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Genotype X Environment Studies in Forage Sorghum

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ABSTRACT

Eight diverse genotypes, their 28 F_1's hybrids and one standard check variety in forage sorghum [*Sorghum bicolor* (L.) Moench] were evaluated in three different environments for studying their stability performance. The experiment was laid out in RBD with three replications. Each genotype was grown in single row with 2.5 meter length spaced at 30 cm. apart. The data on days to 50 per cent flowering, plant height, stem girth, brix, HCN Content, green fodder yield and dry matter yield were recorded. The analysis was done as per Eberhart and Russel (1966). The mean squares due to genotype, environment as well as G x E interaction were significant for all the characters studied. The linear and non-linear components were significant for all the characters, indicated significant differences among the genotypes for their regression on environmental indices and genotypes differed considerably with respect to their stability, respectively.

Among the parents SRF 286 and SRF 305 were found superior in mean performance and stable as compared to remaining parents for green fodder yield and dry matter yield. The highest mean performance with near unity regression co-efficient and least deviation from regression were observed for the hybrid SRF 286 x SRF 305, followed by RSSV 104 x GFS 4 for green and dry matter yield indicated as best performing and stable hybrids over environments. In general, hybrids were better performing with average stability as compared to parents and standard check. Out of 28 hybrids, 12 hybrids were average stable with better performance over check for green fodder yield, whereas 3 parents had high mean value than check with average stability. Stability parameters for remaining characters also calculated and discussed. The hybrid SRF 286 x SSG 59-3 was found stable for green fodder yield whereas the hybrid RSSV 104 x SSG 59-3 was stable for dry matter yield specifically under good environmental conditions, indicated the possibility of exploitation by advancing for isolating stable genotypes in forage sorghum.

Breeding varieties/hybrids for wider adaptability is of prime importance to plant breeder. Crop performance is a function of the genotype of the crop and nature of surrounding environment. The expression of the genotype is not independent of the environment of test, consequently the relative performance of the Genotype x Environment interactions. The existences of G X E interaction inhibit genetic analysis of performance and reduce efficiency of crop improvement largely because they confound comparison among genotypes with the environment of test. The present investigation is an attempt to estimate these interactions as described by Eberhart and Russell (1966).

MATERIAL AND METHODS

The experimental materials consisted of eight diverse forage sorghum lines crossed in half diallel fashion, their resultant 28 F1's and one standard check HC 308, a single cut variety. The experiment was laid at Sorghum Research Station, Navsari Agril. University, Navsari and Surat during *Kharif* 2007 and during Summer-2008 at Surat in RBD with three replications. The plot consisted of a single row of 2.5 m length with 30 cm distance between two rows. The randomly selected five competitive plants were used to record observations on days to 50 per cent flowering, plant height (cm), stem girth (cm), brix(%), HCN content (ppm), green fodder yield per plant (g) and dry matter yield plant^{-1} (g).

The stability parameters for 8 parents and their 28 hybrids were computed on the basis of mean performance, using the statistical model as suggested by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Pooled analysis of variance for phenotypic stability (Table 1) indicated that the mean squares due to genotype and environments were statistically significant for all the characters indicating the presence of variability both among genotypes and environments. The mean squares due to genotype x environment interaction were also significant for all

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Table 1: Analysis of variance for various stability parameters with regard to various characters in forage sorghum.

Source	df	Mean squares						
		Days to 50% flowering	Plant height (cm)	Stem girth (cm)	Brix (%)	HCN content (ppm)	Green fodder yield plant^{-1} (g)	Dry matter yield plant^{-1} (g)
Genotypes	36	140.395••**▪▪	1153.623••**▪▪	0.075••**▪▪	5.665 •▪▪	3939.802 ••**▪▪	4171.415••**▪▪	440.353••**▪▪
Environments	2	378.597••**▪▪	54084.536 ••**▪▪	0.798 ••**▪▪	29.463••**▪▪	2230.483▪▪	42909.335 ••**▪▪	3705.680 ••**▪▪
G X E	72	25.178▪▪	509.179▪▪	0.023▪▪	3.229▪▪	1785.027▪▪	657.131▪▪	101.059▪▪
Env. (linear)	1	757.193 **▪▪	108169 **▪▪	1.597 **▪▪	58.925 **▪▪	4460.966▪▪	85818.671**▪▪	7411.359 **▪▪
G x E (linear)	36	22.428▪▪	571.125▪▪	0.016▪▪	3.072▪▪	1747.963▪▪	808.628▪▪	104.399▪▪
Pooled deviation	37	27.173▪▪	435.146▪▪	0.028▪▪	3.293▪▪	1772.845▪▪	491.967▪▪	95.080▪▪
Pooled error	216	2.502	65.439▪▪	0.002	0.272	16.0755	71.453	6.690

•,•• = Significant when tested against G X E interaction at 5 % and 1 % level of probability, respectively.

*,** = Significant when tested against Pooled deviation interaction at 5 % and 1 % level of probability, respectively.

▪ ▪ = Significant when tested against Pooled error interaction at 5 % and 1 % level of probability, respectively.

Table 2: Stability parameters for green fodder yield and components traits in forage sorghum.

S.N.	Crosses	Days to 50% flowering			Plant height (cm)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	SRF 286	81.00	0.10*	-2.59	214.20	1.36	-50.50
2	SRF 305	83.11	0.28	1.61	197.70	1.02	757.50**
3	SRF 311	88.78	1.14	0.88	199.60	0.89	100.30
4	GFS 3	92.22	-0.25	15.10**	206.90	1.52	97.30
5	RSSV 104	88.56	0.60	1.20	210.60	0.65	612.80**
6	AKFSV 2	76.56	1.52	3.89	230.70	0.86	1193.40**
7	SSG 59-3	68.22	-0.65	4.28	206.80	0.30	-15.00
8	GFS 4	51.33	-0.14	3.00	181.90	0.99	984.20**
9	SRF 286 x SRF 305	76.56	0.79	-1.07	249.10	1.02	71.00
10	SRF 286 X SRF 311	80.22	1.07	5.51	240.20	1.40*	-64.20
11	SRF 286 X GFS 3	79.33	0.73	-0.89	237.80	0.97	-52.90
12	SRF 286 X RSSV 104	76.00	1.96	7.11	229.00	1.00	93.90
13	SRF 286 X AKFSV 2	77.89	0.90	8.18*	201.60	1.22	2141.10**
14	SRF 286 X SSG 59-3	82.89	-0.68	8.05*	213.00	1.77	-48.60
15	SRF 286 X GFS 4	77.56	1.21	-2.37	228.90	1.36	1085.10**
16	SRF 305 X SRF 311	84.67	1.02	18.72**	228.60	1.33	34.40
17	SRF 305 X GFS 3	85.33	1.98	41.29**	219.30	1.09	-59.60
18	SRF 305 X RSSV 104	77.00	1.42	-1.07	217.60	1.17	-58.00
19	SRF 305 X AKFSV 2	78.78	1.48	13.31*	213.30	0.79	1646.60**
20	SRF 305 X SSG 59-3	74.89	0.62	88.32**	202.80	0.91	410.30**
21	SRF 305 X GFS 4	83.56	2.00	1.17	219.20	0.75	-51.10
22	SRF 311 X GFS 3	84.33	0.55	35.38**	195.80	1.06	1093.00**
23	SRF 311 X RSSV 104	81.78	1.38	74.01**	215.60	1.91	275.20*
24	SRF 311 X AKFSV 2	75.22	1.34	132.56**	232.10	0.96	379.60**
25	SRF 311 X SSG 59-3	80.89	2.71	25.00**	225.90	1.36	456.70**
26	SRF 311 X GFS 4	80.78	0.90	109.89**	234.10	0.98	253.20*
27	GFS 3 X RSSV 104	77.00	-0.29	85.29**	230.10	1.04	-64.0
28	GFS 3 X AKFSV 2	84.56	-1.10	2.79	191.10	0.61	369.60*
29	GFS 3 X SSG 59-3	77.67	3.05	44.64**	187.80	-0.56*	-56.90
30	GFS 3 X GFS 4	76.89	-0.02*	-2.53	260.60	1.11	402.70**
31	RSSV 104 X AKFSV 2	80.67	0.00*	-2.60	248.40	0.30	-10.40
32	RSSV 104 X SSG 59-3	82.11	3.50	0.82	231.20	1.39	123.40
33	RSSV 104 X GFS 4	77.22	0.38	98.12**	251.40	1.03	-50.80
34	AKFSV 2 X SSG 59-3	74.67	2.01	3.34	256.60	1.40	1204.50**
35	AKFSV 2 X GFS 4	75.33	1.57	79.86**	234.30	0.75	106.50
36	SSG 59-3 X GFS 4	69.56	1.72	10.02*	238.40	0.40	471.90**
37	HC 308(NC)	84.56	2.19	-1.05	215.10	0.91*	-64.30
	S.E. (m)±	3.69	1.15			14.8	0.40
	Population Mean	79.12				221.5	
	Parental Mean	78.72				206.03	
	Hybrid mean	79.05				226.21	

S.N.	Crosses	Stem girth(cm)			Brix(%)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	SRF 286	1.09	1.45	0.009*	8.91	1.67	-0.19
2	SRF 305	1.20	1.27	0.006	9.07	1.40	-0.18
3	SRF 311	1.00	1.06	0.115**	8.41	1.54	-0.17
4	GFS 3	1.18	1.02	0.032**	7.84	1.69	0.48
5	RSSV 104	1.12	0.72	-0.002	10.66	-0.36	7.17**
6	AKFSV 2	0.86	-0.35	0.098**	7.37	0.95	7.90**
7	SSG 59-3	0.72	0.67	0.006	9.97	0.84	8.78**
8	GFS 4	0.38	0.13	0.004	6.47	0.72	3.07**
9	SRF 286 x SRF 305	0.86	0.39	0.002	12.08	0.40	3.17**
10	SRF 286 X SRF 311	0.87	0.31	-0.002	9.81	-0.41	1.84**
11	SRF 286 X GFS 3	0.89	0.49	0.000	9.68	-2.33	0.75
12	SRF 286 X RSSV 104	1.04	2.03	0.031**	10.51	0.98	2.81**
13	SRF 286 X AKFSV 2	0.86	0.49	0.044**	11.04	3.30*	-0.29
14	SRF 286 X SSG 59-3	1.11	2.41	0.002	12.31	1.44	0.35
15	SRF 286 X GFS 4	1.06	1.56	0.076**	10.51	-1.58	3.10**
16	SRF 305 X SRF 311	1.06	1.84	-0.001	11.37	2.87	1.94**
17	SRF 305 X GFS 3	1.01	1.45	0.004	10.81	0.65	0.56
18	SRF 305 X RSSV 104	1.05	1.37	0.058**	9.88	2.25	9.31**
19	SRF 305 X AKFSV 2	1.03	1.27	0.050**	10.40	0.34	1.41*
20	SRF 305 X SSG 59-3	0.98	1.53	0.006	7.96	1.41	9.13**
21	SRF 305 X GFS 4	0.85	1.12	0.051**	8.88	1.05	2.94**
22	SRF 311 X GFS 3	0.80	1.50	0.010*	9.30	2.15	3.15**
23	SRF 311 X RSSV 104	0.86	0.59	0.029**	8.76	2.36	0.09
24	SRF 311 X AKFSV 2	0.93	1.19	0.004	11.01	1.68	-0.22
25	SRF 311 X SSG 59-3	0.75	0.53	0.023**	9.90	-0.38	5.14**
26	SRF 311 X GFS 4	0.85	1.03	0.017**	10.10	2.15	1.93**
27	GFS 3 X RSSV 104	0.92	1.23	-0.001	9.72	1.74	6.81**
28	GFS 3 X AKFSV 2	0.82	1.33	0.003	9.11	0.40	0.99*
29	GFS 3 X SSG 59-3	1.00	0.87	0.026**	8.40	1.39	2.61**
30	GFS 3 X GFS 4	1.05	1.57	0.034**	11.80	-0.70*	-0.27
31	RSSV 104 X AKFSV 2	0.85	0.77	0.005	11.64	3.86	4.26**
32	RSSV 104 X SSG 59-3	0.95	0.14	0.009*	8.26	2.68	0.44
33	RSSV 104 X GFS 4	0.81	0.26	0.045**	10.87	-1.53	3.04**
34	AKFSV 2 X SSG 59-3	0.84	0.88	0.094**	7.86	-0.79	8.60**
35	AKFSV 2 X GFS 4	0.86	0.55	0.050**	9.52	1.94	10.81**
36	SSG 59-3 X GFS 4	0.64	0.33*	-0.003	8.90	1.68	0.09
37	HC 308(NC)	1.03	2.03	0.008	9.07	-0.43	-0.12
	S.E. (m) ±	0.12	0.81			1.28	1.43
	Population Mean	0.93				9.67	
	Parental Mean	0.94				8.59	
	Hybrid mean	0.92				10.01	

