		CD at 5%	32.94	36.98	2.99	2.12	3.96	0.74

superior over only organics (T_1, T_2) and INM treatments (T_6, T_7) and was at par with the remaining treatments. In case of cowpea, highest number of pods at flowering stage were observed in the treatment receiving (100:25) inorganic + organic i.e. T_4 (13.83) which was closely followed by T_3 i.e. 100 per cent NPK through chemical fertilizers (13.80), and these two treatments were significantly superior over all other treatments except treatment T_5. At harvest stage the highest number of pods plant^{-1} was recorded with T_3 i.e. 100 per cent NPK through chemical fertilizers (22.67), which was closely followed by T_7 i.e. 50:50 inorganic + organic (21.87).

Seed weight plant^{-1}

Amongst all treatment combinations the highest seed weight was recorded in treatment T_3, both for mustard and cowpea (11.38, 6.43 g) with the corresponding mean values of 6.96 and 5.82 g, respectively. In case of mustard crop the treatment T_3 was significantly superior over all the treatments except T_4 and T_5. However, in case of cowpea the effects of T_2 to T_7 were at par with each other. Mandal and Sinha (2002) reported that the improvement in yield attributes of Indian mustard due to integrated use of 50 per cent RDF + FYM @ 10 t ha^{-1} was highest and its effect was at par with 100 per cent RDF.

Yield contributing characters of rice

Number of tillers and panicles

The number of tillers and panicles hill^{-1} were increased significantly due to all treatments compared to control (Table 2). Application of 50:50 per cent NPK through chemical fertilizers plus glyricidia (T_7) consistently contributed the highest number of tillers (10.58, 9.73) at both the stages i.e. PI and harvest. It was also true for number of panicles hill^{-1}. The tillers and panicles were slightly higher with T_7 treatment than those of T_3 treatment.

Weight of panicle

The weight of panicle hill^{-1} of hybrid rice under various treatments increased significantly from 15.76 to 25.52 g as compared to control except T_1 i.e. residual (18.97 g hill^{-1}) and the effects due to T_2 and T_7 treatments were at par with each other. Similar trend was also noticed with respect to grain weight hill^{-1}.

Length of panicle and grain weight panicle^{-1}

The mean length of panicle of rice varied from 22.83 cm to 25.67 cm among various treatments and the treatment differences were observed to be statistically significant. Among the various treatments the panicle length was highest (25.67 cm) with INM treatment i.e. T_7 where 50: 50 organic + inorganic sources of plant nutrients were applied. However, the variation in T_1 to T_7 was statistically at par with each other. Singh *et. al.*, (2001) also reported similar results where they found the highest and significant improvement in yield attributes of rice (tillers, panicle length, panicle weight and grain panicle^{-1}) with application of 50 per cent N through organic source (*Dhaincha* GM / FYM) + 50 per cent N through PU and effect of this treatment was significantly superior over use of either organic nutrient sources or inorganic nutrient sources.

Grain and straw yield

Mustard

The seed yield of mustard increased significantly from 2.67 to 11.01 q ha^{-1} among various treatments and the highest seed yield was contributed by treatment T_3 i.e. 100 per cent NPK (IF) which was at par with those of T_4 (10.95 q ha^{-1}), T_6 (10.12 q ha^{-1}) and T_7 (9.95 q ha^{-1}). Among various treatments, the chemical fertilizers (T_3, T_5) were most effective in boosting the seed yield of mustard by recording 249.06 per cent to 312.36 per cent increase over control, followed by combination of organic + inorganic nutrient sources i.e. T_6, T_7, whereas organic sources T_1 , T_2 were observed to be least effective. The stover yield of mustard also increased significantly from 6.23 to 27.92 q ha^{-1} due to various treatments compared to control. The inorganic sources of nutrients (T_3, T_5), INM treatments (T_4, T_6, and T_7) were at par with each other except T_4 and all of them were significantly superior over organic treatments (T_1 and T_2). Dongale, *et. al.*, (1990) reported graded and significant response of mustard to increasing levels of NP fertilizers in lateritic soil of Konkan and reported the highest mean seed yield of 16.38 q ha^{-1} with N and P_2O_5 application @ 90 and 45 kg ha^{-1}, respectively.

Cowpea

In case of cowpea the treatment T_3 (100 % NPK, IF) contributed the highest grain yield (15.61 q

Table 2: Effect of integrated nutrient management on yield contributing characters of rice in lateritic soil

Treat. No.	Treatments	Rice					
	Rice *Kharif*	No of tillers hill^{-1}		No of panicle	Weight of panicle^{-1}	Grain weight	Length of
		PIS	At Harvest	hill^{-1}	(g hill^{-1})	hill^{-1}(g)	panicle (cm)
T_1	Residual	7.07	7.26	7.26	18.97	18.06	24.50
T_2	50% N (M)	7.84	8.84	8.84	25.32	20.99	25.36
T_3	100% NPK (IF)	7.49	7.85	7.85	25.36	20.15	24.64
T_4	100%NPK(IF) + 25% N (M)	7.38	8.75	8.75	25.52	23.00	24.94
T_5	75% NPK (IF)	7.17	8.13	8.13	23.44	21.73	24.17
T_6	75% NPK (IF) + 25% N (M)	7.83	8.00	8.00	25.27	22.75	25.18
T_7	50% NPK (IF) + 50% N (M)	10.58	9.73	9.73	25.17	22.81	25.67
T_8	Control.	5.83	6.15	6.15	15.76	14.07	22.83
	Mean	7.65	8.09	8.09	23.10	20.44	24.66
	SE (m) ±	0.42	0.68	0.68	1.85	1.47	0.55
	CD at 5% level	1.25	2.00	2.00	5.46	4.33	1.63

Table 3: Effect of integrated nutrient management on yield of mustard, cowpea and rice in lateritic soil

Treat. No.	Treatments			Yield (q ha^{-1})					
				Mustard		Cowpea		Rice	
	Mustard	Cowpea	Rice	Seed	Stover	Grain	Stover	Grain	Straw
T_1	125% N (M)	Residual	Residual	4.81	9.86	12.43	16.96	33.47	33.49
T_2	100% N (M)	100% N (M)	50% N (M)	3.66	9.35	12.83	21.61	46.34	56.95
T_3	100% NPK (IF)	100% NPK (IF)	100% NPK (IF)	11.01	24.83	15.61	24.61	49.71	50.55
T_4	100% NPK (IF) + 25% N (M)	50% NPK (IF)	100% NPK (IF) + 25% N (M)	10.95	27.92	13.46	21.64	51.28	54.25
T_5	75% NPK (IF)	75% NPK (IF)	75% NPK (IF)	9.32	22.71	13.41	19.93	42.85	43.34
T_6	75% NPK (IF) + 25% N (M)	75% NPK (IF) + 25% N (M)	75% NPK (IF) + 25% N (M)	10.12	23.62	12.67	18.16	48.85	47.70
T_7	0% NPK (IF) + 50% N (M)	50% NPK (IF) + 50% N (M)	50% NPK (IF) + 50% N (M)	9.95	22.17	14.77	24.10	55.96	56.45
T_8	5Control.	Control.	Control.	2.67	6.23	12.04	15.88	29.86	31.18
			Mean	7.81	18.34	13.48	20.36	44.79	46.74
			SE (m) ±	0.49	0.99	0.74	1.84	1.21	2.91
			CD at 5%	1.45	2.90	2.19	5.43	3.55	8.56

ha^{-1}) and straw yield (24.61 q ha^{-1}) which was closely followed by INM treatment T_7 (50:50 % proportion) yielding 14.77 q ha^{-1} grain yield and 24.10 q ha^{-1} stover yield. The effect of these two treatments was at par with each other and both of them were significantly superior over control (T_8) and treatments (T_1 and T_2). Similar results were reported by the Bhikane *et al.* (2006) who showed that application of organic manures or vermicompost @ 4 t ha^{-1} along with recommended dose of fertilizers (N @ 25 + P_2O_5 @ 50 + K_2O @ 50 kg ha^{-1}) significantly increased the cowpea grain yield over the treatment receiving recommended dose of NPK.

Rice

In case of rice the grain and straw yield increased significantly from 29.86 q ha^{-1} to 55.96 q ha^{-1} and from 31.18 q ha^{-1} to 56.95 q ha^{-1}, respectively due to different treatments compared to control. The highest grain yield (55.96 q ha^{-1}) was contributed by INM T_7 treatment. With respect to grain yield, the effect of T_7 treatment was at par with T_2 and T_3 treatments. The treatment T_2 i.e. 50 per cent N through glyricidia to rice and the treatment T_3 i.e. 100 per cent NPK (IF) enhanced the grain yield of rice over control. In the present study, the yield level with nutrient integration was higher compared to use of fertilizer alone. Bhoite (2005) and Pramanic and Mahapatra (1997) also reported similar results.

CONCLUSION

It is, therefore, in lateritic soil of Konkan for mustard – cowpea – rice cropping sequence the integrated nutrient management practice i.e. application of 50 per cent recommended dose of N, P_2O5 and K_2O be applied through chemical fertilizers and the remaining 50 per cent recommended dose be applied through manure for each crop in the cropping sequence for yield contributing characters and yield optimization as well as saving of chemical fertilizers. For mustard and cowpea FYM be used as manure and for rice, glyricidia green leaf manuring be used.

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Response of Deshi and American Cotton to Potassium Under Rainfed Conditions

P. D. Bhalerao[1] and Godavari S. Gaikwad[2]

ABSTRACT

Field experiment was conducted during 2005-06 to 2007-08 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to study the effect of Potassium on growth, yield attributes and seed cotton yield of *Deshi* and American cotton. Three years pooled data indicated that *Deshi* variety AKA-7 recorded significantly higher seed cotton yield (15.15 q ha^{-1}) than American variety AKH 8828 (14.51 q ha^{-1}) under rainfed condition. Monetary returns were also significantly more with *Deshi* variety than American variety. Application of potassium along with recommended dose of nitrogen and phosphorous showed significant response in respect of seed cotton yield. Higher values of GMR, NMR and B:C ratios were found with application of recommended dose of N and P with potash (25 kg ha^{-1}). Improvement in growth and yield attributes were noticed with application of potash along with recommended dose and nitrogen and phosphorous. It seems that application of potash is beneficial to *Deshi* and American cotton varieties under rainfed conditions.

Cotton is an important cash crop of India. Maharashtra occupies highest area (31.0 lakh ha) but average productivity is low (336 lint kg ha^{-1}) as compared to National average productivity of 526 lint kg ha^{-1} (Anonymous, 2008). Major reason for low productivity is that the crop is grown under rainfed condition on large area (97%).

Recently Bt. cotton hybrids are grown on an area of about 80 per cent. However, the productivity of cotton is not reached to the national average. It indicates that hybrids are not substitute to varieties for increasing the productivity per unit area. Control of sucking pest on Bt cotton hybrids is difficult due to frequent rains and cloudy weather in the month of July and August. As compared to American varieties sucking pest incidence is very low on *Deshi* varieties. American and *Deshi* varieties can be grown successfully under rainfed conditions for sustainable production. Nitrogen and phosphorus are commonly applied to rainfed cotton varieties but potassium is not applied because of high fertility status of soil in potash. Potassium is required to cotton for obtaining better yield of cotton (Nehra *et.al.*, 2004). In view of above, the present investigation was undertaken to find out the effect of potassium on yield and yield attributes of *Deshi* and American varieties.

MATERIAL AND METHODS

A field experiment was carried out for three years (2005-06 to 2007-08) at Cotton Research Unit, Dr. PDKV, Akola (M.S) under rainfed conditions. The soil was clayey in texture with pH.8.12, low in available nitrogen (193.8 $kgha^{-1}$) and phosphorous (19.6 $kgha^{-1}$) and high in available potassium (497 $kgha^{-1}$). The trial was laid out in Factorial Randomized Block Design with three replications. There were eight treatment combinations, consisted of two varieties (V_1-AKA-7 *Deshi* and V_2- AKH 8828 American) and four fertilizer levels (Control, FYM@5 t ha^{-1}, RDF with 25 kg K_2O and RDF). Recommended doses of fertilizer were 30:15:0 and 50:25:0 NPK kg ha^{-1} for variety AKA-7 and AKH-8828. FYM@ 5 t ha^{-1}, half N and full dose of P and K were applied at the time of sowing and remaining half quantity of N was applied at square formation stage.

Total rainfall received during 2005-06, 2006-07 and 2007-08 was 697.0, 985.1 and 771.0 mm, respectively as against normal rainfall of 768.5 mm (average of 30 years). The sowing was done on 11th July 3rd July and 29th June in first, second and third year, respectively. The recommended spacing of 60 x 15 cm for AKA-7 and 60 x 30 cm for AKH- 8828 were adopted. Uniform cultural practices were followed for both varieties and need based plant protection measures were undertaken to control pest and diseases.

RESULTS AND DISCUSSION

Varieties:

Data presented in Table 1 indicated that plant height and sympodial branches were

1. Cotton Agronomist and 2. Research Assoc., Cotton Research Unit, Dr. PDKV,Akola

significantly more with arboreum (AKA- 7) variety than hirsutum variety (AKH -8828). *Deshi* cotton produced taller plant than American cotton as reported by Md. Shamim and Mahey (2003). **S**ignificantly higher number of bolls plant^{-1}, yield plant^{-1}, boll weight and dry matter accumulation plant^{-1} were found with hirsutum variety than arboreum variety.

Data presented in Table 2 revealed that, seed cotton yield did not differ significantly with American and *Deshi* varieties during first and third year of study. However, during second year of study and in pooled analysis *Deshi* variety (AKA-7) recorded, significantly higher seed cotton yield than American variety (AKH-8828). Higher seed cotton yield produced in *Deshi* cotton as compared to American cotton can be attributed to taller plants, higher plant density and deep root system. These results are in agreement with the findings of More *et. al.,* (2004) and Koutu *et. al.,* (2005). Higher GMR, NMR and B.C. ratios were found with *Deshi* variety as compared to hirsutum variety. This might be due to higher seed cotton yield and less cost of cultivation of arboreum variety.

Fertilizers

Plant height and dry matter accumulation plant^{-1} were significantly higher with application of RDF alongwith potassium (K_2O) than application of FYM only and control but it was at par with application of recommended N and P only. Sympodial branches did not influence significantly with application of potassium except control. Monopodes did not differ significantly with potassium levels. Higher values of yield attributes were observed with application of potash alongwith recommended N and P but differences could not reach to the level of significance. Non significant response of potassium on ancillary characters was reported by Dev Raj *et. al.,* (2009). The effect of potassium on boll weight was also not significant (Table 1).

During first year of study, application of potassium with recommended N and P recorded significantly higher seed cotton yield than control and FYM @ 5 t ha^{-1}, but it was at par with application of recommended dose of N and P. Similar type of results were found in the third year of study. In second year of study, significant response was noticed with application of potassium@ 25 kg ha^{-1} as compared to other treatments. From three years pooled data, it was observed that application of potash to cotton along with recommended dose of N and P recorded significantly higher seed cotton yield than application of FYM. These results indicated that there was significant response to application of potash to *Deshi* and American cotton varieties under rainfed condition though the soils were rich in potassium. Pervez *et. al.,* (2005) also

Table 1: Yield attributers and growth parameters as influenced by various treatments (pooled mean)

Treatments	Height (cm)	Sympodia plant^{-1}	Mono-podia plant^{-1}	Drymatter plant^{-1} (g)	Pickedbolls plant^{-1}	Yield plant^{-1} (g)	Boll wt. (g)
Varieties							
V_1-AKH-8828	76.10	16.02	1.92	55.94	11.63	29.15	2.65
V_2-AKA-7	81.68	18.14	2.16	42.20	11.00	18.07	1.78
SE (m) ±	0.88	0.18	0.11	2.36	0.20	1.55	0.03
CD = 0.05	2.45	0.52	NS	6.56	0.56	4.29	0.08
Fertilizer levels							
K_0- Control	74.42	16.42	1.81	43.31	10.11	20.27	2.08
K_1- FYM @5t ha^{-1}	78.74	17.03	1.92	46.56	11.35	23.41	2.17
K2-RDF + K_2O @25 kg ha^{-1}	82.89	17.60	2.21	56.10	12.27	26.12	2.30
K3-RDF (without K)	79.52	17.26	2.23	50.32	11.53	24.65	2.32
SE (m) ±	1.25	0.27	0.16	2.67	0.29	0.67	0.04
CD = 0.05	3.46	0.74	NS	7.41	0.79	1.87	NS
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 2: Seed cotton yield, NMR and B:C ratio as influenced by various treatments.

Treatments	Seed cotton yield (kg ha^{-1})			Pooled	GMR	NMR	B:C
	2005-06	2006-07	2007-08	mean (kgha^{-1})	(Rsha^{-1})	(Rsha^{-1})	ratio
Varieties							
V_1- AKH-8828	1807	1141	1406	1451	28751	10029	1.53
V_2- AKA-7	1895	1208	1443	1515	30000	11637	1.63
SE (m) $\pm$	37.74	13.26	20.30	15.18	288.00	-	-
CD at 5%	NS	40.24	NS	42.07	800.66	-	-
Potassium levels							
K_0- Control	1633	1022	1280	1312	25995	17645	3.11
K_1- FYM @ 5t ha^{-1}	1789	1094	1325	1403	27746	17457	2.69
K2-RDF+K_2O @ 25 kg ha^{-1}	2063	1332	1557	1651	32673	23393	3.52
K3-RDF (without K)	1918	1250	1534	1567	31090	21920	3.39
SE (m) $\pm$	53.37	18.75	28.71	19.60	408.50	-	-
CD at 5%	161.91	56.90	87.10	59.47	1132.30	-	-
Interaction	Sig	Sig	NS	NS	NS	-	-

Table 3. Interaction of varieties x fertilizers on seed cotton yield (kg ha^{-1}) 2005-06

Treatments	K0	K1	K2	K3	Mean
V_1- AKH-8828	1483	1572	2161	2010	1807
V2- AKA-7	1783	2006	1964	1826	1895
Mean	1633	1789	2083	1918	
SE (m) $\pm$	75.48				
CD at 5%	228.97				

Table 4. Interaction of varieties x fertilizers on seed cotton yield (kg ha^{-1}) 2006-07

Treatments	K0	K1	K2	K3	Mean
V_1- AKH-8828	1045	1114	1216	1188	1141
V_2- AKA-7	999	1073	1448	1312	1208
Mean	1022	1094	1332	1250	
SE m $\pm$	26.53				
CD = 0.05	80.47				

reported significant increase in seed cotton yield with increase in levels of potassium. Application of potash with recommended dose of N and P recorded significantly highest GMR than application of only N P and FYM and control treatments. Higher values of NMR and B.C ratios were found with application of potash, followed by application of N and P only. Lowest value of B:C ratio was noticed with application of FYM only. This might be due to more cost of FYM.

Interaction

During first year of study, variety AKH 8828 with application of 50+25+25 kg NPK ha^{-1} (V_1K_2) recorded significantly highest seed cotton yield (2161 $kgha^{-1}$), followed by V_1K_3 and V_2K_1 treatment combinations (Table3).In the second year of study (Table 4), variety AKA-7 with application of 30+15+25 NPK $kgha^{-1}$ (V2K2) recorded significantly higher seed cotton yield (1448 $kgha^{-1}$) than rest of combinations. The second best treatment combination was (V2K3), followed by (V1K2).

It was concluded from the study that *Deshi* variety recorded higher seed cotton yield than American variety under rainfed condition. Similarly, application of 25 kg potash ha^{-1} along with recommended dose of nitrogen and phosphorous is required for higher seed cotton yield and monetary returns.

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Effect of Different Fertilizer Levels on Yield and Quality of Sweet Sorghum Genotypes

P.J. Kamdi[1] and H.N. Sethi[2]

ABSTRACT

A field experiment to study the effect of different fertilizer levels on green cane and juice yield and quality of sweet sorghum genotypes was conducted at Sorghum Research Unit, Dr.P.D.K.V, Akola during *Kharif* season of 2007-08. The treatments consisted were 3 genotypes and four levels of fertilizers. The genotype AKSSV-22 produced more grain yield, while genotype RSSV-9 produced more fodder yield. Higher green cane yield (421.19 q ha^{-1}), juice yield (10,345 l ha^{-1}), juice extractability (26.40 %), reducing sugar (3.39 %), non-reducing sugar (14.32%) and total sugar (16.52 %) were noticed in genotype RSSV-9, while juice pH (5.26), brix (18.57 %) was more in genotype AKSSV-22. Application of 120:60:60 Kg NPK ha^{-1} produced significantly more grain yield (22.31 q ha^{-1}), fodder yield (181.95 q ha^{-1}), green cane yield (384.84 q ha^{-1}), juice yield (10149.67 l ha^{-1}), juice extractability (26.22 %), pH (5.30), non reducing sugar (14.23 %) and total sugar (16.86 %), while brix (19.55 %), sucrose (13.32 %) and reducing sugar (3.47 %) were higher in control treatment (00:00:00 Kg NPK ha^{-1}).

Sorghum *(Sorghum bicolor* (L.) Moench) is known as sweet sorghum. The name “Sweet sorghum” being sweet and juicy. It is important crop for food, fodder, fuel, jaggery and syrup production and most important in fuel alcohol. The sweet sorghum varieties and hybrid have the ability to produce extremely high stalk yield of 50 t ha^{-1} with juice brix reading between 18-22 per cent and 1.5-2.5 t ha^{-1} grain yield (Ratnavathi *et. al.,* 2003).

Sweet sorghum is special purpose sorghum with a sugar rich stalk, almost like sugarcane. Besides having rapid growth, higher sugar accumulation and biomass production potential. Sweet sorghum has wider adaptability. (Reddy and Sanjana Reddy, 2003). The sugar content in the juice extracted from sweet sorghum varies from 16-23 per cent brix. It has been great potential for jaggery syrup and most importantly fuel and alcohol production (Ratnavathi *et al.,* 2004). The nutrients play important role for improving average yield i.e. green cane yield, grain yield, fodder yield, juice yield and quality parameters of sweet sorghum genotypes. Thus, the present experiment was conducted to study the effect of different fertilizer levels on green cane and juice yield and quality of sweet sorghum genotypes.

MATERIAL AND METHODS

Field experiment was conducted at Sorghum Research Unit, Dr. P.D.K.V, Akola during *Kharif* (2007-08) to study effect of different fertilizer levels on green cane and juice yield and quality of sweet sorghum genotypes. The experiment was conducted on vertisol soil in Factorial Randomized Block Design with three replications. The treatment consisted were 3 sorghum genotypes (AKSSV-22, SSV-84 and RSSV-9) and 4 fertilizer levels (0, 40:20:20, 80:40:40 and 120:60:60 kg NPK ha^{-1}). Experimental soil was low in nitrogen (188.50 Kg ha^{-1}), medium in Phosphorus (20.18 Kg ha^{-1}) and rich in potash (308.58 Kg ha^{-1}) content. The crop was fertilized with half nitrogen, full phosphorus and potassic fertilizer at sowing and half dose of nitrogen was applied at 30 days after sowing. Five plants were selected from net plot randomly for recording observations. Juice extractability was calculated by following formula:

$$\text{Extractability (\%)} = \frac{\text{Weight of juice (ml)}}{\text{Weight of stalk crushed (g)}} \times 100$$

Brix values were standardized (corrected) at 20°C from the table given by Meade (1963), reducing sugar was established by Somagy method (Sadasivan and Manickam, 1996), non reducing sugar percentage was observed by substituting the reducing sugar from total sugar percentage. Total sugar percentage was estimated by using phenol sulphuric acid by Dubois method (Sadasivan and Manickam, 1996).

RESULTS AND DISCUSSION

Data from Table 1 indicated that sorghum genotype AKSSV-22 produced significantly more grain yield (20.53 q ha^{-1}) as compared to other

1. Senior Research Fellow, College of Agriculture, Nagpur and 2. Associate Prof. , Central Research Station, Dr. PDKV,Akola

Table 1 : Grain yield (q ha^{-1}), fodder yield (q ha^{-1}), green cane yield (q ha^{-1}), juice yield (L ha^{-1}) and juice extractability (%) as influenced by various treatments

Treatments	Grain yield (q ha^{-1})	Fodder yield (q ha^{-1})	Green cane yield (q ha^{-1})	Juice yield (L ha^{-1})	Juice extract ability (%)
A) Genotype					
G_1 - AKSSV-22	20.53	171.66	336.65	9033.33	23.64
G_2 - SSV-84	17.02	172.09	313.54	8733.75	24.32
G_3 - RSSV-9	13.97	173.07	421.19	10344.67	26.40
SE(m)±	1.04	0.384	9.32	192.83	0.69
CD at 5%	3.05	1.12	27.35	565.59	2.02
B) Fertilizer levels kg N, P_2O_5 & K_2O ha^{-1}					
F_1-00:00:00 (Control)	10.09	162.00	340.35	8997.88	23.46
F_2 - 40:20:20	16.78	169.70	348.89	9026.44	23.55
F_3 - 80:40:40	19.51	175.43	354.89	9308.33	25.92
F_4 - 120:60:60	22.31	181.95	384.84	10149.67	26.22
SE(m)±	0.90	0.444	10.76	222.66	0.79
CD at 5%	2.62	1.30	31.58	653.08	2.34
C) Interaction (genotype x fertilizer levels)					
SE(m)±	3.12	0.769	18.65	385.66	1.38
CD at 5%	-	-	-	-	-
G.M.	17.17	172.27	357.13	9370.58	24.79

Table 2 : pH, Brix (%), Sucrose (%),Reducing sugar(%), Non reducing sugar (%) and total sugar(%) of juice at harvest as influenced by various treatments

Treatments	Juice pH	Brix (%)	Sucrose (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
A) Genotype						
G_1 - AKSSV-22	5.26	18.57	12.12	3.26	12.14	16.46
G_2 - SSV-84	5.04	17.08	12.94	2.68	13.81	15.20
G_3 - RSSV-9	5.06	15.83	13.06	3.39	14.32	16.52
SE(m)±	0.059	0.619	0.19	0.16	0.33	0.374
CD at 5%	0.175	1.81	0.57	0.47	0.976	1.09
B) Fertilizer levels kg N, P_2O_5 and K_2O ha^{-1}						
F_1- 00:00:00 (Control)	5.00	19.55	13.32	3.47	11.84	15.20
F_2 - 40:20:20	5.09	18.44	13.07	3.19	13.76	15.67
F_3 - 80:40:40	5.09	15.77	12.35	3.13	13.86	16.51
F_4 - 120:60:60	5.30	15.11	12.10	2.65	14.23	16.86
SE(m)±	0.06	0.715	0.22	0.18	0.384	0.431
CD at 5%	0.202	2.09	0.66	0.54	1.12	1.26
C) Interaction (genotype x fertilizer levels)						
SE(m)±	0.11	1.23	0.39	0.32	0.665	0.748
CD at 5%	-	-	-	0.94	1.95	-
G.M.	5.12	17.22	12.71	3.11	13.42	16.06

genotypes recording 20.62 per cent and 46.95 per cent more yield over genotypes SSV-84 and RSSV-9 respectively. (Table 1) While genotype RSSV-9 recorded significantly more fodder yield over (173.07 q ha^{-1}) genotype AKSSV-22 (171.66 q ha^{-1}), however it was at par with genotype SSV-84 (172.09 q ha^{-1}). Fertilizer level significantly influenced the grain and fodder yield of sweet sorghum. Treatment F_4

(120:60:60 Kg NPK ha $^{-1}$) recorded significantly higher grain yield (22.31 q ha^{-1}) and fodder yield (181.95 q ha^{-1}) over rest of the treatments. However, control treatment recorded lowest grain yield (10.09 q ha^{-1}) and fodder yield (162.00 q ha^{-1}). Increase in grain yield with fertilizer levels was also reported by Azzazy *et.al.,* (2001).

Genotype RSSV-9 recorded significantly higher green cane yield (421.19 q ha^{-1}) and juice yield (10,344 l ha^{-1}) over rest of the genotypes. Similarly, significant more juice extractability (26.22 %) was registered in sorghum genotype RSSV-9 over rest of genotypes. Fertilizer levels significantly influenced the green cane yield, juice yield and juice extractability of sweet sorghum. Treatment F_4 (120:60:60 Kg NPK ha^{-1}) recorded significantly higher green cane yield (384.84 q ha^{-1}), juice yield (10149.67 l ha^{-1}) and juice extractability (26.22%) over the treatment F_2 and F_1. Treatment of 120:60:60 Kg NPK ha^{-1} and 80:40:40 Kg NPK ha-1 were at par in response of green cane yield and juice extract ability. The above results are in agreement with Sinare *et.al.,* (2005).

Regarding quality aspect (Table 2) genotype AKSSV-22 registered significantly more values of juice pH and brix per cent over other genotypes while more sucrose per cent was noticed in genotype RSSV-9. Genotype RSSV-9 recorded higher values of reducing sugar, non reducing sugar and total sugar percent as compared to other genotypes. The brix per cent and sucrose per cent of juice was significantly influenced due to fertilizer levels. Treatment F_1 (00:00:00 Kg NPK ha $^{-1}$) recorded significantly higher brix (19.55%) and sucrose per cent (13.32 %) over F_3 and F_4 treatment. However, it was at par with F_2 (40:20:20 Kg NPK ha^{-1}). Decrease in brix per cent and sucrose per cent with increased N levels were also reported by Azzazy *et. al.,* (2001) and Silli *et. al.,* (2001).

Genotype RSSV-9 recorded significantly higher values of reducing sugar (3.39%), non reducing sugar (14.32%) and total sugar (16.52%) over genotype SSV-84 except in non reducing sugar per cent. The non reducing sugar and total sugar per cent increased with increase in fertilizer level. These quality parameter results are in conformity with the findings of Krishnavemi *et. al*., (1990) and Meli (1991).

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Effect of Nutrient Sources on Productivity and Sustainability of Seed Cotton Yield under Rainfed Condition

P.D.Bhalerao[1] and Godavari S. Gaikwad[2]

ABSTRACT

A field experiment was conducted at Akola (MS) during the season of 2005-06 to 2008-09,to assess the effect of insecticides and biopesticides and various manorial treatments on hirsutum cotton (*Gossypium hirsutum*). From pooled data of four years it was observed that seed cotton yield and yield attributes did not differ significantly with adoption of plant protection either through insecticides or biopesticides. As regards to manures, application of 50-25-0 N-P-K Kg ha^{-1} recorded significantly higher seed cotton yield (1479 $kgha^{-1}$) than other organic manurial treatments but it was at par with application of FYM 10 t ha^{-1} (1384 $kgha^{-1}$) and FYM 5 t ha^{-1}+ cotton stalk residues 2.5 t ha^{-1}(1291 $kgha^{-1}$). Among the organic sources, application of FYM 10 t ha^{-1} recorded higher seed cotton yield, followed by application of FYM 5 t ha^{-1} + CR 2.5 t ha^{-1} than (1291kg ha^{-1}) and FYM t ha^{-1} +VC 1.25 t ha^{-1} (1244 $kgha^{-1}$). Alone CR 2.5 t ha^{-1} recorded lowest yield (1047 $kgha^{-1}$) among organic manure treatments. Higher NMR(Rs 7259ha^{-1}) and BC ratio (1.35) were found with adoption of plant protection through insecticides than biopesticides. Similarly application of nutrients through inorganic gave higher NMR (Rs17445 ha^{-1}) and B:C ratio (2.05), followed by application of FYM in combination with cotton stalk residues(1.61).

Cotton is grown on an area of 93.70 lakh ha in India and producing 290 lakh bales with average productivity of 526 kg lint ha^{-1} (Anonymous, 2008-09). The productivity of India is less by 33 per cent than world productivity (785 kg lint ha^{-1}). Yield of cotton is stagnating even by adoption of Bt cotton hybrids. By continuous application of higher doses of chemical fertilizers alone, physico-chemical properties of soil are reduced. Application of chemical fertilizer only has led to environmental pollution and deterioration of soil health. Organic farming of cotton is growing in Maharashtra due to fetching higher prices to seed cotton produced by farmers. Organic cotton is grown without the use of synthetic fertilizers and pesticides from plant which are not genetically modified. Organic cotton was produced in 24 countries. Organic cotton production reached to 0.6 million bales. There are a number of companies driving the expanded use of domestic and International organic cotton. Residual effect of chemical in conventional cotton may irritate consumer's skin. Organic cotton fibers are longer and softer making cotton more comfortable to wear.

