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Influence of Integrated Nutrient Management on Growth and Yield Contributing Characters of Summer Sesamum*

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(Received : 31-11-2008)

ABSTRACT

The growth attributes like plant height and number of branches plant^{-1} and yield components like number of capsules plant^{-1} and thousand seed weight in summer sesamum were favourably influenced due to application of RDF+ 5 t each of FYM and vermicompost ha^{-1} + seed treatment with *Azospirillum* and PSB which was significantly superior to all other treatments followed by 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB.

Key words : Integrated nutrient management, growth contributing characters, summer sesamum.

The inadequate use of nutrients is an important factor for limiting the full expression of sesamum yield potential. The use of organic sources will reduce dependence on costly chemical fertilizers and pesticides besides being ecologically sound and eco-friendly in nature. Response of sesamum to biofertilizers when integrated with organic manure and inorganic fertilizers has not been adequately studied, hence this study was undertaken.

MATERIALS AND METHODS

The present investigation was carried out at Post Graduate Institutional Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer, 2007. The experiment was laid out in a randomized block design with three replications and ten treatments. The different treatments comprised of T_1 absolute control, T_2 - 100 % (60:40:20 NPK kg ha^{-1}) recommended dose of fertilizer (RDF), T_3 - 75 % N (urea) + 25 % N (FYM) + recommended P_2O_5 and K_2O, T_4 - 50 % N (urea) + 50 % N (FYM) + recommended P_2O_5 and K_2O, T_5-75 % N (urea) + 25 % N (vermicompost) + recommended P_2O_5 and K_2O, T_6 - 50 % N (urea) + 50 % N (vermicompost) + recommended P_2O_5 and K_2O, T_7 - 75 % N (urea) + seed treatment of *Azospirillum* and PSB + Recommended P_2O_5 and K_2O, T_8 - 50 % N (urea) + seed treatment of *Azospirillum* and PSB + recommended P_2O_5 and K_2O, T_9 - RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB, T_{10} - 75 % RDF + 5t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB. The gross and net plot sizes were 4.5 x 4.0 m^2 and 3.6 x 3.6 m^2, respectively. The soil of the experimental field was clayey in texture with low in available nitrogen (237.67 kg ha^{-1}), medium in available phosphorus (22.18 kg ha^{-1}) and high in available potassium (427.52 kg ha^{-1}). The soil was moderately alkaline in reaction (pH 8.3). The experimental crop was sown by dibbling at 45 x 10 cm spacing on 12th March, 2007 and harvested on 6th June, 2007.

*Part of M. Sc. (Agri.) thesis submitted by the senior author to MPKV, Rahuri

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RESULTS AND DISCUSSION

Growth attributes : Plant height : The period of grand growth was observed between 30 to 75 days. The maximum plant height was recorded (92.3 cm) at 75 DAS (Table 1). The application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB produced maximum plant height (32.6 cm) at 30 DAS and was significantly superior over rest of the treatments at all the growth stages followed by 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of Azospirillium and PSB (30.9 cm).

At harvest, the application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB produced the maximum plant height (103 cm) and was found significantly superior over rest of the treatments followed by 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatments of *Azospirillum* and PSB (100.9 cm). It might be due to judicious application of all nutrient sources. Similar results were also reported by Palaniappan *et al.*, (1999), Deshmukh *et al.*, (2002) and Jaishankar and Wahab (2005).

Branching : The mean number of branches plant^{-1} were increased with advancement in the age of crop. The maximum number of branches plant^{-1} were recorded at harvest (3.81) due to application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB.

The application of RDF + 5 t each of vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB recorded the maximum number of branches per plant at all the growth stages except at 75 DAS and at harvest and were significantly superior over all other treatments. The second best treatment was 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of

Table 1. Mean plant height (cm) and number of branches plant^{-1} as affected periodically by different treatments.

Treatments		Plant height (cm)			Branches plant^{-1}		
		Days after sowing			Days after sowing		
		45	75	At harvest	45	75	At harvest
T_1	Control	57.5	81.9	81.8	1.80	2.10	2.11
T_2	60:40:20 NPK (RDF)	70.8	97.4	97.3	2.91	3.52	3.53
T_3	75% N (urea) + 25% N (FYM)	69.6	96.8	96.7	2.93	3.40	3.41
T_4	50% N (urea) + 50% N (FYM)	64.9	88.2	88.1	2.67	2.78	2.79
T_5	75% N (urea) + 25% N (Vermi.C.)	67.3	91.8	91.7	2.84	3.20	3.21
T_6	50% N (urea) + 50% N (Vermi.C.)	63.2	86.8	86.7	2.28	2.60	2.61
T_7	75% N (urea) + seed tr. Azo. & PSB	66.3	90.3	90.2	2.80	3.07	3.08
T_8	50% N (urea) + seed tr. Azo. & PSB	60.9	85.9	86.8	2.27	2.47	2.48
T_9	RDF + 5 t each FYM and Vermi.C ha^{-1} + seed tr. Azo. & PSB	75.8	103.1	103.0	3.27	3.80	3.81
T_{10}	75% RDF + 5 t each FYM and Vermi. C ha^{-1} + seed tr. Azo & PSB	73.1	101.0	100.9	3.07	3.68	3.69
Mean		66.9	92.3	92.2	2.69	3.06	3.07
S. E.±		0.22	0.20	0.20	0.04	0.05	0.07
CD at 5%		0.66	0.59	0.60	0.12	0.16	0.18

A dose of P_2O_5 and K_2O was applied uniformly from 2 to 9 treatments

RDF = Recommended dose of fertilizer (kg ha^{-1}), PSB = Phosphate solublizing bacteria

Azospirillum and PSB (3.69) which was at par with the application of RDF (3.53).

At 75 DAS and at harvest, the application of RDF + 5 t each of FYM vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB was at par with 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB. The rate of increased number of branches was accelerated between 30 to 45 DAS. Nutrient availability through different sources might have increased the number of branches between the growth period of 30 to 45 days. This finding corroborate the findings of Tiwari *et al*., (2000), Deshmukh *et al*., (2002) and Pathak *et al*., (2002).

Yield components : Capsules : The data (Table 2) showed that the number of capsules $plant^{-1}$ increased with increase in the age of crop. The maximum number of capsules $plant^{-1}$ (65.48) were recorded at harvest due to application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB followed by the application of 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azosprillum* and PSB (64.64) and was significantly superior over rest of the treatments except application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB.

The minimum number of capsules (31.48) were observed under control at harvest. The highest mean number of capsules $plant^{-1}$ were recorded with RDF + 5 t each of FYM ha^{-1} + vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB treatment due to better utilization of applied nutrient to this treatment. Similar results were recorded by Palaniappan *et al*. (1999), Attia (2001), and Jaishankar and Wahab (2005).

Thousand seed weight : The application of RDF + 5 t each of FYM and vermicompost ha-1 + seed treatment of *Azospirillum* and

Table 2. Mean number of capsules $plant^{-1}$ observed periodically and thousand seed weight (g) as affected by different treatments.

Treatments	Capsules $plant^{-1}$			Thousand seed weight (g)
	45	75	At harvest	
T_1 Control	15.27	31.47	31.48	2.53
T_2 60:40:20 NPK (RDF)	28.80	63.07	63.08	3.47
T_3 75% N (urea) + 25% N (FYM)	26.53	57.87	57.88	3.37
T_4 50% N (urea) + 50% N (FYM)	21.40	46.20	46.21	3.30
T_5 75% N (urea) + 25% N (Vermi.C.)	26.33	52.87	52.88	3.33
T_6 50% N (urea) + 50% N (Vermi.C.)	21.00	42.40	42.41	3.27
T_7 75% N (urea) + seed tr. Azo. & PSB	24.80	48.60	48.61	3.30
T_8 50% N (urea) + seed tr. Azo. & PSB	20.73	37.33	37.34	2.73
T_9 RDF + 5 t each FYM and Vermi.C ha^{-1} + seed tr. Azo. & PSB	31.93	65.47	65.48	3.67
T_{10} 75% RDF + 5 t each FYM and Vermi. C ha^{-1} + seed tr. Azo & PSB	28.87	64.60	64.64	3.63
Mean	24.57	50.99	51.00	3.26
S. E.±	0.06	0.08	0.07	0.07
CD at 5%	0.18	0.25	0.24	0.21

A dose of P_2O_5 and K_2O was applied uniformly from 2 to 9 treatment

RDF = Recommended dose of fertilizer (kg ha^{-1}), PSB = Phosphate solublizing bacteria

PSB recorded the highest thousand grain weight (3.67 g) and was significantly superior over rest of the treatments. However, it was at par with 75 per cent RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB (3.63 g) and RDF treatment (3.47 g). The lowest thousand seed weight was observed with the control (2.53 g) and at par with 50 per cent N (urea) + seed treatment of *Azospirillum* and PSB + recommended P and K.

The highest thousand seed weight was recorded by the application of RDF + 5 t each of FYM and vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB was due to nutrient supply by different inorganic and organic fertilizer combinations which resulted in better development of seed and capsule. Similar results were also obtained by Tiwari *et al.* (2000), Prakash *et al.* (2001), Deshmukh *et al.* (2002) and Pathak *et al.* (2002).

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Nutrient Management for Pearl millet (*Pennisetum glaucum* L.) in Light Soil of Rainfed Areas

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ABSTRACT

An application of 5 tones of FYM + biofertilizer (*Azospirilium* + PSB @ 25g kg^{-1} each) + 60:30:30 kg NPK ha^{-1} produced significantly higher grain yield (25.86 q ha^{-1}), fodder yield (43.96 q ha^{-1}), gross return (Rs. 17742 ha^{-1}) and net returns (Rs. 7600 ha^{-1}) over rest of the treatment except application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} and application 5 tones of FYM + biofertilizer + 40.20.20 kg of NPK ha^{-1}. The application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} recorded highest B:C ratio (1.75) among all treatments. The treatment application of 5 tones of FYM + biofertilizer (*Azospirillium* and PSB @ 25 g kg^{-1} each) + 40.20.20 kg NPK ha^{-1} was most economical and beneficial for achieving higher yield and net returns of pearl millet hybrid Shraddha for the kharif season in the light soil.

Key words : Pearl millet, rainfed condition, fertilizers.

Pearl millet (*Pennisetum glaucum* L.) is the fourth most important cereal crop in India next to rice, wheat and sorghum. Maharashtra stands second in area and fourth in production of pearl millet in India. It is necessary to increase the productivity of pearl millet by using advanced techniques because this crop is being continuously grown on marginal lands with low levels of inputs and inadequate nitrogen and phosphorus fertilization which is already deficient in the soil of arid and semiarid regions (Khateek *et al.* 1999). Fertilizer is also important input for successful crop production. This is necessary to provide adequate and balanced dose of fertilizer to the *kharif* pearl millet. For increasing productivity and fertilizer use efficiency under rainfed condition, hybrids are more responsive to fertilizers in view of this background, the present investigation was under taken to find out the optimum dose of fertilizer in light soil under rainfed condition.

1,2,4. Asstt. Professor, 3. Associate Professor and 5. Jr. Res. Asstt.

MATERIALS AND METHODS

The field investigation on nutrient management for pearl millet hybrid Shraddha in light soil under rainfed conditions was conducted during rainy seasons (*kharif*) in 2004,2005 and 2006 at Bajra Research Scheme, College of Agriculture, Dhule. The soil was light with pH 7.1, low in available nitrogen (163 kg ha^{-1}), and available phosphorus (19 kg ha^{-1}) and rich in available potassium (268 kg ha^{-1}). The experiment was laid out in a randomized block design with 8 treatments replicated thrice. The treatment consisted of N:P:K T_1 - 0:0:0, T_2 - 20:0:0, T_3 - 0:20:0, T_4 - 0:0:20, T_5 - 20:20:20, T_6 - 40:20:20, T_7 - 50:25:25 and T_8 - 60:30:30 kg ha^{-1}. Pearl millet variety Shraddha (RHRBH 8609) was sown at 45 x 15 cm by dibbling every year. In all the treatments 5 tones of FYM ha^{-1} was applied and seed was treated with biofertilizer (*Azospirillum* + PSB @ 25 g kg^{-1} seed each). The fertilizer application was done as per the treatments, the half dose of N, full dose of P and K was applied at the time of sowing and remaining half dose of N was applied at 30 days after sowing. The rainfall received during crop season was 783.6, 392.6, and 860.6 mm in 40, 31 and 44 rainy days in 2004, 2005 and 2006 respectively.

RESULTS AND DISCUSSION

Fertilizer levels : The grain and fodder yield of pearl millet hybrid Shraddha (Table 1) was influenced significantly due to different fertilizer levels. All the treatments produced significantly higher grain and fodder yield over control (T_1). Applicaton of 5 tones of FYM + biofertilizer +50:25:25 kg NPK ha^{-1} (T_7) produced highest grain yield (25.99 q ha^{-1}) in the year 2004. The application of 5 tones of FYM + biofertilier + 60:30:30 kg NPK ha^{-1} (T_8) recorded significantly higher grain (23.43 and 27.20 q ha^{-1}) as well as fodder yield (39.84 and 46.29 q ha^{-1}) during the year 2005 and 2006 respectively. Pooled data over years showed significantly higher grain yield (25.86 q ha^{-1}) and fodder yield (43.96 q ha^{-1}) by the application of 5 tones of FYM + biofertilizer + 60:30:30 kg NPK ha^{-1} (T_8) over rest of the treatments except in application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} (T_7) and application of 5 tones of FYM + biofertilizer + 40:20:20 kg NPK ha^{-1} (T_6) which was on par with treatment (T_8) and produced grain yield (25.36 q ha^{-1} and 24.09 q ha^{-1}) and fodder yield (43.11 q ha^{-1} and 40.87 q ha^{-1}) respectively. These results are in conformity with the finding of Bhagchand and Gautam (2000), Chaubey *et al.* (2001) and Manirathnam and Gautam (2002).

Gross and net return : Application of 5 tones of FYM + biofertilizer + 60:30:30 kg NPK ha^{-1} (T_8) recorded significantly higher gross monetary returns during all three years and in pooled over the seasons (Rs. 17742 ha^{-1}). However, it was on par with treatment of application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} (Rs. 17205 ha^{-1}) (T_7) and application of 5 tones of FYM + biofertilizer + 40:20:20 kg NPK ha^{-1} (T_6) (Rs. 16568 ha^{-1}).

The application of 5 tones of FYM+ biofertilizer + 50:25:25 kg NPK ha^{-1} (T_7) recorded significantly higher net returns during 2005 (Rs. 5712 ha^{-1}). When data was pooled over the seasons, the treatment, application of 5 tones of FYM + biofertilizer + 60:30:30 kg ha^{-1} (T_8) recorded significantly higher net return (Rs. 7600 ha^{-1}) over rest of the treatments combinations but it was on par with the treatment (T_7) i.e. application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} (Rs. 7492 ha^{-1}) and treatment (T_6) i.e. application of 5 tones of FYM+ biofertilizer + 40:20:20 kg NPK ha^{-1} (Rs. 6935 ha^{-1}).

Cost benefit ratio : The highest B:C ratio (1.95) was recorded by the treatment (T_6) application of 5 tones of FYM + biofertilizer + 40:2020 kg NPK ha^{-1} during the year 2006. When data was pooled over the season treatment T_8 i.e. application of 5 tones of FYM + biofertilizer + 60:30:30 kg NPK ha^{-1} reorded

Table 1. Yield and economics of pearl millet as influenced by different fertilizer levels pooled (2004 to 2006).

Treatments NPK (kg ha^{-1})	Grain yield (q ha^{-1})	Fodder yield (q ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
0:0:0	16.13	27.68	11070	2415	1.29
20:0:0	19.68	33.77	13532	4646	1.52
0:20:0	18.72	32.08	12861	3725	1.40
0:0:20	18.91	32.17	13009	4145	1.46
20:20:20	21.18	35.98	14557	5087	1.53
40:20:20	24.09	40.87	16568	6935	1.71
50:25:25	25.36	43.11	17405	7494	1.75
60:30:30	25.86	43.96	17742	7600	1.74
Mean	21.24	36.20	14593	5256	1.55
S. E.±	0.61	1.06	439	405	0.04
C. D. at 5%	1.84	3.31	1334	1229	0.12

the highest B:C ratio (1.75) over rest of the treatments but it was on par with treatments T_7 and T_6.

Yields : On the basis of three years pooled data, it was observed that application of 5 tones of FYM + biofertilizer + 60:30:30 kg NPK ha^{-1} (T_8) to pearl millet hybrid Shraddha produced significantly higher grain yield, fodder yield as well as gross and net monetary returns over rest of the treatments, which was on par with the treatment (T_7) application of 5 tones of FYM + biofertilizer + 50:25:25 kg NPK ha^{-1} and the treatment (T_6) application of 5 tones of FYM + biofertilizer + 40.20.20 kg NPK ha^{-1}.

Highest B:C ratio (1.75) was found in treatment (T_8) i.e. application of 5 tones of FYM + biofertilizer + 60:30:30 kg NPK ha^{-1} which was closely followed by treatment T_7 (1.74) and T_6 (1.71) respectively.

From the above studies it is concluded that the application of 5 tones of FYM + biofertilizer (*Azospirillium* and PSB@ 25 g kg^{-1} each) + 40:20:20 kg NPK ha^{-1} was most economical and beneficial to achive higher yield and net returns of pearl millet hybrid Shraddha during the *kharif* season on the light soil.

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Response of Sorghum Genotypes to Different Levels of Nitrogen in Vertisol under Dryland Condition

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ABSTRACT

Application of nitrogen @ 50 kg N ha^{-1} significantly increased the grain and stover yields, MUE, available N, net monetary returns and B:C ratio as compared with 25 kg N ha^{-1} and control under either sufficient or deficient in total, *kharif* and *rabi* rainfall and it was statistically on par with 75 kg N ha^{-1}. Similar trend was also noticed in case of uptake of nitrogen except total and *rabi* deficient rainfall situation. The SYI was increased with increasing levels of nitrogen. Sorghum genotypes did not influenced the grain yield under sufficient rainfall of total and *kharif* season. However, under deficient total rainfall situation or stress condition the M 35-1 recorded higher grain yield than CSH-15 R and Yashoda. M 35-1 also recorded the highest values of MUE in total and *rabi* deficient rainfall conditions. The MUE, net returns and B:C ratio were increased with increasing the doses of nitrogen upto 50 kg N ha^{-1}. M 35-1 significantly increased the net monitary returns as compared with CSH-15 R under all deficient rainfall situations. Hence, the 50 kg of nitrogen to sorghum cv., M 35-1 is recommended under either sufficient or deficient in *kharif*, *rabi* and total rainfall situation under dryland condition.

Key words : Genotypes, moisture use efficiency, nitrogen use efficiency, *rabi* sorghum, sustainable yield index, vertisol.

Sorghum is a staple food crop of the scarcity zone of Maharashtra. The area under *rabi* sorghum is 32.2 lakh ha with productivity of 568 kg ha^{-1} in Maharashtra. The moisture is a limiting factor as the crop is grown on receding soil moisture with very few showers received during the crop growth period. The fertilizer use in such a soil is far below the recommended dose due to shortage of water in rainfed farming. The cultivation of *rabi* sorghum is mostly confined to the shrink swell soils of Maharashtra which are very low in organic carbon content and the response to nitrogen fertilization in these soils is spectacular (Jadhav *et al*., 1991 and Anonymous 2004-2005). The yield potential of *rabi* sorghum under such condition is very low. The productivity and stability of *rabi* sorghum could be increased through adoption of high yielding varieties with optimum nitrogen levels under low to moderate rainfall situations, drought and other environmental stress conditions in calcareous soil (Anonymous 2007).

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2000, 2001, 2002, 2004 and 2005 at Zonal Agricultural Research Station, Solapur. The soil was clay, deep black (Vertisol) having slightly alkaline reaction with pH (7.85), EC (0.29 dS m^{-1}), low in organic carbon (0.35%), available N (151 kg ha^{-1}), low in available P_2O_5 (13.4 kg ha^{-1}) and high in available K_2O (689 kg ha^{-1}). The experiment was laid out in a factorial randomized block design with 4 levels of nitrogen *viz*., 0, 25, 50, and 75 kg ha^{-1} and 3 sorghum genotypes *viz*., M 35-1, Yashoda and CSH 15-R with 3

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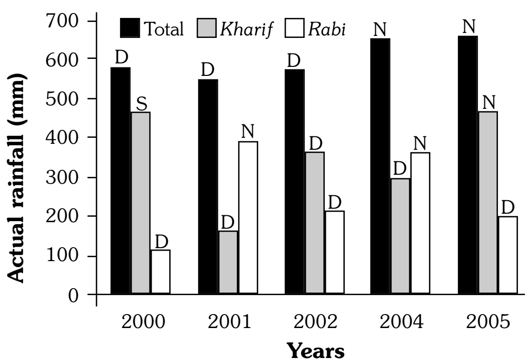
replications. M 35-1 is stress tolerant, resistant to stem borer, suitable for medium to deep black soils excellent grain and fodder quality. CSH-15 R is a hybrid cultivar released in 1994, resistant to charcoal rot and stem borer and suitable for rainfed and irrigated conditions. The cultivar Yashoda is high yielding, resistant to charcoal rot, stem borer and suitable for deep black soil. A uniform dose of 10.91 kg P_2O_5 ha^{-1} was mixed with calculated N quantities of urea and drilled 10 cm below the seed at the time of sowing. The nitrogen and phosphorus were applied through urea and single super phosphate. The sowing was done on 1st October 2000, 24th October 2001, 2nd October 2002, 29th September 2004, 28th September 2005 and harvested on 29th January 2001, 25th January 2002, 24th January 2003, 3rd February 2005 and 4th February 2006 respectively. Seed rate of 10 kg ha^{-1} was used at inter and intra row spacing of 45 and 20 cm, respectively. Thinning was done at 15 days after sowing to keep intra row spacing of 20 cm in all the years. The periodical soil samples at 0-30, 30-60 and 60-90 cm depth were collected for the determination of soil moisture at an interval of



Normal rainfall (mm) : Total : 663.1
Kharif : 381.3
Rabi : 281.8

Fig. 1. Year wise distribution of rainfall (mm) during the experimental period (2000-2005).

15 days after sowing. The cumulative use of moisture (CUM) was calculated and moisture use efficiency (MUE) was worked out based on the grain yield divided by CUM. The data of grain and fodder yield per plot was worked out and it was converted into kg ha^{-1}. For computation of sustainable yield index (SYI), the mean yields for the years were determined. The SYI was computed by using the formula as suggested by Wanjari *et al.* (2004). The rainfall received in *kharif* and *rabi* season was recorded and then sum was considered as total rainfall. The yearwise rainfall distribution during the experimental period is given in Fig 1. The sufficient and deficient rainfall was calculated with the average of 30 years of normal rainfall of the region. Total rainfall for the year 2004 and 2005 were considered as normal, while the 2001, 2002 and 2004 as deficient rainfall for *kharif* season and for *rabi* season 2001 and 2004 were considered as normal, while 2000, 2002 and 2005 were considered as deficient rainfall (Fig. 1). At harvest, the plant samples were collected as per treatment, dried under shade and powdered. The powdered samples were digested using standard procedure and aliquot was used for estimation of N. The total N content was determined by Kjeldhal method. The content of N was multiplied by grain and, stover yield to obtain uptake of N. After harvesting, separate soil samples were collected from each plot for estimation of residual available N. Economics was calculated on the basis of prevailing market prices of inputs and minimum support price of produce.

RESULTS AND DISCUSSION

Grain and stover yields : Application of nitrogen @ 50 kg N ha^{-1} or 75 kg N ha^{-1} significantly increased the grain and stover yields of *rabi* sorghum as compared with 25 kg N ha^{-1} and control under either sufficient or deficient in total, *kharif* and *rabi* rainfall and it was statistically on par with each other (Table

1). When the rainfall is sufficient in *kharif* season, the levels of nitrogen did not differ significantly but all the levels were significantly superior over control. The highest grain yield was recorded due to the application of 75 kg N ha^{-1} under sufficient total and *kharif* rainfall situation and it was on par with 50 kg N ha^{-1}. In general, 50 kg N ha^{-1} recorded higher values of grain yield under deficient total and *kharif* rainfall. In most of the cases 25 kg N ha^{-1} significantly increased the grain and fodder yields at all the rainfall situations. The results revealed that the application of nitrogen @ 50 kg N ha^{-1} is to be applied for increasing the grain and stover yields of *rabi* sorghum either in sufficient or deficient rainfall pattern in *kharif*, *rabi* and total under dryland conditions. Similar observation was made by Jadhav *et al*. (1991), Duraisami *et al*. (2001) and Kaushik and Shaktawat (2005) in sorghum in respect of nitrogen. It is understood that soil moisture is the key factor for increasing the grain and fodder yields under dryland condition. Soil moisture had helped in mineralization of nitrogen and NO_3–N made available to the plants, which helped in increasing the grain yield at sufficient total and *kharif* rainfall. SPV-1591 produced significantly the highest grain yield as compared with Phule Mauli and SPV-1588, but on par with M 35-1 (Anonymous, 2004-2005).

The sorghum genotypes did not influenced grain yield under sufficient rainfall of total and in *kharif* season. When the rainfall is sufficient, the CSH-15R and Yashoda (Table 2) recorded higher grain yield than M 35-1. Daftardar *et al.*, (1987) reported that CSH-15R gave higher grain yield than M 35-1 in favorable annual rainfall average of 720 mm or above at Solapur. Nevertheless, under deficient total rainfall situation i.e. stress condition, the M 35-

Table 1. Pooled grain and stover yields of *rabi* sorghum according to sufficient and deficient rainfall as influenced by N levels and genotypes in Vertisol.

Treat-ments	**Grain yield (kg ha^{-1})**						**Stover yield (kg ha^{-1})**						**SYI**
	Kharif		***Rabi***		**Total rainfall**		***Kharif***		***Rabi***		**Total rainfall**		
	S (2000-05)	**D (2001-02-04)**	**S (2001-04)**	**D (2000-02-05)**	**S (2004-05)**	**D (2000-01-02)**	**S (2000-05)**	**D (2001-02-04)**	**S (2001-04)**	**D (2000-02-05)**	**S (2004-05)**	**D (2000-01-02)**	
Nitrogen levels (kg ha^{-1}) :													
0	1270	773	714	1144	1053	931	3606	2475	2299	3442	2408	3258	0.09
25	1417	1083	1018	1350	1207	1223	4051	3404	2733	3950	2897	3838	0.22
50	1519	1323	1234	1513	1293	1473	4408	3620	3182	4438	3268	4380	0.31
75	1637	1269	1178	1575	1415	1417	4330	3567	3201	4319	3218	4308	0.32
S. E. ±	74	27	30	54	65	30	209	220	107	148	89	108	0.02
C. D. 5%	229	80	93	159	201	88	NS	643	332	434	275	316	0.09
Genotypes :													
M 35-1	1459	1157	1060	1423	1215	1320	4106	3275	2901	4078	2871	4111	0.68
Yashoda	1491	1036	943	1401	1214	1231	4511	3445	3123	4374	3094	4385	0.64
CSH-15R	1433	1142	1104	1362	1297	1233	3680	3076	2537	3584	2897	3342	0.66
S. E. ±	64	24	26	47	56	26	181	190	93	128	77	94	0.02
C. D. 5%	NS	69	81	NS	NS	76	561	NS	288	376	NS	274	NS

S - Sufficient, D - Defficient

1 recorded the highest grain yield than CSH-15R and Yashoda. If the rainfall is deficient in *kharif* season, M 35-1 and CSH-15R were significantly superior over cv., Yashoda. However, under sufficient total and *kharif* rainfall all the genotypes of sorghum were on par. Results revealed that the cv., M 35-1 is the suitable sorghum genotype under dryland conditions. It was observed that in entire rainfall situation cv., Yashoda recorded higher stover yield and it was followed by M 35-1 and CSH-15R. From the above results it could be concluded that differences among various genotypes in responding to the application of nitrogen is to be considered while recommending fertilizer doses to deep black soils under dryland conditions. The differential response to nitrogenous fertilizer in sufficient or deficient moisture conditions in respect of grain and stover yields might be attributed to the genetic make up (Anonymous, 2004-2005). The interaction effects between levels of N and sorghum genotypes in case of grain and stover yields were found to be non significant under all the rainfall situation.

Sustainable yield index (SYI) : The maximum sustainable yield index (0.32) was found due to the addition of 75 kg N ha^{-1} to *rabi* sorghum and was significantly superior to 25 kg N ha^{-1} and control (Table 1) and on par with 50 kg N ha^{-1}. The results revealed that the 50 kg N ha^{-1} is quite sufficient for maintaining the SYI. The varieties were found to be non significant in respect of SYI of *rabi* sorghum under dryland condition. The interaction effects between N levels and genotypes were also found non significant.

Uptake of nitrogen : The application of nitrogen @ 50 kg ha^{-1} recorded the highest (47.08 kg ha^{-1}) uptake of nitrogen which was

Table 2. Pooled N uptake and MUE of *rabi* sorghum according to sufficient and deficient rainfall as influenced by N levels and sorghum genotypes in Vertisol.

Treatments	N uptake (kg ha^{-1})						MAU (kg ha^{-1} mm^{-1})					
	Kharif		*Rabi*		Total rainfall		*Kharif*		*Rabi*		Total rainfall	
	S (2000-05)	D (2001-02-04)	S (2001-04)	D (2000-02-05)	S (2004-05)	D (2000-01-02)	S (2000-05)	D (2001-02-04)	S (2001-04)	D (2000-02-05)	S (2004-05)	D (2000-01-02)
Nitrogen levels (kg ha^{-1}) :												
0	38.93	26.24	23.60	37.33	29.87	33.22	4.32	3.05	2.69	4.14	3.78	3.41
25	49.21	32.54	35.00	41.55	40.06	38.50	4.62	4.26	3.82	4.79	4.21	4.53
50	58.19	37.96	43.08	47.73	47.08	43.56	5.88	5.29	4.77	6.03	5.56	5.50
75	55.46	46.88	42.55	57.48	44.75	55.61	5.12	4.88	4.29	5.43	4.69	5.16
S. E. ±	2.29	4.81	1.11	2.46	1.16	2.37	0.30	0.12	0.07	0.23	0.30	0.14
C. D. 5%	7.11	14.93	3.43	7.65	3.62	7.37	0.94	0.35	0.23	0.67	0.92	0.41
Genotypes :												
M 35-1	49.60	40.07	36.71	41.79	38.49	40.93	5.03	4.40	3.74	5.26	4.50	4.75
Yashoda	52.84	33.29	35.44	47.72	40.30	44.12	5.04	4.17	3.71	5.05	4.44	4.57
CSH-15R	48.91	34.35	36.02	48.56	42.53	43.13	4.88	4.54	4.22	4.98	4.75	4.63
S. E. ±	1.98	4.17	0.96	2.13	1.01	2.06	0.26	0.10	0.06	0.20	0.26	0.12
C. D. 5%	6.16	NS	NS	6.62	3.13	NS	NS	0.31	0.20	NS	NS	NS

S - Sufficient, D - Defficient

significantly superior to 25 kg N ha^{-1} and control under sufficient total rainfall while, it was on par with 75 kg N ha^{-1} (Table 2). The 25 kg N ha^{-1} level significantly increased the uptake of nitrogen as compared with control. Among the genotypes, CSH-15R significantly increased the uptake of nitrogen over M 35-1. The genotype Yashoda was on par with either CSH-15R or M 35-1 in respect of uptake of nitrogen in sufficient total rainfall.

The 75 kg N ha^{-1} level was significantly superior over all other levels under total and *rabi* deficient rainfall situations. The addition of 50 kg N ha^{-1} is significantly superior over control. The lower doses of nitrogen (25 and 50 kg N ha^{-1}) did not increase the yield concomitantly under total and *rabi* deficient rainfall conditions (Table 1). All the genotypes were found to be non significant in respect of uptake of nitrogen in all the sufficient and deficient conditions of rainfall except total sufficient rainfall. The results indicated that the application of 50 kg N ha^{-1} recorded the highest uptake of nitrogen under all sufficient rainfall conditions. If the rainfall situation is deficient in *kharif* and *rabi* season, the more uptake of nitrogen was found at 75 kg N ha^{-1}. The interaction effects were found to be non-significant. The results are in agreement with the observations of Kaushik and Shaktawat (2005).

Moisture use efficiency : With increasing doses of nitrogen MUE increased up to 50 kg N ha^{-1} and on par with 75 kg N ha^{-1} in all the sufficient and deficient rainfall situations (Table 2). The 50 kg N ha^{-1} also significantly increased the MUE over 25 kg N ha^{-1} and control treatments in all sufficient and deficient rainfall situations except *kharif* sufficient rainfall. Jadhav *et al.* (1991) also reported the increasing MUE with increase in N rate on sorghum. The results inferred that 50 kg N ha^{-1} recorded the higher MUE in all the rainfall situations.

The sorghum genotypes were found to be non-significant in all the rainfall situations except *rabi* sufficient. Although the data of genotype in respect of MUE were found to be non-significant, the M 35-1 recorded the highest values of MUE in total and *rabi* deficient rainfall conditions. Hence, the cv., M 35-1 was found to be efficient under stress condition.

Residual N : The available nitrogen content of soil was increased with increasing the doses of nitrogen under sufficient or deficient rainfall of total, *kharif* and *rabi* season (Table 3). Maximum available nitrogen was found at 75 kg ha^{-1} in all the rainfall situations.

Table 3. Poooled available N of *rabi* sorghum according to sufficient and deficient rainfall as influenced by N levels and genotypes in Vertisol.

Treatments	Available N (kg ha^{-1})					
	Kharif		***Rabi***		**Total rainfall**	
	S (2000-05)	**D (2001-02-04)**	**S (2001-04)**	**D (2000-02-05)**	**S (2004-05)**	**D (2000-01-02)**
Nitrogen levels (kg ha^{-1}) :						
0	130	153	155	137	133	151
25	143	177	178	154	147	175
50	152	183	184	162	155	182
75	160	188	189	169	162	187
SE±	3.35	0.58	0.71	2.43	3.30	0.94
CD 5%	10.39	1.71	2.22	7.10	10.24	2.76
Genotypes :						
M 35-1	142	176	177	153	146	174
Yashoda	149	174	175	157	150	174
CSH-15R	147	176	177	156	152	173
SE±	2.90	0.51	0.62	2.10	2.86	0.82
CD 5%	NS	1.48	1.92	NS	NS	NS

S - Sufficient, D - Defficient

Table 4. Pooled net returns (x 10^3 Rs. ha^{-1}) and B:C ratio of *rabi* sorghum according to sufficient and deficient rainfall as influenced by N levels and sorghum genotypes in Vertisol.

Treat-ments	Net returns (Rs. ha^{-1})						B:C ratio					
	Kharif		*Rabi*		Total rainfall		*Kharif*		*Rabi*		Total rainfall	
	S (2000-05)	D (2001-02-04)	S (2001-04)	D (2000-02-05)	S (2004-05)	D (2000-01-02)	S (2000-05)	D (2001-02-04)	S (2001-04)	D (2000-02-05)	S (2004-05)	D (2000-01-02)
Nitrogen levels (kg ha^{-1}) :												
0	14.71	6.76	5.69	12.77	8.78	10.72	2.82	1.73	1.71	2.58	2.09	2.33
25	16.57	10.46	8.75	15.67	10.85	14.27	2.85	2.17	1.98	2.75	2.21	2.59
50	18.35	14.02	11.77	18.40	12.55	17.88	2.99	2.52	2.28	2.99	2.36	2.94
75	18.73	13.12	11.11	18.20	13.07	16.90	2.97	2.38	2.17	2.91	2.37	2.78
SE±	1.16	0.48	0.41	0.87	0.70	0.56	0.13	0.06	0.04	0.10	0.09	0.06
CD 5%	3.59	1.39	1.27	2.54	2.16	1.65	NS	0.19	0.12	0.30	NS	0.19
Genotypes :												
M 35-1	17.10	11.78	9.69	16.72	10.76	16.00	2.90	2.30	2.07	2.86	2.19	2.78
Yashoda	18.77	11.42	9.53	17.58	11.59	16.20	3.10	2.26	2.05	2.96	2.29	2.80
CSH-15R	15.40	10.07	8.77	14.50	11.57	12.63	2.72	2.03	1.97	2.61	2.29	2.40
SE±	1.00	0.41	0.35	0.75	0.60	0.49	0.11	0.06	0.03	0.09	0.08	0.06
CD 5%	3.11	1.20	NS	2.20	NS	1.43	0.35	0.16	NS	0.26	NS	0.16

Cost of cultivation : Rs. 8070/-; Cost of fertilizer N @ Rs. 11.28 kg^{-1} and P_2O_5 @ Rs. 24 kg^{-1}
Price of produce : Grain Rs. 800 q^{-1} and stover Rs. 350 q^{-1}.

The lowest available nitrogen was noticed in 0 kg N ha^{-1} under all the rainfall situations. The 75 kg N ha^{-1} level was found to increase the available nitrogen significantly as compared with 25 kg N ha^{-1} and control treatments in all the rainfall situation. However, it was found to be on par with 50 kg N ha^{-1} under sufficient total and *kharif* rainfall situation and significantly superior to all other doses of nitrogen under sufficient *rabi* rainfall. The results indicated that 75 kg N ha^{-1} under sufficient total and *kharif* rainfall situation and significantly superior to all other doses of nitrogen under sufficient *rabi* rainfall. The results indicated that 75 kg N ha^{-1} under *rabi* sufficient rainfall showed increased availability of nitrogen over its lower doses. The 75 kg N ha^{-1} and 50 kgN ha^{-1} were on par with each other but were significantly superior to 25 kg N ha^{-1} and control under deficient rainfall in *rabi* season. If the total and *kharif* rainfall is deficient, the available status of nitrogen was significantly increased with increasing the levels of nitrogen. It might be attributed to the less utilization of nitrogen under the deficient moisture condition. The genotypes of sorghum did not influence the available nitrogen content of soil in all the rainfall situations except *kharif* deficient and *rabi* sufficient rainfall. In above two situations M 35-1 and CSH-15R were on par with each other but significantly superior to Yashoda. The interaction were non-significant.

Net returns and B:C ratio : Maximum net returns were observed due to the application of nitrogen @ 75 kg ha^{-1} under all sufficient rainfall situations except *rabi* sufficient and it was on par with 50 kg N ha^{-1}

(Table 4). However, under deficient rainfall situation maximum net returns were observed due to the addition of 50 kg N ha^{-1} to *rabi* sorghum. The results indicated that the net returns increased with increasing the doses of nitrogen up to 50 kg N ha^{-1}.

The genotypes of sorghum did not influence the net monitory returns under total and *rabi* sufficient rainfall conditions unlike under all deficient rainfall conditions. The cv., M 35-1 and Yashoda significantly increased the net monitory returns as compared with CSH-15R. The maximum B:C ratio was recorded due to the addition of 50 kg N ha^{-1} in all the situations of rainfall and was on par with 75 kg N ha^{-1} and significantly superior to 25 kg N ha^{-1} and control treatments. Thus, it can be concluded that the application of 50 kg N ha^{-1} to *rabi* sorghum under sufficient or deficient rainfall either in *kharif* or *rabi* season is beneficial for increasing the net monitory returns and B:C ratio under dryland conditions.

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Response of Brinjal (*Solanum melongena* L.) to Placement of Fertilizers and Organic Manure under Drip Irrigation

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ABSTRACT

The treatment combination RDF application below dripper and poultry manure placement below hill recorded significantly superior growth, yield attributes and fruit yield of brinjal and was at par with treatment combination RD through mixed fertilizer and urea below dripper + poultry manure placement below hill. RDF, application below dripper and poultry manure placement below hill recorded highest net income (Rs. 1,30,271.00 ha), B:C ratio (1.83) and water use efficiency (1.05 t ha^{-1} - cm) which was closely followed by the treatment combinations RD through mixed fertilizer and urea, below dripper + poultry manure placement below hill (Rs. 1,18,046 ha^{-1}) with B:C ratio (1.76) and water use efficiency of 1.0. For getting higher yield, net returns, B:C ratio and water use efficiency under drip irrigation from brinjal crop, NPK nutrient dose may be applied below dripper through straight fertilizers and poultry manure may be applied by hill placement before transplanting.

Key words : Brinjal, placement, fertilizer, manure, drip, RDF.

Application of fertilizers along with irrigation is called fertigation which has become the state of art in vegetable and fruit crop production because the nutrients can be applied in correct doses and at appropriate stage of plant growth, In addition it improves fertilizer use efficiency, hastens the maturity of crop and improves the quality of produce (Yadav *et al.* 1993). The fertigation has number of advantages like improvement in nutrient use efficiency, placement of nutrients in the vicinity of crop root zone and saving of nutrients etc.

However, the fertigation has limitations of higher cost of soluble fertilizer and requires special equipments like fertilizer tank, ventury assembly, to be installed by the farmer which increases the cost of irrigation system. Considering the education level of Indian farmers, technique of fertigation is not handled efficiently. It is, therefore essential to standardize the conventional placement techniques of manures and fertilizers to suit water application through emitter which will increase the efficiency of locally available and low cost sources of fertilizers and manures. The common fertilizers are cheaply and readly available in the market than soluble fertilizer used in fertigation which can be used by the farmer, by improving method of placement with optimun yields and profit nearer to that due to soluble fertilizers with low expense. Thus an attempt was made to study the response of drip irrigated brinjal to placement of fertilizers and organic manure.

MATERIALS AND METHODS

A field experiment on brinjal variety Suvarn Pratibha was conducted during *rabi* season of the year 2005-2006 at the Department of Agronomy, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The soil was clay loam with pH 5.09. The available nitrogen was 326.30 kg, with available phosphorus 13.76

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kg, available potassium 249.80 kg ha^{-1}. The trial consisted of five main plot treatments of placement of fertilizers. *viz*., F_1 - RDF, band placement along the rows, F_2 - RDF, application below dripper, F_3 - RD through mixed fertilizers and urea below dripper, F_4 - RD through NPK briquettes below dripper, F_5 - RD through soluble fertilizer and urea (fertigation), while in sub plot treatments comprised of poultry manure placement comprise of M_1 - Band placement along the rows, M_2 - Band placement below lateral, M_3 - Placement below dripper, M_4 - Placement below hill. The trial was conducted in split plot design with three replications. Recommended dose of fertilizer to brinjal was 150 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare. In treatment F_1 and F_2,50 kg of nitrogen, 50 kg P_2O_5 and 50 kg K_2O per hectare was applied to the crop through urea, single super phosphate and muriate of potash, respectively, fifteen days after transplanting and remaining 100 kg nitrogen per hectare was applied through urea in two equal split doses i.e. 30 and 60 days after the first dose of fertilizer application, as per the treatment. Split doses for F_1 and F_2 were applied as per recommendation. In F_1 treatment i.e. band placement along the rows, the fertilizers were applied in band by keeping 5 to 10 cm distance from the hills. In F_2 treatment the fertilizers were applied by excavating a small pit of 10 cm depth below dripper.

In treatment F_3, 50 kg nitrogen, 50 kg P_2O_5 and 50 kg K_2O per hectare were applied through mixed fertilizer i.e. Suphala (15:15:15) and it was applied 5-10 cm below dripper, after two weeks of transplanting and remaining 100 kg nitrogen was given through urea, in three equal split doses at an interval of one month.

In treatment F_4, 150 kg N through diammonium phosphate and urea, 50 kg P_2O_5 through diammonium phosphate and 50 kg K_2O per hectare was applied through muriate of potash. After calculating the quantities of these fertilizers, required for unit experimental area, the briquettes were formed by using briquettes machine. The briquettes were applied uniformly in six equal split doses with an interval of 20 days after transplanting of crop and placed below dripper at a depth of 5 cm.

In treatment F_5, 50 kg dose of N, P_2O_5 and K_2O per hectare each was given through soluble fertilizer (Aquafert 19:19:19) through drip system i.e. fertigation in three split doses and remaining 100 kg N per hectare given through urea in subsequent three equal splits after dissolving it in sufficient quantity of water and applied to the crop through drippers by fertilizer injection pump.

Poultry manure @ 5 tonnes ha^{-1} was applied as per the treatments. For M_1 manure was applied by excavating a small band (shallow furrow) to a depth of 5 cm and 5 to 7 cm away from hill, to both sides of hills. For M_2 the band was excavated at the centre of paired rows, which was below lateral, with depth of 5 cm and quantity of poultry manure was applied in this band. For M_3 treatment the poultry manure was placed in small pits having 5-10 cm depth exactly below dripper. In case of M_4 treatment, the poultry manure was applied at the hill, before transplanting of brinjal seedling at a depth of 5-7 cm. For M_4 treatment manure was applied before transplanting of crop and for M_1, M_2 and M_3, manure was applied after fifteen days of transplanting. The plot size was 5.10 x 3.60 m^2. The paired row planting pattern of 90 - 30 x 30 cm spacing was used for all the treatments. Dripper of 4 lph discharge were used with a spacing 60 cm. The crop was transplanted on 16th November, 2005. The paddy straw mulch @ 10 t ha^{-1} was applied uniformly 15 days after transplanting

Irrigation was scheduled based on the pan evaporation data. The operating pressure of 0.6 kg cm^{-2} was maintained while applying irrigation to the crop. The crop was harvested in 11 pickings during the period of 21/01/2005 to 30/03/2006. Growth and yield observations were recorded periodically and economics of the treatments was studied by calculating net income and B:C ratio.

RESULTS AND DISCUSSION

At 120 DAT treatment F_3 (RD, through mixed fertilizer and urea below dripper), recorded (Table 1) significantly superior mean plant height over F_1, F_2 and F_5 treatments, the former treatment was at par with F_2. The treatment M_1 (Band placement along the rows) recorded significantly superior plant height over the rest of the poultry manure placement treatments. The mean number of leaves per hill were not statistically influenced by placement of fertilizers. Significantly superior mean number of leaves per hill was recorded by treatment M_1 (Band placement of poultry manure along the rows) over the treatment M_2 and M_4, however, the former treatment was at par with treatment M_3. The mean number of branches per hill was not statistically influenced by the methods of placement of fertilizers and poultry manure. The yield contributing character *viz*., number of fruits per hill, average length of fruit (cm) were not differed statistically due to the sources and methods of placement of fertilizers as well as methods of poultry manure placement.

F_2 (RDF below dripper) recorded significantly superior weight of fruit per hill over the treatment F_1 (RDF, band placement along the rows) and F_5 (RD, through soluble fertilizer and urea), however, the treatment F_3 (RD, through mixed fertilizer and urea below dripper) and F_4 (RD through NPK briquettes below dripper) proved at par with treatment F_2. M_3 (Poultry manure placement below dripper) recorded significantly superior weight of fruit per hill over the treatment M_1 (Band placement along the rows) and M_2 (Band placement below lateral). However, the former treatment was at par with M_4 (Poultry manure placement below hill)

The treatment F_2 (RDF below dripper) recorded significantly superior average weight of fruit over the treatment F_1 (RDF, band placement along the rows) and F_5 (RD, through soluble fertilizer and urea). However, the former treatment was at par with F_3 and F_4. Placement of poultry manure did not show significant variation in respect of average weight of fruit.