*, ** significant at 5 per cent and 1 per cent of probability levels, respectively.

Table 2: Cont..

S.N.	Crosses	HCN content (ppm)			Green fodder yield plant^{-1} (g)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	SRF 286	83.70	0.31	26.00	135.00	0.73	-69.07
2	SRF 305	127.20	4.16	174.90**	133.67	1.01	194.33
3	SRF 311	115.20	0.21	1592.40**	107.89	1.11	-38.86
4	GFS 3	102.40	2.60	59.10*	119.67	0.36	254.98*
5	RSSV 104	137.00	-1.30	2527.60**	125.89	1.49	599.84**
6	AKFSV 2	220.30	1.31	851.10**	94.56	0.69	2035.66**
7	SSG 59-3	130.60	0.12	15.50	80.56	0.31	101.35
8	GFS 4	126.70	1.82	501.50**	47.67	0.65	-22.46
9	SRF 286 x SRF 305	63.00	1.46	331.30**	216.56	1.02	202.12
10	SRF 286 X SRF 311	81.10	6.34	357.10**	176.89	1.46	33.17
11	SRF 286 X GFS 3	76.20	3.80	851.20**	127.45	0.13	-55.55
12	SRF 286 X RSSV 104	65.40	-2.96	0.60	148.67	1.62	329.55*
13	SRF 286 X AKFSV 2	92.90	2.47	374.70**	89.67	-0.78	466.63**
14	SRF 286 X SSG 59-3	53.40	4.56*	-11.70	150.33	1.17*	-72.58
15	SRF 286 X GFS 4	159.60	-2.41	2390.10**	164.22	2.21	13.80
16	SRF 305 X SRF 311	73.40	0.82	245.00**	146.67	0.39*	-70.24
17	SRF 305 X GFS 3	87.80	-1.61	-7.00	174.89	0.63	919.39**
18	SRF 305 X RSSV 104	86.80	4.20	4474.50**	170.22	1.42	-34.02
19	SRF 305 X AKFSV 2	142.40	8.65*	-15.60	137.44	1.83	1854.22**
20	SRF 305 X SSG 59-3	74.70	6.84	710.00**	150.89	2.08	1746.52**
21	SRF 305 X GFS 4	78.20	-0.14	5190.40 **	162.45	0.87	-7.26
22	SRF 311 X GFS 3	137.30	2.20	14910.40 **	126.33	1.51	-13.37
23	SRF 311 X RSSV 104	76.90	-1.51	8.20	137.11	1.28	235.27*
24	SRF 311 X AKFSV 2	134.80	11.90	298.40 **	90.22	0.95	405.00*
25	SRF 311 X SSG 59-3	103.10	-4.83	12165.90 **	176.11	1.06	236.30*
26	SRF 311 X GFS 4	119.20	-3.63	594.10 **	167.89	0.96	-46.54
27	GFS 3 X RSSV 104	40.00	-1.60	553.00 **	125.67	1.23	1566.74**
28	GFS 3 X AKFSV 2	86.80	-6.13	3648.10 **	101.89	0.45	788.88**
29	GFS 3 X SSG 59-3	52.20	1.75	301.10 **	130.33	0.82	216.27*
30	GFS 3 X GFS 4	68.20	0.97	793.60 **	204.00	0.87	2282.60**
31	RSSV 104 X AKFSV 2	67.20	5.19	1055.80 **	194.67	0.82	200.59
32	RSSV 104 X SSG 59-3	152.80	-2.62	5601.00**	162.11	1.27	-66.16
33	RSSV 104 X GFS 4	78.90	0.72	-11.80	182.89	1.57	-13.74
34	AKFSV 2 X SSG 59-3	95.70	-2.64	2230.00**	172.00	0.98	73.58
35	AKFSV 2 X GFS 4	112.60	-4.01	2165.00**	98.11	0.04	1097.77**
36	SSG 59-3 X GFS 4	84.30	-0.59	28.20	95.44	1.65	216.35*
37	HC 308(NC)	105.60	0.57	-5.20	131.67	1.16	-72.24
	S.E. (m)±	29.80	3.8			15.7	0.50
	Population Mean	99.87				139.4	
	Parental Mean	130.39				105.61	
	Hybrid mean	90.89				149.33	

Table 2: Cont..

S.N.	Crosses	Dry matter yield per plant (g)		
		Mean	b_i	S^2d_i
1	SRF 286	37.22	0.59	1.16
2	SRF 305	34.35	1.08	20.03
3	SRF 311	31.32	0.19	91.08 **
4	GFS 3	37.92	-0.00	76.81**
5	RSSV 104	33.63	1.64	-5.87
6	AKFSV 2	21.63	1.36	3.82
7	SSG 59-3	28.37	-0.12	96.99**
8	GFS 4	9.82	0.29	-1.03
9	SRF 286 x SRF 305	71.26	1.85	19.00
10	SRF 286 X SRF 311	54.26	1.49	57.25**
11	SRF 286 X GFS 3	36.17	0.70	102.43**
12	SRF 286 X RSSV 104	45.37	1.38	14.18
13	SRF 286 X AKFSV 2	26.50	-0.70	193.32**
14	SRF 286 X SSG 59-3	37.90	0.81	15.24
15	SRF 286 X GFS 4	44.57	1.75	81.51**
16	SRF 305 X SRF 311	44.69	0.96	-5.32
17	SRF 305 X GFS 3	54.64	1.43	108.12**
18	SRF 305 X RSSV 104	50.61	1.60	8.67
19	SRF 305 X AKFSV 2	28.66	0.68	-4.23
20	SRF 305 X SSG 59-3	46.12	1.72	553.76**
21	SRF 305 X GFS 4	39.88	1.27	-2.05
22	SRF 311 X GFS 3	36.33	1.37	10.82
23	SRF 311 X RSSV 104	46.32	1.54	90.16**
24	SRF 311 X AKFSV 2	26.19	0.88	22.79*
25	SRF 311 X SSG 59-3	40.90	-0.22	517.22**
26	SRF 311 X GFS 4	43.18	0.72	3.30
27	GFS 3 X RSSV 104	42.91	1.10	305.93**
28	GFS 3 X AKFSV 2	29.73	0.14	72.32**
29	GFS 3 X SSG 59-3	32.00	1.09	68.72**
30	GFS 3 X GFS 4	63.97	1.38	40.47**
31	RSSV 104 X AKFSV 2	57.46	0.42	393.97**
32	RSSV 104 X SSG 59-3	49.89	2.27 *	-6.69
33	RSSV 104 X GFS 4	51.54	2.21	6.07
34	AKFSV 2 X SSG 59-3	54.56	1.63	92.38**
35	AKFSV 2 X GFS 4	34.78	-0.01	28.26*
36	SSG 59-3 X GFS 4	35.28	1.90	114.16**
37	HC 308(NC)	41.17	0.61	40.48**
	S.E. (m) ±	6.90	0.69	
	Population Mean	40.55		
	Parental Mean	29.28		
	Hybrid mean	43.77		

*, ** significant at 5 per cent and 1 per cent of probability levels, respectively.

the characters studied suggesting differential response of genotypes to different environments. The results are in accordance with the finding of Sankarpandian (2000) and Patil *et al*. (2006). Significant mean squares due to environment(linear) indicated considerable differences among environments and their predominant effects on all the traits, Pooled deviations were significant for all the traits suggesting the importance of non-linear component in the manifestation of genotype x environment interaction for these significant traits (Patil *et al*, 2006).

The three parameters of stability namely mean (xi), regression coefficient (bi) and deviation from the regression (S^2di) presented for green fodder yield and other traits in Table 2. The ideal variety should have high mean, unit linear regression and least deviation from regression. For the character days to flowering parent GFS 4 and hybrid AKFSV 2 X SSG 59-3 found average stable having less mean (early) with non-significant S^2di value and near unity regression coefficient. The cross combination GFS 3 X GFS 4 found suitable under poor farming situation while RSSV 104 X AKFSV 2 found superior under good farming conditions. The character plant height generally contribute maximum to green fodder yield, the parent SRF 286 and hybrid RSSV 104 x GFS 4 were average stable among all parents and hybrids having high mean value than check and hybrid mean. The thinness is important trait in forage sorghum as thin stem plant is liked by animals. The parent GFS 4 having lowest mean with average stability for stem girth. Among hybrids GFS 3 X AKFSV 2 had lowest mean than check with average stability across the environments. For quality parameters brix per cent parent SRF 305 and HCN content, parent SRF 286 had highest mean value in desirable direction with near unity regression coefficient and non significant (least) deviation from regression. The hybrid SRF 286 x SSG 59-3 was average stable for brix reading however it was specifically adapted to better farming situation with higher mean than the check HC 308 for HCN content. The cross GFS 3 X GFS 4 was specifically suited to poor farming situation for brix value. With regard to green fodder yield, total five parents and 12 hybrids were average stable as had non-significant non linear and linear components with bi value around unity and $S^2dia=0$. The mean value of check for green fodder yield plant^{-1} was less than the hybrid mean and was stable. Most promising stable parents were SRF 286, SRF 305 and SRF 311 with higher mean value than parental mean. The promising hybrids in descending mean value with average stability across different environments were SRF 286 X SRF 305, RSSV 104 X AKFSV 2, RSSV 104 X GFS 4, SRF 286 X SRF 311, AKFSV 2 X SSG 59-3 and SRF 305 X RSSV 104. The two crosses SRF 286 X SSG 59-3 and SRF 305 X SRF 311 were stable under good farming situation.