NGO's and other groups of farmers are promoting organic farming. In India few textile mills and exporters are making contract with farmers for organic cotton. For better productivity of cotton, package of practices, particularly use of nutrients through organics sources are not available with farmers. Considering the above facts, the present study was undertaken to find out suitable sources and quantity of organic manures, substitute to chemical fertilizers.

MATERIAL AND METHODS

The field experiment was conducted at cotton research unit of Dr. P.D.K.V., Akola during 2005-06 to 2008-09.The experimental soil contains 3.4 (g kg^{-1}) organic carbon, 142kg ha^{-1} available N, 22 kg ha^{-1} available P and 323 kg ha^{-1} available K. The experiment consisted 18 treatment combinations viz., two plant protection measures (Insecticides and biopesticides) as main plot treatments and nine treatments of various combinations of FYM, Vermicompost and cotton stalk residues including recommended dose of NPK and control as sub plot treatments. The experiment was laid out in split plot design on same site with same randomization for four years and replicated thrice. Organic manures as per treatment were applied before sowing of cotton. Cotton stalks were ground in machine in to small pieces and treated with decomposing 4-7 days culture

1. Cotton Agronomist and 2. Research Associate, Cotton Research Unit, Dr. PDKV, Akola

Trichoderma viridi before application in the field. The hirsutum cotton (PKV Rajat) was sown at 60 x 30 cm spacing on 9 July 2005, 2 July 2006, 1 July 2007 and 28 June 2008, respectively. Recommended package of practices were adopted through out the years of study. For plant protection measures recommended insecticides and biopesticides (Neemark, Bt compound, HNPV and Spinosad) were used for control of Pest as an when required. Rainfall of 697.0 mm 2005, 985.1 mm 2006,771 mm 2007 and 528.2 mm in 2008 was received as against normal rainfall of 768.5 mm. Low yields were recorded during 2006-07 as compared to other years of study due to dry spell in the month of October 2006-07, which was coincided with boll development stage of cotton. Since the five plants were selected randomly for recording observation. Trial was conducted on same site with same randomization the pooled analysis carried out treating homogeneity test over the seasons and pooled averages are given.

RESULTS AND DISCUSSION

Yield attributes and growth parameters

Adoption of plant protection through insecticides and biopesticides did not influence various yield attributes (pooled) and growth parameters significantly. Pooled data of four years indicated that significantly highest seed cotton yield plant^{-1} was recorded with application of chemical fertilizer being at par with application of FYM @ 10 t ha^{-1} and application of FYM 5 t ha^{-1} + CR @ 2.5 t ha^{-1} but significantly higher than all other treatments. Remaining all treatments were at par with each other except application CR @ 5 t ha^{-1} and control. As regards to picked bolls plant^{-1} application of FYM @ 10 t ha^{-1}, 50 - 25 -0 N-P- K kg ha^{-1} and FYM + CR (5 t ha^{-1}+ @ 2.5 t ha^{-1}) treatments were statistically at par but former two treatments were significantly superior than rest of the treatments. Boll weight was maximum with application of

Table 1: Yield attributes and growth parameters as influenced by various treatments (pooled mean)

Treatments	Picked bolls plant^{-1}	Yield Boll plant^{-1}(g)	weight. (g)	Plant Height (cm)	Sympodia plant^{-1}	Mono-podia plant^{-1}	Dry matter plant^{-1}(g)
Main plot treatments (Plant Protection)							
Plant protection with insecticides	8.9	23.7	2.6	73.6	13.6	0.62	57.4
Plant protection with. biopesticides	9.6	22.9	2.4	74.3	13.9	0.62	56.9
SE (m) +	0.25	0.55	0.06	0.28	0.20	0.05	0.69
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Sub plot treatments (Organic manures)							
FYM @10t ha^{-1}	11.0	27.3	2.6	78.6	14.6	0.59	55.7
Vermicompost @ 2.5 t ha^{-1}	8.5	23.2	2.6	70.0	13.6	0.56	57.4
Cotton stalk residues @ 5 t ha^{-1}	8.5	19.6	2.4	72.1	13.1	0.58	54.8
FYM + VC (5t+ 1.25 t ha^{-1})	9.5	23.8	2.5	77.7	13.8	0.68	57.7
FYM + CR.(5 t + 2.5 t ha^{-1})	9.6	25.0	2.7	73.6	14.3	0.67	59.0
VC + CR (1.25 + 2.5 t ha^{-1})	8.6	21.7	2.5	73.1	13.3	0.62	55.8
FYM + VC + CR (3.36 + 0.8 + 1.6 t ha^{-1})	9.5	23.4	2.5	75.3	13.8	0.62	56.1
RDF (50-25-0 kg N-P-K ha^{-1})	10.1	28.7	2.8	79.4	14.6	0.67	64.7
Control	8.4	17.3	2.3	65.8	13.1	0.58	53.1
SE (m) +	0.46	1.32	0.09	2.62	0.27	0.06	1.49
CD at 5%	1.34	3.85	0.26	7.56	0.79	NS	4.12
Interaction	NS	NS	NS	NS	NS	NS	NS

FYM-Farm yard manure, VC- Vermicompost, CR-Cotton stalk residues.
NPK % contain in FYM: 0.82,0.48,1.03, VC: 1.50 2.20, 1.50 and CR: 0.45,0.10,0.65

recommended dose of fertilizer (50 - 25 - 0 N-P-K kg ha^{-1}) being at par with other treatments except cotton stalk residues @ 5 t ha^{-1} and control. As regards to plant height, differences between various treatments were found at par except control treatment. Number of sympodia $plant^{-1}$ were maximum with 50 - 25 - 0 N-P-K $kgha^{-1}$ followed by FYM @10t ha^{-1}. Monopodial branches did not differ significantly with application of nutrient through organic and inorganic sources. As regards to dry matter accumulation, significantly highest dry mater $plant^{-1}$ was recorded with application of 50–25-0N-P-K $kgha^{-1}$ than all other treatments. Differences between remaining treatments were not significant except application of CR @ 5 t ha^{-1} and control treatment.

Seed Cotton Yield

Plant Protection

Seed cotton yield did not influence significantly due to plant protection measures with chemical and biopesticides. Similar trend were also observed in pooled analysis of four years data. This might be due to low incidence of pest and diseases during the course of investigation.

Organic Manures and chemical fertilizers

Solaiappan (2002) reported that application of inorganic fertilizer every year and FYM once in two years recorded higher cotton yield equivalent. Similarly Lomte et al. (2004) reported that application of RDF to cotton gave higher yield followed by application of FYM @ 5 t ha^{-1}.

From pooled analysis of four years data, it was observed that application of 50-25-0 N-P-K kg ha^{-1}, recorded significantly seed cotton yield over treatments over rest of the treatments of FYM @10t ha^{-1} and FYM 5t ha^{-1}+ CR 2.5 t ha^{-1} . However, lateral treatments were at par with RDF treatment. FYM 10t ha^{-1} and FYM 5t ha^{-1}+ cotton stalk residue 2.5 t ha^{-1} recorded statistically equal seed cotton yield.

Application of inorganic manures recorded highest seed cotton yield, followed by FYM at Khandwa, Indore, Nanded and Rahuri centers in

Table 2: Seed cotton yield, NMR and B:C ratio as influenced by various treatments

Treatments	Seed cotton yield (kg ha^{-1})				Pooled mean (kg ha^{-1})	COC (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
	2005-06	2006-07	2007-08	2008-09				
Main plot treatments (Plant Protection)								
Plant protection with insecticides	1538	910	1164	1247	1215	20,688	7,259	0.35
Plant protection with. biopesticides	1410	896	1143	1334	1194	20,954	6,518	0.31
SE (m) $\pm$	4.5	25.9	7.8	30.4	31.2	-	-	-
CD at 5%	27.4	NS	NS	NS	NS	-	-	-
Sub plot treatments (Organic manures)								
FYM @10t ha^{-1}	1713	1017	1265	1540	1384	21,033	10,793	0.51
Vermicompost @ 2.5 t ha^{-1}	1235	873	1237	1337	1171	23,294	3,645	0.16
Cotton stalk residues @ 5 t ha^{-1}	1167	828	989	1204	1047	16,150	7,940	0.49
FYM + VC (5t+ 1.25 t ha^{-1})	1686	859	1123	1306	1244	21,361	7,241	0.33
FYM + CR.(5 t + 2.5 t ha^{-1})	1713	888	1247	1317	1291	18,431	11,271	0.61
VC + CR (1.25 + 2.5 t ha^{-1})	1278	852	1082	1243	1114	19,565	6,053	0.31
FYM + VC + CR (3.36 + 0.8 + 1.6 t ha^{-1})	1348	872	1156	1410	1196	20,298	7,218	0.35
RDF (50-25-0 kg N-P-K ha^{-1})	2130	1104	1411	1269	1479	16,565	17,445	1.05
Control	995	807	876	987	917	13,760	7,323	0.53
SE (m) $\pm$	64.1	62.5	42.6	44.1	75.7	-	-	-
CD (P=0.05)	177.7	181.3	117.9	122.0	221.0	-	-	-
Interaction	NS	NS	SIG	NS	NS	-	-	-

FYM-Farm yard manure, VC- Vermicompost, CR-Cotton stalk residues

Table 3 : Uptake of NPK, Biological yield and harvest index as influenced by various treatments

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Total uptake of NPK (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Main plot treatment (Plant Protection)						
Plant protection with insecticides	30.79	11.43	25.67	67.89	4337	28.01
Plant protection with. biopesticides	30.97	12.47	25.39	68.82	4278	27.91
Sub plot treatments (Organic manure)						
FYM @10t ha^{-1}	30.37	12.61	24.46	67.44	4409	31.39
Vermicompost @ 2.5 t ha^{-1}	31.58	8.20	23.78	63.66	4288	27.31
Cotton stalk residues @ 5 t ha^{-1}	29.70	11.79	23.98	65.47	4017	26.06
FYM + VC (5t+ 1.25 t ha^{-1})	31.66	12.66	27.41	71.73	4400	28.27
FYM + CR.(5 t + 2.5 t ha^{-1})	32.13	12.78	27.50	72.41	4495	28.72
VC + CR (1.25 + 2.5 t ha^{-1})	30.33	12.44	25.11	67.87	4133	26.95
FYM + VC + CR (3.36 + 0.8 + 1.6 t ha^{-1})	30.07	11.79	26.72	68.59	4237	28.23
RDF (50-25-0 kg N-P-K ha^{-1})	32.89	13.36	25.45	71.70	5005	29.55
Control	29.20	11.89	25.36	66.45	3790	24.20

AICRP trials (Anonymous 2007-08). Similarly Solaiappan (2002) reported that application of inorganic fertilizer every year and FYM once in two years recorded higher cotton yield equivalent. Lomate *et. al.*, (2004) also reported that application of RDF to cotton gave higher yield, followed by application of FYM @ 5t ha^{-1}. Among the organic sources application of FYM @ 10 t ha^{-1} recorded significantly higher seed cotton yield than application of Vermicompost 1.25 t ha^{-1} + CR 2.5 t ha^{-1}. CR 5t ha^{-1} and control but differences between remaining treatments were not significant.

Economics

On an average of four years, higher NMR and B:C ratios were observed with recommended plant protection measures of insecticides, followed by plant protection with biopesticides . This might be due to more yield in plant protection with insecticides than biopesticides. From average of four years data, it was observed that highest NMR and B:C ratios were found with application of nutrients through chemical fertilizers (50-25-0 N-P-K kgha^{-1}), followed by application of FYM + CR (5 t + 2.5 t ha^{-1}) and FYM 10t ha^{-1}. Solaiappan (2002) also observed highest net income with application of organic and inorganic manures in combination to cotton crop. Higher values of NMR and B:C ratios with application of nutrients through inorganic might be due to low cost of cultivation as compared to organic manures treatments.

Nutrient uptake

There was not much variation in the uptake of NPK with adoption of plant protection measures either through insecticides or biopesticides. As regards to organic manures, maximum uptake of N – P kg ha^{-1} was observed with 50-25-0 N-P-K kgha^{-1}, followed by application of FYM 5t + 2.5t ha^{-1} cotton stalk residue. However highest uptake of K was found with application of FYM 5t ha^{-1} + CR 2.5 t ha^{-1}, followed by application of FYM + Vermicompost (5t +1.25 t ha^{-1}). Total uptake of NPK was in the range of 63.66 to 72.41 kg ha^{-1}.

Biological yield and harvest index

Plant protection with insecticides recorded slightly higher biological yield and harvest index than plant protection with biopesticides. As regards to manures, application of nutrients through inorganic 50-25-0 N-P-K kg ha^{-1} recorded highest biological yield than all the treatments in which nutrients

Table 4. Interaction of organic manures and plant protection on seed cotton yield (kg ha^{-1}, 2007-08)

Organic manures/ Plant protection	Plant protection with insecticides	Plant protection with. biopesticides	Mean
FYM @10t ha^{-1}	1334	1196	1265
Vermicompost @ 2.5 t ha^{-1}	1304	1170	1237
Cotton stalk residues @ 5 t ha^{-1}	966	1013	990
FYM + VC (5t+ 1.25 t ha^{-1})	1086	1160	1123
FYM + CR.(5 t + 2.5 t ha^{-1})	1302	1192	1247
VC + CR (1.25 + 2.5 t ha^{-1})	1065	1098	1082
FYM + VC + CR (3.36 + 0.8 + 1.6 t ha^{-1})	1147	1165	1156
RDF (50-25-0 kg N-P-K ha^{-1})	1509	1313	1411
Control	766	985	876
Mean	1164	1144	
SE (m) ±	60.18		
CD at 5%	166.82		

supplied through organic sources. This might be due to more height and highest dry matter accumulation in this treatment. Among the organic sources highest biological yield was found with application of FYM 5t ha^{-1} + CR 2.5 t ha^{-1}, followed by application of FYM only (10t ha^{-1}).This indicates the synergistic effect among FYM and cotton stalk residues. Harvest index was maximum with application of FYM @ 10t ha^{-1} followed by application of 50-25-0 N-P-K $kgha^{-1}$.This was due to higher seed cotton yield in these treatments.

It can be concluded from the study that for higher seed cotton yield, application of nutrients through inorganic is better than organic sources. However, for organic cotton production, application of FYM @ 10 t ha^{-1} or FYM 5t ha^{-1} + cotton stalk residues 2.5 t ha^{-1} were substitutes to chemical fertilizer under rainfed conditions.

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Efficacy of Inert Dusts Against Major Storage Insect Infesting Sorghum Seed

R. N. Jane[1], G. S. Jeughale[2], S. V. Sarode[3] and U. P. Barkhade[4]

ABSTRACT

An experiment was conducted to study the potential use of inert dust against store grain pest of sorghum at Seed Technology Research Unit, Dr PDKV,Akola , M.S, India; for three years. The different inert dusts *viz*; Cow dung cake ash, Rice husk ash, Diatomecious earth were used 2.5 and 5.0g kg^{-1} seed and compared with Deltamethrin 2.5 wp @40 mg kg^{-1} seed along with untreated control. After drying in shed, the treated seed was stored in gunny bag lets of 2 kg capacity. The observations on germination, insect infestation and moisture content were recorded at the interval of three months of storage period. The treatments had significant differences regarding insect infestation and germination and non-significant differences in case of moisture content percentage. Amongst, Diatomecious earth and Rice husk ash @ 5 g kg^{-1} seed was found most effective in insect infestation below the Minimum Seed Certification Standard (MSCS) *i.e.* 0.50 per cent after twelve months storage period. These treatments were also found significantly superior in respect of having high germination.

Availability of quality seed is of fundamental importance to farmers. Seed has a catalytic impact in expansion of seed programme in the country. Quality seed is the basic input and all other inputs are contingent upon it for being optimally effective. Therefore, protection of seed from insect pest during storage is having a vital role to provide the quality seed at the time of sowing. Stored sorghum seed is prone for severe infestation by *Rhizopertha dominica* of the family Bostrychide. The genus Rhizopertha commonly known as lesser grain borer invariable attack seeds of sorghum during storage causing heavy losses and if the damage is more than 0.50 per cent, disqualify the seed to satisfy the Minimum Seed Certification Standard. For the management of these losses during storage various chemical insecticides are used. But many effective insecticides have been banned for health and environmental reason. Inert dust particularly those based upon activated silica's, are findings increasing use as storage protectants in the grain industry.

More recently materials including diatomecious earth and silica aero gels, have been increasingly finding use in commercial storage in the developed world, replacing conventional chemicals. Synthetic dusts are effective in controlling primary pests of cereals and pulses, including prostephnus truncates, the larger grain borer, a new and important pest of African farms. Thus as well as being increasingly used in commercial farms, these materials may well replace conventional chemicals as protectants of stored grain in developing countries (Golob P, 1997). Hence an experiment was conducted to avoid environmental hazards due to chemical and to evaluate the various inert dusts to control storage insect for maintaining the Minimum Seed Certification Standard of sorghum seed.

MATERIAL AND METHODS

An experiment was conducted at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) India during the year 2007-08, 2008-09 and 2009-010. Different inert dusts viz. Cow dung cake ash @ 2.5(T_1) and 5.0 g (T_2), Rice husk ash @ 2.5 (T_3) and 5.0 g (T_4), Diatomecious earth @ 2.5 (T_5) and 5.0 g (T_6) were compared with Deltamethrin 2.5wp @ 40mg (T_7) and untreated control (T_8). One kg of freshly harvested seed of Sorghum var. CSV-15 having high percentage of germination (>75%) and low moisture content (<10%) was taken for each treatment. Required quantities of inert dusts to treat one kg seed and deltamethrin 2.5 w.p. was diluted in 10 ml water for proper coating. Each treatment was replicated thrice. After treatment seed was dried in shade, packed in gunny bag lets (2 kg capacity) and kept in storage under ambient condition. Observation on germination, insect

1. Assistant Prof., RRC, Amravati, 2. Senior Res. Asstt., STRU, 3. Director of Research and 4. Head, Department of Entomology, Dr. PDKV, Akola.

infestation and moisture content percentage were recorded at an interval of every three months during the storage period as per standard procedure in the rules seed testing Anonymous,(1985). The statistical analysis was done by using Completely Randomised Design (CRD) as per standard procedure, Panse and Sukhatme, (1976).

RESULTS AND DISCUSSION

1. Effect of different treatments on insect infestation in the seed:

The pooled data of three years (2007-08, 2008-09 and 2009-010) is presented in Table 1, The results indicates that the level of insect infestation is significantly less in all inert dust treatments over control.

However, the treatment, Diatomecious earth @ 5g kg^{-1} seed recorded lowest insect infestation (0.15%) which was found at par with Rice husk ash @5g kg^{-1} seed and Deltamethrin 2.5 wp @ 40 mg kg^{-1} seed (0.20%). The maximum insect infestation was recorded in untreated control. The pooled means of three years study also indicates the same trends, i.e. untreated seed was highly infested with insect (13.41%) over other treatments.

2. Effect of different treatments on germination percentage

The pooled data of three years presented in Table 2. The data indicates that different dusts recorded significantly higher germination percentage than untreated control.

Amongst the various treatments Diatomecious earth @ 5g kg^{-1} seed (86.25, 87.41 and 87.12%) and Rice husk ash @ 5g kg^{-1} seed (85.87, 86.87 and 86.62%) recorded maximum germination percentage during three years storage period. In all inert dusts treatments, the germination percentage was found above MSCS.

After 12 months storage period lowest germination percentage recorded (72.37%) in untreated control i.e. below MSCS.

Table 1. Effect of different treatments on insect infestation in the seed:

S.N.	Treatments	2007-08	2008-09	2009-010	Pooled Mean
1	Cow dung cake ash @ 2.5 g kg^{-1}	0.69	0.57	0.59	0.61
		(0.83)	(0.75)	(0.77)	(0.78)
2	Cow dung cake ash @ 5 g kg^{-1}	0.63	0.46	0.51	0.53
		(0.79)	(0.67)	(0.71)	(0.73)
3	Rice husk ash @ 2.5g kg^{-1}	0.29	0.30	0.26	0.28
		(0.53)	(0.54)	(0.51)	(0.53)
4	Rice husk ash @ 5g kg^{-1}	0.24	0.19	0.19	**0.20**
		(0.49)	(0.44)	(0.44)	**(0.45)**
5	Diatomaceous earth@ 2.5g kg^{-1}	0.26	0.25	0.25	0.25
		(0.52)	(0.50)	(0.50)	(0.50)
6	Diatomaceous earth@ 5g kg^{-1}	0.16	0.14	0.16	**0.15**
		(0.40)	(0.37)	(0.40)	**(0.39)**
7	Deltamethrin 2.5wp @ 40 mg kg^{-1}	0.23	0.18	0.21	0.20
		(0.47)	(0.42)	(0.45)	(0.45)
8	Untreated control	15.83	10.47	13.95	13.41
		(3.97)	(3.23)	(3.73)	(3.66)
	SE (m) $\pm$	0.40	0.27	0.37	0.35
	CD 5%	1.20	0.82	1.11	1.04
	'F' test	Sig	Sig	Sig	Sig

Table 2. Effect of different treatments on germination percentage:

S.N.	Treatments	2007-08	2008-09	2009-10	Pooled Mean
1	Cow dung cake ash @ 2.5 g kg^{-1}	80.37	82.25	81.75	81.45
		(63.55)	(65.05)	(64.52)	(64.45)
2	Cow dung cake ash @ 5 g kg^{-1}	82.00	83.15	82.75	82.63
		(64.92)	(65.73)	(65.42)	(65.35)
3	Rice husk ash @ 2.5g kg^{-1}	84.37	83.75	85.75	84.62
		(66.66)	(66.19)	(67.78)	(66.89)
4	Rice husk ash @ 5g kg^{-1}	**85.87**	**86.87**	**86.62**	**86.45**
		(67.78)	**(68.70)**	**(66.89)**	**(68.36)**
5	Diatomaceous earth@ 2.5g kg^{-1}	84.37	84.00	85.87	84.74
		(66.58)	(66.42)	(67.78)	(66.97)
6	Diatomaceous earth@ 5g kg^{-1}	**86.25**	**87.41**	**87.12**	**86.92**
		(68.11)	**(69.21)**	**(68.95)**	**(68.78)**
7	Deltamethrin 2.5wp @ 40mg kg^{-1}	85.12	85.91	85.75	85.59
		(67.29)	(67.94)	(67.78)	(67.62)
8	Untreated control	70.62	74.14	72.37	72.37
		(57.17)	(59.41)	(58.24)	(58.34)
	SE (m)$\pm$	3.33	2.75	3.10	3.04
	CD at 5%	9.89	8.19	9.22	9.08

Table 3. Effect of different treatment on seed moisture content:

S.N	Treatments	2007-2008	2008-2009	2009-2010	Pooled mean
1	Cow dung cake ash @ 2.5 g kg^{-1}	9.3	9.5	9.4	9.4
		(3.04)	(3.08)	(3.05)	(3.05)
2	Cow dung cake ash @ 5 g kg^{-1}	9.1	9.4	9.2	9.2
		(3.02)	(3.05)	(3.02)	(3.02)
3	Rice husk ash @ 2.5g kg^{-1}	9.2	9.4	9.3	9.3
		(3.02)	(3.05)	(3.04)	(3.04)
4	Rice husk ash @ 5g kg^{-1}	9.1	9.2	9.2	9.2
		(3.01)	(3.02)	(3.02)	(3.02)
5	Diatomaceous earth@ 2.5g kg^{-1}	9.2	9.2	9.1	9.2
		(3.02)	(3.02)	(3.02)	(3.02)
6	Diatomaceous earth@ 5g kg^{-1}	8.9	9.1	9.2	9.0
		(2.98)	(3.01)	(3.02)	(3.0)
7	Deltamethrin 2.5wp @ 40 mg kg^{-1}	9.2	9.2	9.2	9.2
		(3.02)	(3.02)	(3.02)	(3.02)
8	Untreated control	9.9	9.8	10.1	9.9
		(3.14)	(3.12)	(3.17)	(3.15)
	SE(m) $\pm$	0.22	0.035	0.018	0.088
	CD at 5%	_	-	-	-
	'F' test	NS	NS	NS	NS

3. Effect of different treatment on seed moisture content:

The moisture content in the seed for all the three years was found non- significant and remained within the safe limit, throughout the storage period.

The above results on insect infestation and germination percentage corroborate with the findings of Pandey and Varma;1977, Golob; 1997; Lord; 2001, Arthur; 2004, Fabane *et. al*,. Remya 2007 and Anonymous, 2009, they observed that inert dusts are effective in controlling primary pest of cereals and pulses.

Thus the present investigation revealed that the seed treatment of

Diatomecious earth and Rice husk ash @ 5 g kg^{-1} seed is found effective for maintaining the insect infestation below 0.50 per cent and higher germination than MSCS *i.e.* 75 per cent of sorghum seed for the storage period of 12 months.

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Efficacy of Some Newer Insecticides Against Sorghum Stem borer

H. G. Kandalkar[1], P. N. Mane[2] and R. B. Ghorade[3]

ABSTRACT

Some new insecticides imidacloprid 17.8 SL, cartap Hydrochloride 50 SP, cartap hydrochloride 4 G @ 10 kg ha^{-1} ware compared with some conventional insecticides carbofuran 3 G, acephate 75 per cent SP and endosulfan 35 EC against sorghum stem borer *Chillo partellus* Swinhoe in the field of Sorghum Research Unit, Dr. PDKV, Akola during the *Kharif* season of three consecutive years 2005, 2006 and 2007, respectively. Carbofuran 3 G, exhibited minimum leaf injury (6.47 %), peduncle damage (28.35 %) and maximum grain yield i.e 41.64 q ha^{-1}, followed by endosulfan 35 EC, imidacloprid 17. 8 SL and cartap hydrochloride 50 SP. But maximum ICBR i.e 8.02 was noted in the treatment endosulfan 35 EC .

Insect pests are one of the major yield-reducing factors in sorghum on a global basis. Sorghum crop is attacked by nearly 150 insect species, causing an annual loss of over $ 1 billion in SAT (Anonymous, 1992). A wide range of lepidopterous stem borers are especially damaging to sorghum and constitute a major constraint in its production. This complex consists of 27 species spread in 10 genera of Pyralidae and Noctuidae families. Of these, *Chilo partellus* Swinhoe is the important one (Verma and Singh, 1987). In India, incidence of stem borers ranges from 10- 75 per cent. Overall losses due to stem borers may averages 5 - 10 per cent in different regions in India. The borer is found throughout the Indian subcontinent and is a more serious pest in northern and central regions (Chundurwar, 1985). Most work on chemical control of stemberers in India has been done. Chemical control of pest population should only be adopted as a last resort, but still it remains the main tool in pest management. Keeping this view and for evaluating the newer and potent insecticides, the present investigation was carried out.

MATERIAL AND METHODS

The field experiment was conducted at the farm of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola (MS), during *Kharif* season of 2005, 2006 and 2007 in a randomized block design with three replications. CSH-9 variety of sorghum was sown by keeping 45 x 15 cm spacing in 3.00 x 2.25 m plot size. The date of sowing was 4th July 2005, 30th June, 2006 and 2nd July 2007 in respective years. In all, seven treatments including six insecticides along with untreated control were evaluated. Spraying of insecticides were done on 30 and 40th DAE. Leaf injury was recorded on 60th DAE and peduncle damage was recorded at harvest by counting total plants and affected plants. Grain yield was also recorded in each treatment. The obtained data were statistically analyzed.

RESULTS AND DISCUSSION

Leaf injury:

The pooled data given in Table 1 revealed that carbofuran 3 G recorded the lowest 6.47 per cent leaf injury, closely followed by the treatment imidacloprid 17.8 SL (6.53), endosulfan 35 EC (8.41 %) and cartap hydrochloride 50 SP (9.20 %) which found superior over rest of the insecticidal treatments. However, acephate 75 per cent SP (9.92 %) and cartap hydrochloride 4 G (10.06 %) were found at par with endosulfan 35 EC.

Peduncle damage:

Minimum 28.35 per cent peduncle damage was observed in the treatment carbofuran 3 G and it was closely followed by the treatment, endosulfan 35 EC (29.56 %), imidacloprid 17.8 SL (29.85 %) and cartap hydrochloride 50 SP (33.13 %) and these treatments were at par with each other (Table 1).

Grain Yield :

Maximum grain yield 41.64 q ha^{-1} was recorded in the treatment carbofuran 3 G and it was followed by the treatment endosulfan 35 EC (41.48 q

1 & 2. Assistant Prof. and 3. Senior Res. Sci., Sorghum Research Unit, Dr. PDKV, Akola

Table 1: Effect of different insecticides against sorghum stem borer *chilo partellus*.

S.N.	Treatments	Leaf injury (%)				AV. Peduncle damage (%)				Grain yield q/ha				ICBR
		2005-06	2006-07	2007-08	Pooled mean	2005-06	2006-07	2007-08	Pooled mean	2005-06	2006-07	2007-08	Pooled mean	
1	Imidacloprid 17.8	2.92	5.03	11.65	6.53	26.18	28.18	35.20	29.85	40.49	41.67	42.19	41.45	3.83
	SL @ 0.01 %	(9.83)	(12.90)	(19.84)	(14.19)	(30.75)	(32.25)	(36.38)	(33.13)					
2	Cartap Hydrochloride	5.61	9.63	12.36	9.20	32.45	32.47	34.49	33.13	37.03	34.97	43.73	38.58	2.05
	50 SP @ 0.05 %	(13.59)	(18.06)	(20.57)	(17.39)	(34.71)	(33.51)	(35.90)	(34.71)					
3	Cartap Hydrochloride	8.11	11.67	10.42	10.06	35.85	31.21	33.56	33.54	34.07	36.02	44.75	38.28	1.28
	4 G @ 10 kg/ha.	(16.50)	(19.68)	(18.44)	(18.20)	(36.68)	(33.84)	(35.36)	(35.29)					
4	Carbofuran 3 G @	3.04	7.04	9.12	6.47	29.03	29.65	26.38	28.35	38.57	40.12	46.30	41.64	2.53
	10 kg/ha	(9.86)	(15.31)	(17.56)	(14.13)	(32.58)	(33.00)	(30.90)	(32.16)					
5	Acephate 75 % SP @	5.21	11.52	13.02	9.92	33.38	32.75	34.57	33.57	33.08	31.88	41.67	35.54	2.62
	0.05 %	(13.16)	(19.67)	(21.14)	(17.99)	(35.18)	(34.89)	(35.95)	(35.34)					
6	Endosulfan 35 EC @	5.62	8.33	11.29	8.41	29.36	30.80	28.53	29.56	37.53	41.14	45.77	41.48	8.02
	0.05 %	(13.64)	(16.47)	(19.55)	(16.55)	(32.78)	(33.60)	(32.20)	(32.86)					
7	Untreated control	11.84 (19.93)	11.89 (19.96)	23.03 (28.65)	15.59 (22.85)	43.61 (41.29)	46.03 (42.69)	50.84 (45.47)	46.83 (43.15)	29.62	28.80	38.05	32.16	-
	'F' test	Sig	NS	Sig	Sig	Sig	Sig	Sig	Sig	NS	Sig	NS	Sig	-
	SE (m) ±	1.25	1.91	1.00	1.11	2.08	1.94	1.35	1.35	4.26	2.86	1.86	1.13	-
	CD at 5 %	4.35	-	2.82	3.14	7.21	5.94	3.80	3.80	-	8.75	-	3.18	-

Figures in the parenthesis are arc sine value ha^{-1}), imidacloprid 17.8 SL (41.45 q ha^{-1}) and cartap hydrochlorid 50 SP (38.58 q ha^{-1}) and these treatments were at par with each other (Table 1).

ICBR:

Maximum i.e 8.02 ICBR was noted in the treatment Endosulfan 35 EC @ 0.05 per cent spray as compared to other insecticidal treatments, followed by imidacloprid 17.8 SL (3.83) and acephate 75 per cent SP (2.62) (Table 1).

Seed treatments of sorghum with imidacloprid, followed by foliar spray after 30 days with imidacloprid 17.8 SL @ 0.01 per cent were found highly effective for the management of sorghum shootfly and stem borer (Katole, *et. al.*, 2003).

Balikai (2000) reported that imidacloprid 70 WS was the best in controlling shootfly, followed by carabofuran 3 G @ 0.09 kg ha $^{-1}$.

Endosulfan 35 EC @ 0.05 per cent and cartap hydrochloride 50 SP @ 0.05 per cent sprays were highly effective for the management of stem borer Khambadkar (2004).