The treatment F_2 (RDF below dripper) recorded significantly superior fruit yield of brinjal over the treatment F_1 (RDF, band placement along the rows) and F_5 (RD, through soluble fertilizer and urea), however, former treatment was at par with F_3 (RD, through mixed fertilizer and urea below dripper) and F_4 (RD through NPK briquettes below dripper). The treatment F_1 (RDF, band placement along the rows) and F_5 (RD, through soluble fertilizer and urea) recorded statistically equal fruit yield of brinjal. M_4 (Poultry manure placement below hill) recorded significantly superior fruit yield of brinjal over the treatment M_1 (Band placement along the rows) and M_3 (Poultry manure placement below dripper). However, the treatment M_4 was at par with M_2 (Poultry manure placement below lateral).

The dose of nutrient was same for treatment F_1 to F_5. Statistically superior values of weight of fruits per hill, average weight of fruit and fruit yield of brinjal were observed in F_2, might be due to placement of nutrients at proper plant growth stage and nutrient placement where water is available i.e. below dripper unlike check basin irrigation. In check basin irrigation water was flooded in restricted area due to which fertilizers was dissolved and distributed

Table 1. Growth, yield attributes and fruit yield of brinjal influenced by placement of fertilizers and manures.

Treatment	Plant height at 20 DAT (cm)	Functional leaves hill^{-1} at 20 DAT	Branches hill^{-1}	Fruits hill^{-1}	Average length of fruits (cm)	Weight of fruits per hill (g)	Average weight of fruits (g)	Weight of stalk dry matter (kg ha^{-1})	Fruit yield (t ha^{-1})
Methods of fertilizers placement :									
F_1 - RDF, band placement along the rows	76.77	43.15	17.15	12.98	11.06	1099.33	84.49	6561.52	57.26
F_2 - RDF application below dripper	79.16	47.05	17.73	14.37	11.22	1338.08	93.70	7570.31	66.55
F_3 - RD through mixed fertilizer and urea below dripper	80.76	44.80	17.47	13.18	11.75	1167.83	88.97	7432.35	65.08
F_4 - RD through NPK briquettes below dripper	77.01	44.03	17.50	13.73	11.25	1217.25	88.63	7230.63	62.83
F_5 - RD through soluble fertilizer and urea (fertigation)	75.28	39.50	16.80	12.27	10.86	1006.83	80.43	6333.03	55.13
S. E. ±	1.08	2.29	0.70	0.78	0.33	52.81	2.33	185.76	2.45
C. D. at 5%	3.54	-	-	-	-	172.25	7.60	605.93	7.98
Placement of poultry manure :									
M_1 - Band placement along the rows	80.74	47.03	18.32	12.56	11.08	1074.13	85.21	6799.41	58.92
M_2 - Band placement below lateral	76.62	41.57	17.27	13.04	11.11	1127.33	85.32	7211.44	62.35
M_3 - Placement below dripper	77.23	44.79	17.59	13.68	11.05	1253.47	91.97	6786.54	59.02
M_4 - Placement below hill	76.61	41.44	16.15	13.95	11.68	1208.53	86.47	7304.88	65.19
S. E. ±	1.05	1.11	0.54	0.41	0.28	41.05	2.41	181.56	1.36
C. D. at 5%	3.02	3.11	-	-	-	118.56	-	-	3.92

through out root zone and became available to the plants. While in drip irrigation, water was applied in very small quantity as per the need of crop therefore, the nutrients needs to be placed where water was applied. Brinjal crop under treatment F_2 responded better, might be due to slow release of nutrients applied through straight fertilizer unlike the treatment F_5 where the nutrients were applied in readily available form through drip irrigation system in six split doses. Split doses in treatment F_5 may did not match the nutrient requirement as per the growth stage of brinjal crop and resulted in comparatively less yield. Similar results were reported by Shinde *et al*., (2002) in case of brinjal under lateratic soils of Konkan.

In case of medium duration crop like brinjal, it was observed from the data, that application of poultry manure close to the root zone i.e. below hill was found to be superior as it provide the plant nutrients available in poultry manure in vicinity of root zone unlike remaining methods of poultry manure application studied under this investigation which has accelerated the vegetative growth of crop. After short vegetative growth periods, brinjal crop, has a longer reproductive phase which reflected in a

Table 2. Input cost, total cost, yield, gross income, net income and benefit cost ratio as influenced by different method of placement of fertilizers and manure treatment combinations

Treat-ments	Input cost (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Yield of fruit (t ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Benefit cost ratio	Field water use efficiency (t ha^{-1} cm)
F_1M_1	70,849	1,41,241	49.82	1,99,280	58,039	1.41	0.73
F_1M_2	70,849	1,45,729	54.80	2,19,200	73,471	1.50	0.81
F_1M_3	70,849	1,47,443	57.37	2,29,480	82,037	1.55	0.84
F_1M_4	70,849	1,53,902	67.06	2,68,240	1,14,338	1.74	0.99
F_2M_1	70,849	1,52,536	65.01	2,60,040	1,07,504	1.70	0.96
F_2M_2	70,849	1,52,616	65.13	2,60,520	1,07,904	1.71	0.96
F_2M_3	70,849	1,52,009	64.22	2,56,880	1,04,871	1.69	0.94
F_2M_4	70,849	1,57,089	71.84	2,87,360	1,30,271	1.83	1.05
F_3M_1	71,242	1,52,634	64.47	2,57,880	1,05,246	1.69	0.95
F_3M_2	71,242	1,53,527	65.81	2,63,240	1,09,713	1.71	0.97
F_3M_3	71,242	1,50,801	61.72	2,46,880	96,079	1.64	0.91
F_3M_4	71,242	1,55,194	68.31	2,73,240	1,18,046	1.76	1.0
F_4M_1	70,465	1,48,089	59.01	2,36,040	87,951	1.59	0.87
F_4M_2	70,465	1,53,036	66.43	2,65,720	1,12,684	1.74	0.98
F_4M_3	70,465	1,48,802	60.08	2,40,320	91,518	1.61	0.88
F_4M_4	70,465	1,52,602	65.78	2,63,120	1,10,518	1.72	0.97
F_5M_1	74,163	1,50,590	56.30	2,25,200	74,610	1.50	0.83
F_5M_2	74,163	1,52,757	59.55	2,38,200	85,443	1.56	0.88
F_5M_3	74,163	1,47,524	51.70	2,06,800	59,276	1.40	0.76
F_5M_4	74,163	1,48,537	52.95	2,11,800	63,443	1.43	0.78

F_1 - RDF band placement along the rows, F_2 - RDF application below dripper, F_3 - RD through mixed fertilizer and urea belows dripper, F_4 - RD through NPK briquettes below dripper, F_5 - RD through soluble fertilizer and urea fertigation.
M_1 - Poulty mannre band placement along the rows, M_2 - Poulty manure placement below lateral, M_3 - Poultry manure placement below dripper, M_4 - Poultry manure placement below hill.

significantly superior fruit yield under the treatments M_4. Similar findings were also reported by Kallela (2002).

The seasonal water requirement of brinjal under check basin irrigation grown on lateratic soils of Konkan was 135 ha cm. Under drip system water used was 68 ha cm which indicated that drip irrigation saved 49.63 per cent irrigation water over the water required for brinjal under check basin irrigation. The field water use efficiency (Table 2) was maximum (1.05 t ha^{-1} -cm) in treatment F_2M_4 (RDF, application below dripper and poultry manure placement below hill) followed by F_3M_4 (RD, through mixed fertilizer and urea below dripper + poultry manure placement below hill). The higher field water use efficiency was attributed to production of higher fruit yield. Proper choice and source of fertilizer, placement of fertilizer and proper placement of organic manure under drip irrigation system was helpful in increasing yield as well as saving of irrigation water. The results are in conformity with Shinde *et al.*, (2002).

Economics : It was observed that highest total cost was recorded by treatment combination i.e. RDF application below dripper + poultry manure placement below hill (Rs. 1,57,089 ha^{-1}) followed by F_3M_4 i.e. RD through mixed fertilizer and urea below dripper

+ poultry manure below hill (Rs. 1,55,194 ha^{-1}). The lowest total cost of production was recorded by the treatment combination F_1M_1 i.e. RDF, band placement along the rows and poultry manure placement along the rows (Rs, 1,41,24 l ha^{-1}). The highest input cost (Rs ha^{-1}) was recorded by the F_5 treatment due to higher cost of soluble fertilizer.

The highest gross income was recorded by the treatment combination (F_2M_4) RDF application below dripper + poultry manure placement below hill (Rs. 2,87,360 ha^{-1}) while the lowest gross income was in the treatment combination (F_1M_1) RDF band placement along the rows + poultry manure band placement along the rows (Rs. l,99,280 ha^{-1}).

The treatment combination (F_2M_4) RDF application below dripper + poultry manure below hill recorded highest net profit and B:C ratio (Rs. 1,30,271 ha^{-1}, 1:83) followed by (F_3M_4) RD through mixed fertilizer and urea below dripper + poultry manure placement below hill (Rs. 1,18,046 ha^{-1}, B:C ratio 1.76). The lowest benefit cost ratio was observed in (F_5M_3) RD through soluble fertilizer and urea + poultry manure placement below dripper (1.40).

From the investigation, it could be concluded that under drip irrigation the fertilizer and manure must be applied considering the application of water by dripper. For getting higher net returns and B:C ratio under drip irrigation the NPK nutrient dose should be applied below dripper through straight fertilizers *viz*., urea, single super phosphate and muriate of potash. Similarly, application of poultry manure under drip irrigation must be applied by using hill placement before transplanting of crop.

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Judicious Use of Organic Manures and Inorganic Fertilizers for Sustaining Productivity and Fertility Dynamics Under Rice-Maize and Rice- Groundnut Cropping Systems

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ABSTRACT

Rice yield was highest (71.64 q ha^{-1}), where 50 per cent NPK was applied through inorganic source and 50 per cent N through glyricidia (T_{10}), followed by 50 per cent RDF + 50 per cent N through FYM (T_8), 75 per cent RDF + 25 per cent N either through glyricidia (T_{11}) or FYM (T_9). The grain yield of maize in *rabi* season was higher (44.43 q ha^{-1}) when 100 per cent NPK was applied through inorganic source (T_9) preceded with application of NPK 75 per cent through inorganic and 25 per cent through organic to the rice crop in rice-maize sequence, whereas the pod yield of groundnut was higher (22.59 q ha^{-1}) when 75 per cent NPK was applied through inorganic source (T_8) with application of NPK 50 per cent through inorganic and 50 per cent through organic to the preceding rice crop in rice-groundnut sequence. Combined grain yield of rice and maize was the highest where 50 per cent RDF + 50 per cent N through green manure (glyricidia) was applied to rice and 75 per cent RDF to maize crop followed by 75 per cent RDF + 25 per cent N through glyricidia to rice and 100 per cent RDF to maize. The results further indicated that combined application of organic manures and chemical fertilizers i.e. 50 per cent RDF + 50 per cent N through FYM (T8) as well as 75 per cent RDF + 25 per cent N through FYM (T9) recorded the lowest value of bulk density and the highest value of water holding capacity compared to 100 per cent RDF. There was increase in bulk density after harvest of maize due to continuous application of chemical fertilizers alone. whereas after harvest of groundnut, bulk density was more or less mainlained near its initial value. Thus, use of FYM or green manure to the extent of 50 per cent of recommended with 50 per cent NPK through fertilizers to rice and 75 per cent recommended NPK to succeeding maize and groundnut is a judicious blend to maintain soil fertility and desirable soil physical condition and at the same time sustain crop productivity under rice-maize and rice-groundnut sequences in South Konkan region.

Key words : Organic manures, inorganic fertilizers, productivity, fertility dynamics, cropping system.

In the tropical countries the inherent soil fertility is low because of intensive loss of nutrients through erosion and leaching. There is increasing concern on the role of fertilizers in maintaining long-term soil productivity. In intensive agriculture with high yielding varieties, crop yields have adverse effect on physical properties of soil such as bulk density, water holding capacity and water stable aggregates (Ramteke *et al.*, 1998). In spite of increased cost of fertilizers and their adverse effect (particularly N fertilizers) on soil and environment (Von Uexkull, 1993), the best alternative sources for plant nutrients to be explored to meet partial or full requirement of crop. Hence, it is time to pay serious attention to nutrient management. The integrated use of organic manures and inorganic fertilizers can help to maintain optimum crop yields and long-term soil productivity. There is vast scope for increasing nutrient supply through use of organic manures; green manures and adoption of proper cropping system, which together can contribute significantly to the required nutrient pool. With these views in mind, the experiment was conducted to explore the production potential of cereal-cereal and cereal-legume

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cropping systems with integrated nutrient supply system with sustainable productivity.

MATERIALS AND METHODS

The experiments were conducted at Agronomy Farm, Konkan Krishi Vidyapeeth, Dapoli for two consecutive seasons, 1998-99 and 1999-2000. The soil of the experimental plot was clay loam in texture. It was medium in available nitrogen (295.22 kg ha^{-1}), low in available phosphorus (12.96 kg ha^{-1}) and potassium (105.03 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatment details are given in Table 1. During both the years, rice seedlings were transplanted in the first week of July in *kharif* and maize and groundnut were grown in *rabi*-summer season. Fertilizers were applied as per treatments. N was applied in three splits to rice crop along with basal application of P and K, while it was supplied in two equal splits to maize crop i.e. 50 per cent at the time of sowing and remaining 30 DAS. In case of groundnut full dose of N and P_2O_5 were applied to each plots as per treatments. Recommended package of practices for different crops were followed. Plant protection measures were undertaken as and when required.

RESULTS AND DISCUSSION

Cropping system productivity : Data presented in Table 1 clearly indicated that, rice yield was the highest (71.64 q ha^{-1}), where 50 per cent NPK was applied through inorganic source and 50 per cent N through glyricidia (T_{10}), followed by 50 per cent RDF + 50 per cent N through FYM (T_8), 75 per cent, RDF + 25 per cent N either through glyricidia (T_{11}) or FYM (T_9), These results gave evidence to the fact that about 25-50 per cent fertilizers can be saved with the integrated use of organic manures and inorganic fertilizers in rice-maize and rice-groundnut crop sequences under South Konkan condition. Substitution of 25-50 per cent N through organic sources not only helped to sustain the production but also increased it over 100 per cent NPK through inorganic source alone. Srinivasu Reddy (1988) and Kulkarni *et al.*, (1993) reported similar beneficial effect of integrated nutrient management in rice based cropping systems.

The grain yield of maize in *rabi* season

Table 1. Grain yield of rice based crop sequences as affected by integrated nutrient management (Average. of two years).

Treat-ment	*Kharif*	*Rabi*	Rice-maize (q ha^{-1})			Rice-groundnut (q ha^{-1})		
			Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total
T_1	Control	Control	37.27	19.43	56.70	37.27	10.53	47.80
T_2	50% RDF	75% RDF	53.89	33.99	87.88	53.89	14.57	68.48
T_3	50% RDF	100% RDF	55.26	40.06	95.32	55.26	18.68	73.94
T_4	75% RDF	75% RDF	62.30	34.95	97.25	62.30	14.98	77.28
T_5	100% RDF	100% RDF	68.52	41.86	110.38	68.52	20.10	88.62
T_6	100% RDF	75% RDF	68.14	36.14	104.28	68.14	15.13	83.27
T_7	75% RDF	100% RDF	63.06	41.25	104.31	63.06	19.86	82.92
T_8	50% RDF + 50 N through FYM	75% RDF	70.37	43.03	113.40	70.37	22.59	92.96
T_9	75% RDF + 25 N through FYM	100% RDF	69.36	44.43	113.79	69.36	21.05	90.41
T_{10}	50% RDF + 50 N through Gly.	75% RDF	71.64	42.64	114.28	71.64	21.71	93.35
T_{11}	75% RDF + 25 N through Gly.	100% RDF	70.07	43.80	113.87	70.07	20.48	90.55
SE$\pm$			0.91	0.56		0.91	0.56	
C. D. at 5%			2.51	1.54		2.51	1.54	

(Table 1) was higher (44.43 q ha^{-1}) when 100 per cent NPK was applied through inorganic source (T_9) preceded by application of 75 per cent NPK through inorganic and 25 per cent N through organic to the rice crop in rice-maize sequence, whereas the pod yield of groundnut was higher (22.59 q ha^{-1}) when 75 per cent NPK was applied through inorganic source (T_8) with application of 50 per cent NPK through inorganic and 50 per cent N through organic to the preceding rice crop in rice-groundnut sequence. Combined grain yield of rice and maize was the highest where 50 per cent RDF + 50 per cent N through green manure (glyricidia) was applied to rice and 75 per cent RDF to maize crop followed by 75 per cent RDF + 25 per cent N through glyricidia to rice and 100 per cent RDF to maize. Samui *et al.*, (1998) reported possibility of substituting 50 per cent N through organic source during *kharif* without any reduction in total grain productivity of rice-wheat system. Similarly, the grain yield of rice-groundnut sequence was higher, where 50 per cent RDF+ 50 per cent N through glyricidia was applied to rice and 75 per cent RDF to groundnut followed by 50 per cent RDF + 50 per cent N through FYM to rice and 75 per cent RDF to succeeding groundnut crop. This might be due to the carry over effect of organic manures used in preceding crop of rice, (Thakur, *et al.*, 1999). The grain yield of rice reduced significantly when the fertilizer application was reduced to 50 or 75 per cent of the recommended dose. The lowest grain yield was recorded in control (T_1). The results confirm the findings of Mondal and Mondal (1994).

The results clearly demonstrated that green manures, as well as farmyard manures could substitute 50 per cent N need in rice, cutting down 25 per cent nutrient requirement of succeeding maize and groundnut in a sequence without any detrimental effect on the productivity of the system. The results are in close confirmatory with Gill and Meelu, (1992).

Physical properties of soil : Data regarding physical properties of soil (Table 2) such as bulk density, WHC and WSA after

Tabel 2. Bulk density, water stable aggregates and water holding capacity of soil after harvest as affected by integrated nutrient management (mean of two years).

Treat-ments	Bulk density (g cc)			Water stable aggregate (WSA) >0.2 mm (%)			Water holding capacity (%)		
	After rice	After maize	After groundnut	After rice	After maize	After groundnut	After rice	After maize	After groundnut
T_1	1.19	1.20	1.20	38.20	37.58	38.67	50.19	50.06	50.09
T_2	1.20	1.21	1.21	36.78	36.16	37.04	49.90	49.38	49.83
T_3	1.20	1.23	1.21	36.68	35.38	36.24	49.80	48.42	49.48
T_4	1.21	1.22	1.21	35.72	35.59	36.77	48.62	48.50	48.52
T_5	1.22	1.24	1.22	35.02	34.60	35.55	47.25	46.71	47.06
T_6	1.22	1.23	1.23	35.01	34.69	35.74	47.28	47.05	47.11
T_7	1.21	1.23	1.22	35.79	35.09	36.45	48.65	47.35	47.85
T_8	1.16	1.17	1.16	45.52	46.20	46.31	51.93	52.05	52.11
T_9	1.16	1.17	1.16	44.26	45.73	45.93	50.90	51.02	51.34
T_{10}	1.17	1.18	1.17	44.17	45.09	45.69	51.41	51.46	51.60
T_{11}	1.17	1.18	1.17	43.58	44.71	44.79	50.32	50.48	50.63
S.E.±	0.03	0.04	0.003	0.55	0.70	0.78	0.68	0.71	0.68
C. D. at 5%	0.01	0.01	0.01	1.63	2.08	2.3	1.95	2.11	2.03

Table 3. Balance sheet for available 'N, P_2O_5 and K_2O' (Based on two season's average).

Treat-ments	After rice (kg ha^{-1})			Gain / loss (kg ha^{-1})			After maize (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	264.30	9.76	69.53	-30.92	-3.20	-35.50	237.10	6.05	85.02
T_2	292.95	13.76	80.81	-2.27	+0.80	-24.22	279.46	12.35	72.33
T_3	292.86	14.55	82.27	-2.36	+1.59	-22.76	283.55	13.28	74.89
T_4	300.82	17.14	85.27	+5.60	+4.18	-19.90	287.48	15.88	76.83
T_5	310.24	20.36	95.09	+15.02	+7.40	-9.94	301.84	19.83	87.95
T_6	310.53	20.18	93.95	+15.31	+7.22	-11.08	300.43	19.01	85.74
T_7	301.05	17.22	85.38	+5.83	+4.26	-19.65	292.14	16.39	78.11
T_8	347.89	21.95	147.20	+52.67	+8.99	+42.17	342.30	24.00	140.86
T_9	339.06	21.12	128.74	+43.84	+8.16	+23.71	331.70	22.77	122.03
T_{10}	354.44	17.50	145.61	+59.22	+4.54	+40.58	348.94	18.08	139.01
T_{11}	337.04	17.71	126.59	+41.82	+4.75	+21.56	328.58	18.06	119.62

Table 3. (Cont.). Balance sheet for available 'N, P_2O_5 and K_2O' (Based on two season's average).

Treat-ments	Gain / loss (kg ha^{-1})			After groundnut (kg ha^{-1})			Gain / loss (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	-58.12	-6.91	-47.01	267.54	8.44	61.43	-27.68	-4.52	-43.60
T_2	-15.76	-0.61	-32.70	300.32	15.99	74.60	+5.10	+3.03	-30.43
T_3	-11.67	+0.32	-30.14	300.48	17.20	77.08	+5.26	+4.24	-27.95
T_4	-7.74	+2.92	-28.20	308.26	19.56	79.03	+13.04	+6.60	-26.00
T_5	+6.62	+6.87	-17.08	318.71	23.75	90.14	+23.49	+10.79	-14.89
T_6	+5.21	+6.05	-19.29	318.03	22.68	87.41	+22.81	+9.72	-17.62
T_7	-3.08	+3.43	-26.92	309.30	20.20	80.30	+14.08	+7.24	-24.73
T_8	+47.08	+11.04	+35.83	369.08	27.86	143.01	+73.86	+14.90	+37.98
T_9	+36.48	+9.81	+17.00	351.34	25.01	124.19	+56.12	+12.05	+19.16
T_{10}	+53.72	+5.12	+33.98	365.88	21.15	141.15	+70.66	+9.19	+36.12
T_{11}	+33.36	+5.10	+14.59	345.54	20.75	121.78	+50.32	+7.79	+16.75

harvest of rice revealed that organic manures combined with chemical fertilizers in general had beneficial effect on these properties, compared to chemical fertilizer alone. The results further indicated that combined application of organic manures and chemical fertilizers i.e. 50 per cent RDF + 50 per cent N through FYM (T_8) as well as 75 per cent RDF + 25 per cent N through FYM (T_4) recorded the lowest value of bulk density and the highest value of water holding capacity compared to 100 per cent RDF, followed by 50 per cent RDF + 50 per cent N through glyricidia (T_{10}). Decrease in bulk density may be partly attributed to increase in porosity and high accumulation of organic matter (Malewar and Hasnabade, 1995). Similarly, additional quantity of organic manures delay the development of hard pan in soil helping into lower down the bulk density. The results were in line with those obtained by Selviranganarhan and Selvisedan (1997) and Ramteke *et al.*, (1998). Further, there was increase in bulk density after harvest of maize due to continuous application of chemical fertilizers alone, whereas after harvest of groundnut bulk density was more or less maintained near its initial value. This may probably be due to organic manures applied to previous rice crop. The differences between 50 per cent RDF + 50 per cent N either through FYM or glyricidia, as well as 75 per cent RDF + 25 per cent N through FYM were at par, but proved superior than 100 per cent RDF alone in terms of water holding capacity. Similarly, increase in water holding capacity, was mainly attributed to decrease in bulk density due to organic manure in the said treatments. Application of 50 per cent RDF + 50 per cent N through FYM registered the highest value of WSA, after rice followed by 50 per cent RDF + 50 per cent N through glyricidia, 75 per cent RDF + 25 per cent N through FYM. Similar finding were also reported by Kapur *et al*., (1981). Increased water stable aggregates may be due to application of organic manures combined with chemical fertilizers which acts as a binding agent because of the presence of active functional groups like carboxylic and phenolic (Biswas *et al*., 1971). Thus, coarse aggregates in FYM provided a better soil structure, which was responsible for improving mean weight of diameter of aggregates.

Application of 75 per cent RDF recorded higher value of WHC and WSA after harvest of maize compared to 100 per cent RDF. A sharp increase in these properties was obtained when *kharif* 100 per cent RDF was split into half inorganic and half organic as FYM or glyricidia. This was evidently due to the residual effect of organic sources (Jana and Ghosh, 1996). The trend after harvest of groundnut was similar to that obtained after harvest of maize crop. In general, green manure and FYM helped to improve the soil physical conditions through microbial cells, decomposition products and penetration of fine roots, which acts as a binding agent for stable aggregate formation. Thus, these observations suggested that use of FYM or green manures to the extent of 50 per cent recommended N with 50 per cent through NPK fertilizers is a judicious blend to maintain soil fertility and desirable soil physical condition for sustainable crop productivity under lateritic soils of Konkan region.

The data presented in Table 3 showed that the maximum gain of NPK after rice was due to combined application of organic manures and chemical fertilizers (T_8, T_9, T_{10} and T_{11}) as compared to control (T_1). The improvement of N status was to the extent of 59.22 kg N ha^{-1} due to 50 per cent RDF + 50 per cent N through glyricidia (T_{10}), while it was only 15.02 kg N ha^{-1} due to 100 per cent RDF (T_5) alone. The order of the effect of N improvement was T_8>T_9>T_{11}>T_5>T_7>T_4. Application of 50 per cent RDF alone (T_3) showed negative balance of N after harvest office (2.36 kg N ha^{-1}), whereas in case of maize all (RDF alone) the treatments showed negative balance of N, except T_8, T_9, T_{10} and T_{11} as the preceding crop of rice received 100 per cent RDF in the form of organic (25-50%) and inorganic source (50-75%). This was evidently due to residual effect of organic sources applied to previous rice crop, whereas after harvest of groundnut all the treatments showed positive balance of N.

In short rice-maize (cereal-cereal) sequence showed a deficit balance of 58.12 kg N ha^{-1} in control but the extent of deficit was less (27.68 kg N ha^{-1}) in rice-groundnut sequence. According to Rao and Sharma (1978), in a maize-wheat sequence total nitrogen in soil at the end of two years showed a deficit balance of the order of 53 kg N ha^{-1} while other crop sequences particularly those including legumes, build up the nitrogen status of the soil.

The increased available P ranged from 1.59

to 8.99 kg P ha^{-1} due to various treatments after rice. The highest gain was due to 50 per cent RDF + 50 per cent N through FYM (T_8). More or less similar trend was observed after maize and groundnut crops, but extent of gain was more under rice-groundnut compared to rice-maize sequence. Combined application of chemical fertilizer and organic manures further increased the available K-status after rice, whereas application of 50 per cent, 75 per cent and 100 per cent RDF showed negative balance of K. After maize and groundnut, all the fertilizer treatments showed negative balance of K, except T_8. T_9, T_{10} and T_{11} as the preceding crop of rice received 100 per cent RDF through organic (25-50%) and inorganic source (50-75%). The cropping systems particularly including legumes build up soil fertility. In general, the sequence of rice-groundnut with half inorganic and half organic form of FYM to rice and 75 per cent RDF to succeeding groundnut was found more beneficial for improving the fertility status of soil. This was mainly attributed to addition of residue and fixation of N as compared to rice-maize sequence.

Conclusion : Green manuring with glyricidia or FYM could substitute 25 - 50 per cent of nutrient requirement of *kharif* rice, which can economize the 25 per cent nutrient requirement of succeeding maize and groundnut under rice - maize and rice - groundnut sequence. Similarly as rice - maize sequence recorded the highest productivity compared to rice -groundnut sequence as both the crops have high productivity and less element to risk, continuous growth of rice - maize deplete the soil fertility to greater extent.

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Correlation and Path Analysis in Groundnut (*Arachis hypogaea* L.)*

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ABSTRACT

The genotypic correlation coefficients were slightly higher than phenotypic correlation coefficients. The characters *viz*. number of pods plant^{-1}, number of primary branches plant^{-1}, number of kernels plant^{-1} and kernel yield plant^{-1}, showed significant positive correlation with dry pod yield plant^{-1}. Path analysis revealed that number of pods plant^{-1}, shelling percentage, pod length, 100-seed weight and kernel yield plant^{-1} had positive direct effect on dry pod yield.

Key words : Correlation, path analysis, groundnut.

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop grown in Konkan region of Maharashtra. The knowledge of association among the yield and yield contributing characters would be of great help in constructing a suitable plant type and in planning breeding programme. However, the correlation coefficient does not give any indication about comparative magnitude of contribution made by various component characters. Therefore, genotypic path coefficient analysis as outlined by Dewey and Lu (1959) was carried out to find the direct and indirect effects of yield components and their correlation with dry pod yield.

MATERIALS AND METHODS

The material used for the experiment included 40 genotypes of groundnut out of which 34 genotypes from 16 different countries collected from National Research Centre for Groundnut, Junagarh (Gujrath) and 6 genotypes were cultivated varieties. The experiment was laid out in a randomized block design with three replications dung *kharif* 2006 at research farm, Department of Agricultural Botany, College of Agriculture, Dapoli. Each genotype had four row's of two meter length with spacing of 30 x 10 cm. Recommended package of practices were adopted. Observations were recorded on five randomly selected plants for characters *viz*., days to first flowering, days to 50 per cent flowering, days to maturity, plant height, number of primary branches, number of pods, shelling percentage, pod length, 100-seed weight, number of kernels plant^{-1}, kernel yield plant^{-1} and oil percentage. Mean values from each treatment in each replication were used for statistical analysis. The phenotypic and genotypic correlation coefficients were calculated according to the method suggested by Singh and Chaudhary (1977) and path coefficient analysis was carried out as per the Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance revealed that highly significant differences were observed for yield and yield components indicating presence of

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good amount of genetic variability. The genotypic correlations were higher than the phenotypic correlations for most of the characters studied (Table 1). Similar results were also reported by Singh and Singh (2001). The pod yield exhibited significant positive association with number of primary branches plant^{-1}, number of pods plant^{-1}, number of kernels plant^{-1} and kernel yield plant^{-1} at both phenotypic and genotypic levels. The dry pod yield also showed positive correlation with days to first flowering, days to 50 per cent flowering, days to maturity, shelling percentage and pod length. While the dry pod yield had negative correlation with plant height and oil percentage. Rao (1979) reported positive correlation of pod yield with days to flowering. Prasad *et al.*, (2001) reported negative correlation between pod yield and plant height. Reddy and Gupta (1992) reported positive significant correlation between dry pod yield and number of primary branches plant^{-1}, number of pods plant^{-1} and kernel yield plant^{-1}. Khote (2006) recorded positive correlation of dry pod yield with pod length and number of kernels plant^{-1}.

The path coefficient analysis indicated that the 100-seed weight and shelling percentage had the highest positive direct effect on dry pod yield plant^{-1} (Table 2). Number of pods plant^{-1}, pod length and kernel yield plant^{-1} also showed positive direct effect on dry pod yield plant^{-1}, while days to first flowering, days to 50 per cent flowering, days to maturity, plant height, number of primary branches plant^{-1}, number of kernels plant^{-1} and oil percentage had negative direct effect on dry pod yield. Badwal and Singh (1973) reported high positive direct effect of 100-seed weight and shelling percentage on dry pod yield. Ursal *et al.*, (1995) recorded positive direct effect of kernel yield plant^{-1} on dry pod yield. Venkataravana *et al.*, (2000) and Singh and Singh (2001) observed that days to maturity, oil percentage and plant height had negative direct effect on pod yield.

Table 1. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients of different characters with dry pod yield in groundnut.

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.986**	1.000**	-0.252	0.134	0.330*	0.218	-0.472**	-0.015	0.336*	0.322*	0.091	0.229
2	0.620**	1.000	0.900**	-0.271	0.331*	0.495**	-0.122	-0.458**	0.125	0.291	0.442**	-0.380*	0.462**
3	0.782**	0.706**	1.000	-0.157	0.114	0.319*	0.132	-0.464**	0.004	0.218	0.161	-0.175	0.233
4	-0.103	-0.213	-0.140	1.000	-0.474**	-0.378*	-0.271	0.221	-0.217	-0.156	-0.462**	0.118	-0.282
5	0.117	0.174	0.009	-0.278	1.000	-0.121	-0.315*	0.407**	0.783**	-0.695**	0.441**	-0.291	0.447**
6	0.177	0.242	0.160	-0.243	0.104	1.000	0.312*	-0.857**	-0.452**	0.898**	0.433**	-0.151	0.493**
7	0.019	0.089	0.130	-0.204	-0.086	0.197	1.000	-0.616**	-0.332*	0.560**	0.431**	0.072	0.196
8	-0.330*	-0.277	-0.400**	0.199	0.279	-0.478**	-0.288	1.000	0.590**	-0.686**	0.059	0.106	0.123
9	-0.018	0.092	-0.002	-0.168	0.490**	-0.290	-0.172	0.509**	1.000	-0.874**	0.352*	-0.165	0.366*
10	0.065	0.054	0.107	-0.076	-0.071	0.667**	0.289	-0.330*	-0.476**	1.000	0.310	0.075	0.336*
11	0.077	0.151	0.045	-0.228	0.401**	0.527**	0.121	0.023	0.204	0.504**	1.000	0.185	1.000**
12	-0.083	-0.315*	-0.173	0.095	-0.174	-0.065	0.043	0.105	-0.143	0.139	-0.008	1.000	-0.129
13	0.171	0.157	0.067	-0.148	0.363*	0.398*	0.042	0.094	0.159	0.397*	0.695**	-0.055	1.000

1-Days to first flowering, 2-Days to 50% flowering, 3-Days to maturity, 4-Plant height (cm), 5-Primary branches plant^{-1}, 6-Pods plant^{-1}, 7-Shelling percentage, 8-Pod length (mm), 9-100-seed weight (g), 10-Kernels plant^{-1}, 11-Kernels yield plant^{-1} (g), 12-Oil percentage, 13-Dry pod yield plant^{-1} (g). * and ** indicate significant at 5 and 1 per cent level respectively.

Table 2. Direct (diagonal) and indirect effect of 12 yield components on pod yield of groundnut.

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**-0.170**	-5.713	6.009	-0.153	-0.009	1.649	-0.053	-1.596	-0.026	0.172	0.039	0.080	0.229
2	-5.793	**-0.168**	4.913	-0.165	-0.023	2.472	0.030	-1.551	0.210	0.149	0.054	0.334	0.462**
3	5.457	-0.188	**-5.215**	-0.095	-0.008	1.593	-0.032	-1.571	0.007	0.152	0.020	0.154	0.233
4	0.608	0.043	1.568	**-0.856**	0.033	-1.888	0.066	0.748	-0.365	-0.080	-0.056	-0.104	-0.282
5	-0.069	-0.023	-1.918	0.620	**-0.288**	-0.604	0.077	1.379	1.318	-0.356	0.054	0.255	0.447**
6	4.990	-0.056	-2.869	1.742	-0.230	**0.008**	-0.076	-2.900	-0.761	0.460	0.053	0.133	0.493**
7	-0.244	-0.037	0.709	0.720	-0.165	0.022	**1.558**	-2.084	-0.559	0.287	0.052	-0.063	0.196
8	3.384	0.080	2.654	-2.533	0.134	-0.028	-4.276	**0.150**	0.995	-0.352	0.007	-0.093	0.123
9	1.685	0.003	-0.722	0.022	-0.132	-0.054	-2.255	0.081	**1.998**	-0.448	0.043	0.145	0.366*
10	0.513	-0.057	-1.688	1.191	-0.095	0.048	4.481	-0.137	-2.322	**-1.472**	0.038	-0.163	0.336*
11	0.122	-0.055	-2.559	0.878	-0.281	-0.030	2.161	-0.105	0.200	0.478	**0.159**	0.043	1.000**
12	-0.879	0.016	2.200	-0.954	0.072	0.020	-0.754	-0.018	0.358	-0.278	0.095	**-0.006**	-0.29

1-Days to first flowering, 2-Days to 50% flowering, 3-Days to maturity, 4-Plant height (cm), 5-Primary branches plant^{-1}, 6-Pods plant^{-1}, 7-Shelling percentage, 8-Pod length (mm), 9-100-seed weight (g), 10-Kernels plant^{-1}, 11-Kernels yield plant^{-1} (g), 12-Oil percentage, 13-Geno. Corr. Coeff. with dry pod yield plant^{-1} (g). R = 1.223702, *,** Significant at 5 and 1 %

From present study on correlation and path analysis it is concluded that selection for kernel yield plant^{-1}, number of pods plant^{-1}, shelling percentage and 100-seed weight may lead to improve the dry pod yield in groundnut.

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Intercropping of Soybean and French bean in Basmati Rice Grown by Ridges and Furrow Method

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ABSTRACT

An experiment was conducted to study the effect of inter-cropping of soybean and french bean in Basmati rice grown by ridges and furrow method. In sole cropping system, Basmati rice recorded higher grain yield and net returns, but B:C ratio was higher in french bean than other sole cropping systems. While in various intercropping system rice (furrow) + one line of soybean on ridge sown after one month of rice by direct seeding produced significantly higher grain yield , rice grain equivalent, LER, net returns and B:C ratio than other intercropping systems.

Key words : Rice, intercropping, soybean, french bean, yield, LER and B:C ratio.

Substantial advantage in yield from intercropping compared with sole cropping occurs from complementary effect of different crops on each other; making better use of resources when grown together. It has been advocated as a source of nutrient economy (Balyan and Seth. 1991). Rice is the most important cereal crop m world ranking first in area. In rainy season, the emergence and growth of weeds is quite vigorous on the ridges, if rice is grown in furrow. Introduction of legumes in such cropping system which have fast development covering land quickly in rainy season will be most suitable. Thus, an experiment was conducted to find suitable and economical intercrop and its row proportion in Basmati rice grown by ridges and furrow method.

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 2001, 2002 and 2003 at Agricultural Research Station, Karad to study the intercropping of soybean and french bean in Basmati rice grown by ridges and furrow method. The soil was clay loam with pH 7.8, available NPK 180.7, 21.00 and 536.00 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with seven treatments replicated thrice. The gross plot size was 9.0 x 5.0 m^2. The sole rice was taken in furrow. Five ridges and furrow were opened in each plot at 100 cm apart and rice seed was directly broadcasted in opened furrow. Dibbling of french bean and. soybean was done as per treatments on the ridges. The treatment comprised seven intercropping system, *viz*. T_1-sole crop of rice (ridges and furrow), T_2-sole crop of soybean (flat bed), T_3-sole crop of french bean (flat bed), T_4-rice (furrow) + one line of soybean on ridge, T_5- rice (furrow) + one line of french bean on ridge, T_6-rice (furrow) + two line of soybean on ridge, T_7-rice (furrow) + two line of french bean on ridge. The rice was broadcasted in furrows in first week of June and soybean and french bean was dibbled in first week of July and harvested in month of October during three seasons. The yields of all three crops were recorded and rice equivalent yield was worked out on the basis of prevailing

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market prices. In all the three years of experimentation, the crop seasons were normal.

RESULTS AND DISCUSSION

Higher grain yield was recorded under sole cropping, irrespective of crops, sole crop of rice recorded higher grain yield than sole crops of soybean and french bean. In intercropping system higher yield was obtained in rice (furrow) + one line of soybean than other intercropping system (30.86+ 15.47 q ha^{-1}). Rice grain equivalent (43.53 q ha^{-1}) and land equivalent ratio (1.50) was significantly higher, than sole crops and other intercropping systems. This indicates the higher yield production resulting in more efficient utilization of land and available resources under intercropping system in one line of intercrop than two line of intercrops on ridges in rice grown in furrow system (Table 1). As intercrops differed remarkably in their duration of growth, the competition for resources at particular stage and growing condition, legumes had some beneficial effect towards yield of rice in comparison with sole crop of rice. This was mostly due to early harvest of intercrops, after which the resources were effectively utilized by rice, leading to development of temporal complementarity. Rao *et al.*, (1982) Mandal *et al.*, (1990) also found higher rice grain yield in rice + green gram intercropping system. The lower yield of rice and intercrops with two lines as compared to one line sown on ridges was mostly due to crowding and shading effects of intercrops on main crop. Sharma and Madgal (1984) also reported that the cultivation of pigeonpea on the ridges significantly decreased rice yield.

Sole crop of french bean treatment recorded significantly higher B:C ratio than other sole and intercropping treatments. Among the different treatment combinations sole crop of soybean gave the lowest value of net returns (Table 1). The highest .net returns and B:C ratio were obtained from rice (furrow) + one line of soybean on ridge intercropping than other intercropping system. French bean sole cropped treatment showed higher B:C ratio due to higher price than soybean and rice.

Table 1. Effect of different treatments on yield, land equivalent ratio and economics of rice based intercropping system (Pooled data of 3 years).

Treatments	Grain yield (q ha^{-1})	Rice grain equivalent (q ha^{-1})	Land equi-valent ratio	Total monetary returns (Rs. ha^{-1})	Cost of culti-vation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Sole rice	33.83	33.83	1.00	46000	25025	20975	1.81
Sole soybean	26.89	22.08	1.00	28644	14359	14285	1.99
Sole french bean	18.94	22.96	1.00	29973	11766	18207	2.55
Rice (furrow) + 1 line of soybean	30.86 15.47	43.53	1.50	57170	25946	31224	2.20
Rice (furrow) + 1 line of french bean	25.14 6.97	34.61	1.14	45371	25946	19425	1.75
Rice (furrow) + 2 line of soybean	24.55 13.98	36.02	1.25	47280	25947	21333	1.82
Rice (furrow) + 2 line of french bean	22.05 10.02	30.97	1.19	45296	25947	19350	1.75
S. E.±	1.43	1.67	0.04	1847	-	1847	0.10
C. D. at 5%	4.33	5.16	0.12	5693	-	5693	0.30

* Market price per quintal 1) Rice Rs. 1350/- 2) Soybean Rs. 1100/- 3) French bean Rs. 1580/-

Thus, if can be concluded that intercropping of one line of soybean on ridges one month after sowing of rice in furrow is advantageous in rice grown by ridges and furrow method of planting.

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Characterisation of Pearlmillet Hybrids and Their Parental Lines Through Morphological Characteristics

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ABSTRACT

From the study of morphological characteristics of plant, it revealed that RHRB-14B genotype was distinct for small seed size, hexagonal seed shape, very late time of spike emergence, purple spike anther colour and very dwarf plant height. The hybrid DHBH-2097 could be identified on the basis of distinct brown spike bristle colour. The hybrid DHBH-2097 and RHRBH-8924 could be differentiated from other hybrids due to its anthocynin pigmentation and loose spike density respectively.

Key words : Characterisation, pearlmillet, morphological characteristics.

India is signatory of WTO, as per its conditions of TRIPS, we should have our own system for protection of plant varieties. As such enacted the "Protection of plant varieties and farmers right act (2001)". The study on morphological characterisation will form the basis for DUS testing. In view of the above, the present study was conducted on six hybrids and their parental lines to develop database on morphological characteristics for DUS testing.

MATERIALS AND METHODS

An experimental material consisted of 6 pearlmillet hybrids and their parental lines. The pearlmillet hybrids *viz.*, Shraddha and Saburi and their parental lines were taken as reference

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Table. 1. List of morpholigcal characteristics as per NTG.

Sr. No.	Characteristics	States	Stage of observation
1	Plant anthocyanin colouration of first leaf sheath	Absent, Present	Seedling emergence
2	Plant : growth habit	Erect, Intermediate	Spike emergence
3	Time of spike emergence (50% plants with at least one spike emerged fully)	Very early (<43 days), Early (43-46 days), Medium (47-50 days), Late (51-54 days), Very late (>54 days)	Spike emergence
4	Leaf : sheath pubescence	Absent, Present	Spike emergence
5	Leaf : sheath length	Short (<11 cm), Medium (11-15 cm), Long (>15 cm)	Spike emergence
6	Leaf : blade length	Very short (<41 cm), Short (41-50 cm), Medium (51-60 cm), Long (61-70 cm), Very long (>70 cm)	Spike emergence
7	Leaf : blade width (at widest point)	Narrow (<3 cm), Medium (3-4 cm), Broad (>4 cm)	Spike emergence
8	Spike anther colour	Yellow, Brown, Purple	Anthesis
9	Plant : node pubescence	Absent, Present	Dough grain
10	Plant : number of nodes	Low (<11), Medium (11-15), High (>15)	Dough grain
11	Plant : node pigmentation	Whitish, Green, Brown, Red, Purple	Dough grain
12	Plant : internode pigmentation (between 3rd and 4th node from top)	Whitish, Green, Brown, Red, Purple	Dough grain
13	Spike : exertion	Partial, Complete	Dough grain
14	Spike : length	Very small (<11 cm), Small (11-20 cm), Medium (21-30 cm), Long (31-40 cm), Very long (>40 cm)	Dough grain
15	Spike : anthocyanin pigmentation of glumes	Absent, Present	Dough grain
16	Spike : bristle	Absent, Present	Dough grain
17	Spike : bristle colour	Green, Brown, Red, Purple	Dough grain
18	Spike : girth at maximum point (excluding bristles)	Thin (<1.6 cm), Medium (1.6-3.0 cm), Thick (>3.0 cm)	Dough grain
19	Spike : shape	Cylindrical, Conical, Spindle, Candle, Lenceolate, Dumb-bell, Club, Oblanceolate, Globose	Dough grain
20	Plant : number of productive tillers	Monoculm, Low (2-3), Medium (4-6), High (>6)	Dough grain
21	Plant : hight (excluding spike)	Very short (<101 cm), Short (101-150 cm), Medium (151-200 cm), Long (201-250 cm), Very long (>250 cm)	Dough grain
22	Spike : tip sterility	Absent, Present	Harvest maturity
23	Spike : density	Very loose, Loose, Semi-compact, Compact, Very compact	Harvest maturity
24	Seed : colour	Whitish, cream, yellow, Grey, Deep grey, Grey brown, Yellow brown, Purple, Purplish black	Harvest maturity
25	Seed : shape	Obovate, Elliptical, Hexagonal, Globular	Harvest maturity
26	Seed : weight of 1000 grains	Very low (<5 gm), Small (5.1-7.5 gm), Medium (7.6-10.0 gm), Bold (10.1-12.5 gm), Very bold (>12.5 gm)	Harvest maturity

lines for study. The pure seeds were obtained from AICRP on Bajara, College of Agriculture, Dhule. Three lines of 5 m length were sown by dibbling 3-4 seeds per hill at 45 x 15 cm spacing. Recommended practices were followed properly to raise good crop.

The observations (Table 1) were noted at seedling, flowering and maturity stages as per the National Test Guidelines (NTG) (Anonymous, 2003).

RESULTS AND DISCUSSION

Seed morphology : The observation on morphological characteristics on hybrids and parental lines of pearlmillet are presented in Table 2. All the six hybrids had bold seed size and obovate seed shape except hybrid RHRBH-8609 which showed hexagonal seed shape. Similar types of results were reported by Rao *et al.*, (1986) in pearlmillet genotypes which varied for seed shape and seed size.

All the female lines showed deep grey seed colour except RHRB-13A which had distinct yellow brown seed colour. On the basis of 1000 seed weight all the maintainer lines were classified as medium group except line RHRB-1B which was included in small seed size group. Gupta and Dhillon (1974) reported high heritable differences for grain size.