For dry matter yield same parents SRF 286 and SRF 305 and hybrids SRF 286 X SRF 305, RSSV 104 X GFS 4 and SRF 305 X RSSV 104 found average stable with high mean value. The check HC 308 was unstable while cross combination RSSV 104 X SSG 59-3 was suitable under favourable environmental situation. A perusal of the result indicated that parent SRF 286 having stability over environment for green fodder and dry matter yield also had stability for yield components like plant height and quality parameters like brix value and HCN content. The results are in conformation with Dangi and Paroda (1978) and Patel (1993). Similarly hybrids SRF 286 x SRF 305, RSSV 104 X AKFSV 2, RSSV 104 X GFS 4, etc., are stable across different environmental condition for green fodder yield owing to stability in component characters. Such type of crosses can be advanced and better segregants can be identified for developing stable cultivar with high yield potentiality.

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Effect of Conjoint Use of Diammonium Phosphate and Rock Phosphate in Combination with Phosphate Solubilizing Bacteria for Pigeonpea in Vertisol

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ABSTRACT

A field experiment was conducted on Vertisol at Pulses Research Unit, Akola (MS) during *Kharif* season of 2001-02, 2002-03 and 2003-04 to study the effect of diammonium phosphate (DAP) and rock phosphate with or without PSB. Grain and straw yield, number of pods plant^{-1} and grain weight plant^{-1} were significantly higher with 40 kg P_2O_5 ha^{-1} used in the form of DAP with phosphate solubilizing bacteria, followed by application of 40 kg P_2O_5 ha^{-1} through rock phosphate with PSB. Harvest index followed the order of DAP+PSB (T_{10}) and rock phosphate + PSB (T9) and it decreased with increasing phosphorus levels. Maximum net returns was noticed with seed inoculation with PSB and 40 kg P_2O_5 ha^{-1} used in the form of DAP (Rs 14212) followed by 40 kg P_2O_5 ha^{-1} through rock phosphate + PSB (Rs 12471) (T9). However, returns per rupee invested was more in T_{10} (Rs 2.63), followed by T_9 (Rs 2.41).

Pigeonpea is the most preferred pulse crop all over India and has indispensable place in all regional food habits and subsistence agriculture. India is the largest pigeonpea growing country encompassing over 80 per cent of the world area under pigeonpea. Its ability to produce economic yield under limited moisture conditions makes it an important crop of dryland agriculture. To enhance the productivity of this crop, use of phosphorus along with phosphate solubilizing bacteria (PSB) is of great importance. Phosphorus is important nutrient for growth and yield of pigeonpea (Matiwade and Sheelavantar, 1992) which is known as energy currency of the living cells. Phosphate solubilizing bacteria play an important role in making phosphorus available to crop plants (Gautam and Pant, 2002). Indian soils are low to medium in available phosphorus. Supply of phosphorus through fertilizer is still below the optimum level due to very high prices of phosphorus fertilizers. In India, most common source of phosphorus is diammonium phosphate (DAP). Alternate source of phosphorus can ease the current situation. Rock phosphate is the cheapest source of phosphorus for crops. India alone is estimated to have about 140 million tonnes of rock phosphate deposits, most of these are, however, of low grade, with substantial impurities and are not suitable for the production of phosphatic fertilizer (Gowarikar *et al.* 2006). Therefore, it may be desirable to workout a technology for exploiting this indigenous resource of phosphorus for direct application to field crops in combination with and without PSB. There is a little information available on the integrated phosphate management in pigeonpea. Hence, the present investigation was carried out to find out the optimum dose of phosphorus along with PSB in pigeonpea under rainfed conditions.

MATERIAL AND METHODS

A field experiment was conducted during *Kharif* seasons of 2001-02, 2002-03 and 2003-04 at Pulses Research Unit, Akola (MS). The initial soil was medium clayey in texture, medium in organic carbon (0.38, 0.42 and 0.43 per cent), available N (220, 224 and 225 kg ha^{-1}), available P_2O_5 (30.73, 31.02 and 28.56 kg ha^{-1}) and available K (630, 718 and 672 kg ha^{-1}) with pH (7.84, 8.39 and 8.40). The treatments consisted of two sources (Rock phosphate and DAP), two levels of phosphorus (20 and 40 kg ha^{-1}) along with seed inoculation with PSB (*Bacillus megatherium*) and PSB alone besides a control. Rock phosphate of Mussorie rock contents P_2O_5 11per cent and it was applied at the time of sowing. In all, ten treatments were tested in randomized block design with three replications. The crop variety ICPL 87119 was sown on 12 July 2001, 8 July 2002 and 19 July 2003 and was harvested on 29 January 2002, 29 January 2003 and 8 January 2004, respectively. The total rainfall received during the crop growth was

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Table 1. Effect of phosphorus and PSB on growth and yield attributes of pigeonpea (Pooled over 3 years)

Treatments	Plant height at harvest (cm)	Days to 50% flowering	Days to maturity	No. of branches Plant^{-1}	No. of pods plant^{-1}	100-seed weight (g)	Grain weight plant^{-1}
T_1 - Control	149.6	129	176	6.57	81.36	9.03	13.30
T_2 - 20 kg P_2O_5 ha^{-1} through rock phosphate	150.6	130	178	7.08	86.10	9.04	14.96
T_3 - 20 kg P_2O_5 ha^{-1} through DAP	151.0	130	177	7.44	86.53	9.03	15.98
T_4 - 40 kg P_2O_5 ha^{-1} thorough rock phosphate	153.3	130	178	7.37	92.13	9.09	17.96
T_5 - 40 kg P_2O_5 ha^{-1} thorough DAP	154.0	131	179	7.48	99.20	9.05	18.20
T_6 - PSB alone	149.8	130	178	6.95	87.40	9.22	14.21
T_7 - T_2 + PSB	149.3	132	178	7.60	93.53	9.15	15.73
T_8 - T_3 + PSB	153.0	131	177	7.22	96.66	9.10	16.35
T_9 - T_4 + PSB	157.0	131	177	8.73	104.40	9.16	20.28
T_{10} - T_5 + PSB	155.6	132	179	8.12	109.53	9.20	21.61
CD (P=0.05)	NS	—	—	NS	11.33	NS	1.23

659.6, 414.6, and 692.8 mm in 25, 23, and 37 rainy days during 2001-02, 2002-03 and 2003-04, respectively.

RESULTS AND DISCUSSION

The data pertaining to yield contributing characters showed that the increasing dose of diammonium phosphate from 20 to 40 kg P_2O_5 ha^{-1} with and without PSB increased the plant height, number of branches plant^{-1}, number of pods plant^{-1}, grain weight plant^{-1} and test weight as compared to the equal levels of P_2O_5 used in the form of rock phosphate with and without PSB, respectively. However, these increases did not reach the level of significance during the experimentation with the exception of number of pods plant^{-1} and grain weight plant^{-1} (Table 1). Application of 40 kg P_2O_5 ha^{-1} used in the form of DAP increased the number of pods plant^{-1} and grain weight plant^{-1} significantly over no application of phosphorus.

Phosphorus application @ 20 and 40 kg P_2O_5 ha^{-1} used in the form of DAP with and without PSB increased the grain and straw yield as compared to the yields obtained with the equal doses of P_2O_5 when applied in the form of rock phosphate with and without PSB, respectively. However, the difference in yields between two types of fertilizer at all the levels was not found significant. These results are in agreement with the results obtained by Mehrotra (1986). The efficacy of both the forms of phosphatic fertilizer was significantly increased by the addition of PSB with all the levels, however, significant difference was noticed with 40 kg P_2O_5 ha^{-1} used in the form of diammonium phosphate with PSB (T_{10}). This might be because of making unavailable form of phosphorus available to plant by producing organic acid *i.e.*, citric acid and sulphuric acid which convert tricalcium phosphate to basic phosphate (Tomar *et al.* 1996). The per cent increase in grain yield in T_{10} treatment was 29.8, 7.9 and 11.76 per cent over the control and application of phosphorus @ 40 kg ha^{-1} through DAP (T_5) and rock phosphate alone (T_4) respectively. Lack of rock phosphate response may be attributed to a low application levels, high P-fixation capacity of soil and moderately alkaline soil pH likely inhibited the dissolution reaction for rock phosphate (Chen and Menon 1995 and Sanyal and De Datta, 1991). PSB alone produced statistically equal yields as compared to 20 kg P_2O_5 ha^{-1} used in either form with or without PSB. Plant growth and yield were also affected due to scarce supply of moisture especially at flowering

Table 2. Effect of phosphorus and PSB on yield, harvest index and economics of pigeonpea (Pooled over 3 years)

Treatments	N kg ha^{-1} added through Urea	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})	Harvest Index (per cent)	Gross monetary return (Rs)	Cost of cultivation (Rs)	Net monetary return (Rs)	B:C ratio
		2001-02	2002-03	2003-04	Pooled						
T_1 - Control	15.65	1150	729	1098	995	1114	47.18	17641	8005	9636	2.20
T_2 - 20 kg P_2O_5 ha^{-1} through rock phosphate	15.65	1180	825	1188	1064	1192	47.19	18865	8405	10460	2.24
T_3 - 20 kg P_2O_5 ha^{-1} through DAP	7.82	1190	820	1247	1085	1215	47.19	19237	8341	11582	2.30
T_4 – 40 kg P_2O_5 ha^{-1} thorough rock phosphate	15.65	1230	962	1279	1156	1295	47.18	20497	8805	11691	2.32
T_5 - 40 kg P_2O_5 ha^{-1} thorough DAP	0	1225	1057III	1312	1197	1341	47.18	21324	8677	12646	2.45
T_6 - PSB alone	15.65	1175	779	1180	1044	1169	47.18	18510	8023	10487	2.30
T_7 - T_2 + PSB	15.65	1195	865	1231	1097	1229	47.19	19451	8423	11027	2.30
T_8 - T_3 + PSB	7.82	1195	868	1316	1126	1261	47.19	19965	8359	11605	2.38
T_9 - T_4 + PSB	15.65	1280	972	1353	1201	1345	47.18	21294	8823	12471	2.41
T_{10} –T_5 + PSB	0	1310	1064	1504	1292	1447	47.18	22908	8695	14212	2.63
CD (P=0.05)	-	47.80	127.7	144.28	83.18	93.18	NS	1477	-	1477	-

Pigeonpea: Rs 1679 q^{-1}, Straw: Rs 84 q^{-1}, DAP: Rs 970 q^{-1}, Rock phosphate: Rs 400 q^{-1}, Urea: Rs 500 q^{-1}

and pod filling stages under rainfed conditions. A significant yield response in pigeonpea to phosphorus up to 40 kg P_2O_5 ha^{-1} through DAP has been reported earlier (Singh and Sekhon, 2007). Seed inoculation of PSB + phosphorus application resulted significantly more grain and straw yields, pods $plant^{-1}$ and grain weight $plant^{-1}$ as compared with the control. Harvest index of pigeonpea did not vary significantly with the treatments due to balance growth and yield with the application of PSB + phosphorus. Inoculation of PSB and PSB + phosphorus @ 40 kg ha^{-1} used in the form of rock phosphate and DAP, respectively gave Rs.851, Rs. 780 and 1566 ha^{-1} higher net returns over control. This was attributed due to comparatively higher gross returns ha^{-1} and less cost of DAP fertilizers owing to quantity required as compared to rock phosphate. Net returns of pigeonpea was maximum in seed inoculation with PSB + phosphorus @ 40 kg ha^{-1} used in the form of DAP (Rs 14,212 ha^{-1}) which showed Rs 4576 and Rs 1566 more over the control and phosphorus application @ 40 kg ha^{-1} used in the form of DAP alone, respectively (Table 2).