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Effect of Some Surface Protectants Against Pulse Beetle Infesting Stored Grains of Dolichos Bean

S.K. Kadlag[1], R.S. Patil[2], R.S. Mule[3] and Vaishali P. Sawant[4]

ABSTRACT

Results of the laboratory studies indicated that the treatments with undi oil, neem oil and karanj oil each @ 10 ml kg^{-1} of seed were found most promising giving complete protection to the grains of dolichos bean upto 40 days after treatment. Absolutely no loss in weight was noticed in treatments with neem oil, undi oil and karanj oil each at the dose of 10 ml kg^{-1} of seed. The leaf powder of rantulas was found comparatively less effective in preventing loss in weight. The mean number of eggs laid by *C. maculatus* on dolichos bean treated with surface protectants varied between 0.0 to 165.0 as against 186.0 in untreated control. The treatments with high dose of neem, karanj and undi oil were found most effective in preventing egg laying by bruchid, followed by sweet flag rhizome powder @ 10 g kg^{-1} of seed (9.0 eggs). No significant effect of surface protectants was noticed on germination of stored grains of dolichos bean upto 6 months of treatment.

Pulse beetle, *Callosobruchus maculatus* (Fab.) (Coleoptera; Bruchidae) is one of the most important and destructive pests of stored pulses, in general and dolichos bean *Lablab purpureus* (L.), in particular in Konkan region of Maharashtra. Maximum damage being incurred to black eyed cowpea (69.3%), followed by moth bean (55.7%) and green gram (50.3%) (Ramzan *et. al.,* 1990). To save the pulses from the attack of bruchids in storage, farmers have tried several conventional methods including use of pesticides. However, synthetic chemicals have posed many problems like toxicity to mammals, environmental pollution, etc. The ill effect of pesticides has forced the entomologists to look towards plant and plant products as an alternative to the highly persistent synthetic chemicals. Botanicals are non toxic to both human being and animals and environmentally harmless means of controlling or eliminating insect pests which inflict quantitative and qualitative losses in storage. They have also been reported to cause inhibition in oviposition and multiplication of bruchids (Pandey *et al.,* 1976; Singh *et al.,* 2001). An attempt was, therefore, made to evaluate the effect of some plant products and oils as surface protectants against pulse beetle infesting dolichos bean.

MATERIAL AND METHODS

(i) Details of plant material used: The four powders of different plant species and three different oils extracted from various parts of plants (Table 1) were used for testing their efficacy against pulse beetle, *C. maculatus*. The desired parts of test plants collected locally from the forest area of Dapoli tahsil, were dried under shade, ground in mixer separately and passed through 50 mesh sieve to obtain fine powder of each. Adequate quantity of *Sweet flag Rhizome* powder and three different oils *viz., Undi* oil, *Neem* oil and *Karanj* oil were purchased directly from the local market. The healthy and clean seed of local variety of dolichos bean (*Kadve-wal*) was also purchased from the local market and stored under airtight condition.

(ii) Effect of surface protectants preventing grain damage and weight loss due to *C. maculatus*: A statistically designed experiment was laid out during the year 2008-09 in the laboratory of Department of Agricultural Entomology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri (Maharashtra) in Completely Randomized Design (CRD) comprising fifteen treatments replicated twice. The required quantity of plant powders and plant oils were mixed thoroughly in previously weighed 100 g healthy seed of dolichos bean and placed in transparent glass bottles separately (8 cm in height and 7 cm in diameter) after drying under shade for two hours. The untreated control was also maintained. Three pairs of freshly emerged male and female adults of

1. M.Sc.(Agri.) student. 2 & 4. Assistant Prof., and 3. Senior Res. Asstt., JSW-TPP Mango Project, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli

C. maculatus were released in each glass bottle (including control) with plastic lid provided with minute holes for aeration. The date and time of release of beetles per treatment were marked on the glass bottle using marking pencil. Two such sets were maintained. In addition to this, one transparent glass bottle in each replication containing only 100 g seed of dolichos bean was also maintained simultaneously to record any loss or gain in weight due to environmental factors like humidity and temperature.

Adults emerged in each treatment were removed daily starting from initiation of emergence (29 days post treatment) till cessation of same. After completion of adult emergence, larval debris and excreta were removed from each treatment to record the final weight of grains. The total number of grains present in each of these glass bottles and number of infested grains were counted to workout per cent grain damage due to pulse beetle. The per cent grain damage and weight loss were calculated by using formula given below.

$$\text{Per cent weight loss} = \frac{\text{Initial weight (g)} - \text{final weight (g)} + \text{weight gain or loss due to environmental factor}}{\text{Initial weight (g)}} \times 100$$

$$\text{Per cent grain damage} = \frac{\text{Total number of grains damaged}}{\text{Total number of grains examined}} \times 100$$

iii) Effect of surface protectants on ovipositional preference of *C. maculatus*: The 15 g seed of dolichos bean treated separately with different oils and plant powders was taken out and placed randomly in the test tubes fixed to olfactometer. Each test tube was then labelled properly. The twenty pairs of freshly emerged (0 to 12 hr old) male and female adults of *C. maculatus* were released into the olfactometer through the hole provided at the centre of the lid. This opening hole was then plugged tightly with cotton wool. Two such sets were maintained simultaneously. The total number of eggs laid by the beetle in each treatment were counted after death of all the beetles. The total number of eggs deposited by each female/ treatment was considered as criteria for judging the ovipositional preference.

(iv) Effect of surface protectants on seed germination of dolichos bean: A sample of 100 seeds of dolichos bean / treatment was washed initially with 0.01 per cent mercuric chloride and then with distilled water and was placed separately in a glass petri dish of 20 cm diameter and labeled accordingly with marking pencil. The circular cut pieces of germination paper (20 cm diameter) were prepared, disinfected with 0.01 per cent mercuric chloride and subsequently washed with distilled water and placed at the bottom and inner surface of the lid of each petri dish. Water was sprinkled on them to keep them in moist form. The set was replicated twice. The germination count was taken at the end of fourth day on appearance of a healthy radical measuring about 1.5 cm in length.

Table 1. Details of plant material tested during present investigation

	Common Name	Botanical name	Order	Family	Plant part used	Doses (g or ml kg^{-1} seed) tried
(A) Powders						
i)	Rantulas	*Hyptis suaveolens* (L.) Point	Lamiales	Lamiaceae	Leaf	5, 10
ii)	Karanj	*Pongamia pinnata* Linn.	Fabales	Fabaceae	Seed	5, 10
iii)	Neem	*Azadirachta indica* A. Juss	Sapindales	Meliaceae	Seed kernel	5, 10
iv)	Sweet flag	*Acorus calamus* Linn.	Acorales	Araceae	Rhizome	5, 10
(B) Oils						
i)	Undi	*Calophyllum inophylum*L.	Malpigiales	Clusiaceae	Seed	5, 10
ii)	Neem	*Azadirachta indica* A. Juss	Sapindales	Meliaceae	Seed	5, 10
iii)	Karanj	*Pongamia pinnata* Linn.	Fabales	Fabaceae	Seed	5, 10

The germination tests were carried out three times namely, 3 days, 3 months and 6 months after treatment.

RESULTS AND DISCUSSION

(i) Effect of surface protectants preventing grain damage due to *C. maculatus*:

Data (Table 2) revealed that all the treatments with plant products and oils were found significantly effective over control in preventing grain damage. The treatments with undi oil, neem oil and karanj oil each @ 10 ml kg^{-1} of seed were found the most promising giving complete protection to the grains of dolichos bean upto 40 days after treatment. The grains treated with sweet flag rhizome powder @ 10 g kg^{-1} of seed was the next better treatment in order of merit with per cent grain damage of 1.23. The maximum per cent grain damage of 25.32 was noticed in untreated grains of dolichos bean. All plant oils and sweet flag rhizome powder at higher dose of 10 ml or g kg^{-1} of seed were found to provide better protection to dolichos bean for prolonged period of 40 days. These findings in respect of neem oil and sweet flag rhizome powder are in agreement with Pandey *et al.* (1976) who reported that gram seed treated with 1 to 2 parts of sweet flag rhizome powder and 2 parts of neem oil per 100 parts of seed (w/w) protected effectively from damage by the bruchid. Kumar *et. al.,* (1990) demonstrated that chickpea treated with neem oil @ 1.0 per cent level provided significant reduction in seed damage due to pulse beetle.

(ii) Effect of surface protectants preventing weight loss due to *C. maculatus*: Perusal of data (Table 2) revealed that the maximum per cent weight loss of 6.73 was recorded in untreated grains of dolichos bean. The treatments with *Neem* oil, *Undi* oil and *Karanj* oil each @ 10 ml kg^{-1} of seed resulted in zero per cent loss in weight of dolichos bean upto 40 days after treatment. The *Neem* oil @ 5 ml kg^{-1} of seed was the next best treatment in order of merit with per cent weight loss of 0.34, followed by sweet flag rhizome powder @ 10 g kg^{-1} of seed (0.35), *Karanj* oil @ 5 ml kg^{-1} of seed (0.37) and *Undi* oil @ 5 ml kg^{-1} of seed (0.37). The effectiveness of plant oils observed during present study corroborates with Singh (2003) who obtained complete protection of pigeon pea treated with *Neem* oil and *Karanj* oil @ 8 ml kg^{-1} of seed upto three months after storage. Singh *et. al.,* (2001) recorded 0.63 per cent loss in weight of pea seed treated with *neem* oil.

(iii) Effect of some surface protectants on ovipositional preference of *C. maculatus*: Data recorded on number of eggs laid by *C. maculatus* on dolichos bean treated with different treatments with plant products and oils (Table 2) indicated that mean number of eggs laid by pulse beetle varied between 0.0 to 165.0 as against 186.0 in untreated control. The treatments with high dose of oils *viz.,* neem oil, undi oil and karanj oil were found most effective in preventing egg laying by bruchid. The sweet flag rhizome powder @ 10 g kg^{-1} of seed was the next best treatment in order of merit (9.0 eggs) and significantly superior over rest of the treatments. The mean number of eggs laid on dolichos bean treated with neem oil, karanj oil and undi oil each at 5 ml kg^{-1} of seed were 24.00, 39.50 and 42.00, respectively. Overall observations revealed that the high dose of plant oils (10 ml kg^{-1}) resulted in no egg laying while the lower dose of the same inhibited the egg laying to the greater extent as compared with powders of most plant species. The plant oils showed greater repellent action and lesser preference for oviposition. Present results when viewed in the light of existing work find support from Naik (1980) and Khaire *et. al.,* (1993) who proved significant reduction in oviposition of pulse beetle on cowpea and pigeon pea seed treated with neem oil and karanj oil. Patkar (1990) recorded similar observation in mung bean treated with 2.0 per cent powder of sweet flag.

(iv) Effect of some surface protectants on germination of dolichos bean: Data on effect of surface protectants on germination of seed recorded at 3 days, 3 and 6 months of treatment were observed to be non significant. The per cent germination of dolichos bean within the treatments with plant products and oils recorded during above periods varied from 88.0 to 90.50, 87.00 to 88.50 and 87.00 to 88.50 as against 90.00, 88.50 and 89.00 in untreated control, respectively. Overall observations showed that the seed germination of dolichos bean was not affected due to various treatments with plant powders and oils. Present finding is in conformity with Pandey *et. al.,* (1976) and Khaire *et. al.,*(1992) who also recorded similar observations. Geetha

Table 2. Effect of some surface protectants in preventing grain damage, weight loss, ovipositional preference of *C. maculatus* and seed germination of dolichos bean

Treatments	Dose (g or ml kg^{-1} of seed)	Per cent grain damage	Per cent weight loss	Mean number of eggs laid	Per cent seed germination		
					3 DAT**	90 DAT	180 DAT
Rantulas leaf powder	5	18.30	4.38	165.00	90.50	88.50	88.50
		(25.33)*	(12.69)*		(72.05)*	(70.18)*	(70.18)*
Karanj seed powder	5	14.43	3.80	107.00	89.00	88.00	88.00
		(22.33)	(11.23)		(70.63)	(69.73)	(69.73)
Neem seed kernel powder	5	13.72	3.62	82.50	89.50	88.50	88.00
		(21.74)	(10.97)		(71.09)	(70.18)	(69.73)
Sweet flag rhizome powder	5	1.61	0.43	57.50	90.00	88.50	88.50
		(7.28)	(3.76)		(71.57)	(70.18)	(70.18)
Undi oil	5	1.33	0.37	42.00	88.50	88.00	87.50
		(6.61)	(3.51)		(70.18)	(69.73)	(69.30)
Neem oil	5	1.25	0.34	24.00	88.50	87.50	88.00
		(6.42)	(3.32)		(70.18)	(69.30)	(69.73)
Karanj oil	5	1.37	0.37	39.50	88.00	87.50	87.50
		(6.72)	(3.46)		(69.73)	(69.30)	(69.30)
Rantulas leaf powder	10	14.68	4.06	143.00	90.00	88.00	88.50
		(22.53)	(11.62)		(71.57)	(69.73)	(70.18)
Karanj seed powder	10	10.21	2.70	46.50	88.50	88.50	87.50
		(18.64)	(9.46)		(70.18)	(70.18)	(69.30)
Neem seed kernel powder	10	9.23	2.33	39.50	90.00	88.50	88.00
		(17.69)	(8.79)		(71.57)	(70.18)	(69.73)
Sweet flag rhizome powder	10	1.23	0.35	9.00	90.50	88.50	88.00
		(6.35)	(3.37)		(72.05)	(70.18)	(69.73)
Undi oil	10	0.00	0.00	0.00	88.00	87.00	87.50
		(0.00)	(0.00)		(69.73)	(68.87)	(69.30)
Neem oil	10	0.00	0.00	0.00	88.00	87.50	87.00
		(0.00)	(0.00)		(69.73)	(69.30)	(68.87)
Karanj oil	10	0.00	0.00		88.50	87.50	87.00
		(0.00)	(0.00)	0.00	(70.18)	(69.30)	(68.87)
Untreated control	–	25.32	6.73		90.00	88.50	89.00
		(30.21)	(15.04)	186.00	(71.57)	(70.18)	(71.09)
Mean	–	–	–	–	89.17	88.07	87.87
S.E. ±	–	0.17	0.14	2.40	–	–	–
C.D. at 5 %	–	0.51	0.41	7.23	–	–	–
					NS***	NS	NS

*** Figures in parenthesis are arcsin values ** Days after treatment *** Non Significant**

Lakshmi and Venugopal, (2007) noticed no any adverse effect on seed germination of green gram treated with rhizome powder of sweet flag.

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Role of Fungi and Bacteria in Decomposition of Different Substrate

Deepti Bhagat[1], Mina D. Koche[2], Y. N. Mohod[3] and R. W. Ingle[4]

ABSTRACT

Three different type of fungi and one bacterial isolate were studied to see their effect on seven different types of organic material. The rate of decomposition was measured by estimating CO_2 evolved during the process. Higher amount of CO_2 evaluation was recorded within first week of incubation but it was declined to the extent of fifty per cent during second week and later it was drastically reduced till seventh week of degradation. Maximum amount of CO_2 was released with the inoculation of *T. spiralis+ C. globosum+T. viride* in wheat straw, followed by sorghum straw, pigeonpea stalk, cotton stalk, sugarcane trash, parthenium and weed. The combination of *T. spiralis+ C. globosum+T. viride* gave highest per cent loss in weight of wheat straw (63.95%) and it was followed by parthenium (62.75%), sorghum stalk (61.85%), pigeonpea stalk (60.90%), cotton stalk (59.75%), weeds (58.45%) and sugarcane trash (57.50%).

With the increasing of high yielding crop varieties, disposal of crop residues is becoming a problem especially in the intensive wheat and rice growing areas. A large quantity of crop residues, such, as various straws, stubbles, groundnut husk, sugarcane trashes, etc., is piled us every seasons. A normal practice among farmers is to dispose off straws by burning due to which a potent source of organic matter is lost. As there is a shortage of fertilizers every where in the world, the use of organic materials has to be promoted. In order to reduce the period of decomposing of various materials, it is necessary to use an efficient strain of fungus which can play an important role in decomposition. The present paper deals with the decomposition rate of organic substrates by pure culture of fungi and bacteria.

MATERIAL AND METHODS

Seven substrates *viz.*, cotton stalk, sorghum stalk, pigeonpea stalk, sugarcane trash, wheat straw, parthenium and weeds were used to study the rate of decomposition. The substrates were sterilized at 1.05 kg / cm^2 for 30 minutes. Then decomposition acitivity was assertained by following method.

CO_2 evolution

Estimation of CO_2 evolution during the process was carried out according to the method described by Pramer and Schmidt (1964) with little modification as mentioned below.

Twenty gram finely chopped (2-3 cm in length) substrate was added in each flask (2000 ml capacity). Moisture level was maintained at 60 per cent water holding capacity. Two agar disc (9 mm) of previously grown cultures were inoculated in flask.

A vial containing 10 ml N/10 of sodium hydroxide (NaoH) solution was hung in each flask. These flasks were then corked tightly and sealed with parafin wax and incubated at room temperature (i.e. 27 ± 2°C) and further observations were recorded.

The rate of decomposition of substrates was estimated day^{-1} up to eight week. In order to calculate the amount of CO_2 evolved the vial containing alkali was removed, at the said interval and transferred to 250 ml beaker containing 50 ml distilled water, 5 ml of 1 N solution of $Bacl_2$ (Barium chloride) was added to precipitate carbonates as $BaCO_3$ and the remaining NaoH titrated against N/10 HCL using methyl orange as an indicator. The observations were recorded and the amount of CO_2 evolved was calculated (According to Pramer and Schmidt, 1964).

The amount of CO_2 evolved as

NaOH consumed (c) = Volume of NaOH taken (x) - Volume of HCl consumed (y)

Calculation

The reactions involved are as follows

$2NaOH + CO_2$ - $Na_2CO_3 + H_2O$

$Na_2CO_3 + BaCl_2$ - $BaCO_3 + 2NaCl$

1., 2. &3. Ph.D. Scholar and 4. Associate Prof. Department of Plant Pathology, Dr. PDKV , Akola

Table 1. Total CO_2 evoluation (mg/week) from organic materials with incorporation of fungi and bacteria.

Sr. No.	Treatments	CO_2 evolved mg/week (cotton stalk)				CO_2 evolved mg/week (sorghum stalk)				CO_2 evolved mg/week (pigeonpea stalk)				CO_2 evolved mg/week (sugarcane trash)			
		I	III	V	VII	I	III	V	VII	I	III	V	VII	I	III	V	VII
1	*Trichurus spiralis*	123.2	41.8	26.6	21.6	130.5	39.2	31.9	22.0	135.1	37.2	25.3	20.2	116.0	30.1	31.2	15.6
2	*Chaetomium globosum*	121.7	43.3	20.2	17.2	133.3	42.7	33.0	24.2	137.3	37.2	27.7	23.1	116.9	53.6	29.0	16.5
3	*Trichoderma viride*	129.6	51.5	33.0	18.5	140.4	46.2	37.6	21.8	141.2	40.9	30.1	21.1	119.5	35.2	28.5	15.9
4	*T. spiralis + C. globosum*	134.2	51.3	36.3	24.2	147.4	49.5	43.1	23.5	145.9	50.4	33.7	26.4	121.0	49.7	30.1	18.3
5	*T. spiralis + T. viride*	137.1	58.1	29.0	23.9	146.4	48.4	30.4	26.6	141.9	47.3	36.1	24.9	124.7	51.0	35.6	16.3
6	*T. spiralis + C. globosum + T. viride*	142.3	60.1	35.2	25.5	151.1	53.2	39.6	24.2	147.4	50.6	35.4	27.5	127.2	53.1	38.2	19.4
7	*Cellulomonas bibula*	128.0	36.2	22.0	12.5	137.3	41.4	27.3	18.5	139.4	39.4	21.1	16.3	116.6	42.5	28.6	17.8
8	Control	19.3	15.2	9.2	9.2	21.3	13.2	10.1	6.6	22.4	12.8	10.1	6.2	18.7	17.2	9.2	7.0

Sr. No.	Treatments	CO_2 evolved mg/week (wheat straw)				CO_2 evolved (mg/week) (parthenium)				CO_2 evolved mg/week (weed)			
		I	III	V	VII	I	III	V	VII	I	III	V	VII
1	*Trichurus spiralis*	141.5	41.8	38.5	24.2	92.2	27.1	16.3	14.3	87.12	20.2	20.0	13.4
2	*Chaetomium globosum*	140.9	45.5	36.1	25.3	90.2	34.1	17.4	15.2	85.58	22.0	23.1	13.2
3	*Trichoderma viride*	146.5	50.6	41.1	26.2	94.6	37.2	17.2	14.1	90.20	24.6	22.0	14.5
4	*Trichurus spiralis + C. globosum*	150.5	51.7	42.2	25.7	96.8	32.1	19.6	17.2	92.84	25.5	20.5	15.6
5	*Trichurus spiralis + T. viride*	149.2	54.3	45.1	28.6	99.7	31.0	22.9	18.7	95.48	30.4	16.5	13.6
6	*T. spiralis + C. globosum + T. viride*	154.0	57.2	48.4	26.4	112.2	30.8	25.1	17.4	97.24	34.3	29.3	18.0
7	*Cellulomonas bibula*	145.2	43.8	29.5	19.6	93.7	29.0	15.9	14.5	89.54	22.4	20.2	12.5
8	Control	20.4	12.5	13.2	7.7	16.7	7.70	12.1	7.26	15.18	12.5	9.5	6.6

Table 2 – Per cent loss in weight of different substrate by each fungal and bacterial cultures.

Sr. No.	Fungi and Bacteria	Per cent loss weight of substrate after decomposition (%)						
		Cotton stalk	**Sorghum stalk**	**Pigeonpea stalk**	**Sugarcane trash**	**Wheat straw**	**Parthenium**	**Weeds**
1	*Trichurus spiralis*	48.60 (44.19)	52.85 (46.63)	50.70 (45.38)	45.95 (42.67)	54.80 (47.74)	54.25 (47.43)	49.75 (44.85)
2	*Chaetomim globosum*	50.90 (45.50)	54.00 (47.27)	51.85 (46.04)	47.75 (43.70)	55.00 (47.90)	54.95 (47.84)	51.70 (45.97)
3	*Trichodera viride*	51.95 (46.95)	54.70 (47.70)	52.90 (46.64)	49.40 (44.65)	56.70 (48.83)	55.25 (48.00)	53.60 (47.04)
4	*T. spiralis+ C. globosum*	53.55 (47.55)	56.80 (46.88)	54.75 (47.71)	52.75 (46.57)	58.65 (49.67)	57.95 (49.55)	53.60 (47.62)
5	*T. spiralis +T. Viride*	56.65 (48.81)	59.70 (50.58)	57.15 (49.10)	55.00 (47.87)	61.90 (51.90)	61.40 (51.58)	56.50 (48.73)
6	*T. spiralis +C. globosum+ T. viride*	59.75 (50.60)	61.85 (51.85	60.90 (51.17)	57.50 (49.30)	63.95 (53.14)	62.75 (52.40)	58.45 (49.85)
7	*Cellulomonas bibula*	45.50 (42.40)	49.60 (44.75)	48.35 (44.02)	42.85 (40.87)	52.50 (46.42)	51.75 (45.98)	46.50 (42.97)
8	Control	07.00 (15.28)	07.60 (15.81	06.10 (14.19)	5.25 (13.12)	8.25 (16.54)	7.90 (16.33)	7.40 (15.73)
	'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE (m) +	0.81	1.47	1.06	0.98	1.45	1.22	0.78
	CD(P=0.01)	3.37	6.08	4.38	4.06	6.00	5.05	3.24

Calculation

1 ml of N/10 HCl = 1 ml of N/10 NaOH = 2.2 mg of CO_2

Loss in weight of substrates

After CO_2 evolution studies the flasks containing decomposed agricultural wastes were used to estimate the loss in weight. The content of these flasks were sundried and air dried under hot air oven at 50°C for 72 h. Loss in weight of substrates during the process of decomposition, was determined by subtracting final weight from the initial weight.

RESULTS AND DISCUSSION

The incubation studies undertaken for eight weeks with seven types of organic matters viz., cotton stalk, sorghum stalk, pigeonpea stalk, sugarcane trash, wheat straw, parthenium and weeds inoculated with three different fungi and one bacteria in single and with combination revealed that out of seven organic material wheat straw was the most suitable materials for rapid decomposition. Maximum rate of CO_2 evaluation was found during first week and reduced thereafter, during decomposition period. The combination of T. *spiralis* + *C. globosum* + *T. viride* evolved maximum amount of CO_2 during first and all seven weeks, followed by *T. spiralis* + *T. viride*. Similar trend was noticed in all organic materials i.e. cotton stalk, sorghum stalk, pigeonpea stalk, sugarcane trash, wheat straw, parthenium and weeds (Table 1.)

In the present investigation, CO_2 evolution was maximum during first week of incubation and subsequently gradually declined second week in all agricultural wastes. The results are in agreement with the observations of Pande (1978). He also observed that *C. lagopus* and *M. echinata* inoculated in farm wastes *viz.* cotton stalk, *Mug* trash and *Tu*r stalks evolved maximum CO_2 in first week and reduced there after. Similarly, *T. spiralis, C. globosum* inoculated substrates evolved maximum CO_2 during first week (Somani and Wangikar, 1979). Similar line of finding reported by Potdukhe (1990). He studied that *T. viride* and *C. globosum* were promising in CO_2 evolution process during decomposition of cotton stalk, groundnut shells and sorghum stubbles.

Ravankar *et. al.,* (2000) observed that maximum amount CO_2 evolved from groundnut husk in first 15 days and after 30 days of incubation and lowest obtained from parthenium, due to low carbon content in the material.

Trichurus spiralis, Chaetomium globosum and *Trichoderma viride* inoculated alone and in combination substrates evolved maximum amount of CO_2. These results are in conformity with those of Kalekar *et al.* (1976). He also noticed that *T. spiralis, A. awamori*, etc., were effective in enhancing decomposition of all organic material however, wheat straw evolved more CO_2. Sonwane (1982) also measured the rate of CO_2 evolution of organic material using eight fungi, of which *T. viride C. globosum* found efficient degrader. However, *B. polymyxa* and *T. viride* inoculated legume straw released higher amount of CO_2 (Gupta *et. al.*, 2004).

Deepali Wankar (2005) *T. viride*, *A. niger* and *T. harzianum* were inoculated vegetable wastes evolved maximum CO_2 in the first week and reduced after subsequent weeks.

Moisture is one of the important factors that regulates the growth and activities of microorganisms in decomposition of organic material. Estimation of weight loss is an important factor for ascertaining the rate of degradation.

Maximum loss in weight of all substrates was observed by *T. spiralis+ C.globosum + T. viride* Table 2. The loss in weight can be correlated with the amount of CO_2 released during decomposition process. These results conform the findings of Somani *et al.* (1982). They reported that maximum weight loss of organic matter *viz.*, cotton stalk, pigeonpea stalk and *Mug* trash by *T. spiralis, C. globosum* (A), *C. lagopus,*. However, *P. funiculosum, C. globosum* and *T. viride* were found good decomposer related to loss in weight of organic wastes *viz.*, sorghum stubbles, groundnut shells, cotton stalks (Potdukhe, 1990).

Gawade (2001) studied *T. harzianum, T. viride* and *C. globosum* were more promising in loss in weight of substrates *viz.*, cotton stalk, pigeonpea stalk, groundnut shells, sorghum stubbles and soybean trash. Similarly, *Trichoderma* sp., *A. niger* and *T. spiralis* were found more effective in reducing the weight of the organic wastes *viz.*, sorghum stubble, sugarcane trash, pigeonpea waste, cotton stalk and coconut waste (Sudrik, 2004) and among 23 cellulolytic fungi, maximum loss in weight of vegetable wastes found with the inoculation of *T. viride*, *A. niger*, and *T. harzianum* (Deepali Wankar, 2005).

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Yield, Quality and Nutrient Uptake of Gerbera Influenced by Different Sources and Levels of Potassium Under Polyhouse Conditions

S. V. Deshmukh[1], U. S. Kudtarkar[2], Rachana S. Deshmukh[3] and M. B. Jadhav[4]

ABSTRACT

The experiment was undertaken to study the effect of different sources and levels of potassium fertilizers on growth, yield and quality of gerbera under polyhouse conditions at High-tech Floriculture Project, College of Agriculture, Pune-5 during 2005-06. There were three sources of potassium *viz.*, muriate of potash, sulphate of potash and nitrate of potash and four levels of potassium i.e, 75 per cent, 100 per cent, 125 per cent and 150 per cent K of recommended dose by using factorial completely randomized block design with three replications under controlled conditions.

The object of the project was to study the effect of sources and levels of potassium on yield and quality of gerbera and to know potassium requirement of gerbera and its economics.

The gerbera was grown on cocopeat media. The analysis of cocopeat indicated that the cocopeat was most suitable media for growing gerbera in pots. The effects of sources and levels of potassium on gerbera, various growth parameters like length of flower stalk and flower diameter were recorded and for yield parameter weight of flower and flowers plant^{-1} was studied. Further for quality study, vase life of flower was studied. All these observations indicated that amongst all sources sulphate of potash was the best and amongst all levels of K 100 per cent recommended dose of K was found beneficial. Similar observations were recorded for uptake of nutrients by flowers plant^{-1}. The potassium content in leaves and plant was increased as the levels of K increased indicating luxurious consumption of potassium by gerbera. Application of 100 per cent dose (200:70:100, L_2) of K showed beneficial effects on gerbera, higher application of K had not shown any favorable effect on growth, yield and quality of gerbera.

In India, now a days floriculture is emerged as a growing and upcoming business. There is huge market availability and vast scope for production of ornamental and cut flowers due to increasing demand for flowers in market. Gerbera is one of the important cut flower in the international floriculture trade. Gerbera (*Gerbera Jamesonii*) a beautiful ornamental flowering plant growing under polyhouse conditions and it is a fast emerging area in the world. New technologies have been developed for higher production with better quality. Hence, balanced nutrient application is very necessary. Among various major nutrients like N, P and K, potassium plays an important role in improving nutrient use efficiency yield and quality of flowers. Therefore, the present investigation was undertaken to study the effect of various sources as well as levels of potassium on yield and quality of gerbera.

MATERIAL AND METHODS

The experiment was planned at Hi-tech Floriculture located at College of Agriculture, Pune-5 during the year 2005-06. The pot culture experiment under polyhouse condition was laid out in a factorial completely randomized block design with three replications and twelve treatment combinations by using cocopeat as a growth media. Cocopeat having pH 5.80, EC 0.19 dSm^{-1}, Organic carbon 48.75 per cent, Water holding capacity 850 per cent, total N, P and K was 0.42, 0.18 and 0.50 per cent, respectively. Dong *et. al.*, (1999) reported that the cocopeat was the most effective for seedling growth of gerbera due to its suitable porosity, water holding capacity, air permeability, EC and pH.

Three Source of potassic fertilizers i.e. Potassium chloride (S1), Potassium sulphate (S2) and potassium nitrate (S3) were used in four levels of NPK dose i.e. 200:70:75 (L1), 200:70:100(L2), 200:70:125 (L3) and 200:70:150 (L4) mg plant^{-1} alternate

1. Technical Officer, 2. Junior Res. Asstt., 3. Senior Res. Fellow, and 4. Associate Prof., Regional sugar and Jaggary Research Station, Kolhapur.

day^{-1}, respectively for first 2.5 months and 120:60:225 (75 % RD-K), 120:60:250(100 % RD-K), 120:60:275 (125% RD-K) and 120:60:300 (150 % RD-K) mg plant^{-1} alternate day^{-1}, respectively after flowering were used.

Fifteen days after planting only plain water was given manually as per the water requirement plant^{-1} (200 ml day^{-1}). Thereafter, fertilizer treatments were given alternate day upto completion of study.

RESULTS AND DISCUSSION

During the span of study, the morphological observations, such as, number of flowers plant^{-1}, size of flower, weight of flower, stalk length and vase life were recorded.

The data regarding total number of flowers at 240 days (Table 1) indicated that sulphate of potash showed highest number of flowers plant^{-1} (22.5). This was statistically superior over S1 muriate of potash (18.7) and S2 nitrate of potash (20.8). The interaction effects of sources and levels of potassium were found to be non significant.