From the study of all genotypes it was revealed that RHRB-14B showed distinct seed characteristics i.e. hexagonal seed shape, grey brown seed colour and small seed size and can be differentiated from the other genotypes on the basis of seed characteristics. Thus, it can be stated that, seed morphological characteristics such as seed colour, seed shape are the most important diagnostic characteristics, easy to detect and could classify the varieties in distinct categories.

Plant morphology : Among the eighteen genotypes only seven genotypes showed anthocynin colouration of first leaf sheath which also include the only one hybrid i.e. DHBH-2097 which also showed pigmentation. Yadav (1976) stated that, the seedling pigmentation of coleoptile leaf was due to monogenic dominance. Four leaf characteristics namely leaf sheath pubescence, leaf sheath length, leaf blade length and leaf blade width were studied in all eighteen cultivars. Generally, most of genotypes showed medium leaf sheath length, leaf blade length and leaf blade width. From all genotypes studied, none had shown the presence of leaf sheath pubescence. However, the genotype RHRB-14B could be differentiated from others due to its short leaf sheath length, very long leaf blade length and broad leaf blade width. These results are in conformity with those reported by Jabeen *et al*. (1998).

On the basis of number of nodes, all the genotypes studied, were grouped as low (less than 11 nodes) therefore, differentiation was not possible among the genotypes studied. It was observed that nodal hairs were present in all genotypes except RHRBI-1019, DHBH-3050, RHRB-14A and RHRB-14B. Similar results have been reported by Gill *et al*., (1971). Among all the genotypes studied, only one genotype i.e. RHRBI-1019 exhibited purple nodal pigmentation. Remaining genotypes showed green pigmentation. It was observed that most of genotypes showed green internodal pigmentation but in some genotypes i.e. RHRBH-2028, RHRBI-1019, DHBH-3050 and RHRBI-I38 showed purple internodal pigmentation.

It was possible to identify genotypes on the basis of height of plant and number of productive tillers. Out of eighteen genotypes only one genotype RHRBH-14B was categorized as very dwarf. Genotypes RHRB-5A and RHRBI-438 were categorized as with low number of productive tillers (2-3).

Talukdar and Prakash babu (1997) identified parents from dwarf and non-dwarf inbred lines using eleven morphological characters across the environment.

On the basis of days required to spike emergence genotypes were categorized into different groups. Only one genotype *viz*., RHRB-14B was very late (>54 days). In respect of glume colour, thirteen genotypes showed light purple to purple colour glume colouration, remaining genotypes had green glume colour. Among six hybrids only RHRBH-8924 did not exhibit glume pigmentation, remaining all hybrids had purple glume pigmentation

Spike characteristics : Spike characteristics are very important to differentiate the genotypes from each other. Nine different spike characteristics were studied (Table 2). The genotype RHRB-14B was differentiated from other genotypes due to its purple colour anther. Remaining eleven had yellow colour anther and six had brown colour anther. The genotypes RHRB-13B, RHRB-14A, RHRBI-138 showed partial spike exertion. Similar results have been reported by Kumar *et al*. (1993) on the basis of spike exertion.

The genotypes were also classified on the basis of spike length. All female lines showed small spike length. The genotypes DHBH-2097, RHRBI-138, RHRBH-8609, RHRBH-8924 and RHRB1-458 were differentiated from other genotypes and hybrid due to presence of spike bristle. Genotype DHBH-2097 showed brown bristle colour while remaining three exhibited purple bristle colour. Among the genotypes studied, four types of spike shape were observed. Genotypes RHRB-I3B and RHRB-5B differentiated from other genotypes due to its candle spike shape. Considering girth of spike all the hybrids and restorer lines comes under group of thick spike girth.

Table 2. Morphological characteristics of eighteen perlmillet genotypes.

Genotypes	Seed characteristics			Plant morphology									
	Seed shape	Seed colour	Seed size	Antho-cynin pigmen-tation	Time of spike emer-gence	Leaf sheath pube scence	Plant growth habit	Leaf sheath length	Leaf blade length	Leaf blade width	Spike anther colour	Plant node pube-scence	Plant number of nodes
1	2	3	4	5	6	7	8	9	10	11	12	13	14
RHRBH-9808	Obovate	Grey brown	Bold	Absent	Early	Absent	Erect	Medium	Long	Broad	Yellow	Present	Low
RHRB-13A	Globular	Yellow brown	Small	Present	Late	Absent	Erect	Medium	Medium	Medium	Yellow	Present	Low
RHRBI-1314	Obovate	Grey brown	Medium	Absent	Early	Absent	Erect	Medium	Medium	Medium	Brown	Present	Low
RHRB-13B	Globular	Grey	Medium	Absent	Early	Absent	Intermediate	Short	Short	Medium	Yellow	Present	Low
RHRBH-2028	Globular	Deep grey	Bold	Absent	Early	Absent	Erect	Medium	Medium	Broad	Brown	Present	Low
RHRBI-1019	Obovate	Deep grey	Bold	Absent	Medium	Absent	Erect	Long	Medium	Broad	Brown	Absent	Low
DHBH-3050	Obovate	Grey	Bold	Absent	Early	Absent	Erect	Medium	Long	Medium	Brown	Absent	Low
RHRB-14A	Hexagonal	Deep grey	Medium	Present	Medium	Absent	Erect	Medium	Medium	Broad	Brown	Absent	Low
RHRB-14B	Hexagonal	Grey brown	Small	Present	Very late	Absent	Intermediate	Short	Very long	Broad	Purple	Absent	Low
DHBH-2097	Obovate	Grey	Bold	Present	Early	Absent	Erect	Long	Long	Medium	Brown	Present	Low

Table 2. Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
RHRB-5A	Obovate	Deep grey	Bold	Absent	Late	Absent	Intermediate	Short	Medium	Medium	Yellow	Present	Low
RHRBI-138	Globular	Deep grey	Bold	Absent	Medium	Absent	Intermediate	Long	Long	Medium	Yellow	Present	Low
RHRB-5B	Obovate	Grey	Medium	Present	Late	Absent	Erect	Short	Short	Medium	Yellow	Present	Low
RHRBH-8609	Hexagonal	Deep grey	Bold	Absent	Medium	Absent	Intermediate	Long	Long	Medium	Yellow	Present	Low
RHRB-1A	Obovate	Deep grey	Bold	Present	Medium	Absent	Erect	Long	Medium	Broad	Yellow	Present	Low
RHRB-1B	Obovate	Deep grey	Medium	Present	Medium	Absent	Erect	Medium	Medium	Broad	Yellow	Present	Low
RHRBH-8924	Obovate	Deep grey	Bold	Absent	Late	Absent	Intermediate	Long	Long	Medium	Yellow	Present	Low
RHRBI-458	Globular	Grey brown	Bold	Absent	Medium	Absent	Intermediate	Long	Very long	Medium	Yellow	Present	Low

Table 2. Contd.

Genotypes	Plant morphology												
	Plant node pigmentation	Plant internode pigmentation	Spike exertion	Spike length	Plant anthocyn in pigmentation of glume	Spike bristles	Spike bristles colour	Spike girth at maximum point	Spike shape	Productive tillers plant^{-1}	Plant height	Spike tip sterility	Spike density
RHRBH-9808	Green	Green	Complete	Medium	Present	Absent	Absent	Thick	Lanceolate	Medium	Medium	Absent	Compact
RHRB-13A	Green	Green	Complete	Small	Present	Absent	Absent	Medium	Spindle	Medium	Dwarf	Present	Semi compact
RHRBI-1314	Green	Green	Complete	Small	Absent	Absent	Absent	Thick	Lanceolate	Medium	Medium	Present	Compact
RHRB-13B	Green	Green	Partial	Small	Present	Absent	Absent	Thick	Candle	High	Dwarf	Absent	Loose
RHRBH-2028	Green	Purple	Complete	Small	Present	Absent	Absent	Thick	Conicle	High	Medium	Absent	Semi compact
RHRBI-1019	Purple	Purple	Complete	Medium	Absent	Absent	Absent	Thick	Lanceolate	Medium	Medium	Present	Semi compact
DHBH-3050	Green	Purple	Complete	Medium	Present	Absent	Absent	Thick	Conicle	Medium	Medium	Present	Compact
RHRB-14A	Green	Green	Partial	Small	Present	Absent	Absent	Medium	Spindle	Medium	Dwarf	Absent	Compact
RHRB-14B	Green	Green	Complete	Medium	Present	Absent	Absent	Thick	Lanceolate	Medium	Very dwarf	Present	Compact
DHBH-2097	Green	Green	Complete	Medium	Present	Present	Brown	Thick	Lanceolate	High	Medium	Present	Compact
RHRB-5A	Green	Green	Complete	Small	Absent	Absent	Absent	Medium	Lanceolate	Low	Dwarf	Present	Semi compact
RHRBI-138	Green	Purple	Partial	Medium	Present	Present	Purple	Thick	Conicle	Medium	Medium	Present	Semi compact
RHRB-5B	Green	Green	Complete	Small	Absent	Absent	Absent	Medium	Candle	Medium	Dwarf	Present	Compact
RHRBH-8609	Green	Green	Complete	Small	Present	Present	Purple	Thick	Conicle	Medium	Medium	Present	Semi compact
RHRB-1A	Green	Green	Complete	Small	Present	Absent	Absent	Medium	Lanceolate	High	Dwarf	Present	Semi compact
RHRB-1B	Green	Green	Complete	Small	Present	Absent	Absent	Medium	Spindle	Medium	Dwarf	Absent	Compact
RHRBH-8924	Green	Green	Complete	Small	Absent	Present	Purple	Thick	Conicle	Medium	Medium	Present	Loose
RHRBI-458	Green	Green	Complete	Medium	Present	Present	Purple	Thick	Lanceolate	Low	Medium	Present	Semi compact

The genotypes RHRBH-9808, RHRB-13B, RHRBH-2028, RHRB-14A and RHRB-1B differentiated from other genotypes due to absence of spike tip sterility. On the basis of spike density, only two genotypes i.e. RHRB-13B and RHRBH-8924 comes under loose spike density.

The genotype studied exhibited unique morphological characteristics which can be used for identification of hybrids and their parental lines of pearlmillet.

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Effect of Irrigation Regimes, Planting Layouts and Fertilizer Levels on Growth and Yield of Potato (cv. Kufri jyoti)

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ABSTRACT

Growth contributing characters in potato (cv. Kufri jyoti) *viz*., plant height, spread, number of leaves, number of branches and total dry matter weight and yield contributing characters, number of tubers plant^{-1}, size of potato, weight of tuber plant^{-1} of tuber yield, haulm weight ha-1 significantly increased with the application of 50mm CPE irrigation regimes with normal planting on ridges and furrows and at higher fertilizer levels of 160:80:80 kg NPK ha^{-1}.

Key words : Kufri jyoti, irrigation regimes, planting layouts, fertilizer levels.

As the potato crop is susceptible to the excess and shortage of irrigation water, the optimum level of irrigation water should be applied at particular time. A systematic attempt has not been made so far to relate yield with climatic data and different levels of irrigation

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water on the basis of cumulative pan evaporation for potato crop in this region. Further, the information regarding the performance of potato under varied row spacings, planting systems with surface irrigation and fertilizer levels under Rahuri conditions is to be standardized through investigation. Potato which is underground tuber crop needs more nutrient as compared to cereals. Nutrient management is an important agronomic factor responsible for increasing the yield of potato and affecting the quality of potato. In view of the above considerations, an experiment was conducted to study the effect of irrigation regimes, planting layouts and fertilizer levels on growth and yield of potato (cv. Kufri jyoti) during *rabi* 1998-99.

MATERIALS AND METHODS

The field experiment was conducted at the Institutional farm of Interfaculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during *rabi* 1998. The soil was sandy clay loam, low in available nitrogen (146.20 kg ha^{-1}) and phosphorus (10.82 kg ha^{-1}) and high in potassium (252.10 kg ha^{-1}) with slightly alkaline in reaction (pH 8.1). The experiment was laid out in a factorial randomized block design with twelve treatment combinations including three fertilizer levels *viz*., 80:40:40, 120:60:60 and 160:80:80 kg NPK ha^{-1}. Two irrigation regimes at 50 mm CPE at 6 cm and 75 mm CPE at 8 cm depth, with two planting layouts treatments for potato crop i.e. ridges and furrows and broad bed furrows with three replications were tried. The gross and net plot sizes were 6.0 x 4.8 m^2 and 5.40 x 3.60 m^2, respectively.

RESULTS AND DISCUSSION

The height of plant (Table 1) was progressively increased with the advancement in the age of crop. The maximum height of 41.74 cm was recorded at 50 mm CPE than 75 mm CPE. Ingale and Dahatonde (1975) also reported similar results in potato when irrigations were applied at 40 mm than 60 mm CPE. Similarly, plant height was higher under ridges and furrows than broad bed furrows. Plant height was also higher at 160:80:80 kg NPK ha^{-1} of fertilizer level than lower levels of fertilize i.e. 80:40:40 and 120:60:60 kg NPK ha^{-1}. Ingale and Dahatonde (1975) reported similar results with the application of 100:100:50 NPK kg ha^{-1}. The difference in spread of the plant due to irrigation regimes were statistically significant at all stages of crop growth, however the maximum plant spread was observed at 50 mm CPE (41.50 cm) than 75 mm CPE (39.33 mm). Plant spread in ridges and furrows and in broad bed furrows at harvest were 41.30 and 39.43 cm respectively. Similar results were reported by Tarade (1984) in groundnut. The mean number of leaves per plant increased with an advancement in the age of crop till harvest of crop. The number of leaves were maximum at 50 mm CPE (i.e. 40.76 cm) than 75 mm CPE (i.e. 39.33 cm) at harvest. Girase (1996) reported similar results in cabbage indicating number of leaves per plant goes on increasing rapidly and significantly higher number of leaves per plant were recorded in treatments receiving irrigation at 50mm CPE at 10 days interval. The number of leaves per plant recorded in treatment 75 mm CPE were significantly lower. The number of leaves per plant increased significantly and were maximum (39.70) at harvest in ridges and furrows than broad bed furrows (38.38). Girase (1996) observed similar results in cabbage and reported that at harvest the number of leaves per plant were 14.14 and 13.55 in ridges and furrows and in flat beds respectively. The difference in mean number of leaves per plant at harvest were statistically significant due to different levels of fertilizers. Maximum numbers of leaves were observed at 160:80:80 kg NPK

ha^{-1} (41.23) than at 80:40:40 (36.93) and 120:60:60 kg NPK ha^{-1} (38.95). Similarly the difference in mean number of branches recorded at harvest stage of crop growth were maximum at 50 (5.84) than 75 mm CPE (3.83). The number of branches were maximum at normal planting on ridges and furrows (5.41) than the broad bed furrows (4.26). However, maximum number of branches were observed at higher dose of 160:80:80 kg NPK ha^{-1} (5.91). The drymatter of plant increased with an advancement in the age of crop. The mean drymatter accumulation at harvest was significantly higher in 50 (54.73) than 75 mm CPE (52.68). Similar results were reported by Sharma and Paraskar (1982) in cauliflower. The dry matter production increased with the advancement in the age of the crop upto harvest due to different planting layouts. It was significantly higher in normal planting of ridges and furrows (54.46) than broad bed furrows (52.96).

Increase in vigour as measured in terms of plant height, plant spread, number of leaves, number of branches due to normal planting on ridges and furrows compared to broad bed furrows was probably due to efficient utilization of radient energy, proper aeration, more availability of water and nutrient which would have increased the photosynthesis ultimately carbohydrates resulting in increased dry matter production per plant. Similar results were also reported by Tarade (1984) in groundnut with different fertilizer levels, significantly influenced by mean drymatter production plant-1 at all the stages of crop growth. The maximum dry matter production at harvest was observed at 160:80:80 (55.38 q) than 80:40:40 (52.28 q) and 120:60:60 kg NPK ha^{-1} (53.47q). Singh

Table 1. Mean growth and yield components in potato. (cv. Kufri jyoti) as influenced by different treatments.

Treatment	Mean growth components					Mean yield components				
	Plant height (cm)	Plant spread (cm)	Leaves $plant^{-1}$	No. of branches $plant^{-1}$	Total dry matter $plant^{-1}$ (g)	Tubers $plant^{-1}$ (cm)	Size of tuber $plant^{-1}$ (cm)	Weight of tuber $plant^{-1}$ (g)	Tuber yield (t ha^{-1})	Haulm weight (q ha^{-1})
Irrigation regimes (mm CPE) :										
50	42.98	41.50	40.76	5.84	54.73	5.14	15.81	314.03	16.68	7.41
75	40.51	39.33	37.31	3.83	52.68	3.32	13.90	286.19	15.22	6.59
S. E.±	0.20	0.25	0.21	0.25	0.17	0.13	0.20	0.29	0.44	6.44
C. D. at 5%	0.75	0.75	0.62	0.73	0.51	0.38	0.60	0.86	1.30	1.28
Plant layouts :										
Ridges and furrows	42.35	41.39	39.70	5.41	54.46	4.83	15.00	290.13	16.76	7.54
Broad bed furrows	41.14	39.43	38.38	4.26	52.96	3.63	13.91	287.05	15.14	6.47
S. E.±	0.20	0.25	0.21	0.25	0.17	0.13	0.20	0.29	0.44	0.44
C. D. at 5%	0.57	0.75	0.62	0.73	0.51	0.38	0.60	0.86	1.30	1.28
Fertilizer levels (NPK kg ha-1) :										
80:40:40	40.36	37.91	36.93	3.66	52.28	2.99	12.94	284.44	13.51	5.50
120:60:60	41.41	40.22	38.95	4.93	53.47	4.15	14.18	288.60	16.92	7.91
160:80:80	43.46	43.11	41.23	5.91	55.38	5.54	16.20	292.73	17.68	8.25
S. E.±	0.24	0.31	0.26	0.31	0.21	0.16	0.25	0.36	0.54	0.54
C. D. at 5%	0.70	0.91	0.76	0.89	0.62	0.47	0.73	1.05	1.59	1.59
Interaction	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.
Mean	41.74	40.41	29.37	4.84	53.71	4.23	14.45	291.87	15.95	7.00

and Paliwal (1978) reported that shoot drymatter weight per plant was maximum under higher dose of fertilizer 180:120:120 kg NPK ha^{-1} and was found superior as compared to lower levels tried.

The mean number of tubers per plant was maximum at 50 (5.14) than 75 mm CPE (3.32) at harvest. The number of tubers $plant^{-1}$ were higher in ridges and furrows (4.83) than broad bed furrows (3.63). At 160:80:80: kg NPK ha^{-1} fertilizer level, the number of tubers per plant were maximum (5.54) than lower levels of fertilizer. Singh and Paliwal, (1978) also reported higher number of tubers per plant at 140:50:50 kg NPK ha^{-1} than 70 kg N ha^{-1}.

Size of tubers per plant was higher at 50 (15.81 cm) than 75 mm CPE (13.80). At harvest also the size of tubers per plant was higher in normal planting (15.00 cm) as compared to broad bed furrows (13.91 cm). Similar trend was noticed in single row planting and double row planting in potato crop at Modinapuram (Anonymous, 1990). The maximum size of tubers was observed at 160:80:80 kg NPK ha^{-1} (16.20 cm) than lower levels of fertilizer.

The maximum weight of tubers per plant was observed at 50 mm CPE (314.03 g) irrigation than at 75 mm CPE irrigation (286.19 g) at harvest. Similarly the weight of tubers per plant was higher in ridges and furrows (290.13 g) than broad bed furrows (287.05 g). The maximum weight of tubers per plant was observed with 160:80:80 kg NPK ha^{-1} (292.73 g) than lower levels of fertilizer.

It is interesting to note that irrigation regimes had spectacular effects on production of tuber yield. Irrigation at 50 mm CPE, produced 16.68 t ha^{-1} than at 75 mm CPE (15.22 t ha^{-1}).

The potato tuber yield was higher in ridges and furrows (16.76 t ha^{-1}) than broad bed furrows (15.14 t ha^{-1}). The development of tuber when grown on ridges and furrows was better. This might be due to uniform distribution of soil moisture and efficient use of solar energy under normal planting as compared to paired row planting. The potato tuber yield was higher in 160:80:80 kg NPK ha^{-1} levels of fertilizer (17.65 t ha^{-1}) than at 80:40:40 (13.51 t ha^{-1}) and 120:60:60 kg NPK ha^{-1} (16.92 t ha^{-1}). Grewar and Singh (1978) also obtained higher tuber yield at higher levels of fertilizer (180:100:100 kg NPK ha^{-1}).

The mean haulm weight was significantly higher at 50 mm CPE (7.41 q ha^{-1}) than at 75 mm CPE (6.59 q ha^{-1}). Singh and Paliwal (1978) reported similar results and indicated that haulm weight was maximum at 40 than 60 mm CPE. The mean haulm weight was significantly higher in ridges and furrows (7.54 q ha^{-1}) than broad bed furrows (6.47 q ha^{-1}). Similarly mean haulm weight was significantly higher at 160:80:80 (8.25 q ha^{-1}) than at 80:40:40 kg NPK ha^{-1} (5.50 q ha^{-1}). Krishnappa *et al.*, (1979) observed that higher dose of 180 kg N, 50 kg P_2O_5 and 50 kg K_2O $hectare^{-1}$ increased the haulm weight (15.45 q ha^{-1}) over control. In this investigation, interaction effects between different factors in respect of growth, yield and yield contributing characters were found to be not significant.

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Correlation and Path Analysis in Chickpea

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ABSTRACT

Correlation and path coefficients were studied for thirteen characters in 30 chickpea genotypes. Character association studies indicated that number of pods per plant, seeds per pod, 100 seed weight, dry matter per plant and days to maturity were having highly significant positive association with grain yield. However, path coefficient analysis revealed that number of pods per primary branch had highest direct positive effect on grain yield followed by dry matter per plant.

Key words : Correlation, path analysis, chick pea.

The yield being a complex character, is dependent on a number of component characters. The association among themselves and with grain yield is quite important for devising an efficient selection, criterion for grain yield. The estimation of character association alone do not provide a clear cut picture of cause and effects of characters on yield. Hence, selection based only on correlation is of no use while applying selection on particular character to increase yield. The interrelationships among the yield components can be analysed with the help of path coefficient analysis which permits the separation of correlation coefficient into direct and indirect effects. The present study was conducted to know the extent of character association between yield and its components and their direct and indirect effects on grain yield in chick pea.

MATERIALS AND METHODS

The experimental material for the present investigation comprised of thirty genotypes of chickpea representing desi and *kabuli* groups of cultivars, having variability in morphological, physiological and agronomical traits. This experiment was conducted at the Research Farm of Agricultural Botany, College of

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Each genotype had 3 rows which were spaced at 40 cm, while spacing between plants within a row was 20 cm. Observations were recorded on five randomly selected plants for thirteen yield contributing characters. The mean of five plants of each genotype in each replication was used for statistical analysis. The analysis of variance and correlation were calculated for all pairs of characters. Path analysis was carried out according to the method suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The phenotypic and genotypic correlation between different pairs of characters are given in Table 1. In the present investigation, correlation studies at phenotypic and genotypic levels were made to determine the direction and magnitude of association of characters. In general most of the characters had higher genotypic correlation values than the phenotypic correlation values.

Table 1. Phenotypic and genotypic correlation coefficient for twelve characters in chickpea.

Characters	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Pods primary^{-1} branch	Pods secondary^{-1} branch	Plant height (cm)	Seeds pod^{-1}	100 seed weight (g)	Dry matter plant^{-1} (g)	Protein content in seed (%)	Days to maturity	Grain yield plant^{-1} (g)
1	-0.218 (-0.325)	-0.119 (-0.537)**	-0.157 (-0.166)	-0.158 (-0.273)	-0.228 (-0.490)**	0.241 (0.323)	-0.139 (-0.156)	0.229 (0.251)	-0.084 (-0.104)	0.300 (0.325)	0.286 (0.264)	-0.083 (-0.095)
2		0.222 (0.583)**	-0.054 (-0.087)	0.291 (0.031)	0.419* (0.288)	-0.163 (-0.164)	-0.276 (-0.338)	-0.314 (-0.370)*	0.110 (0.132)	-0.008 (-0.072)	-0.029 (-0.063)	-0.096 (-0.154)
3			0.111 (0.440)*	0.223 (-0.124)	0.398* (0.781)**	0.016 (-0.124)	-0.082 (-0.437)*	0.144 (0.732)**	0.265 (1.00)**	-0.016 (0.140)	0.077 (0.478)**	0.218 (0.839)**
4				0.343 (0.432)*	0.305 (0.521)**	0.143 (0.176)	0.475* (0.509)**	0.218 (0.223)	0.686** (0.708)**	0.002 (0.006)	0.289 (0.311)	0.876** (0.884)**
5					0.502** (0.163)	-0.071 (-0.034)	0.095 (0.167)	-0.129 (-0.142)	0.190 (0.188)	0.007 (-0.063)	0.020 (-0.040)	0.248 (0.266)
6						-0.036 (0.020)	0.048 (0.126)	0.017 (0.074)	0.405* (0.667)**	-0.079 (-0.317)	0.096 (0.175)	0.356 (0.556)**
7							0.048 (-0.057)	0.644** (0.762)**	0.388 (0.504)**	0.215 (0.283)	0.575** (0.689)**	0.299 (0.378)*
8								0.190 (0.210)	0.216 (0.236)	-0.265 (-0.296)	0.210 (0.206)	0.479** (0.542)**
9									0.479** (0.518)**	-0.025 (-0.015)	0.525** (0.580)**	0.566** (0.589)**
10										-0.007 (-0.022)	0.438* (0.498)**	0.808** (0.814)**
11											0.250 (0.290)	-0.069 (-0.084)
12												0.466** (0.520)**

1=Days to first flowering, 2=Primary branches plant^{-1}, 3=Secondary branches plant^{-1}, 4=Pods plant^{-1}, 5=Pods primary branch^{-1}, 6=Pods secondary branch^{-1}, 7=Plant height (cm), 8=Seeds pod^{-1}, 9=100 seed weight (g), 10=Dry matter plant (g), 11=Protein content in seed (%), 12=Days to maturity.

**,* Significant at 1 and 5 per cent respectively. The first figures are phenotypic correlations. Figures in parenthesis are genotypic correlations.

Table 2. Phenotyupic and genotypic direct effect of twelve characters on grain yield of chick pea.

Characters		Days to first flowering	Primary branches plant^{-1}	Secondary branches plant^{-1}	Pods plant^{-1}	Pods primary^{-1} branch	Pods secondary^{-1} branch	Plant height (cm)	Seeds pod^{-1}	100 seed weight (g)	Dry matter plant^{-1} (g)	Protein content in seed (%)	Days to maturity	Grain yield plant^{-1} (g)
1	P	-0.015	-0.001	-0.003	-0.097	0.001	-0.014	-0.034	-0.10	0.088	-0.015	-0.006	0.022	-0.083
	G	0.037	-0.020	-0.007	-0.108	-0.008	-0.074	-0.064	-0.013	0.131	0.001	0.004	0.026	-0.095
2	P	0.005	0.003	0.005	-0.033	-0.001	0.025	0.0023	-0.20	-0.121	0.019	0.000	-0.022	-0.096
	G	0.061	-0.012	0.008	-0.057	0.001	0.043	0.033	-0.028	-0.194	-0.001	-0.001	-0.006	-0.154
3	P	0.023	0.002	0.001	0.068	-0.001	0.024	-0.002	-0.006	0.055	0.047	0.000	0.00	0.218
	G	0.013	-0.020	0.035	0.286	-0.004	0.118	0.025	-0.037	0.384	-0.010	0.002	0.046	0.839
4	P	0.615	0.002	-0.000	0.003	-0.001	0.018	-0.020	0.032	-0.084	0.121	-0.000	0.023	0.876
	G	0.650	-0.006	-0.005	0.006	0.013	0.079	-0.035	0.043	0.117	-0.007	0.000	0.030	0.884
5	P	-0.004	0.002	0.001	0.005	0.211	0.030	0.010	0.007	-0.050	0.033	-0.000	0.002	0.248
	G	0.031	-0.010	0.002	-0.002	0.281	0.025	0.007	0.014	-0.074	-0.002	0.001	-0.004	0.266
6	P	0.060	0.003	0.002	0.009	0.187	-0.002	0.005	0.003	0.007	0.071	0.002	0.007	0.356
	G	0.151	-0.018	0.017	0.011	0.338	0.005	-0.004	0.011	0.039	-0.007	-0.004	0.017	0.556
7	P	-0.142	-0.004	-0.001	0.000	0.088	0.000	-0.002	0.003	0.248	0.068	-0.004	0.045	0.299
	G	-0.199	0.012	-0.010	-0.002	0.114	-0.001	0.003	-0.005	0.399	-0.005	0.004	0.067	0.378
8	P	0.071	0.002	-0.001	-0.002	0.281	-0.000	0.003	-0.007	0.073	0.038	0.005	0.016	0.479
	G	0.084	-0.006	-0.020	-0.006	0.331	0.005	0.019	0.011	0.110	-0.002	-0.004	0.020	0.542
9	P	0.384	-0.003	-0.002	0.003	0.134	0.001	0.001	-0.092	0.013	0.084	0.001	0.041	0.566
	G	0.524	0.009	-0.022	0.010	0.145	-0.004	0.011	-0.151	0.018	-0.005	-0.000	0.056	0.589
10	P	0.176	0.001	0.001	0.006	0.422	-0.001	0.024	-0.055	0.015	0.184	0.000	0.034	0.808
	G	-0.010	-0.004	0.008	0.014	0.460	0.006	0.101	-0.100	0.020	0.272	-0.000	0.048	0.814
11	P	-0.020	-0.005	-0.000	-0.000	0.001	-0.000	-0.005	-0.031	-0.019	-0.010	-0.001	-0.019	-0.069
	G	0.014	0.012	-0.004	0.002	0.004	-0.002	-0.048	-0.056	-0.025	-0.008	0.000	0.028	-0.084
12	P	0.078	-0.004	-0.000	0.002	0.178	-0.000	0.006	-0.082	0.015	0.202	0.077	-0.005	0.466
	G	0.097	0.010	-0.004	0.006	0.202	-0.001	0.026	-0.137	0.017	-0.304	-0.005	0.004	0.520

1=Days to first flowering, 2=Primary branches plant^{-1}, 3=Secondary branches plant^{-1}, 4=Pods plant^{-1}, 5=Pods primary branch^{-1}, 6=Pods secondary branch^{-1}, 7=Plant height (cm), 8=Seeds pod^{-1}, 9=100 seed weight (g), 10=Dry matter plant (g), 11=Protein content in seed (%), 12=Days to maturity

**,* Significant at 1 and 5 per cent respectively, underline figures indicated direct effect. R : P = 4.614619, G = 1.384845

In present investigation, number of pods plant^{-1}, seeds pod^{-1}, 100-seed weight, dry matter plant^{-1} and days to maturity showed highly significant positive correlation with grain yield plant^{-1} at both genotypic and phenotypic levels, while number of secondary branches plant^{-1} and number of pods secondary^{-1} branch showed highly significant positive correlation with grain yield plant^{-1} only at genotypic level. Chavan *et al*., (1994), Yadav *et al*., (1999), Narayana and Reddy (2002) and Babbar and Patel (2005) observed the similar results in case of chickpea. It indicated that yield was highly dependent on pods plant^{-1}, seeds pod^{-1}, 100 seed weight, dry matter plant^{-1} and days to maturity.

Days to first flowering, number of primary branches plant^{-1} and protein content in seed showed negative and nonsignificant association with grain yield plant^{-1}. Sandhu and Mangal (1995) and Raval and Dobariya (2003) observed negative association of grain yield plant^{-1} with days to flowering and protein percentage. It suggests that reduction in growth characters like number of primary branches plant^{-1} and earliness alongwith more number of pods plant^{-1} and increasing secondary branches plant^{-1} may contribute to high yields in chickpea.

Path values based on phenotypic and genotypic correlations showing direct and indirect effect of twelve characters on yield are presented in Table 2. The path coefficient analysis showed maximum direct positive effect of number of pods primary^{-1} branche followed by dry matter plant^{-1} on grain yield at phenotypic level. While maximum direct positive effect on grain yield at genotypic level was of number of pods primary^{-1} branch followed by dry matter plant^{-1}, days to first flowering and number of secondary branches plant^{-1}. Number of secondary branches plant^{-1}, number of pods plant^{-1} and 100 seed weight showed the direct positive effect on grain yield at both levels. Muppidathi *et al.*, (1995) and Bhaduoria *et al.*, (2003) also observed similar results.

Further days to first flowering showed positive indirect effect via 100-seed weight and days to maturity on grain yield at both levels. Number of pods plant^{-1} showed highest positive indirect effect on grain yield via days to first flowering followed by 100-seed weight and number of pods secondary^{-1} branch at genotypic level.

Plant height showed positive indirect effect on grain yield via 100-seed weight, number of pods primary^{-1} branch and days to maturity at both levels. Seeds per pod showed positive indirect effect via number of pods primary^{-1} branch followed by 100 seed weight and days to first flowering at both levels. Dry matter plant^{-1} and 100 seed weight showed positive indirect effect via number of pods primary^{-1} branch, days to maturity, plant height and number of pods plant^{-1}.

From the results of the present study, it is apparent that, yielding ability in chickpea might be improved by selecting more number of pods plant^{-1}, more dry matter coupled with more number of seeds pod^{-1}. So utmost importance should be given for these characters while going for selection.

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Estimates of Genetic Variability and Heritability in Chickpea

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ABSTRACT

Population parameters such as range, mean, phenotypic and genotypic variances, PCV and GCV, heritability and genetic advance for 13 agronomic characters were studied in a set of 30 chick pea genotypes. Range of variability was appreciable for days to first flowering, secondary branches, plant height, dry matter and grain yield. Values of genotypic and phenotypic variances were highest for number of pods, while lowest for seeds. PCV showed higher values than GCV for all characters. High heritability coupled with high genetic advance was observed for grain yield, plant height, dry matter, days to first flowering and days to maturity indicated high additive gene effects.

Key words : Genetic variability, heritability, chickpea.

To bring about genetic improvement in any crop, presence of genetic variability is of paramount importance. One of the major reasons constraining productivity in chickpea is that genetic diversity available from worldwide collection of germplasm in the past has been utilized and mobilized to a limited extent by the breeders. Collection of divergent germplasm from all over the world, its quantitative assessment and its use in the breeding programme offers possibilities of genetic upgrading of this crop. A study was therefore, undertaken to gather information on this aspect, which is considered essential for planning a successful breeding programme.

MATERIALS AND METHODS

The experimental material for the present investigation comprised of thirty genotypes of chickpea representing desi and kabuli groups of cultivars, having variability in morphological, physiological and agronomical traits. This experiment was conducted at the Research Farm of Agricultural Botany, College of Agriculture, Dapoli, during rabi 2006-07, using a randomized block design with 3 replications. Each genotype had 3 rows which were spaced at 40 cm., while spacing between plants within a row was 20 cm. Observations were recorded on five randomly selected plants for thirteen yield contributing characters. Mean, range, components of variance, coefficients of variation and genetic advance were worked out using standard statistical procedures.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among genotypes for all the characters studied. This suggests that there was considerable variability in the experimental material for different traits. Population parameters observed in the 30 genotypes of chickpea in terms of range, mean, components of variances, coefficients of variability, heritability and genetic advance is given in Table 1.

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*Part of M. Sc. (Agri.) thesis submitted by senior author.

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Table 1. Range, mean, components of variances, coefficient of variability, heritability and genetic advance for different characters in chickpea.

Characters	Range	General mean	Variances			GCV (%)	PCV (%)	h^2b (%)	GA as % of mean
			Pheno-typic	Geno-typic	Environ-mental				
Days to first flowering	29.33-55.33	36.72	37.97	34.931	3.039	16.10	16.79	92.00	11.68
Primary branches plant^{-1}	4.90-11.57	8.26	3.055	1.968	1.087	16.99	21.16	64.41	2.32
Secondary branches plant^{-1}	4.90-15.57	9.02	38.344	1.720	36.624	26.37	33.39	62.35	3.87
Pods plant^{-1}	20.82-83.63	46.45	221.641	219.868	1.773	31.93	32.05	99.20	8.82
Pods primary^{-1} branch	2.79-10.58	4.97	3.724	2.062	1.662	28.81	38.79	55.15	2.19
Pods secondary^{-1} branch	2.17-4.22	3.27	0.643	0.188	0.455	13.30	24.53	29.39	0.49
Plant height (cm)	30.75-60.92	42.80	71.92	50.085	21.835	16.53	19.81	69.62	12.16
Seeds pod^{-1}	1.01-1.30	1.08	0.007	0.005	0.001	6.81	7.60	80.57	0.14
100 seed weight (g)	11.06-29.57	20.46	18.076	17.695	0.381	20.56	20.78	97.89	8.57
Dry matter plant^{-1} (g)	9.10-32.97	18.21	41.205	37.547	3.658	33.64	35.25	91.12	11.84
Protein content in seed (%)	18.75-24.17	22.32	2.549	2.083	0.465	6.47	7.15	81.74	2.65
Days to maturity	90.67-116.00	100.46	45.86	38.282	7.578	6.15	6.74	83.47	11.47
Grain yield plant^{-1} (g)	5.20-20.23	9.00	23.879	23.107	0.772	53.41	54.29	96.76	9.57

A wide range of variation was observed for all the characters studied. It was maximum in case of number of pods plant^{-1}, while minimum for seeds pod^{-1}. Shinde *et al*., (1998) and Kaur *et al*., (2004) reported maximum range of variability for number of pods per plant in chickpea. The character showing high range of variation proved an ample scope for selecting the desirable types.

The highest and lowest phenotypic variances were observed in number of pods per plant and seeds per pod respectively. The character number of pods plant^{-1} showed maximum genotypic variance, while seeds per pod showed minimum genotypic variance. The characters *viz*. number of secondary branches plant^{-1}, plant height and days to maturity showed sensitivity to environment as revealed by the higher amount of environmental variances for these characters.

Among all the characters studied, grain yield plant^{-1}, number of pods primary^{-1} branch, number of pods plant^{-1} and dry matter plant^{-1} showed highest magnitude of PCV and GCV, indicated that, these characters can be improved through phenotypic selection. The similar results were also reported by Raval and Dobariya (2003).

High values of heritability coupled with high genetic advance were observed for grain yield plant^{-1}, plant height, dry matter plant^{-1}, days to first flowering and days to maturity. Sood and Kumari (2000), Kaur *et al*., (2004) and Pratap *et al*., (2004) reported medium to high values of heritability with high genetic advance for days to flowering, 100 seed weight, seed yield and pods plant^{-1}. High heritability with high genetic advance may be due to the high additive gene effects and selection pressure could profitably be applied on these characters for yield improvement.

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In Vitro Propagation of Malkangni (*Celastrus paniculatus* Wild) a Rare Endangered Medicinal Species

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ABSTRACT

In vitro plantlet production of *Celastrus paniculatus* Wild was established using stem and leaves (leaf segment) as explants. Healthy calli were produced on MS medium supplemented with 1 mgl^{-1} BA + 1 mg l^{-1} Kin + 0.5 mgl^{-1} NAA. A wide range of variability was observed for days to initiation of callus on MS medium. The response of genotypes varied according to type of explant. The species Dapoli local had taken minimum days for initiation of callus. The range for days to initiation of callus was from 18.84 to 27.75 in stem explants and 14.04 lo 23.26 in leaves (leaf segment) explants.

Key words : *Celastrus paniculatus*, Malkangni, callus, variability.

Celastrus paniculatus Wild is a threatened medicinal plant used for a wide range of medicinal applications in Indian system of medicine, i.e. Ayurveda. The leaf sap is an emmenagogue and a good antidote for opium poisoning. Seeds are stimulant, diaphoretic, diuretic, tonic, appetizer, anti-inflammatory and used for abdominal disorders, leprosy, pruritus, skin diseases, paralysis, asthma, leucoderma, cardiac, inflammation, amenorrhoea and fever. The seed oil is used to cure beriberi, sores, and to promote intelligence and sharp memory. It is also used in mental disorders. More recently, it has been reported to be an antidepressant.

Wild population of *Celastrus paniculatus* Wild are severely depleted owing to injudicious exploitation on the places where they occur on large scale. Uncontrolled destructive harvesting of plants long before flowering has hampered natural regeneration through seed, while seeds exhibited poor viability and germination restrict their use in multiplication.

Likewise conventional propagation through vegetative cutting is slow and cumbersome. Realizing the threat of extinction *Celastrus paniculatus* Wild, there is an urgent need to develop quick propagation protocols and conservation strategies in Malkangni. Therefore, attention has been turned to establish a reliable micropropagation method

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so that multiplication and conservation of plants for future supply will be possible.

MATERIALS AND METHODS

The experimental material consisted of two genotypes of Malkangni *viz*., Dapoli local and Talavali local. These genotypes were potted and maintained in greenhouse condition. The experiment was carried out using completely randomized design. The experiment was conducted at Plant Biotechnology Unit, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri (MS) India. The data were subjected to statistical analysis as suggested by Panse and Sukhatme (1985).

Actively growing plant material was collected and washed under running tap water. In order to standardize the most effective explant for callus induction the leaf discs of 5 mm size, stem explants of 5.8 mm were prepared as explants and washed under running tap water. Explants were treated with 0.1 per cent bavistin + 0.1 per cent cetrimide for 1 hour followed by repeated washing in double distilled water. Further surface sterilization was carried out with 0.1 per cent $HgCl_2$ for 10 min and 70 per cent ethanol for 30 sec. were carried out under aseptic conditions of a laminar air flow cabinet followed by repeated washing with double distilled water. Then surface sterilized explants were quickly inoculated on suitable nutrient medium. In order to study the effect of different media on shoot growth, multiplication and development for clonal propagation, the explant were cultured on MS medium supplemented with 3 per cent sucrose and varied concentrations of BAP, NAA and Kinetin.

RESULTS AND DISCUSSION

The effect of different media combinations on callus induction of Malkangni (*Celastrus paniculatus* Wild) along with various plant growth regulators were given in Table 1. Murashige and Skoog (1962) medium supplemented with 1 mg l^{-1} BA + 1 mg l^{-1} Kin + 0.5 mg l^{-1} NAA gave highest per cent callus induction (81.43 %) while, MS + 1.5 mgl^{-1} BA + 0.1 mgl^{-1} NAA + 25 mgl^{-1} Ads 4- 25 mgl^{-1} arginine + 25 mgl^{-1} citric acid + 50 mgl^{-1} acetic acid reported the lowest callus induction (10.14 %). The MS medium supplemented with 1 mg l^{-1} BA + 1 mg l^{-1} Kin + 0.5 mg l^{-1} NAA produced average 2 to 3 shoots without

Table 1. Effect of media composition on callus induction of *Celastrus paniculatus* Wild.

Tr. No.	Medimum	Per cent callus induction
M_1	MS + 1.5 mgl^{-1} BA + 0.1 mgl^{-1} NAA + 25 mgl^{-1} Ads + 25 mgl^{-1} arginine + 25 mgl^{-1} citric acid + 50 mgl^{-1} acetic acid	11.22 (19.58)
M_2	MS + 1.8 mgl^{-1} BA + 0.1 mgl^{-1} NAA + 25 mgl^{-1} Ads + 25 mgl^{-1} arginine + 25 mgl^{-1} citric acid + 50 mgl^{-1} acetic acid	10.14 (18.56)
M_3	MS + 1 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA	81.43 (64.47)
M_4	MS + 2 mgl^{-1} BA + 2 mgl^{-1} Kin + 0.1 mgl^{-1} NAA + 80 mgl^{-1} Ads	12.50 (20.70)
M_5	MS + 2 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.1 mgl^{-1} NAA + 80 mgl^{-1} Ads	40.13 (39.27)
M_6	MS + 3 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.1 mgl^{-1} NAA + 80 mgl^{-1} Ads	39.00 (38.64)
M_7	MS + 2 mgl^{-1} BA + 2 mgl^{-1} Kin + 1 mgl^{-1} NAA	60.93 (51.30)
	Mean	36.47
	S. E.±	0.14
	C. D. at 5%	0.46

(Figures in parentheses indicate arcsine values) subculturing within 9 weeks in case of stem explant, while 7 weeks in case of leaf explant.

Genotypic variability for days to callus induction from stem explants are given in Table 2. It is evident from the data that, genotypes had shown significant differences for days to initiation of callus from stem explanls. The different media combinations showed significant differences for days to initiation of callus by using stem explants of both the genotypes.

The interaction of genotype and medium combinations showed non significant difference for days to initiation of callus. The genotype Dapoli local look (18.16) minimum days for days to initiation of callus with medium combination of 1 mg l^{-1} BA + mg l^{-1} Kin + 0.5 mg l^{-1} NAA, while genotype Talavali local (28.04) required maximum days with medium combination 1.8 mg l^{-1} BA + 0.1 mgl^{-1} NAA + 25 mgl^{-1} Ads + 25 mgl^{-1} arginine + 25 mgl^{-1} citric acid + 50 mgl^{-1} acetic acid. For callus induction different effective explants were used by many workers for example stem explants and seed were used for callus induction by Maruti *et al*., (2004).

Genotypic variability for days to callus induction from leaf explants is given in Table 2. The minimum days required for callus induction were 18.11 days. The genotypes showed significant differences for days to initiation of callus from leaf explants. The minimum days (13.5) were taken by Dapoli local while maximum days by Talavali local (23.76) using leaf explant for days to initiation of callus. The different media combinations showed highly significant differences for days to initiation of callus for both the genotypes. The minimum days (14.06) were required for initiation of callus were in media combination MS 1 mg l^{-1} BA + 1 mg l^{-1} Kin + 0.5 mg l^{-1} NAA.

The interaction of genotypes and media combination showed non significant differences for days to initiation of callus. The genotype Dapoli local required minimum days (13.5) on media combination l mgl^{-1} BA +1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA while genotype Talavali local required maximum days (23.76) with medium combination of 1.8 mg l^{-1} BA + 0.1 mg l^{-1} NAA + 25 mgl^{-1} Ads + 25 mgl^{-1} citric acid + 50 mgl^{-1} acetic acid. Leaf explants were used for callus induction by Sharada *et al*., (2003). The coteledonary leaves from mature embryo are also used for callus induction.

Table 2. Genotypic variability for days to callus indiction from stem and leaves explants of *Celastrus paniculatus* Wild.

Tr. No.	Days to callus initiation		Mean
	Dapoli local (G_1)	Talavali local (G_2)	
M_1	25.41 (18.7)	26.3 (18.8)	25.85 (18.75)
M_2	27.11 (22.77)	28.04 (23.76)	27.75 (23.26)
M_3	18.16 (13.5)	19.53 (14.53)	18.84 (14.06)
M_4	23.53 (20.25)	24.58 (19.88)	24.05 (20.06)
M_5	21.63 (16.92)	21.6 (17.33)	21.61 (17.12)
M_6	22.6 (16.46)	23.63 (16.70)	23.11 (16.58)
M_7	20.4 (15.73)	20.5 (16.00)	20.45 (16.86)
Mean	19.46 (17.76)	23.50 (18.15)	23.09 (18.11)
	Genotype	Treatment	Interaction
S. E.$\pm$	0.46 (0.46)	0.70 (0.70)	0.46 (0.99)
C.D. at 5%	1.97 (1.97)	3.01 (3.01)	N. S. (N. S.)

Figures out and inside the parentheses indicate stem and leaves explants, respectively.