Returns per rupee invested was more in PSB + phosphorus @ 40 kg ha^{-1} used in the form of DAP (Rs 2.63), followed by PSB + phosphorus @ 40 kg ha^{-1} used in the form of rock phosphate (Rs 2.41), owing to greater gross returns ha^{-1} of respective treatments as compared with cost involved in production of pigeonpea. Thus, inoculation of PSB + phosphorus @ 40 kg ha^{-1} used in the form of DAP was found productive and remunerative system for pigeonpea under rainfed conditions of Vidharbha region.

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Effect of Seed Priming and Foliar Fertilization of Nitrogen on Growth and Yield of Chickpea (*Cicer arietinum*)

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ABSTRACT

Field experiments were carried out during *Kharif* season of 2005-06, 2006-07 and 2007-08 showed that seed priming gave significantly higher grain yield over no priming. The increase was to the tune of 11.68 per cent. Foliar application of urea (2 per cent) twice at flowering and 10 days thereafter significantly increased the number of pods plant^{-1}, and grain weight plant^{-1} resulted in higher grain yield than the water spray.

Poor stand establishment due to drought, lack of irrigation facilities is a major constraint in chickpea cultivation under rainfed condition. Seed priming benefits included faster emergence of seedlings, better stands and a lower incidence of re-sowing, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield (Harris *et al.* 1999). Priming of seeds is economical, simple and safe technique for improving germination, seedling growth, crop production and that would be appropriate for all farmers irrespective of their socio-economic status. For a large proportion of the time that seeds spend in the soil that are simply imbibing water, often very slowly and do not promote good seed-soil contact owing to low-precision sowing methods. Speed of germination and emergence was an important determinant of successful establishment. Nitrogen due to leaching and volatilization may not be available adequately at flowering and pod formation stages of crop and results in shading of flowers and pods. The crop need more nitrogen at the reproductive phase (Hamid, 1988), and the nutrient uptake after flowering either becomes slow or stop due to inactivation of roots. Foliar nutrition may be a useful option particularly for the areas where soil application of fertilizers often leads to locking or loss of nutrients. Foliar application of amide form of nitrogen is easily available to the plant system without any expenditure of energy through cuticle and stomata to the site of food synthesis directly, leaving no wastage. It revealed that foliar application of nitrogen through urea sustained foliar activity and root nitrogen absorption leading to a higher utilization of available nitrogen (Martigone and Nakyama, 1983) and being non-polar molecule making, it is an ideal for foliar application. Chickpea is the major crop grown on residual soil moisture in Southern Maharashtra where crop establishment is a major constraint and foliar spray of fertilizer may result in economic use of fertilizer which is a high cost input. Keeping this view in mind, the present investigation was carried out.

MATERIAL AND METHODS

Field investigations were carried out at Akola during *Rabi* 2005-06, 2006-07 and 2007-08 on medium black soil. The soil was low in available nitrogen (214 kg ha^{-1}, medium in available phosphorus (21.60 kg ha^{-1}) and high in available potash (304 kg ha^{-1}), with pH- 8.30, electrical conductivity 0.32 dS m^{-1} and O.C. 4.40 g kg^{-1}. The experiment was laid out in a factorial randomized block design with four replications, keeping plot size as 4 x 4.5m. The treatments consisted of seed priming 4 h in water (S_1) and no seed priming (S_2) under foliar nutrition water spray at foliar nutrition (N_1), 2 per cent urea spray at vegetative (N_2), flowering (N_3), pod formation stage (N_4), vegetative + flowering stage (N_5) and flowering + 10 days thereafter (N_6) were given. Chickpea variety SAKI-9516 was sown at 30 x 10 cm spacing using 55 kg seed ha^{-1} seed rate on 26 October 2005, 11October 2006 and 5 November 2007 and harvested on 7 February, 25 February and 24 January 2008 during first, second and third year respectively. The preceding crop during *Kharif* was mungbean, urdbean and mungbean during 2005-06, 2006-07 and 2007-08, respectively. The crop was fertilized with uniform dose of fertilizer 20 kg N and 40 P_2O_5 kg ha^{-1}. The main aim of this investigation

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Table 1 : Grain, straw GMR, NMR and B:C ratio of Chickpea as influenced by different treatments

Treatments	Spraying At DAS	Grain yield (kg ha^{-1})			Pooled	Straw yield (kg ha^{-1})	Gross monetary returnRs.	Net monetary returnRs	B:C ratio
		05-06	06-07	07-08					
Seed Priming									
S_1 - No seed soaking	-	611	885	914	770	1115	18443	6818	1.59
S_2 - Seed soaking 4hrs in water	-	682	970	1030	860	1240	20591	8974	1.77
SE (m)±		20.72	18.26	27.43	13.11	18.25	308.90	308.90	—
CD at 5%		60.76	53.55	80.45	37.08	51.62	873.69	873.69	—
Foliar Nutrition									
N_1 - Water spray	35	601	815	859	725	1052	17371	5746	1.49
N_2 - Urea spray 2% at vegetative stage	35	629	885	923	779	1127	18656	7031	1.60
N_3 - Urea spray 2% at flower initiation	45	656	960	996	837	1208	20052	8427	1.72
N_4 - Urea spray 2% at pod formation stage	65	608	871	872	750	1087	17967	6342	1.55
N_5 - Urea spray 2% at vegetative + flower initiation stage	3545	663	1002	1076	880	1269	21052	9450	1.81
N_6 - Urea spray 2% at flowering + 10 days there after.	5060	721	1032	1105	919	1322	22004	10379	1.89
SE (m)±		35.88	31.62	47.51	22.71	31.61	535.02	535.04	—
CD at 5%		NS	92.76	139.35	64.91	89.41	1513.26	1513.31	—
Interaction (Seed priming x Foliar nutrition)									
SE (m)±		50.75	41.02	67.19	32.11	44.70	756.64	756.66	—
CD at 5%		NS	NS	NS	NS	NS	NS	NS	—
CV%		13.59	8.35	10.86	11.82	11.38	11.63	28.75	—

Table 2: Ancillary observation of Chickpea as influenced by different treatments (Mean of 3 years)

Treatments	Days to 50% flowering	DAS to maturity	Plant height (cm)	No.of Branches plant^{-1}	No.of pods plant^{-1}	Grain weight plant^{-1}(g)	100 Seed weight (g)
A. Seed Priming							
S_1 - No seed soaking	50.85	104.61	34.92	6.84	29.27	4.57	15.91
S_2 - Seed soaking 4 hrs in water	50.25	104.94	37.11	8.32	31.35	4.95	16.68
SE (m)±	0.09	0.17	0.29	0.11	0.43	0.06	0.09
CD at 5%	0.26	NS	0.84	0.32	1.25	0.17	0.27
B. Foliar Nutrition							
N_1 - Water spray	50.33	102.67	35.30	6.67	27.00	4.31	15.96
N_2 - Urea spray2% at vegetative stage	51.27	105.00	36.00	6.68	29.3	4.70	16.08
N_3 - Urea spray 2% at flower initiation	51.10	104.83	35.93	8.00	30.73	4.79	16.45
N_4 - Urea spray 2% at pod formation stage	49.94	104.67	35.60	7.45	29.19	4.51	16.60
N_5 - Urea spray 2% at vegetative + flower initiation stage	50.00	105.5	36.87	8.11	31.77	4.95	16.11
N_6 - Urea spray 2% at flowering + 10 days there after.	50.67	106.0	36.42	8.57	33.87	5.30	16.57
SE (m)±	0.15	0.30	0.50	0.19	0.74	0.10	0.16
CD at 5%	0.45	1.23	NS	0.55	2.17	0.30	0.47
C. Interaction							
SE (m)±	0.22	0.42	0.70	0.27	1.04	0.14	0.23
CD at 5%	NS	NS	NS	NS	NS	NS	NS
CV%	2.73	2.69	3.38	6.06	5.97	5.23	2.40

was to study the effect of priming of chickpea seeds (4 h soaking in water) on the performance of crop in the field, in comparison with crop raised from non-primed seeds and decide the proper stage of foliar spray of urea for rainfed chickpea so as to ascertain the practical utility of low cost technology of seed priming and foliar nutrition on the yield parameters of chickpea crop.

RESULTS AND DISCUSSION

Effect of Priming

Seed priming resulted in maximum number of branches, number of pods plant^{-1}, grain weight plant^{-1}, earlier flowering and earlier harvest than no priming. However, 1000-seed weight was not affected by any of the treatments. Seed priming 4 h in water recorded significantly highest grain yield (860 kg ha^{-1}) than no priming (770 kg ha^{-1}). The increase was to the tune of 11.68 per cent and 11.21 per cent higher grain and straw yield, respectively over no priming. The beneficial role of priming was attributed to the alterations in enzymes activities of carbohydrate metabolism in the seedlings. Kaur *et. al.*, (2002 a) reported that activities of amylase, invertase, sucrose synthase and sucrose phosphate synthase in shoots, sucrose synthase and invertase in roots, and sucrose phosphate synthase in cotyledons increased in primed seedling as compared to non-primed seedlings.

Foliar Nutrition

The maximum seed yield was recorded with foliar spray of 2 per cent urea solution twice at flowering and 10 days thereafter (N_6), which was significantly superior to other treatments except foliar spray of urea (2 %) at vegetative + flower initiation stage (N_5) and urea spray (2 %) at flower initiation (N_3) during the individual years (excluding during 2005-06) and spray of 2 per cent urea at vegetative + flower initiation stage alone (N_5) in pooled data. Yield increment due to 2 per cent urea

spray was 26.76 per cent over water spray. The increase in grain yield due to urea application could be obtained because of improvement in crop growth and yield attributes (Table 2). Ali and Kumar (2006) reported beneficial effect of foliar application with 2 per cent urea solution at the reproductive stage i.e. flowering and pod formation in most of the pulse crops. It might be due to the fact that pulses under rainfed conditions often experience nitrogen deficiency during flowering and pod formation because nitrogen fixation usually declines at reproductive stages and this is preceded by a decrease in fixation rate per unit weight of root nodules which probably results from bacteriod decay in the oldest nodules or in other words, gradual degeneration of root nodules. Yield improvement due to 2 per cent urea spray was very well reflected in the higher values obtained for number of pods plant^{-1} and grain weight plant^{-1}. Similar increase in grain yield was observed through foliar spray (Hamid 1988). The response to foliar application of 2 per cent urea solution has also been reported from different locations (Jeswani and Baldev, 1997).

Economics

Seed priming significantly influenced gross (Rs. 20591/-) and net monetary return (Rs.8974/-) over no priming. It has recorded 11.65 and 31.62 per cent higher GMR and NMR, respectively over no seed priming. Similarly, the highest C:B ratio was recorded with seed priming over no seed priming.