The data regarding mean fresh weight of flower (Table 1) indicated that the source sulphate of potash recorded highest mean fresh weight (30.2 g) from flowering to 240 days of crop age. This source had given significantly higher fresh and dry weight of flowers over all other sources, The level 100 per cent RD of K has recorded higher fresh weight of flowers up to 240 days and it was statistically superior over level 75 per cent K indicating low dose of K showed less weight of fresh flowers. The interaction effect of sources and levels of potassium for mean weight of flowers found to be non significant.

The mean diameter of flower in the treatment of sulphate of potash was 11.3 cm, which was statistically superior over muriate of potash (10.4 cm) and at par with nitrate of potash (10.8 cm) indicating that use of muriate of potash showed adverse effect on quality of flowers at later stage, which might be due to accumulation of salts at 240 days. The treatment 100 per cent K showed more diameter of flower and it was statistically superior over 75 per cent K indicating less dose of K have

Table 1. Effect of different sources and levels of potash on various parameters of gerbera from flowering to 240 days crop age.

Treatments	Flowers plant^{-1}	Weight of flower (g)	Diameter of flower (cm)	Stalk length (cm)	Vase life (days)
Sources					
S_1–MOP	18.7	24.7	10.4	41.0	5.2
S_2–SOP	22.5	30.2	11.3	45.6	7.8
S_3–NOP	20.8	26.8	10.8	43.3	6.7
SE (m) $\pm$	0.2	0.8	0.2	1.2	0.07
CD 5%	0.7	2.8	0.6	3.9	0.3
Levels					
L_1-75%K	18.6	23.8	10.2	42.0	5.0
L_2-100%K	22.9	28.9	11.6	46.1	7.6
L_3-125%K	20.5	28.2	11.0	43.6	7.4
L_4-150%K	20.4	27.8	10.4	41.0	6.2
SE (m) $\pm$	0.3	0.5	0.2	1.5	0.2
CD 5%	1.1	1.8	0.7	NS	0.8
Interaction					
SE (m) $\pm$	0.3	0.6	0.3	2.7	0.3
CD 5%	NS	NS	NS	NS	NS

adverse effect on quality of flower at later stage of harvest. The interaction effects between different sources and levels of potassium found to be non significant. This is in conformity with result obtained by Kamel *et. al*., (1975).

The maximum length of stalk (46.1 cm) was observed in 100 per cent K treatment, and it was superior over rest of the levels. Also maximum length of stalk (45.6 cm) observed in sulphate of potash and it was on par with nitrate of potash and superior over muriate of potash indicating that there was shortening of stalk length due to use of muriate of potash, which might be due to higher accumulation of salts of chloride at 240 days. The interaction effects of sources with levels of potassium were found to be non significant.

The vase life of flower was improved due to use of source sulphate of potash. It was statistically superior over other two sources. So far levels of K were concerned at 240 days there was significant difference on vase life of flower. Levels 100 and125 per cent K were on par with each other but superior over other level 75 and150 per cent K, indicating higher application of K had not much beneficial effect on vase life of flower. The effect of interaction between sources and levels found to be non significant.

Among the potassium sources, sulphate of potash gave significantly higher number of flowers, mean weight of flower, flower diameter, stalk length, vase life of the flower than rest of the sources. Application of 100 per cent potassium gave significantly higher number of flowers, flower diameter, stalk length and vase life. The interaction effects were found to be non significant.

The data regarding nutrient removed through flowers of gerbera upto 240 days (Table 2) indicated that 1.87 to 3.49 g of nitrogen, 0.53 to 0.80 g of phosphorus and 2.06 to 2.88 g of potassium were removed by one plant of gerbera during the period of 240 days under polyhouse condition. The highest uptake of N, P and K was observed in the treatment of sulphate of potash, which was statistically superior over muriate of potash,

Table 2 : Effect of different sources and levels of potash on nutrient uptake

Treatment	Nutrient removed by flowers ($g\ plant^{-1}$)		
	N ($g\ plant^{-1}$)	P ($g\ plant^{-1}$)	K ($g\ plant^{-1}$)
Sources			
S_1–MOP	2.35	0.53	2.57
S_2–SOP	3.49	0.80	3.86
S_3–NOP	2.62	0.63	2.88
SE $\pm$	0.09	0.02	0.07
CD 5%	0.31	0.09	0.24
Levels			
L_1-75%K	1.87	0.51	2.06
L_2-100%K	3.32	0.72	3.41
L_3-125%K	3.02	0.68	3.42
L_4-150%K	3.02	0.68	3.55
SE $\pm$	0.12	0.03	0.08
CD 5%	0.38	0.10	0.27
Interaction			
SE $\pm$	0.18	0.08	0.14
CD 5%	NS	NS	NS

indicating use of muriate of potash had adverse effect on uptake of nutrients as compared to other sources.

The levels of K showed significant effect on uptake of NPK by gerbera. The highest uptake of NPK was observed in level 100 per cent K and it was statistically superior over 75 per cent K. Further the data indicated that higher application of K to gerbera, did not help in increasing uptake of NPK. Similar observations were recorded by Garther (1969) and Heathcote (1972). The interaction effects of sources with levels of potassium were found to non significant.

Sulphate of potash was the good source of K and the application of K sources was found in the order of K_2SO_4>KNO_3>KCL. Application of 100 per cent K mg $plant^{-1}$ alternate day^{-1} through Sulphate of potash was better for yield and quality of gerbera.

Table 3: Income from different treatments

	Treatment	No. of flower plant^{-1}	No. of flowers (Rs)	Total income (Rs)	Total cost (Rs)	Benefit (Rs)	B:C ratio
1.	$S_1 L_1$	19	57000	142500	56612	85888	1.52
2.	$S_1 L_2$	18	54000	135000	56612	78388	1.38
3.	$S_1 L_3$	19	57000	142500	56612	85888	1.52
4.	$S_1 L_4$	18	54000	135000	56612	78388	1.38
5.	$S_2 L_1$	20	60000	150000	56612	93388	1.65
6.	$S_2 L_2$	21	63000	157500	56612	100888	1.78
7.	$S_2 L_3$	20	60000	150000	56612	93388	1.65
8.	$S_2 L_4$	20	60000	150000	56612	93388	1.65
9.	$S_3 L_1$	20	60000	150000	56612	93388	1.65
10.	$S_3 L_2$	21	63000	157500	56612	100888	1.78
11.	$S_3 L_3$	21	63000	157500	56612	100888	1.78
12.	$S_3 L_4$	21	63000	157500	56612	100888	1.78

Total income from S_2L_2, S_3L_2, S_3L_3 and S_3L_4 was same hence, it is suggested not to apply higher dose of K fertilizer over 100 per cent RD-K (200:70:100, L_2) and it will save fertilizer. As maintenance (Electricity, irrigation, polyhouse climate etc.) and other labour charges were more compare to fertilizer cost hence, cost of fertilizer was considered same for all sources. As per availability of source of fertilizer among Potassium chloride (S_1), Potassium sulphate (S_2) and Potassium nitrate (S_3) the cheaper source can be used as it gave no significant difference in the income.

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Leaf Nutritional Status and Growth Parameters of Healthy and Decline Nagpur Mandarin Gardens

S.P.Wagh[1], M.S.Bande[2] and M.V.Kadu[3]

ABSTRACT

The present investigation was carried out to determine the leaf nutritional status and growth parameters of healthy and declined Nagpur mandarin gardens in Warud tahsil of Amravati district. The results showed that nitrogen, phosphorus and potassium content in leaf of healthy and declined gardens varied from 2.30 to 2.55per cent, 1.70 to 2.08per cent, 0.12 to 0.16per cent, 0.08 to 0.11per cent, 0.80 to 1.00per cent and 0.83 to 1.73per cent, respectively. Calcium, magnesium and sulphur content in healthy and declined gardens ranged from 3.02 to 3.86per cent, 2.46 to 3.21per cent, 0.57 to 0.71per cent, 0.31 to 0.70 per cent, 0.19 to 0.17per cent and 0.16 to 0.20per cent, respectively. Results pertaining to micronutrient showed that iron, manganese, copper and zinc in healthy and declined gardens varied from 101.6 to 138.6 ppm, 73.66 to 102.00 ppm, 28.45 to 37.18 ppm, 22.38 to 30.67 ppm, 27.40 to 33.96 ppm, 20.72 to 25.05 ppm, 19.72 to 31.62 ppm and 17.22 to 24.00 ppm, respectively. Perusal of the data indicated that the healthy gardens had significantly higher content of nutrient than declined gardens except potassium content. There was no appreciable difference observed in growth parameters like girth, height and canopy between healthy and declined orchards. Number of fruits plant^{-1} and average weight of fruits were more in healthy gardens as compared to declined gardens.

Citrus is World's leading fruit crop and often regarded as a queen of all fruits. It is one of the ruminative commercial fruit crops of India after mango and banana and occupies about 9 per cent of total land under various fruits in India. The citrus fruits are well known for nutritional and medicinal values. It is rich source of vitamin 'C' (containing 50-60 mg 100 g^{-1} of juice) besides containing fair amount of B1, B2 and vitamin D. Among the important citrus fruits, Nagpur mandarin is cultivated on a very large scale specially in central and south India. Maharashtra state is leading in Nagpur mandarin cultivation. Vidarbha region of the Maharashtra state particularly Warud Tahsil of Amravati district have more growing area under Nagpur mandarin.

Recently many orchards of Nagpur mandarin around Warud Tahsil of Amravati district have proven to be failure because of defective selection of soil site and less availability of nutrients causes deterioration in orange, thus affecting yield, fruit bearing and growth of the trees.

Leaf analysis in recent years has been widely used to identify nutritional problems, to detect deficiency of nutrient and measure the response to the applied plant nutrients. It is considered fairly good index to measure the fertilizer need of citrus plants. Nutritional deficiencies especially of the micronutrient have been observed based on visual observation or leaf analysis in different orchards of the state. The present investigation is related to find out mean values of macro and micronutrients in the leaf tissues and growth parameters of Nagpur mandarin plants. These norms will be used for identifying the deficiencies or adequacy of nutrient elements in plants and assess the appropriate time of harvesting of fruits for their potential use in commercial industry.

MATERIAL AND METHODS

For the present investigation of Nagpur mandarin gardens, eight villages of Warud tahsil of Amravati district (M.S.) were surveyed and six each orchards from healthy and declined condition were selected on the basis of their yield performance for last five years and visual observations. From each orchard, 50 leaves from 4-7 month old flush from non fruiting terminals preferably 2nd, 3rd, and 4th leaf at the height of 1.5 to 1.8 meter from ground were collected randomly from all the side of the plant and prepared for analysis as per Srivastava and Singh (2003). The leaf samples were analyzed for Nitrogen, Phosphorus, Potassium, Calcium Magnesium and Sulphur by standard methods as described by Jackson (1967). Total Iron, Manganese, Copper and Zinc were determined by Atomic Absorption Spectrophotometer method (Lindsay and Norvell, 1978). For growth parameters, ten fruits from each orchard were drawn for growth parameter analysis.

1. Assistant Prof., 2. Agriculture Specialist, and 3.Assistant Prof., Department of Soil Science and Agricultural Chemistry, M.W. College of Agriculture, Yavatmal.

RESULTS AND DISCUSSION

Data regarding Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Iron, Manganese, Copper and Zinc in Nagpur mandarin gardens are presented in Table 1.

Leaf nutritional status of healthy and declined Nagpur mandarin gardens

Macro-nutrient status of leaves:

Total Nitrogen

The data regarding nitrogen content in leaves of healthy orange gardens varied from 2.30 to 2.55 per cent with mean value of 2.41per cent, whereas in case of declined gardens leaf nitrogen content varied from 1.70 to 2.08 per cent with mean value of 1.92per cent. Such type of large variation of nitrogen content in Nagpur mandarin was also observed by Shrivastava and Singh (2001) and Kharkar *et. al.*, (1991)

It was further observed that nitrogen content in leaves of healthy orange gardens trees was higher as compared to declined ones. Similar results were also reported by Kharkar *et. al.*, (1991). This may be due to higher soil nitrogen status of healthy orange gardens than declined orange gardens.

Phosphorus

It was seen from the data that phosphorus content in the leaves of Nagpur mandarin varied from 0.12 to 0.16 per cent in healthy trees and 0.08 to 0.11per cent in declined trees with a mean value of 0.14 and 0.09 per cent in the leaves of healthy and declined gardens, respectively. The wide variation in phosphorus concentration in leaves of Nagpur mandarin was also observed by Shrivastava and Singh (2001). Further it was observed that phosphorus content in the leaves of healthy trees was higher as compared to declining trees. Similar observations were also reported by Saini *et. al.*, (1999). Low concentration phosphorus might be due to low available phosphorus status in soils of declined orange gardens and inadequate use of phosphatic fertilizers.

Potassium

It would be seen from the data that potassic content in the leaves of healthy trees varied from 0.80 to 1.00 per cent with an average of 0.89 per cent. In declining trees it varied from 0.83 to 1.73per cent, with mean value of 1.06 per cent.

Further it was observed that the declined trees accumulated more potassium in the leaves than the healthy ones which is in accordance with the findings of Rana *et. al.*, (1984). It seems that potassic start accumulating in the leaves when some growth factor or any other nutrient becomes more limiting than potassium. This conforms by the observation of Chapman and Brown (1950).

Secondary Nutrients

Calcium

Calcium has two fold importance as far as orange is concerned viz., as a nutrient and soil improving agent. Citrus plants contain more calcium than any other plant nutrient. It was seen from the results that the mean concentration of calcium in leaves of Nagpur mandarin was 3.42 per cent, with a range of 3.02 to 3.86 per cent in healthy trees. Even in the declined trees, it ranged from 2.46 to 3.21per cent with a mean value of 2.90 per cent.

Most of the healthy and declined trees contained calcium in optimum range. Further it was observed that calcium status was higher in healthy trees than that of declined one. Similar observations were also reported earlier by Awasthi *et. al.*, (1984).

Magnesium

It was seen from the data that the average magnesium concentration was 0.64 per cent, which ranged from 0.57 to 0.71per cent in healthy gardens and in declined gardens it varied from 0.31 to 0.70 per cent with mean value of 0.45per cent. Magnesium was optimum in both healthy and declined trees. Perusal of the data indicate that the healthy tree had significantly higher magnesium content than that of declined one. Particularly low magnesium content could be attributed to the antagonistic affect of potassium present in high amount. Similar observations were also reported by Mann *et. al.*, (1978).

Sulphur

Sulphur is a constituent of protein. It plays an important role in chlorophyll synthesis. It was seen from the results that the means of sulphur concentration in leaves of healthy and declined trees were 0.19 and 0.17per cent respectively. It ranged from 0.18 to 0.21 per cent in healthy and 0.16 to 0.20per cent in declined trees of Nagpur mandarin gardens, respectively. Similar observations were also reported by Mann *et. al.*, (1978).

Table 1. Leaf Nutrient Content of Healthy and Declined Nagpur Mandarin Gardens.

S. N.	Location	Age of trees	Total 'N' (%)	Total'P' (%)	Total'K' (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
						Healthy Nagpur Mandarin Gardens						
1	Loni	14	2.38-2.42 (2.40)	0.14-0.16 (0.15)	0.85-0.88 (0.87)	3.64-3.70 (3.78)	0.59-0.65 (0.61)	0.19-0.21 (0.20)	132-147 (138.6)	26.05-30.12 (28.45)	27.0-29.0 (27.69)	27.92-29.10 (28.37)
2	Dhanodi	12	2.36-2.40 (2.37)	0.12-0.14 (0.13)	0.86-0.88 (0.87)	3.18-3.22 (3.20)	0.52-0.62 (0.57)	0.17-0.22 (0.19)	108-130 (122.3)	25.07-31.50 (28.52)	24.22-30.06 (27.40)	26.01-31.62 (29.13)
3	Bahda	12	2.50-2.53 (2.51)	0.16-0.17 (0.16)	0.82-1.10 (0.99)	3.96-4.02 (3.86)	0.68-0.74 (0.71)	0.18-0.23 (0.20)	98-107 (102.6)	30.01-35.55 (32.54)	28.11-31.00 (29.94)	27.27-28.86 (28.31)
4	Temburkheda	8	2.38-2.47 (2.43)	0.12-0.14 (0.12)	0.79-0.84 (0.81)	2.92-3.12 (3.02)	0.56-0.68 (0.64)	0.17-0.14 (0.18)	129-132 (130.6)	31.03-41.02 (37.18)	32.01-33.19 (32.46)	23.57-29.50 (25.79)
5	Dhanodi	9	2.17-2.29 (2.30)	0.15-0.17 (0.16)	0.78-0.81 (0.80)	3.14-3.38 (3.37)	0.58-0.62 (0.60)	0.16-0.24 (0.20)	92-109 (101.0)	32.0-39.00 (36.16)	31.00-36.10 (33.96)	19.72-24.41 (22.31)
6	Warud	15	2.52-2.60 (2.55)	0.14-0.18 (0.16)	0.77-1.18 (1.00)	3.26-3.50 (3.34)	0.68-0.75 (0.71)	0.19-0.24 (0.21)	128-131 (130)	35.06-37.22 (36.16)	22.70-33.31 (28.37)	27.42-29.33 (28.08)
	Mean		**2.41**	**0.14**	**0.89**	**3.42**	**0.64**	**0.19**	**120.81**	**33.16**	**29.97**	**26.99**
Declined Nagpur Mandarin Gardens.												
7	Loni	7	1.78-1.87 (1.82)	0.09-0.12 (0.10)	1.58-1.98 (1.73)	3.04-3.14 (3.08)	0.68-0.74 (0.70)	0.16-0.23 (0.19)	87-102 (96.66)	28.70-31.30 (30.00)	20.0-24.70 (22.00)	19.50-23.40 (20.30)
8	Jamalpur	15	2.05-2.11 (2.08)	0.08-0.09 (0.08)	0.97-1.06 (1.00)	2.70-2.74 (2.72)	0.48-0.51 (0.49)	0.14-0.19 (0.16)	79-98 (82.66)	21.22-23.83 (22.38)	18.0-23.19 (20.72)	18.92-24.00 (21.54)
9	Jamalpur	9	1.64-1.75 (1.70)	0.09-0.13 (0.11)	0.91-0.99 (0.95)	3.06-3.18 (3.10)	0.44-0.52 (0.48)	0.19-0.22 (0.20)	97-109 (94.00)	22.O2-27.00 (24.20)	22.70-28.06 (24.92)	19.71-22.00 (20.72)
10	Pusla	13	1.93-2.05 (1.99)	0.08-0.10 (0.08)	0.85-0.97 (0.89)	3.16-3.27 (3.21)	0.34-0.54 (0.44)	0.14-0.21 (0.18)	70-77 (73.66)	28.70-31.70 (30.67)	21.01-26.81 (23.08)	17.22-23.70 (20.93)
11	Wathoda	16	2.00-2.10 (2.04)	0.08-0.12 (0.09)	0.79-0.88 (0.83)	2.30-2.72 (2.46)	0.30-0.36 (0.33)	0.14-0.19 (0.16)	95-110 (102.00)	22.88-28.77 (25.61)	20.0-23.72 (21.60)	19.80-22.08 (22.60)
12	Dhanodi	9	1.87-1.93 (1.90)	0.09-0.11 (0.09)	0.69-1.10 (0.97)	2.78-2.90 (2.83)	0.22-0.38 (0.31)	0.15-0.21 (0.17)	97-103 (100.33)	21.12-24.44 (23.18)	19.89-29.00 (25.05)	17.72-21.03 (19.58)
	Mean		**1.92**	**0.09**	**1.06**	**2.90**	**0.45**	**0.17**	**91.55**	**25.53**	**22.89**	**20.94**

Micro-nutrient status of leaves

Iron

Though iron is not a constituent of chlorophyll, it is essential for its synthesis. It acts as catalyst in enzymes. In general, iron deficiency is common in calcareous soils. It was evident from the results that the concentration of iron in the leaves of healthy gardens varied from 101.0 to 138.6 ppm with mean concentration of 120.81ppm. In declined gardens it varied from 73.66 to 102.00 ppm with mean concentration of 91.55 ppm. Results indicated that the iron content in the leaves of healthy trees was higher as compared to declined gardens. Similar findings were reported by Mann *et. al.*, (1979). The iron content in the leaves of healthy and declined trees was in the optimum range as per Mann *et al.*, (1979).

Magnesium

Magnesium is essential for chlorophyll synthesis. It exercises an influence on iron transport and its utilization within the plant. It plays an important role in photosynthesis and nitrogen metabolism and activates enzymes.

It was evident from the results that manganese content ranged from 28.45 to 37.18 ppm with mean value of 33.16 ppm in leaves of healthy gardens and 22.38 to 30.67 ppm with mean value 25.53 ppm in declined gardens.

From the results, it was observed that manganese content in the healthy gardens was found higher as compared to declined gardens. Similar findings reported by Kharkar and Patil (1999).

Copper

Copper is a constituent of several enzymes participation in the cellular oxidation and reduction process. Citrus trees usually receive enough copper by fungicidal nutritional sprays. It would be seen from the results that concentration of copper varied from 27.40 to 33.96 ppm with an average 29.97 ppm in healthy gardens and in declining gardens it varied from 20.72 to 25.05 ppm with an average value of 22.89 ppm. More critical examination of the data indicates that copper content in healthy trees was higher than that of declined gardens. Similar observations were also reported by Kharkar *et. al.*, (1991) and Mann *et. al.*, (1979). Considering the leaf analysis standards given by Embleton *et., al.* (1976) all healthy and declined Nagpur mandarin gardens contained copper concentration in high range.

Zinc

Zinc is required in very minute quantity by citrus trees. It ranks next to nitrogen in citrus nutrition. It was evident from the results that zinc concentration ranged from 22.31 to 29.13 ppm with mean value of 26.99 ppm in leaves of healthy gardens and in declined gardens it varied from 19.58 to 22.60 ppm with mean value of 20.94 ppm. It was evident from the results that the concentration of zinc in leaves of healthy gardens was higher than that of declined gardens. Similar findings were reported by Awasthi *et. al.*, (1984).

Table 2. Leaf Nutrient Content of Healthy and Declined Nagpur Mandarin Gardens.

S.N.	Locations	Age of trees	Growth Parameters			Yield Parameters	
		(Yrs.)	Girth (M)	Height (M)	Canopy (M^3)	Number of Fruits / Tree.	Average Weight of Fruit (g)
Healthy Nagpur Mandarin Gardens.							
1	Loni	14	0.73	4.90	42.70	1070	137.00
2	Dhanodi	12	0.65	4.30	38.83	977	141.30
3	Bahda	12	0.68	4.38	39.82	1037	132.40
4	Temburkheda	8	0.54	3.59	28.33	1108	151.30
5	Dhanodi	9	0.57	4.47	20.70	980	142.00
6	Warud	15	0.68	4.29	44.27	1087	133.20
Declined Nagpur Mandarin Gardens.							
7	Loni	7	0.49	3.67	15.38	203	121.00
8	Jamalpur	15	0.72	5.52	40.90	170	103.90
9	Jamalpur	9	0.56	4.74	23.60	130	120.70
10	Pusla	13	0.68	4.40	37.00	79	97.00
11	Wathoda	16	0.73	5.00	41.00	132	102.10
12	Dhanodi	9	0.59	4.48	21.30	205	117.30

A comparison of leaf zinc status with the standards values as suggested by Embleton et al (1976) shows that all declined trees were in low range where as most of the healthy trees were in optimum range except trees of garden no 5.

Growth parameters of healthy and declined Nagpur mandarin trees

Data regarding Girth, Height and Canopy of trees, Number of fruits per plant and Average fruit weight of Nagpur mandarin trees are presented in Table 2.

Girth, Height and Canopy of Trees

Results indicated that girth of healthy trees varied from 0.54 to 0.73m. and in declined trees it varied from 0.49 to 0.73m. Height of healthy and declined trees varied from 3.59 to 4.90m and 3.67 to 5.52m, respectively.

Results indicated that canopy in healthy trees varied from 20.70 to 44.27m^3. In declined trees it varied from 15.38 to 41.00m^3. The data regarding growth parameters revealed that there no any appreciable difference was observed in respect of girth, height and canopy of both healthy and declined trees.

Number of fruits plant^{-1} and Average weight of fruits

Data regarding growth parameters revealed that number of fruits plant^{-1} in healthy trees was found higher as compared to declined trees. The average number of fruits in healthy trees was 1043.16 fruits plant^{-1} and it varied from 977 to 1108. In declined trees it varied from 79 to 205 fruits plant^{-1} with an average of 153.16. From data it would be seen that number of fruits plant^{-1} was more in healthy trees as compared to declined trees.

Data regarding average fruit weight showed that in healthy trees it varied from 132.4 to 151.3 g. with an average 139.53 g. In declined trees it varied from 97.0 to 121.0 g. with an average 110.5g. From data it would be seen that average weight of fruit was more in healthy trees than declined trees.

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Soil Test Crop Response Correlation Studies Under Integrated Plant Nutrient System for *Rabi* Onion

Mohammad Sajid[1], M. N. Patil[2], N.M. Konde[3], V.A. Tiwari[4] and N. S. Ukey[5]

ABSTRACT

Soil test crop response correlation studies were conducted with onion (Var. Akola *Safed*) under integrated plant nutrient system. Fertilizer adjustment equations were formulated for onion following Ramomoorthy's targeted yield approach. The nutrient requirement for producing one quintal of onion bulbs was found to be 0.85 kg N, 0.35 kg P and 1.25 kg K. The per cent contribution from soil for onion was 6.34 N, 39.8 P and 8.86 per cent K, respectively. The per cent contribution from fertilizer were 15.20, 7.54 and 27.53 N P and K, respectively. While the contribution from fertilizer in presence of FYM for N, P and K were 17.75, 8.08 and 38.42 per cent, respectively. Whereas per cent contribution of N, P and K from FYM was 5.52, 4.02 and 7.80, respectively.

Onion is grown on an area of about 4.55 lakh hectares with an annual production of 60.34 lakh tonnes of onion bulbs. Maharashtra is a leading onion growing state with an area of 84.48 thousand hectares and a production of 16.61 lakh tonnes of onion bulb annually (Anonymous, 2006).

Lack of adequate and balanced supply of nutrients is one of the major constraints towards the low yield and quality of onion. Fertilizers are, perhaps, the most important inputs in increasing the yield of crop like onion. They are even more important on many soils with poor fertility levels.

A significant work has been done by many workers on fertilizer application for higher production of onion bulbs. However, work on balanced use of fertilizer, based on targeted yield approach particularly on vegetable crops in Maharashtra is still in its infancy. It is the need of the hour to conduct soil test crop response correlation studies and derive fertilizer prescription equations for onion crop by balanced use of fertilizers.

The present investigation on soil test crop response correlation studies on *Rabi* onion as a test crop was undertaken based on fertility gradient approach of Ramamoorthy *et. al.,* (1967).

MATERIAL AND METHODS

A standard main experiment was conducted on *Rabi* onion using the fertility gradient approach (*Ramamoorthy et al.,* 1967) during 2004-05. The soil of the experimental field was moderately deep, moderately well drained, clayey in texture and developed on weathered basalt, which comprise member of fine, clayey smectitic, hyperthermic family of Typic Haplusterts with pH 8.32 and EC 0.43 dSm^{-1}. The initial available N, P and K status were 194.30, 16.13 and 328.31 kg ha^{-1}, respectively. Following the methodology of Ramamoorthy *et. al.,*(1967), four fertility gradients were created by dividing the experimental field into four equal strips viz., L_0, $L_{1/2}$, L_1 and L_2 which were fertilized with 0:0:0, 100:75:75, 200:150:150 and 400:300:300 kg N, P_2O_5 and K_2O, respectively. An exhaust crop of fodder maize was grown in *Kharif* on all four fertility gradient strips, so that the added fertilizers could undergo transformations in the soil with plant and microbial agencies.

By growing the exhaust crop, the operational range of soil fertility was created in the fertility strips which was evaluated in terms of variations in fodder yield and soil test values. After harvest of the exhaust crop, each fertility strip was divided into 24 equal plots, out of which there were 20 treated plots with five levels of N (0,50,100,150 and 200 kg N ha^{-1}), four levels of P_2O_5 (0,50,100 and 150 kg P_2O_5 ha^{-1}) and four levels of K_2O (0,50,100 and 150 kg K_2O ha^{-1}). Four control (untreated/ unfertilized) plots were superimposed in each strip. The four fertility gradients were divided into four FYM blocks across the fertility gradients. The Four FYM blocks viz., F_0, F_1, F_0 and F_2 were superimposed with three levels of FYM (0, 20 and 40 Mg ha^{-1}). Pre-plant soil samples were collected from each plot before the superimposition of the treatments and were analysed for available N (Subbiah and Asija, 1956), available P (Olsen *et. al.,* 1954) and available K (Hanway and Heidel, 1952). The test crop onion (*Allium cepa* L.) var. Akola *Safed*, was planted in January, 2005 and grown to maturity and harvested

1& 4. Junior Res. Asstt., 2. Ex. Professor, 3. Senior Res. Asstt. and. 5. M. Sc. Student, Department of SSAC, Dr. PDKV, Akola.

during May, 2005. The bulb and straw (tops) yields were recorded plotwise. The plant samples were analysed for Total N, P and K content (Jackson, 1967). The total uptake of nutrients was computed using onion bulb and straw (tops) yield.

The data on onion bulb yield, nutrient uptake, pre-plant soil available nutrients and fertilizer doses applied was used to calculate the basic parameters, viz, nutrient requirement (kgt^{-1}), contribution of nutrients from soil (CS) and fertilizers (CF) as described by Ramamoorthy *et. al.,* (1967). The per cent contribution from added FYM was estimated. These all parameters were used for the formulation of fertilizer adjustment / prescription equations for deriving fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of ready reckoner for desired yield target of onion under NPK alone as well as along with FYM.

RESULTS AND DISCUSSION

Creation of soil fertility gradients:

The range and mean values of soil available nutrients of treated and control plots are furnished in Table 1. The data revealed that variations in soil test values were observed for available nitrogen, phosphorus and potassium and found to increase gradually with increase in fertility gradient from L_0 to L_2. This increase in N, P and K content clearly indicated that the fertility gradients have been developed. A wide variability existed in the soil test values of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Basic parameters :

The basic data of onion i.e. nutrients requirement (NR), per cent contribution of nutrients from soil (CS), percent contribution of nutrients from applied fertilizer alone (CF), per cent contribution of nutrient from applied fertilizer in presence of FYM, (CF FYM) and per cent contribution from applied FYM derived on the basis of onion yield, initial soil test values, nutrients uptake and applied fertilizer and FYM to onion indicates (Table 2) that for production of one tonne of onion 0.85 kg N, 0.35 kg P and 1.25 kg K were required. While the percent contribution from soil in respect of N, P and K was 6.34, 39.80 and 8.86, respectively. The contribution from fertilizer was 15.20, 7.54 and 27.53 per cent in respect of N, P and K, respectively. While the per cent contribution from fertilizer in presence of FYM was 17.75, 8.08 and 38.42 in respect of N, P and K, respectively. Whereas per cent contribution of N, P and K from FYM was 5.52, 4.02 and 7.80, respectively.

The data indicated that the nutrient contribution from the fertilizer source was greater than that from the soil. The findings are in close conformity with those reported earlier by Rao *et al.,* (1997), Meena *et. al.,* (2001) and Santhi *et. al.,* (2002). The addition of FYM along with fertilizer would have provided enough carbon, the source of energy for build-up of bacterial population, which in turn would have enhanced the contribution of N. The higher contribution of phosphorus from soil might be due

Table 1. Range and average soil test values in different fertility gradients after harvest of maize

Available nutrients ($kg\ ha^{-1}$)		Fertility gradients			
		L_0	$L_{1/2}$	L_1	L_2
Nitrogen	**Range**	150.24 – 209.79	160.08 – 275.99	184.54 – 278.78	230.54 – 285.89
	Average	178.29	196.21	213.73	246.41
Phosphorus	**Range**	11.02 – 14.92	16.04 – 18.92	21.08 – 25.04	25.02 – 28.50
	Average	12.77	17.84	23.18	27.01
Potassium	**Range**	220.37 – 239.62	255.08 – 276.06	285.02 – 328.38	279.38 – 344.52
	Average	234.85	267.50	297.81	330.59

Table 2. Basic data for onion

Nutrient	NR ($kg\ t^{-1}$)	CS (%)	Without FYM	With FYM	
			CF (%)	CF (%)	CFYM (%)
N	0.85	6.34	15.20	17.75	5.52
P	0.35	39.8	7.54	8.08	4.02
K	1.25	8.86	27.53	38.42	7.80

do addition of FYM which might have helped in increasing the solubility of phosphorus in soil which resulted by better absorption of P nutrient. Santhy *et al.,* (2005) had also reported the similar results.