In the present investigation, better results of callus induction was obtained by using leaf, stem explants. Callus induction was initiated by using MS media with different seven growth regulator combinations. The varied response of callus induction was noticed in both genotypes of Malkagni. The medium supplemented with 1 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA exhibited higher callus induction in both the genotypes. On the same medium shoots differentiated within 9 weeks in case of stem explants and within 7 weeks in case of leaf segment explants. For callus induction different effective explants were used by many workers for example stem explants and seed were used for callus induction by Maruti *et al.,* (2004), Leaves explants were used for callus induction by Sharada *et al*., (2003). The coteledonary leaf from mature embryo are also used for callus induction. Maximum callus induction was noticed in MS + 1 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA followed by MS + 2 mgl^{-1} BA + 2 mgl^{-1} Kin + 1 mgl^{-1} NAA. Minimum days required for callus induction through stem and leaf explants was observed in MS + 1 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA. By and large MS + 1 mgl^{-1} BA + 1 mgl^{-1} Kin + 0.5 mgl^{-1} NAA medium proved to be the best medium for early callus induction in *Celastrus paniculatus* Wild.

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Combining Ability Analysis for Yield and Yield Components in Sesame

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ABSTRACT

The 8 x 8 diallel analysis in F_1 generation without reciprocals in sesame revealed that the variances due to GCA and SCA were significant suggesting importance of additive and non-additive gene actions for all the characters studied. The estimated components of SCA variances were higher than the GCA variances for all the characters, indicating the predominance of non-additive or dominant gene action for the characters .The parents PT-1 was good general combiners for the seed yield plant^{-1}, branches plant^{-1}, capsules plant^{-1} and seeds capsule^{-1}, JLT-54 for plant height and internodes plant^{-1} and Hawari and AVT-3 for oil content and for days to maturity, respectively, which could be utilized in hybridization programme for improvement of these traits. The cross combinations *viz*., JLT-54 x Hawari, PT-1 x JLSV-4, Padma x TC-25 and JLT-54 x AVT-1 appeared to be good for seed yield and most of the contributing characters.

Key words : Combining ability, gene effects, sesame.

Sesame (*Sesamum indicum* L.) is an important oilseed crop. However, sesame seed yields are possibly the lowest of all major oilseeds in India because of unavailability of cultivars responsive to different agro-ecological situations and management conditions.

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Combining ability studies are more reliable as they provide useful information for the selection of parents in terms of performance of the hybrids and elucidate the nature and magnitude of various types of gene actions involved in the expression of quantitative traits. The main objective of the study reported was to identify good general combiners for seed yield and its components so as to use them in hybridization programme for improving seed yield based on 8 x 8 diallel cross of sesame.

MATERIALS AND METHODS

Eight genetically diverse genotypes of sesame *viz.*; AVT-3, PT-1, Padma, JLT-54, AVT-1, JLSV-4, TC-25 and Hawari were crossed in all possible combinations, excluding reciprocals. The resultant 28 F_1's along with their eight parents were grown in a randomized block design with three replications at College of Agriculture, Pune during *kharif* 2003. Each entry was sown in a single row of 4.5 meter length with inter and intra distances of 30 and 15 cm, respectively. The data were collected on five competitive plants selected randomly for ten yield and yield contributing characters. The combining ability analysis was done as per Griffing (1956) using Model - I, Method - II.

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among the treatments, parents, and hybrids and as well as in the parents vs. crosses for all the characters studied except seeds capsule^{-1} for parents vs. crosses, which indicated wider genetic variability among them (Table 1). The mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all the characters studied (Table 2). This indicated that both additive as well as non-additive types of gene actions were involved in the control of traits under study. Both additive and non-additive gene action has been reported earlier by Chaudhari *et al.*, (1984), Khorgade *et al.*, (1989), Narkhede and Kumar (1991) and Krishnaiah *et al.*, (2002) in governing the yield and its components in sesamum. The estimates of SCA variances were higher than GCA variances for all the characters, indicating predominance of non-additive gene action for these traits. Predominance of non-additive gene action reported earlier by Shrivas and Singh (1981), Goyal and Kumar (1991) and Jayalakshmi *et al.*, (2000) for seed yield, plant height, branches plant^{-1}, capsules plant^{-1}, seeds capsule^{-1} days to flower and maturity in

Table 1. Analysis of variance for ten characters in 8 x 8 half diallel in sesame.

Source of variation	**Mean sum of squres**					
	Replications (2)	**Treatments (35)**	**Parents (7)**	**Crosses (27)**	**P vs. C (1)**	**Error (70)**
Days to 50% flowering	0.070	6.551**	6.517**	6.329**	12.781**	0.570
Days to maturity	4.312	14.053**	21.136**	12.446**	7.859**	1.591
Plant height (cm)	1.25	365.992**	314.781**	364.754**	757.906**	4.132
Branches plant^{-1}	0.008	4.587**	9.432**	3.303**	5.333**	0.075
Internodes plant^{-1}	0.153	18.679**	13.515**	19.139**	42.390**	0.239
Capsules plant^{-1}	18.796	477.358**	239.540**	505.377**	1385.563**	8.947
Capsule length (cm)	0.0007	0.202**	0.095**	0.235**	0.074**	0.0005
Seeds capsule^{-1}	0.516	60.301**	20.286**	72.869**	1.085	0.511
Oil content (%)	6.429	44.991**	13.145**	52.792**	57.261**	0.724
Seed yield plant^{-1}	0.122	41.211**	19.056**	44.322**	112.289**	0.224

*,** Significant at 5 and 1 per cent respectively. Figures in parentheses indicate degrees of freedom.

sesamum. Estimates of GCA effects showed that it was not possible to pick up good general combiner for all the characters because the combining ability effects of parents were not consistence for the entire yield attributes studied (Table 3).

Among the parents, AVT-3 exhibited significant negative GCA for days to 50 per cent flowering and days to maturity indicating its usefulness for obtaining short duration recombinants. PT-1 was the best combiner for seed yield plant^{-1}, branches plant^{-1}, capsules plant^{-1} and seeds capsule^{-1}, while JLT-54 was the best general combiner for plant height and internodes plant^{-1}. High GCA estimates of JLSV-4 and Hawari indicated that these parents were good combiners for capsule length and oil content, respectively. In general, good general combiners for seed yield had good or average combining ability for one or more yield components. Parents PT-1, Padma, AVT-1 and Hawari exhibited high GCA effects, which associated with high *per se* performance. These results are in agreement with earlier finding of Pushpa *et al*., (2002) for various traits.

Out of 28 cross combinations, six each for seed yield plant^{-1} and days to 50 per cent

Tabel 2. Analysis of variance for combining ability for ten characters in sesame.

Character	Mean squares for different parameters					
	GCA	SCA	Error	σ^2 GCA	σ^2 SCA	A/D
Days to 50% flowering	2.40**	2.13**	0.19	0.03	1.94	0.03
Days to maturity	5.39**	4.51**	0.53	0.09	3.98	0.04
Plant height (cm)	64.06**	136.49**	1.38	-7.24	135.11	-0.11
Branches plant^{-1}	2.12**	1.38**	0.03	0.07	1.36	0.11
Internodes plant^{-1}	3.70**	6.86**	0.08	-0.32	6.78	-0.09
Capsules plant^{-1}	195.78**	149.96**	2.98	4.58	146.98	0.06
Capsule length (cm)	0.09**	0.06**	0.00	0.00	0.06	0.10
Seeds capsule^{-1}	23.50**	19.25**	0.17	0.42	19.08	0.04
Oil content (%)	40.70**	8.57**	0.24	3.21	8.33	0.77
Seed yield plant^{-1}	29.79**	9.72**	0.07	2.01	9.65	0.42

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

Table 3. Estimates of GCA effects of parents in seasame.

Parents	Dasys to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Internodes plant^{-1}	Capsules plant^{-1}	Capsule length (cm)	Seeds capsule^{-1}	Oil content (%)	Seed yield plant^{-1}
AVT-3	-1.05**	-1.53**	1.50**	0.24**	-0.46**	-3.84**	-0.19**	-2.69**	-4.65**	-2.54**
PT-1	0.15	0.47*	3.48**	0.74**	0.81**	4.84**	0.09**	2.3**	1.12**	2.76**
Padma	-0.18	0.13	-2.43**	0.16**	-0.59**	-0.55	-0.01	-0.71**	1.25**	0.52**
JLT-54	0.45**	0.43*	3.65**	0.33**	0.97*	4.57**	0.00	0.26*	-0.32*	0.68**
AVT-1	0.29*	0.17	-0.91**	-0.36**	0.07	1.32**	-0.03**	-0.58**	0.11	0.30**
JLSV-4	0.42**	0.90**	-1.71**	-0.004	-0.32**	-3.78**	0.12**	0.68**	0.67**	-0.63**
TC-25	-0.18	-0.23	-2.56**	-0.64**	-0.58**	6.68**	-0.04**	-1.40**	-0.05	-2.12**
Hawari	0.08	-0.33	-1.02**	-0.46**	0.10	4.12**	0.05**	0.70**	1.88**	1.04**
SE± (gi)	0.13	0.22	0.32	0.05	0.08	0.51	0.004	0.12	0.15	0.08

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

flowering; ten for plant height; eleven each for branches plant^{-1}, capsule length and protein content; five each for days to maturity, internodes plant^{-1} and capsules plant^{-1} and twelve for seeds capsule^{-1} exhibited significant desirable SCA effects. The five most promising crosses for each trait are listed in Table 4. The cross JLT-54 x Hawari having highest SCA effect for seed yield plant^{-1} also had significant SCA effect for plant height, internodes plant^{-1}, capsules plant^{-1}, capsule length and seeds capsule^{-1}. Likewise, PT-1 x JLSV-4 had significant SCA effect for plant height, internodes plant^{-1}, capsule length and seeds capsule^{-1}. Similarly Padma x TC-25 had significant SCA effect for plant height, branches plant^{-1}, internodes plant^{-1} and capsules plant^{-1}. These heterotic crosses involved parents belong to high x high, high x low or low x high and low x low general combiners. These findings indicate that it is not necessary to get best recombinants only from high x high general combiners. Goyal and Kumar (1991) suggested that low x high or low x low crosses also showed higher heterosis for various attributes than even high x high cross combinations.

The most promising cross is the one that involves parents with high GCA and shows high SCA effects. The major portion of such variance would be fixable in later generation. Such crosses were JLT-54 x Hawari for internodes plant^{-1} and capsules plant^{-1}. JLT-54 x Hawari, PT-1 x JLSV-4, Padma x JLSV-4 and Padma x JLT-54 for seeds capsule^{-1}; JLT-54 x Hawari, PT-1 x Hawari and JLT-54 x AVT-1 for seed yield plant^{-1}. The cross combinations AVT-1 x JLSV-4 and JLT-54 x JLSV-4 for days to flowering and maturity; Padma x TC-25 and JLSV-4 x Hawari for plant height; Padma x TC-25, Padma x JLSV-4 and AVT-3 x JLSV-4 for internodes plant^{-1}; Padma x TC-25 for capsules plant^{-1} exhibited significant SCA effect though both the parents

Table 4. Crosses showing significant desirable SCA effects for ten quantitative traits in sesame.

Characters	Crosses	SCA effect
Days to 50% flowering	AVT.1 x TC. 25	-2.42**
	AVT.1 x JLSV.4	-2.38**
	AVT.3 x Padma	-2.08**
	JLT.54 x JLSV.4	-1.55**
	AVT.3 x TC.25	-1.42**
Days to maturity	AVT.1 x TC. 25	-5.30**
	AVT.1 x JLSV.4	-3.44**
	AVT.3 x TC.25	-2.94**
	AVT.3 x Padma	-2.64**
	JLT.54 x JLSV.4	-1.70**
Plant height (cm)	PT.1 x JLSV. 4	14.93**
	JLT.54 x Hawari	14.10**
	Padma x TC.25	12.37**
	PT.1 x AVT.1	11.29**
	JLSV.4 x Hawari	11.08**
Branches plant^{-1}	JLT.54 x AVT.1	1.78**
	Padma x TC.25	1.70**
	JLSV.4 x Hawari	1.48**
	AVT.3 x AVT.1	1.14**
	JLT.54 x TC.25	1.06**
Internodes plant^{-1}	JLT.54 x Hawari	9.86**
	Padma x TC.25	1.96**
	PT.1 x JLSV. 4	1.71**
	Padma x JLSV.4	1.17**
	AVT.3 x JLSV.4	0.83**
Capsules plant^{-1}	JLT.54 x Hawari	28.66**
	JLSV.4 x Hawari	20.54**
	AVT.3 x PT.1	7.81**
	JLT.54 x TC.25	7.52**
	Padma x TC.25	7.51**
Capsule length (cm)	JLT.54 x Hawari	0.48**
	PT.1 x JLSV.1	0.34**
	PT.1 x AVT.1	0.33**
	Padma x JLSV.4	0.27**
	JLSV.4 x TC.25	0.26**
Seeds capsule^{-1}	JLT.54 x Hawari	8.74**
	PT.1 x JLSV.4	7.69**
	Padma x JLSV.4	7.13**
	PT.1 x AVT.1	6.29**
	Padma x JLT.54	2.90**
Oil content (%)	AVT.3 x Hawari	4.47**
	PT.1 x AVT.1	3.30**
	JLSV.4 x TC.25	3.11**
	AVT.1 x JLSV.4	2.13**
	PT.1 x JLT.54	1.87**
Seed yield plant^{-1}	JLT.54 x Hawari	7.52**
	PT.1 x JLSV.4	5.44**
	Padma x TC.25	2.64**
	PT.1 x Hawari	2.03**
	JLT.54 x AVT.1	0.85**

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

were having low GCA effects, suggesting epistatic interactions.

The estimates of genetic variance influences breeding methodologies. The simple progeny selection of breeding exploits additive genetic variance. For utilization of genetic variability of non-fixable nature, population improvement programmes such as biparental mating followed by recurrent selection are likely to result in better results. These procedures though difficult to follow in self-pollinated crops have great promise to give encouraging results.

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Integrated Weed Management in Upland Direct-Seeded Rice

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ABSTRACT

A field experiment was conducted to study the effect of integrated weed management in upland rice. Among the various weed management practices, two hand weeding at 20 and 40 days after sowing (DAS) and pre emergence application of Pendimethalin + 2, 4-D at 0.75 + 0.5 kg a. i, ha^{-1}, respectively + one hand weeding at 40 DAS were at par. These treatments significantly increased the growth yield attributes and yieid of rice, weed control efficiency and lower weed index after the weed free treatment. Similar trend was also noticed in case of economics of the different integrated weed-management practices.

Key words : Upland direct-seeded rice, weed management, hand weeding

Upland direct-seeded irrigated rice is now becoming more popular as an alternative to transplanted rice, as it is more remunerative if

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the crop is managed properly. Weed is one of the major constraints for low productivity of upland rice (Angiras, 2002), In upland direct-seeded rice, weeds pose serious competition to the crop in early stage and cause heavy reduction in rice yield. Uncontrolled weeds reduce the yield up to 80 per cent in direct-seeded upland rice (Suhbaiah *et al*., 2005). Weeds grow faster than the crop plants an thus absorbs the available nutrients earlier, resulting in lack of nutrient for growth of the crop plants. Thus, weed control facilitates higher absorption of applied nutrient by crop plant and increases the efficiency of fertilizer application to the crop (Amarjit *et al*., 2006), Since information on integrated weed-management in upland irrigated rice is mearge under this condition, thus, present investigation was undertaken to find out suitable economic weed control method in upland irrigated condition for direct-seeded rice.

MATERIALS AND METHODS

A field experiment was conducted under irrigated conditions at Agricultural Research Station, Karad during the kharif season of 2005, 2006 and 2007. The soil was medium-deep with pH 7.9 and organic carbon 0.45 per cent, available N 112.0 kg ha^{-1}, available P 13.5 kg ha^{-1} and available K 432.0 kg ha^{-1}. The experiment was laid out in randomized block design, replicated thrice. The treatments consist of three combinations of Anilofos, 2, 4-D and hand weeding and Pendimethalin, 2, 4-D and hand weeding and hand hoeing. The treatment details are T_1 - weedy check till maturity, T_2 - Hand weeding twice (20 and 40 DAS), T_3 - Anilofos (0.4 kg a. i. ha^{-1}) as pre-emergence, T_4 - Anilofos + 2, 4-D (0.3 + 0.5 kg a.i. ha^{-1}) as pre-emergence, T_5 - Anilofos (0.4 kg a.i ha^{-1})as pre-emergence + one hand weeding (40 DAS), T_6 - Anilofos + 2, 4-D (0.3 + 0.5 kg a.i ha^{-1}) as pre-emergence + 2, 4-D (0.5 kg a.i ha^{-1}) as post emergence (25 DAS), T_7 - Anilofos + 2, 4-D (0.3 + 0.5 kg a. i ha^{-1}) as pre-emergence + one hand weeding (40 DAS), T_8 - Peadimethalin (1.0 kg a. i ha^{-1}) as pre-emereencc, T_9 - Pendimethalin + 2, 4-D

Table 1. Growth, yield attributes and yield of rice as influenced by different treatments (pooled data).

Treatment	Plant height (cm)	Panicle length (cm)	Panicle $hill^{-1}$	Grain $panicle^{-1}$	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
1. Weedy check	81.13	8.37	77.00	39.27	19.54	51.89
2. HW at 20 & 40 DAS	98.47	9.63	90.67	45.73	39.61	77.36
3. A. F. (0.4 kg a. i ha-1) PE	88.47	8.43	81.33	40.67	24.96	59.41
4. A. F. + 2, 4D (0.4 + 0.5) PE	85.20	8.87	77.33	41.67	25.67	58.25
5. A. F. PE + HW at 40 DAS	94.40	9.13	82.67	41.00	29.00	62.50
6. A. F. + 2, 4D PE + 2, 4D POE	93.87	8.93	81.67	40.53	29.36	62.11
7. A.F. + 2, 4D PE + HW 40 DAS	91.67	8.93	83.33	40.13	31.52	66.16
8. PDMT (1.0 kg a. i ha-1) PE	92.07	9.13	81.33	42.60	28.91	61.73
9. PDMT + 2, 4D (1.0 + 0.5) PE	89.33	8.90	83.67	40.47	30.77	66.55
10. PDMT PE + HW 40 DAS	90.67	8.64	83.00	42.33	35.52	72.53
11. PDMT + 2, 4D PE + 2, 4D POE	91.27	8.87	84.67	42.20	34.71	71.57
12. PDMT + 2, 4D PE + HW 40 DAS	97.60	9.47	89.67	45.53	37.20	74.84
13. Weed free till maturity	98.60	9.77	90.67	48.93	48.05	84.48
14. Three HW 20, 40 & 60 DAS	93.33	8.57	84.67	43.00	29.58	61.15
S. E. ±	1.61	0.22	2.88	1.58	1.03	2.05
C. D. at 5%	4.67	NS	8.67	4.74	3.00	5.95

(1.0 + 0.5 kg a.i ha^{-1}) as pre-emergence, T_{10} - Pendimethalin (1.0 kg a.i. ha^{-1}) as pre-emergenee + one hand weeding (40 DAS), T_{11} - Pendimethalin + 2, 4-D (0.75 + 0.5 kg a.i ha^{-1}) pre-emergence + 2, 4-D (0.5 kg a. i ha^{-1}) as post emergence (25 DAS), T_{12} - Pendimethalin + 2, 4-D (0.75 + 0.5 kg a.i. ha^{-1}) as pre-emergence + one hand weeding (HW) (40 DAS), T_{13} - Weed free till matunry, T_{14} - Three hand hoeing (20, 40 and 60 DAS).

The seeds of rice variety "Basmati-370'" was sown in rows of 30 cm apart and 10 cm in between plant on 7th June 2005, 10th June 2006 and 12th June 2007 using seed rate of 100 kg ha^{-1}. The crop received a uniform dose of NPK ha^{-1} as per recommendation through urea, single super phosphate and murriate of potash. The nitrogen was applied in three split doses i.e, 40 per cent at sowing, 40 per cent at tillering and 20 per cent at flowering stage of rice. The dry weight of weeds were taken at harvest from each treatment plot. The weedicides were applied as per the treatment. Irrigation was given as per requirement during the crop period. The total rainfall received June to Sept. during the year 2005, 2006 2007 were 1175.9, 1094.6 and 1015.6 mm, respectively,

RESULTS AND DISCUSSION

Weed management practices had significant effect on growth and yield attributes of rice. Weed free treatment recorded the highest values of growth and yield attributes. Among the other weed management practices two hand weeding at 20 and 40 DAS recorded significantly higher growth and yield attributes followed by application of Pendimethalin + 2, 4-D (0.75 + 0.5 kg a. i ha^{-1}) as pre- emergence + one hand weeding at 40 DAS. This could be attributed to efficient control of weeds, which reduced the nutrient uptake by weed (Table 1) and resulted in better growth and yield attributes of rice crop, Severe weed infestation decreased the growth and yield attributes in weedy check.

Table 2. Weed control measures and economics of rice as influenced by different treatments (Pooled data).

Treatment	Weed control efficiency	Weed index	Total monetary returns (000 ha^{-1})	Net returns (000 ha^{-1})	B:C ratio
Weedy check	00.00	54.46	27.991	06.325	1.29
HW at 20 & 40 DAS	83.29	06.94	55.997	29.813	2.14
A. F. (0.4 kg a. i ha-1) PE	37.58	41.99	35.490	13.152	1.59
A. F. + 2, 4D (0.4 + 0.5) PE	33.79	40.17	36.436	13.962	1.62
A. F. PE + HW at 40 DAS	73.67	32.52	41.070	16.473	1.67
A. F. + 2, 4D PE + 2, 4D POE	54.81	31.38	41.596	16.725	1.67
A.F. + 2, 4D PE + HW 40 DAS	75.94	26.33	44.635	19.901	1.81
PDMT (1.0 kg a. i ha-1) PE	71.25	32.78	40.926	17.515	1.74
PDMT + 2, 4D (1.0 + 0.5) PE	75.47	28.65	43.586	20.026	1.85
PDMT PE + HW 40 DAS	83.03	17.68	49.851	24.181	1.94
PDMT + 2, 4D PE + 2, 4D POE	83.18	18.85	47.553	25.430	2.00
PDMT + 2, 4D PE + HW 40 DAS	83.26	12.68	52.664	26.857	2.04
Weed free till maturity	100.00	00.00	60.413	29.711	1.97
Three HW 20, 40 & 60 DAS	71.13	31.57	41.325	18.906	1.85
S. E.±	6.29	2.81	1.42	-	0.07
C. D. at 5%	18.28	8.17	4.13	-	0.20

All the weed management treatments significantly increased the grain and straw yield compared to weedy check. The pronounced effect of increase in grain and straw yield by crop was observed with two hand weeding at 20 and 40 DAS and application of Pendimethalin + 2, 4-D (0.75 +0.5 kg a. i. ha^{-1}) as pre-emergence + one hand weeding at 40 DAS after weed free treatment and were found at par with each other, but significantly superior to rest of the treatments. The increase in yields under these treatments may be attributed to significant reduction in weed index.

The hand weeding at 20 and 40 DAS proved to be most effective in reducing weed index, increasing total and net monetary returns and benefit-cost ratio, followed by pre-emergence application of Pendimethalin + 2, 4-D (0.75 + 0.5 kg a. i. ha^{-1}) + one hand weeding at 40 DAS. Plot receiving two hand weeding recorded the highest net returns (Rs-25,086/-) and benefit-cost ratio (1.96), The effective control of weeds under these treatment resulted in higher weed control efficiency, lower weed index and higher B:C ratio. Similar findings were reported by Choubey *et al.*, (1999) and Singh *et al.*, (2005). Weedy check recorded the highest weed index and lower weed control efficiency owing to their greater competitive ability resulted in lower yield under weedy check condition.

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Assessment of Different Cropping Sequences in Relation to Time of Sowing and Planting Techniques for Western Maharashtra

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ABSTRACT

The soybean - wheat cropping sequence recorded significantly maximum pearlmillet equivalent per hectare yield (100.16 q), gross monetary returns (Rs. 66,665), net monetary returns (Rs. 45,930) than pearmillet - wheat and soybean - rabi sorghum cropping seauences. However, maximum B:C ratio (3.30) was observed with soybean - *rabi* sorghum cropping sequence. The maximum sustainable value index (0.56) was recorded by the soybean - wheat cropping sequence. The soybean wheat cropping sequence recorded numerically maximum energy input value (33540). However, energy output (204013), energy balance (170474), energy balance per unit input (5.09) and energy input output ratio (6.09) were significantly higher with pearlmilet - wheat cropping sequence. As regards to sowing time the normal sowing dale recorded significantly higher pearlmillet equivalent yield (98.10 q ha^{-1}), monetary returns, sustainable value index (0.59) and energy assessment values as compared to early and late sowing dates. Among planting techniques conventional planting techniques proved its superiority over alternate row skipped planting and one row skipped after every two rows planting by recording significantly higher values in respect of pearlmillet equivalent (91.23 q ha^{-1}), monetary returns and maximum sustainable value index (0.49), however, maximum B : C ratio (3.19) was recorded by alternate row skipped planting technique. Similarly, conventional planting technique recorded significantly higher values of all energy parameters as compared to rest of the planting techniques.

Key words : Sowing dates, cropping sequences, planting techniques, monetary returns, sustainable value index and energy.

Cropping systems with suitable grain legume, fodder, oilseed, vegetable and other high value and remunerating crops in proper sequence give high crop productivity and economic returns. A proper sequence of cropping with fertility improvement and exhaustive crops and shallow and deep rooted crops helps to maintain the soil fertility and productivity at high level. Double cropping or multiple cropping have become popular among the farmers in both rainfed as well as irrigated areas. Soybean-*rabi* sorghum wheat and pearl millet-wheat are the most prominent cropping systems adopted on considerable areas of Western Maharashtra. Sowing time is one of the most important non monetary inputs affecting yield of crops. Even in photo and thermo-insensitive crop it is a critical input for higher yield. Besides time of sowing, planting methods/techniques or change of crop geometry is another non cash input for enhancing the productivity of crops. The efficiency of agricultural producer depends not only on maximum utilization of natural resources but also development of suitable cropping system. Change of crop geometry is one of the new concept for increasing the efficiency of utilization of natural resources and to increase the production of crops. In view of this the experiment was conducted to study the effect of sowing dates and planting methods on production potential of different crop sequences.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* and *rabi* seasons of 2002-2003 and 2003-2004 on clayey soil having 0.49 per cent organic carbon and electrical conductivity 0.239 dSm^{-1}. It was moderately alkaline in reaction (pH 8.2), the soil was low in available nitrogen (171 kg ha^{-1}), medium in available phosphorus (20.37 kg ha^{-1}) and high in available potassium (425 kg ha^{-1}). The experiment was laid out in a split plot design, replicated thrice. The treatments consisted of three sowing dates and three cropping sequences as a main plot treatments. The sowing dates were early sowing date (pearl millet and soybean - 23rd MW, *rabi* sorghum 39th MW and for wheat 44th MW), the normal sowing date (pearl millet and soybean - 25th MW, *rabi*-sorghum 41st MW and wheat 46th MW) and late sowing dates (pearl millet and soybean - 27th MW, *rabi*-sorghum 43rd MW and wheat 48th MW) and three cropping sequences (soybean - *rabi* sorghum, pearl millet - wheat and soybean - wheat) whereas three planting techniques were, conventional planting (soybean 30 x 10 cm, pearl millet and *rabi*-sorghum 45 x 15 cm and wheat 22.5 cm), Alternate row skipped planting (soybean 60 x 5 cm, pearl millet and *rabi*-sorghum 90 x 7.5 cm and wheat 45.0 cm) and one row skipped after every two rows planting (soybean 30-60 x 7.5 cm, pearl millet and *rabi* sorghum 45-90 x 10 cm and wheat 22.5-45 cm) as a sub plot treatments. The gross and net plot sizes were 4.50 x 3.60 m and 3.90 x 2.70 m, respectively. The cultivars used were soybean (JS-335), pearl millet (Shradha), *rabi*-sorghum (Phule Yashoda) and wheat (HD-2189). The fertilizers were applied as per the targeted yield concept in the form of urea, single super phosphate and muriate of potash each plot. The targeted yield for soybean, pearl millet, *rabi*-sorghum and wheat were 25,30,35 and 35q ha^{-1}, respectively. The economics of the cropping sequences were worked out to assess the production potential of different crop sequences. The gross and net returns, and cost of cultivation for individual crop and sequence were calculated on the basis of prevailing market rate of produce and inputs. For computation of productivity of different cropping systems pearlmillet equivalent yield was calculated on the basis of prevailing market prices. The sustainable value index was determined as per the standard method. While energy balance was calculated by using input and output energy values given by the Varma *et al*., (1994).

RESULTS AND DISCUSSION

Productivity :

Pearlmillet equivalent yield of system :

Sowing date : Data presented in Table 2 revealed that the normal sowing date registered significantly higher pearl millet equivalent yield than late sowing date during both the years and on pooled mean basis. However, it was at par with early sowing date on pooled mean basis. Significantly least pearlmillet equivalent yield of system was rest with late sowing date. The magnitude of increase in pearlmillet equivalent yield of system due to normal sowing date over early and late sowing date was 5.96 and 30.52 per cent, respectively on pooled mean basis.

Cropping sequence : The soybean-wheat cropping sequence registered significantly higher pearlmillet equivalent yield as compared to soybean-*rabi* sorghum and pearlmillet - wheat cropping sequence. Whereas, it was significantly lowest due to pearlmillet wheat cropping sequence during both the years and on pooled mean basis. The magnitude of increase in pearlmillet equivalent yield due to soybean-wheat cropping sequence over soybean-*rabi* sorghum and pearlmillet - wheat cropping sequences were 13.42 and 28.48 per cent, respectively on pooled mean basis.

Planting techniques : The conventional planting technique recorded maximum and significantly higher pearlmillet equivalent yield than alternate row skipped and one row skipped after every two rows planting techniques during both the years and on pooled mean basis. The magnitude of increase in pearlmillet equivalent yield due to conventional planting technique over alternate row skipped and one row skipped after every two rows planting techniques were 7.54 and 9.1 1 per cent, respectively. This might be due to higher grain yield and market rates of soybean and wheat crops as compared to pearlmillet and *rabi* sorghum crops during both the years. These results are in conformity to the findings of Kumar and Prasad (1999).

Monetary evaluation : Sowing dates : The gross and net monetary returns and B:C ratio of different sowing dates indicated that the net monetary returns (Rs. 48243 ha^{-1}) and B:C ratio (3.50) were at higher magnitude when crops were sown at normal sowing date followed by early sowing date (Rs. 44564 ha^{-1}) with B:C ratio (3.69) on pooled mean basis. This has clearly brought out that the sowing at proper time has an added advantage to enhance the accrued net monetary returns. Further, it was noticed that delayed sowing of *kharif* and *rabi* crops decreased significantly net returns (Rs. 27635 ha^{-1}) with B:C ratio (2.44) as compared to early and late sowing dates. These findings are substantiated by the findings of Dhoble *et al.*, (1990), Bhoite and Nimbalkar (1997) and Chavan *et al.*, (1998).

Cropping sequences : The soybean based cropping sequences *viz.*, soybean-*rabi* sorghum and soybean-wheat was found superior in respect of monetary benefit than pearlmillet-wheat cropping sequences during

Table 1. Pooled mean grain and straw yield (q ha^{-1}) of different crops as influenced by sowing dates, cropping sequences and planting techniques.

Treatment	Soybean		Pearlmillet		*Rabi* sorghum		Wheat	
	Grain	Straw	Grain	Fodder	Grain	Fodder	Grain	Straw
Sowing date :								
Early	28.47	31.35	30.12	55.10	30.96	75.18	34.67	43.47
Normal	29.27	34.63	31.47	56.50	32.94	75.42	36.96	51.24
Late	20.45	20.16	25.56	39.20	16.71	52.40	28.17	32.45
S. E.±	1.82	1.30	1.05	3.22	0.24	3.40	0.35	2.59
C. D. at 5%	4.55	3.93	2.63	9.56	0.61	10.24	1.11	7.83
Cropping sequences :								
Soybean-*rabi* sorghum	26.16	27.76	-	-	-	-	-	-
Pearlmillet-wheat	-	-	-	-	-	-	32.79	40.60
Soybean-wheat	27.27	29.66	-	-	-	-	33.75	44.18
S. E.±	0.47	0.94	-	-	-	-	0.28	1.50
C. D. at 5%	NS	NS	-	-	-	-	0.84	NS
Planting techniques :								
Conventional	27.88	30.84	32.06	54.52	28.43	73.73	34.82	44.62
Alternate row skipped	25.90	28.08	27.86	48.56	26.54	65.25	32.67	41.26
One row skipped after every two rows	25.41	27.22	27.24	47.71	25.64	64.53	32.32	41.29
S. E.±	0.32	0.77	1.06	2.20	0.32	3.14	0.33	0.56
C. D. at 5%	0.91	2.31	3.45	5.06	0.67	NS	0.94	1.60

All interactions : Non significant

both the years. Among the cropping sequences soybean-wheat cropping sequence registered significantly maximum net returns (Rs. 45930 ha^{-1}) than pearlmillet-wheat cropping sequence (Rs. 31088 ha^{-1}). Soybean-*rabi* sorghum was second in order. However, significantly higher B:C ratio (3.30) was registered by soybean-*rabi* sorghum cropping sequence than soybean-wheat and pearlmillet-wheat cropping sequence. This might be due to low cost of production as compared to soybean-wheat cropping sequence. The soybean-wheat cropping sequence was most remunerative crop sequence produced maximum economical yield than soybean-*rabi* sorghum and pearlmillet-wheat cropping sequence which ultimately reflected on monetary returns. These results are in agreement with those reported by Gaikwad *et al*., (1998), Raskar *et al*., (2000) and Halwankar *et al*., (2005).

Planting techniques : Among the planting techniques conventional planting technique registered significantly higher gross

Table 2. Pearl millet equivalent yield (q ha^{-1}), mean gross monetary returns, cost of cultivation, net monetary returns, B:C ratio and sustainable value index as influenced by different treatments (pooled mean).

Treatment		Perlmillet equivalent yield of system	Gross monetary returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio	SVI
A. Sowing dates (Main) :							
Early		92.25	63622	19059	44564	3.36	0.53
Normal		98.10	64603	19361	48243	3.50	0.59
Late		68.16	46880	19245	27635	2.44	0.26
S. E.±		2.64	1776	-	1836	0.14	-
C. D. at 5%		8.02	5328	-	5510	0.43	-
B. Cropping sequences (Main) :							
Soybean-*rabi* sorghum		86.72	62436	19013	43423	3.30	0.50
Perlmillet wheat		71.63	49002	17916	31088	2.77	0.32
Soybean-wheat		100.16	66665	20735	45930	3.24	0.56
S. E.±		2.17	1391	-	1118	0.06	-
C. D. at 5%		7.11	4175	-	3356	0.19	-
C. Planting techniques (Sub) :							
Conventional		91.23	62919	21015	41904	3.01	0.49
Alternate row skipped		84.35	58078	18202	39875	3.19	0.46
One row skipped after every two rows		82.92	57108	18447	38662	3.10	0.44
S. E.±		0.74	385	-	906	0.04	-
C. D. at 5%		2.12	1088	-	2707	0.13	-
D. Interaction :							
A x B	S. E.±	2.67	559	-	559	0.05	-
	C. D. at 5%	NS	1566	-	1566	NS	-
A x C	S. E.±	1.36	969	-	969	0.06	-
	C. D. at 5%	NS	NS	-	NS	NS	-
B x C	S. E.±	1.36	969	-	969	0.06	-
	C. D. at 5%	NS	NS	-	NS	NS	-
A x B x C	S. E.±	1.47	994	-	994	0.06	-
	C. D. at 5%	NS	NS	-	NS	NS	-

and net monetary returns (Rs. 62919 ha^{-1} and Rs. 41904 ha^{-1}) than alternate row skipped (Rs. 58078 and Rs. 39875 ha^{-1}) and one row skipped after every two rows (Rs. 57108 and Rs. 38662 ha^{-1}) planting techniques on pooled mean basis. Significantly higher, B:C ratio was obtained with alternate row skipped planting technique (3.19) followed by one row skipped after every two rows planting technique (3.10) and least with conventional planting technique (3.01) on pooled mean basis. This might be due to higher grain and straw yield, whereas, lower B:C ratio might be due to higher cost of production as compared to skipped row planting techniques. Thus, conventional planting technique was more remunerative than rest of the skipped row planting techniques. However, both the skipped rows planting techniques were more cost effective due to lower cost of cultivation. These results are in close agreement with those findings of Dubey (1998) and Pandey *et al*., (1999).

Sustainable value index :

Sowing dates : The maximum sustainable value index was recorded by normal sowing date (0.59) followed by early sowing date (0.53) and minimum sustainable value index was observed with late sowing date (0.26).

Cropping sequences : The maximum sustainable value index was observed with soybean - wheat cropping sequence (0.56) followed by soybean - *rabi* sorghum crop sequence (0.50), while it was minimum in respect of pearl millet - wheat (0.32).

Planting techniques : The conventional planting technique recorded maximum sustainable value index (0.49) followed by alternate row skipped planting technique (0.46). The maximum sustainable values index

Table 3. System energy (MJ ha^{-1}) as influenced by different treatments. (Pooled mean)

Treatment	Energy input (MJ ha^{-1})	Energy output (MJ ha^{-1})	Energy balance (MJ ha^{-1})	Energy balance per unit input	Energy input output ratio
A. Sowing dates (Main) :					
Early (44 MW)	33687	208245	174558	5.20	6.20
Normal (46 (MW)	33618	224051	190433	5.68	6.68
Late (48 MW)	33616	150214	116598	3.49	4.48
S. E.±	-	2807	2839	0.10	0.095
C. D. at 5%	-	17067	17265	0.33	0.32
B. Cropping sequences (Main) :					
Soybean-*rabi* sorghum	32661	197447	164786	5.04	6.05
Perlmillet-wheat	33540	204013	170474	5.09	6.09
Soybean-wheat	34720	181050	146330	4.22	5.22
S. E.±	-	5426	5646	0.20	0.20
C. D. at 5%	-	16281	16941	0.64	0.63
C. Planting techniques (Sub) :					
Conventional	33679	207248	173569	5.17	6.16
Alternate row skipped	33613	189006	155394	4.64	5.64
One row skipped after every two rows	33619	186255	152627	4.55	5.55
S. E.±	-	4001	3999	0.12	0.12
C. D. at 5%	-	12004	11998	0.39	0.39
D. Interation : N.S.					

recorded in normal sowing date, soybean - wheat cropping sequence and conventional planting technique were might be due to higher and sustainable monetary returns compared to other treatments.

Energy relationship :

Sowing date : Energy output, energy balance, energy balance per unit input and energy output input ratio were significantly increased with normal sowing date than early and late sowing dates during both the years and on pooled mean basis. The maximum decreases in these indices were noticed in late sowing date. This could be assigned to decrease in grain and straw yield of *kharif* crops *viz*., soybean and pearlmillet and *rabi* crops *viz*., *rabi* sorghum and wheat with delayed sowing (Table 3).

Cropping sequences : Energy output, energy balance, energy balance per unit input and energy output input ratio were increased in pearlrnillet-wheat cropping sequence as compared to soybean-*rabi* sorghum and soybean-wheat cropping sequence. This might be due to the fact that soybean-wheat cropping sequence required comparatively more energy input than pearlmillet-wheat and soybean-*rabi* sorghum cropping sequence. This could be assigned to higher biomass production in pearlmillet-wheat cropping sequence which is directly proportional to energy production.

Billore *et al*., (1994) stated that cereal produces more tonnage than legumes. Soybean-wheat sequence was the most energy intensive crop sequence. These differences might be due to differences in yield levels, prices of output and energy inputs.

Planting techniques : Energy output, energy balance and energy output input ratio were significantly higher with conventional planting technique as compared to both the skipped rows (viz., alternate row skipped and one row skipped after every two rows) planting techniques during both the years and on pooled mean basis. This might be due to higher biomass production with conventional planting technique as compared to rest of the skipped rows planting techniques.

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Micropropagation in Gladiolus (*Gladiolus grandiflorus* L.) var. White Friendship

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ABSTRACT

In gladiolus cv. White Friendship, axillary buds showed best establishment and proliferation than leaf tissues and nodal explants. Surface sterilization of explants with 70 per cent ethyl alcohol dipping followed by 0.2 per cent $HgCl_2$ for 7 minutes gave maximum established and maximum number of proliferating cultures. Maximum establishment of axillary buds of gladiolus cv. While Friendship was observed on MS medium supplemented with 3.0 mg l^{-1} BAP (76.66%) with significantly minimum days of reporting maximum proliferation and axillary bud production. MS medium of half strength supplemented with 1.0 mg l^{-1} IBA and 3.0 gl^{-1} activated charcoal (A.C.) gave maximum number of roots (8.75) and growth of roots in terms of length. While thickness of root was better on half strength MS medium supplemented with 1.0 mg l^{-1} NAA.

Key words : Micropropagation, gladiolus, *in vitro*, MS medium.

Gladiolus, the queen of the bulbous flowers is grown in many parts of the world. It is used as cut flower as well as for garden display purpose and is gaining popularity because of its beauty and vase life. It is commonly propagated by cormels or corms. But this clonal propagation is very slow and it lakes 8-10 years to produce a clone which is large enough for commercial purpose.

Micropropagation or *in vitro* propagation has strong regenerative potential of individual cells and tissues to produce numerous true to type plants from a single parent plant. Considering the importance of micropropagation of gladiolus the present investigation was undertaken to find out suitable methodology for clonal multiplication of gladiolus by micropropagation means for cv. White Friendship.

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MATERIALS AND METHODS

The present investigation was conducted in the tissue culture laboratory of the Plant Biotechnology Unit, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, (Maharashtra) India, during the year 2006-07. The experimental material comprised of gladiolus cv. White Friendship. Corms and cormels of this variety were obtained from Fla Pvt. Ltd. Pune. Axillary buds, leaf tissues and nodal segments were used as explants. These explants were washed under running water for 15 minutes and then cut with sterilized scalpel into leaf tissues, nodal segments and axillary buds. Sterilization of explants was carried out by dipping in 70 per cent alcohol for 30 sec. and then treated with $HgCl_2$ (0.1-0.3%) aqueous solution for 3, 5, 7 and 9 minutes and washed with sterile DDW for 4-5 times. Then these explants were inoculated on MS (Murashige and Skoog) medium supplemented with different combinations of auxins and cytokines to identify the appropriate media combinations for regeneration of gladiolus. All operations like surface sterilization, their dissection and inoculation etc. were carried out under the Laminar Air Flow Bench (LAF). MS media were consisted of 3 per cent sucrose, 0.8 per cent agar, pH was adjusted to 5.8 and autoclaved at 121°C temperature and 15 lb/inch^2 pressure for 25 to 30 minutes. The inoculated container were kept in the incubation chamber where temperature ranged between 27 ± 2° C and relative humidity around 70 per cent. The experiments were replicated for three times and the means and standard errors of the results were calculated.

RESULTS AND DISCUSSION

In this experiments, explants like axillary buds, leaf tissues and nodal segments were used and MS medium supplemented with different concentration and combination of auxins and cytokinins were used which is given in Table 1. Out of three explants axillary buds showed best establishment and proliferation cultures while other two did not show any response. Hussey (1977b) used axillary buds from corms of gladiolus plants. Sutter (1986) reported the growth response of axillary buds cultured on different media. Hussain *et al.*, (1995) used axillary buds from cv. While Friendship while Amrapali (2001) used axillary buds during *in vitro* multiplication studies in gladiolus cvs. White Friendship and Fidelio.

The results obtained from effect of culture media on culture establishment showed that MS basal medium supplemented with 3 mgl^{-1} of BAP was the best media combination for culturing axillary buds of gladiolus (76.66%) through tissue culture. Hussey (1977 a) obtained highest growth rate of cv. Forest Fire on 0.12 mgl^{-1} BAP. Elviro and hybrid 48812 grew best on 0.5 mgl^{-1} BAP. Dantu and Bhojwani (1995) obtained best elongation of shoot culture, initiated from axillary buds on liquid MS medium containing 0.5 mgl^{-1} in cv. White Friendship. Misra and Singh (1998) reported establishment of MS medium supplemented with 3 mgl^{-1} BAP in cv. American Beauty. Amarapali (2001) obtained 100 per cent culture establishment of explants on media MS + BAP 0.5 mgl^{-1}, MS + BAP 1.0 mgl^{-1}, MS + BAP 2.0 mgl-1 and MS + BAP 3.0mgl^{-1}.

Table 1. Effect of different media combination on establishment and proliferation of cultures.

Media combination	Per cent cultures established	Per cent of proliferate cultures
MS + 0.5 mgl^{-1} BAP	14.33 (22.24)	27.50 (31.39)
MS + 1.0 mgl^{-1} BAP	20.00 (26.55)	30.00 (32.83)
MS + 0.5 mgl^{-1} KIN	18.88 (25.75)	27.50 (31.39)
MS + 0.1 mgl^{-1} KIN	18.55 (25.51)	25.00 (29.89)
MS + 0.5 mgl^{-1} NAA	16.77 (24.80)	27.50 (31.39)
MS + 1.0 mgl^{-1} NAA	23.66 (29.10)	30.00 (33.05)
MS + 2.0 mgl^{-1} KIN + 1.0 mgl^{-1} NAA	53.33 (47.00)	40.00 (42.05)
MS + 4.0 mgl^{-1} BAP + 0.5 mgl^{-1} NAA	52.22 (46.27)	35.00 (31.02)
MS + 2.0 mgl^{-1} BAP	65.55 (54.09)	55.00 (46.50)
MS + 3.0 mgl^{-1} BAP	76.66 (61.410)	57.50 (53.99)
MS + 2.0 mgl^{-1} KIN	54.44 (47.60)	52.50 (44.78)
MS + 3.0 mgl^{-1} KIN	56.67 (48.84)	55.46 (44.00)
MS + 0.1 mgl^{-1} NAA + 2.0 mgl^{-1} BAP	69.99 (57.01)	47.50 (42.12)
MS + 0.1 mgl^{-1} NAA + 3.0 mgl^{-1} BAP	72.22 (58.81)	50.00 (49.61)
MS + 0.2 mgl^{-1} NAA + 2.0 mgl^{-1} BAP	51.11 (45.63)	45.00 (36.00)
MS + 0.2 mgl^{-1} NAA + 3.0 mgl^{-1} BAP	45.55 (42.43)	55.00 (47.94)
MS + 0.2 mgl^{-1} + KIN + 8.0 mgl^{-1} BAP + 2.0 mgl^{-1} GA_3	67.76 (55.63)	45.00 (42.05)
S. E.±	2.81	3.97
C. D. at 5%	8.10	11.47

(Values in parenthesis indicates are sine values)

Per cent proliferating cultures was maximum on MS medium supplemented with 3.0 mgl^{-1} BAP (76.6%) and was at par with MS

Table. 2. Effect of culture media on production of number of roots.