Foliar spray of urea (2 %) at flowering + 10 days thereafter (N_6) registered highest gross (Rs.21104) and net monetary returns (Rs.9186 ha^{-1}), respectively over remaining foliar spray of urea and water spray, closely followed by urea spray at flowering and vegetative stage (N_5) which in turn did not differ conspicuously from urea spray at flower initiation stage (N_3). The aforesaid treatment was significantly superior over different foliar nutrition of urea spray and water spray. The highest B:C ratio was recorded with Urea spray 2 per cent at flower initiation and 10 days thereafter (N_6) and Urea spray 2 per cent at vegetative + flower initiation stage (N_5)

CONCLUSION

Under rainfed condition for *Desi* chickpea, for higher grain yield, soaking of seed for 4 h in water in addition to recommended dose of fertilizer to recover nitrogen deficiency at critical stage, supplemental dose of urea (2 %) sprays at flowering and 10 days thereafter be given for obtaining higher grain yield.

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Impact of Institutional Credit on Weaker Section

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ABSTRACT

The study on "Impact of Institutional Credit on Weaker Section in Akola District was undertaken with the objectives to study the employment pattern, income and expenditure pattern and the impact of credit on income and employment of selected samples. As per the guidelines on lending to priority sector issued from the Reserve Bank of India, the weaker section includes,

1. Small and marginal farmers with landholding of 5 acres and less and landless labourers, tenant farmers and share croppers. 2. Artisans, village and cottage industries where individual credit limits do not exceeds Rs. 50,000/-

Akola tahsil was purposively selected. The data were collected from five villages of 100 respondents from weaker sections, out of which 50 were beneficiaries and 50 were non-beneficiaries. The data pertain to the year 2007-08.

Perform average employment, annual income was higher in beneficiaries than non-beneficiaries. In beneficiaries, highest proportion of loan (78.57%) was availed for crop production followed by livestock purchase (20.45 %), and implement and machinery (only 0.97 %). Gross return was higher in beneficiaries over non- beneficiaries. At overall level annual employment in beneficiaries was higher (291.56 days) as compared to non-beneficiaries (266.58 days).

Majority of farmers being small have limited resources of their own and have to depend on credit for acquiring crucial and costly inputs with the technological changes in Indian agriculture. The capital needs of farmers for modern inputs have increased manifolds. The increased capital needs cannot be met from the farmers' own fund. The farmers get income during the limited period while their expenses are spread throughout the year. Therefore they have to depend on some other sources for obtaining the funds to meet their farming requirements. The requirement of production credit varies from farm to farm and also from crop to crop. It also depends on the level of technology being adopted by the farmers in the region. Lack of adequate capital has been acknowledged as one of the most serious inhibiting factors in modernization of traditional agriculture and the key element behind the vicious cycle of poverty.

Creation of adequate credit facilities has been identified as the principal solution for all Indian Agricultural problems. By taking all this into consideration, the study entitled "Impact of Institutional credit on weaker section in Akola district" was undertaken with the following objectives:

1. To study the employment pattern. 2. To study the income and expenditure pattern.
3. To study the impact of credit on income and employment of selected sample farmers.

MATERIAL AND METHODS

Akola tahsil was purposively selected for the study. The sampling technique followed for collection of data for the present study was purposively random sampling. From this tahsil, five villages were selected for the study i.e. Chikhalgaon, Sindkhed, Kapsi road, Mhaispur and Lakhanwada. List of beneficiaries and non beneficiaries of weaker section were prepared separately for each selected village with the help of Grampanchayat,Primary agricultural credit societies and other financing institutions.

The farmers who availed agricultural credit from any institutional sources for at least three years were called as beneficiaries and those who have not taken any financial assistant from any institutional sources for last three years were called as non beneficiaries, for the purpose of studying the impact of credit on income. As such, whole sample was consisted of 50 beneficiaries and 50 non beneficiaries. Thus the total sample consisted of 100.

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Analysis of data:

Cost concepts : The following commonly cost concepts were used for estimating the cost of cultivation of crops.

Cost A: This cost includes the following items of expenditure.

1. Hired human labour 2. Owned and Hired bullock labour 3. Seed (both home produced and purchased) 4. Manures (owned and purchased). 5. Fertilizers 6. Depreciation and repairs to implements and machinery 7. Land revenue and other cesses. 8. Irrigation charges 9. Interest on working capital 10. Miscellaneous charges.

Cost B = Cost A + Rental value of land + Interest on fixed capital

Cost C: Cost 'C' is the total cost of cultivation. It is arrived by adding imputed value of family labour to cost B.

Output- Input Ratio : The output-input ratio shows the profitability of investment on farm. This was worked out by dividing the gross return by the cost. The output-input ratio was worked at cost A, and cost C for farm as a whole under study.

For the income from the farm as a whole for the beneficiaries and non-beneficiaries farm was measured by estimating following measures.

Farm Business Income = Gross income – Cost A

Family labour income = Gross income – Cost B

Net income = Gross income – Cost C

Cropping Intensity : Cropping intensity refers to the intensity with which land is cultivated.

$$\text{Cropping intensity (\%)} = \frac{\text{Grossed cropped area}}{\text{Net sown area}} \times 100$$

RESULTS AND DISCUSSION

Employment pattern

It was observed from Table 1 that the annual employment in beneficiaries at overall level was 291.56 days out of which crop production provided 71.30 per cent employment, followed by subsidiary occupation (21.85 %) and livestock (6.85 %). Total labour employment in non-beneficiaries group at overall level was 266.58 days, out of which crop production provided 70.06 per cent employment, followed by subsidiary occupation (23.35 %) and livestock (6.59 %) employment.

At overall level, the total labour employment opportunities on beneficiaries group were more (291.56 days) as compared to non-beneficiaries group (266.58 days). Thus an additional 24.98 days of employment opportunities were created in beneficiaries over non-beneficiaries. Thus use of credit had increased the input use and as such it helped in creating additional employment opportunities.The studies carried out on employment by other research workers indicated similar results, Misra and Maurya (2007). It was observed that

Table 1 Employment pattern of selected farmers.

S.N.	Particulars	Beneficiaries				Non-Beneficiaries			
		Marginal	Small	Artisans	Overall	Marginal	Small	Artisans	Overall
1	Crop Production	206.55	219.01	198.11	207.89	198.29	204.54	157.49	186.77
		(71.99)	(73.26)	(68.60)	(71.30)	(72.70)	(73.59)	(63.24)	(70.06)
2	Livestock	24.68	26.57	8.59	19.95	20.69	24.74	7.28	17.57
		(8.60)	(8.89)	(2.97)	(6.85)	(7.59)	(8.90)	(2.92)	(6.59)
3	Subsidiary occupation	55.67	53.37	82.11	63.72	53.78	48.68	84.27	62.24
		(19.40)	(17.85)	(28.43)	(21.85)	(19.72)	(17.51)	(33.84)	(23.35)
4	Total labour employment	286.91	298.95	288.81	291.56	272.76	277.96	249.04	266.58
		(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.0)	(100.00)
5	Additional Employment over Non-beneficiary	14.15	20.99	39.77	24.98				

Note: Figures in parentheses are percentages to total labour employment

income and employment both on per hectare and farm^{-1} basis were higher on borrower farms than non-borrower farm.

Annual income

Table 2 reveals that the beneficiary at overall level the annual total income from all sources farm^{-1} was Rs. 42527.47. Largest share in the total gross income of farm^{-1} was from crop production (55.53%), followed by subsidiary and artisans occupation (39.25%), wage earning (3.18%) and from service and business (2.04%). However, in case of non-beneficiaries at over all level the annual total income farm^{-1} was Rs. 27637.84. Largest share in total gross income of farm^{-1} was from crop production (71.94%), followed by subsidiary and artisans occupation (19.58%), wage earning (5.84%) and farm service and business (2.64%). The major source of annual income in beneficiaries and non-beneficiaries of selected sample was crop production. These results are in conformity with the observation of Anjugam and Ramasamy (2007).

Expenditure pattern

It was observed from Table 3 that in case of beneficiaries at overall level the total farm and family consumption expenditure was Rs. 39390.01. Out of these expenditure, agriculture incurred 46.48 per cent, subsidiary / Artisan 22.84 per cent and on family consumption 30.68 per cent which includes total food item (18.93%) and total non food items (11.75%).

In case of non-beneficiaries at overall level the total expenditure was Rs. 31114.55. Out of these expenditure, agriculture incurred 52.91 per cent, subsidiary and artisan 17.39 per cent and on consumption 29.69 per cent which includes total food item (17.93%) and total non-food items (11.76%).

It is concluded that major expenditure in beneficiaries and non- beneficiaries was on agriculture. It was also observed that the expenditure on total non food item in beneficiaries was more in all the groups.

Cost, Returns and Profit

It could be seen from Table 4 that in beneficiaries at overall level the farm^{-1} gross return was Rs. 23616.75 as against Rs. 19883.16 for non-beneficiaries. For beneficiaries Cost A and cost C farm^{-1} were Rs. 14709.92 and 18307.46, respectively and for non-beneficiaries it was RS. 12962.60 and Rs. 16463.91, respectively. Thus farm^{-1} expenditure incurred by the beneficiaries was higher than non-beneficiaries.

The farm business income represents profit over direct cost (Cost A) was Rs. 8906.83 for beneficiaries as against Rs. 6920.56 for non-beneficiaries. The net income over total cost (Cost C) on beneficiaries for the farm as a whole was

Table 2: Annual income of selected samples through various sources

(Rs. Farm^{-1})

S.N.	Particulars	Beneficiaries				Non-Beneficiaries			
		Marginal	Small	Artisans	Overall	Marginal	Small	Artisans	Overall
1	Crop Production	19971.65 (54.32)	36914.57 (69.21)	13964.04 (37.25)	**23616.75** (55.53)	17900.56 (71.82)	29825.56 (78.99)	11923.35 (58.93)	**19883.16** (71.94)
2	Subsidiary and Artisans Occupation	14789.49 (40.23)	14119.06 (26.47)	21166.14 (56.47)	**16691.56** (39.25)	4410.19 (17.69)	5718.27 (15.14)	6105.58 (30.18)	**5411.35** (19.58)
3	Wage Earning	2003.45 (5.45)	1054.78 (1.98)	996.23 (2.66)	**1351.49** (3.18)	2614.00 (10.49)	1168.12 (3.09)	1056.76 (5.22)	**1612.96** (5.84)
4	Service & Business	0.00 (0.00)	1245.00 (2.33)	1358.00 (3.62)	**867.67** (2.04)	0.00 (0.00)	1045.00 (2.77)	1146.11 (5.66)	**730.37** (2.64)
	Total	**36764.59** (100.00)	**53333.41** (100.00)	**37484.41** (100.00)	**42527.47** (100.00)	**24924.75** (100.00)	**37756.95** (100.00)	**20231.80** (100.00)	**27637.84** (100.00)

Note: Figures in parentheses indicate the percentage to total

Table 3 :Pattern of expenditure of selected samples (Rs./Family/Year)