Fertilizer prescription equations:

The Fertilizer prescription equations for *Rabi* onion with sole use of chemical fertilizers and with conjoint use of fertilizers and FYM were computed from the basic data on NR, CS and CF. The fertilizer prescription equations for *Rabi* onion are, as follows -

Sole use of chemical fertilizers (without FYM)

$FN = 5.59\,T - 0.42\,SN$

$FP_2O_5 = 4.38\,T - 4.93\,SP$

$FK_2O = 3.25\,T - 0.23\,SK$

Conjoint use of chemical fertilizers and FYM

$FN = 4.79\,T - 0.36\,SN - 1.49\,FYM$

$FP_2O_5 = 4.64\,T - 5.28\,SP - 1.87\,FYM$

$FK_2O = 4.54\,T - 0.32\,SK - 1.69\,FYM$

Where, FN, FP_2O_5, FK_2O and SN, SP, SK indicate fertilizer N, P_2O_5, K_2O and soil available N, P, K respectively in kg ha^{-1}, while T indicates the yield target in t ha^{-1} and FYM is farm yard manure in Mg ha^{-1}. The fertilizer adjustment equations computed for the prescription of fertilizer dose were used to calculate the nutrient requirement of onion for different yield targets in the form of ready reckoners for application of fertilizer alone and for combined use of fertilizers and FYM.

It can be concluded from these ready reckoners that for 50 t ha^{-1} yield target of onion bulb with a soil test values of 190 kg N, 12 kg P_2O_5 and 400 kg K_2O ha^{-1} requires 199.70, 159.84 and 70.50 kg ha^{-1} N, P_2O_5 and K_2O, respectively, by using only fertilizer nutrients. But with the combined use of FYM @ 20 t ha^{-1} and fertilizer, for the same yield target and soil test values, the nutrients requirement comes to 141.30 kg N, 131.24 kg P_2O_5 and 65.20 kg K_2O ha^{-1}. Thus about 58.4 kg N ha^{-1}, 28.6 kg P_2O_5 ha^{-1} and 5.30 kg K_2O ha^{-1} can be saved by combined use of FYM @ 20 t ha^{-1} and inorganic fertilizers, over fertilizer alone. Similar observations were also reported earlier by Konde (2002) and Santhi *et. al.,* (2002).

Thus, the findings of the present investigation indicate that in STCR-IPNS technology, the fertilizer doses are tailored to the requirements of specific yield targets of onion (upto 60 t ha^{-1}) taking into account the nutrient requirement of onion, contribution of nutrients from soil, fertilizers, FYM and in combination with organics and inorganics i.e., in the form of fertilizer adjustment equations. Hence, there will be a balanced supply of nutrients coupled with recycling of organic materials avoiding either under or over usage of fertilizer inputs.

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Effect of Nitrogen Levels on Productivity and Quality of Forage Sorghum Genotypes in Vertisol

S. S. Rewatkar[1], Prerna Gadge[2], B.A.Sonune[3] and V.V. Gabhane[4]

ABSTRACT

A field experiment was conducted to study the effect of nitrogen levels on yield and quality of forage sorghum genotypes during *Kharif* season of 2005-06 on Vertisol at Research Farm, Dept. of Soil Science and Agril. Chemistry, Dr. PDKV, Akola. The twelve treatments replicated thrice in Factorial Randomized Block Design comprised four nitrogen levels (100, 80, 60 and 40 kg N ha^{-1}) with three genotypes (SSG-59-3, SSG-87, AKFR-89) and their combinations. The treatment consisting of 100 kg N ha^{-1} resulted in maximum green fodder, dry fodder, protein content and sugar content, while, the crude fibre content decreased with increasing rate of nitrogen from 40 kg N ha^{-1} to 100 kg N ha^{-1}. The genotype SSG-59-3 was found significantly superior in respect of green fodder yield, dry fodder yield as well as in protein and crude fibre content. The forage sorghum genotype SSG-87 was found significantly higher in respect of sugar content in both the cuttings.

Sorghum (*Sorghum bicolor* (L.) Moench) is an important forage crop grown for green as well as dry forage production over large areas in India, particularly during the *Kharif* season. Forage sorghum provides good quality fodder to animals and almost unique in its ability to grow over a very wide range of climatic and soil conditions due to its quick growing habit, high yield potential, better palatability, digestibility and rationing ability.

Fertilizers play an important role in increasing forage production of sorghum with beneficial nutritive value. Application of nitrogenous fertilizer is generally known to improve the N content in the plant and thus the crude protein content (Thangamuthu and Sundram, 1974). Increasing level of nitrogen successively decreased crude fibre content of sorghum. Minimum crude fibre content means the more total digestive nutrients (Shinde *et. al.,* 1987). If the sorghum variety records less fibrous stem and more TSS (total soluble solid) percentage, it indicates palatability and its juiciness.

The increase in the livestock population has widened the gap between demand and supply of fodder in India. This gap can be narrowed by increasing productivity by developing superior hybrids and varieties of forage crops. In order to achieve a higher production from forage sorghum with short span, application of adequate amount of plant nutrients, particularly N and P would be required even under dryland conditions. Therefore, the present investigation was undertaken to evaluate the effect of nitrogen levels on productivity and quality of forage genotypes.

MATERIAL AND METHODS

The field investigation was conducted during *Kharif* season 2005-06 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soils of the experimental site was Vertisol, clay in texture, slightly calcareous, moderate in organic carbon, low in available nitrogen, available phosphorus and high in available potassium.

The experiment was laid out with twelve treatment combinations replicated thrice in Factorial Randomized Block design comprised of four nitrogen levels (100, 80, 60 and 40 kg N ha^{-1}) with three genotypes (SSG-59-3, SSG-87, AKFR-89) and their combinations. A common dose of 30 kg P and 20 kg K ha^{-1} was applied to all the treatments. Dose of nitrogen, phosphorus and potassium were applied through urea, SSP and MOP, respectively. Half dose of N and full dose of P_2O_5 and K_2O were applied at the time of sowing. Remaining half dose of nitrogen was top dressed one month after sowing. The seed treated with Azotobacter @ 25 g kg^{-1} before sowing.

The plant samples collected were at 60 DAS and at harvesting stage and dry matter was calculated. These plants were air dried and then in

1& 4 Associate Prof., 2. M.Sc. Student, 3. Senior Res. Asstt., Dept. of Soil Science & Agril. Chemistry, Dr. PDKV, Akola

oven dried at 65^0 C and digested in diacid mixture (HNO_3: $HCLO_4$ in 9: 4 ratios). Total nitrogen was determined by Kjeldahl method (Piper, 1966). Protein was calculated by multiplying the percent nitrogen by factor 6.25. The crude fibre was calculated by acid – alkali method by Chopra and Kanwar (1980). Sugar per cent was estimated by using phenol sulphuric acid by Dubois Method (Sadasivan and Manickam, 1996).

RESULTS AND DISCUSSIONS

Effect of nitrogen levels on forage sorghum:

Green and dry fodder yield : The response of applied nitrogen on green and dry fodder yield was found significant in both the cuttings (Table 1). Increasing level of nitrogen from 40 kg N ha^{-1} to 100 kg N ha^{-1} increased the green and dry fodder yield of forage sorghum. The highest total green (814.8 q ha^{-1}) and dry fodder (122.2 q ha^{-1}) were observed with treatment of 100 kg N ha^{-1} which were significantly superior over lower levels of nitrogen (80, 60 and 40 kg N ha^{-1}) in both the cuttings. In first cut the green and dry fodder yield of forage sorghum was maximum and subsequently decreased during second cut. The superiority of first cut over second cut may be attributed to more development of growth in forage sorghum. Patil *et al*. (1988) also reported increased fodder yield of forage sorghum with increasing nitrogen levels. Similar results were also reported by Shinde *et. al.,* (1987).

Protein and sugar content: The protein and sugar content increased significantly with increasing levels of nitrogen (Table 2). Protein content in forage sorghum was found to be significantly highest in first cut (8.56 %) and subsequently decreased in second cut (5.46 %) by 36.21 per cent in treatment N_1 consisting 100 kg N ha^{-1}. However, sugar content was highest in second (3.36 %), which was 42.37 per cent more over first cut (2.36) with the nitrogen level of 100 kg N ha^1. The increase in protein content might be due to augmentation in protein content and dry matter yield with increasing levels of nitrogen (Karwasra and Dahiya, 1997).

Crude fibre content: The crude fibre content of forage sorghum successively decreased with increasing levels of nitrogen (Table 2). The minimum crude fibre content (30.84 %) in first cut and (27.74 %) in second was recorded with 100 kg N ha^{-1} whereas; the maximum crude fibre content (31.87 %) in first cut and (29.08 %) in second was recorded with 40 kg N ha^{-1}. The lowest crude fibre content was recorded with 100 kg N ha^{-1} indicating more total digestive nutrients. The highest crude fibre was recorded with 40 kg N ha^{-1} in both the cuttings indicating poor fodder quality. Patel *et. al.,* (1994) reported that higher crude fibre with control treatment and minimum crude fibre content was obtained with 120 kg N ha^{-1}.

Response of genotypes to varying nitrogen level

Green and dry fodder yield: Among the various genotypes (Table 1), variety SSG-59-3 produced highest total green (797.21 q ha^{-1}) and dry fodder yield (119.51 q ha^{-1}), followed by var. SSG-87 which were found at par with each other. However, the results are non significant during second cut. The forage yield decreased from first cut to second cut. Higher fodder yield of SSG-59-3 during different cuts and overall total yield was due to better contribution of growth components like height, number of leaves and dry matter accumulation $plant^{-1}$ (Shinde *et. al.,* 1987). Similarly Patil and Gill (1985) also observed that var. SSG-59-3 and Hyderabad sorghum recorded significantly higher green fodder yield over M.P. Chari and Sorghum alnum.

Protein content: Among the genotypes, the highest protein content (8.52 %) was recorded by genotype SSG-59-3, followed by SSG-87 (8.39 %) during the first cut (Table 2). The lowest crude protein (8.34 %) was recorded by var. AKFR-89 in first cut and (4.80 %) in second cut. Joon *et al.* (1993) also recorded higher values of protein content in var. SSG-59-3.

Sugar content: The significantly highest percentage of sugar (2.37 %) in first cut and (3.28 %) in second cut was observed by genotype SSG-87, followed by var. SSG-59-3 (Table 2). The var. SSG-87 was superior over var. SSG-59-3 and AKFR-89 in firstand second cut. Parvatikar and Manjunath (1991) also observed that the sweet sorghum var. SSV-53, SSV-119, SSV-6228, SSV-12611 and HES-4 gave the higher yield of total sugar because of their higher brix values and better extractability.

Crude fibre content: The data (Table 2) in respect with crude fibre content of forage sorghum genotypes was significant with different nitrogen levels in both the cuttings. The var. SSG-87 recorded

Table 1. Green and dry fodder yield (q ha^{-1}) of forage sorghum as influenced by nitrogen levels Green fodder yield (q ha^{-1})

N levels	1st cut				2nd cut				Total			
	Genotype											
	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**
100 (N1)	658.33	597.22	638.88	**631.47**	205.55	147.22	197.22	**183.33**	863.88	744.44	836.10	**814.80**
80 (N2)	625.00	633.33	611.11	**623.14**	161.10	188.88	152.77	**167.58**	786.10	821.88	763.88	**790.72**
60 (N3)	641.66	616.66	611.10	**623.14**	177.77	144.44	174.99	**165.73**	819.43	761.10	786.09	**788.87**
40 (N4)	577.77	644.44	563.88	**595.36**	141.66	183.32	133.33	**152.77**	719.43	827.76	697.21	**748.13**
Mean	**625.69**	**622.91**	**606.24**		**171.52**	**165.96**	**164.58**		**797.21**	**788.87**	**770.82**	
	F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %	
N levels	Sig.	2.62	7.68	N levels	Sig.	2.30	6.76	N levels	Sig.	4.56	13.39	
Genotypes	Sig	2.27	6.65	Genotypes	Sig	NS	-	Genotypes	Sig	3.95	11.60	
Interaction	Sig.	4.54	13.31	Interaction	Sig.	3.99	11.72	Interaction	Sig.	7.91	23.20	

Dry fodder yield (q ha^{-1})

N levels	1st cut				2nd cut				Total			
	Genotypes											
	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	
100 (N1)	98.73	89.56	95.79	**94.70**	30.83	22.08	29.58	**27.50**	129.56	111.64	125.37	**122.20**
80 (N2)	93.69	95.00	91.63	**93.44**	24.16	28.33	22.91	**25.13**	117.85	123.33	114.54	**118.57**
60 (N3)	96.10	92.46	91.66	**93.41**	26.66	21.66	26.25	**24.86**	122.76	114.12	117.91	**118.27**
40 (N4)	86.63	97.06	85.83	**89.84**	21.25	27.50	20.00	**22.91**	107.88	124.56	105.83	**112.75**
Mean	**93.79**	**93.52**	**91.23**		**25.72**	**24.89**	**24.68**		**119.51**	**118.41**	**115.91**	
	F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %	
N levels	Sig.	0.41	1.21	N levels	Sig.	0.34	1.01	N levels	Sig.	0.63	1.86	
Genotypes	Sig	0.35	1.05	Genotypes	Sig	NS	-	Genotypes	Sig	0.54	1.61	
Interaction	Sig.	0.71	2.11	Interaction	Sig.	0.59	1.75	Interaction	Sig.	1.09	3.22	

Table 2. Protein and sugar crude fibre content of forage sorghum as influenced by nitrogen levels

Protein content (%)								
	1st cut				2nd cut			
N levels	**Genotype**							
	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**
100 (N1)	8.81	8.10	8.79	**8.56**	6.12	4.54	5.74	**5.46**
80 (N2)	8.59	8.45	8.35	**8.46**	4.43	5.29	4.75	**4.82**
60 (N3)	8.41	8.35	8.20	**8.32**	4.81	4.27	4.70	**4.59**
40 (N4)	8.27	8.66	8.04	**8.32**	4.16	5.08	4.02	**4.42**
Mean	**8.52**	**8.39**	**8.34**		**4.88**	**4.79**	**4.80**	
	F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %	
N levels	Sig.	0.01	0.03	N levels	Sig.	0.01	0.03	
Genotypes	Sig	0.01	0.03	Genotypes	Sig	0.01	0.03	
Interaction	Sig.	0.02	0.06	Interaction	Sig.	0.02	0.06	
Sugar content (%)								
N levels	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**
100 (N1)	2.59	2.37	2.13	**2.36**	3.68	3.40	3.56	**3.55**
80 (N2)	2.14	2.84	1.51	**2.16**	2.84	3.81	2.62	**3.09**
60 (N3)	1.65	1.91	2.58	**2.04**	3.31	2.60	3.56	**3.15**
40 (N4)	1.41	2.97	2.13	**1.97**	2.38	3.33	3.08	**2.93**
Mean	2.08	2.37	1.94		3.05	3.28	3.20	
	F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %	
N levels	Sig.	0.003	0.009	N levels	Sig.	0.002	0.007	
Genotypes	Sig	0.002	0.007	Genotypes	Sig	0.002	0.006	
Interaction	Sig.	0.005	0.015	Interaction	Sig.	0.004	0.013	
Crude fibre (%)								
	1st cut				**2nd cut**			
N levels	**Genotype**							
	SSG – 59-3	SSG – 87	akfr – 89	**Mean**	SSG – 59-3	SSG – 87	akfr – 89	**Mean**
100 (N1)	30.21	32.06	30.24	**30.84**	27.07	29.01	27.13	**27.74**
80 (N2)	31.41	31.11	31.81	**31.44**	28.31	27.30	28.64	**28.08**
60 (N3)	31.16	32.01	31.31	**31.49**	28.04	29.11	28.15	**28.44**
40 (N4)	32.21	31.10	32.31	**31.87**	29.27	28.22	29.75	**29.08**
Mean	31.24	31.57	31.41		28.17	28.41	28.41	
	F test	SE (m) ±	CD at 5 %		F test	SE (m) ±	CD at 5 %	
N levels	Sig.	0.009	0.027	N levels	Sig.	0.10	0.31	
Genotypes	Sig	0.008	0.024	Genotypes	Sig	0.09	0.27	
Interaction	Sig.	0.01	0.03	Interaction	Sig.	0.18	0.54	

significantly highest crude fibre in first cut (31.57 %) and in second cut (28.41 %), followed by AKFR-89, which were at par with each other in first cut. The lowest crude fibre was recorded (31.24 %) in first cut and (28.17 %) in second cut by var. SSG-59-3 indicating good palatability.

Interaction effect (nitrogen levels x genotypes) on forage sorghum:

Green and dry fodder yield : The interaction effect between genotypes and nitrogen levels for green and dry fodder yield were significant (Table 1). The highest values (863.88 and129.56 q ha^{-1}) were noticed with treatment N_1G_1 (100 kg N ha^{-1} and var. SSG-59-3) which were superior over all treatment combinations. The treatment N_1G_1 recorded 23.90 and 22.42 per cent more total green and dry fodder yield over N_4G_3. The lowest values were noticed with treatment N_4G_3. The findings corroborates with the results reported by Shinde *et. al.,* (1987).

Protein content: In all the genotypes, the protein content of forage sorghum was decreased with decreasing the levels of nitrogen. Among the all treatment combinations, the maximum protein content and protein yield were observed with N_1G_1 treatment combination (8.81 %) in first cut and reduced with subsequent cut, while the lowest protein content (8.04 %) was found in N_4G_3 treatment combination in 1st cut.

Sugar content: The interaction effect was found significant for total sugar percentage (Table 2). The treatment combination N_4G_1 recorded significantly highest sugar per cent (2.97 %) in first cut, followed by N_2G_2 and N_1G_1 treatment combination whereas, N_2G_2 recorded higher sugar per cent in second cut (3.81 %). The treatment combination N_4G_1 recorded lowest sugar percent (1.41 %) in first cut and (2.38 %) in second cut. The greater increase in sugar yield of genotypes could be attributed to greater accumulation of dry matter and juice in the stem.

Crude fibre content: The interaction effect in respect of genotypes and nitrogen levels were found significant (Table 2). In all the genotypes, the crude fibre content of forage sorghum was observed to be decreased with increasing rate of nitrogen fertilization. The minimum crude fibre content was observed with N_1G_1 treatment combination (30.21 %) in first cut and (27.07 %) in second cut, followed by N_1G_3 and N_2G_2 treatment combination.

It is concluded from the present study that the application of 100 kg N ha^{-1} is optimum for getting higher yield with improvement in quality parameters of forage sorghum and among the genotypes the variety SSG-59-3 was found to be superior in quality and productivity.

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Distribution of Soil Zinc Fraction in Healthy and Declined Nagpur Mandarin Orchards

Sarika D. Patil[1], Ommala D. Kuchanwar[2] and S. P. Wagh[3]

ABSTRACT

The present investigation was carried out for studying the zinc fraction status of healthy and declined Nagpur mandarin orchards in Warud Tahsil of Amravati District. Fractionation of zinc in soil showed that the content of water soluble, exchangeable, complexed, organically bound, occulated and zinc bound to crystalline oxides in healthy orchards was on an average 0.21, 0.31, 3.34, 1.30, 1.83, 3.76 ppm and in declined orchard 0.21, 0.37, 3.20, 1.31, 1.91, 3.44 ppm, respectively. The concentration of water soluble and exchangeable zinc was least as compared to other fractions. Average content residual zinc in healthy and declined orchards was 106.34 and 104.43 ppm, respectively, it was largest fraction of total zinc content in soil. The average content of total and available zinc in healthy orchard was 117.69 ppm, 0.53 ppm and in declined orchard 104.45 ppm, 0.35 ppm, respectively.

Citrus is World's leading fruit crop and often regarded as a queen of all fruits. It is one of the ruminative commercial fruit crops of India after mango and banana, occupies about 9 per cent of total land under various fruits in India. The citrus fruits are well known for nutritional and medicinal values. Among the important citrus fruits, Nagpur mandarin is cultivated on a very large scale especially in central and south India. Maharashtra state is leading in Nagpur mandarin cultivation. Vidarbha region of Maharashtra State particularly Warud Tahsil of Amravati District (M.S.) have more growing area under Nagpur mandarin orchard.

Citrus require judicious supply of plant nutrients for its growth and yield of high quality fruits. Nutrient deficiencies especially of the micronutrients are of common occurrence in different Nagpur mandarin orchards. It is one of the most limiting factors contributing to low yields. Zinc is one of the micronutrient whose deficiency not only adversely affects the tree vigour, but also the crop yields and consequently the quality of the fruits. The distribution of soil zinc among various chemical pools has been a focal point of research from many years (Prasad and Shukla, 1996). Chemical fractionation of soil zinc has been viewed as means of assessing the source of plant available zinc (Iyengar and Deb, 1981).

However, current and comprehensive information on soil zinc fraction status, depthwise's distribution and their contribution to the total zinc in Nagpur mandarin orchards based on soil analysis have not been documented so far and, therefore, the present investigation was carried out.

MATERIAL AND METHODS

For the present investigation, Nagpur mandarin orchards around Warud Tahsil of Amravati District (M.S.) were surveyed and six each healthy and declined orchards from eight villages were randomly selected on the basis of their yield performance for last five years and visual observation. Representative forty-two depth wise soil samples were collected from these orchards for analysis of different zinc fractions, available and total zinc.

Available zinc was extracted by DTPA-extractant (Lindsay and Norvell, 1978) method and total zinc was estimated by digesting the material with HNO_3-$HCLO_4$-H_2SO_4-HF in platinum crucible (Trierweiler and Lindsay, 1969). Zinc fractions were determined by the procedure of Smith and Shoukry (1968) as suggested by Singh *et. al*., (1987). The zinc content in the extract was determined using Atomic Absorption Spectrophotometer and residual zinc was calculated by subtracting the sum of all fractions from the total zinc content.

RESULTS AND DISCUSSION

Data on zinc fractions, total and available zinc status in healthy and declined Nagpur mandarin orchard soils are presented in table 1 and 2.

1. M.Sc. Student, 2. Associate Prof. and 3. Assistant Prof., Department of Soil Science and Agricultural Chemistry, College of Agriculture, Nagpur

Water soluble zinc

Among the various zinc fractions, the concentration of water soluble zinc constituted the most readily available form of soil for plant nutrition (Gowrisankar and Murugappan, 1998).

Water soluble zinc in healthy orchard varied from 0.16 to 0.27 ppm i.e. 0.12 to 0.25 per cent of total zinc with a mean value of 0.218 ppm but it varied according to depth. In declined orchard it varied from 0.18 to 0.25 ppm i.e. 0.16 to 0.27 per cent of total zinc with a mean value of 0.22 ppm. Similar findings were reported by Sinha and Prasad (1996), Gowrisankar and Murugappan (1998) and Raina *et al.* (2003). The results revealed that zinc content in water soluble form was very least in all healthy and declined Nagpur mandarin orchards.

Easily exchangeable zinc

The exchangeable zinc in healthy orchards varied from 0.23 to 0.42 ppm i.e. 0.18 to 0.36 per cent of total zinc with mean of 0.32 ppm. In declined orchards it varied from 0.32 to 0.43 ppm i.e. 0.27 to 0.49 per cent of total zinc with mean of 0.37 ppm. Similar findings were reported by Iyengar and Deb (1977), Sinha and Prasad (1996) and Raina *et. al.*, (2003). The concentration of exchangeable zinc was least as compared to other fractions of zinc but greater than water soluble zinc. The exchangeable zinc was the most readily available form of soil for plant nutrition (Gowrisankar and Murugappan, 1998).

Complexed zinc

Complexed zinc fraction is a major source of plant available zinc in soil (Prasad *et. al*., 1996). The complexed zinc is most important fraction from plant nutrition point of view (Sarkar and Deb, 1982).

In healthy orchards it varied from 2.37 to 4.30 ppm i.e.1.87 to 4.06 per cent of total zinc with the mean 3.16 ppm while in declined orchards it ranged from 2.23 to 4.26 ppm i.e. 2.23 to 4.57 per cent of total zinc with the mean 3.21 ppm. Similar findings where reported by Prasad and Shukla (1996) and Raina *et. al*., (2003).

Organically bound zinc

The release and complexing of zinc by organic matter cause zinc to redistribute in soil solution and increased with higher organic matter due to release of complexed zinc through providing chelating agent for added zinc and reduce adsorption and precipitation. Organically bound zinc is an important fraction in predicting availability of zinc in soil (Sinha and Prasad, 1996).

Organically bound zinc varied from 0.85-1.80 ppm i.e. 0.72 to 1.79 per cent of total zinc with the mean 1.30 ppm in healthy Nagpur mandarin orchards. In declined orchards it varied from 0.91 to 1.85 ppm i.e. 0.79 to 1.97 per cent of total zinc with the mean 1.31 ppm. Similar observations were reported by Prasad and Shukla (1996), Gowrisankar and Murugappan (1998) and Raina *et. al*., (2003).

Occulated zinc

Occulated zinc fraction comprises the substantial part of zinc in mineral soil and it is associated with oxides and primary, secondary minerals. It is relatively unavailable to plants and it is extracted by using 0.1M HCL as a extractant (Iyengar and Deb 1977). The extractant 0.1M HCL being a strong mineral acid, might have attached the crystalline lattice structure partially dissolving the zinc fraction associated with it.

From the data of present investigation it was observed that occulated zinc varied from 1.31 to 2.83 ppm i.e. 1.18 to 2.50 per cent of total zinc with the mean of 1.91 ppm in healthy orchards. In declined orchards it varied from 1.37 to 2.78 ppm i.e. 1.18 to 2.47 per cent of total zinc with the mean value 1.93 ppm. These values very well coincided with Prasad and Shukla (1996) and Raina *et. al*., (2003).

Zinc bounded by crystalline oxides

Zinc bound by crystalline oxides comprises the major part of zinc in soil. It is bound by crystalline oxides and extracted by using the CBD (Citrated Bicarbonate Dithionite) as extractant.

Zinc bound by crystalline oxides varied from 2.47 to 4.67 ppm i.e. 2.01 to 4.27 per cent of total zinc with the mean of 3.89 ppm in healthy orchards. In declined orchards it ranged from 2.81 to 4.32 ppm i.e. 2.53 to 4.80 per cent of total zinc with the mean 3.42 ppm. The lower amounts of zinc bound by crystalline oxides observed in the present study might have resulted due to poor dissolution of crystalline Fe oxides by dithionite coupled with micronutrient precipitation. Similar results were reported by Edward raja and Iyengar (1986), Sinha and Prasad (1996) and Raina *et. al*., (2003).

Table 1. Zinc Fraction Status of Healthy Nagpur Mandarin Orchards.

S.N.	Depth (cm)	Different forms of zinc (ppm)							Total- Zn (ppm)	DTPA - Zn (ppm)
		WS - Zn	EXCH - Zn	COM - Zn	ORG - Zn	OCC-Zn	CBD- Zn	RES - Zn		
1	Location : Loni (Age of trees – 07 years)									
	0 - 20	0.21	0.42	4.13	1.56	1.92	3.91	105.25	117.40	0.56
		(0.18)	(0.36)	(3.52)	(1.33)	(1.63)	(3.33)	(86.95)		
	20 -50	0.20	0.29	4.22	1.48	1.46	4.12	92.23	104.00	0.63
		(0.19)	(0.27)	(4.06)	(1.48)	(1.46)	(3.96)	(88.68)		
	50 - 80	0.19	0.23	2.81	0.85	1.75	3.14	103.63	112.60	0.50
		(0.17)	(0.20)	(2.49)	(0.85)	(1.55)	(2.79)	(92.03)		
	80 - 100	0.20	0.34	4.05	1.28	1.98	3.80	109.77	121.60	0.41
		(0.16)	(0.28)	(3.33)	(1.28)	(1.63)	(3.12)	(90.27)		
2	Location : Dhanodi (Age of trees – 12 years)									
	0 - 20	0.22	0.31	3.94	1.80	2.27	4.25	110.41	123.20	0.84
		(0.18)	(0.25)	(3.20)	(1.46)	(1.84)	(3.44)	(89.62)		
	20 -50	0.22	0.31	3.25	1.29	1.38	3.31	106.64	116.40	0.42
		(0.19)	(0.27)	(2.80)	(1.11)	(1.18)	(2.84)	(91.61)		
	50 - 80	0.23	0.27	2.89	1.91	1.62	2.64	121.64	131.20	0.38
		(0.17)	(0.20)	(2.20)	(1.45)	(1.23)	(2.01)	(92.71)		
	80 - 100	0.25	0.33	2.49	1.78	1.31	2.47	90.97	99.60	0.32
		(0.25)	(0.33)	(2.50)	(1.79)	(1.31)	(2.48)	(91.33)		
3	Location : Bahda (Age of trees – 12 years)									
	0 - 20	0.27	0.35	4.30	1.19	2.82	4.51	114.67	128.20	0.69
		(0.21)	(0.27)	(3.35)	(0.93)	(2.20)	(3.52)	(89.45)		
	20 -50	0.23	0.33	3.85	1.17	1.37	4.17	102.48	113.60	0.52
		(0.20)	(0.29)	(3.39)	(1.03)	(1.20)	(3.67)	(90.21)		
	50 - 80	0.22	0.30	2.98	1.34	1.71	3.83	82.42	92.80	0.30
		(0.24)	(0.32)	(3.21)	(1.44)	(1.84)	(4.13)	(88.81)		
	80 - 100	0.24	0.30	2.73	0.94	1.80	3.92	94.47	104.40	0.32
		(0.23)	(0.29)	(2.61)	(0.90)	(1.72)	(3.75)	(90.49)		
4	Location : Temburkheda (Age of trees – 08 years)									
	0 - 20	0.22	0.36	2.82	1.20	1.63	3.12	119.25	128.60	0.80
		(0.17)	(0.28)	(2.19)	(0.93)	(1.27)	(2.43)	(92.73)		
	20 -50	0.23	0.33	3.31	1.18	1.83	3.50	126.82	137.20	0.62
		(0.17)	(0.24)	(2.41)	(0.86)	(1.33)	(2.55)	(92.43)		
	50 - 80	0.22	0.33	4.19	0.94	2.06	3.93	106.47	114.60	0.41
		(0.19)	(0.29)	(3.66)	(0.82)	(1.80)	(3.43)	(92.9)		
	80 - 100	0.23	0.36	2.88	1.75	1.51	3.27	115.00	125.00	0.41
		(0.18)	(0.29)	(2.30)	(1.40)	(1.21)	(2.62)	(92.00)		
5	Location : Dhanodi (Age of trees – 09 years)									
	0 - 20	0.23	0.37	2.89	1.31	2.83	4.33	101.4	113.20	0.63
		(0.20)	(0.33)	(2.55)	(1.16)	(2.50)	(3.82)	(89.43)		
	20 -50	0.21	0.33	2.47	1.17	1.33	4.12	86.77	96.40	0.52
		(0.21)	(0.29)	(2.56)	(1.21)	(1.38)	(4.27)	(90.01)		
6	Location : Warud (Age of trees – 15 years)									
	0 - 20	0.21	0.30	4.03	1.38	1.97	4.67	104.04	116.60	0.73
		(0.18)	(0.26)	(3.46)	(1.18)	(1.69)	(4.00)	(89.23)		
	20 -50	0.16	0.27	3.46	1.03	2.21	4.35	121.32	132.80	0.64
		(0.12)	(0.20)	(2.60)	(0.77)	(1.66)	(3.27)	(91.35)		
	50 - 70	0.19	0.23	2.37	0.91	1.82	3.72	117.76	127.00	0.42
		(0.15)	(0.18)	(1.87)	(0.72)	(1.43)	(2.92)	(92.72)		
	mean	**0.21**	**0.32**	**3.16**	**1.21**	**1.91**	**3.89**	**110.98**	**117.69**	**0.53**

(Value in the parenthesis indicate per cent over total zinc)

WS = Water soluble zinc, **EXCH** = Easily exchangeable zinc, **COM** = Complexed zinc, **ORG** = Organically bound zinc, **OCC** = Occulated zinc, **CBD** = zinc bound by crystalline oxides, **RES** = Resudual zinc