Media combination	No. of roots
MS + 0.5 mgl^{-1} NAA	0.00
MS + 1.0 mgl^{-1} NAA	1.50
MS + 0.5 mgl^{-1} IBA	0.00
MS + 0.1 mgl^{-1} IBA	1.75
1/2 MS + 0.5 mgl^{-1} NAA	0.00
1/2 MS + 0.5 mgl^{-1} NAA + 3.0 gl^{-1} A.C.	0.00
1/2 MS + 0.1 mgl^{-1} NAA	4.50
1/2 MS + 1.0 mgl^{-1} NAA + 3.0 gl^{-1} A.C.	3.25
1/2 MS + 0.5 mgl^{-1} IBA	1.75
1/2 MS + 0.5 mgl^{-1} IBA + 3.0 gl^{-1} A.C.	2.00
1/2 MS + 1.0 mgl^{-1} IBA	2.75
1/2 MS + 1.0 mgl^{-1} IBA + 3.0 gl^{-1} A.C.	8.75
S. E.±	0.35
C. D. at 5%	0.99

+ 0.2 mgl-1 NAA + 3.0 mgl^{-1} KIN (45.55%), MS + 3.0 mgl^{-1} KIN (56.66%), MS + 2 mgl^{-1} BAP (65.55%), MS + 2.0 mgl^{-1} KIN (54.44%), MS + 0.1 mgl^{-1} NAA + 3.0 mgl^{-1} BAP (72.22%) and MS + 0.1 mgl^{-1} NAA + 2.0 mg l^{-1} BAP (69.99%) and MS +0.1 mgl^{-1} NAA + 3 mgl^{-1} BAP (72.22%). Gupta and Sehgal (1997) obtained similar results when gladiolus hybrids varieties were cultured on MS medium supplemented with 3.0 mgl^{-1} BAP for proliferation of cultures. Rao *et al*., (1991) used 4.0 mgl^{-1} BAP for proliferation of cv. Kinneret. Amrapali (2001) recorded maximum number of shoots on MS basal medium supplemented with 2.0 mgl^{-1} BAP in cvs. White Friendship and Fidelio.

The experimental results given in Table 2 showed that, MS medium of full strength and half strength supplimented with different concentrations of NAA and BAP with or without charcoal, the production of maximum number of roots was on half strength MS medium (1/2 MS) supplemented with 1.0 mg l^{-1} IBA and 3.0 mgl^{-1} A.C. (8.75) followed by 1/2 MS + 1.0 mgl^{-1} NAA (4.50) and 1/2 MS + 1.0 mgl^{-1} NAA + 3.0 mgl^{-1} A.C. (3.25). Similar results were obtained by Beura and Singh (2006).

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In vitro Multiplication of Elite Cultivars of Banana through Shoot-Tip Culture

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ABSTRACT

Shoot-tip cultures of banana cultivars was induced by culturing small excised shoot-tip on modified MS semisolid medium with various concentrations and combinations of auxins, and cytokinins. Protocols were standardized for *in vitro* propagation and large scale multiplication of five elite local cultivars *viz*., Safed Velchi, Lal Velchi, Rasable, Savarbond and Lokhandi. Amongst different surface sterilizing treatments, the use of 0.1 per cent $HgCl_2$ for 4 minutes was better. The most suitable media for different genotypes were MSB + 5.5 mgl^{-1} + 60 mgl^{-1} Ads for Basrai, MSB + 6 mgl^{-1} + 60 mgl^{-1} Ads for Grand Naine and Shrimanti, MSB + 6.5 mgl^{-1} + 80 mgl^{-1} Ads for Lokhandi, Rasabale and Savarbond and MSB + 7 mgl^{-1} + 80 mgl^{-1} Ads for Safed Velchi and Lal Velchi.

Key words: MS medium, morphogenesis, *In vitro*, organogenesis.

The propagation of various cultivars of banana by conventional methods are laborious and time consuming as far as the production of large number of homogenous plants is concerned. Banana is conventionally propagated by suckers and as there is limitation of individual plant for the production of productive suckers (2-3), the rate of propagation of banana by conventional methods is rather slow. Therefore, attention has been turned towards *in vitro* techniques for rapid clonal micropropagation of banana in some cultivars (Doreswamy *et al*., 1983, Cronauer and Krikorian, 1984). However, protocols have been developed for large scale multiplication of some commercial varieties and research on clonal propagation of elite banana genotypes through tissue culture is rather scanty. It is highly desirable to define the procedure for fast rate of propagation *in vitro*.

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MATERIALS AND METHODS

The present investigation was undertaken at Plant Biotechnology Unit., College of Agriculture, Dapoli, Dist. Ratnagiri with five different genotypes of banana *viz*.. Lal Velchi, Lokhandi, Rasbale, Savarbond and Safed Velchi utilized as the source material for obtaining shoot-tips. These varieties are different genotypes and as such they are genotypically different. Small sword suckers were carefully removed from field. The plant material obtained from the field was thoroughly washed in running tap water followed by washing with Teepol solution (0.5%) so as to remove adhering dust particles. Outer leaves, leaf bases and corm tissues were trimmed away using stainless steel knife until the length of explants were of about 4-6 cms and diameter at leaf base was 2 to 4 cms. The more or less cubical pieces of tissues enclosing the shoot tip and leaf primordial of banana were soaked in Bavistin (500 mgl^{-1}) solution overnight. After trimming one more outer layer of leaf bases they were soaked in 500 mg lit^{-1} Centrimide solution prepared in DDW for 30 minutes. The shoot-tips were surface sterilized using 0.1 per cent $HgCl_2$ for 4 min and 70 per cent alcohol for 30 sec. All traces of $HgCl_2$ were removed by washing several times with sterilized water and inoculated after dissection (5mm) into culture tubes. Murashige and Skoog (1962) medium supplemented with Benzyl adenine (BA). Indole Butyric Acid (IBA), Naphthalene acetic acid (NAA) and Adenine sulphate (Ads) in various concentrations, sucrose (3%) and jelled with agar (0.8%) was used as basal medium. The pH of the medium was adjusted to 5.8. Cultures were incubated at 27 $\pm$ 2°C temperature under constant light of 1600 Lux and 60 per cent relative humidity for establishment and subsequent 2 subculture cycles where each cycle consisted 3 weeks.

RESULTS AND DISCUSSION

The media combination which was used played significant role in success of tissue culture work as it determines the growth of culture. In present study MS medium (Table 1) supplemented with 6.5 mgl^{-1} BA + 80 mgl^{-1} Ads gave highest shoot establishment (70.69 %) followed by MS medium supplemented with 7 mgl^{-1} BA + 80 mgl^{-1} Ads (64.82%). But there were marked differences among the genotypes and different culture media combinations studied for culture establishment and morphogenetic response.

The maximum shoot development was observed for genotype Savarbond (21 .0) by using medium MSB + 6.5 mgl^{-1} BA + 80 mg l^{-1} Ads followed by genotypes Lal Velchi (14.33) and Safed Velchi (13.00) in the medium MSB + 7 mgl^{-1} BA + 80 mgl^{-1} Ads However, MSB + 6.5 mgl^{-1} BA + 80 mg Ads was better medium for maximum shoot formation in Lokhandi and Rasbale at the end of 7th subculture. From the Table 2 it is evident that, the shoot multiplication rate in first 2 to 3 culture cycles was slow showing initial lag phase but later on the medium which had profound effect of multiple shoot production could produce higher number of shoots per subculture at the end of 7th culture cycle. The probable reason might be that the individual cultivar has responded differently to the media as well as plant growth regulator (auxins and cytokinins) combinations as reported earlier by Damasco and Barba,(1985), Banerjee and De Langhe (l985), Lameira *et al.*, (1990) and Dhumale *et al.*, (1997).

Table 1. Media composition used for *in vitro* studies.

Treatment details	Per cent shoot stablish-ment
M_1 : MSB + 5 mgl^{-1} BA + 60 mgl^{-1} Ads + 30 gl^{-1} sucrose	51.22
M_2 : MSB + 5.5 mgl^{-1} BA + 60 mgl^{-1} Ads + 30 gl^{-1} sucrose	58.38
M_3 : MSB + 6.0 mgl^{-1} BA + 60 mg Ads + 30 gl^{-1} sucrose	60.57
M_4 : MSB + 6.5 mgl^{-1} BA + 80 mgl^{-1} Ads + 30 gl^{-1} scurose	70.69
M_5 : MSB + 7 mgl^{-1} BA + 80 mgl^{-1} Ads + 30 gl^{-1} sucrose	64.82

Table 2. Proliferation rates of the banana cultivars studies *in vitro* in different subcultures.

Geno-type	Number of shoots per explants		
	1st subculture	4th subculture	7th subculture
Lal Velchi	3.00	8.33	14.33
Lokhandi	3.33	8.66	11.66
Rasbale	3.00	8.66	12.66
Savarbond	4.00	15.00	21.00
Safed velchi	3.66	9.66	13.00

Rooting involves the regeneration of adventitious roots from the shoot obtained *in vitro*. MS medium supplemented with NAA (1

mgl^{-1}) was better with respect to initiation of roots in all the genotypes. These findings are similar to those obtained by Cronauer and Krikorian (1984), Babylatha *et al*., (1997) and Buah *et al*., (1998).

The rooted plantlets were removed from culture vessels and then transferred to pot filled with cocopit. All the cultivars had satisfactorily given 90 to 95 per cent pot culture survival. It appears that, in banana, the root induction was not a problem. The adventitious root system induced *in vitro* is quite suitable for the pot culture establishment of banana plantlets.

From the present investigation it could be concluded that, it was possible to establish shoot-tip culture of all the five local genotypes from small size explants (5mm) obtained from sword suckers of banana. This will serve as important guideline for large-scale multiplication of elite local genotypes. The most remarkable advantage of the present study is that it will help to conserve valuable genotypes.

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Variability Studies for Weight of Callus in Finger Millet (*Eleusine coracana* (L.))

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ABSTRACT

Highest callus weight with mature embryo axes explant was observed in MS media supplemented with 2 mgl^{-1} 2, 4-D (126.68 mg). Mean values for callus weight ranged from 52.10 to 101.57 mg. In epicoty explant callus weight was ranged from 43.84 to 60.49 mg. In case MS + 2 mgl^{-1} 2, 4-D reported maximum (91.99 mg) callus weight. When mature embryo axes explant inoculated in B_5 media enriched with 2 mgl^{-1} 2, 4-D recorded maximum (85.25 mg) callus weight. In genotype and explant interaction in mature embryo axes highest (78.06 mg) callus weight was observed in genotype IVT 10 while, genotype and media interaction, recorded highest callus weight (91.69 mg), by IVT 10 in MS media. In genotype explant and media interaction, the highest callus weight (114.01 mg) was recorded by IVT 10 in MS media while the least was recorded by the genotype GOA 8/1 revealing the genotypic differences for weight of callus per explant.

Key words : Finger millet, variability, callus weight.

Finger millet is highly self pollinated, cliestogamous plant having tiny florets. densely present on inflorescence and anthesis takes place during midnight. This restricts the use of genotypic variation present in the base population only, hence, number of superior genes present in different genotypes could not be brought together in one genotype through traditional breeding methods. Hence, only the possibility to get rid over this is to adopt biotechnological tools for crop improvement in finger millet for yield in general and nutritional characters in particular. Highest weight of callus having more number of cells which is useful for regeneration of more number of plantlets.

An implication of somaclonal variation in breeding is that novel variants can arise and these can be of agronomic use. The plants regenerated from callus cultures show heritable variations for both qualitative and quantitative traits. Somaclonal variation may be profitably used in crop improvement since it reduces the time required for release of new variety. It also acts as a continuous reservoir of genetic variability in crop production, thereby making selection in the population easier for further improvement.

The presence of variability for callus induction and plantlet regeneration offers a great scope for creating somaclonal variation which may be utilized for improving varieties of finger millet.

MATERIALS AND METHODS

Callus induction and *in vitro* regeneration was tried, two explant types, *viz*., mature embryo and epicotyl of twelve genotypes *viz*., follows - IPGSM 10. IPGSM 15, IPGSM 17, IPGSM 18, IVT 4, IVT 10,1VT 16, IVT 27, GOA 8/1. WARC12/4. AVTE 11 and Dapoli 1 which were carried out aseptically under well defined conditions at Plant Biotechnology Unit, College of Agriculture Dapoli, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli- 415 712 (MS).

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MS and B_5 medium supplemented with 2, 4-D, NAA, BAP, Kinetin and IBA in different combinations and concentrations was used for callus induction, plantlet regeneration and rooting.

For preparation of explants the seeds were surface sterilized by 0.1 per cent Teepol for few minutes followed by washing under running tap water. After that, seeds were quick deeped with 70 per cent ethanol and further immersed in mercuric chloride (0.1%) for 10 minutes, followed by several washing with double distilled water. These treated seeds were soaked for six hours in double distilled water. These treated seeds along with mature embryo axes were inoculated on callus induction media. Similarly, seeds were also inoculated on MS basal medium without hormones for epicotyl explants. After 6-7 days epicotyls were used as aseptic explant for callus induction. Observations were recorded as weight of callus after four weeks. Completely randomized

Table 1. Genotypic variability in relation to explant and media for weight of callus (mg).

Genotype	Mature embryo axes		Mean	Epicotyl		Mean
	MS	B_5		MS	B_5	
IPGSM 10	105.44	47.91	76.68	34.29	33.54	33.92
IPGSM 15	66.97	42.41	54.69	18.57	17.46	18.02
IPGSM 17	70.79	44.84	57.69	64.33	45.65	54.99
IPGSM 18	68.50	25.43	46.96	16.70	9.12	12.91
IVT 4	68.39	36.26	52.33	78.06	22.54	50.30
IVT 10	114.01	42.10	78.05	69.37	45.62	57.49
IVT 16	65.03	22.02	43.53	26.49	43.40	34.95
IVT 27	63.76	20.67	42.22	40.59	39.85	40.22
GOA 8/1	58.71	18.99	38.85	15.68	8.70	12.19
WARC 12/4	58.11	29.60	43.86	45.80	20.25	33.02
AVTE 11	58.96	28.02	43.49	29.72	24.63	27.18
DAPOLI 1	61.51	26.62	44.07	34.44	18.12	26.28
Mean	71.68	32.07	51.86	39.50	27.41	33.45

	Genotype	Explant	Genotype x Explant
S. E. ±	0.90	0.36	1.28
C. D. at 5%	3.44	1.40	4.87

Table 2. Genotypic variability in relation to auxin levels (mgl^{-1}) for weight of callus (mg) in mature embryo in MS media.

Genotype	MS									
	2, 4-D (mgl^{-1})					NAA (mgl^{-1})				
	0.1	0.5	1.00	2.00	Mean	1.00	2.00	3.00	4.00	Mean
IPGSM 10	57.25	67.65	107.22	232.83	107.15	31.78	56.77	100.66	189.43	94.66
IPGSM 15	34.71	49.74	79.89	110.53	65.29	25.19	45.55	82.11	108.11	65.24
IPGSM 17	32.1	55.11	92.55	124.11	69.41	22.22	38.77	92.44	108.78	65.55
IPGSM 18	30.78	56.72	91.77	110.66	66.52	20.11	43.55	89.55	104.88	64.52
IVT 4	29.37	60.81	98.22	100.92	64.44	19.74	38.88	94.77	104.44	64.45
IVT 10	61.14	80.92	113.00	250.75	114.95	36.15	59.92	112.67	197.55	101.57
IVT 16	27.85	48.71	87.22	103.75	61.35	22.22	32.22	96.00	102.33	63.19
IVT 27	34.08	58.19	97.00	95.75	61.97	20.15	34.99	93.22	76.78	56.28
GOA 8/1	29.14	50.93	95.00	86.22	55.82	17.86	24.22	79.33	87.00	52.10
WARC 12/4	23.04	35.44	97.22	94.39	63.13	21.48	39.44	73.00	80.89	53.70
AVTE 11	21.89	33.59	94.55	108.66	61.49	17.55	25.22	82.00	88.22	53.24
DAPOLI 1	38.22	48.04	92.55	101.64	58.90	17.28	24.15	88.66	81.00	52.77
Mean	34.96	53.82	95.51	126.68	77.74	22.64	38.84	90.36	110.78	65.60

	Genotype	Explant	Genotype x Explant
S. E.±	0.56	0.45	1.53
C. D. at 5%	1.52	1.35	2.94

design (CRD) was employed for the experiment. All these statistical analysis were done in MSTAT-C software programme developed by, Russel D. Freed, MSTAT director, Crop and Soil Science department, Mishigan State University, Version 2.10.

RESULTS AND DISCUSSION

Effect of genotype : The significant response for weight of callus was found between two media and explant type are presented in Table 1. In mature embryo axes genotype IVT 10 recorded maximum callus weight (114.01 mg) on MS media followed by IPGSM 10 (105.44 mg) and IPGSM 17 (70.79 mg). While the B_5 media the genotype IPGSM 10 (47.91 mg) recorded maximum callus weight followed by IPGSM 17 (44.84 mg) and IPGSM 15 (42.41 mg). In Epicotyl explant media MS recorded maximum weight of callus in IVT 4 (78.06 mg) followed by IVT 10 (69.37 mg) and IPGSM 17 (64.33 mg) while, the media B_5 recorded maximum callus weight in IPGSM 17 (43.65 mg) followed by IVT 10 (45.62 mg) and IVT 27 (39.85 mg).

Effect of growth regulators : Two growth regulators with different concentrations gave variable responses for weight of callus in MS media with mature embryo axes explant as shown in Table 2. Highest callus weight with mature embryo axes explant was observed in MS media supplemented with 2 mgl^{-1} 2, 4-D (126.68 mg) while lowest callus weight (34.96 mg) with 0.1 mgl^{-1} 2, 4-D concentration. The similar results was recorded by Rangan (1976). Similarly, 4 mgl^{-1} NAA had given maximum (110.78 mg) callus weight whereas; minimum (22.64 mg) was recorded in 1.00 mgl^{-1} NAA. Mean values for callus weight ranged from 52.10 to 101. 57 mg.

As like mature embryo axes explant, in epicotyl explant callus weight was ranged from 43.84 to 60.49 mg. In case of 2, 4-D

Table 3. Genotypic variability in relation to auxin levels (mgl^{-1}) for weight of callus (mg) in epicotyl explant in B_5 media.

Genotype	B_5										Mean
	2, 4-D (mgl^{-1})					NAA (mgl^{-1})					
	0.1	0.5	1.00	2.00	Mean	1.00	2.00	3.00	4.00	Mean	
IPGSM 10	0.00	56.11	85.11	96.00	59.30	0.00	28.84	53.00	91.22	43.26	51.28
IPGSM 15	0.00	47.55	80.89	86.00	53.61	0.00	29.32	46.55	78.33	38.55	46.08
IPGSM 17	0.00	46.37	69.44	76.11	47.98	0.00	34.97	46.67	85.22	41.71	44.85
IPGSM 18	0.00	43.74	73.16	75.44	48.08	0.00	28.87	40.11	87.89	39.21	43.65
IVT 4	0.00	40.38	70.39	83.44	48.55	0.00	32.44	62.44	86.44	45.33	46.94
IVT 10	0.00	60.92	88.82	109.89	64.90	0.00	34.42	80.33	93.92	52.16	58.54
IVT 16	0.00	47.04	71.35	91.22	52.40	0.00	27.51	57.83	85.00	42.58	47.90
IVT 27	0.00	39.63	69.70	85.55	48.72	0.00	24.74	59.70	79.89	41.08	44.90
GOA 8/1	0.00	39.47	69.54	75.33	46.08	0.00	27.19	56.72	76.67	40.14	43.11
WARC 12/4	0.00	41.80	70.42	86.44	49.66	0.00	25.68	69.11	81.33	44.03	46.85
AVTE 11	0.00	39.36	69.55	77.53	46.61	0.00	24.85	56.89	89.77	42.87	44.74
DAPOLI 1	0.00	12.56	68.17	80.00	40.18	0.00	26.31	51.33	81.66	39.82	40.00
Mean	0.00	42.91	73.88	85.25	50.51	0.00	28.76	56.72	84.78	42.56	46.54

	Genotype	Explant	Genotype x Explant
S. E.±	0.74	0.59	1.41
C. D. at 5%	1.88	1.68	2.98

Table 4. Genotypic variability in relation to auxin levels (mgl^{-1}) for weight of callus (mg) in epicotyl explants in B_5 media.

Genotype	B_5										Mean
	2, 4-D (mgl^{-1})					NAA (mgl^{-1})					
	0.1	0.5	1.00	2.00	Mean	1.00	2.00	3.00	4.00	Mean	
IPGSM 10	0.00	0.00	66.74	75.46	35.55	0.00	0.00	46.32	62.92	27.31	31.43
IPGSM 15	0.00	0.00	68.65	74.78	35.85	0.00	0.00	42.68	82.51	31.29	33.58
IPGSM 17	0.00	0.00	64.20	66.98	32.79	0.00	0.00	42.51	73.00	28.87	30.84
IPGSM 18	0.00	0.00	62.96	63.68	31.66	0.00	0.00	48.89	61.33	27.55	29.56
IVT 4	0.00	0.00	75.28	90.79	41.51	0.00	0.00	56.46	78.55	33.75	37.63
IVT 10	0.00	0.00	58.00	62.96	30.24	0.00	0.00	56.46	78.55	33.75	37.63
IVT 16	0.00	0.00	64.51	65.94	32.61	0.00	0.00	42.91	74.67	29.39	31.01
IVT 27	0.00	0.00	63.97	61.77	31.43	0.00	0.00	45.35	70.30	28.91	30.17
GOA 8/1	0.00	0.00	63.10	63.93	31.75	0.00	0.00	41.69	71.00	28.17	29.97
WARC 12/4	0.00	0.00	64.11	61.76	31.46	0.00	0.00	44.34	71.01	28.83	30.15
AVTE 11	0.00	0.00	62.30	59.65	30.48	0.00	0.00	42.15	61.28	25.85	28.17
DAPOLI 1	0.00	0.00	66.03	69.03	33.76	0.00	0.00	45.73	73.20	29.73	31.75
Mean	0.00	0.00	65.40	67.64	33.26	0.00	0.00	46.29	71.52	29.45	31.82

	Genotype	Explant	Genotype x Explant
S. E.±	0.23	0.41	0.89
C. D. at 5%	1.54	1.68	2.13

concentration MS media with 2 mgl^{-1} concentrations recorded maximum (91.99 mg) callus weight while no callusing was recorded in 0.5 mgl^{-1} 2, 4-D concentration. Similarly, 4 mgl^{-1} NAA had given highest (83.72 mg) callus weight as compared to 1 mgl^{-1} NAA.

When mature embryo axes explant inoculated in B_5 media enriched with 2, 4-D and NAA provided variability in callus weight (Table 3). Mean values ranged from 40.00 mg to 58.54 mg. Medium with 2 mgl^{-1} 2, 4-D recorded maximum (85.25 mg) callus weight whereas minimum was observed (42.91mg) with 0.5 mgl^{-1} concentration. 2, 4-D concentration of 0.1 mgl^{-1} failed to show callusing. In case of NAA supplemented media 4 mgl^{-1} recorded highest callus weight (84.78 mg) followed by 3.00 mgl^{-1} (56.72 mg) and 2.00 mgl^{-1} (28.76 mg).

Data regarding epicotyl explant in B_5 media with different auxin levels is presented in Table 4. Mean values ranged from 29.56 to 37.63 mg. Among 2, 4-D concentrations, 2 mgl^{-1} 2, 4-D was found to be effective for maximum callus weight (67.64 mg). No callusing was observed with 0.5 and 0.1 mgl^{-1} 2, 4-D concentrations. Similarly, 4 mgl^{-1} NAA found to be effective for callus weight. Similar kind of results were obtained by Rangan (1976), Wakizuka and Yamaguchi (1987) and Ramble *et al.*, (2004).

Genotype x explant interaction : In mature embryo axes highest (78.06 mg) callus weight was observed in genotype IVT10 and lowest (38.86 mg) in genotype GOA 8/1. In epicotyl explant maximum (61.84 mg) callus weight observed in genotype IVT10 while minimum (13.18 mg) in genotype GOA 8/1.

Genotype x media interaction : The highest callus weight (91.69 mg) was recorded by genotype IVT10 in MS media and lowest (37.19 mg) in GOA 8/1. In B_5 media maximum (45.20 mg) callus weight was observed in genotype IVT10 and minimum (13.85 mg) in GOA 8/1.

Genotype x explant x media interaction : The highest callus weight (114.01 mg) was recorded by genotype IVT10 and minimum (58.11 mg) was recorded by genotype WARC 12/4 when mature embryo axes used as an explant, in MS media. The same explant when used with B_5 media gave maximum (47.91 mg) callus weight in genotype IPGSM 10 and minimum (18.99 mg) in GOA 8/1. Similarly, genotype IVT10 recorded highest (69.37 mg) callus weight when epicotyl explant used with MS media while lowest (15.68 mg) by GOA 8/1. In B_5 media genotype IVT10 gave maximum (45.62 mg) callus weight as compared to genotype WARC 12/4 (8.70 mg).

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Intercropping Studies in Finger millet (*Eleusine coracana* L.)

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ABSTRACT

Rainfall zone IX of sub-montane zone with shallow and lighter soils, blackgram or mothbean intercrop in 4:1 row proportion in finger millet are suitable for obtaining maximum grain and straw yield. The grain equivalent yield increase in figermillet with the intercrops *viz*., blackgram and mothbean (4:1) was 24.39 and 22.28 per cent respectively over sole cropping. The net returns showed similar trend recording 55.28 and 45.46 per cent increase over sole cropping.

Key words : Pulse, fingermillet, row proportion, intercropping, equivalent yield.

Finger millet crop is grown by transplanting method in sub-montane zone, as a sole crop. Intercropping is a potential system for maximizing crop production under rainfed condition in terms of space and time in subsistence farming situation (Mitra *et al*., 2001). Finger millet crop is grown during *kharif* season on very shallow and light soil on

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sloppy lands under rainfed condition. The low productivity is due to a number of factors and combination thereof. To overcome this situation intercropping of pulses in finger millet will be helpful to increase the production per unit area and time, and additional returns of legume and also helpful to improve soil health. The stability of yield is greater with intercropping than sole crop (Rao and Willey 1980). Keeping these views the present investigation was planned.

MATERIALS AND METHODS

Field experiments were conducted for three seasons from *kharif* 2005 to 2007 under rainfed conditions at the Zonal Agricultural Research Station, Shenda Park, Kolhapur (Maharashtra). The experimental site was sandy loam with pH 7.20, E.C. 0.10 dSm^{-1}, organic carbon 0.96 per cent. Available N 101.0, P_2O_5 10.6 and K_2O 198.0 kg ha^{-1}. Different pulses taken as intercrop in finger millet (RAU 8) were black gram (TPU 4), moth bean (MBS 27), red gram (Vipula) and soybean (DS 228). These crops were sown in finger millet in different row proportions of 4:1 and 8:2. All crops *viz*. finger millet and pulses were also grown as the sole crops. The row spacing of 30 cm was used for all the crops. All the pulse crops were sown by dibbling method. The treatment farmers' practice includes growing of fingermillet crop without any fertilizer with mixture of other millets. The thinning of pulses was done 15 days after sowing and only one healthy plant was kept per hill by maintaining the distance of 15 cm between the plants. The experiment was laid out in randomized block designwith three replications. The gross plot size was 7.20 x 5.40 m with the net plot of 6.50 x 5.40 m. The 5.0 tones of FYM ha-1 was given to the entire experimental crop. Similarly, the recommended dose of fertilizers was applied to the respective crop when they were sown alone. While under the treatments of intercropping recommended dose of fertilizers (60:30:00 kg NPK ha^{-1}) was given to the finger millet crop which was applied through urea and single super phosphate. Half dose of N was applied at sowing along with full dose of P_2O_5 and the remaining N was top dressed at 25 days after sowing in all the crops. The crops were sown during the first week of July in every season. Necessary plant protection measures were taken to protect the crop from pest and diseases. Two weedings were followed by one hoeing. Economics of the various treatments was worked out considering the prevailing market prices of grain and straw.

RESULTS AND DISCUSSION

Growth parameters : The data presented in Table 1 revealed that, the highest plant height (84.7 cm) was observed with sole crop of finger millet which was significantly superior

Table 1. Growth and yield characters of fingermillet under sole and intercropping with different legumes (pooled data of 3 years).

Treatments	Plant height (cm)	Productive tillers $plant^{-1}$	Ear length (cm)	No. of fingers ear^{-1}	1000 grain weight (g)
Sole fingermillet	84.0	4.4	5.6	7.1	2.960
Sole redgram	-	-	-	-	-
Sole blackgram	-	-	-	-	-
Sole mothbean	-	-	-	-	-
Sole soybean	-	-	-	-	-
Finger millet + redgram (4:1)	82.1	3.9	5.1	7.1	2.95
Finger millet + redgram (8:2)	81.3	3.8	4.9	7.0	2.97
Finger millet + blackgram (4:1)	81.2	3.8	5.1	6.9	3.01
Finger millet + mothbean (4:1)	81.5	3.7	4.9	6.8	3.03
Finger millet + soybean (4:1)	80.5	3.7	4.7	6.7	2.94
Farmers practice	73.7	3.0	4.3	6.2	2.86
S. E. m $\pm$	1.46	0.13	0.19	0.15	0.027
C. D. (P=0.05)	4.51	0.39	0.59	0.46	0.085

over farmers practice but at par with other intercrop treatments. Productive tillers plant^{-1}, ear length and number of fingers were also significantly highest with the treatment sole crop of fingermillet. Similar results were also reported by Ramamoorthy *et al.*, (2004). However, the thousand grain weight was significantly highest with the treatment finger millet + mothbean intercrop in 4:1 proportion.

Grain and straw yield : The highest grain yield (29.95 q ha^{-1}) was recorded with the sole crop of finger millet, which was significantly superior over all the treatments. The highest straw yield (41.79 q ha^{-1}) was recorded with the treatment sole crop of finger millet which was significantly superior over farmers practice and at par with intercrop treatments. Grain and straw yield reduces considerably when intercropped with legumes compared to pure stand of fingermillet as reported by Singh and Arya (1999) and Mitra *et al.*, (2001). As regards the intercrop yields, the sole crop of soybean recorded the highest grain yield (12.28 q ha^{-1}). Amongst the intercrop treatments the maximum yield was recorded with the treatment T_{10} (5.09 q ha^{-1}) in finger millet + soybean (4:1) followed by in finger millet + black gram (4:1).

Grain equivalent yield : As regards the finger millet grain equivalent yield, significantly highest FMGEY (40.08 q ha^{-1}) was recorded with the treatment T_8 where black gram intercrop was taken in 4:1 proportion. It was significantly superior over sole crop treatments and farmers practice but on par with intercrop treatment T_7, T_9 and T_{10} where red gram, mothbean and soybean intercrop was taken in 8:2 and 4:1 row proportion respectively. Similar results were also reported by Thorat *et al.*, (1986), Mahadkar and Khanvilkar (1988), Shankarlingappa and Hegade (1992), Ramamoorthy *et al.*, (2004). The land equivalent ratio (LER) was also higher with the treatments T_8 and T_9 where black gram and mothbean intercrop was taken as intercrop in 4:1 row proportion. It indicates that it is

Table 2. Pooled mean grain and straw yield of finger millet, intercrop yield, economics of intercropping system, FMGEY and LER as influenced by intercropping studies in finger millet (*kharif* 2005-2007).

Tr. No.	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Inter crop yield (q ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio	FMGEY (q ha^{-1})	LER
T_1	Sole fingermillet	29.95	41.79	-	20101	9048	1.82	32.22	1.00
T_2	Sole redgram	-	-	8.71	15695	5619	1.51	26.16	1.00
T_3	Sole blackgram	-	-	8.28	20285	9937	195	33.61	1.00
T_4	Sole mothbean	-	-	7.76	18587	8239	1.79	31.05	1.00
T_5	Sole soybean	-	-	12.28	17674	6312	1.49	29.39	1.00
T_6	Finger millet + redgram (4:1)	24.38	38.41	2.09	20615	9790	1.82	32.81	1.06
T_7	Finger millet + redgram (8:2)	25.14	40.94	2.61	22044	10712	1.95	35.35	1.14
T_8	Finger millet + blackgram (4:1)	25.31	39.86	3.13	25357	14050	2.24	40.08	1.24
T_9	Finger millet + mothbean (4:1)	24.73	37.82	2.92	24497	13161	2.16	39.40	1.24
T_{10}	Finger millet + soybean (4:1)	24.77	35.56	5.01	23272	11779	2.03	36.71	1.13
T_{11}	Farmers practice	20.29	34.22	-	14074	5149	1.57	22.40	1.00
S. E. m±		0.68	1.45	-	1616.8	1563.6	0.15	2.28	-
C. D. (P=0.05)		2.09	4.46	-	4768.7	4612.0	0.44	6.73	-

Selling rates : 1) Finger millet grain - Rs. 700 q^{-1}, 2) Finger millet straw - Rs. 50 q^{-1}, 3) Redgram - Rs. 2200 q^{-1}, 4) Blackgram - Rs. 3000 q^{-1}, 5) Mothbean - Rs. 3200 q^{-1}, 6) Soybean - Rs. 1800 q^{-1}.

beneficial to take fingermillet with the intercrops rather than sole crop alone.

Economics : The highest gross and net monetary returns and B:C ratio was obtained with the treatment T_8 where black gram intercrop was taken in 4:1 proportion. The highest gross monetary return (Rs. 25357/-) was obtained with the treatment T_8 which was significantly superior over sole crop and farmers practice. Ramamoorthy *et al*., (2004) also reported similar observations.

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Effect of Corm Size on Growth, Flowering and Spike Yield in Gladiolus cv. American Beauty Under Konkan Condition

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ABSTRACT

The results revealed significant variation in growth, flower quality and flower yield. The larger corms (above 5.0 cm diameter) recorded significantly profuse growth in terms of early sprouting, maximum numbers of leaves and bigger size leaves; early commencement of flower (81.0 days), better floret quality in respect of spike length (96.92 cm), number of florets spike^{-1} (14.98), floret size (11.95 cm), floret length (10.18 cm) and diameter of flower stalk (0.923 cm) as well as number of spike yield plant^{-1} (1.29) and also per plot (11.22) as compared with other corm sizes and found significantly superior over other corm sizes.

Key words : Gladiolus, corms, spike, floret.

Gladiolus (*Gladiolus grandiflorus* (L.) is an important commercial growing most beautiful and fascinating flower grown in many parts of world. Performance of bulbous-crop is greatly influenced by the size of bulbs or corms and successful cultivation of gladiolus depends much upon corm size used for planting. The

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corm size influences growth, development, flowering, flower quality, flower yield and ultimately corm and cormel yield. Konkan region of Maharashtra have great scope for flower cultivation because of good transport facilities as well as nearest markets like Mumbai, Panaji etc. The present study was undertaken with a view to find out the effect of corm size on growth, flowering and flower yield of gladiolus under Konkan conditions of Maharashtra.

MATERIALS AND METHODS

The experiment was conducted at Department of Horticulture, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist.- Ratnagiri (MS) during rabi season of the 2002-2003 in a randomized block design with four corm sizes *viz*. 2.1 - 3 cm diameter (V_1), 3.1 - 4 cm diameter (V_2), 4.1 -5 cm diameter (V_3) and Above 5 cm diameter (V_4) and replicated five times. The soil was lateritic with uniform depth and good drainage capacity having a pH of 6.5. All recommended agro-techniques were applied to get optimum crop. The corms of cv. American Beauty were planted at a spacing of 30 x 20 cm in plots of 1.2 x 1.2 m^2 size. Observations on growth and yield attributes were recorded and analyzed statistically.

RESULTS AND DISCUSSION

Growth attributes : There was great amount of variation in respect of growth characteristics due to various corm sizes observed during present investigation. The variation in the corm size significantly influenced the days required for sprouting of corms as well as growth characteristics (Table 1). Large size corms (above 5.0 cm diameter) took significantly the minimum number of days for sprouting (16.95 days) and found significantly superior over other corm sizes, while that of small corms took more number of

Table 1. Effect of corm size on growth of gladiolus cv. American Beauty.

Corm size	Days to sprouting	Plant height (cm)	Leaves plant^{-1}	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm)	Leaf area index
V_1	25.13	97.76	9.17	50.18	2.18	623.87	1.04
V_2	24.00	102.83	9.70	55.11	2.35	725.03	1.21
V_3	18.31	105.40	10.83	59.68	2.48	835.47	1.39
V_4	16.95	109.62	11.53	66.67	2.74	983.75	1.64
S.E.±	0.370	0.437	0.097	0.373	0.012	5.420	0.009
C. D. at 5%	1.084	1.325	0.295	1.095	0.036	15.896	0.026

V_1 = 2.1-3.0 cm, V_2 =3.1-4.0 cm
V_3 = 4.1-5.0 cm, V_4 = Above 5.0 cm

days (25,13 days) for sprouting. The bigger size corms (above 5.0 cm diameter) recorded maximum values for all the growth characteristics under study i.e. plant height (109.62 cm), number of leaves (11.53), leaf length (66.67 cm), leaf breadth (2.74 cm), leaf area (983.75 cm^2), leaf area index (1.64) and found significantly superior over other corm sizes. Similar results were also recorded by Mohanty *et al.*, (1994), Singh (2000 b) and Singh (2001) in gladiolus. Profuse growth recorded in large corms was mainly due to the more reserved food available in these corms (Bankar and Mukhopadhyay, 1980).

Flowering attributes : The variation in the corm size significantly influenced the days taken for commencement of flowering. Large size corms (above 5.0 cm diameter) took significantly lowest number of days (81.00) to flower and found significantly superior over other corm sizes while that of small corms (2.1-3.0 cm diameter) took comparatively more number of days (87.82) to flower. Since, the plants raised from large corms produces more number and bigger sized leaves, they were able to synthesize enough photosynthates and supply to satisfy the sink demand, and as a result they complete juvenile phase earlier and enters in reproductive phase earlier as

Table 2. Effect of corm size on commencement of flowering, flower quality and yield of spike in gladiolus cv. American Beauty.

Size of corm	Days to flowering	Flower quality					Spike yield (No)	
		Spike length (cm)	Florets spike^{-1}	Floret size (cm)	Floret length (cm)	Diameter of flower stalk (cm)	Per plant	Per plot
V_1	87.82	84.97	12.82	10.52	9.12	0.724	1.0	8.00
V_2	85.96	87.93	13.51	10.82	9.50	0.819	1.00	8.00
V_3	83.71	91.84	14.02	11.35	9.84	0.864	1.02	8.44
V_4	81.00	96.92	14.98	11.95	10.18	0.923	1.29	11.22
S. E.±	0.314	0.312	0.113	0.064	0.035	0.003	0.022	0.133
C. D. at 5%	0.922	0.916	0.330	0.189	0.104	0.009	0.065	0.390

compared to other corm sizes and flower earlier. These results, in general are in agreement with those of Gowda and Gowda (1988), Singh (2000 b) and Singh (2001) in gladiolus. Corm size also showed significant effect (Table 2) on various flowering attributes as well as spike yield. Spike length significantly varied due to different corm sizes. The spike length increased from 84.97 cm in small size corms (V_1) to 96.92 cm in large size corms (V_4). The large size corm (above 5.0 cm diameter) found significantly superior over other corm sizes by recording highest spike length. Gowda and Gowda (1988) obtained longest spikes from the plants raised from large sized corms. Singh (2000 a) and Singh (2001) reported similar results in gladiolus. Corm size also greatly influenced the floret number on spikes and significantly maximum number of florets/spikes (14.98) were recorded in the plants raised from bigger sized corms (V_4) and found significantly superior over smallest size corms (12.82). This increase in floret production might be due to more food reserves in the large corms as well as profuse growth than small and medium size corms. Similar results were also obtained by Yadav (1991), Singh *et al.*, (1998), Singh (2000 a) and Singh (2000 b) in gladiolus at various locations in India. The great variation in quality parameters of floret was also observed during present investigation. Floret size, floret length and diameter of flower stalk were greatly influenced by corm size. The largest corm size (above 5.0 cm diameter) recorded the highest floret size (11.95 cm), floret length (10.18 cm) and floret stock diameter (0.923 cm) as compared to smaller size corms and found significantly superior over other corm sizes.

The corm size had significant effect on production of spikes plant^{-1}. Spike yield increased with increase in size of the corm. The plants raised from V_1 and V_2 corms (smaller corms) produced a spike yield of one per plant while those, raised from V_3 and V_4 corms (larger corms) recorded a spike yield of 1.02 and 1.29 spikes plant^{-1} respectively. It is observed from data that bigger corm size (T_4) in gladiolus recorded significantly maximum number of spikes (1.29) per plant and found superior over other corm sizes. Higher food reserves in large sized corms as well as profuse growth resulted in increased spike production. The results are in agreement with those reported by Kalasareddi *et al.*, (1998) and Singh (1998) who reported more number of spikes plant^{-1} with bigger size corms It is concluded from present studies that bigger size corms (above 5.0 cm diameter) recorded early sprouting of corms, profuse growth in terms of more leaves, leaf size, leaf area and early flowering with better quality flower in terms of length of spikes, bigger size florets as well as more yield (spikes) and found significantly superior over other corm sizes under Konkan conditions of Maharashtra.

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Effect of Mother Clove Size on Growth, Yield and Storage Quality of Garlic var. G. 41 (*Allium sativum* L.)

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ABSTRACT

An experiment was carried out to study the effect of mother clove size on growth, yield and storage quality of garlic var.G.41.The results revealed that, among the various sizes of mother cloves evaluated for planting, mother clove size ranged from 1.4 -1.5g recorded higher growth in terms of plant height and number of leaves per plant. Apart from these traits, higher marketable bulb yield was also obtained from bigger cloves. Moreover, it was also observed that the lowest physiological weight loss and decay were noticed in bigger clove treatment and the highest incidence of rotting and physiological weight loss was observed in bulbs harvested from small size cloves.

Key words : Garlic, mother clove, growth, yield, and storage quality.

Garlic (*Allium sativum* L) is an important commercial spice vegetable valued for seasoning and flavouring dishes. Among the

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bulb crops, garlic is the second most important crop grown throughout country. It is consumed as a green as well as dried in the spice form. It is also an ingredient to flavour various vegetarian and non-vegetarian dishes and pickles. The production and productivity of garlic in India is very low than many other countries. It is mainly due to unawareness of the farmers about suitable improved varieties, optimum planting material, improved agronomic practices etc.

Among the various reasons for low productivity, the optimum planting material size is most important (Shinde and Sontakke, 1986). The yield of garlic is drastically reduced by use of different size of mother cloves in various parts of the country. Hence the present experiment was conducted to study the effect of different size of mother clove on growth, yield and production related attributes and storage quality of garlic to develop the suitable technology and recommendation.

MATERIALS AND METHODS

The experiment was conducted at National Research Centre for Onion and Garlic (NRCOG), Rajgurunagar at Pune representing VII Agricultural Zone, in *rabi* season for three years during 1999 - 2003.The experiment was laid out in a randomized block design with three treatments and seven replications. Planting was done in 3 x 2 m size beds with a spacing of 10 x 15 cm. The variety used for this experiment was G.41. A basal dose of NPK @ 50:50:50 kg ha^{-1} was applied at the time of dibbling, where as the remaining dose of N (50 kg ha^{-1}) was applied in two split doses at an interval of 30 days after dibbling. Standard cultural practices and recommended plant protection measures were followed uniformly for all treatments. The crop was harvested when the tops turned yellowish/brownish in colour and showed signs of drying up. Observations on vegetative growth characters were recorded at 90-110 days after dibbling and bulb characters were recorded after 10-15 days of field curing of bulbs. Biometric observations such as plant height, number of leaves, neck thickness, polar and equatorial diameter of bulbs, average weight of bulbs, number of cloves per bulb, per cent of A (30mm), B (20mm), C (10mm) grade bulbs were computed on the basis of the means of ten randomly selected plants per replication per treatment. The total and marketable bulb yield of A, B and C grade bulbs per plot was calculated. Storage observations were taken after four months of storage under ambient conditions. The generated data were analyzed as per standard statistical procedures recommended by Panse and Sukhatme (1985)

RESULTS AND DISCUSSION

Growth is a multidimensional character governed by many parameters. In the present study the growth of garlic was influenced by clove size was reflected in characters such as plant height, number of leaves, neck thickness.

Table 1. Effect of mother clove size on growth, bulb characters and bulb grade contribution of garlic var. G.41 (pooled mean).

Treatments	Plant height (cm)	Number of leaves	Neck thick-ness (cm)	Bulb polar diameter (cm)	Bulb equatoriol diameter (cm)	Number of cloves $bulb^{-1}$	% of A grade bulb	% of B grade bulb	% of C grade bulb
T_1 : 0.4 - 0.5 g	49.5	9.23	0.58	2.51	2.92	18.2	39.7	23.4	32.6
T_2 : 0.9 - 1.0 g	56.8	9.37	0.61	2.68	3.10	20.7	48.3	29.6	22.6
T_3 : 1.4 - 1.5 g	62.2	10.9	0.68	2.91	3.53	24.7	53.0	33.6	18.9
S. E.±	0.85	0.26	0.27	0.08	0.06	0.65	1.25	0.38	0.47
C. D. at 5%	2.64	0.72	N.S.	0.21	0.17	1.94	3.46	1.10	1.32

etc. The plant height is primary character which decided the vigour of the plant and in turn the dry matter production. (Table 1). Plant height is an important yield attribute in garlic. Any practice to alter the plant height would influence the bulb development. Results indicated that plant height and number of leaves per plant were significantly influenced by the use of different size of mother cloves. The highest plant height and number of leaves were recorded in T_3 (1.4-1.5 g) followed by T_2 (0.9-1.0 g) and the lowest was noticed in T_1 (0.4 - 0.5 g).

The variations in growth habit under different treatments might be due to differential amount of stored food material in clove which resulted in early sprouting with vigorous leaves. It was also due to uptake of nutrients by plants which resulted in difference in growth. A plant should produce sufficient number of leaves to harness light energy and synthesize adequate photoassimilates for biomass production. More number of leaves in bigger cloves plants were due to the adequate availability and supply of nutrients in proportion, which ultimately resulted in triggering the production of plant growth hormones. The bigger size bulbs had ability to absorb nutrients on greater extent from the soil. The nutrients absorbed in combination with the carbohydrates synthesized by the leaves through increased photosynthetic activity and would have caused the growth and formation of new tissues. This is in line with previous findings of Ramniwas *et al*., (1998), Alam *et al*., (2000) and Hafidh (2000).

The yield contributing traits like polar and equatorial diameter of bulbs, average weight of bulbs, number of cloves per bulb, per cent of A, B, C grade bulb were also on higher side in clove size weight of 1.4 to 1.5 g. This might be due to bigger bulb size contributed towards greater availability of reserved food for better development of the underground bulb. Brar and Gill (2000) studied the yield parameters of garlic and observed that improvement due to bigger cloves than smaller one.

The ultimate goal to be achieved in any production management system is to maximize the yield. The marketable bulb yield of garlic (Table 2) was significantly influenced by different size of mother cloves. The highest marketable bulb yield of garlic (10.6 t ha^{-1}) was recorded at T_3 followed by T_2 treatment with mean yield of 8.30 t ha^{-1}. Larger bulbs with more stored food produced better volume of plants, which in turn, improved the yield contributing characters. The increased yield was mainly due to bigger bulbs and cloves ultimately had more percent of A grade bulbs. Singh *et al*., (1992) also reported that maximum yield per hectare was obtained with larger size bulbs. The results are in confirmation to the earliar findings of Minard (1978), Ramniwas *et al*., (1998) and Prabal and Kohli (1998) who also obtained higher yields with increased size of cloves.