S.N.	Particulars	Beneficiaries				Non-Beneficiaries			
		Marginal	Small	Artisans	Overall	Marginal	Small	Artisans	Overall
A	Agriculture	15972.56	28137.38	10812.44	**18307.46**	14897.44	23546.87	10947.41	**16463.91**
		(46.40)	(54.59)	(33.57)	(46.48)	(55.45)	(58.54)	(41.70)	(52.91)
B	Subsidiary/	8588.00	8998.79	9405.58	**8997.46**	4410.19	5718.27	6105.58	**5411.35**
	Artisan	(24.95)	(17.46)	(29.20)	(22.84)	(16.42)	(14.22)	(23.26)	(17.39)
C	Consumption								
1	Total cereals	2720.64	3113.64	2831.40	2888.56	2660.40	3227.88	2908.08	2932.12
		(7.90)	(6.04)	(8.79)	(7.33)	(9.90)	(8.02)	(11.08)	(9.42)
2	Total Pulses	984.24	1224.84	1140.48	1116.52	841.44	1328.16	1144.80	1104.80
		(2.86)	(2.38)	(3.54)	(2.83)	(3.13)	(3.30)	(4.36)	(3.55)
3	other food items	2825.40	3937.96	3591.88	3451.74	1333.00	1782.00	1510.28	1541.76
		(8.21)	(7.64)	(11.15)	(8.76)	(4.96)	(4.43)	(5.75)	(4.96)
4	Total Food items	6530.28	8276.44	7563.76	7456.82	4834.84	6338.04	5563.16	5578.68
		(18.97)	(16.06)	(23.48)	(18.93)	(18.00)	(15.76)	(21.19)	(17.93)
5	Total Non	3329.40	6127.28	4428.14	4628.27	2724.04	4621.68	3636.12	3660.61
	Food items	(9.67)	(11.89)	(13.75)	(11.75)	(10.14)	(11.49)	(13.85)	(11.76)
6	Food +	9859.68	14403.72	11991.90	**12085.09**	7558.88	10959.72	9199.28	**9239.29**
	Non-food items	(28.65)	(27.95)	(37.23)	(30.68)	(28.13)	(27.25)	(35.04)	(29.69)
	Total	**34420.24**	**51539.89**	**32209.92**	**39390.01**	**26866.51**	**40224.86**	**26252.27**	**31114.55**
	Expenditure	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Figures in parentheses indicate the percentage to total.

Table 4 : Cost, Returns and Profit on selected farms. (Rs. Farm^{-1})

S.N.	Particulars	Beneficiaries				Non-Beneficiaries			
		Marginal	Small	Artisans	Overall	Marginal	Small	Artisans	Overall
1	Gross cropped area(ha)	1.21	2.43	0.72	1.45	1.09	2.12	0.63	1.28
2	Gross returns	19971.65	36914.57	13964.04	23616.75	17900.56	29825.56	11923.35	19883.16
		(16505.50)	(15191.18)	(19394.50)	(16287.42)	(16422.53)	(14068.66)	(18925.95)	(15533.72)
3	Cost A	11564.89	24566.63	7998.25	14709.92	10456.33	20887.36	7544.11	12962.60
		(9557.76)	(10109.72)	(11108.68)	(10144.77)	(9592.96)	(9852.53)	(11974.78)	(10127.03)
4	Cost B	13887.81	26489.52	9055.44	16477.59	12778.42	21799.85	9011.44	14529.90
		(11477.53)	(10901.04)	(12577.00)	(11363.86)	(11723.32)	(10282.95)	(14303.87)	(11351.49)
5	Cost C	15972.56	28137.38	10812.44	18307.46	14897.44	23546.87	10947.41	16463.91
		(13200.46)	(11579.17)	(15017.28)	(12625.83)	(13667.38)	(11107.01)	(17376.84)	(12862.43)
6	Farm business income	8406.76	12347.94	5965.79	8906.83	7444.23	8938.20	4379.24	6920.56
		(6947.74)	(5081.46)	(8285.82)	(6142.64)	(6829.57)	(4216.13)	(6951.17)	(5406.68)
7	Family labour income	6083.84	10425.05	4908.60	7139.16	5122.14	8025.71	2911.91	5353.25
		(5027.97)	(4290.14)	(6817.50)	(4923.56)	(4699.21)	(3785.71)	(4622.08)	(4182.23)
8	Net income	3999.09	8777.19	3151.60	5309.29	3003.12	6278.69	975.94	3419.25
		(3305.03)	(3612.01)	(4377.22)	(3661.58)	(2755.16)	(2961.65)	(1549.11)	(2671.29)
9	Out-input ratio at								
	i) Cost A	1 : 1.73	1 : 1.50	1 : 1.75	1 : 1.61	1 : 1.71	1 : 1.43	1 : 1.58	1 : 1.53
	II) Cost C	1 : 1.25	1 : 1.31	1 : 1.29	1 : 1.29	1 : 1.20	1 : 1.27	1 : 1.09	1 : 1.21

Figures in parentheses indicate values per hectare

Rs. 5309.29, whereas for non- beneficiaries farm it was Rs. 3419.25. Output – input ratios for beneficiaries and non- beneficiaries at cost A were 1.61 and 1.53 and at cost C were 1.29 and 1.21, respectively. This shows that crop production was profitable in both the groups but more so on beneficiaries. It was observed that gross return; cost A, cost B, farm business income and net income

Table 5: Pattern of Utilization of Loan

(Figures in Rs.)

S.N.	Particulars	Beneficieries			
		Marginal	Small	Artisans	Overall
1	Crop Production	121520.00	254640.00	27200.00	134453.33
		(72.98)	(84.98)	(57.63)	(78.57)
2	Live stock purchase	45000.00	45000.00	15000.00	35000.00
		(27.02)	(15.02)	(31.78)	(20.45)
3	Implements/Machinery	0.00	0.00	5000.00	1666.67
		(0.00)	(0.00)	(10.59)	(0.97)
	Total	**166520.00**	**299640.00**	**47200.00**	**171120.00**
		(100.00)	(100.00)	(100.00)	(100.00)

Note : Figures in parenthesis are percentage to total

Table 6 : Impact of Credit on Employment.

Figures in Days

S. N.	Particulars	Beneficiaries	Non - beneficiaries	Additional employmentover non beneficiaries
1	Marginal	286.91	272.76	14.15
		(32.80)	(34.11)	(18.89)
2	Small	298.95	277.96	20.99
		(34.18)	(34.76)	(28.02)
3	Artisans	288.81	249.04	39.77
		(33.02)	(31.14)	(53.09)
4	Overall	291.56	266.58	24.98
		(33.33)	(33.33)	(33.35)

Note : Figures in parenthesis are percentage to total

Table 7 : Impact of Credit on Income.

S. N.	Particulars	Beneficiaries	Non - beneficiaries	Additional incomeover non beneficiaries
1	Marginal	36764.59	24924.75	11839.84
		(28.82)	(30.06)	(26.51)
2	Small	53333.41	37756.95	15576.46
		(41.80)	(45.54)	(34.87)
3	Artisans	37484.41	20231.80	17252.61
		(29.38)	(24.40)	(38.62)
4	Overall	42527.47	27637.84	14889.63
		(33.33)	(33.33)	(33.33)

Note : Figures in parenthesis are percentage.

per hectare were higher in beneficiaries than non-beneficiaries. Thus the study revealed that the farm^{-1} income in beneficiaries were higher as compared to non- beneficiaries.

Pattern of utilization of loan

It was revealed from Table 5 that at overall level the highest proportion of loan (78.57%) availed for crop production followed by livestock purchase (20.45%) and implements and machinery (only 0.97 %). The study indicated that the major share of loan amount was utilized towards crop production, followed by purchase of livestock. This contradict with the result of Gupta, *et. al.*,(2007).

Impact of credit on employment

It was observed from Table 6 that overall annual employment in beneficiaries was higher (291.56 days) as compared to non-beneficiaries (266.58 days). Thus an additional 24.98 days of employment opportunities were created in beneficiaries over non-beneficiaries. Additional employment in beneficiaries over non- beneficiaries in case of artisan, small and marginal groups were 53.09 per cent, 28.02 per cent and 18.89 per cent, respectively. In all, it was concluded that the additional employment over non- beneficiaries found to be 24.98 days.

Impact of credit

It was observed from Table 7 that at overall level, income in beneficiaries was higher (Rs. 42527.47) as compared to non- beneficiaries (Rs. 27637.84). Thus an additional income of Rs. 14889.63 was created in beneficiaries over non- beneficiaries. Additional income in beneficiaries over non-beneficiaries in case of artisans, small and marginal groups were 38.62 percent, 34.87 per cent and 26.51 per cent, respectively.

In all, it was found that the additional income in case of beneficiaries over non-beneficiaries was Rs. 14889.63.

CONCLUSION

An additional 24.98 days of employment opportunities were created in beneficiaries over non-beneficiaries. Expenditure on non food items in beneficiaries was more than non- beneficiaries while an additional income to the extent of 33.33 per cent were more in beneficiaries.

From the results of the study, it is concluded that the institutional credit had positive impact on employment and income of weaker sections. The studies also suggest that institutional agency should also undertake sale of inputs and commodities and provide other agriculture related services to enlarge its membership to perform better.

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Optimum Crankshaft Height and Crank Length for Hand Operated Rotary Maize Sheller

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ABSTRACT

A Laboratory study was carried out at the Central Institute of Agricultural Engineering, CIAE, Bhopal to find out the optimum crankshaft height and crank length for a hand operated rotary maize sheller with ergonomic considerations. Studies were carried out to evaluate physiological and psychophysical responses of six female agricultural workers during hand cranking at five crankshaft heights and crank lengths at a shaft torque of 18.0 N-m and the speed of 50 rpm. The independent variables were selected as crankshaft height with respect to elbow height (EH) varied as 0.8 , 0.9 , 1.0 , 1.1 and 1.2 EH and crank length was varied in relation to shoulder grip length (SGL) as 0.4, 0.45, 0.5, 0.55 and 0.6 SGL of individual worker. Based on the results of experiment, a crankshaft height of 0.9 EH and crank length of 0.45 SGL was optimised for the hand operated rotary maize sheller.

Traditional maize shelling is energy and labour intensive operation. At present, maize shelling has been improved by the use of tubular maize shellers and hand operated rotary maize shellers. The tubular maize sheller is getting popularity among the small and marginal farmers (Agrawal and Satapathy, 2006).

Hand operated rotary maize sheller is manually operated machine consisting of a flywheel, a frame, a hopper and three shelling gears. With one hand a person operates the equipment by hand cranking whereas with the other hand he feeds the cobs into the machine one by one. The shelled cobs come out through the port on opposite side. Removing grains from the cob by hand operated rotary maize sheller are preferred for seed production due to less damage to the grain during the shelling operation.

During maize shelling operation crankshaft height and crank length are one of the important aspects whereby physiological cost can be reduced. Therefore, a laboratory study was carried out at CIAE, Bhopal to find out the optimum crankshaft height and crank length for a hand operated rotary maize sheller with ergonomic considerations.

MATERIAL AND METHODS

The experiment was performed with six healthy female agricultural workers. All the subjects were well acquainted with maize shelling operation. Their mean ± SD of age, stature, elbow height, shoulder grip length and weight were 32.16 ± 1.94 years, 154.98 ± 2.69 cm, 96.18 ± 3.20 cm, 66.66 ± 1.54 cm and 50.83 ± 9.55 kg, respectively. During the experiment the mean climatic conditions were 'comfortable' (ASHARE,1974) with the dry bulb temperature, wet bulb temperature and relative humidity during the experiments varied from 29 to 35 °C, 18 to 25 °C and 20 to 55 per cent, respectively.