Table 2. Zinc Fraction Status of Declined Nagpur Mandarin Orchards

S.N.	Depth (cm)	Different forms of zinc (ppm) WS - Zn	EXCH - Zn	COM - Zn	ORG - Zn	OCC-Zn	CBD- Zn	RES - Zn	Total- Zn (ppm)	DTPA - Zn (ppm)
7	Location : Loni (Age of trees – 07 years)									
	0 - 20	0.21	0.42	2.47	1.46	2.13	2.84	95.47	105.00	0.42
		(0.20)	(0.40)	(2.35)	(1.39)	(2.03)	(2.70)	(90.92)		
	20 -50	0.20	0.37	3.37	1.04	1.47	3.73	96.23	106.40	0.45
		(0.19)	(0.35)	(3.16)	(0.98)	(1.38)	(3.50)	(90.44)		
	50 - 80	0.20	0.41	3.48	1.40	1.94	3.32	78.45	89.20	0.21
		(0.22)	(0.46)	(3.90)	(1.57)	(2.17)	(3.72)	(87.95)		
	80 - 100	0.19	0.42	3.45	1.33	1.84	4.24	105.53	117.00	0.2
		(0.16)	(0.36)	(2.95)	(1.14)	(1.58)	(3.62)	(90.20)		
8	Location : jamalpur (Age of trees – 15 years)									
	0 - 20	0.19	0.43	3.50	1.73	1.42	3.66	76.87	87.80	0.51
		(0.22)	(0.49)	(3.99)	(1.97)	(1.62)	(4.17)	(87.55)		
	20 -50	0.19	0.41	3.64	0.96	1.91	3.19	102.9	113.20	0.31
		(0.17)	(0.36)	(3.21)	(0.85)	(1.69)	(2.82)	(90.90)		
	50 - 80	0.20	0.42	4.2	1.19	1.86	3.93	80.00	91.80	0.30
		(0.22)	(0.46)	(4.57)	(1.30)	(2.03)	(4.28)	(87.15)		
	80 - 100	0.21	0.40	3.54	0.91	1.37	4.14	105.03	115.6	0.20
		(0.18)	(0.35)	(3.06)	(0.79)	(1.18)	(3.58)	(90.85)		
9	Location : jamalpur (Age of trees – 09 years)									
	0 - 20	0.23	0.39	2.75	1.61	2.57	2.63	93.62	103.8	0.42
		(0.22)	(0.37)	(2.65)	(1.55)	(2.47)	(2.53)	(90.19)		
	20 -50	0.23	0.40	2.44	1.05	2.34	2.57	100.17	109.2	0.39
		(0.21)	(0.37)	(2.23)	(0.96)	(2.14)	(2.35)	(91.73)		
	50 - 80	0.23	0.41	4.26	1.44	2.00	3.96	101.05	113.8	0.22
		(0.20)	(0.36)	(3.74)	(1.26)	(1.76)	(3.48)	(89.19)		
	80 - 100	0.24	0.37	3.43	0.96	1.99	3.52	110.69	121.2	0.20
		(0.20)	(0.30)	(2.83)	(0.79)	(1.64)	(2.90)	(91.33)		
10	Location : Pusla (Age of trees – 13 years)									
	0 - 20	0.24	0.36	3.87	1.70	1.78	3.33	86.32	97.60	0.51
		(0.24)	(0.37)	(3.97)	(1.74)	(1.82)	(3.41)	(88.44)		
	20 -50	0.24	0.36	3.06	1.41	1.66	3.48	104.79	115.00	0.54
		(0.21)	(0.31)	(2.66)	(1.23)	(1.44)	(3.03)	(91.12)		
	50 - 70	0.18	0.33	2.61	1.37	1.60	2.81	94.30	103.20	0.31
		(0.17)	(0.32)	(2.53)	(1.33)	(1.55)	(2.72)	(91.37)		
11	Location : Wathoda (Age of trees – 16 years)									
	0 - 20	0.24	0.32	3.16	1.85	2.78	3.73	107.52	119.60	0.46
		(0.20)	(0.27)	(2.64)	(1.55)	(2.32)	(3.12)	(89.89)		
	20 -50	0.20	0.32	2.23	1.10	1.68	1.68	79.35	89.20	0.36
		(0.22)	(0.36)	(2.50)	(1.23)	(1.88)	(4.84)	(88.96)		
	50 - 80	0.21	0.34	3.07	1.00	1.86	3.34	97.78	107.60	0.31
		(0.19)	(0.31)	(2.85)	(0.93)	(1.73)	(3.10)	(90.87)		
	80 - 100	0.22	0.34	3.45	1.31	1.93	3.58	73.77	84.60	0.30
		(0.26)	(0.40)	(4.08)	(1.55)	(2.21)	(4.23)	(87.20)		
12	Location : Dhanodi (Age of trees – 09 years)									
	0 - 20	0.25	0.35	2.84	1.83	2.03	3.13	82.57	93.00	0.39
		(0.27)	(0.37)	(3.05)	(1.97)	(2.18)	(3.36)	(88.78)		
	20 -50	0.21	0.33	2.49	0.90	1.97	2.82	100.68	109.40	0.30
		(0.19)	(0.30)	(2.28)	(0.90)	(1.80)	(2.58)	(92.03)		
	mean	**0.22**	**0.37**	**3.21**	**1.31**	**1.93**	**3.42**	**93.97**	**104.45**	**0.35**

(Value in the parenthesis indicate per cent over total zinc)

WS = Water soluble zinc, **EXCH** = Easily exchangeable zinc, **COM** = Complexed zinc, **ORG** = Organically bound zinc, **OCC** = Occulated zinc, **CBD** = zinc bound by crystalline oxides, **RES** = Resudual zinc

Residual zinc

Residual fraction of zinc is strongly bound to the soil minerals not being extracted by any of the reagent. This fraction may be considered as primary form of native zinc. Sarkar and Deb (1987) reported that residual zinc fraction contributed very little to plant uptake and it was evaluated by the difference between sum of all fractions and total zinc

It is seen from the results that bulk of native zinc was found in the residual fractions. In healthy orchards the residual zinc content varied from 82.42 to 126.82 ppm i.e. 88.68 to 92.97 per cent of total zinc with the mean 110.98 ppm where as in declined orchards the residual zinc content varied from 73.77 to 107.52 ppm i.e. 87.15 to 92.03 per cent of total zinc with the mean 93.79 ppm. Similar observation reported by Prasad and Shukla(1996) and Raina *et. al*., (2003)

Total zinc

Data pertaining to total zinc content of soil in healthy Nagpur mandarin orchards indicated that total zinc content varied from 92.8 to 137.2 ppm while in declined orchards it varied from 84.9 to 121.2 ppm. Similar findings where reported by Prasad and Shukla (1996) and Raina *et. al*., (2003).

DTPA – Zn

It is evident from the result that available zinc content in healthy and declined Nagpur mandarin orchards varied from 0.56 to 0.84 ppm and 0.39 to 0.51 ppm in surface soil samples, respectively. It was further observed that by and large, the soil samples from declined Nagpur mandarin orchards soils contained comparatively less available zinc than healthy orange orchards soils. Similar observation was also reported by Awasthi *et. al*., (1984). The critical limit for available zinc is 1.0 ppm (Anonymous, 1991) so zinc content in all declined Nagpur mandarin orchards showed low availability of zinc which may be due to non application of zinc and may be attributed to excessive potassium in the soil as earlier reported by Nijjar and Singh (1971).

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Income and Expenditure Status of the Farmers who committed Suicide in Vidarbha Region

N. M. Kale[1], S. R. Khonde [2] and D.M.Mankar [3]

ABSTRACT

The average annual income and expenditure of the selected victims were Rs. 27,924 and Rs. 37,120 respectively. There existed an overall income gap of Rs. –9196 among annual income and annual expenditure of the victims. Thus, this study shows the dreadful condition of the households that victims were in severe distress due to the income that they derived from all sources was not even enough to meet the essential family expenditure. Hence, for managing this gap between income and expenditure, deceased farmers might have borrowed possibly loans from various credit sources to meet the family expenditure. Hence, this research study clears that almost in all victims, livelihood was not found to be sustainable and low annual income might be the one of the causes of farmers' suicide in Vidarbha.

In recent years, a larger agrarian crisis, particularly in low rainfall and low irrigation tracts of Vidarbha region of Maharashtra has precipitated a spate of suicide death among farmers. This is now public policy concern and has been scholarly attention. As per Government record total 5036 farmers committed suicide during 2001 to 2008 in suicide hit six districts of Vidarbha, where PM's Package is going to implement. These districts are Yavatmal, Buldana, Amravati, Akola, Washim from Amravati revenue division and Wardha from Nagpur revenue division.

"To be, or not to be." (Shakespeare, Hamlet) has been an important question among thinkers (Rauscher, 2000). As suicide is a complex social and psychological phenomena, which factors are mostly responsible for suicides in Vidarbha region of Maharashtra and which factors should have to be taken for study is a big question among researchers. However, Madan (1980) and Singh (2005) pointed out that the causes of suicide are complex as are the causes of any social phenomenon. Many factors combine to cause one particular individual (and not another) to divert his aggression upon himself in the form of suicide. Durkheim (2002) also pointed out that the neurobiological and socio-economic dimensions of risk factors are responsible for committing suicide but the intersection of these two sets where the relative risk of committing suicide is higher.

In recent review of the neurobiological literature, Mann (2002) cleared that the neurobiological risk factors are predisposing in nature and they internally exist with the individual, for example, reducing serotonin input to the brain and disorder of the central nervous system, particularly those affecting the pathology of the brain carry a higher relative risk of suicide in an individual. The neurobiological risks factors internally exist with an individual, hence it becomes difficult to study and identify. However, the socio-economic dimensions of risk factors that are external to the individual become important and they are precipitating in nature, can be identified. Hence, for the current research study of farmers' suicide, researcher has formulated research methodology for assessing the livelihood sustainability of an individual deceased farmer and his family members with the following objectives.

1. To find out the annual income and expenditure of the farmers' who committed suicide in Vidarbha region.
2. To find out the income gap between annual livelihood income and expenditure of the farmers committing suicide in Vidarbha region.

MATERIAL AND METHODS

The present study was based on exploratory design of social research and carried out in six districts of Vidarbha region of Maharashtra where percentage of farmers' suicide was found relatively more than other districts.These districts were Yavatmal, Washim, Buldana, Akola, Amravati from Amravati revenue division and Wardha from

1. Associate Prof., 2. Ex-Director of Extension Education and 3. Head, Department of Extension Education, Dr. PDKV, Akola

Nagpur revenue division. In this study respondents were the households of selected victim who committed suicide during 1st January 2006 to 31st December 2006 and had declared as a legal victims by district level committee headed by Collector of the respective district, for allotting compensation of Rs. 1 lakh and had got Rs. 1 lakh compensation. The time period 1st January to 31st December 2006 was selected purposively as in this period maximum number of suicides were committed in selected districts of Vidarbha. Before sampling researcher had contacted personally to the collector offices of these selected districts, and obtained the complete list of farmers those who committed suicide during 1st January to 31st December 2006. In all, there were 1448 total suicide cases in selected six districts, out of which 874 cases were declared as illegal and 574 cases were declared as legal victims. From the list of 574 legal suicide cases, researcher had selected 200 victims by proportionate method of random sampling. It covered 178 villages and 34 *tahsils / talukas* of six districts. As suicide is a sensitive social issue and thus the investigation has to be made with very guarded and careful manner, and without hurting the sentiments of the family. Data were collected by personal interview method with the help of structured interview schedule. Interview was conducted at residence of respondent so as to review over all situation of the family by researcher.

RESULTS AND DISCUSSION

Annual income of the Victims

Income is a major determinant of the economic status of an individual. Every individual's style of living is decided largely by his income. His expenditure on farming, allied occupations, household matters, indebtedness, and fulfillments of family responsibilities is decided by the income he earns. Every thing can be adjusted but not the money. Low income creates very difficulty for an individual to manage affairs of the family. Such people become discouraged and cannot perform their functions properly (Madan, 1980). Keeping this in view, the annual income was considered for the study. The distribution of selected victims according to their annual income has been presented in Table 1. From table 1, it is observed that majority of the victims (62.00%) had annual income upto Rs.25,000. This was followed by over one fourth (29.00%) respondents belonging to the annual income between Rs. 25,001 to Rs. 50,000, whereas 5.50 per cent of victims had annual income between Rs. 50,001 to Rs. 75,000 and only 3.50 per cent deceased farmers had annual income above Rs. 75,000. The average annual income of all victims' household was Rs. 27,924, which included cultivation, wages, non-professional business income, service/ pension and income from allied occupations. Thus, it is observed that majority of suicides were concentrated having annual income upto Rs.25, 000 (62.00%) and between Rs. 25,001 to Rs. 50,000 (29.00%). It is clearly revealed that as the income level declines, the rate of suicide increases. Hence, the low income of the farmers has been proved as important specified cause of farmers' suicide in Vidarbha region of Maharashtra.

Table 1: Distribution of victims according to their Annual income (2005-06)

S.N.	Annual income	Number of victims	Percentage
1.	Up to 25,000	124	62.00
2.	25,001 to 50,000	58	29.00
3.	50,001 to 75,000	11	5.50
4.	Above 75,000	7	3.50
	Total	**200**	**100.00**

Average income Rs.27, 924

Expenditure pattern of the households

Expenditure pattern is the indicative of the standard of living and ability of the respective groups to spend under different items. In the present research study, it was assumed that those who committed suicide in Vidarbha region their essential family expenditure did exceed than their annual income and they might have come under financial tension for fulfilling the growing urgent family needs. In the present study, actual expenditure made by the households on different livelihood items, like expenditure on food, clothing, housing, education, health, traveling, lighting, religious functions, agriculture, taxes, etc., has been studied and data have been presented in detail in Table 2. It could be observed from table 2 that out of total expenditure of overall deceased farmers, the expenditure on food has largest share contributing nearly 60.00 per cent (59.41%), followed by expenditure on health, religious functions and clothing (10.20, 7.09 and 6.20 per cent share, respectively). The expenditures on agriculture, education, traveling and lighting were

Table 2 : Annual expenditure pattern of the victims' household on different Items (2005-06)

S.N.	Items	Amount in Thousand	Percentage
1	**Food**	4410.40	**59.41**
2	**Clothing**	460.30	**6.20**
3	Housing	55.80	0.75
4	**Education**	306.55	**4.13**
5	**Health**	756.90	**10.20**
6	Traveling	271.95	3.66
7	Lighting	217.38	2.93
8	**Religious functions**	526.70	**7.09**
9	**Agriculture**	334.03	**4.50**
10	Taxes	30.72	0.41
11	Others	53.30	0.72
	Total	**7424.04**	**100.00**

4.50, 4.13, 3.66 and 2.93 per cent, respectively. While shares of expenditure on housing (repairs / construction), taxes and others were noted very negligible.

Gap between Income and Expenditure of the deceased farmers:

For demonstrating, the income and expenditure status of the deceased farmers, researcher tried to show the gap between income and expenditure of the deceased farmers, because in majority of deceased farmers expenditure was found to be more than their annual income. For this, annual income and expenditure of the victim's households have been taken into consideration and data have been presented as per the amount of gap between annual income and expenditure among each victim, across land holding groups and across respective caste groups.

Identified gap between annual livelihood income and expenditure

For identification of gap between annual livelihood income and expenditure of each victim, the annual expenditure of each victim is deducted from his annual income from all sources. Distribution of selected victims according to their identified gap between annual livelihood income and expenditure is presented in Table 3. It is evident from Table 3 that out of 200 victims, among only 24 (12.00 %) victims there was no gap between annual livelihood income and expenditure that meant their livelihood income

Table 3: Distribution of selected victims according to their identified gap between annual livelihood income and expenditure

S.N.	Gap range in Rs.	Number of Victims	Percentage
1	No Gap	24	12.00
2	Upto 3000	29	14.50
3	3001 to 6000	32	16.00
4	6001 to 9000	42	21.00
5	Above 9000	73	36.50
	Total	200	100.00

Average Gap = Rs. – 9196

was enough to fulfill the essential family expenditure. While among rest of the 88.00 per cent victims, gap was observed, that meant their annual income was short for fulfilling the essential livelihood expenditure of the family. Gap was noted, upto Rs. 3000 among 14.50 per cent victims, Rs. 3001 to Rs. 6000 among 16.00 per cent victims, Rs. 6001 to Rs. 9000 among 21.00 per cent cases, while among more than one third (36.50 %) victims, gap was found to be above Rs. 9000. The average gap was observed of Rs. 9196. It is shown by putting negative sign because expenditure amount is more than income amount. From the data it is clear that as the gap between income and expenditure increased, the suicide rate also increased and hence it is clear that present spate of suicide in Vidarbha was due to economic crisis.

Gap between income and expenditure across land size

The results of average income, expenditure and gap between income and expenditure of selected households across land holding group has been presented in Table 4. It is obvious from the Table 4 that the average annual income of all the selected households came to be Rs. 27924 per household, which included cultivation, wages, allied occupations, non-professional business and service/pensions. While the average expenditure worked out to be Rs. 37120. Here shockingly to note that in all land size group the average annual expenditure was higher, than the annual income by Rs. 9196.

A critical examination of the data shows that the annual income and expenditure of the deceased farmers were increased with the increase in their land holding. While deducting the average

Table 4: Average livelihood income, expenditure and gap between income and expenditure of victims' household across land holding (Year 2005-2006)

S.N.	Land size	Number of victims	Per household		Gap between income & expenditure
			Income	Expenditure	
1.	**Upto 1.00 Ha.** (Marginal)	47 (23.50)*	17023	25330	-8307
2.	**1.01-2.00 Ha.** (Small)	87 (43.50)	24706	35439	-10733
3.	**2.01-4.00 Ha.** (Semi medium)	41 (20.50)	29415	37145	-7730
4.	**4.01-10.00 Ha** (Medium)	25 (12.50)	57168	65096	-7928
	Total	200 (100.00)	27924	37120	-9196

* Figures in parenthesis indicate percentage

Table 5 : Average livelihood income, expenditure and gap between income and expenditure of victims' household across Caste group (Year 2005-2006)

S.N.	Caste category	Number of victims	Per household		Gap between income & expenditure
			Income	Expenditure	
1	SC	24	24820	31072	- 6252
2	ST	10	15850	26000	-10150
3	VJ-A	15	30593	35105	-4512
4	NT-B	11	23936	32491	-8555
5	NT-C	10	29860	39543	-9683
6	NT-D	03	15666	22373	-6707
7	OBC	114	30303	40301	-9998
8	SBC	08	18962	24989	-6027
9	Open	05	43280	55488	-12208
	Total	**200**	**27924**	**37120**	**-9196**

income of the victims' household from expenditure across at each land size groups, it is also evident that more or less in four mentioned land size groups, the expenditure exceeded than income and hence gap between income and expenditure was negative. It was more (Rs. -10733) in small farmers (having land, 1.01-2.00 ha), followed by marginal (Rs. -8307). While in medium and semi medium land size group it worked out to be Rs. -7928 and Rs. -7730, respectively.

Gap between income and expenditure across caste groups

Gap between income and expenditure within each caste group is workout and presented in Table 5. From the data presented in Table 5, it was also observed that more or less in all caste groups, victims' expenditure exceeded than their annual income. Hence the gap between income and expenditure was negative and noted in the range of Rs. -4512 to Rs. -12208. The higher gap was noted among OPEN caste group (Rs.-12208), followed by ST caste group (Rs.–10150), OBC (Rs.–9998) and NT-C (RS. – 9683), than overall gap of Rs. –9196.

Thus, it could be concluded that the more or less similar trend was observed in all land size and caste groups, that their annual expenditure was more than the annual income. There existed overall gap of Rs. -9196. Similarly, it was noted that gap between income and expenditure was found to be more than overall gap among small farmers (having land 1.01-2.00 ha) and in OPEN, ST, OBC and NT-C caste groups.

CONCLUSION

It was observed that majority of the victims were from small and marginal holding groups. Almost all holdings were rainfed, hence non remunerative. This study shows the dreadful condition of the households that victims were in severe distress due to the income that they got from all sources was not even enough to meet the essential expenditure of the households. Hence, there existed an overall gap of Rs. -9196. For managing this gap between income and expenditure, deceased farmers might be possibly borrowing loans from various credit sources to meet the family expenditure. Hence, this research study clears that almost in all victims, livelihood was not found to be sustainable and thus this might be the one of the causes of farmers' suicide in Vidarbha.

This study suggests that this situation can be improved, if economic empowerment is ensured by creating subsidiary occupations in study area. It is observed that 99 per cent of respondents (suicide victims) had no subsidiary occupations to support their livelihood and majority of them had medium to large family size. This implies that efforts are needed by respective line departments to involve such farmers in goat farming, dairy, small dairy unit with one or two milch animals and small poultry unit. Small units of subsidiary as mentioned herein are within the reach of most of the farmers because family labour are abundant, require low fodder and can be produced in available land and marketing of meat, eggs, milk is high. The movement is also relatively easy. This is very effective way to bring the distressed poor farmer's families to uplift economically strong position. In future, efforts can be directed to organize these farmers to form bigger units, may be on co-operative basis, but initially establishment of such enterprises well within the potential of the individual farmer is necessary. In addition to this, it is also suggested to motivate a few farmers' household from big families to migrate willingly for search of better employment opportunities to ease the pressure on their own land. Policy makers have to think for increasing irrigation potential in study area for remunerative farming.

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Impact of Nutrition Improvement Technology Training on Adolescent Girls

Manisha P. Kale[1], Asha G. Mane[2], P.W. Kale[3] and Neeta M. Sakarkar[4]

ABSTRACT

Adolescent girls, who are future mothers, can provide our nation efficient working healthy population if they are empowered with Nutrition Improvement Technologies (Seema Chaudhri, 2003). In this context, a study on impact of nutrition improvement technologies (NITs) training among adolescent girls was conducted during 2004-06. A sample of 400 adolescent girls was drawn from four blocks of Amravati district; two villages from each block and 50 adolescent girls from each village by resorting to random sampling technique at every stage. System approach of training was followed for providing training to adolescent girls. Dependent variable in the study was impact of training about NITs in terms of change in adoption behaviour of adolescent girls, that is, change in knowledge, attitude and practice. To assess the significance of difference between before and after training, period 't' test was applied and it was found highly significant at .01 level of probability for knowledge, attitude and practice. Percentage change was calculated for each dimension of adoption behaviour. Based on composite mean of all the three dimensions, it could be clearly stated that the NITs found to be the most popular among the adolescent girl trainees to the extent of 85.78 per cent change over and above.

A developing country, like India, is in dire need for efficient healthy population to improve its economic condition and compete with other nations. India is predominantly an agricultural country, nearly 80 per cent of its population lives in rural areas. Due to poverty, illiteracy and superstitions prevalent in rural areas, people in the villages are far away from scientific and technological developments, especially in nutrition, hence people in the villages are centuries behind their metropolitan counterparts. In order to bridge the gap between the two, an extension education and transfer of technology seem to be in its real perspective for bringing overall development, in general, and nutrition improvement, in particular.(Puri, 1984, Rao,1994 and Jain, 1998). Nutrition Improvement Technologies (NITs) refer to preservation technology of *Chuteny* from locally available sources i.e. instant *Chuteny*, tamarind *Chuteny*, tomato *Chuteny*, and turmeric *Chuteny*, simple preservation technology of selected simple nutritious lunch, dinner foods from locally available food sources i.e. *Khichari* with vegetables, *Satupeeth*, sweet *Thalipeeth*, radish *Paratha*, *Adai*, wheat and green gram *Dal Laddu*, and simple processing and preservation technologies of fruit and vegetable available locally i.e., mix vegetable pickle, tamarind sauce, fruit jelly and fruit jam. It is in this context, a study on impact of nutrition improvement technology training among rural adolescent girls was undertaken with the objective: To assess the impact of nutrition improvement technology training among rural adolescent girls. Execution of the present study with these technologies is very important to encourage traditional recipes with the value addition with locally available sources of foods and also helpful to improve nutritional status of all sections of society.

MATERIAL AND METHODS

The present investigation was carried out in Amravati district of Maharashtra state. Four blocks, namely Amravati, Chandur Railway, Nandgoan Khandeshwar and Bhatkuly were selected randomly from the district. Two villages from each block and 50 adolescent girls from each village were selected randomly, thus making a total of 400 adolescent girls which constituted sample respondents for the present study. Training plan was fixed considering the target group, probable training result, time period required for training programme, schedule and dates of training module. Training responsibility was specified for project personnel.

1. Reader, 2. Professor , 3. Head, Dept. of Business Organization, Vidhya Bharati Mahavidhyalaya and 4. Research Associate, Department of Home Science, Sant Gadge Baba Amravati University, Amravati

Under independent variables age, education, occupation, monthly income and size of family were selected. Dependent variable in the study was the impact of training of NITs. It was measured in terms of change in adoption behaviour of adolescent girls i.e. change in knowledge, attitude and practice. Adoption behavior of an individual is a complex phenomenon comprising knowledge about technology and practicing it for a longer time, till it is routinized into their daily practices and get popularized among people (Sharma and Sharma, 1993). In order to measure knowledge, attitude and practice in the quantitative terms, teacher made tests were developed. The test consisted 21 items for knowledge and 8 items for practice. Then these items were converted into statements. The statements of knowledge, attitude and practice (KAP) tests were administered to the respondent trainees to elicit their responses. The responses were rated on three point continuum. The changes occurred on the three dimensions of adoption behaviour i.e., change in knowledge, attitude and practice about NITs among the adolescent girls as an effect of training imparted to them, have been studied and measured dimensions wise in terms of per cent change. Per cent change was computed for all the three dimensions of adoption behaviour i.e., knowledge, attitude and practice (KAP) with the help of formula, as below:

$$\text{Impact in terms of per cent change} = \frac{\text{Sum of Post Training Score on} - \text{Sum of Pre Training Score}}{\text{Sum of pre training score}} \times 100$$

RESULTS AND DISCUSSION

1. Socio personal and economic characteristics of adolescent girls

The profile of trainees was studied in terms of their socio personal and economic characteristics. The study of these characteristics was made with reference to age, education, occupation, monthly income and size of family. The data in this regard have been furnished in Table 1.

Study of Socio personal and economic characteristics of adolescent girls revealed that majority of (58.75 %) girls were in the age range of 16 to 17 years, had educated up to high school level, (97.75 %), belonged to medium sized family (61.50 %), had income from labour (80.00%), as a principal source of subsistence in between Rs. 3001 to 5000 (74.50 %).

Table 1: Distribution of trainee respondents according to their socio personal and economic characteristics

S. N.	Particulars	Respondents (n=400)	
		Number	Percentage
1	**Age (Yrs.)**		
	14 to 15	165	41.25
	16 to 17	235	58.75
2	**Education**		
	S.S.L.C.	391	97.75
	H.S.S.C.	9	2.25
3	**Occupation**		
	Labour	320	80.00
	Farmer	32	8.0
	Business	48	12.00
4	**Monthly Income**		
	Low (Upto 3,000)	88	22.00
	Medium (3,001to 5,000)	298	74.50
	High (Above 5,000)	14	3.50
5	**Size of Family**		
	Small (Upto 4 members)	124	31.00
	Medium (5 to 7 members)	246	61.50
	Big (Above 7 members)	30	7.50

Table 2: Distribution of respondents according to knowledge, attitude and practice (Before and after)

S. N.	Particulars	Knowledge			Attitude			Practice		
		L	M	H	UF	F	HF	L	M	H
1	Before exposure to training	174 (43.75)	211 (52.75)	15 (3.75)	153 (38.25)	17 (43.25)	74 (18.50)	189 (47.25)	163 (40.75)	48 (12.00)
2	After imparting training	23 (5.75)	01 (0.25)	376 (94.00)	12 (03.00)	14 (03.50)	374 (93.50)	06 (1.50)	29 (7.25)	365 (91.25)

The figure in the parenthesis indicates percentage

L - Low   M - Medium   H - High   UF - Unfavourable   F - Favourable   HF - Highly Favourable

2. Knowledge, Attitude and Practice

Knowledge, attitude and practice of trainee respondents were examined before and after training about NITs and presented in Table 2.

The percentage of respondents after exposing them to training found to be much higher than the percentage (3.75 %) before imparting training to them in the knowledge category. In the same way, 93.50 per cent trainee respondents developed highly favourable attitude after the training programme and 91.25 per cent respondents found to use the nutrition improvement technologies regularly in their daily life after exposing them to the training.

Hence, it can be concluded that training was very effective in providing knowledge and developing favourable attitude towards about NITs for adolescent girls. Training and organizer played a crucial role in changing their practices towards NITs positively.

3. Impact of NITs

3.1 Impact of NITs in terms of per cent change

Impact of NITs has been opertionalized as the adoption behaviour of the adolescent girls about NITs as a consequence of the training imparted to them. Adoption behaviour is a composite measure of the KAP. Per cent change was calculated for each dimension of adoption behaviour. Mean per cent change of knowledge, attitude and practice was calculated and termed as impact of training, and the data have been presented in Table 3.

Table 3: Impact of NITs in terms of per cent change

S.N.	Impact dimension	Per cent change
1	Knowledge	88.43
2	Attitude	88.46
3	Practices	80.46
	Overall Mean	**85.78**

Table 3 reveals that per cent change in knowledge, attitude and practice was 88.43, 88.46 and 80.46, respectively. Based on the composite mean of all the three dimension it could be clearly stated that NITs found to have impact on the adolescent girls trainees to the extent of 85.78 per cent change over and above.

3.2 Testing the significance of the difference between two means of before and after participation in training by the adolescent girls

With view to examine the effect of training in terms of change in knowledge, attitude and practice (KAP), if any, the means of KAP before training and after training were worked out. The significance of difference of the means (before, after) was analysed by employing paired ‘t’ test and the data thus obtained have been furnished in Table 4.

Table 4: Testing the significance of difference between two means before- after participation in training

S.N.	Particulars	Mean		Difference	‘t’ value
		Before	After		
1	Knowledge	25.95	48.87	22.92	53.81**
2	Attitude	20.06	74.57	54.51	48.81**
3	Practice	10.97	19.29	8.32	53.86**

** Significant at .01 level of probability

Table 4 reveals that the 't' value in respect of knowledge (53.81), attitude (48.81) and practice (53.86) found to be highly significant at 0.01 level of probability. It could, therefore, be stated that the training did increase the knowledge, attitude and practices of NITs among the rural adolescent girls who had undergone the training.

CONCLUSION

From the results emerged out of the present study, researchers have drawn certain conclusions and the same have been presented as below.

- Well designed training programme based on the needs of the trainees resulted in gain in their knowledge, change in their attitude and practices substantially which ultimately led to adoption, as could be seen from the significant impact.
- Adolescent girls, target group of the study, realized the fact that improvement in nutritional status of the whole family was very essential to achieve good health, which should be the first priority in their life. They were also made aware about nutrition improvement technologies and its importance in making the family healthy through organizing and leaving its significant impact on them.

Implications

More than 80 per cent of the change in knowledge, attitude and practice of NITs was brought out by the training programme among the adolescent girls with over all mean 85.78per cent. This gives out the latent implication that the training was very effective in popularizing the NITs among the adolescent girls leading to improving their health status through routinizing in their daily diets. This calls for attention of the state department of health services administration to take up necessary steps in this regard and promote NITs among the rural masses through organizing appropriate trainings at grass root level.

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Total Factor Productivity of Cotton in Central Vidarbha Zone

Shubhangi Alexander[1], S. S. Marawar[2], G. B. Malthane[3] and S.W. Jahagirdar[4]

ABSTRACT

The study was carried out using Tornqvist-Theil Chained Divisia Index Number approach. The results of the study indicated that the growth in output was higher in first period and thereafter it was more or less same during overall period. At overall level, among the different inputs used in production of cotton, the growth of inputs like seed, machine labour, manures, fertilizers and rental value of land were significantly increased over the years. This study revealed that amongst eighteen years, three years were said to be the best where output index was higher than input index. Over the entire period of study the output index recorded a growth rate of -1.09 per cent annum $^{-1}$ while, input index was -1.18 per cent annum^{-1} which was slightly lower than output index resulted in a incline in total factor productivity by 0.10 per cent annum^{-1}

Increased use of inputs, to a certain extent, allows agricultural sector to move up along the production surface by increasing yield unit^{-1} area. Their use may also induce an upward shift in production function to the extent that a technological change is embodied in them. It has long been recognized that partial productivity measures, such as output unit^{-1} of individual inputs are of limited use as indicators of real productivity change as defined by a shift in a production function. Most studies focus on the estimate of the effects of technological change in agriculture as a whole or total crop production. Owing to non-availability of input allocation data on individual crops, this may overestimate or under estimate technological change which is one of the most important factors affecting crop production and is ought to be examined for individual crop.