Table 2. Effect of mother clove size on yield and yield contributing characters and storage quality of garlic var. G.41 (pooled mean).

Treatments	Average weight of bulb (g)	Total yield (t ha^{-1})	Marketable bulb yield (t ha^{-1})	Physiological loss of weight (%)	Rotting (%)	Total loss (%)
T_1 : 0.4 - 0.5 g	17.1	7.63	7.25	25.7	3.13	28.8
T_2 : 0.9 - 1.0 g	22.5	8.49	8.30	21.5	2.00	23.5
T_3 : 1.4 - 1.5 g	27.1	10.8	10.6	19.8	1.85	21.7
S. E.±	0.70	0.17	0.13	0.55	0.14	0.91
C. D. at 5%	2.23	0.52	0.41	1.83	0.41	2.93

With respect to storage quality of bulbs (Table 2), the lowest physiological weight loss and decay were noticed in bigger clove treatment (T_3) and the highest incidence of rotting and physiological weight loss was observed in bulbs harvested from small size cloves. But there was no significant difference observed between medium (T_2) and large (T_3) size cloves. More over, there was no sprouting loss on any of the treatment. Medium to large size mother cloves or bulbs noticed good storage ability than smaller ones. (Gupta *et al.*, 2003) In general, Garlic is produced in India once in a year. Reduction of total loss including physiological and decay during storage is to be avoided to prevent glut in the market as well as to ensure steady supply. It necessitates that the proper cloves of optimum size as a planting material is prime factor to produce good quality bulbs with reduced post harvest losses. Similar results were also obtained by Jeong and Park (1994) and Lallan Singh *et al.*, (1996).

The present study suggested that the bigger cloves significantly improved growth, yield and storage quality of garlic in all the years. Keeping in view, to get higher bulb yield coupled with good storage quality, the average mother clove size for planting should be more than one gram.

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Effect of Sowing Time and Spacing on Yield of Cabbage cv. Golden Acre

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ABSTRACT

Cabbage crop sown on 15th October produced significantly highest yield than delayed sowing on 30th October and 15th November. Planting of cabbage with spacing of 45 x 45 cm recorded significantly highest yield than 60 x 30 cm and 60 x 45 cm. The interaction between the sowing of cabbage crop on 15th October with spacing of 45 x 45 cm produced significantly higher cabbage yield than the remaining treatment combinations.

Key words : Sowing time, spacing, weather, cabbage crop.

In Konkan region, cabbage is grown mostly in *rabi* season after *kharif* rice. Since, this crop is thermo sensitive, shows an adverse effect on growth and head formation with increasing temperature towards summer season. De Moel and Everaarts (1989) reported that the cabbage planted late in the season resulted in substantially reduced yield at the end of the season. It was, therefore, necessary to study its optimum sowing time for better head formation and more yield. Similarly, planting geometry also plays a vital role on growth and development and yield of cabbage crop. The present investigation was undertaken to decide the optimum sowing time and spacing for cabbage in the Konkan region under irrigated condition.

MATERIALS AND METHODS

A field trial was carried out during the rabi seasons of the years 2004-05,2005-06 and 2006-07 at Agronomy Farm, College of Agriculture, Dapoli in factorial randomized block design with three replications. The soil of the experimental plot was lateritic having 221.56,12.34 and 201.19 kg, N, P_2O_5 and K_2O ha^{-1}, respectively. The soil was acidic in reaction with PH 6.28 and organic carbon content was 0.86 per cent Three sowing dates *viz*., 15th October, 30th October and 15th November and three spacings *viz*. 45 x 45, 60 x 30 and 60 x 45 cm with nine treatment combinations were tested. The gross plot size was 5.40 x 3.60 m and the net plot sizes were different according to different spacings such as 3.60 x 2.25 m, 3.30 x 2.55 m and 3.30 x 2.25 m. Sowing of the crop in nursery was done as per the prescribed sowing dates and transplanted at 30 days after sowing (DAS) as per the treatments. In nursery, 53.7 kg N, 53.3 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied at sowing. The manures and fertilizer doses of 10 tones FYM, 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} were uniformly applied to all the treatments. Out of which, 1/3rd dose of nitrogen and full dose of phosphorus and potassium was applied as basal dose and 1/3rd nitrogen was applied 30 days after transplanting (DAT) and remaining 1/3rd dose of nitrogen was applied 60 DAT. Need based weeding and plant protection measures were

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carried out. Pooled data for three years on yield was used for interpretation of results. Growing Degree Days (GDD) was calculated by following formula with 10°C as the base temperature of the Konkan region.

$$GDD = \frac{\text{Daily Tmax.+Daily Tmin.}}{2} - \text{Base temp.}$$

Whene,

T max = maximum temperature

T min = minimum temperature

RESULTS AND DISCUSSION

Effect of sowing time : Data presented in Table 1 indicated that sowing time influenced significantly the yield of cabbage during all the three years of experimentation and in the pooled data. The crop sown on 15th October (D_1) recorded significantly higher yield as compared to delayed sown crop on 30th October (D_2) and 15th November (D_3) during all the three years and in the pooled data. On pooled mean basis the magnitudes of increase in yield due to sowing on 15th October over 30th October and 15th November were 8.58 and 178.38 per cent, respectively. Similar observations were recorded by De Moel and Everaarts (1989) and Dixit *et al*., (2005).

Effect of spacing : Data presented in Table 1 showed that the crop sown at the spacing of 45 x 45 cm (S_1) recorded significantly higher yield as compared to the spacings of 60 x 30 cm (S_2) and 60 x 45 cm (S_3) during all the three years and in the pooled data. On pooled mean basis, the magnitudes of increase in yield due to 45 x 45 cm spacing over remaining two spacings *viz*., 60 x 30 and 60 x 45 cm were 13.04 and 51.48 per cent, respectively, indicating that the spacing of 45 x 45 cm is better for obtaining higher production of cabbage than the remaining spacings. Similar results were reported by Bradshaw (1984) and Hamid. (2002).

Table 1. Mean yield of cabbage as affected by different treatments (pooled data for 3 years).

Sowing date	Cabbage yield ($q\ ha^{-1}$)
D_1 (15 October)	322.20
D_2 (30 October)	296.80
D_3 (15 November)	115.74
S. E.±	7.31
C. D. at 5%	21.90
Spacing (cm)	
S_1 (45 x 45)	312.30
S_2 (60 x 30)	276.27
S_3 (60 x 45)	206.17
S. E.±	7.31
C. D. at 5%	21.90
Interaction A x B	
S. E.±	2.76
C. D. at 5%	8.30

Table 2. Mean yield of cabbage ($q\ ha^{-1}$) as affected by interaction due to sowing dates and spacings (pooled data for 3 years).

Spacings	Sowing dates		
	D_1	D_2	D_3
S_1	332.4	296.0	92.2
S_2	323.9	360.9	224.8
S_3	312.1	287.4	210.0
S. E. ±	2.76		
C. D. at 5%	8.30		

Interaction effects : Data presented in Table 2 revealed that interaction effects between sowing dates and spacings were significant for all the three years and in the pooled data under study. The treatment combination between sowing on 15th October with spacing of 45 x 45 cm (D_1 S_1) produced significantly higher yield of cabbage than the remaining treatment combinations.

Effect on growing degree days : From Table 3, it can be seen that the crop sown on

Table 3. Growing degree-days in cabbage under different sowing dates.

Growth stages	Growing Degree Days								
	2005-06			2006-07			2007-08		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
Seedling stage (0-30 days)	398.4	343.7	342.3	418.1	442.1	461.3	416.5	469.8	531.2
Vegetative stage (31-45 days)	599.7	537.4	524.1	557.7	651.2	673.2	604.8	614.7	640.6
Head formation and development stage (46-94 days)	767.8	1115.7	1206.4	1167.9	1208.1	1269.0	1282.1	1310.3	1354.4
Total	1765	1996.7	2072.8	2163.7	2301.4	2403.5	2303.4	2394.8	2526.4
Yield (q ha^{-1})	332.4	296.0	92.5	323.9	300.9	224.8	312.1	287.4	210.0

15th October during 2005-06 received 1765.9 growing degree days (GDD) and were proved to be optimum to produce higher cabbage yield. Out of this total GDD, the utilization pattern was to the extent of 22.6, 34.0 and 43.4 per cent at seedling, vegetative and head formation stages, respectively. Further, the differences in cabbage yields were also recorded in early sown crop on 15th October (D_1) during all the three years and it was more during 2005-06 than during 2006-07 and 2007-08 where lower yield was obtained due to the increase in GDD. It has been proved that the crop is thermosensitive and therefore, the cabbage yield was reduced with advancement of sowing dates towards summer season due to increase in GDD during all the three years.

Crop weather relationship : It is clear from the Table 4, that the correlation and regression analysis of cabbage yield with AGDD during 2005-06 indicated strong negative correlation (-0.786) with GDD at seedling stage (-0.634) and GDD at head formation and development (-0.713) whereas strong positive correlation (0.738) with GDD in vegetative stage, thus during this year GDD contributed 62 per cent variation in the yield. Whereas during 2006-07 AGDD indicated strong negative correlation (-0.786), GDD at seedling stage (-0.634) and GDD at head formation and development stage (-0.683) with yield, where as strong positive correlation (0.678) with GDD at vegetative stage. Thus during this year GDD contributed 60 per cent variation in the cabbage yield. The correlation and regression analysis of yield with AGDD during 2007-08 indicated strong negative correlation (-0. 643), with GDD at seedling stage (-0.571) and GDD at head formation and development (-0.805), whereas strong positive correlation (0.646)

Table 4. Regression and correlation analysis during 2005-06, 2006-07 and 2007-08.

Regression equation	R^2	Correlation coefficient
2005-06 :		
Y=1478.0-0.636 AGDD	0.62	-0.786
Y=685.8 + 2.56 GDD Seedling	0.50	-0.634
Y=1069.1 + 2.37 GDD Vegetative	0.54	0.738
Y=357.3 - 0.174 GDD Head formation and development	0.52	-0.713
2006-07 :		
Y=1478.0-0.636 AGDD	0.60	-0.786
Y=685.8 + 2.56 GDD Seedling	0.40	-0.634
Y=1069.1 + 2.37 GDD Vegetative	0.44	0.678
Y=357.3 - 0.174 GDD Head formation and development	0.52	-0.683
2007-08 :		
Y=1238.0-0.423 AGDD	0.53	-0.643
Y=535.2 + 3.24 GDD Seedling	0.36	-0.571
Y=958.1 + 1.47 GDD Vegetative	0.48	0.646
Y=258.3 - 0.24 GDD Head formation and development	0.60	-0.805

with GDD in vegetative stage, indicating that the GDD during this year contributed 53 per cent variation in the yield. On an average, during all these three years the cabbage yield was reduced with increasing GDD to the extent of 58.33 per cent than optimum. From the above investigation, it can be concluded that under Konkan conditions the cabbage crop should be sown on 15th October with spacing of 45 x 45 cm for higher yield.

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Population Dynamics of Serpentine Leafminer (*Liriomyza trifolii* Burgess) on Tomato and its Relation with Meteorological Parameters

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ABSTRACT

The incidence of the pest was observed throughout the year and ranged from 3.53 to 7.73 livemines on eighteen terminal leaflets per plant. The lowest incidence (3.53 livemines per plant) was recorded on crop transplanted in the month of November, 1999 and the highest incidence (7.73 livemines per plant) was recorded on crop transplanted in the month of February, 2000. The peak activity of this pest was recorded during January to April with highest incidence in February, 2000, when the maximum temperature and morning relative humidity was at 34.14°C to 35.23°C and 70.75 to 77.32 per cent respectively. The maximum temperature showed significant and positive correlation (r = 0.872**), whereas morning relative humidity showed significant but negative correlation (r = -0.578*) with *L. trifolii* incidence. In case of *L. trifolii*, linear equation Y = 7.8155 + 0.5187 Tmax - 0.2587 MRH (R^2 = 0.88) was found to be the best fit for predicting the leafminer incidence in tomato crop based on weather parameters.

Key words : Population dynamics, *Liriomyza trifolii*, weather parameters, correlation, linear equation and tomato.

The serpentine leafminer (*Liriomyza trifolii* Burgess) is the polyphagous species dramatically increased its host range and spread into new areas becoming serious threate to many crops in India.Tomato and cucumber are the most preferred hosts than other crops (Jagannatha and Viraktamath, 1997), Krishna

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Kumar (1998) reported that *L. trifolii* was prevalent throughout the year with two peaks between January-April and June-September and also reported that, only relative humidity was negatively correlated with number of mines. The meteorological parameters are key factors, in deciding the peaks of the pest. Therefore, population dynamics of *L. trifolii* was studied on tomato crop in realation with weather paramter in Maharashtra state.

MATERIALS AND METHODS

The seedling of 'Dhanshree' variety of tomato was planted at monthly interval from 6^{th} August, 1999 to 6^{th} July, 2000. The experiment was laid out in a randomised block design with three replications having plot size of 1.80 x 4.50 m in *kharif* and 1.80 x 6.0 m in *rabi,* summer seasons with spacing of 0.60 x 0.45 m in *kharif* and 0.60 x 0.60 m in *rabi* summer season. All the recommended agronomic practices were followed for raising the crop. The number of livemines at weekly interval starting from 14 days after transplanting up to last harvest were receded on 3 terminal leaflets of 2 top, 2 middle and 2 bottom leaves (18 leaflets) of 5 randomly selected plants per plot. The weather data were recorded daily. The average number of livemines of 18 terminal leaflets per plant in each month was correlated with the mean meteorological parameters of the same month. The multiple linear regression equation was finally worked out for predicting the pest incidence based on common significant weather parameters.

RESULTS AND DISCUSSION

The incidence of leafminer during the year ranged from 3.53 to 7.73 livemines on 18 terminal leaflets $plant^{-1}$. The incidence of the pest was above ETL (1 live larva 3^{-1} terminal leaflets $plant^{-1}$) from August, 1999 to July, 2000. The lowest incidence (3.53 livemines $plant^{-1}$) was recorded on crop transplanted in the month of November, 1999 and highest incidence (7.73 livemines $plant^{-1}$) was recorded on crop transplanted in the month of February, 2000. The peak activity of this pest was recorded during January to April with highest incidence of 7.73 livemines on eighteen terminal leaflets $plant^{-1}$ in February, 2000 (Table 1).

The realationship of pest activity with weather parameters on monthly planted tomato crop is given in Table 2 and Fig 1. It could be seen that the maximum temperature of 31.77°C had a significant and positive correlation with the incidence of the pest, the 'r' value being 0.872**. The mean temperature of 23.79°C had significant and strong positive correlation with the pest incidence, the 'r' value being 0.841**. The morning relative humidity (79.92 %), on the other hand exhibited a weak significant negative correlation with the pest incidence, the 'r' value being 0.578*. It was observed that mean maximum temperature ranging from 29.46 to 35.23°C and mean temperature from 19.31 to 27.20°C are favourable for the pest incidence. The mean morning relative humidity 70.75 to 86.51 per cent was also favourable for the pest activity.

The multiple linear regression equations

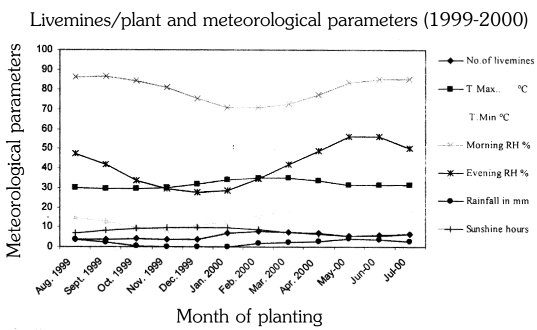

Fig. 1. Average number of live mines per plant and mean meteorological parameters during the year 1999-2000.

Table 1. Seasonal activity of *L. trifolii* on tomato and meteorological parameters during the year 1999-2000.

Time of planting	Av. No. of livemines/18 terminal leaflets plant^{-1}	Mean weather parameters								
		T max. °C	T min. °C	T mean °C	Morning RH (%)	Evening RH (%)	Mean RH (%)	Rainfall (mm)	BSS (hrs)	D. Mx. and Mn. T.°C.
Aug. 1999	3.63	29.81	14.67	22.24	86.40	47.65	67.03	3.65	6.98	15.14
Sept. 1999	3.58	29.52	13.10	21.31	86.51	41.78	64.15	2.36	8.17	16.42
Oct. 1999	4.13	29.46	9.82	19.64	84.11	33.66	58.89	0.43	9.29	19.64
Nov. 1999	3.53	29.94	8.68	19.31	80.89	29.69	55.29	0.0	9.57	21.26
Dec. 1999	3.74	31.77	10.38	21.08	75.40	27.78	51.59	0.0	9.63	21.39
Jan. 2000	7.00	34.14	12.83	23.49	71.02	28.72	49.87	0.01	9.45	21.31
Feb. 2000	7.73	35.23	15.89	25.56	70.75	34.55	52.65	2.01	8.61	19.34
Mar. 2000	7.24	34.88	18.43	26.66	72.63	42.13	57.38	2.17	7.35	16.45
Apr. 2000	7.08	33.84	20.56	27.20	77.32	48.92	63.12	2.58	6.43	13.28
May 2000	5.53	31.55	21.11	26.33	83.28	56.43	69.86	4.11	5.58	10.44
June 2000	6.08	31.39	20.81	26.10	85.29	56.15	70.72	3.88	5.60	10.58
July 2000	6.68	31.24	18.93	25.09	85.45	50.38	67.92	2.73	6.64	12.31

between per cent incidence and various meteorological parameters were derived for the year 1999-2000 to predict the incidence of *L trifolii* on tomato. Twelve regression equations were dervied in a year, but four multiple linear regression equations *viz*., (1). Y = -2.3065 - 5.3105 Tmax - 4.8368 Tmin + 11.2442 Tmean + 8.3295 MORH + 7.8695 ERH - 16.4583 MRH -0.0768 RF - 0.8898 SSH (August, 1999) (R^2 = 0.91), (2). Y = + 69.4233 - 57.5233 Tmax - 59.1574 Tmin + 115.8255 Tmean - 1.3485 MORH -0.6231 ERH + 1.5048 MRH + 4.3828 RF - 2.2514 SSH (January, 2000) (R^2 - 0. 0.93), (3). Y = - 20.5934 - 50.1474 Tmax - 52.6268 Tmin + 103.2302 Tmean + 194.7105 MORH + 195.2926 ERH - 389.8570 MRH + 0.5086 RF - 0.2936 SSH (February, 2000) (R^2 = 0.96) and (4). Y = - 65.7111 - 388.9112 Tmax +332.3602 Tmin + 57.7771 Tmean + 96.9642 MORH + 97.4747 ERH - 194.0242 MRH - 0.4810 RF - 0.5469 SSH + 362.4524 Diff Tmax and Tmin (March, 2000) (R^2 = 0.95) with maximum parameters, (Y = Expected number of livemines) showed maximum per cent variability and these were selected for predicting the incidence of *L. trifolii* on tomato crop.Regression Equation No. 3 (February, 2000) based on all the meteorological factors except the factor difference between maximum and minimum temperature, recorded the maximum R^2 value of 0.96. In March 2000, difference between maximum and minimum temperature showed maximum R^2 value of 0.95 including all the

Table 2. Correlation co-efficients between bi-weekly means of meteorological parameters and *L. trifolii* incidence on tomato for the year 1999-2000.

Meteorological parameters	r' values
Maximum temperature °C	0.872** (31.90)
Mininmum temperature °C	0.648* (15.43)
Mean temperature °C	0.841** (23.66)
Morning relative humidity %	-0.578* (79.92)
Evening relative humidity %	0.227 (41.49)
Mean relative humidity %	-0.079 (60.71)
Rainfall in mm	0.215 (1.99)
Sunshine hrs.	-0.329 (7.78)
Difference between Max. and Min. Temp.	-0.266 (16.42)

*,** Significant at 5 and 1 per cent. Figures in parentheses are mean values.

weather parameters. This data may be considered good enough for predicting the incidence of *L. trifolii*.

In case of linear regression analysis, the prediction equation of February, 2000 was more appropriate for prediction of leafminer incidence of *L. trifolii* on tomato, giving 96.00 per cent variability. It may be tried for further investigation in order to get better prediction at early stage and preventing the losses by the pest.

The meteorological parameters *viz*., maximum temperature and morning relative humidity played major role for deciding the pest incidence of *L. trifolii* on tomato. The linear equation, Y = 7.8155 + 0.5187 Tmax - 0.2587 MRH (R^2 = 0.88) was selected as the best fit for predicting the leafminer incidence with minimum weather parameters. However, Bagmare *et al*., (1995) reported that, mean temperature and sunshine hours had a positive correlation with the population of *L. trifolii*. Rainfall and relative humidity had a negative correlation with population level of agromyzid species and for *L. trifolii* linear equation $Y = 1.48 + 0.06 X_1 + 0.06 X_2 - 0.03 X_4$ (R^2 = 0.75) was reported as the best fit for predicting its population on tomato.

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Evaluation of Liquid Formulation of Entomopathogenic Fungus (*Verticillium lecanii* (Zimmermann) Viegas) Against Mealy Bug (*Maconellicoccus hirsutus* Green)*

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ABSTRACT

The study revealed that all the treatments of liquid formulations A (VGTA50512) and B (VGTA502105) of the entomopathogenic fungus, *Verticillium lecanii* (Zimmermann) Viegas were significantly superior to untreated control recording 74.22 to 92.22 per cent mortality of grape mealy bug (*Maconellicoccus hirsutus* Green) at 14 days after treatment. *V. lecanii* at 1.00 per cent concentration of the liquid formulation gave the highest mortality of 90.50 per cent (Formulation A) and 92.22 per cent (Formulation B). Although, 1 per cent concentration of the formulation recorded highest mortality of the pest, it was on par with 0.45 to 0.75 per cent. In long run, it shall be the most appropriate treatment suggesting biosafety of the entomopathogenic fungus, *V. lecanii*.

Key words : Bioefficacy, liquid formulation, mealy bug, *Verticillium lecanii*.

Biological control is an important component of IPM in almost all important crops for the development of sustainable cropping systems. *Verticillium lecanii* (Zimmermann) Viegas is extensively used entomopathogenic fungus suppressing most of the Homoptera including scale insects which are difficult to control with insecticides have been briefly reviewed by McClelland and Tucker (1929). Easwaramoorthi and Jayaraj (1978) reported the effectiveness of *V. lecanii* against *Coccus viridis* when applied at 1.6 x 10^6 spores ml^{-1}. Kadam and Jaichakravarthy (2003) observed that the fungus, *V. lecanii* caused 80.20 per cent mortality of mealy bug at 2 x 10^5 CPU ml^{-1} dose within two weeks. The present investigations were undertaken with a view to test bioefficacy of *V. lecanii* against grape mealy bug (*Maconellicoccus hirsutus* Green).

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MATERIALS AND METHODS

Studies on liquid formulation of *V. lecanii* was carried out at Biocontrol Research Laboratory, Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, during 2002-04 utilizing the culture isolated from spiralling whitefly (*A. dispersus*) infesting wild guava plant in 1999.

Autoclaved potato-dextrose broth medium was used for multiplication and growth of the fungus. The nymphs and adults of *M. hirsutus* collected from the naturally infested fields at the Central Campus, MPKV, Rahuri, were brought to laboratory and reared under controlled condition on sprouted tubers of potato. From this stock culture, the nymphs and adults were taken up for evaluation of the liquid formulation of *V. lecanii*.

Bioefficacy against *M. hirsutus* : Liquid formulation A (VGTA 50512) and Formulation B (VGTA 502105) of *V. lecanii* at 0.15, 0.30, 0.45, 0.60, 0.75 and 1.00 per cent concentration comprising combination of inoculum with different concentrations of the adjuvants were evaluated against *M. hirsutus* using Phule bugicide (WP formulation) as a check. The experiment was laid out in a completely randomized design with 16 treatments and three repeats. Single spray of *V. lecanii* was given.

Observations on mortality of insects at 1st, 3rd, 5th, 7th, 9th, and 14th days after treatment were recorded. Corrected mortality was calculated as per Abbott's formula (Abbott, 1925) and then subjected to statistical analysis.

RESULTS AND DISCUSSION

The data on bioefficacy of liquid formulations A and B along with Phule bugicide and dimethoate against mealy bug recorded at 1, 3, 5, 7, 9 and 14 days after treatment are presented in Table 1. Significantly highest

Table 1. Bioefficacy of liquid formulations of *V. lecanii* against mealy bug (*M. hirsutus*).

Treatments	Conc. (%)	Mortality (%) on days after treatment					
		1	3	5	7	9	14
V. lecanii liquid formulation A 8 x 10^8 CFU ml^{-1}	0.15	2.14 (8.33)**	12.66 (20.88)	27.26 (31.50)	41.16 (39.93)	55.26 (47.96)	74.22 (59.47)
	0.30	3.57 (10.63)	13.13 (21.22)	28.04 (31.95)	43.13 (41.03)	56.29 (49.72)	78.45 (62.31)
	0.45	4.82 (12.66)	15.54 (23.19)	30.08 (33.27)	44.61 (41.90)	60.34 (50.94)	83.26 (65.80)
	0.60	6.67 (15.00)	17.29 (24.28)	32.44 (34.7)	46.03 (42.71)	64.50 (53.43)	86.29 (68.19)
	0.75	8.19 (16.64)	20.00 (26.56)	33.12 (35.12)	47.16 (43.39)	66.67 (54.76)	88.73 (70.36)
	1.00	10.33 (18.72)	22.21 (28.11)	35.67 (36.69)	51.82 (46.03)	69.91 (56.73)	90.50 (72.05)
V. lecanii liquid formulation B 8 x 10^8 CFU ml^{-1}	0.15	2.82 (9.63)	14.41 (22.30)	28.00 (31.95)	42.23 (40.51)	57.20 (49.14)	78.71 (62.51)
	0.30	3.91 (11.39)	15.15 (22.87)	29.54 (32.90)	43.61 (41.32)	49.45 (50.48)	82.00 (64.90)
	0.45	5.02 (13.18)	16.56 (24.04)	39.19 (33.96)	45.22 (42.25)	62.18 (52.00)	85.67 (67.78)
	0.60	7.44 (15.79)	18.33 (25.33)	33.36 (35.91)	46.74 (43.11)	66.72 (54.76)	88.14 (69.82)
	0.75	9.26 (14.66)	22.41 (28.25)	35.28 (36.39)	48.83 (44.31)	69.14 (56.23)	90.66 (72.44)
	1.00	12.84 (20.94)	16.64 (24.04)	38.11 (38.12)	52.67 (46.61)	72.69 (59.50)	92.22 (73.78)
V. lecanii WP formulation (Phule Bugicide) 2 x 10^8 CFU ml^{-1}	0.2	10.79 (18.72)	16.27 (23.73)	26.69 (31.11)	44.62 (41.09)	61.50 (51.65)	82.71 (65.42)
Dimethoate	0.30	16.74 (24.20)	28.07 (32.01)	40.19 (39.35)	64.48 (53.37)	71.18 (57.54)	81.82 (64.75)
U. C. (only water spray)*	-	0.00	00.00	0.00	0.00	0.00	0.00
S. E.±	-	1.30	1.56	1.62	1.79	2.55	2.91
C. D. at 5%	-	3.93	4.67	4.84	5.28	7.64	8.79

* The corrected mortality at 7th, 9th and 14th day using Abbott's formula when actual mortality in U.C. was 11.52, 14.06 and 15.83 per cent respectively. ** Figures in parenthesis are arc sin tranformed values.

mortality (16.74 %) was observed in the treatment with dimethoate (0.03 %) after a day of treatment application. The nymphal mortality ranged from 12.66 to 28.07 per cent after 3 days.

Formulation A caused 27.26 to 35.67 per cent mortality against 28.00 to 38.11 per cent in formulation B at 0.15 to 1.00 per cent concentrations. Formulation A at 1.00 per cent concentration showed maximum mortality (35.67 %). However, 0.60 and 0.75 per cent concentrations caused 32.44 and 33.12 per cent mortality, respectively. Formulation B at 1 per cent recorded highest kill of test insect (38.11 %). However, it was on par with the dose of 0.60 per cent (33.36 %) and 0.75 per cent (35.28 %). *V. lecanii* WP (Phule bugicide) 0.2 per cent caused 26.69 per cent mortality, while dimethoate 0.03 per cent killed 40.19 per cent *M. hirsutus* after 5 days of application.

The nymphal mortality was moderate to high (41.16 to 64.48 %) in all the treatments. Although the lethal effect was higher in all treatments, it was significantly less 64.48 % than that of dimethoate 0.03 per cent. Formulation A caused 41.16 to 51.82 per cent mortality, while formulation B showed 42.23 to 52.67 per cent mortality at 7 days of application.

Microscopic examination of *V. lecanii* treated aphid showed presence of mycosis. Formulation A resulted in 55.26 to 69.91 per cent mortality against 57.20 to 72.69 per cent kill in formulation B. Phule bugicide (WP) at 0.2 per cent inflicted 61.50 per cent mortality of mealy bug. Dimethoate (0.03 %) caused highest kill (71.18 %) of the pest after 9 days of treatment.

Formulation A caused 74.22 to 90.50 per cent mortality of mealy bug reaching maximum (90.50 %) at 1.00 per cent concentration. However, 0.45, 0.60 and 0.75 per cent concentrations of the formulation A inflicted at par mortality of test insect. Formulation B at 1.00 per cent concentration gave the highest kill of 92.22 per cent and was on par with 0.45 to 0.75 per cent. Phule bugicide (*V. lecanii* WP) at 0.2 per cent concentration caused 82.71 per cent mortality of mealy bug which were on par with (81.82 %) in dimethoate 0.03 per cent after 14 days of application.

Easwaramoorthi and Jayaraj (1978) obtained 73.10 per cent mortality of *Coccus viridis* by *V. lecanii* alone and addition of 0.05 per cent tween-20 increased the mortality to 92.60 per cent. Gonzalez *et al.*, (1995) observed 84.81 per cent mortality of *Planococcus citri* within 10 days. Kadam and Jaichakravarthy (2003) noted 80.20 per cent mortality of the mealy bug by Phule bugicide (*V. lecanii* WP) 0.2 per cent within 14 days supporting findings.

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Relative Susceptibility of *Helicoverpa armigera* (Hubner) to Insecticides in Western Maharashtra*

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ABSTRACT

The relative susceptibility of *Helicoverpa armigera* (Hubner) collected from different locations (Amalner. Shirpur, Shahada, Madha and Rahuri) to commonly used insecticides *viz*. endosullan, quinalphos. carbaryl, cypermethrin and fenvalerate was assessed by discriminating dose assay in laboratory during 2002-04. Amalner population was found comparatively more resistant to all the insecticides tested. It was followed by Shirpur and Shahada population. However, Madha and Rahuri populations were comparatively less resistant to insecticides. Irrespective of locations, high frequency of resistance was recorded to cypermethrin followed by quinalphos and carbaryl. Fenvalerate was next to follow in the level of resistance exhibited by *H. armigera*, However, comparatively low level of resistance was recorded in case of endosulfan.

Key words : *Helicoverpa armigera*, insecticides, relative susceptibility.

The American bollworm (*Helicoverpa armigera* (Hub.) has remained as the major distinctive pest in cotton belt of Western Maharshlra. It has developed substantial and often- uncontrollable level of resistance to virtually all the neurotoxic insecticides used for its control. (Armes *et al*., 1996; Ragupathy *et al*., 1998; Rao *et al*., 2000 and Kranthi *et al*., 2002). Continued selection with insecticides has allowed the survival of resistant populations, which is difficult to control. However, systematic and scientific assessment of level of resistance is lacking in the Western Maharashtra. In the present study, the level of susceptibility/resistance of *H. armigera* (from five locations) to commonly used insecticides was studied by discriminating dose assay.

MATERIALS AND METHODS

The level of resistance in *H. armigera* was assessed by discriminating dose assay twice in the cropping season of 2003-04. *H. armigera* larvae collected from different locations *viz*. Amalner (Jalgaon). Shirpur (Dhule). Shahada (Nandurbar), Rahuri (Ahmednagar) and Madha (Solapur) were reared on semisynthetic diet in plastic vials individually to avoid cannabalism until pupation. The pupae were surface sterilized with 0.25 per cent sodium hypochloride solution and kept in a cage for adult emergence. Adults were confined in mating chamber with 10 per cent honey as a food source. The eggs laid on black cloth in mating chamber were kept in incubation chamber for hatching. Neonate larvae were transferred to plastic trays containing semisynthetic diet using a camel hairbrush and reared individually to avoid cannabalism. The larva reached third instar stage (approximate weight 30-40 mg) at 6th or 7th day after hatching. Third instar larvae weighing 30-40 mg were used for assessing susceptibility to insecticides.

About forty larvae of *H. armigera* from first generation were exposed to discriminating

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doses of insecticides. Discriminating doses of insecticidal solutions were prepared in acetone. One µl of insecticide was placed on the thoracic dorsum of each larva using a microlitre syringe. Control larvae were treated with acetone alone. The mortality was assessed upto 6 days after treatment. Moribund larvae giving no response to probing were supposed to be dead. The control mortality was corrected by Abbott's (1925) formula. From this, the level of resistance was worked out as suggested by Ragupathy and Dhamu (2001).

RESULTS AND DISCUSSION

Among the populations collected from different regions in Western Maharashtra, Amalner population was found comparatively more resistant to all the insecticides tested (Table 1 to 5). It was followed by Shirpur and Shahada population. However, Madha and Rahuri populations were comparatively less resistant to insecticides. Irrespective of locations, high frequency of resistance was recorded to cypermethrin 0.1 g followed by quinalphos and carbaryl. Cypermethrin 1 g and fenvalerate were next to follow in the level of resistance exhibited by *H. armigera*. However, though significant, comparatively low level of resistance was recorded in case of endosulfan.

The data (Table 6) indicated the development of resistance in *H. armigera* from

Table 1. Resistance of *H. armigera* population from Amalner to different insecticides.

Insecticide	Discriminating dose µg/larva	Population collected in – Early reproductive phase				Population collected in – Peak reproductive phase				Mean % resistance
		No. tested	Corrected mortality %	% resistance	SE ±	No. tested	Corrected mortality %	% resistance	SE ±	
Endosulfan 35 EC	10.00	40	40.0	60.0	7.84	40	37.5	62.5	7.75	61.3
Qinalphos 25 EC	0.75	40	2.5	87.5	5.29	40	15.0	85.0	5.72	86.8
Carbaryl 50 WP	1.00	40	20.0	80.0	6.41	40	22.5	77.5	6.69	78.8
Cypermethrin 25 EC	0.10	40	5.0	95.0	3.49	40	2.5	97.5	2.52	96.3
Cypermethrin 25 EC	1.00	40	17.5	82.5	6.08	40	17.5	82.5	6.08	82.5
Fenvalerate 20 EC	0.20	40	20.0	80.0	6.41	40	22.5	77.5	6.69	78.8

Table 2. Resistance of *H. armigera* population from Shirpur to different insecticides.

Insecticide	Discriminating dose µg/larva	Population collected in – Early reproductive phase				Population collected in – Peak reproductive phase				Mean % resistance
		No. tested	Corrected mortality %	% resistance	SE ±	No. tested	Corrected mortality %	% resistance	SE ±	
Endosulfan 35 EC	10.00	40	42.5	57.5	7.91	40	42.5	57.5	7.91	57.5
Qinalphos 25 EC	0.75	40	17.5	82.5	6.08	40	20.0	80.0	6.41	81.3
Carbaryl 50 WP	1.00	40	25.0	75.0	6.93	40	27.5	72.5	7.15	73.8
Cypermethrin 25 EC	0.10	40	5.0	95.0	3.49	40	7.5	92.5	4.22	93.8
Cypermethrin 25 EC	1.00	40	20.0	80.0	6.41	40	22.5	77.5	6.69	78.3
Fenvalerate 20 EC	0.20	40	25.0	75.0	6.93	40	27.5	72.5	7.15	73.8

all the populations to endosulfan, quinalphos, carbaryl, cypermethrin and fenvalerate. The larvae of *H. armigera* showed highest resistance when exposed to lower dose of cypermethrin followed by quinalphos. However, endosulfan showed lowest resistance of *H. armigera* when exposed to discriminating dose. The data also revealed that *H. armigera* collected from Madha recorded lowest level of resistance lo all the insecticides followed by Rahuri. The *H. armigera* population from Amalner exhibited highest level of resistance to all the insecticides indicating least susceptibility among the five populations. The order of resistance of *H. armigera* to various insecticides in different sampling location was Madha < Rahuri < Shahada < Shirpur < Amalner.

Locational variation in susceptibility of *H. armigera* to different insecticides is very common. Such difference in the sensitivity of *H. armigera* had been attributed to frequent application of different groups of insecticides (Pasupathy and Ragupathy, 1994 and Suryawanshi *et al.*, 2004). Variation in the degree of resistance to different insecticides in *H. armigera* is evident both from earlier findings and the current study.

In the present study, the development of resistance to endosulfan was highest (61.3 %) in Amalner followed by Shirpur (57.5 %),

Table 3. Resistance of *H. armigera* population from Shahada to different insecticides.

Insecticide	Discriminating dose µg/larva	Population collected in								Mean % resistance
		Early reproductive phase				Peak reproductive phase				
		No. tested	Corrected mortality %	% resistance	SE ±	No. tested	Corrected mortality %	% resistance	SE ±	
Endosulfan 35 EC	10.00	40	52.5	47.5	8.00	40	52.5	47.5	8.00	47.5
Qinalphos 25 EC	0.75	40	25.0	75.0	6.95	40	27.5	72.5	7.15	73.8
Carbaryl 50 WP	1.00	40	30.0	70.0	7.34	40	30.0	70.0	7.34	70.0
Cypermethrin 25 EC	0.10	40	7.5	92.5	4.22	40	10.0	90.0	4.80	91.3
Cypermethrin 25 EC	1.00	40	32.5	67.5	7.50	40	32.5	67.5	7.50	67.5
Fenvalerate 20 EC	0.20	40	32.5	67.5	7.50	40	30.0	70.0	7.34	68.5

Table 4. Resistance of *H. armigera* population from Rahuri to different insecticides.

Insecticide	Discriminating dose µg/larva	Population collected in								Mean % resistance
		Early reproductive phase				Peak reproductive phase				
		No. tested	Corrected mortality %	% resistance	SE ±	No. tested	Corrected mortality %	% resistance	SE ±	
Endosulfan 35 EC	10.00	40	60.0	40.0	7.84	40	65.0	35.0	7.64	37.5
Qinalphos 25 EC	0.75	40	35.0	65.0	7.64	40	35.0	65.0	7.64	65.0
Carbaryl 50 WP	1.00	40	40.0	60.0	7.84	40	37.5	62.5	7.75	61.3
Cypermethrin 25 EC	0.10	40	7.5	92.5	4.22	40	22.5	87.5	5.29	90.0
Cypermethrin 25 EC	1.00	40	47.5	52.5	8.00	40	40.0	60.0	7.84	58.8
Fenvalerate 20 EC	0.20	40	42.5	57.5	7.91	40	45.0	55.0	7.97	56.3

Shahada (47.5 %), Rahuri (37.5 %) and lowest in Madha (26.3 %). These findings are almost comparable to 42.5 to 69.2 per cent from Parbhani and Hingoli (Suryawanshi *et al.*, 2004). The resistance development to quinalphos, was highest (86.8 %) in Amalner followed by Shirpur (81.3 %) and Shahada (73.8 %). It was lowest in Madha (61.3 %). Suryawanshi *et al.*, (2004) reported 48.1 to 81.5 per cent resistance in *H. armigera* from Parbhani and Hingoli. However, low level of resistance to the extent of 3 to 50 per cent was noticed in *H. armigera* populations from Nagpur (Anon., 1997).

Similarly, resistance development of carbaryl was highest (78.8 %) in Amalner followed by Shirpur (73.8%) and Shahada (70.0 %) but lowest in Madha (53.8 %). These findings are almost in accordance with Wale (2001) who recorded level of resistance in the range of 41.7 and 84.8 per cent in Akola population. The level of resistance recorded against fenvalerate was highest in Amalner (78.8 %) followed by Shirpur (73.8 %) and Shahada (68.5 %) but lowest in Madha (47.5 %). These findings are almost in agreement with Gouthaman (1994) and Suryawanshi *et al.*, (2004).

Resistance development to cypermethrin 1µ g was highest in Amalner (82.5 %) followed by Shirpur (78.3 %) and Shahada (67.5 %) as compared to 58.8 per cent in case of Madha. Kapoor *et al.*, (2000) reported 50 to 100 per cent resistance to cypermethrin 1.0 g in different cotton growing areas of Punjab. Armes *et al.* (1993) recorded 85.50 to 95.50 per cent resistance to cypermethrin 1.0 g in different populations of Andhra Pradesh.

Table 5. Resistance of *H. armigera* population from Madha to different insecticides.

Insecticide	Discriminating dose µg/larva	Population collected in								Mean % resistance
		Early reproductive phase				Peak reproductive phase				
		No. tested	Corrected mortality %	% resistance	SE ±	No. tested	Corrected mortality %	% resistance	SE ±	
Endosulfan 35 EC	10.00	40	72.5	27.5	7.15	40	75.0	25.0	6.93	26.3
Qinalphos 25 EC	0.75	40	37.5	62.5	7.57	40	40.0	60.0	7.84	61.3
Carbaryl 50 WP	1.00	40	47.5	52.5	8.00	40	45.0	55.0	7.97	53.8
Cypermethrin 25 EC	0.10	40	10.0	90.0	4.80	40	12.5	87.6	5.29	88.8
Cypermethrin 25 EC	1.00	40	42.5	57.5	7.91	40	40.0	60.0	7.84	58.8
Fenvalerate 20 EC	0.20	40	50.0	50.0	8.00	40	55.0	45.0	7.97	47.5

Table 6. Susceptibility of resistance in *H. armigera* to commonly used insecticide from different locations.

Insecticides	Discriminatin dose (mg/larva)	Mean per cent resistance				
		Amalner	Shirpur	Shahada	Rahuri	Madha
Endosulfan 35 EC	10.00	61.3	57.5	47.5	37.5	26.3
Qinalphos 25 EC	0.75	86.8	81.3	73.8	65.0	61.3
Carbaryl 50 WP	1.00	78.8	73.8	70.0	61.3	53.8
Cypermethrin 25 EC	0.10	96.3	93.8	91.3	90.0	88.8
Cypermethrin 25 EC	1.00	82.5	78.3	67.5	58.8	58.8
Fenvalerate 20 EC	0.20	78.8	73.8	68.5	56.3	47.5

Suryawanshi *et al*., (2004) recorded 47.7 and 87.4 per cent resistance in Parbhani and Hingoli, respectively.

The present finding revealed that *H. armigera* from different locations showed 25 to 96 per cent resistance to all these commonly used insecticides. It has been observed that *H. armigera* from low pesticide usage area recorded significant resistance though low as compared to heavy and moderate pesticide usage area. Endosulfan, quinalphos, and carbaryl have been extensively used since their introduction and still continued to be in use in this part of Western Maharashtra. fenvalerate and cypermethrin, introduced in 1980 have also been used indiscriminately in the cotton ecosystem. The selection pressure due to use pattern for almost three decades might be the cause of resistance to these insecticides. Indiscriminate use of insecticides, mixture of different insecticides and repeated applications of these insecticides might have resulted in the development of resistance in *H. armigera* to insecticides.

From the ongoing discussion, it may be suggested that sole reliance on these insecticides should be avoided. The usage of all these insecticides needs to be properly monitored as a strategy to contain the development of resistance. It may be concluded that the usage of different control techniques with integrated approach should be promoted for the effective and economic management of *H. armigera* in the studied locations.

Thus, the susceptibility data indicated that *H. armigera* from different locations showed 25 to 96 per cent resistance to all these commonly used insecticides. The selection paressure due to use pattern for almost three decade might be the cause of resistance to these insecticides in Maharashtra.

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Biology of *Helicoverpa armigera* (Hubner) on Pods of Three Gram Cultivars

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ABSTRACT

The mean incubation period of *H. armigera* varied from 2.96 to 3.01 days on pods of three cultivars of gram. The significantly shortest larval duration (17.43 days), the highest growth index (3.54), the highest per cent pupation and shortest pupal period to the tune of 13.26 days was observed in those larvae which fed on pods of Virat cultivar. The significantly highest pupal duration (14.99 days) and lowest adult emergence (67.00 per cent) was observed on BDN-9-3. The life cycle duration of male and female moths of *H. armigera* was found to be lowest on pods of Virat to the extent of 46.21 and 44.68 days respectively. The significantly highest oviposition period (8 days) was recorded on Virat pods. The significantly highest number of eggs (937.38) laid by female moths which were emerged from the larvae fed on the pods of Virat.

Key words : Biology, pods of gram cultivars, *Helicoverpa armigera*.

Amongst the various insect-pests of pulses, *H. armigera* is the most serious causing appreciable losses. In chickpea this pest possesses a wide variation in growth and development depending upon the cultivars of host plant on which it is reared. According to Bilapate *et al*., (1991) the larval duration of *H. armigera* reared on gram variety GL-600 and BDNG-1-106 has no significant differances and these two had significantly less larval duration than the rest of BDN-86, PBG-83-33, BDNG-2-236, T-69. A poor growth index was observed on variety T-69 and PBG-83-33. Hence the studies on biology of *H. armigera* were conducted on pods of gram cultivars.

MATERIALS AND METHODS

The studies on biology of *H. armigera* were carried out on pods of three different cultivars of gram *viz*., Virat, G-12, BDN-9-3 in a completely randomized design replicated five times under laboratory conditions. Three cultivars of gram were sown in a plot size of 5 x 5 m each at the planting distance of 45 x 15 cm on the farm of College of Agriculture, Latur during *rabi* 2006-2007.

One hundred eggs of *H. armigera* were obtained from the oviposition cage in order to study the biology on pods of each of three gram cultivars. The eggs were transferred to moist tissue paper kept in petriplates with a total of 20 eggs in each petriplate as one replication. The observations on incubation period and per cent egg hatch were recorded. The newly hatched larvae were reared individually in clean plastic boxes on pods of gram cultivars under study as food substrate. The observations on larval duration, per cent larvae pupated, pre-pupal and pupal durations, per cent adult emergence and life cycle duration of male and female moths were recorded on pods of the gram cultivars under study.

The adults emerged (male and female) on

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the same day were paired in 1:1 proportion. Such ten pairs were kept for laying eggs in plastic containers of 15 x 20 cm size. The water soaked sponge was kept at the bottom of the container in order to create humidity. The cotton swabs dipped into 50 per cent honey solution were placed in the containers as food for the moths. The containers were covered with black muslin cloth fitted with the help of rubber band. The observations on pre-oviposition and oviposition periods were also recorded along with the number of eggs laid by each female moth every day till its death. The growth index was calculated by using the formula Growth index = Per cent larvae pupated / Mean larval duration.