Preliminary trials conducted with five female agricultural workers on hand operated rotary maize sheller indicated that irregular feeding rate and speed of operation affected the physiological cost of the operator during maize shelling operation. This happens because when the subject concentrates on rotating the handle with right hand, she fails to maintain the desired cob feeding with left hand due to improper coordination. A test set-up was developed to measure the torque and speed required for the operation of hand operated rotary maize sheller as shown in Fig. 1. The brief specifications of test set-up are given in Table 1.

Table 1. Specifications of the hand operated rotary maize sheller

Particulars	Measurements
Length, mm	1030
Width, mm	470
Height, mm	1080
Diameter of fly wheel, mm	480
Crankshaft height, mm	760
Crank length, mm	270

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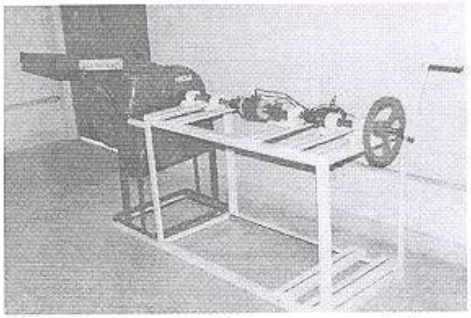


Fig. 1. Test setup used for measurement of Torque and speed

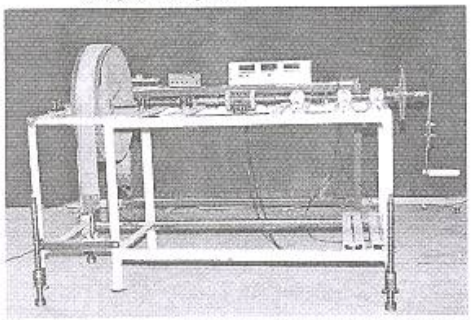


Fig. 2. Experimental setup for optimization of crankshaft height and crank length

To have uniform torque and speed of operation another experimental set-up was developed as shown in Fig. 2. Torque required and speed of operation was recorded by using a torque indicator. A metronome was used to guide the worker for maintaining constant speed of operation. A set of trials were conducted to know the weight required to be put on slack side of the belt to get the desired torque of 18 N-m at 50 rpm of the crankshaft rotation. It was observed that 66 g weight was required to be put on the slack side of the belt to get the desired torque of 18 N-m at 50 rpm of hand cranking. A provision was made in four legs of the experimental test set-up to change crankshaft height and crank length.

The physiological observations made during the experiment were heart rate and oxygen consumption rate of the subjects. Heart rate was continuously recorded throughout the experiment by using Polar heart rate monitor (Polar Vontage NV). Oxygen consumption rate was estimated using correlation between heart rate and oxygen consumption. In the present study the following equation proposed by Anonymous (2007) was used.

$$Y = 0.0162\,X - 1.314$$

Where,

Y = Oxygen consumption rate in l/min

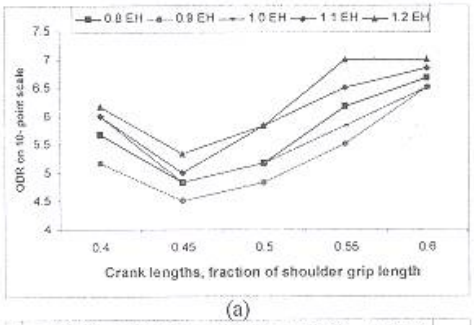
X = Heart rate in beats/min

A 10–point visual analogue discomfort (VAD) scale proposed by Legg and Mahanty (1985) was used for assessment of overall discomfort rating (ODR) and to measure body part discomfort score (BPDS) Corlett and Bishop (1976) Technique was used.

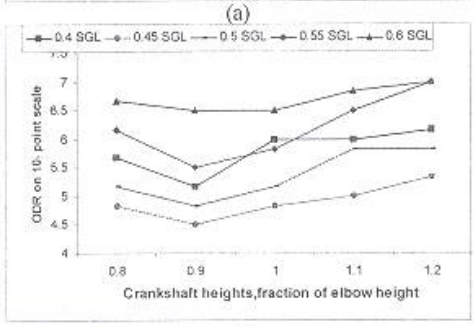
Depending on elbow height (EH) the working crankshaft height i.e. 0.8, 0.9, 1.0, 1.1 and 1.2 EH were fixed and depending on shoulder grip length (SGL) the working crank length i.e. 0.4, 0.45, 0.5, 0.55 and 0.6 SGL were fixed. The duration of trial was kept for 15 minutes.

RESULTS AND DISCUSSION

The relationship between the physiological, psychophysical responses and the parameters crankshaft height and crank lengths are shown in Figs. 3, 4, 5 and 6.

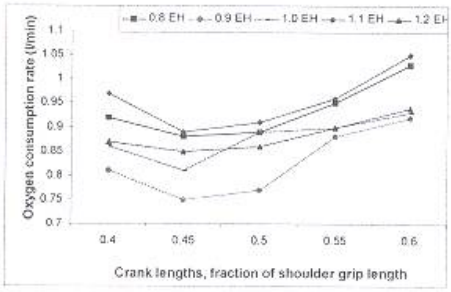


(a)

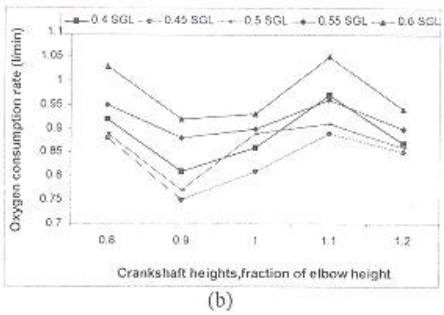


(b)

Fig. 5 Variation in overall discomfort rating with different crank lengths and crankshaft heights

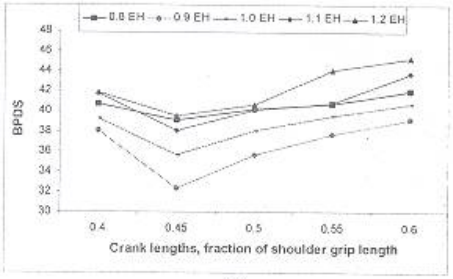


(a)

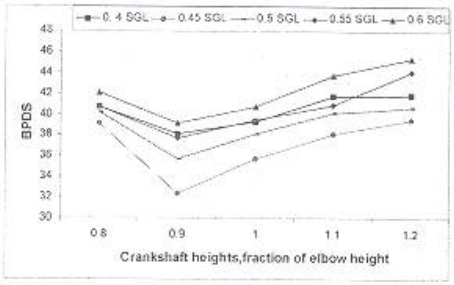


(b)

Fig. 4 Variation in oxygen consumption rate (VO_2) with crank lengths and crankshaft heights.

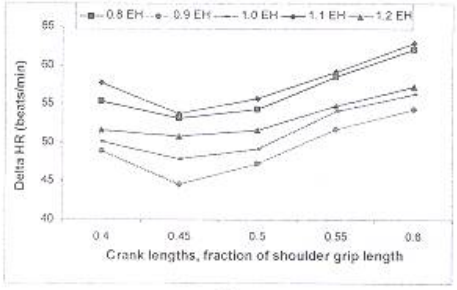


(a)

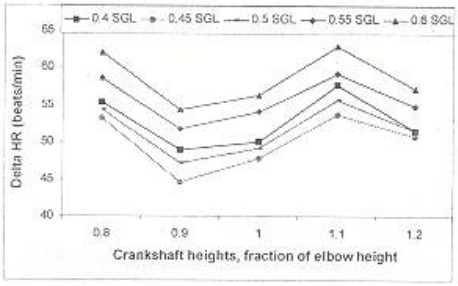


(b)

Fig. 6. Variation in body part discomfort score (BPDS) with different crank lengths and crankshaft heights.



(a)



(b)

Fig 3. Variation in delta heart rate ("HR) with different crank lengths and crankshaft heights

From figs. 3, 4, 5 and 6 it may be observed that at a given crankshaft height increase in delta heart rate and oxygen consumption rate was first decreased when the crank length was increased from 0.40 to 0.45 of shoulder grip length. Afterward it increased with increase in crank length from 0.45 to 0.60 of shoulder grip length. Whereas, with increase in crank length at a given crankshaft height, the overall discomfort rating and body part discomfort score of female workers first decreased with increase in crank length from 0.40 to 0.45 of shoulder grip length and afterward increased with increase in crank length from 0.45 to 0.6 of shoulder grip length. From above figures it is observed that minimum

physiological and psychophysical responses values were observed when crankshaft height was 0.9 EH and crank length was 0.45 SGL. The analysis of variance states that there was a clear physiological and psychophysical difference between hand cranking operation with different crankshaft heights and crank lengths. During hand cranking at lowest crankshaft height and crank length the downward position forced the workers to bend their back during the operation, therefore due to large trunk movements during cranking operation subjects felt it strenuous. Due to comfortable posture and less body movements, during hand cranking operation with crankshaft height of 0.9 EH and crank length of 0.45 SGL physiological and psychophysical responses decreased.

For maize shelling operation with hand operated rotary maize sheller the crankshaft height should be taken as 0.9 EH and crank length as 0.45 SGL so that the physiological and psychophysical responses will be minimum. Considering this position and the available anthropometric data of Madhya Pradesh female agricultural workers, a crankshaft height of 86 cm and crank length of 30 cm is recommended for female agricultural workers.

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Response of New Sunflower Varieties to Fertilizer Levels

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ABSTRACT

A field experiment to evaluate the response of new sunflower varieties to fertilizer levels was conducted at Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during –*Kharif* season of 2007-08. The variety LSF-1-28 was significantly superior over rest of the varieties and check in respect of growth attributes, growth functions (AGR, RGR and NAR), yield attributes and consequently seed yield. As regards fertilizer levels, all the growth attributes, growth functions, yield attributes and seed yield increased linearly and significantly with successive increasing level of fertilizer from 50 per cent to 150 per cent RDF. Variety LSF-1-28 responded appreciably to the application of 150 per cent RDF and recorded significantly highest seed yield than rest of the combinations.

At present there is acute shortage of edible oil in India, which has been fulfilling by expending foreign exchange of Rs. 101.89 billions. India has the largest area under oilseeds but ranks 4 in production (next to China and Brazil) due to low yields per hectare.

The average yield (900 kg ha^{-1}) is about half of the world average production and the lowest among the major oilseeds producing countries. The demand of vegetable oil for edible and industrial purposes is expected to grow by 3-4 per cent $annum^{-1}$ over the next five to ten years. It is estimated that by the end of 2010-2015, the demand will increase by 14.3 to 18.3 million tones (Agrawal, 2007). The oil production is unstable because of fluctuation in the yield of groundnut which is the major oilseed crop and also due to their unsuitability to varied soil and climatic conditions. Hence, there is a need to introduce such a oil bearing crops or varieties which have high yield potential and which could meet the escalating demand of oil in the country. Sunflower (*Helianthus annuus* L.) holds good promise and potential in this respect and becoming popular among the farmers, because of their photo-thermo insensitiveness and short duration, and also as a catch crop in contingency planning. But the growth rate in productivity of sunflower from 1970 to 2007 was - 0.30 per cent as compared to all oilseeds i.e. + 1.37 percent and productivity is almost stagnant around 550 kg ha-^{1} during the last three decades. Causes of low productivity might be cultivation of varieties having narrow genetic response to fertilizers and under nutrition of crop due to continuous soil mining. Therefore the present investigation was taken up to study response of different sunflower varieties to fertilizer levels in respect of growth, growth functions and yield.