Analysis of total factor productivity attempts to measure the amount of increase in total output which is not accounted for by increase in total inputs. Changes in the TFP index can be used as one measure of the effects of the technological change (Dhillon and Ali, 2002, Kumar Praduman and Mruthyunjaya, 1992).

Main purpose of this paper is to study growth of input and productivity in cotton production in Central Vidharbha Zone and to study Total Factor Productivity (TFP) of cotton in Central Vidharbha Zone.

MATERIAL AND METHODS

Central Vidarbha Zone includes districts like Nagpur, Yavatmal and Wardha. The study was carried out from 1987-88 to 2004-2005. Data pertaining to inputs used and its value were collected from Agriculture Price Scheme, Department of Agricultural Economics and Statistics, Dr. PDKV, Akola and secondary data were obtained from various government publications.

Analytical tools

i. Compound growth rates

These growth rates were estimated using following exponential model.

$$Y = ab^x e^u$$

Where,

Y = Dependent variable

a and b = Parameters

x = Period (in years)

u = Error term

The above equation is reduced to the following linear function, on taking logarithms on both sides,.

$$\log Y = \log a + X (\log b) + u$$

Compound growth rate was estimated by -

$$CGR = [\text{Antilog} (\log b) - 1] \times 100$$

Analysis of Total Factor Productivity (TFP)

The Divisia- Tornqvist index is used for computing the total output, total input, input price and total factor productivity indices. For calculating input indices and price indices, following inputs were considered - Male labour (days ha^{-1}), Female labour (days ha^{-1}), Bullock labour (days ha^{-1}), Machine labour (days ha^{-1}), Seed (kg ha^{-1}), Manure (t ha^{-1}), Fertilizer (kg ha^{-1}) i.e. N, P, K, Insecticide (l ha^{-1}) and Rental value of land (Rs. ha^{-1}). Main and by produce were included for calculating output index.

1.Assistant Prof. 2. Ex. Professor and Head 3. Assistant .Prof, and 4. Associate Prof; Department Agril. Economics and Statistics, Dr.P.D.K.V; Akola.

Tornqvist-Theil Divisia Chained Index Number Approach

Tornqvist-Theil index is considered as the superior index for calculating total factor productivity (Kumar praduman and Rosegrant, 1994, Dholakia and Dholakia, 1993). Total output, total input, TFP and input price indices were calculated, as follows :

Total Output Index (TOI)

$(R_{jt} + R_{jt-1}) / 2$

$TOI_t / TOI_{t-1} = \pi_j (Q_{jt} / Q_{jt-1})$

Total Input Index (TII)

$(S_{it} + S_{it-1}) / 2$

$TII_t / TII_{t-1} = \pi_j (X_{it} / X_{it-1})$

Input Price Index (IPI)

$(S_{it} + S_{it-1}) / 2$

$IPI_t / IPI_{t-1} = \pi j (P_{it} / P_{it-1})$

Where,

R_{jt} = Share of output j in total revenue

Q_{jt} = Output j

S_{it} = Is the share of input i in the total input cost

X_{it} = Quantity of input i

P_{it} = Price of input i, all in period t

For productivity measurement over a long period of time, chaining indices for successive time period is preferable with chain-linking, an index is calculated for two successive periods t and t-1 over the whole period to T (samples from time t=0 to t=T) and the separate indices are then multiplied together.

TOI(t) = TOI (1) . TOI(2) ……… TOI(t-1)

TII(t) = TII(1) . TII(2) ………… TII(t-1)

IPI(t) = IPI(1) . IPI(2) ………… IPI(t-1)

Total factor productivity index (TFP)

$\mathbf{TFP_t = (TOI_t / TII_t)}$

The average annual growth rates were calculated by taking average of index of second year minus index of previous year. However, growth in the total factor productivity was calculated by taking subtraction of growth in output index minus input index.

RESULTS AND DISCUSSION

The growth rates of inputs and output of cotton are presented in Table 1

The results of the study indicated that the growth in output was higher in first period and thereafter it was more or less same during overall period. At overall level, among the different inputs used in production of cotton, the growth of inputs like seed, machine labour, manures, fertilizers and rental value of land were significantly increased over the years. As regards to inputs like human labour, bullock labour, and insecticides, its use over the year was more or less same.

Table 1. Growth rate of inputs and output of cotton

	Input and output	Growth rate		
		Period I	Period II	Overall period
	Output (q ha^{-1})	4.01	3.05	0.82
	Inputs			
1.	Seed	1.15	1.99	3.13***
2.	Human labour (days ha^{-1})			
i.	Male	7.52***	5.75*	0.41
ii.	Female	1.87***	3.59	0.45
3.	Bullock labour (days ha^{-1})	0.25	0.45	0.13
4.	Machine labour (days ha^{-1})	3.35	9.28	6.97***
5.	Manures (q ha^{-1})	6.15***	3.52	3.31***
6.	Fertilizers (kg ha^{-1})			
i.	N	6.16***	0.45	3.37***
ii.	P	7.23***	2.38	3.11***
iii.	K	6.88***	3.08**	3.76***
7.	Insecticides (l ha^{-1})	16.19	6.44	2.85
8.	Rental value of land (Rs.ha^{-1})	19.30***	5.19	8.69***

*** Indicate significance at 1% level of probability, ** Indicate significance at 5% level of probability
* Indicate significance at 10% level of probability

Measurement of total factor productivity

The total output index (TOI), total input index (TII) and total factor productivity index (TFP) and its average annual growth rate are presented in Table 2 and 3, respectively.

Table 2 : Tornqvist – Theil Divisia Index of output, input and TFP of cotton

Year	Output index	Input index	TFP
1988-89	100.00	100.00	100.00
1989-90	156.922	88.95	176.43
1990-91	87.73	105.62	83.06
1991-92	75.11	102.36	73.38
1992-93	128.43	92.77	138.45
1993-94	153.22	92.52	165.60
1994-95	102.25	103.05	99.22
1995-96	108.07	109.22	98.95
1996-97	105.70	92.69	114.04
1997-98	43.162	71.36	60.49
1998-99	156.44	122.27	127.95
1999-2000	181.65	95.61	189.80
2000-01	65.30	88.69	73.62
2001-02	115.96	110.34	105.09
2002-03	102.16	84.24	121.26
2003-04	129.78	98.59	131.64
2004-05	82.63	81.11	101.88

Over the entire period of study, the output index recorded a growth rate of -1.09 per cent annum^{-1}. During the same period, input was -1.18 per cent annum^{-1} which was slightly lower than output index resulted in a incline in total factor productivity by 0.10 per cent annum^{-1}. During the first period, the growth in output index was 1.15 per cent annum^{-1} and growth in input index was 1.32 per cent annum^{-1} and total factor productivity recorded a growth rate of -0.17 per cent annum^{-1}. In the second period, the growth in output index and input index was declined by -2.83 and -3.12 per cent annum^{-1}, respectively which resulted in a increase of total factor productivity by 0.29 per cent annum^{-1}. The incline in total factor productivity was not only due to output growth but also due to proportionally low increase in the use of inputs.

Table 3 : Average annual growth rates of output, inputs and TFP indices of Cotton

Period	Output index	Input index	TFP
Overall period	-1.09	-1.18	0.10
Period I	1.15	1.32	-0.17
Period II	-2.83	-3.12	0.29

Thus, study reveals that amongst eighteen years, three years were said to be the best i.e., 1989-90, 1993-94 and 1999-2000, wherein output index was higher than input index. The reason might be that in these years actual rainfall received was higher than normal rainfall and timely onset of monsoon, while remaining five to six years were said to be bad years for production of cotton. This might be because of late onset of monsoon particularly during 1996-97 and 1997-98 and occurrence of drought in the year 1997-98.

CONCLUSION

1. The results of the study indicated that the growth in output was higher in first period and thereafter it was more or less same during overall period. At overall level, among the different inputs used in production of cotton, the growth of inputs like seed, machine, labour, manures, fertilizers and rental value of land were significantly increased over the years.
2. This study revealed that amongst eighteen years, three years were said to be best where output index was higher than input index.
3. Over the entire period of study the output index recorded a growth rate of -1.09 per cent annum^{-1} while, input was -1.18 per cent annum^{-1} which was slightly lower than output index resulted in a incline in total factor productivity by 0.10 per cent annum^{-1}.

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Cost of Feeding Crossbred Calves Under Different Housing Systems and Probiotic Supplementation

S.N. Rokde[1], U.V. Galkate[2], R.M. Zinjarde[3] and S. G. Thote[4]

ABSTRACT

The present investigation was carried out to estimate the cost of feeding crossbred calves for a period of six months .The overall findings of the present study showed that, the cost of feeding skimmed milk to the crossbred calves was the largest cost component of feeding and contributed nearly 63 per cent of the total cost of feeding the crossbred calves. The cost of feeding skimmed milk to the crossbred calves was highest in H_3 P_1 (Rs 4118.31) and lowest in H_3 P_0 (Rs.3786.72). The effects of probiotic supplementation on cost of whole milk, cost of forage and total cost of feeding were found to be highly significant($P<0.01$), whereas, the effects of probiotic supplementation on cost of skimmed milk and cost of concentrate were found to be non- significant ($P>0.01$). The effect of housing systems on cost of concentrate and cost of forage were found to be highly significant($P<0.01$), whereas, the effects of housing systems on cost of whole milk, skimmed milk and total cost of feeding were found to be non- significant ($P>0.01$). The effect of period on cost of all the components of feeding was found to be highly significant ($P<0.01$).

The estimation of cost of rearing calves is of strategic importance since it forms a major capital investment for starting a dairy enterprise. The estimates of cost in different age groups of calves indicate the break up of expenses among different periods and can assist in devising the ways and means to reduce the cost of rearing calves. The estimate of component-wise cost in different treatment groups is also required to know the best treatment combination. There are some studies on this aspect. But still there are many research gaps and there is lot of scope to estimate the cost of rearing calves of Karan Swiss and Karan Fries breed maintained under different systems of housing .Hence in order to fill up these research gaps, the present study was undertaken at N.D.R.I., Karnal, Haryana, India under Indian conditions.

MATERIAL AND METHODS

Forty eight crossbred calves of Karan Swiss and Karan Fries breed of either sex ageing five days were taken from calf section of N.D.R.I., Karnal , Haryana. They were allotted randomly into six groups having eight calves in each group in 3x2 factorial randomized block design. Groups were maintained under three different housing systems viz. loose housing in group (H_1);Individual housing in cages (H_2) and Individual tying with string (H_3) with (P_1) or without probiotic supplementation (P_0). The six experimental groups formed were H_1 P_0, H_1 P_1, H_2 P_0, H_2 P_1, H_3 P_0 and H_3 P_1.The details of housing is given underneath. Thus, there were 16 calves under each housing system.

1. Loose housing in group (H_1): The crossbred calves under this housing system were let loose day and night in a closed shed having *Pucca* floor and 29'x14' dimension adjoining an open paddock having same dimension. Each calf availed an open area 72.75 ft ^{2} and covered area of 52.93 ft ^{2} .

2. Individual housing in cages (H_2): This system comprised housing the calves in individual cages installed on a slatted floor. A raised flooring 1.5' above the ground level was installed using wooden slats having 5'x3''x1' dimension. The gap between the slats was 1'' and individual cages having 5'x3' dimensions. The cages were made up of wire mesh partitions having 5'x3' dimensions built on the slatted floor. The calves were housed in those individual cages all day and night except for one hour each in the morning and noon when they were let loose for milk feeding and exercise and to enable the workers to clean the cages.

3. Individual tying with string (H_3): In this system the calves were tied individually with a string on partially *Kutcha* floor during day time and on *Pucca*

1. Principal Scientist (LP&M) , KVK, CICR (ICAR) , Nagpur, 2. & 3. Assistant Prof.and 4. Associate Prof., College of Agriculture, Nagpur

floor at night during summer and *vice versa* during winter. They were let loose for milk feeding and exercise and to enable the workers to clean the cages.

All the experimental calves were maintained under N.D.R.I. feeding schedule (Anonymous,1979) except the crossbred calves in experimental groups namely, H_1 P_1, H_2 P_1 and H_3 P_1 which were supplemented with live cell suspension of yeast *Saccharomyces cerevisiae* (NCDC-47) fed @ 5 x 10^9 c. f. u . day^{-1} into the milk provided to them (Panda *et al.*,1995). During the entire period of experimental period various managemental practices viz., feeding , washing and grooming, etc., were followed as per standard practices followed at calf section of N.D.R.I., Karnal. The intake of whole milk and skimmed milk was recorded twice a day once in the morning and in the evening at the time of feeding at weekly intervals for a period of initial three months. The intake of forage and concentrate of all the crossbred calves was recorded at weekly intervals for a period of six months. The economics (variable cost only) of rearing crossbred calves maintained under different treatment combinations was estimated upto the age of six months. The feed cost comprising whole milk, skimmed milk, forage and concentrate were estimated. The data were analyzed by using analysis of variance technique as per Snedecor and Cochran (1974).

RESULTS AND DISCUSSION

It was observed that the total cost of feeding whole milk to the crossbred calves was highest in treatment group H_1 P_0 and lowest in H_1 P_1.However, the variations among treatment combinations was not marked. The cost of feeding skimmed milk to the crossbred calves was highest in H_3 P_1 (Rs. 4118.31) and lowest in H_3 P_0 (Rs.3786.72).The cost of feeding concentrate to the crossbred calves was highest (Rs.338.67) in treatment group H_3 P_1 and the same was lowest (Rs.259.28) in H_2 P_1. The cost of feeding forage to the crossbred calves was highest (Rs.222.04) in treatment group H_1 P_1 and lowest (Rs.180.74) in H_1 P_0 (Table1) An additional expenditure of Rs.420/- was involved in feeding probiotic to the crossbred calves in the treatment group H_1 P_1, H_2 P_1 and H_3 P_1. The effect of probiotic supplementation on cost of whole milk, cost of forage and total cost of feeding were found to be highly significant (P<0.01), whereas, the effect of probiotic supplementation on cost of skimmed milk and cost of concentrate were found to be non-significant (P>0.01) (Table 3).

The effect of housing systems on cost of concentrate and cost of forage were found to be highly significant (P<0.01) whereas, the effect of housing systems on cost of whole milk, skimmed milk and total cost of feeding were found to be non-significant (P>0.01) (Table-3). The effect of period on cost of all the components of feeding was found to be highly significant (P<0.01) (Table 3) because with the passage of time, the calves grew up and their requirements of various components of feeding also increased simultaneously and thereby there was enhancement in their cost.

It was further observed that, the cost of feeding skimmed milk to the crossbred calves was the largest cost component of feeding and contributed nearly 63 per cent of the total cost of feeding the crossbred calves. The treatment combination-wise share of skimmed milk to the total cost of feeding the crossbred calves ranged between 62.57 and 64.54 per cent in treatment combinations H_3 P_0 and H_2 P_1. The relative share of whole milk varied between 27.38 in H_3 P_1 and 29.74 per cent in H_1 P_0. The costs of feeding concentrate and forage were observed to be 4 and 3 per cent, respectively. It was found that the percentage share of whole milk and skimmed milk together came to 90-92 per cent.

The cumulative cost reveals that, the cost of feeding during first month ranged between Rs.664.07 in H_1P_1 and 775.79 in H_1P_0.The share of cost of feeding during first month to the total cost of feeding ranged between Rs.715.79 in H_1 P_0. The share of cost of feeding during the first month to the total cost of feeding ranged between 10.98 in H_1 P_1 and 11.70 per cent in H_1P_0. The total cost of feeding crossbred calves was highest (Rs.6435.01) in H_3P_0 (Table-2).This was followed by H_3P_1 (Rs.6166.05), H_2P_0 (Rs.6137.00), H_1P_0 (Rs.6119.78), H_3P_0 (Rs.6051.64) and least in H_1P_1(Rs.6046.37) The gross cost of feeding crossbred calves was highest (Rs 6855.01) in H_3P_1 and lowest (Rs.6051.64) in H_3P_0. The cost of feeding crossbred calves in H_1P_1, H_2P_1, and H_3P_1 comprised of cost of probiotic (Rs. 420/-).

Table-1: Component –wise cost of feeding crossbred calves under different treatment combinations

Component	Cumulative cost of feeding (Rs) crossbred calves under different treatment combinations					
	H_1P_0	H_1P_1	H_2P_0	H_2P_1	H_3P_0	H_3P_1
Whole milk (Rs)	1820.03(29.74)	1633.04(27.50)	1802.74(29.37)	1735.75(28.15)	1762.11(29.12)	1761.59(27.38)
Skimmed milk(Rs)	3836.21(62.69)	3846.08(63.61)	3841.04(62.59)	3979.71(64.54)	3786.72(62.57)	4118.31(64.00)
Concentrate(Rs)	282.80(4.62)	315.21(5.21)	306.60(5.00)	259.28(4.20)	294.91(4.87)	338.67(5.26)
Forage(Rs)	180.74(2.95)	222.04(3.43)	186.62(3.04)	191.31(3.10)	207.90(3.44)	216.44(3.36)
Total cost (Rs)	6119.78	6046.37	6137.00	6166.05	6051.64	6435.01
Cost of probiotic(Rs)	——	420.00	—	420.00	—	420.00
Gross cost(Rs)	6119.78	6466.37	6137.00	6586.05	6051.64	6855.01

Note: Figures in parenthesis indicate percentage share in the cost of feeding.

Table-2: Monthwise cumulative cost of feeding crossbred calves under different treatment combinations

Period	Cumulative cost (Rs) of feeding crossbred calves under different treatment combinations					
Month	H_1P_0	H_1P_1	H_2P_0	H_2P_1	H_3P_0	H_3P_1
1	715.79 (11.70)	664.07 (10.98)	690.48 (11.10)	665.91 (11.22)	704.55 (11.64)	699.83 (11.32)
2	1616.18 (26.41)	1530.62 (25.31)	1589.68 (25.55)	1655.34 (27.89)	1523.48 (25.29)	1563.47 (25.29)
3	2703.37 (44.18)	2543.64 (42.69)	2780.99 (44.69)	2590.03 (43.64)	2595.46 (42.89)	2695.46 (43.59)
4	3881.05 (63.05)	3742.88 (61.90)	3970.71 (63.81)	3733.28 (62.90)	3793.79 (62.69)	3892.75 (62.95)
5	5106.61 (83.45)	5005.89 (82.79)	5204.88 (83.64)	4953.17 (83.19)	5034.47 (83.19)	5160.38 (83.46)
6	6119.58	6046.37	6222.68	5935.34	6051.64	6183.01
Gross cost (Rs)	20,142.55	19,533.47	20,452.42	19,533.07	19,703.39	20,194.90

Note: Figures in tparenthesis indicate percentage share in the cost of feeding.

Table 3 : Analysis of variance for cost of feeding crossbred calves

Source of variation	d.f.	Mean sum of squares				
		Cost of whole milk	Cost of Skimmed milk	Cost of concentrate	Cost of forage	Total cost of feeding
Housing	2	9.91 NS	18.21 NS	5.10**	2.26**	24.08 NS
Probiotic supplementation	1	206.66**	34.47	0.62 NS	4.07**	1629.24**
Period	11	11313.56**	6343.46**	73.90**	38.88**	1074.89**
Error	561	16884.17	14.03	0.68	0.15	31.99

** Significant at 0.01 per cent level of probability. N.S. - Non Significant

The variation in feed cost between the two extreme groups i.e. maximum and minimum was found to be Rs. 638/-.The housing systems and the probiotic supplementation did not affect the total cost of feeding crossbred calves appreciably. Similar to these results, Malik (1993) reported that the total cost of feeding during a feeding trial was little higher in yeast supplemented group (Rs. 4173.15) over non –probiotic group i.e. control (Rs. 3912.94). Legha (1994) studied the economics of feeding female crossbred calves of Karan Swiss and Karan Fries breed and reported that the total cost of rearing was Rs.5830.00,Rs.4368.00,Rs.6016.00 and Rs.4760.00 in the four treatment groups. The figures obtained during this study for total cost of feeding are little higher than the figures obtained by him. This is due to overall increase in the cost of inputs over the years. From the present study, it can be concluded that, there is considerable scope for devising alternative feeds to whole milk and skimmed milk because these two components together were found to enhance the cost of feeding crossbred calves.

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Research Note

Genetic Variability in Tomato

Tomato (*Lycopersicon esculentum* Mill.) is an important fruit vegetable in Indian diet as it provides protein, carbohydrates, minerals, vitamins and roughages which constitute the essential part. Per capita consumption of vegetable in our country is around 140 g (Hazara and Som, 1999).

The study of genetic variability is one of the important considerations in any crop improvement programme. The estimates of heritable components of characters give an idea while planning breeding programme for improvement in the characters. The effectiveness of selection in any crop depends upon the extent and nature of phenotypic and genotypic variability present in different traits of the population. Therefore, the present investigation was aimed for the assessment of genetic variability for different characters in tomato.

The experimental material comprised of forty genotypes *viz*., TMN-1, TMN-2, TMN-3, TMN-4, TMN-5, TMN-6, TMN-7, TMN-8, TMN-9, TMN-10, TMN-11, TMN-12, TMN-13, TMN-14, TMN-14, TMN-16, TMN-17, TMN-18, TMN-19, TMN-20, TMN-21, TMN-22, TMN-23, TMN-24, TMN-25, TMN-26, TMN-27, TMN-28, TMN-29, TMN-30, TMN-31, TMN-32, TMN-33, TMN-34, TMN-35, Pusa Ruby, Pusa Rohini, Dhanashree, PKM-1,and S-22. These lines were grown at college garden, College of Agriculture, Nagpur during *Rabi* 2007-08 in randomized complete block design replicated thrice. Observations were recorded on five randomly selected plants from each genotype for various characters *viz.*, plant height (cm), number of branches plant^{-1}, days to first flower, days to first fruit set, days to first harvest, length of fruit (cm), diameter of fruit (cm), number of fruits plant^{-1}, weight of fruit (g), acidity (%), ascorbic acid (mg 100g^{-1}), TSS (%) and yield plant^{-1} (kg).

The three genetic parameters *viz.* genotypic, phenotypic and environmental coefficient of variation (GCV, PCV and ECV), heritability (broad sense) and expected genetic advance (EGA) were

Table 1: Estimates of genetic parameters-range, mean, GCV, PCV, ECV, heritability and EGC for various characters

Characters	Range	Mean	Genotypic coefficient of variation (GCV%)	Phenotypic coefficient of variation (GCV%)	Environmental coefficient of variation (GCV%)	Heritability (h^2)	Expected Genetic Advance (EGA) %
Plant height (cm)	64.85-106.46	80.72	8.66	15.08	12.35	92.37	11.10
No. of primary branches plant^{-1}	8.40-13.00	10.35	7.39	14.53	12.51	98.42	17.80
Days to first flower	33.00-39.00	35.86	2.51	5.13	4.47	95.24	13.30
Days to first fruit set	39.66-46.66	43.44	2.84	5.48	4.68	96.72	15.82
Days to first harvest	78.33-84.33	81.32	1.39	2.17	8.38	96.80	17.80
No. of fruit plant^{-1}	21.13-42.60	29.15	14.22	16.51	8.38	92.70	22.45
Weight of fruits plant^{-1}	24.90-73.77	42.30	22.65	23.96	7.81	97.45	87.32
Length of fruit (cm)	3.54-6.18	4.52	14.46	15.40	5.29	98.12	25.42
Diameter of fruit (cm)	3.63-6.17	4.54	14.38	15.53	5.86	98.40	18.25
Acidity %	0.49-0.68	0.58	9.01	9.36	5.29	98.90	16.20
Ascorbic acid (mg/100g)	23.94-29.66	26.19	6.32	7.04	3.09	97.45	11.10
TSS%	3.43-6.30	4.85	15.03	16.24	6.16	98.70	40.72
Yield plant^{-1}	0.777-1.972	1.22	16.47	18.46	8.33	99.82	62.40

estimated as per the method suggested by Burton (1951) and Johnson *et. al*., (1955), respectively.

The data on various genetic parameters are presented in Table 1. A wide range of variation was noticed for most of the characters which indicated the presence of substantial variability in the experimental material. The genotypic coefficient of variation ranged from 1.39 per cent to 22.65 per cent among all the fourteen characters under study. The phenotypic coefficient of variation studies for different characters ranged from 2.17 per cent to 23.96 per cent. The characters days to first fruit harvest recorded minimum values of genotypic and phenotypic coefficient of variation (1.39 % and 2.17%), respectively. However, it was maximum for weight of fruit (22.65% and 23.96%), respectively. Considerable amount of genotypic and phenotypic coefficient of variation was observed for yield plant^{-1} (16.47% and 18.46%), while environmental coefficient of variation was minimum for ascorbic acid (3.09%) and maximum for number of branches plant^{-1} (12.51%). The values of ECV were found to be lower than GCV and PCV for all the characters except plant height and number of primary branches plant^{-1}. The high estimates of genotypic coefficient of variation indicated that the high degree of variation was due to genetic factors.

The importance of GCV, PCV and ECV when compared with one another,. GCV is considered to be more important than PCV and ECV as it gives the amount of genetic variation *i.e.* due to genetic cause. The variation in the values of GCV might be attributed to source material of the genotype which had accumulated the genes in its production during the process of natural selection. In the present study, the high genetic variability observed for the characters weight of fruit, yield plant^{-1} and TSS indicated the significance of these characters to be used for selecting superior genotypes. This trend of high GCV has been already reported by Singh *et al.* (1973), Kumar *et. al.*, (1980), Supe (1985) and Sharma *et. al.*, (2006) for yield plant^{-1}. Brar *et. al.*, (2000), Mohanty (2002) and Sharma *et. al.*, (2006) for weight of fruit in tomato.

A perusal of heritability estimated reveals that all the characters under study exhibited high estimates indicating that these characters were less influenced by environmental fluctuations. Under the circumstances of variability, the response to selection for the character on the basis of heritability estimates alone could not be effective. Therefore, heritability of the characters in conjugation with expected genetic advance could be considered. In the present investigation, weight of fruits, yield plant^{-1} and TSS per cent exhibited high estimates of genetic advance accompanied with high estimates of heritability which is very encouraging, since the selection based on these characters, being of additive nature, is likely to be more efficient for their improvement. The results of similar nature were also reported in tomato by Brar *et. al.*, (2000) and Bharti *et. al.*, (2002).

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Section of Horticulture
College of Agriculture, Nagpur

S.R.Parate
S.A. Badge
N.H. Sable

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Effect of Weed Management Practices on Productivity of Blackgram

An increased cropping intensity due to availability of modern farm technology and irrigation water, short duration crops and varieties and increased use of fertilizers are some of the reasons that lead to greater weed infestation in recent years. The weed free condition during early period can be maintained either by cultural practices or by means of pre planting or pre- emergence application of herbicides or combination of chemical and mechanical methods. It is also necessary to develop cheaper method of weed control with herbicide alone or in combination with other mechanical methods. The objective of this experiment was to study the efficacy of different weed management practices and to work out comparative economics and energetic of different weed management practices in blackgram.

The field experiment was carried out during *Kharif* 2007-08 at the farm of Agronomy Department Dr. PDKV, Akola. The soil of the experiment field was clay loam in texture, and moderately alkaline pH (8.3); moderate O.C.(0.4 %); low available N content (234.58 kg ha^{-1}); medium phosphorus (20.86 kg ha^{-1}) and fairly high in potassium status (322.94 kg ha^{-1}). The experiment was laid out in RBD with three replications. There were fourteen treatment combinations, comprised of herbicidal, mechanical and both along with control. The gross and net plot size were 3.6 m x 4.6 m and 3.0 m x 4.0 m respectively. The sowing of blackgram was carried out 3rd July 2007. The crop was fertilized with 20 kg N, 40 kg P_2O_5 ha^{-1}.

The herbicides were applied as pre-emergence on 4th July 2007 and post emergence application on 10 DAS. Hand weeding and hoeing were done on 15th DAS in cultural treatments. The crop was grown with recommended package of practices.

Treatment details

T_1 – Weedy check
T_2 – Pendimethalin PRE (1000g a.i.ha^{-1})
T_3 – Imazethapyr PRE (75 g a.i. ha^{-1})
T_4 – Pendimethalin PRE + Imazethapyr PRE (500 + 50g a.i.ha^{-1})
T_5 – Imazethapyr EPOE (5g a.i. ha^{-1} 10 DAS)
T_6 – Quizalfop-p-ethyl EPOE (50ga.i.ha^{-1} 10 DAS)
T_7 – Pendimethalin PRE 1000g a.i.ha^{-1} + 1H 30 DAS
T_8 – Imazethapyr PRE (75 g a.i. ha^{-1}) + 1H 30 DAS
T_9 – Pendimethalin + Imazethapyr PRE (500 + 50g a.i.ha-1) + 1H 30 DAS
T_{10} – Imazethapyr EPOE (5g a.i. ha^{-1}10 DAS) + 1H 30 DAS
T_{11} – Quizalfop-p-ethyl EPOE (50ga.i.ha^{-1} 10 DAS) + 1H 30 DAS
T_{12} – 2H 15 and 30 DAS
T_{13} – 1H 15 DAS + 1HW 30 DAS
T_{14} – 1HW 15 DAS

PE – Pre-emergence, H-Hoeing,
EPOE – Early post emergence
DAS- Days after sowing , HW-Hand weeding

Highest weed intensity (Table 1) was observed in weedy check (51 weeds m^{-2}). Lowest weed intensity was observed in T_{13} treatment i.e. 1H 15 DAS + 1 HW 30 DAS (12 weeds m^{-2}) and it was followed by Quizalfop-p-ethyl EPOE +1H (T_{11}). Because of lower weed intensity competition was maximum there by crop growth enhanced and obtained good yield. These results are coinciding with Ali Masood (1984) and De *et. al.,* (1995).

Table 1: Weed intensity, weed control efficiency, dry matters of weed and different growth characters of blackgram as influenced by different treatments.