RESULTS AND DISCUSSION

The egg duration of *H. armigera* ranged from 2.96 to 3.01 days on pods of gram cultivars. The egg duration of *H. armigera* was reported to be in the range of 2.76 ± 0.43 to 5.17 ± 0.38 days on gram (Srivastava and Saxena, 1958, Hus *et al.*, I960, Reed., 1965 and Singh, 1970). The numerically highest eggs hatch of *H. armigera* to the tune of 90 per cent was recorded on pods of G-12 followed by pods of Virat (88 %) and BDN-9-3 (87 %). The significantly lowest larval duration and highest growth index to the extent of 17.43 days and 3.54 respectively were recorded when grown on pods of Virat, as compared to rest of the gram cultivars (Table 1). On the basis of growth index the preference for pods of food plants could be arranged as Virat followed by G-12 and BDN-9-3. More or less similar larval duration to the extent of 18.0 days on gram, 14.0 and 14.6 days on gram pods and leaves, 14.26 days on gram, 17.0 and 15.0 days on gram leaves and pods and 19.0 days on gram was reported by Dubey *et al.* (1981), Ghosh *et al.* (1986), Bilapate (1988), Bajpai and Sehgal (1993), Choudhary *et al.* (1993), respectively.

The significantly highest pupation of *H. armigera* to the extent of 58.40 per cent was recorded on pods of Virat followed by G-12

Table 1. Growth and development of *H. armigera* on pods of three gram cultivars.

Particulars	Gram cultivars			S. E.±	C. D. at 5%	CV (%)
	Virat	G-12	BDN-9-3			
Mean incubation period (days)	2.96 (9.90)	3.01 (10.00)	3.01 (9.99)	0.07	N. S.	0.22
Per cent egg hatch	88.00 (9.41)	90.00 (9.51)	87.00 (9.35)	0.14	N. S.	1.73
Mean larval duration (days)	17.43 (24.67)	23.03 (28.68)	22.31 (28.19)	0.14	0.44	6.88
Mean per cent larvae pupated	58.40 (7.67)	45.40 (6.77)	38.10 (6.21)	0.09	0.29	9.47
Growth index	3.54	2.30	1.99	0.03	0.09	26.67
Mean pre-pupal duration (days)	3.28 (10.43)	3.22 (10.34)	3.26 (10.39)	0.17	N. S.	3.33
Mean pupal duration (days)	13.26 (21.35)	13.95 (21.93)	14.99 (22.78)	0.086	0.26	2.87
Per cent adult emergency	81.60 (9.06)	74.40 (8.65)	67.00 (8.21)	0.08	0.25	4.56
Mean life cycle duration (♂) (days)	46.21 (42.83)	64.79 (53.61)	52.86 (46.65)	0.62	1.92	10.05
Mean life cycle duration (♀) (days)	44.68 (41.95)	62.57 (52.28)	48.57 (44.18)	0.45	1.39	10.17
Pre-oviposition period (days)	3.33 (10.49)	3.70 (11.07)	3.76 (11.18)	0.33	N. S.	7.19
Oviposition period (days)	8.00 (16.42)	6.50 (14.76)	6.60 (14.88)	0.30	0.91	6.48
Fecundity (Number ♀)	937.38	841.40	800.12	0.30	0.92	4.04
Mean longevity (♂) (days)	9.26 (17.71)	9.00 (17.44)	8.00 (16.83)	0.29	0.89	4.80
Mean langivity (♀) (days)	11.60 (19.91)	9.70 (18.14)	11.20 (19.54)	0.27	0.84	5.06

Figures in parentheses indicate arc sine transformed values.

(45.40 per cent) and BDN-9-3 (38.10 per cent). The pupal duration of *H. armigera* was found to be significantly lowest on pods of Virat (13.26 days) when compared to pods of G-12 (13.95 days) and BDN-9-3 (14.99 days). The pupal duration of *H. armigera* to the tune of 13.2, 13.7, 15.40 (male) and 14.30 (female), 13.8 to 14.9 and 14.0 days was reported on gram by Dhandapani and Balasubramanian (1980), Dubey *et al*. (1981), Bilapate (1988), Srivastava and Srivastava (1990) and Venkataiah *et al*. (1994), respectively. The adult emergence was observed to be significantly maximum on Virat (81.60%) followed by G-12 (74.40%) and BDN-9-3 (67.00%).

The life cycle duration of male, female and in general moths of *H. armigera* was found to be significantly lowest on pods of Virat (46.21, 44.68 and 45.77 days). These investigations are in agreement with the earlier results of Rajgopal and Basavanna, 1982, 41.85 days on Bengal gram.

The significantly minimum pre-oviposition period and highest oviposition period of *H. armigera* to the extent of 3.33 and 8.00 days were recorded on pods of Virat . These results on pre-oviposition and oviposition period of *H. armigera* are in pursuant with the data reported by Dhandapani and Balasubramanian (1980), Bilapate (1988) and Bhatt and Patel (2001) who reported the pre-oviposition and oviposition period of *H. armigera* on gram to the extent of 2.7 and 7.6, 3.17 and 9.27 and 2.85 $\pm$ 0.41 and 7.56 $\pm$ 0.86 days, respectively.

The significantly highest egg laying capacity of *H. armigera* to the tune of 937.38 eggs was recorded on pods of Virat over fecundity on pods of rest of the gram cultivars under study. The results obtained in the present investigations in relation to fecundity are in conformity with the earlier worker, Bhatt and Patel (2001) who reported the egg laying capacity of *H. armigera* to the tune of 996.70 $\pm$ 127.40 eggs per female.

The longevity of female moths was observed to be significantly more on pods of gram variety, Virat (11.60 days) over longevity on pods of G-12 (9.70 days). However, it was at par with longevity on pods of BDN-9-3 (11.20 days). The present findings pertaining to longevity of *H. armigera* are in line with the data reported by Ameta and Bhardwaj (1996) who reported the longevity of moths of *H. armigera* to the tune of 9.68 days on gram pods.

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Biometrics of Leafminer (*Aproaerema modicella* Deventer) on Three Different Host Plants*

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ABSTRACT

The larval growth of *A. modicella* each on soybean, groundnut and bawachi was completed by passing through four instars. The duration of I, II, III and IV larval instars ranged from 2.14 to 2.42, 2.84 to 3.61, 3.31 to 4.01 and 4.70 to 5.13 days, respectively when fed on different host plants under investigation. The mean larval head capsule width of *A. modicella* was found to be 0.12, 0.22, 0.39 and 0.62 mm for I to IV instars, respectively when reared on leaves of soybean. The corresponding values for groundnut and bawachi were 0.12, 0.22, 0.37 and 0.59 mm and 0.12, 0.23, 0.36 and 0.62 mm respectively. The mean observed body length x width of *A. modicella* was 1.11 x 0.22, 2.06 x 0.35, 3.89 x 0.76 and 4.81 x 1.02 mm. for I to IV instars respectively when fed on leaves of soybean. The corresponding values for groundnut and bawachi were 0.98 x 0.19, 2.14 x 0.36, 3.62 x 0.72 and 4.46 x 0.95 mm. and 1.22 x 0.23, 2.16 x 0.39, 3.51 x 0.72 and 4.51 x 0.96 mm respectively. The pupal length, breadth and weight of *A. modicella* on different host plants varied from 3.76 to 3.91 mm 1.01 to 1.24 mm and 2.93 to 3.44 mg respectively.

Key words : *A. modicella*, bawachi, biometrics, groundnut and soybean.

Groundnut and soybean are important oilseed crops grown in different parts of world. The leafminer *Aproaerema modicella* (Deventer) (Lepidoptera : Gelechiidae) is one of the major pests of soybean and groundnut in India (Amin, 1983) and South East Asia (Wightman *et al.*, 1990). More than 50 per

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cent yield losses in groundnut were caused by leafminer (Logiswaran and Mohanasundaram, 1985 and Logiswaran and Madhavarao, 1985). The losses caused by *A. modicella* to soybean were reported to the extent of 40 to 66 per cent (Kalvanasundaram and Murugesan, 1989). So far there is no information available on its comparative biometrics on different host plants, the present study was therefore, undertaken to understand the biometrics of *A. modicella* on groundnut, soybean and bawachi.

MATERIALS AND METHODS

The studies on number of larval instars and biometrics of *A. modicella* were carried out on three host plants *viz*., groundnut, variety TLG-45, soybean variety, JS-335 and bawachi weed (*Psoralea corylifolia*) under ambient room temperature. Three hundred sixty neonate larvae immediately after hatching were transferred into separate plastic boxes and reared individually on fresh leaves of respective host plants. Every day fresh food was provided

Table 1. The mean larval instar duration of *A. modicella* on three different host plants.

Host plants	Larval instar duration (days)				Total larval duration (days)
	I	II	III	IV	
Soybean	2.14 (8.41)	2.84 (9.70)	3.31 (10.49)	4.72 (12.54)	13.01
Groundnut	2.24 (8.60)	3.03 (10.03)	3.41 (10.98)	4.70 (12.52)	13.38
Bawachi	2.42 (8.92)	3.61 (11.11)	4.01 (11.63)	5.13 (13.09)	15.17
Mean	2.27	3.16	3.58	4.85	13.85
S. E.±	0.23	0.09	0.14	0.10	
C. D. at 5%	N.S.	0.29	0.42	0.32	
C. V. (%)	6.11	6.35	5.08	2.75	

Figures in parentheses indicate arcsine transformed values.

Table 2. Comparison of observed and calculated values of mean measurements of larval head capsule width (mm) of *A. modicella* on three different host plants.

Host plants	Parameters	Larval instars				Progression factor
		I	II	III	IV	
Soybean	Observed head capsule width (mm) ± S. E.	0.12 ±0.00	0.22 ±0.01	0.39 ±0.00	0.62 ±0.01	
	Growth ratio	-	1.83	1.77	1.59	1.73
	Calculated head capsule width (mm)	0.12	0.21	0.37	0.64	
	Growth ratio	-	1.75	1.76	1.73	1.75
	Difference	0.00	0.01	0.02	-0.02	
	Per cent difference	0.00	4.55	5.13	-3.23	
Groundnut	Observed head capsule width (mm) ± S. E.	0.12 ±0.00	0.22 ±0.01	0.37 ±0.00	0.59 ±0.01	
	Growth ratio	-	1.83	1.68	1.59	1.70
	Calculated head capsule width (mm)	0.12	0.21	0.36	0.61	
	Growth ratio	-	1.75	1.71	1.69	1.72
	Difference	0.00	0.01	0.00	-0.02	
	Per cent difference	0.00	4.55	2.70	-3.39	
Bawachi	Observed head capsule width (mm) ± S. E.	0.12 ±0.00	0.23 ±0.01	0.36 ±0.00	0.62 ±0.01	
	Growth ratio	-	1.92	1.57	1.72	1.74
	Calculated head capsule width (mm)	0.13	0.21	0.37	0.63	
	Growth ratio	-	1.62	1.76	1.70	1.69
	Difference	-0.01	0.02	-0.01	-0.01	
	Per cent difference	-8.33	8.70	-2.78	-1.61	

to the larvae. The observations on the casting of larvae were made under microscope during each instar. Immediately after moulting the head capsule width and body length and width of each larva were measured with the help of ocular and stage micrometer to the nearest value of 0.0091 mm. The larval instar duration of *A. modicella* was recorded on three different host plants. The application of Dyar's rule (1890) was tested for the number of larval instars when fed on different host plants.

The regression relationship between the instar and mean value of head capsule width and larval body length and width in different instars was calculated using the formula $Log_{10} Y = a + b_x$

Where,

Y = Head capsule width / body length / body width of larva (mean)

a = Constant

b = Logarithum of growth ratio

x = Number of instars

The growth ratio was calculated by dividing the mean value of head capsule width / body length / body width of larval instar by the value of mean head capsule width / body length / body width of larva of preceding instar. Progression factor is the average of growth ratio.

RESULTS AND DISCUSSION

The larval growth of *A. modicella* was completed by passing through four instars each when fed on leaves of soybean, groundnut and bawchi separately. The study indicated that the number of larval instars was not influenced by food plants. The duration of I, II, III and IV larval instars of *A. modicella* ranged from 2.14

Table 3. Comparison of observed and calculated values of mean measurements of larval body length (mm) of *A. modicella* on three different host plants.

Host plants	Parameters	Larval instars				Progression factor
		I	II	III	IV	
Soybean	Observed body length (mm) ± S. E.	1.11 ±0.01	2.06 ±0.07	3.89 ±0.07	4.81 ±0.12	
	Growth ratio	-	1.86	1.89	1.24	1.66
	Calculated body length (mm)	1.20	1.99	3.29	5.44	
	Growth ratio	-	1.66	1.30	1.65	1.54
	Difference	-0.09	0.07	0.60	-0.63	
	Per cent difference	-8.11	3.40	15.42	-13.10	
Groundnut	Observed body length (mm) ± S. E.	0.98 ±0.01	2.14 ±0.07	3.62 ±0.07	4.46 ±0.12	
	Growth ratio	-	2.18	1.69	1.23	1.70
	Calculated body length (mm)	1.13	1.87	3.11	5.16	
	Growth ratio	-	1.65	1.66	1.66	1.66
	Difference	-0.15	0.27	0.51	-0.70	
	Per cent difference	-15.31	12.62	14.09	-15.70	
Bawachi	Observed body length (mm) ± S. E.	1.22 ±0.01	2.16 ±0.07	3.51 ±0.07	4.51 ±0.12	
	Growth ratio	-	1.77	1.63	1.28	1.57
	Calculated body length (mm)	1.31	2.04	3.17	4.92	
	Growth ratio	-	1.56	1.55	1.55	1.55
	Difference	-0.09	0.12	0.34	-0.41	
	Per cent difference	-7.38	5.56	9.69	-9.09	

to 2.42, 2.84 to 3.61, 3.31 to 4.01 and 4.70 to 5.13 days, respectively when fed on different host plants under study (Table 1).

The significantly minimum duration to the tune of 2.84 and 3.31 days was required by 11 and III larval instars when fed on soybean over respective larval instar durations on groundnut and bawachi. The duration of IV larval instar was observed to be significantly lowest on groundnut (4.70 days) over bawachi. Many earlier workers reported different number of larval instars when fed on different food plants. However, the present findings are in conformity with that of Gujarati *et al*., (1973). Patnaik and Senapati (1974) and Lavekar *et al*., (1992). Gujarati et al., (1973) reported the duration of *A. modicella* for I to IV larval instars in the range of 2 to 3, 2 to 4, 2 to 4 and 2 to 5 days on groundnut, respectively.

The studies on biometrics of *A. modicella* were made by measuring their larval head capsule width and body length and width when fed on leaves of soybean, groundnut and bawachi. According to Dyar (1890), the head capsule width of any lepidopterous larvae is more or less constant for any instar of a given species. Also the successive larval instars of given species show more or less regular geometrical progression in the growth of head capsule. He also described that the growth ratio of the mean head capsule width of each instar and that of the preceding one indicate growth directly i.e. greater the ratio, greater is the growth. The ratio is also known as Dyar's ratio. The mean larval head capsule width was found to be 0.12, 0.22, 0.39 and 0.62 on soybean, 0.12, 0.22, 0.37 and 0.59 on groundnut and 0.12, 0.23, 0.36 and 0.62 on bawachi for I to IV instars, respectively. The observed progression factors for head capsule width on

Table 4. Comparison of observed and calculated values of mean measurements of larval body width (mm) of *A. modicella* on three different host plants.

Host plants	Parameters	Larval instars				Progression factor
		I	II	III	IV	
Soybean	Observed body width (mm) ± S. E.	0.22 ±0.01	0.35 ±0.01	0.76 ±0.01	1.02 ±0.02	
	Growth ratio	-	1.59	2.17	1.34	1.70
	Calculated body width (mm)	0.22	0.38	0.65	1.11	
	Growth ratio	-	1.73	1.71	1.71	1.72
	Difference	0.00	-0.03	0.11	-0.09	
	Per cent difference	0.00	-8.57	14.47	-8.82	
Groundnut	Observed body width (mm) ± S. E.	0.19 ±0.01	0.36 ±0.01	0.72 ±0.01	0.95 ±0.02	
	Growth ratio	-	1.89	2.00	1.32	1.74
	Calculated body width (mm)	0.20	0.35	0.61	1.06	
	Growth ratio	-	1.75	1.74	1.74	1.74
	Difference	-0.01	0.01	0.11	-0.11	
	Per cent difference	-5.26	2.78	15.28	-11.58	
Bawachi	Observed body width (mm) ± S. E.	0.23 ±0.01	0.39 ±0.01	0.72 ±0.01	0.96 ±0.02	
	Growth ratio	-	1.70	1.85	1.33	1.63
	Calculated body width (mm)	0.24	0.39	0.64	1.04	
	Growth ratio	-	1.63	1.64	1.63	1.63
	Difference	-0.01	0.00	0.08	-0.08	
	Per cent difference	-4.35	0.00	11.11	-8.33	

soybean, groundnut and bawachi were 1.73, 1.70 and 1.74, respectively (Table 2).

These results on head capsule width are in agreement with that of Lavekar *et al.* (1992) who reported the larval head capsule width of soybean leafminer to the extent of 0.14, 0.21, 0.39 and 0.50 mm for I to IV instars, respectively. The calculated values of larval head capsule width of respective instars on soybean, groundnut and bawachi were more or less similar to that of observed values. When the logs of head capsule width were plotted in relation to different larval instars of *A. modicella* reared on soybean, groundnut and bawachi, a definite geometrical relationship was observed for all the instars on tested food plants as derived by Dyar (1890). Thus the data on head capsule width supported the Dyar's hypothesis indicating that the four larval instars of *A. modicella* observed in the present investigations are fairly constant on soybean, groundnut and bawachi. The mean observed body length of *A. modicella* for I to IV instar larvae was 1.11, 2.06, 3.89 and 4.81 mm when reared on soybean. The corresponding values on groundnut and bawachi were 0.98, 2.14, 3.62 and 4.46 mm and 1.22, 2.16, 3.51 and 4.51 mm. The observed progression factor for larval body length when fed on leaves of soybean, groundnut and bawachi was 1.66, 1.70 and 1.57 respectively (Table 3).

The mean body width of *A. modicella* for I to IV instar larvae when fed on leaves of soybean was 0.22, 0.35, 0.76 and 1.02 mm. The corresponding values on groundnut and bawachi were 0.19. 0.36, 0.72 and 0.95 mm and 0.23, 0.39, 0.72 and 0.96 mm. The mean progression factor for larval body width on soybean, groundnut and bawachi was 1.70, 1.74 and 1.63 respectively (Table 4).

The results of present investigation in respect of larval body length and width are in accordance with the earlier workers. According to Nair (1975) and Shanower *et al.*, (1993), the last instar larvae of *A. modicella* fed on groundnut leaves measured to the extent of 6.00 mm in length, while Subramanyam *et al.*, (2000) observed 5 to 7 mm length. The statistically non-significant differences were observed in respect of pupal length, breadth and weight of *A. modicella* on different host plants (Table 5). However, it varied from a 3.76 to 3.91 mm, 1.01 to 1.24 mm and 2.93 to 3.44 mg on different host plants. It indicated that the host plants under study did not affect the pupal measurements significantly. Similar studies in respect of pupal weight were also conducted by Motka *et al.*, (1985) who recorded the highest pupal weight of *A. modicella* (4.64 mg) on JL-24 variety of groundnut as compared to R-33-1 (2.30 mg).

Table 5. The mean pupal length, width and weight of *A. modicella* on three different host plants.

Host plants	Pupal length (mm)		Pupal width (mm)		Pupal wt. (mg)	
	Male	Female	Male	Female	Male	Female
Soybean	3.78	3.84	1.01	1.10	2.93	3.23
Groundnut	3.87	3.84	1.04	1.09	3.03	3.44
Bawachi	3.76	3.91	1.04	1.24	3.08	3.23
S. E.±	0.08	0.06	0.02	0.09	0.10	0.11
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C. V. (%)	4.47	3.36	3.88	16.67	7.31	7.58

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Efficacy of Phosphate Solubilizing Isolates from Rhizosphere of Pigeonpea

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ABSTRACT

The phosphate solubilizing capacity of the isolates ranged from 47.40 to 61.00 per cent using tricalcium phosphate and from 9.00 to 18.20 per cent using rock phosphate as P source. The results also indicated that the 30°C temperature was most favourable for maximum P solubilization, except for *Aspergillus fumigatus*, which solubilized maximum phosphate at 35°C. The incubation period of 14 days was optimum for maximum phosphate solubilization by the isolates. The optimum pH for P solubilization was 6 and 8 for fungal and bacterial isolates, respectively.

Key words : Phosphate solubilizing microorganisms, rock phosphate, tricalcium phosphate.

A major portion of phosphatic fertilizers applied for crop production gets fixed in the soil. On an average only 15-20 per cent of it is utilized by crop and rest gets fixed in the soil and becomes unavailable to plants (Wani, 1980 and Gaur, 1985).

The soil microorganisms are known to play an important role in solubilizing phosphate in

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soil and making it available to plants. Pigeonpea crop requires as high as 50 kg P_2O_5 ha^{-1} and suffers from P deficiency in P fixing soils. Keeping this in view the present investigation was conducted.

MATERIALS AND METHODS

Twenty soil samples were collected from rhizosphere of pigeonpea grown in the farm area of the Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, and villages Kapadane and Devbhane of Dhule district and Kundewadi and Dhikshi of Nashik district. For isolation of phosphate solubilizing bacteria and fungi Pikovaskaya's liquid medium was used. The pH of the medium was adjusted to 6.5. Only the amount of tricalcium phosphate was excluded and definite amount of the same or other form was added as per the treatments.

Isolations of phosphorus solublizing micro-organisms was done by the serial dilution and plating method (Aneja, 1993).

The isolates showing transparent zones of clearing around the microbial colonies were transferred on slants of Pikovaskaya's medium and maintained for further studies.

Pikovaskaya's agar medium of 6.5 pH was prepared and inoculated at the centre in the petriplates so that zone of P solubilization would be observed clearly within 4-5 days.

Similarly phosphate solubilizing ability of the isolates was tested in liquid medium by using pure tricalcium phosphate and rock phosphate supplying 50 mg of P in 50 ml of medium maintaining suitable control.

Phosphorus solubilized was determined by chlorostannous acid reduced molybdophosphoric blue colour method in HCL-system using Spectronic-20 with 660 nm red filter (Jackson, 1971). The pH of the liquid medium was also determined after two weeks incubation period by using Elico pH meter.

The pH of the liquid medium was adjusted with standard buffer solution to pH 3, 4,5,6,7,8 and 9. After two weeks incubation period, phosphorus solubilized was determined for each pH by chlorostannous acid reduced molybdophosphoric blue colour method in HCL system (Jackson, 197l).

Further the isolates after inoculation in medium were incubated at 30°C for 7, 14, 21 and 28 days along with the control. The amount of P solubilized was determined by using Elico pH meter.

In temperature requirement study the medium were inoculated with the micro-organisms and incubated for two weeks at 25, 30, 35 and 40°C temperature along with the control. The amount of P solubilized was determined by chlorostannous acid reduced molybdophosphoric blue colour method in HCL-system. The final pH of the liquid medium was determined by using Elico pH meter (Jackson, 1971).

Table 1. Phosphate solubilization by the isolate in liquid medium using tricalcium phosphate and rock phosphate.

Isolate	Tricalcium phosphate		Rock phosphate	
	Final pH after two weeds	P solubi-lization (%)	Final pH after two weeds	P solubi-lization (%)
Fungal isolates :				
Aspergillus fumigatus	4.8	51.00	4.70	9.00
Aspergillus niger	4.8	61.00	4.93	17.40
Aspergillus awamori	4.7	57.00	4.80	9.50
Control	6.4	-	6.45	-
Bacterial isolates :				
Bacillus strain-1	4.8	55.00	4.90	18.20
Bacillus strain-2	4.7	47.40	4.84	16.60
Control	6.4	-	6.45	

RESULTS AND DISCUSSION

Phosphate solubilizing ability : The fungal isolates *Aspergillus fumigatus*, *A. niger*, *A. awamori*, *Bacillus* strain-1 and *Bacillus* strain-2 which were recovered from the rhizosphere of pigeonpea were found to produce prominent zone of phosphate solubilization and proved to possess the ability to solubilize insoluble phosphate.

Among the fungal isolates *Aspergillus niger* and *A. awamori* produced more prominent zones of phosphate solubilization than *A. fumigatus*, whereas in case of bacterial isolate *Bacillus* strain-1 showed more prominent zone as compared to *Bacillus* strain-2.

All the isolates solubilized P in the range of 47.40 to 61.00 per cent (Table 1) using tricalcium phosphate and 9.00 to 18.20 per cent using rock phosphate as P source. The fungal isolates *Aspergillus niger* and *A. awamori* solubilized more phosphate as compared to bacterial isolates *Bacillus* strain-1 and *Bacillus* strain-2, respectively. The solubilization of tricalcium phosphate through isolates was comparatively more than rock phosphate except *Aspergillus niger* and *Bacillus* strain-1. The pH of the Pikovaskaya's liquid medium using tricalcium phosphate or rock phosphate changed from 6.4 to 4.7 indicating the production of acid by all the isolates. Tricalcium phosphate was easily and effectively solubilized as compared to rock phosphate (Wani *et al*., 1979). Similar results were obtained by Singh and Kapoor, (1994).

Table 2. Effect of the incubation temperature on phosphate solubilization by the isolates.

Isolates	Incubation temperature °C							
	25		30		35		40	
	Final pH	% P solubili-zation	Final pH	% P solubili-zation	Final pH	% P solubili-zation	Final pH	% P solubili-zation
Aspergillus fumigatus	4.9	15.90	4.6	46.50	4.3	62.50	4.2	55.50
Aspergillus niger	5.0	17.20	4.7	52.30	4.2	50.00	4.1	34.50
Bacillus strain-1	5.1	16.30	4.5	44.50	4.2	45.50	4.4	37.80
Bacillus strain-2	4.7	16.00	4.1	41.60	4.0	40.60	4.3	32.60

Note : The values for P solubilization are corrected for the blank (uninoculated control).

Table 3. Effect of the incubation period on phosphate solubilization by the isolates.

Isolates	Incubation period (days)							
	25		30		35		40	
	Final pH	% P solubili-zation	Final pH	% P solubili-zation	Final pH	% P solubili-zation	Final pH	% P solubili-zation
Aspergillus fumigatus	4.9	28.60	4.8	55.20	4.5	46.50	4.3	46.80
Aspergillus niger	5.3	22.50	4.7	46.60	4.3	42.20	4.2	38.50
Bacillus strain-1	5.0	17.90	4.9	49.50	4.6	41.60	4.6	37.60
Bacillus strain-2	4.8	13.60	4.1	40.60	4.2	31.50	4.1	30.10

Note : The values for P solubilization are corrected for the blank (uninoculated control).

The results also indicated that the isolates produced acid as evidenced from the change in pH of the medium from 6.4 to 4.7 when tricalcium phosphate or rock phosphate was used as P source. The change in pH of the medium due to activities of P solubilizing micro-organisms in liquid medium has also been reported earlier by (Sattar and Gaur, 1986, Yadav and Shigh, 1991).

The maximum phosphate solubilization by the microorganisms was at incubation temperature 30°C except isolate *Aspergillus fumigatus* (Table 2) which showed maximum solubilization of phosphate at 35°C. The minimum solubilization of phosphate was observed at 25°C. In general, results indicated that an optimum temperature for phosphate solubilization was 30°C. The present results are in conformity with the earlier reports of Wani *et al.*, (1979) and Gaind and Gaur (1991).

The results indicated that the maximum solubilization of phosphate (Table 3) by the bacteria and fungal isolates was at 14 days of incubation as reported earlier by Wani *et al.* (1979) and Singh and Kapoor, (1994). Further the maximum percentage of phosphate solubilization by the fungal isolates was obtained at pH 6, while the bacterial isolates solubilized maximum phosphate at pH 8. Fungal isolates *Aspergillus fumigatus*, *A. niger*, *A. awamori* solubilized maximum phosphate i.e. 44.10, 49.10, 41.60 per cent respectively at pH 6. Among bacterial isolates *Bacillus* strain-1 and Bacillus strain-2 were found to solubilized maximum phosphate i.e. 54.80 and 52.60 per cent, respectively at pH 8.00. The overall results indicated that the optimum pH for phosphate solubilization by the fungal and bacterial isolates under study was 6 and 8, respectively. Similar results were obtained by Wani *et al.*, (1979).

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Effect of Sulphur Oxidizing Microorganisms on Nutrient Availability in Soil under Soybean*

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ABSTRACT

Sulphur oxidizing microorganisms showed synergistic effect on nutrient availability under soybean cropped soil. The composite culture of microorganisms *viz*., *Thiobacillus thiooxidans, Aspergillus terreus, A. niger, Trichoderma harzianum* and *Myrothecium cinctum* was found to be the most effective in increasing available nitrogen, phosphorus, potash and sulphur in soil. Among the cultures, *Thiobacillus thiooxidans* showed superior results over all the fungal cultures. The available nitrogen, phosphorus, potash and sulphur were increased from 119.82 to 127.89, 15.47 to 19.31, 140.05 to 145.08 kg ha^{-1} and 19.70 to 39.65 mg kg^{-1} respectively. The sulphur treatment alone also increased nutrients in soil significantly over control. The sulphur uptake by soybean crop increased from 249 to 367 mg 100 g^{-1} dry weight of plant and soil pH reduced from 7.6 to 7.0 during crop growth period due to inoculation of sulphur oxidizing microorganisms with sulphur application. The combined inoculation of sulphur oxidizing microorganisms with sulphur can be adopted as a mean to attain high nutrient availability in soil under soybean.

Key words : Sulphur oxidizing microorganisms, soil nutrients, soybean.

Some heterotrophic microorganisms of the genera *viz*., *Aspergillus, Myrothecium, Scolecobasidium* and *Trichoderma* can participate in sulphur oxidation in the soil. In due course of oxidation, elemental sulphur produces sulphate and sulphuric acid and both these products of reaction have greatest value to fulfill the sulphur requirement, lowering the soil pH and making the other macro and micronutrients available to the plants. In view of the importance gained by the sulphur oxidizing microorganisms, it was felt worthwhile to undertake the study on this topic.

MATERIALS AND METHODS

A pot culture experiment was conducted in factorial completely randomized design (FCRD) with three replications during *kharif* 2005. There were eighteen combinations of the treatments comprising of nine cultures and two sulphur levels (Table 1). The recommended dose of NPK (50:75:00 kg ha^{-1}) and elemental sulphur powder 100 kg ha^{-1} were applied on soil weight basis and evenly distributed in the pots. The bacterial cultures under study were obtained from National Chemical Laboratory, Pune and fungal cultures from Department of Plant Pathology and Agril. Microbiology, College of Agriculture, Pune. The bacterial cultures were further multiplied in sulphur liquid medium (Waksman, 1922) and fungal cultures on modified sulphur medium (Wainwright, 1978). The microorganisms having 10^7 CFU ml^{-1} were inoculated in the soil before sowing @ 250 ml pot^{-1}. The soybean cv. MACS-124 was sown in each pot and finally three plants were kept pot^{-1} for analysis. The soil samples were analysed before sowing and after harvesting of crop for availability of nutrients. The available nutrients *viz*., N,P,K and S were estimated by adopting the methods described

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by Piper (1996) and sulphur uptake in soybean crop was determined by turbidometric method (Kanwar and Chopra, 1980).

RESULTS AND DISCUSSION

The available N content of soil after harvesting of crop (Table 1) revealed that all the cultures with and without sulphur increased available N of the soil significantly over the control. The interaction effects of culture and sulphur showed that each culture has recorded higher N with sulphur than the culture alone. Further it is interesting to note that maximum available N content in soil was recorded under composite culture treatment with sulphur followed by *Thiobacillus thiooxidans* (SB-4), *T. thiooxidans* (SB-1), *Aspergillus terreus* (SF-5), *A. terreus* (SF-2), *Myrothecium cinctum* (SF-4), *Trichoderma harzianum* (SF-9), *Aspergillus niger* (SF-10) and minimum with the control, i.e. 130.02, 128.82, 127.49, 126.04, 124.80, 123.51, 122.38, 121.27 and 120.35 kg ha^{-1} respectively. More or less similar trend of the results were also observed in respect of available P and K in soil. Available P and K were increased due to inoculation of cultures with sulphur treatments from 15.65 to 20.27 kg ha^{-1} and 140.25 to 146.05 kg ha^{-1} respectively. Deokar (1998) reported that sulphur application increases the available N, P and K content in soil. The major and micronutrients were also increased due to sulphur and microorganisms treatments (Mc Lean, 1971 and Sangale, 1999).

The available sulphur in soil (Table 2) was increased due to inoculation of sulphur oxidizing microorganisms in conjunction with sulphur application. The maximum sulphur (39.65 mg kg^{-1} soil) was observed in composite culture treatment followed by *Thiobacillus* (36.05 mg), *Aspergillus* (32.70 mg), *Myrothecium* (27.80 mg) and *Trichoderma* culture (25.25 mg kg^{-1} soil). The sulphur treatment alone also helped in increasing available sulphur level in soil from 7.10 to 32.30 mg kg^{-1} soil.

Table 1. Effect of sulphur oxidizing microorganisms on available N, P and K in the soil.

Treatments	Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})		
	With sulphur	**Without sulphur**	**Mean**	**With sulphur**	**Without sulphur**	**Mean**	**With sulphur**	**Without sulphur**	**Mean**
Aspergillus niger (SF-10)	121.47	120.09	120.78	16.17	15.72	15.95	140.93	140.25	140.59
Trichoderma harzianum (SF-9)	122.38	120.74	121.56	16.69	16.02	16.36	141.67	140.73	141.20
Myrothecium cinctum (SF-4)	123.51	121.18	122.35	17.04	16.43	16.74	142.34	141.17	141.76
Aspergillus terreus (SF-2)	124.80	121.91	123.36	17.61	16.89	17.25	143.02	141.86	142.44
Aspergillus terreus (SF-5)	126.04	122.63	124.34	18.13	17.21	17.67	143.83	142.29	143.06
Thiobacillus thiooxidans (SB-1)	127.49	123.45	125.47	18.78	17.66	18.22	144.51	142.98	143.75
Thiobacillus thiooxidans (SB-4)	128.82	124.39	126.61	19.48	18.08	17.78	145.29	143.67	144.48
Composite culture	130.02	125.76	127.89	20.07	18.54	19.31	146.05	144.11	145.08
Control	120.35	119.28	119.82	15.65	15.29	15.47	140.25	139.84	140.05
Mean	124.97	122.16	-	17.74	16.87	-	143.09	141.88	-
Characters	S. E. ±	C. D. at 5%		S. E. ±	C. D. at 5%		S. E. ±	C. D. at 5%	
Culture	0.09	0.27		0.01	0.04		0.15	0.44	
Sulphur	0.20	0.58		0.25	0.74		0.32	0.93	
Culture x Sulphur	0.06	0.19		0.08	0.24		0.11	0.31	

Initial available 'N, P, K' in the soil were = 244, 18.02 and 238 kg ha^{-1} respectively.

Table 2. Effect of sulphur oxidizing microorganisms on available sulphur, pH of soil and sulphur uptake.

Treatments	Available 'S' (mg ha^{-1})			pH of the soil			Sulphur uptake (mg $100g^{-1}$)		
	With sulphur	Without sulphur	Mean	With sulphur	Without sulphur	Mean	With sulphur	Without sulphur	Mean
Aspergillus niger (SF-10)	36.10	10.30	23.20	7.53	7.72	7.63	317	255	286
Trichoderma harzianum (SF-9)	38.40	12.10	25.25	7.45	7.65	7.55	322	260	291
Myrothecium cinctum (SF-4)	40.20	15.40	27.80	7.40	7.59	7.50	329	264	297
Aspergillus terreus (SF-2)	43.50	18.20	30.85	7.33	7.52	7.43	337	269	303
Aspergillus terreus (SF-5)	45.70	19.70	32.70	7.25	7.44	7.35	342	275	309
Thiobacillus thiooxidans (SB-1)	48.30	21.23	34.80	7.17	7.40	7.29	348	280	314
Thiobacillus thiooxidans (SB-4)	49.30	22.80	36.05	7.10	7.35	7.23	353	284	319
Composite culture	43.70	25.60	39.65	7.01	7.29	7.15	367	293	330
Control	32.30	7.10	19.70	7.67	7.83	7.75	311	249	280
Mean	43.06	16.94	-	7.32	7.53	-	336.22	269.89	-
Characters	S. E. ±	C. D. at 5%		S. E. ±	C. D. at 5%		S. E. ±	C. D. at 5%	
Culture	0.05	0.15		0.005	0.015		1.60	4.44	
Sulphur	0.02	0.07		0.002	0.007		0.75	2.09	
Culture x Sulphur	0.01	0.05		0.001	0.005		0.53	1.47	

Initial available 'S' in the soil = 5.2 mg kg^{-1}, Initial pH of the soil = 8.01.

The sulphur uptake by soybean crop (Table2) revealed that all the cultures with or without sulphur treatment increased sulphur uptake significantly over control. The sulphur uptake ranged from 249 to 367 mg 100^{-1} g dry weight of plant and maximum was observed in composite culture treatment. The sulphur uptake also increased due to sulphur application alone from 269.89 to 336.22 mg 100^{-1} g dry weight of plant. Earlier, Shinde *et al.*, (2000) recorded similar results in groundnut and cotton crops. The observations in respect of soil pH (Table 2) revealed that sulphur oxidizing microorganisms could reduce pH level of soil and the results were more pronounced in sulphur application alongwith cultures. The maximum reduction (7.0) was recorded by the composite culture with sulphur treatment and the reduction in pH ranged from 7.2 to 7.0. The sulphur alone also reduced the soil pH from 7.5 to 7.3 and minimum reduction (7.8) in the control treatment. Several workers also reported that sulphur oxidizing microorganisms could reduce the soil pH and increases the available sulphur and its uptake in plants (Starkey, 1950 and Jazen and Bettany 1987).

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Imidacloprid, the Potential Pesticide Against Sucking Pests of Okra

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ABSTRACT

Field experiment was conducted in summer to evaluate neem formulations in alternation with synthetic insecticides against sucking pests of okra. The result revealed that, imidacloprid (0.004%) was the most superior treatment followed by cypermethrin (0.01%), the treatment with neem formulations *viz*., Achook (0.5%), ZA-199 (0.5%), NSKE (5%) alternated with imidacloprid (0.004%) and cypermethrin (0.01%) was found promising in checking the population of aphids and jassids infesting okra.

Key words : Imidacloprid, neem formulations, cypermethrin, sucking pest, okra.

Okra (*Abelmoschus esculentus* (L.) Moench) is a very popular vegetable grown throughout India during all the seasons of the year. Okra is a good source of vitamins, proteins, minerals and excellent source of iodine. This crop is attacked by a number of pests. Butani and Verma, (1976) listed 20 pests infesting okra. Among these, the most important pests include, aphids (*Aphis gossypii*), jassids (*Amrasca biguttula biguttula*) and shoot and fruit borer (*Earias vitella*). These pests were found to be predominantly present on okra crop grown in Pune area in Maharashtra. It was therefore, decided to manage these pests with imidacloprid, cypermethrin and neem based insecticides.

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MATERIALS AND METHODS

Field bio-efficacy studies against sucking pests of okra were carried out during summer season of 2001 at the experimental farm of Entomology Section, College of Agriculture, Pune (M.S.), The experiment was laid out in a randomized block design with 12 treatments, including untreated control, replicated thrice.

The spacing of okra variety 'Arka Anamika' was maintained at 30 x 10 cm with individual plot size of 3.5 x 2.5 m^2. The recommended doses of fertilizers were applied. The treatment comprised spraying with neem formulations *viz*., Achook (0.5%), ZA-199 (0.5%), NSKE (5%) and synthetic insecticides *viz*., cypermethrin (0.01 %) and imidacloprid, (0.004%). These were sprayed alone and in alternation, 4 times at an interval of 15 days.

The observations on aphids and jassids, were recorded one day before spraying as pre-treatment counts. The post treatment counts were recorded at 2nd, 5th and 15th day after each spraying.

RESULTS AND DISCUSSION

The average number of aphids (Table 1) prior to insecticidal treatments ranged from 3.2 to 13.86. The difference among the treatments were non-significant. After 2 days of spraying, the treatment comprising imidacloprid (0.004%) was found to be effective (2.60 aphids per plant). All other treatments were at par except ZA-199 (0.5%) which recorded 8.31 aphids per plant. Five days after spraying the number of aphids ranged from 0.80 to 4.03 per plant in the insecticidal treatments as against 16.36 aphids per plant in untreated control. Imidacloprid, (0.004%) was again found to be most effective (0.80 aphids per plant) and was on par with all other treatments except ZA - 199 (0.5%) alternated with imidacloprid, 0.004 per cent (3.15 aphids per plant). After 15 days of spraying it was observed that all the treatments were superior over control. Average number of aphids ranged from 5.10 to 12.26 per plant in insecticide treatments as against 20.70 population per plant in control. The treatment comprising imidacloprid (0.004%) proved to be most effective (5.10 aphids per plant) and was on par with all other treatments except ZA-199 (0.5%) and NSKE (5%) alternated with cypermethrin (0.01 %).

It is evident that all the insecticidal treatments were superior in checking aphid population in okra at 2, 5 and 15 days after spraying as against untreated control. However, the treatment with imidacloprid (0.004%) was found to be most effective followed by cypermethrin (0.01 %.). Similar findings were reported by Calafiori *et al.*, (1998) who tested imidacloprid at different concentrations against aphids infesting cotton.

Table 1. Effect of neem formulations alone and in alternation with synthetic insecticides against aphids infesting okra.

Treatments	Pre-count	Mean aphids per plant days after spraying		
		2	5	15
Achook 0.5%	10.53 (2.62)	5.31 (2.23)	2.53 (1.52)	8.10 (2.84)
ZA-199 0.5%	12.86 (3.34)	8.31 (2.78)	4.03 (1.85)	12.26 (3.41)
NSKE 5%	9.26 (2.66)	5.13 (2.25)	2.01 (1.41)	7.90 (2.80)
Cypermethrin 0.01%	7.80 (2.54)	4.03 (2.00)	0.91 (0.95)	7.55 (2.74)
Imidacloprid 0.004%	3.20 (1.78)	2.60 (1.59)	0.80 (0.85)	5.10 (2.20)
Achook 0.5% alternated with Cypermethrin 0.01%	4.93 (2.21)	3.32 (1.81)	2.95 (1.62)	7.30 (2.69)
ZA-199 0.5% alternated with Cypermethrin 0.01%	8.13 (2.79)	4.06 (1.97	1.85 (1.30)	7.40 (2.70)
NSKE 5% alternated with Cypermethrin 0.01%	7.13 (2.67)	5.01 (2.23)	2.26 (1.47)	8.36 (2.88)
Achook 0.5% alternated with Imidacloprid 0.004%	3.46 (1.84)	2.95 (1.66)	1.05 (1.02)	5.83 (2.41)
ZA-199 0.5% alternated with Imidacloprid 0.004%	8.60 (2.79)	5.11 (2.22)	3.15 (1.70)	8.33 (2.86)
NSKE 5% alternated with Imidacloprid 0.004%	5.06 (2.17)	3.30 (1.81)	1.36 (1.15)	6.38 (2.52)
Untreated control	13.86 (3.33)	17.20 (4.14)	16.36 (4.02)	20.78 (4.55)
S. E.±	0.71	0.25	0.28	0.23
C. D. at 5%	NS	0.72	0.82	0.67

Figures in parenthesis are means of $\sqrt{X + 0.5}$ transformed vlaues.

The average number of jassid nymphs (Table 2) prior to insecticidal treatments ranged from 8.40 to 11.00 per plant. The difference among the treatments were non-significant. All the insecticidal treatments were significantly superior over untreated control after 2 days of spraying. The average number of jassid nymphs

Table 2. Effect of neem formulations alone and in alternation with synthetic insecticides against jassids infesting okra.

Treatments	Pre-count	Mean jassids per plant days after spraying		
		2	5	15
Achook 0.5%	18.00 (4.19)	8.06 (2.83)	6.31 (2.50)	8.48 (2.90)
ZA-199 0.5%	16.20 (3.98)	9.86 (3.07)	8.20 (2.82)	11.80 (3.37)
NSKE 5%	12.80 (3.56)	6.50 (2.61)	7.13 (2.66)	11.76 (3.37)
Cypermethrin 0.01%	12.80 (3.56)	4.78 (2.17)	3.21 (1.78)	9.51 (3.07)
Imidacloprid 0.004%	13.60 (3.39)	1.03 (1.11)	1.25 (1.08)	5.10 (3.10)
Achook 0.5% alternated with Cypermethrin 0.01%	17.46 (4.03)	6.81 (2.59)	5.52 (2.33)	9.62 (3.10)
ZA-199 0.5% alternated with Cypermethrin 0.01%	13.26 (3.47)	6.70 (2.53)	5.86 (2.38)	9.61 (3.09)
NSKE 5% alternated with Cypermethrin 0.01%	8.40 (2.89)	6.52 (2.46)	5.51 (2.25)	9.53 (3.08)
Achook 0.5% alternated with Imidacloprid 0.004%	15.66 (3.80)	5.46 (2.32)	4.78 (2.17)	8.28 (2.87)
ZA-199 0.5% alternated with Imidacloprid 0.004%	16.73 (3.96)	5.69 (2.36)	4.81 (2.17)	8.63 (2.93)
NSKE 5% alternated with Imidacloprid 0.004%	14.06 (3.74)	7.08 (2.66)	5.75 (2.39)	9.93 (3.14)
Untreated control	16.53 (3.95)	16.45 (4.05	16.16 (4.01)	19.06 (4.36)
S. E.±	0.57	0.25	0.23	0.21
C. D. at 5%	N. S.	0.72	0.68	0.63

Figures in parenthesis are means of $\sqrt{X + 0.5}$ transformed vlaues

ranged from 1.03 to 9.87 per plant in the insecticidal treatments as against 16.46 per plant in control. The treatment comprising imidacloprid (0.004%) was most effective (1.03 jassids per plant) followed by cypermethrin, 0.01 per cent, (4.78 jassids per plant) which was on par with rest of the treatments except ZA-199, 0.5 per cent (9.86 jassids per plant). A similar trend was observed five days after spraying. Fifteen days after spraying the observations indicated that all the insecticidal treatments were significantly superior over control. The treatment comprising imidacloprid (0.004%) was most effective against jassids and registered 5.10 jassids per plant. This treatment was significantly superior over rest of the treatments except, Achook,(0.5 %) alternated with imidacloprid, 0.004 per cent (8.28 jassids per plant).

The present findings with respect to effectiveness of cypermethrin are in agreement with studies of Khaire and Naik (1986). Similarly the results of neem formulations are in confirmation with Thombare (1991).

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Agro-Based Enterprises of Farmers in Marathwada Region of Maharashtra State-Some Management Aspects

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ABSTRACT

Most of the farmers had taken up more than one enterprise so that income from different sources is generated and employment is available throughout the year. It not only helps in keeping the labour busy throughout the year, but also helps in bringing diversification in farming. The respondents used different combinations of source of information from time to time, which showed their anxiety to know about the latest advancements/recommendation made with respect to the enterprise they have taken up. Most of the respondents were the regularly paying their loan installments. Almost all the respondents kept the regular records related to their enterprises. Most of the respondents sold their agricultural produce through commission agents and very few sold direct to the consumers. It has been established that most of the profits were earned by the middleman (commission agents) and the producers remain at a loss. Therefore, efforts need to be made to reduce the number of middlemen so as to get maximum profits.

Key words : Agribusiness, intermediaries, farming system, agro based enterprises, agro service centers.