Treatments	Weed Intensity m^{-2} at harvest	WCE (%)	Plant height (cm)	No. of functional leave per plant	Leaf area per plant at 45 DAS	LAI at 45 DAS	Dry matter per plant at harvest	Root nodules per plant at 45 DAS
T_1 - Weedy check	7.14 (50.67)	—	38.00	13.13	8.42	2.81	8.33	38.00
T_2 - Pendimethalin PRE (1000g a.i.ha^{-1})	5.42 (29.33)	42.28	43.07	16.80	12.78	4.26	11.96	43.67
T_3 - Imazethapyr PRE (75 g a.i. ha^{-1})	5.81(33.33)	40.94	40.20	16.40	11.64	3.88	11.28	45.00
T_4 - Pendimethalin PRE + Imazethapyr PRE (500 + 50g a.i.ha^{-1})	5.41 (29.33)	35.57	41.77	16.27	11.57	3.86	11.04	42.67
T_5 - Imazethapyr EPOE (5g a.i. ha^{-1} 10 DAS)	6.02 (36.00)	34.23	39.60	15.67	11.02	3.67	10.98	41.00
T_6 - Quizalfop-p-ethyl EPOE (50ga.i.ha^{-1} 10 DAS)	6.56 (42.67)	14.77	41.63	16.73	10.48	3.49	10.34	39.33
T_7 - Pendimethalin PRE 1000g a.i.ha^{-1} + 1H 30 DAS	4.20 (17.33)	69.80	47.90	19.33	14.50	4.83	14.55	49.00
T_8 - Imazethapyr PRE (75 g a.i. ha^{-1}) + 1H 30 DAS	4.20 (17.33)	67.11	44.27	18.27	12.91	4.30	13.15	47.00
T_9 - Pendimethalin + Imazethapyr PRE (500 + 50g a.i.ha-1) + 1H 30 DAS	4.64 (21.33)	61.74	45.20	18.53	13.28	4.43	13.44	45.00
T_{10} - Imazethapyr EPOE (5g a.i. ha^{-1}10 DAS) + 1H 30 DAS	4.47 (20.00)	60.40	44.47	18.20	12.39	4.13	12.66	49.00
T_{11} - Quizalfop-p-ethyl EPOE (50g a.i.ha^{-1} 10 DAS) +1H 30 DAS	4.81(22.67)	53.02	46.37	18.73	12.58	4.19	12.23	45.67
T_{12} - 2H 15 and 30 DAS	5.57(30.67)	46.31	46.40	19.80	13.19	4.40	13.14	49.33
T_{13} - 1H 15 DAS + 1HW 30 DAS	3.50 (12.00)	74.50	46.97	20.07	14.79	4.93	14.19	52.67
T_{14} - 1HW 15 DAS	5.33 (28.00)	44.97	44.80	18.47	13.73	4.58	12.65	43.33
SE(m)+	0.32	—	1.0	0.78	0.53	—	0.51	1.47
CD 5%	0.95	—	2.94	2.29	1.57	—	1.50	4.80
GM	5.22(27.90)	—	43.62	17.60	12.38	4.13	12.14	45.05

First value or transformed values x + 0.5 PE – Pre-emergence, H-Hoeing, EPOE – Early post emergence

Figures in parenthesis are original values. DAS- Days after sowing , HW-Hand weeding

Table 2: Grain yield, straw yield, biological yield, GMR, NMR & B:C ratio as influenced by different treatments

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	GMR (Rs.ha^{-1})	NMR (Rs.ha^{-1})	B:C ratio
T_1 - Weedy check	2.53	12.50	15.03	6995	680	1.11
T_2 - Pendimethalin PRE (1000g a.i.ha^{-1})	5.58	16.94	22.53	14917	6992	1.88
T_3 - Imazethapyr PRE (75 g a.i. ha^{-1})	4.00	15.83	19.83	10872	3286	1.43
T_4 - Pendimethalin PRE + Imazethapyr PRE (500 + 50g a.i.ha^{-1})	5.25	16.81	22.06	14070	6136	1.77
T_5 - Imazethapyr EPOE (5g a.i. ha^{-1} 10 DAS)	4.12	15.42	19.54	11166	3580	1.47
T_6 - Quizalfop-p-ethyl EPOE (50ga.i.ha^{-1} 10 DAS)	3.31	16.25	19.56	9142	1277	1.16
T_7 - Pendimethalin PRE 1000g a.i.ha^{-1} + 1H 30 DAS	7.58	20.28	27.86	20124	11909	2.45
T_8 - Imazethapyr PRE (75 g a.i. ha^{-1}) + 1H 30 DAS	6.33	17.50	23.83	16835	8959	2.14
T_9 - Pendimethalin + Imazethapyr PRE (500 + 50g a.i.ha-1) + 1H 30 DAS	6.75	18.33	25.08	17927	9703	2.18
T_{10} - Imazethapyr EPOE (5g a.i. ha^{-1}10 DAS) + 1H 30 DAS	5.22	17.78	23.00	14049	6173	1.78
T_{11} - Quizalfop-p-ethyl EPOE (50ga.i.ha^{-1} 10 DAS) + 1H 30 DAS	4.78	18.61	23.39	12971	4816	1.59
T_{12} - 2H 15 and 30 DAS	6.28	18.61	24.89	16751	9856	2.43
T_{13} - 1H 15 DAS + 1HW 30 DAS	7.86	19.44	27.30	20782	12777	2.60
T_{14} - 1HW 15 DAS	5.78	18.19	23.97	15470	7755	2.01
SE(m)+	0.37	0.95	1.22	947	947	—
CD 5%	1.08	2.78	3.59	2776	2776	—
GM	5.38	17.32	22.70	14434	6707	1.86

PE – Pre-emergence, H-Hoeing, EPOE – Early post emergence DAS- Days after sowing , HW-Hand weeding

The highest weed control efficiency was observed in treatment (T_{13}) i.e. 1H+1HW (74.50%) followed by treatment (T_7)i.e. Pendimethalin PRE +1H.Lowest dry matter of weeds plant^{-1} was observed in WC (T_1) treatment and followed by T_6 i.e. Quizalfop-p-ethyl EPOE. These results are in conformity with Ali Masood (1984). Because of effective control of weeds lowest dry matter of weed was observed in one hoeing and one hand weeding, followed by pre-emergence application of Pendimethalin + 1H (T_7). These results are in accordance with Jain *et. al.,* (1997) and Singh *et. al.,* (1992).

There was also significant effect of weed management practices on growth characters like number of functional leaves, leaf area plant^{-1} and leaf area index at 45 DAS. The maximum number of functional leaves (20.07), leaf area plant^{-1} (14.79) and LAI at 45 DAS (4.93) were observed in 1H+ 1HW (T_{13}) treatment. Pre-emergence application of Pendimethalin +1H (T_7) recorded maximum plant height (47.90cm), followed by 1H+1HW (46.97cm), Root nodules plant^{-1} were maximum in treatment (T_{13}) i.e. (52.67), followed by 2H (T_{12}) treatment i.e. (43.93). Similar results were reported by Soni *et. al.*, (1988) and Yadao *et. al.,* (1998).

Regarding grain, straw and biological yield (Table 2) was also significantly influenced by different treatments. Maximum straw yield (20.28 q ha^{-1}) and biological yield (27.86 q ha^{-1}) were obtained in Pre-emergence application of Pendimethalin + 1H treatment (T_7) and it was followed by 1H + 1HW (19.44 q ha^{-1})

Maximum grain yield was recorded with 1H 15 DAS + HW 30 DAS, followed by treatment (T_7) (7.58 qha^{-1}). Lowest grain, straw yield and biological yield were recorded in weedy check (T_1). These results are in conformity with Singh *et. al.* (1992), Ali Masood (1998), Yadao *et. al.*,(1998) and Shaikh *et. al.,* (2002).

Highest net monetary returns (Rs12,777 ha^{-1}), gross monetary returns (20782 ha^{-1}) and B:C ratio (2.60) were observed in treatment 1H 15 DAS + 1HW 30 DAS (T_{13}) , followed by Pendimethalin pre-emergence + 1H. These results are similar to the Soni *et. al.* (1988); Singh *et. al.*,(1990) and Yadao *et. al,* (1998).

The findings of present investigation revealed that the improvement in grain; straw yield of blackgram was observed when weeds were controlled either with mechanical or herbicidal use. From economic point of view 1H 15 DAS and 1HW 30 DAS proved superior with maximum net monetary returns, followed by integrated weed management through pre-emergence application of Pendimethalin 1000 g a.i. ha^{-1} plus one hoeing at 30 DAS (T_7).

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Department of Agronomy,
Dr. PDKV, Akola

B. S. Adpawar,
A. P. Karunakar
N. D. Parlawar
K. R. Chavhan

❖ ❖ ❖

Effect of Different Irrigation Methods on Yield and Water Use Efficiency of Summer Cotton

Cotton is an important commercial cash crop in India .The average productivity of crop in the country is 500 kg lint ha^{-1} (Anonymous, 2006). The productivity of crop is comparatively low in the Maharashtra (300 kg ha^{-1}) mainly due to erratic pattern of rainfall in rainfed and limited irrigation resources and poor water management practices under irrigated area. As the irrigation efficiency of micro irrigation methods were more than 90 per cent, they can increase crop as well as water use productivity. Hence, the study was undertaken to evaluate suitable micro irrigation methods to increase the water use efficiency of cotton.

The field experiment was conducted for two year during 2005-2007 at water Management Project, MPKV, Rahuri. The soil of experimental field was clayey in texture, low in available nitrogen (188.16 kg ha^{-1}), available phosphorous is (16.45 kg ha^{-1}) and very high in potassium (720.8 kg ha^{-1}) and moderately alkaline in reaction (pH 8.2). The treatment consisted of four different irrigation methods viz. Surface, Subsurface, drip and micro sprinkler along with three replications. The gross and net plot size were 8.1X7.2 m and 5.4X5.4 m, respectively.

The summer cotton cultivar Phule-492 sown on 12.4.2005 and 15.4.2006 by paired row planting technique (90-180 x 90 cm). After dibbling of seeds two common surface irrigations were given to all treatments. Thereafter, it was scheduled with subsurface, drip and micro sprinkler irrigation methods on an alternate day. Surface irrigation was scheduled at 75 mm CPE with 8 cm depth throughout the growing period with 9 and 6 irrigations during first and second season, respectively. The crop was fertilized with 100 Kg N, 50 Kg P_2O_5 and 50 kg K_2O kg ha^{-1} during each season along with recommended agronomic package of practices. Initially five plants were selected randomly from each net plot and the data on various growth and yield contributing character were evaluated on the basis of mean values. The data were pooled over the two season. The water use efficiency was calculated by dividing seed cotton yield with total water applied in respective irrigation treatment.

All yield parameters were found to be maximum under all micro irrigation than surface irrigation (Table 1). Sampathkumar *et. al.* (2006) observed similar result who reported that under drip method water delivered only at root zone, ensured

Table 1. Effect of irrigation methods on yield parameter of cotton at harvest (2 year mean)

Irrigation methods	No. of developed boll (120 DAS)	Total no. of picked boll	Seed cotton yield $plant^{-1}$ (g)	Ginning percentage (%)
Surface	35.56	49.11	175.23	36.33
Subsurface	46.31	60.62	243.01	37.98
Drip	52.66	69.72	283.27	38.14
Micro- sprinkler	36.91	53.38	208.77	37.06
General Mean	42.86	58.21	227.57	37.38

Table 2.Effect of irrigation methods on yield and water use efficiency of cotton (2 year mean)

Irrigation methods	Dry matter (q ha^{-1})	Seed cotton yield (q ha^{-1})	Lint yield (q ha^{-1})	Seed yield (q ha^{-1})	Total water applied (ha-cm)	Water use efficiency (kg ha^{-1} mm)
Surface	26.91	14.03	5.11	8.92	83.97	1.70
Subsurface	51.67	19.71	7.48	12.23	38.77	5.20
Drip	52.23	22.72	8.79	14.04	44.27	5.30
Micro- sprinkler	55.07	18.93	6.28	10.66	56.94	3.30
General Mean	46.47	18.85	6.92	11.46	55.99	3.80

maximum availability by maintaining the soil moisture at field capacity which in turn resulted in more flower production and subsequent development into boll. This corroborates the findings of Cetin and Bilgel (2002). The drip irrigation method recorded maximum number of developed boll plant^{-1} (52.66) at 120 DAS, followed by subsurface irrigation method. Bilwalkar and Gulati (2004) observed similar result who reported that appropriate amount of water available at square and flowering did not enhance vegetative growth but maximized number of developed boll plant^{-1}. Bharambe *et. al.,* (2002) recorded observation on soil-plant-water relations, indicated that irrigation applied through drip to cotton maintained higher soil water potential as well as plant water potential and it was grown without water deficit during growth period as compared to surface method. Plant enzymes functioned most efficient under well watered plant (Wanjura *et. al.,* 2002) under micro irrigation that will indirectly affect the cotton yield.

From Table 2 it was observed that, micro-irrigation methods doubled dry matter yield and required very less water as compared to surface irrigation method. Among the irrigation methods, drip irrigation was found to be better with maximum seed cotton yield (22.72 q ha^{-1}), lint yield (8.79 q ha^{-1}) and seed yield (14.04 q ha^{-1}) which led to higher ginning percentage (38.14 %), followed by subsurface and micro-sprinkler mainly due to production of more number of developed bolls plant^{-1} and seed cotton yield plant^{-1}. This is in line with findings of Veerputhrin *et. al.,* (2000), Muthuchamy and Subramaniyan (2004). The data also indicated that drip and subsurface methods recorded higher water use efficiency by saving water of 54 and 47 per cent over surface method, respectively. The results are in agreement with Shelke *et. al.,* (1999), Mussadak and Somi (2001) and Kamilov *et. al.,* (2003).

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Department of Agronomy
Shri. Shivaji College of Agriculture, Amravati

N.A. Hirwe
A.S. Jadhav

❖ ❖ ❖

Response of Aromatic Rice to Different Fertility Levels in Eastern Vidarbha Zone

Aromatic rice has a special place in domestic as well as the international trade and is cultivated commercially. The aromatic rice is India's gift to the whole world. The aromatic fine quality rice is traditionally grown in North and North-Western parts of Indian subcontinent. The yield of this kind of rice is low because the plants are medium tall and prone to lodging (Ganajaxi et al., 2001). PKV *Khamang* a medium maturing (135 days) scented variety developed by Agriculture Research Station, Sindewahi of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) for Eastern Vidarbha region. The present study was undertaken to study the performance of newly released scented variety PKV *Khamang* to prove its potential and increase the productivity of the region under different fertility levels in Eastern Vidarbha Zone of Maharashtra.

A field experiment was conducted at Agriculture Research Station, Sindewahi Dist Chandrapur (M.S.) during *Kharif* 2007- 2008 in factorial randomized block design with four replications. The soil was clay loam, having PH 7.3 and available N, P and K were 271.2, 31.50 and 192.8 Kg ha^{-1}, respectively. There were two scented varieties viz., PKV *Khamang* (V1) and *Chinoor* (V2) and four fertility levels viz., 50 per cent RDF 75per cent RDF, 100 per cent RDF and 125 per cent RDF. Both the varieties were sown on 03.07.2007 and transplanted on 20.07.2007 with 2-3 seedlings $hill^{-1}$ by adopting 20 cm x 20 cm spacing in a plot size of 5.00 x 4.00 m^2 in gross and 4.00 x 3.60 m^2 in net. The seed rate used was 50 kg ha^{-1}. Fertilizer doses were applied as per treatments where the entire quantity of phosphorus and potash was applied at the time

Table 1. Growth, yield attrobites and yield as influenced by various treatment

Treatments	Plant height tillers $hill^{-1}$	Productie	Test weight q ha^{-1}	Grain yield yieldq^{-1} ha^{-1}	Straw
PKV Khamang (V1)	107.70	12.50	16.35	58.50	66.66
Chinoor (V2)	122.85	7.58	15.69	32.10	89.20
SE (m) ±	1.62	0.25	0.21	0.95	0.77
CD at 5 % level	4.89	NS	0.62	1.57	5.01
Fertilizer Levels					
F1 - 50% Recommendaed of inorganic fertilizer (50:25:25) Kg NPK ha^{-1}	107.35	12.05	16.34	51.68	60.88
F2 - 75% Recommened of inorganic fertilizer (75:37.5:37.5) kg NPK ha^{-1}	108.15	12.85	16.35	54.77	63.71
F3 - 100% Recommened of inorganic fertilizer (100:50.50) kg NPK ha^{-1}	108.17	12.85	16.41	59.11	67.10
F4 - 125% Recommened of inorganic fertilizer (125:65.5:62.5)	110.91	13.07	16.39	56.16	63.97
SE (m) ±	-	-	-	-	-
CD at 5% level	1.97	0.35	0.24	0.83	1.10
Interaction	–	1.06	1.32	2.44	4.48
SE (m) ±					
CD at 5% level	2.81	0.52	0.37	1.91	2.11
Interaction	NS	NS	NS	5.59	7.62

of transplanting as basal dose and nitrogen was applied through urea in three splits viz, 50 per cent at transplanting, 25 per cent at active tillering stage and 25 per cent at panicle initiation stage. The other agronomic practices were followed as per standard recommendations for aromatic rice cultivation. The growth and yield components were recorded at maturity.

Effect of Variety

The results presented in Table 1 revealed that grain yield (q ha^{-1}), test wt.(g) and productive tillers plant^{-1} were significantly higher in the variety PKV *Khamang* than *Chinoor*. PKV *Khamang* recorded (58.52 q ha^{-1}) significantly higher grain yield over local variety *Chinoor* (32.10.q ha^{-1}). The *Chinoor* recorded significantly higher straw yield (89.20 q ha^{-1}) than newly released aromatic variety PKV *Khamang* (66.66 q ha^{-1}). This might be due to the height of the *Chinoo*r. *Chinoor* is tall growing variety (122.85 cm.) than PKV *Khamang* (107.70 cm). PKV *Khamang* recorded significantly higher number of productive tillers (12.50 hill^{-1}) than *Chinoor* (7.58 hill^{-1}). The test weight (1000 grains weight) was also higher in PKV *Khamang*.

Effect of Fertility Levels

Growth and yield attributing characters like plant height (cm), productive tillers hill^{-1}, test weight (g) was increased linearly with the increse in fertility levels from 50 per cent RDF to 100 per cent RDF. As the fertility levels increased the grain and straw yield also increased. This might be due to higher availability of nutrients to the crop. The yield attributing characters like test wt. (g), grain yield (q ha^{-1}) and straw yield (q ha^{-1}) had increased with increased fertility levels upto 100 per cent RDF and thereafter there was decrease in these characters. Similar findings were also reported by Bahera (1998), Jadhav and Sahane (1998). Bahera (1998) reported linear increse in grain yield up to 90 kg^{-1}and thereafter marginal grain yield. Jadhav and Sahane (1998) also reported numerically higher yield to higher doses of fertilizers. Grain yield was not significantly differed with application of various levels of fertilizers.

Interaction Effect

Interaction effect was significant in respect of grain yield. The highest grain yield of PKV *Khamang* was recorded with 100 per cent RDF.

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Zonal Agri. Research Station,
Sindewahi, Dr. PDKV, Akola

R. F. Raut
N. V. Kayande
P. P. Debaje

❖ ❖ ❖

Nitrate Contamination in Groundwater of Jalgaon District

Water is our most precious natural resource. In India, agriculture forms the backbone of the economy, with the advancement of technology for increased crop production, higher quantity of nutrients are added to soil, salts are drained out in groundwater while sediments are carried out in streams. The present investigation concentrates on addition of nitrogen through fertilizer and manure use, resulting in nitrate contamination in groundwater. The distribution and application of fertilizers are not uniform throughout the country showing disparity in fertilizer consumption and nutrient ratio. The efficiency of added N to soils in waterlogged conditions and uplands range from 30 to 70 per cent (Shibu and Ghuman, 2001). The remaining quantity of nitrogen is lost into the environment. A large proportion of this nitrogen gets converted into nitrate which being soluble in water and not retained by soil, gets leached into groundwater. Leaching of nitrates from agricultural lands and other sources to groundwater is a global phenomenon. The role of nitrates as a contaminant in drinking water primarily lifted up from groundwater and wells have been well established due to its hazardous biological effects. Concentration of nitrate in food may cause methemoglobinemia in babies (Prakasa Rao and Puttanna, 2000). It has been cited as a risk factor in developing gastric and intestinal cancer (Stanley *et. al.,* 1975).Therefore, a great emphasis has been given to identify sources of nitrate pollution and to evaluate their relative contribution. Necessary preventive measures may be taken so as to help in alleviating this problem. The permissible limit of nitrate load in drinking water given by World Health Organization is 45 ppm nitrate while USA follows much strict norms of 10 ppm nitrates as maximum limit (Mueller *et. al.,* 1995).

The investigation was carried out during the Post-monsoon 2006 and Pre-monsoon 2007. The villages were finally selected in consultation with the Sr.Geologist, Groundwater Survey and Development Agency, Jalgaon and the Project Director, Jal Swaraj Project, Jalgaon. Stratified random sampling especially for water samples was adopted. The basis wasTalukawise fertilizer (N+ P_2O_5 + K_2O) consumption as low (<100 kg $ha^{-1)}$, medium (100 – 200 kg ha^{-1}) and high (>200 kg ha^{-1}). Based on the fertilizer consumption, the Talukas in the district were categorized as low, medium and high fertilizer consumption. The number of villages were selected in the ratio of 1:3:6 low, medium and high fertilizer consuming Talukas, respectively. This facilitated to collect proportionately less samples from Talukas with lower fertilizer use and more samples from Talukas with higher fertilizer use. Analysis of nitrate in water was carried out at Indian Institute of Soil Science, Bhopal with the help of Flow Injection Analyser (Model: Foss FIA Star 5000). In order to evaluate nitrate contamination in groundwater, preference was given to those sites which are sources both for irrigation and drinking purposes. In sampling a river, water was taken from a rapidly flowing part/near the bank avoiding any kind of debris in the water. Samples from tube wells were collected after allowing to flow for at least 10 minutes. Similarly sufficient water was pumped out from open wells before sampling. The sample sites were kept same to observe seasonal variations. The water samples for nitrate analysis were filled in the polyethylene bottles of 25ml capacity. The bottles were filled to 90-95 per cent of their capacity, containing few drops of concentrated H_2SO_4. The purpose of adding conc. H_2SO_4 was to bring the pH of water sample down to 2 or less. The samples were preserved for 30 days by cooling at 4^0C in the laboratory in refrigerator. The analysis of NO_3^--N using Flow Injection Analyzer employing modified colorimetric procedure of Griess–Ilosvay (Ferore and O'Brien, 1962), was carried out.

The results pertaining to variations in nitrate load of water samples on the basis of talukawise fertilizer consumption are presented in Table 1. The nitrate load in water samples during Post-monsoon 2006 varied from 0-13.65, 0-17.66 and 0-13.40 mg kg^{-1} in the Talukas of low, medium and high fertilizer use, but during Pre-monsoon it varied from 0-4.85 mg kg^{-1}.The overall mean of nitrate load in the respective season were 1.57 and 0.01 mg kg^{-1}. The mean values for nitrates in irrigation water were found higher in low and moderate fertilizer consuming as compared to high consuming talukas in Post-monsoon 2006 season.

The data in Table 2 revealed that the maximum (35.7%) number of water samples had

Table 1. Variation in NO_3^--N (mg kg^{-1}) of irrigation water from Jalgaon district

Fertilizer use (kg ha^{-1})	No.of Taluka	No.of villages	No.of water samples	Post monsoon 2006			Pre monsoon 2007		
				Range	Mean	SD	Range	Mean	SD
Low : <100	5	5	46	0.00 – 13.65	2.02	2.89	0.00 – 0.61	0.01	0.09
Medium: 100-200	5	15	126	0.00 – 17.66	2.00	2.61	Absent	-	-
High: >200	5	30	254	0.00 – 13.40	1.28	1.69	0.00-4.85	0.02	0.31
Total	15	50	426		1.57	2.17		0.01	0.24

'_t_' value – 8.54** *significant at 1% level

Table 2. Seasonwise distribution of water samples according to nitrate-N concentration

Category of NO_3^- - N	Post monsoon 2006		Pre monsoon 2007	
	No.of samples	%	No.of samples	%
Nil	110	25.8	423	99.30
0 – 1	101	23.7	2	0.47
1 – 3	157	35.7	-	-
3 – 7	51	12.0	1	0.23
7 – 10	6	1.4	-	-
> 10	6	1.4	-	-
Total	426		426	

Table 3. Frequency distribution in irrigation water at different depths and with varying nitrate content (mg kg^{-1})

Nitrate cont.	Nil	0-1	1-3	3-7	7-10	>10	Total
			Post-monsoon 2006				
Depth, m							
< 30	70	55	109	43	7	5	289
31-60	30	24	29	4	0	0	87
61-90	6	15	11	1	1	1	35
91- 120	6	3	2	1	0	0	12
121-150	0	1	2	0	0	0	3
>150	0	0	0	0	0	0	0
			Pre-monsoon 2007				
< 30	287	1	0	1	0	0	289
31-60	86	1	0	0	0	0	87
61-90	35	0	0	0	0	0	35
91- 120	12	0	0	0	0	0	12
121-150	3	0	0	0	0	0	3
>150	0	0	0	0	0	0	0

nitrate content ranging from 1-3 mg kg^{-1} in the Post-monsoon 2006 season. In 1-3 mg kg^{-1} nitrate-N, 23.7 per cent samples were categorized which are in safe limit, whereas in 25.8 per cent samples the nitrate-N load was not detected. However, only in 6 water samples the nitrate-N was recorded higher than 10 mg kg^{-1} which were located in the viscinity of the villages. Near source of these wells the dung pits were located. From these pits the nitrate might have leached in to the well water after rainy season.

Depthwise distribution of nitrates in well water indicated that the nitrate was concentrated in the water up to 30 m depth. Out of 426 water samples tested, 289 (67.8%) samples containing nitrate were found in less than 30m depth, during Pre-monsoon 2006 also the nitrates in water samples of the wells noticed higher than 7mg kg^{-1} having depth less than 30m.From this study, it was observed that the nitrate did not reach the deeper level of water.

In the Pre-monsoon 2007 season, nitrate content higher than 7mg kg^{-1} was not noticed. Water from tube wells, rivers and deeper wells was found safer for irrigation as well as drinking. However, water from shallower wells (30m) may pose health problem. Thus, from the present study it can be concluded that, the nitrate contamination in groundwater was not observed because of deeper water table in the Jalgaon district of Maharashtra.

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Department of soil Sci. and Agril. Chemistry,
Dr. PDKV, Akola

Soniya K. Thakare
S. N. Ingle
R. N . Katkar

❖ ❖ ❖

Seasonal Incidence and Field Parasitization of Gram Pod Borer on Chickpea

Due to high nutritional value, low cost of cultivation, capacity to withstand water-stress condition and ability to add nitrogen in the soil, chickpea occupied prominent place amongst pulses. It is reported to be attacked by about 57 insect pests amongst which gram pod borer *Helicoverpa armigera* is the only major pest (Sarode and Sarnaik, 1996). Its incidence varied both in space and time and is directly influenced by field parasitization. Therefore, efforts were made in the present investigation to study the seasonal incidence and field parasitization of *Helicoverpa armigera* on chickpea.

The present investigation was carried out at the research farm of Department of Entomology, Dr. PDKV, Akola during two consecutive *Rabi* seasons of 2003-04 and 2004-05. Chickpea cultivar 'Chaffa' was sown at 30 x 10 cm spacing by hand dibbling on 13th October 2003 and 7th October 2004. The crop was raised by following all the recommended agronomic practices for the locality.

To study the seasonal incidence of *H. armigera* on chickpea, larval count on ten randomly selected plants was taken at weekly interval. To know the field parasitization of the pest, twenty-five eggs and larvae of *H. armigera* were collected at weekly

Table 1 : Weekly larval population of *H. armigera*, field parasitization and weather parameters during 2003-04

Met. Week	Period	Larval population / 10 plants	Per cent parasitization due to			Meteorological Parameters				
						Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
			C. cholorideae	*Eriborus* sp	Both parasitoids	Max.	Min.	Mor.	Even	
45	05-11 Nov., 2003	3	4	0	4	32.3	20.2	85	57	0.5
46	12-18 Nov., 2003	4	0	4	4	33.0	16.0	65	32	0
47	19-25 Nov., 2003	5	4	0	4	31.6	14.6	70	34	0
48	26-02 Dec., 2003	5	4	8	12	32.3	15.7	71	29	0
49	03-09 Dec., 2003	7	12	0	12	32.2	16.5	77	33	0
50	10-16 Dec., 2003	7	20	4	24	31.2	11.9	64	21	0
51	17-23 Dec., 2003	6	16	12	28	31.4	12.6	63	26	0
52	24-31 Dec., 2003	4	8	4	12	28.6	10.8	72	30	0
1	01-07 Jan., 2004	3	16	0	16	26.8	10.3	72	36	4.9
2	08-14 Jan., 2004	0	0	0	0	28.1	12.6	75	39	3.8

NB : Larval population and per cent parasitization is of corresponding week, while weather parameters are of previous week

No egg and Pupal parasitoids were recorded.

Table 2 : **Weekly larval population of *H. armigera* , field parasitization and weather parameters during 2004-05.**

Met. Week	Period	Larval population / 10 plants	Per cent parasitization due to			Meteorological Parameters				
			C. chlorideae	*Eriborus* sp	Both parasitoids	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
						Max.	Min.	Mor.	Even	
44	29-04 Nov., 2004	3	4	0	4	33.0	14.6	64	19	0
45	05-11 Nov., 2004	5	0	8	8	32.2	15.2	65	27	0
46	12-18 Nov., 2004	5	8	4	12	31.7	16.3	72	38	0
47	19-25 Nov., 2004	9	12	0	12	31.8	18.3	86	41	41
48	26-02 Dec., 2004	13	24	12	36	32.0	12.9	66	22	0
49	03-09 Dec., 2004	8	12	4	16	30.5	11.7	67	23	0
50	10-16 Dec., 2004	9	18	8	24	29.8	10.2	62	23	0
51	17-23 Dec., 2004	7	16	4	20	30.1	10.3	68	22	0
52	24-31 Dec., 2004	6	8	0	8	30.4	9.8	66	23	0
1	01-07 Jan., 2005	4	0	0	0	29.8	11.9	69	32	0
2	08-14 Jan., 2005	3	0	4	4	30.6	15.1	75	37	0

NB : Larval population and per cent parasitization is of corresponding week, while weather parameters are of previous week

No egg and pupal parasitoids were recorded interval. They were kept individually in plastic containers. Eggs were kept till hatching while larvae were reared till the adult stage. They were observed daily for the emergence of parasitoids

Weekly meteorological data for a period during which the field studies were carried out were obtained from the agro-meteorological observatory, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The data on larval population, field parasitization and weather parameters were subjected to analysis to find out co-relation coefficients between them.

Seasonal incidence of *H. armigera*

It is seen from the Table 1 that, the incidence of *H. armigera* during *Rabi*, 2003-04 was initiated during 45th meteorological week (3 larvae 10 plants^{-1}) i.e., nearly one month after sowing. It went on increasing and reached its peak (7 larvae 10 plants^{-1}) during 49th and 50th meteorological week with a temperature variation of 16.5 to 32.2 °C and 11.9 to 31.2°C, while relative humidity between 33 to 77 per cent and 21 to 64 per cent, respectively during its previous week. Further it declined up to 1st meteorological week and was zero during 2nd meteorological week.

During *Rabi*, 2004-05, the incidence of *H. armigera* was noticed during 44th meteorological week (Table 2) i.e. 3 larvae 10 plants^{-1} with temperature between 14.6 to 33.0 °C, relative humidity 19 to 64 per cent and no rainfall during its previous week. Highest population of pest (13 larvae 10 plants^{-1}) was recorded in 48th meteorological week with temperature between 12.9 to 32.0 °C, relative humidity 22 to 66 per cent, no rainfall during its previous week. Afterwards the population started decreasing and was minimum (3 larvae 10 plants^{-1}) during 2nd meteorological week.

Yadava and Lal (1985) observed the peak activity of this pest on chickpea during 47th and 50th meteorological weeks. Likewise, Yadava *et. al.*, (1988) also observed peak activity of pest during 47th – 51st meteorological weeks. Similarly, Patel and Koshiya (1999) observed the highest incidence of pest during 3rd week of December.

Field Parasitization in *H. armigera*

During both the seasons of investigation no egg and pupal parasitoids were recorded. Only two larval parasitoids viz., *Campoletis chlorideae* and *Eriborus* sp were found parasitizing *H. armigera* larvae.

During 2003-04, the highest parasitization by *Campoletis chlorideae* (20 %) was recorded in 50th meteorological week, whereas the parasitization by *Eriborus sp* was highest (12 %) in 51st meteorological week. The total parasitization due to both parasitoids was highest during 51st meteorological week i.e. 28 per cent. The temperature and relative humidity ranged between 12.6 to 31.4 °C and 26 to 63 per cent, respectively during its previous week.

During 2004-05 the highest parasitization due to *C. chlorideae* and *Eribrus sp* was recorded in 48th meteorological week i.e. 24 and 12 per cent, respectively. The temperature and humidity ranged between 12.9 to 32.0 °C and 22 to 66 per cent, respectively.

Bilapate (1981) and Sachan and Bhumik (1998), observed maximum parasitization in the month of December. Findings regarding absence of egg parasitoids in chickpea are in conformity with Yadav and Patel (1981) and Kulat *et. al.*, (1999) who reported the ineffectiveness of egg parasitoids in chickpea due to its acidic secretion.

Correlation studies

Correlation coefficient values between larval population, field parasitization and weather parameters calculated from two years data presented in Table 3 revealed significant positive correlation between field parasitization and the larval population of the pests. However, larval population and field parasitization did not show any significant correlation with the weather parameters.

Table 3 : Relationship between larval population, field parasitization and weather parameter

S. N.	Particulars	Larval population	Field parasitization
1	Larval Population	—	0.777*
2	Maximum temp.	0.387	0.115
3	Minimum temp.	0.320	0.118
4	Morning humidity	0.230	0.181
5	Evening humidity	0.009	-0.079

* Significant at 5 % level of probability

Vaishampayan and Veda (1980) and Devi *et. al.*, (2002) observed positive correlation between larval population and field parasitization. Whereas, Yadav and Lal (1985) and Metange *et. al.*, (2002) observed the positive correlation between larval population and maximum and minimum temperature.

Thus, from the present study it can be concluded that, larval parasitoid *Campoletis chlorideae* and *Eriborus* sp were the key mortality factor of *H. armigera* in chickpea and their parasitization was highest in the month of December which was positively correlated with the larval population.

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Department of Horticulture,
Dr. PDKV, Akola

S. N. Kale
N. S. Ukey

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