The present study is an attempt to get first hand information regarding the agricultural problems faced by the farmers .The selected farmers are scattered all over the area are the member of these committees. The present study has been planned to know the types of agro-based enterprises taken by them; sources of their technical information and financial assistance and also to know their mode of marketing of their produce.

The findings of the study will help to know as to which enterprises the progressive farmers have taken up at commercial level in addition to crop growing. The results will also reveal the sources of their technical information and financial assistance. The other important aspects, which will come to light, would be the mode of their marketing the agricultural produce. The study will also bring out the problems being faced by the farmer's .These findings will help to educate the fellow farmers of the state to strengthen the enterprises already taken by them and the enterprises, which can be taken up by them at commercial level.

Depending on cereals, pulses and oilseeds grown in the study districts, the farmer cannot derive much benefit. The diversification in farming system now has been advocated based on past experiences. These districts have enough scope to have variety of land-based enterprises.

MATERIALS AND METHODS

The study was conducted at Marathwada region of Maharashtra State. All the members-farmers of the different farmers committees of Marathwada region were considered for this study and the farmers who sent back the duly-filled in questionnaires were taken as the respondents for this study. A questionnaire was

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specially designed in local languge for the collection of data which included items to collect information regarding various agro-based enterprises taken up, source of technical information and financial assistance and the mode of selling the produce for the convenience of the farmers. In all 100 questionnaires was distributed in the farmers and fifty seven were received. The data were analyzed with the help of frequencies and percentages.

RESULTS AND DISCUSSION

Enterprises taken up by the respondents : Although the respondents were the members of the Krishi Utpann Bajar Samiti (APMC) yet it was fell neeessary to find out different enterprises taken by them. The information in this respect has been given in Table 1. The cultivation of field crops was taken up by majority (82.45%) of the respondents followed by vegetable production (49.12%), dairy and seed production (43.85 and 38.59%). The fruit cultivation had been taken up by 33.33 per cent, flower cultivation by 36.84 per cent, bee keeping 12.28 per cent. The enterprises like mushroom growing, poultry, fish farming and sericulture had been taken up by 14.03, 5.26, 1.75 and 3.50 per cent respondents, respectively. Similar results were also reported by Bhattacharya (1997) and Kumar *et al.*, (2001).

It was further found that most of the farmers (96.25 %) had taken up more then one enterprises and the maximum numbers of enterprises taken up by the respondents were four. The most of the farmers had taken up more than one enterprises so as to generate income and employment throughout the year. It not only helps in keeping the labour busy throughout the year, but also helps in bringing diversification in farming (Hindu, 2007). Flower cultivation, seed production of various crops are some of the indicators of progressiveness of the respondents, which need to be encouraged.

Table 1. Distribution of respondents according to their enterprises. (Multiple response) N=57.

Enterprises	Percentage
Crop production	82.45
Vegetable production	49.12
Seed production	38.59
Fruit cultivation	33.33
Flower cultivation	36.84
Bee-keeping	12.28
Dairy	43.85
Poultry	14.03
Mushroom growing	05.26
Fish farming	01.75
Sericulture	03.50

Table 2. Distribution of respondents according to their different sources of information N=57.

Particulars	Percentage
MAU Scientists	89.47
Newspapers	82.45
Officers of the State Departments of Agriculture & Other development departments	70.17
Friends	64.91
Television	61.40
Package of practices	59.64
Shethibhati journal	52.63
MAU Handbook	47.36
Radio	45.61
Relatives	42.10

Information sources of the respondents : For the success of any enterprise, latest technical know-how plays a very important role. The different sources of information used by the respondents were studied and the information has been given in Table 2. It has been noticed that for most (89.47%) of the respondents. MAU scientists were the source of information followed by newspapers (82.45%) and officers of the state Departments (70.17%).

On the whole the respondents used different combinations of source of information from time to time, which showed their anxiety to know about the latest advancements/ recommendation made with respect to the enterprise they have taken up. Similar observations were also reported by Kalra and Kumar (1995).

Sources of financial assistance : For smooth running of any enterprise the finances are needed from time to lime. The information regarding various sources of finance used by the respondents has been given in Table 3. The figures showed that majority of respondents (73.68%) used cooperative societies for obtaining finances for their enterprises as compared to Nationalized banks (59.64%).It is very interesting to note that very few respondents took the financial assistance from commission agents (20.80%) and relatives (12.28%).

The reason for getting financial assistance from the recognized sources may be that most of the respondents are the regularly repaying their loan installments as per conditions laid down by credit institutions.

Role played in different enterprises : From the figures given in Table 4 it has been found that majority of the respondents (66.66%) played the role of managers followed by supervisors, (63.51 %). However, 50.87 per cent of the respondents involved themselves for carrying out different operations. Less than half (43.85%) of the respondents involved themselves as managers, supervisors and also carriedout different operations for running the enterprises. It can also be concluded that the progressive farmers involved themselves in different capacities for the success of the enterprises taken up by them. It was very interesting to note that 90.29 per cent respondents, kept the regular records related to their enterprises.

Table 3. Distribution of respondents according to their sources of financial assistance.

Particulars	Percentage
Co-operatives societies	73.68
Nationalised banks	59.64
Commission agents	22.80
Relatives	12.28

Table 4. Distribution of respondents according to their role played in different enterprises N=57.

Particulars	Frequency	Percentage
Manager	38	66.66
Supervisor	36	63.15
Self involvement in different operations	29	50.87
All of the above	25	43.85

Table 5. Distribution of respondents according to the form in which they sell their produce.

Particulars	Frequency	Percentage
Unprocessed	75.44	
Processed	24.56	

Marketing : Marketing is the key link between the two forces in agribusiness, i.e. the agricultural producer and the consumer. An efficient marketing system minimizes the cost of marketing, increases the share of the producer, minimizes the effects of seasonal and geographical differences and handles the farm surpluses efficiently. But the marketing system in the country is insufficient. It comprises a system of reducing of intermediatre, grading, packing, storing and transportation etc.

It has been found that majority of the respondents (75.44%) sell most of their produce unprocessed. However, some part of the produce is sold after processing. The percentage of such respondents is only 24.56

per cent (Table 5).The processed items in addition to others include honey, turmeric powder, desi ghee, chilli powder, khawa and pickles. The reason for not processing their produce at a large scale may be the non-availability of necessary infrastructure, lack of financial assistance and technical know-how regarding processing, market for immediate returns. However, the farmers can be encouraged for value addition of their produce and the government should formulate some policies so that farmer can sell their produce in processed form.

Regarding the mode of sale of their farm produce 80.70 per cent of the respondents informed that they sell it through commission agents. The 36.84 per cent sold directly to the consumers, 24.56 per cent to shop keepers and only 12.28 per cent sold their produce through cooperatives. It can be concluded that most of the respondents sold their agricultural produce, through commission agents and very few sold direct to the consumers. It has been established that most of the profits are earned by the middleman (commission agents) and the producers remain at a loss. Therefore efforts need to be made to reduce the number of middleman so as to get maximum profits.

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Growth of Silk Reeling in Karnataka - An Application of Orthogonal Polynomial Regression Analysis

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ABSTRACT

The number of charkas and cottage basins in Karnataka exhibited slow increasing trend upto 1980-81 and then onwards, increased at an increasing rate upto 1996 and decreasing thereafter. The growth of charkas and cottage basins in selected districts of Karnataka revealed that charkas and cottage basins in Bangalore and cottage basins in Kolar district increased almost at a constant rate due to increased government efforts as well as increased demand for silk. The charkas and cottage basins in Mysore district decreased fastly in the recent years mostly due to the commencement of Kabini canal irrigation in Kollegal and Yalandur areas of the erstwhile Mysore district wherein, sericulture farmers started replacing mulberry by sugarcane, paddy and coconut crops.

Key words : Growth, status, silk reeling, trend.

Central Silk Board (CSB) has been implementing a centrally sponsored scheme namely "Catalytic Development Programme (CDP)" in collaboration with State Governments for development of sericulture and silk industry in the country during the XI five year plan (2007-12). Keeping in view the thrust, the research was conducted to study the growth and status of silk reeling in different parts of the state. The main objective of the scheme is to focus on the holistic development of sericulture industry in the country involving States and beneficiaries for sustainability and for improvement in inputs in terms of quantity and quality.

MATERIALS AND METHODS

The study was conducted before the formation of the new districts in 1998. Hence, the data pertains to the erstwhile districts of Karnataka. The data on number of charkas and cottage basins were collected districtwise for a period of 15 years from 1984-85 to 1998-99.

The orthogonal polynomial regression analysis was employed to study the trends in charka and cottage basin silk reeling in selected districts of Karnataka *viz*., Bangalore, Mysore and Kolar districts as well as for the state. The analysis covers only envisaged districts since, the volume of concentration is very high and these together accounts for more than 95 per cent of the State's total reeling units. (Ann. 1999).

The orthogonal polynomial regression analysis involves fitting of polynomial functions for the data of number of charkas and cottage basins by using orthogonal polynomials. The trend function of the following formula was employed.

$$\hat{Y} = \bar{Y} + b_1Z_1 + b_2Z_2 + b_3Z_3 \ldots\ldots\ldots\ldots\ldots B_nZ_n$$

Where,

$\hat{Y}$ = The predicted charkas/cottage basins

$\bar{Y}$ = the general mean of charkas/cottage basins

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Z_i's = are the orthogonal polynomials

$Z_1 = X - \bar{X}$

$Z_2 = (x - \bar{x})^2 - (n^2 - 1)/12$, etc.

Expressed explicitly in terms of equally spaced original Xi and bi's are the regression coefficients whose values are to be determined from the sample data.

Since the objective is to find the polynomial of lowest degree that seems an adequate fit for the data, it is necessary to test the significance of each b coefficient in successive stages until two successive b turn out to be non-significant (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Trends in charkas/cottage basins are shown in the graphs with the period plotted along x axis and the number of charkas/cottage basins on y axis. The significant 'F' values and high R^2 values indicated the goodness of fit and the appropriateness of the application of orthogonal polynomial analysis. From Table 1, it is clear that, the number of charkas at the state level increased at slow rate upto 1980-81 and then onwards increased at an increasing rate upto 1996 (Fig. 1). After 1996 again it decreased. This might be due to the fact that during 1980-81, Karnataka Sericulture Project I (KSP-1) was started and subsequently after five years, during 1989-90, Karnataka Sericulture Project - II (KSP-II) was implemented. There has been substantial increase in the area under mulberry and also in the cocoon production during this period. The declining trend after 1994 may be due to the decreased charkas in Mysore and Kolar districts which are potential districts. The growth of cottage basins in Karnataka also exhibited similar trend as observed in the trend of charkas and in the KSP-1 phase, it has increased faster than the charkas due to a temporary increase of units in the new sericulture areas (Northern Karnataka) and suddenly decreased due to the initiative coming from the government rather than by the people. In addition, the lack of infrastructure, lacuna in implementation of the government programmes and operational problems in silk reeling have added to the non-

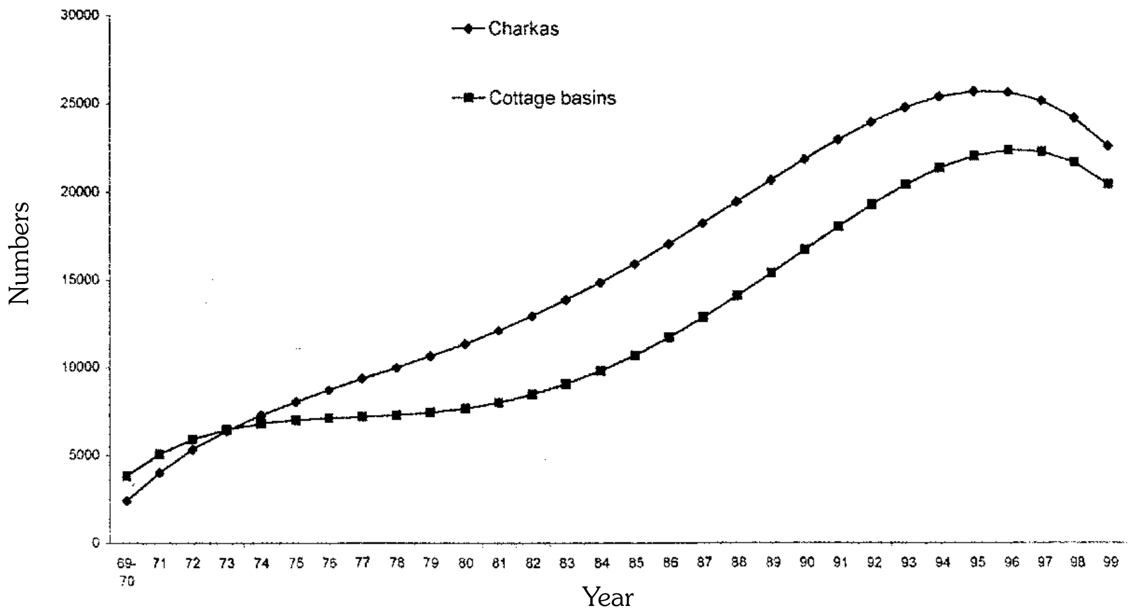

Fig. 1. Trends of charka and cottage basin reeling in Karnataka

Table 1. Estimated orthogonal trend functions for charka and cottage basin reeling.

District/ State	Type of reeling units	Intercept	X	X^2	X^3	X^4	R^2	F
Bangalore	Charka	2752.44	477.14**	-	-	-	0.54	15.16
	Cottage basin	5807.00	456.05	-	-	-	0.42	9.34
Mysore	Charka	7840.50	-1343.17**	531.06**	-58.19NS	1.86*	0.82	11.19
	Cottage basin	4723.35	-2259.00*	805.46**	-86.86NS	2.84**	0.85	13.95
Kolar	Charka	1205.10	2208.84**	-259.27NS	10.22*	-	0.80	15.01
	Cottage basin	1009.53	428.58**	-	-	-	0.89	102.25
Karnataka	Charka	450.59	2183.78**	-220.99NS	12.85*	-0.24*	0.94	96.66
	Cottage basin	2175.83	1936.30**	-275.79*	16.38NS	-0.29**	0.90	54.20

*,** Significant at 5 and 1 per cent level respectively. NS : Non significant

acceptance of the sericulture programmes. This reveals the repetition of earlier experiences, wherein the new programmes failed to pick up whenever the initiatives come from the government without adequate ancillary support and lack of developing human resources.

The growth of silk reeling in selected districts of Karnataka could be seen from the Tables 1 and 2. During 1984-85 and 1998-99, charkas and cottage basins in Bangalore district and cottage basins in Kolar district increased almost at a constant rate due to increased government efforts and also increased demand for silk as evidenced by increased production as well as imports of silk in India. While charkas in Kolar district had shown mixed pattern. However, the charkas and cottage basins in Mysore district decreased rapidly in the recent years. This might be due to the commencement of Kabini canal irrigation in Kollegal and Yalandur areas of the Mysore district wherein the sericulture farmers started replacing mulberry by sugarcane, paddy and coconut crops. The extra attention required to rear silkworms and for cocoon production may not be forthcoming due to increasing attention towards the other crops including even in rainfed areas of Mysore district, the cropping pattern has changed. Farmers are now growing more of cotton replacing mulberry. Recently Kolar is catching up in silk reeling overtaking

Table 2. Growth rate functions of charka and cottage basin reeling.

District/ state	Type of reeling	Growth rate (G = dy/dx)
Bangalore	Charka	G = 477.136
	Cottage basin	G = 456.050
Mysore	Charka	G = 1343.170 + 1062.116x - 174.570 x^2 + 7.440 x3
	Cottage basin	G = -2259.004 + 1610.196x - 260.574 x^2 + 11.352 x3
Kolar	Charka	G = 2208.836 - 518.548 x + 30.672 x^2
	Cottage basin	G = 428.575
Karnataka	Charka	G = 2183.780 - 441.980 x + 38.550 x^2 - 0.944 x3
	Cottage basin	G = 1936.299 - 551.586 x + 49.137 x^2 - 1.156 x3

the Mysore, which was supposed to be a home of sericulture. This may be due to a congenial atmosphere. The suitability of soil to grow mulberry and the most ideal water availability in the Sidlaghatta areas of Kolar district. The researcher also observed that due to the suitability of reeling water in Sidlaghatta areas of Kolar district. Some people are engaged in the business of water in Sidlagnatta areas of Kolar district. Some people are engaged in the business of water supply to the reeling activity even at far away places. It may be one of the reasons that the rate of exploitation of ground water was reported to be more than 100 per cent of the rate of recharge in Kolar district of Karnataka. That is why the silk processed in this area has fetched higher prices. Similar results have also been reported earlier by Sastry *et al.* (1976), Mundinamani (1993) and Pattan Shetti (1993).

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Study on Indebtedness Issues of Cotton Farmers in Karnataka State

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ABSTRACT

The study revealed that both the cost and yields were higher in the case of 'big farmers'. The 'small' farmers could barely break-even while, the profits were good for 'large farmers'. With respect to family income, both the big and small farmers could hardly break-even since the cost of cultivation of cotton and their major cash crop was high. The farmers borrowed from both the formal and informal sources. Loans were drawn for crop cultivation as well as domestic purposes and equipment replacement. All the respondents were indebted and only 15-22 per cent of the farmers had repaid their loans. Reasons for default of loan payment were crop failure and price fluctuation.

Key words : Cotton cultivation, indebtedness.

Indebtedness is one of the major factors of farmer's distress and even suicides and the agrarian crisis of the country. High cost of cultivation, dependence on external sources especially, moneylenders for working capital, lack of adequate agricultural extension agencies, fluctuating production and price have made agriculture in general and cotton in particular, unprofitable to majority of farmers. The inability to repay the past debts and thereby access to fresh loans has been widely accepted as the most significant cause for the farmer's distress.

India ranks first with respect to cotton area

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(about 29 per cent of the world's cotton area), third and fifth with respect to production and productivity of cotton respectively, in the world. It is also the second largest consumer of cotton. As per estimates of the Cotton Advisory Board, the total area under cotton in 2007-08 was 95.30 lakh hectares, production was 310 lakh bales (bales of 170 kg each) and productivity has remained at 553 kg ha^{-1}. Karnataka is one of the nine major cotton-growing states in the country. As per figures for 2007-08, area under cotton in Karnataka was 3.71 lakh hectares, production was 8 lakh bales and productivity was 367 kg ha^{-1}.

There is a fluctuation in cotton area and production over the years owing to various factors such as weather and price (Ann. 2001). Cotton has been in the news in the state and cultivation of the crop has been projected as the reason for the insolvency of farmers and even their suicides in certain Northern districts of Karnataka. The present paper focuses on the economic viability of cotton cultivation in these districts and how farmers degenerate into financial crisis in the course of its cultivation.

MATERIALS AND METHODS

Sampling frame : A purposive sampling has been adopted for the selection of districts. Taluks and villages were selected based on the criteria of highest area under cotton cultivation and the number of farmers' suicides in the area. Thus, two districts *viz*., Haveri and Bellary were selected for the study.

From each district, two taluks *viz*., from Haveri district, Haveri and Shiggoan taluks and from Bellary district, Bellary and Siraguppa taluks were selected for the investigation. From each taluk, five villages were selected. From each village, ten farmers, consistently growing cotton were randomly selected and from each district 50 small and 50 big farmers were selected; thus, 100 farmers were totally selected from each district. The total sample size constituted for the study was 200 respondents. The study pertained to the year 2007-08.

Table 1. Socio economic characteristics (per cent) of the sample farmers (N = 100).

Category	Small farms	Big farms
Age :		
Young (Up to 35)	17	18
Middle (36 to 50)	40	52
Old (51 and above)	43	30
Education :		
Illiterate	27	4
Primary education (Up to 4th std)	30	23
Middle school (5th to 7th std)	18	25
High school (8th to 12th std)	17	30
College education (Above 12th std)	8	18
Occupation :		
Cropping + casual labour	45	22
Cropping	23	46
Cropping + Animal husbandry	12	16
Cropping + business	4	8
Cropping + salaried job	16	8
Family type :		
Joint	30	23
Nuclear	70	77
Annual gross income (thousand) :		
Up to Rs. 25,	13	4
Rs. 25 to Rs. 50	12	16
Rs. 50 to 75	18	16
Rs. 75 to Rs. 1,00	26	20
Above Rs. 1,00	34	44

Collection of data : Secondary sources from Department of Agriculture were utilized to obtain cropping data. The data pertained to the study year 2007-08, were collected from the respondents through personal interview with the help of structured interview schedule.

Analysis of data : The collected data were tabulated, scored and analyzed by applying appropriate statistical methods *viz*., frequency, percentage and mean. The tabular analysis was used to arrive at meaningful results. The analysis was presented category-wise i.e., for farmers having <2 ha (small farmers) and for farmers having 2 to 4 ha of land (big farmers).

RESULTS AND DISCUSSION

The socio-economic profile of the families has been presented in Tables 1. It can be inferred that majority of the farmers engaged in cotton cultivation were middle-aged, educated up to 4^{th} standard; education level being better among large farms.

Cultivating field crops emerged as the main business of the sample. Small farmers mostly supplemented their farming income by working elsewhere as hired out or casual this tendency was comparatively less on large farms, which were mainly cropping based. Both categories farms were largely nuclear families. Gross annual incomes were mostly concentrated around Rs.1 lack. Large farms generally had higher incomes than small farms.

Table 2 and 3 indicates the farm size and characteristics of the sample farms. The overall operational holding was 2.88 hectares, which in majority of the cases was self cultivated. Overall, the farmers supplemented their own land with land leased-in.

Both the size farms had common soil characteristics and irrigation facilities. Irrigation was mainly by canals and was concurrent with the south-west monsoon months. Only a few farms had irrigation facilities throughout the year through conjunctive use of water. Cropping was characterized mainly through seasonal crops during the South-West monsoon season (*kharif*) and North East monsoon (*rabi*).

Table 4 revealed that cotton was the dominant crop accounting for, nearly 50 per cent of the gross cropped area. Bt-cotton was grown in an area of 1.31 ha with production of 16.17 quintals. The productivity was 12.35 quintals ha^{-1}. While Non-Bt cotton was grown in an area of 0.12 ha with production of 1.11 quintal and its productivity was 9.29 quintal

Table 2. Land holding pattern of the respondents under study.

Type of land	Total owned land (ha)			Lea-sed in from others (ha)	Total oper-ation hold-ing
	Hect-ares	Self oper-ated	Lea-sed out to others		
Small farmers :					
Rainfed	0.50	0.40	0.10	0.00	0.40
Irrigated (Seasonal)	1.00	1.00	0.00-	0.40	1.40
Total	1.50	1.40	0.10	0.40	1.80
Big farmers :					
Rainfed	1.56	1.40	0.16	0.00	1.40
Irrigated (Seasonal)	2.22	2.08	0.14	0.48	2.56
Total	3.78	3.48	0.30	0.48	3.96
Overall :					
Rainfed	1.03	0.9	0.13	0	0.9
Irrigated (Seasonal)	1.61	1.54	0.07	0.44	1.98
Total	2.64	2.44	0.2	0.44	2.88

Table 3. Farm characteristics (per cent) of the respondents proportion.

Characteristic	Small	Large	Overall
Type of soils :			
Very deep	6.00	7.00	6.50
Deep	17.00	18.00	17.50
Moderately deep	48.00	49.00	48.50
Shallow	26.00	25.00	25.50
Very shallow	3.00	1.00	2.00
Sources of irrigation :			
None	12.00	10.00	11.00
River	-	-	-
Well	-	-	-
Tube well	4.00	4.00	4.00
Canal	84.00	86.00	85.00

Table 4. Cropping pattern of the respondents under study (N=200).

Crop sown	Variety	Area in hectares			Total produ-ction (q)	Produc-tivity (q ha^{-1})	Av. rate received (Rs. q^{-1})	Gross returns (Rs.)
		Irrigated	Rainfed	Total				
***Kharif* (July-Sept.) :**								
B. T. Cotton	Brahma	1.10	0.21	1.31	16.17	12.35	2289.50	37040.68
Non B. T. cottons	DCH-32 etc.	0.12	-	0.12	1.11	9.29	2310.00	2575.18
Paddy	BPT	0.72	-	0.72	39.60	55.00	570.60	22595.76
Chilli	Guntur	0.50	-	0.50	6.60	13.20	3150.00	20790.00
Maize	Vijay	0.23	-	0.23	4.60	20.00	600.00	2760.00
Total				2.88				
Cropping intensity (%)-*kharif*		100.00						
***Rabi* (October-Feb.) :**								
Paddy	BPT	1.05	-	1.05	53.81	51.25	645.00	34709.06
Wheat	Local	-	0.14	0.14	1.54	11.00	900.00	1386.00
Safflower	KBSH-1	-	0.78	0.78	5.85	7.50	1850.00	10822.50
Jowar	M35-1	-	0.91	0.91	9.19	10.10	800.00	7352.80
Total				2.88				Rs. 14,0032
Cropping intensity (%)-*rabi*		100.00						
Gross area (ha)				5.76				
Annual cropping intensity (%)		200.00						

Table 5. Economics of cotton cultivation.

Particulars	Average cost (Rs. ha^{-1})	
	Small farms	Big farms
Human and bullock labour	4619	5286.70
Inputs (other than labour etc)	11311.88	11719.20
Total (Cost 'A')	15930.88	17005.90
Cost B (Cost 'A' + Interest on value of owned capital, land)	21434.45	22888.69
Cost C (Cost 'B' + Imputed value of family labour) or total cost	23764.45	25278.69
Yield	11.05	16.40
Gross returns	25300.00	37525.50
Net returns	1535.55	12246.81
Benefit : Cost ratio	1.06	1.48

Table 6. Average annual income and expenditure of the sample farms.

Net income	Rs.	Expenditure	Rs.
Cropping	49,500	Food	8736
Wages, Animal husbandry etc.	2,000	Clothing	4500
		Housing	3150
		Education	2500
		Health	4500
		Traveling	4000
		Lighting and fuel	1700
		Religious festival & family functions	5500
		Debt servicing	11764
		Miscellaneous	2000
Total	51,500	Total	48,350
		Net returns	3150

ha^{-1}. On an average rate received by the farmers were Rs.2289.50 and Rs.2310 $quintal^{-1}$ for Bt-cotton and non-Bt cotton (DCH-32) respectively. In both *kharif* and *rabi* seasons, sample respondents were obtained gross income of Rs. 1,40,032.

Genetically, modified 'Bt' and other non-GM varieties were cultivated. Most of the *kharif* crops, apart from paddy, were cash crops

Table 7. Sources of loan for the sample.

Scores of loan	Average loan taken (Rs.)	Rate of interest	Loan repaid (Rs.)	Interest paid (Rs.)	Average loan outstanding (Rs.)
Formal sources :					
Co-operative Societies	12109	13	-	-	12109
Co-operative Bank	14580	12	-	-	14580
Urban Bank	-	-	-	-	-
Commercial Bank	20846	14	5410	-	15430
Rural Bank	12000	12	-	-	12000
Sub-total	59535				54125
Informal Sources :					
Money lender	14240	48-84	-	5126.40	14240
Self helf groups	2400	24	857.50	370.08	1542.50
Sub-total	16640				15782.5
Grand total	76170	-	6267.5	5496.48	69907.5

dependant on assured canal water. Food crops were mostly relegated to *rabi* and were largely dependant on rainfall or residual soil moisture. Cotton yields ranged from 11.05 to 16.40 quintals per hectare as compared to benchmark yields of 20 quintals under rainfed and 30 quintals under irrigated conditions.

Table 5 showed the brief economics of cotton cultivation in the study. Apart from land and family labor, the farmer had to incur considerable paid-out costs in cotton cultivation.

Between the two types of farms, labor use was high among large farms resulting in about 6 per cent increase in the total cultivation costs while input usage was on par among small farms. Cotton yields were higher among large farms by 32 per cent which was reflected in the gross and net returns as well. In general cotton cultivation was profitable only for large farms than for small farms where the farms could barely manage to breakeven.

Table 6 indicates the annual income and expenditure of the sample farm families. The gross incomes were from cropping, animal husbandry and earnings from both local jobs and through jobs taken up after migration. Nearly two-thirds of the returns from total crop cultivation (Rs. 14,0032) were appropriated (Rs.90,532) by the respective cultivation costs. The remaining were costs of basic essential items and servicing of debts - both installments as well as interest payments. Faced with a financial situation depicted above, one of the first measures that the farmers had resorted to borrow (Table 7). All respondents had taken loans from external agencies. Formal agencies were given first preference due to easier interest rates and informal agencies were approached only in the event of non-availability of loan from formal sources. About half of the

Table 8. Borrowing structure of the sample farmers (%).

Type of loan	Small	Large	Total	% share of institution
Borrowers	100	100	100.00	100
Only formal	27.08	72.92	100.00	48
Only informal	83.33	16.67	100.00	15
Both formal and informal	66.22	33.78	100.00	37
Total	50.00	50.00	100.00	100

Table 9. Purpose, utilization and repayment of the loans.

Borrowing behavior	Small (%)	Large (%)
Purpose of the loan :	100	100
Crop cultivation	68	35
Domestic expenses	32	40
Equipment replacement	20	25
Loan utilization :	100	100
Total loan utilized for the purpose interded	85	80
Part of loan utilized for some other purposes	10	9
Total loan utilized for the purpose other than intended	5	11
Repayment :		
Loan taken	100	100
Loan partially repaid	30	32
Loan fully repaid	15	22
Defaulters	55	46
Reasons for loan default :	100	100
Crop failure	68	52
Low price for produce	32	48

farmers borrowed from formal sources and one-third borrowed conjunctively both from formal and informal sources. Outstanding loans were high among formal sources. Informal sources employed stringent measures to recover interest on their loans. Similar results were also reported by Banakar and Suryaprakash (1987).

Table 8 displays that the sources of debt for the farmers were both formal and informal sources. Most of the farmers first availed loan from formal sources and then from informal sources. Table 9 describes the type of loans availed, utilization and their repayment. Small farms availed loan basically to purchase seed, fertilizer etc. Other expenses were for domestic purposes such as for marriages, major hospitalization etc. Equipment replacement mostly comprised of agricultural equipment, machinery, two wheelers repair etc. Even though 80 to 85 per cent of the loans were used totally for the purpose for which they were intended, total repayment ranged only between 1 5 to 22 per cent. The reasons were mainly either failure to realize the crop due to adverse weather conditions or due to low price at the time of sale of realized produce. Thus the liability positions of the farms were compounded by enterprise failures, non-productive domestic loans and equipment purchase loans which had long term return spans and which were linked with the agricultural enterprises. Similar observations were also reported in Ann. (1998) and Deshpande and Prabhu (2005).

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Factors Affecting Birth Weight in Osmanabadi Kids*

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ABSTRACT

The overall least squares mean for birth weight was 1.898 + 0.018 kg. The least squares analysis of variance revealed highly significant (P<0.01) effect of season of birth, type of birth and sex on birth weight while, period of birth had non-significant effect on birth weight. Winter born kids showed higher birth weight than those born in summer and rainy season. Males were significantly heavier than female. The single born kids had higher birth weight than those born as twins and triplets.

Key words : Birth weight, Osmanabadi goat, non-genetic factors.

The economic value of goat depends on growth, production and reproduction traits. Birth weight is the first observed economic character expressed at an early stage of life. The Osmanabadi goat is meat type breed in Maharashtra. The present study was under taken to see the effect of period of birth, season of birth, sex and type of birth on birth weight in Osmanabadi kids.

MATERIALS AND METHODS

The data pertained to 1297 birth weight records of Osmanabadi kids born during 1993-2005 at P. G. Goat Unit, M.P.K.V., Rahuri (Maharashtra) were utilized. Goats were maintained under semi-intensive system of production management. The year was divided into three seasons *viz*., S_1 (October-January), S_2 (February- May) and S_3 (June- September) to study the effect of season on birth weight of kids. The data were subjected to least squares analysis (Harvey, 1990) and effect of period of birth, season of birth, sex and type of birth were considered as potential source of variation.

RESULTS AND DISCUSSION

The least squares mean of birth weight of Osmanabadi kids are presented in Table 1. The average birth weight of Osmanabadi kids was 1.89 ± 0.02 kg. Broadly, similar values of birth weights were reported by Deshmukh (1996), Anonymous (1999 and 2001) and Mandakmale (2002) in Osmanabadi and Bobhate *et al*., (2003) in Sannen and Osmanabadi and Alpine x Osmanabadi kids.

Period of birth : The analysis of variance indicated non-significant effect of period of birth on body weight at birth in Osmanabadi kids; which agreed with Malik and Kanaujia (1991) in Beetal, Roy *et al*., (1997) in Jamunapari, Mandakmale (2002) in Osmanabadi, Singh and Khan (2002) in Jakhrana, Tomar *et al*., (2004) in Sirohi and Sivakumar *et al*., (2005) in Boer x Kanni goats. However, the significant results were reported by Roy *et al*., (2003), Rai *et al*., (2004) and Swami *et al*., (2006).

Although the period of birth had non-

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significant effect on birth weight of kids, the average birth weights declined gradually during later periods. The non-significant effect of period of birth on birth weight of kids was probably due to regular concentrates supplementation to does during breeding, pregnancy and lactation and consistence feeding and management practices over years of period under study.

Effect of season of birth : The results revealed significant (P<0.01) effect of season of birth on birth weight of kids. The mean birth weight recorded during winter season (1.95 ± 0.02 kg) was significantly higher than in summer and rainy seasons. However, the birth weights of kids born during summer and rainy season (1.85 ± 0.02 and 1.88 ± 0.02 kg) were at par with each other (Table 1). The differences might be due to the most congenial atmosphere available during winter season. Whereas, the shortage of good fodder on grazing lands, coupled with adverse climatic conditions during advanced pregnancy in late winter and early summer months might be the reasons for low birth weights of kids during summer and rainy season. Similar significant influence of season of birth on birth weight was noted by Deshmukh (1996) in Osmanabadi, Mandakmale (2002) in Osmanabadi under field condition, Anonymous (2001) in Osmanabadi, Bobhate *et al*., (2003) in Osmanabadi and its crossbred with Beetal, Alpine and Sannen, Roy *et al*., (2003) in Jamunapari, Rai *et al*., (2004) in Marwari, Ganesh Kumar *et al*., (2005) in Tellicherry and Swami *et al*., (2006) in Sirohi goats. On the contrary the non-significant effect of season of birth on birth weight of kids was noticed by Madakmale (2002) in Osmanabadi under project condition and Sivakumar *et al*., (2005) in Boer x Kanni goats.

Effect of type of birth : The statistical analysis of data indicted significant (P<0.01) effect of type of birth on birth weight of kids.

Table 1. Least squares means for body weight at birth in Osmanabadi goats.

Effects	N	Body weight (kg)	
		Mean	S. E.±
μ	**1297**	**1.898**	**0.018**
Period of birth :			
P_1 (1993-1996)	217	1.915	0.027
P_2 (1996-1999)	265	1.924	0.026
P_3 (1999-2002)	476	1.883	0.021
P_4 (2002-2005)	339	1.868	0.026
Season of birth :			
Winter (S_1)	528	1.956^b	0.021
Summer (S_2)	346	1.856^a	0.022
Rainy (S_3)	423	1.883^a	0.022
Sex :			
Male	683	1.956^b	0.020
Female	614	1.840^a	0.020
Type of birth :			
Single	531	2.069^c	0.018
Twins	704	1.924^b	0.017
Triplets	62	1.701^a	0.037

The means under each class with different superscripts differ significantly.

The single born kids weighed (2.07 ± 0.02 kg) significantly heavier than the twins (1.92 + 0.02 kg) and triplets (1.70 ± 0.04 kg). The higher birth weight in singles than those of twins and triplets probably due to sharing of uterine space and nutrients by fetus of multiple birth, leading to lower birth weight. The results confirmed the findings of Bobhate et al., (2003) in Osmanabadi and its crosses with Beetal, Sannen and Alpine and Roy *et al*., (2003) in Jamunapari goats. While, Ganesh Kumar et al., (2005) and Sivakumar *et al*., (2005) stated that the type of birth had non-significant influence on birth weight in kids.

Effect of sex : Analysis of variance indicated significant (P<0.01) influence of sex on birth weight of Osmanabadi kids.

The male kids were significantly (P<0.01) heavier than female kids (1.96 ± 0.02 vs. 1.84 ± 0.02 kg). This variation could be due to hormonal effects and genes associated during pre-natal period. The significant effect of sex on birth weight with higher values in favour of males were in accordance with Deshmukh (1996) and Anonymous (1999 and 2001) in Osmanabadi, Mandakmale (2002) in Osmanabadi under project condition, Roy *et al*., (2003) in Jamunapari, Rai *et al*., (2004) in Marwari, Ganesh Kumar *et al*., (2005) in Tellicherry and Tomar *et al*., (2004) and Swami *et al*., (2006) in Sirohi goats. However, non-significant results were obtained by Mandakmale (2002) in Osmanabadi under field condition.

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Studies on Scrotal Biometry and Semen Attributes of Pandharpuri Buffalo Bulls

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ABSTRACT

Three hundred thirty observations of 11 Pandharpuri buffalo bulls (30 from each bull) were recorded to study sexual behaviour and semen attributes. Findings revealed that, overall means of semen volume per ejaculate, mass activity (0-4), initial motility, post thaw motility, live and dead sperm count were 2.44 + 0.17 ml, 3.01 ± 0.11, 68.33 ±1.78 per cent, 40.72 ± 1.37 per cent, 84.71 ± 1.92 per cent and 15.28 + 1.92 respectively. While overall occurrence of semen colour i.e. milky, creamy and watery was 46.36, 49.99 and 3.02 respectively. Consistency observed thick, thin and watery as 51.51, 44.84 and 3.57 per cent respectively. The overall sexual behaviour of bulls was observed *viz*. reaction time, nudging, sniffing, licking, chin resting and Flehmen reaction which were 37.45 ± 1.86 sec, 12.11, 18.48, 12.72, 16.05 and 10.30 per cent respectively. The scrotal biometry of bulls included scrotal circumference, length of right testicle, left testicle and average length of both testicles, width of right testicle, left testicle and total width and means of these were 31.54, 14.59, 14.68, 14.63, 5.52, 5.82 and 11.34 cm respectively. Scrotal circumference showed significant correlation with live sperm count and positive correlation with semen volume and initial motility. Testicle width showed significant correlation with initial motility and live sperm count. It was concluded that, testicular biometry should be given due importance before selection of breeding bulls.

Key words : Semen attributes, scrotal biometry, sexual behavior.

The success of dairy cattle and buffalo husbandry is in ensuring proper and optimal reproductive rhythm and increasing productivity, through cross-breeding with semen of superior sires. "As the male is half of the herd", sire contributes approximately 50 per cent of its genetic make up to his off-springs and remaining improvement comes through the dam selection. The breeding performance of sire depends on the ability of it to produce good quality semen. Therefore, production of superior quality semen from genetically potent healthy breeding bulls is of prime importance in national AI programme, it mainly depends on the normal testicular size, proper functioning of seminiferous tubules and leyding cells.

The information on semen attributes, scrotal biometry and sexual behaviour is plenty for most cattle and buffalo breeds but it is scarce particularly in Pandharpuri bulls. Hence the present study was attempted to know these aspects in breeding bulls in the breeding tract of the Maharashtra i.e. Solapur, Sangli and Kolhapur districts and neighboring borders of Karnataka which is used for buffalo development programme.

MATERIALS AND METHODS

Three hundred thirty observations of 11 Pandharpuri buffalo bulls (30 from each bull) were recorded to study sexual behavior and semen attributes. Study was conducted at Network project on Pandharpuri buffalo, Shenda Park; Kolhapur.The observations were taken twice in a week regularly. The bulls were approximately of same age and were

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maintained under identical nutritional and managemental practices throughout the year. The scrotal biometry of bulls included scrotal circumference, length of right and left testicle and average length of both testicles, width of right and left testicle, and total width was recorded by the method given by Bhosarekar (1990). Observations on sexual behaviour were recorded at the time of collection for different aspects i.e. reaction time (sec), sniffing, licking, nudging, chin resting and Flehmen behaviour. After each collection semen was also evaluated for macro and microscopic tests by the methods given by Sane *et al.,* (1982). The mean values of scrotal biometry, semen attribute and sexual behaviour were calculated. (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The results obtained in the present investigation regarding scrotal biometry, semen attributes and sexual behavior of Pandharpuri buffalo bulls are presented in Table 1 and correlation coefficients among semen attributes and scrotal biometry are given in Table 2.

Table 1. Mean scrotal biometry, semen attributes and sexual behavior of Pandharpuri buffalo bulls.

Parameters			Values
Scrotal circumference (cm)			31.54
Length of testicle (cm) -	Right		14.59
	Left		14.68
	Average		14.63
Width of testicle (cm) -	Right		05.52
	Left		05.82
	Average		11.34
Semen attributes			
a) Qualitative - i) Colour (%) -	Milky		46.36
	Creamy		49.99
	Watery		03.02
ii) Consistency (%) -	Thick		51.51
	Thin		44.84
	Watery		03.57
b) Quantitative :			
	i) Semen volume/ejaculate (ml)		2.44±0.17
	ii) Mass activity (0-4)		3.01±0.11
	iii) Initial motility (%)		68.33±1.78
	iv) Post thaw motility (%)		40.72±1.37
	v) Live sperm (%)		84.71±1.92
	vi) Dead sperm (%)		15.28±1.92
Sexual behaviour			
	i) Reaction time (sec)		37.45±1.86
	ii) Nudging (%)		12.11
	iii) Sniffing (%)		18.48
	iv) Licking (%)		12.72
	v) Chin resting (%)		16.05
	vi) Flehmen behaviour (%)		10.30

Scrotal biometry : The overall mean of the scrotal circumference was 31.54 cm. The similar results were obtained by Rana and Bilaspuri (1999) in Murrah buffalo and Dhami *et al*., (2001) in Jafarabadi buffalo. The average length for right and left testicle was 14.59 and 14.68 cm respectively. While average length of both testicles collectively was 14.63 cm. The average values for right and left testicle width were 5.52 cm and 5.82 cm respectively, while average total width of the bulls testicle was 11.34 cm. Similar values were reported by Dhami *et al*., (2001) in Jafarabadi buffalo bulls.

Qualitative semen attributes : The average values for occurrence of semen colour as milky, creamy and watery were 46.36, 49.99 and 3.02 per cent. While average values for the consistency of semen were 51.51, 44.84 and 3.57 per cent for the thick, thin and watery respectively.

Quantitative semen attributes : The overall semen volume per ejaculate was 2.44 ± 0.17 ml of 11 Pandharpuri buffalo bulls. Nearly similar results were reported by Sagdeo *et al*., (1991) in Surti buffalo bulls. The overall mass activity of Pandharpuri buffalo bulls' semen was 3.01 ± 0.11. The overall initial motility of all the Pandharpuri buffalo bulls was 68.33 ± 1.78 per cent. The results were similar to the Mandal *et al*., (2002) in Murrah buffalo and Rana and Dhami (2003) in Jafarabadi bulls. The overall post thaw motility for 11 Pandharpuri buffalo bulls was 40.72 ± 1.37 per cent. Similar results were found by Pawan Singh *et al*., (2000) in Murrah buffalo and Mandal *et al*., (2005) in Jafarabadi bulls.The overall value for live sperm was 84.71 ± 1.92 per cent. Similar results were found by Arora *et al*., (1996) in buffalo bull semen and Dhami and Shelke (2002) in Jafarabadi bulls. The overall mean for dead sperm count of Pandharpuri buffalo was 15.28 ± 1.92 per cent. Similar results were found by Dhami and Shelke (2005) in Jafarabadi buffalo.

Semen volume/ejaculate : The semen volume/ejaculate was showed positive but non-significant correlation ($P < 0.05$) with the scrotal circumference, average length of both testicles and total width of scrotum. Pant *et al*., (2003) found the significant correlation between scrotal circumference and semen volume.

Semen mass activity : The mass activity showed the non-significant positive correlation ($P < 0.05$) with scrotal circumference and scrotal width. Also non-significant negative correlation observed between mass activity and average length of both testicles. Galmessa *et al*., (2003) studied correlation between testicular biometry and semen quality and found positive non significant correlation between scrotal circumference and mass activity in Karan fries bull.

Initial motility : Initial motility was showed positive significant correlation ($P < 0.05$) with total width of scrotum. Initial motility showed non-significant correlation with the scrotal circumference and average length of both testicles. Galmessa *et al*., (2003) studied correlation between testicular biometry and semen quality and found positive non significant correlation between scrotal circumference and initial motility in Karan fries bull.

Table 2. Correlation coefficients among semen attributes and scrotal biometry of Pandharpuri buffalo bulls.

Scrotal biometry semen attributes	Circum-ference	Average length of both testicles (cm)	Total width of scrotum (cm)
Semen valume/ejaculate	0.31	0.33	0.07
Mass activity	0.05	-0.04	0.2 5
Initial motility	0.44	-0.23	0.65*
Post thaw motility	0.15	-0.34	0.31
Live sperm count	0.67*	-0.16	0.64*
Dead sperm count	-0.55	0.41	-0.43

*($P<0.05$)

Post thaw motility : Positive and non-significant correlation ($P < 0.05$) was observed between post thaw motility and scrotal circumference and total width of scrotum. Non-significant negative correlation was observed between post thaw motility and average length of both testicles. Galmessa *et al*., (2003) reconded positive non-significant correlation between scrotal circumference and post thaw motility in Karan fries bull.

Live sperm count : Significant positive correlation ($P < 0.05$) was observed between live sperm count and scrotal circumference and total width of scrotum. While negative non-significant correlation observed between live sperm count and average length of both testicles. Galmessa *et al*., (2003) also recorded positive and significant correlation between scrotal circumference and live sperm in Karan fries bull.

Dead sperm count : Dead sperm count showed non-significant and negative correlation ($P<0.05$) with the scrotal circumference and total width of scrotum. Also dead sperm count showed non-significant positive correlation with average length of both testicles.

Thus present study acquaints with the scrotal biometry, semen attributes and sexual behavior of Pandharpuri buffalo bulls, so as to select the bulls for semen collection purpose.

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HEADINGS - Centre and capitalize letters of main headings of the paper i.e. ABSTRACT, MATERIALS AND METHODS, RESULTS AND DISCUSSION and LITERATURE CITED. Do not centre secondary headings. Place the secondary headings with the first letter of the word capitalized at the beginning of the paragraph.

STYLE - Manuscripts must conform to current standards of English style and usage. The first person pronoun is accepted and often preferred for clarity. Main clauses should usually be stated first. The introduction without a heading should state clearly why the research was conducted with reference to earlier work. Give enough information on methods to indicate how the research was conducted so that the reader will have confidence in the validity of the result. Omit details unless it is method paper. Present results succinctly with emphasis on main effects. Use tables and figures to illustrate the text, interprete the results in discussion. Brief conclusion can terminate the discussion. Complex conclusions should form a separate section. Underline the botanical/scientific names.

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EXAMPLES :

Dorsey, M.J. and J.W. Bushnall. 1920. The hardiness problem. Proc. Amer. Soc. Hort. Sci. 17:210-224.

Snedecor, G.W. 1956. Statistical Methods. 5th Edn. Iowa State Univ. Press, Ames, Iowa, pp.534.

Whiteside, W.F. 1973. A study of light as influenced by time and planting date on growth of onion (*Allium cepa* L.) in the glasshouse and the field. Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, pp.53.

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