MATERIAL AND METHODS

A field experiment was conducted at Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2007-08. The soil of experimental field was clayey, having pH 8.2 with electrical conductivity 0.49 dSm^{-1}, organic carbon 0.35 per cent, and available N, P_2O_5 and K_2O was 215, 14.2 and 485 kg ha^{-1}, respectively. The treatments comprising six sunflower varieties viz., DRSF-119 (V_1), DRSF-108 (check) (V_2), GAUSUF-12 (V_3), DRSF-118 (V_4), SS-2038 (V_5) and LSF-1-28 (V_6) and three fertilizer levels viz, 50 per cent RDF (40:30:00 kg NPK ha^{-1}) (F_1), 100 per cent RDF (80:60:00 kg NPK ha^{-1}) (F_2) and 150 per cent RDF (120:90:00 kg NPK ha^{-1}) (F_3), were laid out in factorial randomized block design with three replications. Seed of different varieties were received from Directorate of Oilseeds Research, Hyderabad and sowing was done at spacing of 60 x 30 cm^2. Fertilizers were drilled in the soil as per treatment combinations. A half dose of N and full dose of P were applied at the time of sowing and the remaining half dose of N was applied in the rows at 30 days after sowing. The crop was sown on 13 July and harvested on 18 October, 2007. The rainfall of 453.8 mm was recived during crop season in 27 rainy days. Observations on growth and yield

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attributes were recorded at harvest and growth functions were worked for peak vegetative and early reproductive stage and expressed as a mean.

RESULTS AND DISCUSSION

Growth and Growth Functions

Data on growth attributes and growth functions are presented in Table 1 and 2.

Varieties

Differences among varieties in respect of plant height, number of functional leaves plant^{-1}, leaf area, dry matter plant^{-1} and for different growth functions were found to be significant. Variety LSF-1-28 recorded significantly highest dry matter per plant than rest of the varieties. This highest dry matter production was due to combined effect of significant increase in plant height, number of functional leaves plant^{-1} and leaf area, which might be resulted in better light interception due to exposure of individual leaves at wider vertical interval and of highest plant height in this variety. It was followed by maximum values of growth attributes recorded with variety DRSF-108 (check), which was at par with DRSF-118 and significantly superior over rest of the varieties.

As regards growth functions, variety LSF-1-28 showed significantly highest AGR, RGR and NAR during both peak vegetative and early reproductive stages (40-60 and 60-80 DAS) indicating highest dry matter production rate per unit leaf area per day. This may be related to its genetic characters to maintain more number of photosynthetic structures per unit area, which leads to the increase in photosynthetic efficiency. It was followed by maximum dry matter production rate observed with variety DRSF-108, which was at par with DRSF-118 and significantly superior over rest of the varieties.

Fertilizer levels

The variation imposed through fertilizer level significantly influenced all the growth parameters viz. plant height, number of functional leaves, leaf area and dry matter accumulation plant^{-1} (Table 1 and 2). All the growth attributes successively increased with increasing level of fertilizer from 50 per cent RDF to 150 per cent RDF. Highest values of growth parameters were recorded with application of 150 per cent RDF (120:90:00 NPK kg ha^{-1}) and which was significantly superior over 50 per cent and 100 per cent RDF. The significant improvement in growth attributes with the application of 150 per cent RDF might be due to increase in availability of nutrients resultanting early root ramification and development of extensive root system, which led to the higher nutrient uptake and thereby increased cell division, their elongation and resulted in gain in growth. The present investigations are in consonance with the findings of Sarmah *et al.* (1992) and Purohit *et al.* (2006).

Growth functions viz. AGR, RGR and NAR of dry matter increased linearly with increase in level of fertilizer from 50 per cent to 150 per cent RDF. Application of 150 per cent RDF recorded significantly highest values of growth functions at both peak vegetative and early reproductive stages over 50 per cent and 100 per cent RDF. The difference in dry matter production rate with fertilizer level may be attributed to the role of nutrients in increasing photosynthetic efficiency.

Interaction (V x F)

Interaction effect between varieties and levels of fertilizers for dry matter accumulation per plant was found to be significant (Table 2). Application of 150 per cent RDF to variety LSF-1-28 (V_6F_3) recorded maximum dry matter plant^{-1}, which was significantly superior over all other treatment combinations but was at par with V_2F_3, V_6F_2 and V_4F_3.

Yield and Yield Attributes

The data in respect of yield attributes and yield of sunflower are presented in Table 2.

Varieties

The variety LSF-1-28 recorded highest diameter of disc and maximum number of seeds per disc which was significantly superior over rest of the varieties and check (Table 2), followed by maximum diameter of disc and number of seeds per disc was recorded with variety DRSF-108 was at par with DRSF-118. However, highest values of test weight was recorded with variety GAUSUF-12 which was significantly superior over rest of the varieties and check. Followed by varietiy LSF-1-28 recorded better test weight, which was at par with DRSF-108 and SS-2038. Maximum values of yield attributes with variety LSF-1-28 might be attributed to highest dry matter synthesis in this variety and its efficient translocation to reproductive structure.

Table 1: Growth attributes and growth functions of sunflower as influenced by varieties and fertilizer levels.

Treatments	Plant height (cm)	No. of functional leaves plant^{-1} 60 DAS	Leaf area plant^{-1} (dm^2) 60 DAS	Absolute growth rate (AGR) (g day^{-1})		Relative growth rate (RGR) (g/g/day)		Net assimilation rate (NAR) (g/dm^2/day)	
				40-60 DAS	60-80 DAS	40-60 DAS	60-80 DAS	40-60 DAS	60-80 DAS
Varieties									
V_1 - DRSF-119	158.46	18.36	17.87	0.855	1.126	0.0126	0.0077	0.0142	0.0188
V_2 - DRSF-108 (check)	167.55	21.93	21.35	0.975	1.360	0.0141	0.0106	0.0185	0.0260
V_3 - GAUSUF-12	158.47	18.79	18.29	0.863	1.138	0.0127	0.0077	0.0143	0.0189
V_4 - DRSF-118	167.53	21.91	21.33	0.964	1.345	0.0141	0.0105	0.0184	0.0259
V_5 - SS-2038	162.98	20.39	19.85	0.914	1.236	0.0134	0.0091	0.0164	0.0223
V_6 - LSF-1-28	172.11	23.64	23.01	1.021	1.456	0.0151	0.0121	0.0205	0.0296
SE (m) ±	1.60	0.52	0.50	0.007	0.030	0.0002	0.0004	0.0006	0.0011
CD at 5%	4.44	1.44	1.40	0.022	0.083	0.0005	0.0012	0.0018	0.0032
Fertilizer level									
F_1 - 50% RDF	160.62	19.20	18.69	0.896	1.152	0.0127	0.0085	0.0156	0.0209
F_2 - 100% RDF	164.40	21.09	20.53	0.929	1.298	0.0137	0.0097	0.0171	0.0236
F_3 - 150% RDF	168.53	22.21	21.62	0.971	1.381	0.0146	0.0107	0.0185	0.0263
SE (m) ±	1.13	0.36	0.35	0.005	0.021	0.0001	0.0003	0.0004	0.0008
CD at 5%	3.14	1.02	0.99	0.015	0.058	0.0004	0.0008	0.0012	0.0023
Interaction V x F									
SE (m) ±	2.77	0.90	0.87	0.013	0.052	0.0004	0.0008	0.0013	0.0021
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM.	164.51	20.83	20.29	0.932	1.276	0.0136	0.0096	0.0170	0.0235

Table 2: Dry matter accumulation, yield attributes and yield of sunflower as influenced by varieties and fertilizer levels.

Treatments	Dry matter (g plant $^{-1}$)	Diameter of disc (cm)	No. of seedsdisc^{-1}	Test weight (g)	Seed yield (q ha^{-1})	Harvest index
Varieties						
V_1 - DRSF-119	68.97	9.91	435.91	35.09	9.65	20.60
V_2 - DRSF-108 (check)	79.93	12.23	685.66	35.50	12.31	27.12
V_3 - GAUSUF-12	69.30	9.93	448.25	37.65	10.49	22.34
V_4 - DRSF-118	79.80	12.21	678.17	34.92	12.17	27.05
V_5 - SS-2038	76.25	10.95	589.76	35.37	11.34	24.66
V_6 - LSF-1-28	83.94	14.29	739.09	35.53	13.60	29.41
SE (m)±	0.91	0.30	3.28	0.15	0.27	0.80
CD at 5%	2.53	0.83	9.11	0.43	0.77	2.24
Fertilizer level						
F_1 - 50% RDF	69.96	10.71	486.13	33.44	10.26	22.60
F_2 - 100% RDF	77.41	11.39	595.12	35.45	11.39	25.63
F_3 - 150% RDF	81.72	12.69	707.17	38.12	13.14	27.86
SE (m)±	0.64	0.21	2.32	0.11	0.19	0.57
CD at 5%	1.78	0.59	6.44	0.30	0.54	1.58
Interaction V x F						
V_1F_1	58.33	9.48	331.80	32.79	8.91	19.52
V_1F_2	72.61	9.56	440.47	34.91	9.68	22.22
V_1F_3	75.97	10.70	535.47	37.58	10.37	23.05
V_2F_1	75.28	11.73	571.15	33.2	10.90	24.29
V_2F_2	79.89	11.52	680.40	35.32	12.41	28.17
V_2F_3	84.63	13.43	805.44	37.99	13.63	28.89
V_3F_1	58.64	9.58	343.18	35.35	9.38	20.73
V_3F_2	71.99	10.49	452.18	37.47	9.68	22.35
V_3F_3	77.28	9.91	549.38	40.14	12.43	23.95
V_4F_1	75.36	10.77	563.87	32.62	11.09	24.79

Variety LSF-1-28 recorded significantly highest seed yield and harvest index, which was a cumulative effect of growth and yield attributes and efficient translocation of stored food material in source to sink, thus increase in seed yield and consequently harvest index.

Fertilizer levels

Yield attributing characters i.e. diameter of disc, number of seeds per disc and test weight increased linearly and significantly with successive increase in levels of fertilizer over their lower levels (Table 2). Highest values of yield attributes obtained with application of 150 per cent RDF. Similar increase in diameter of disc, number of seeds per disc and test weight with increase in fertilizer levels were also reported by Rao and Saran (1981) and Raj *et al.* (1999).

Application of 150 per cent RDF (120:90:00 NPK kg ha^{-1}) recorded highest seed yield and harvest index which may be the result of better development of thalamus and good seed filling. The experimental soil was low in available nitrogen and very poor in available phosphorus status, hence 50 per cent higher level fertilizer than the recommended would have been better utilized by sunflower varieties to produce higher seed yield. Similar yield increase

with higher fertilizer level was quoted by Sabale (2003) and Sivamurugan *et al.* (2003).

Interaction (V x F)

The significant interaction between varieties and fertilizer levels was found in respect of diameter of disc, number of seeds disc^{-1} and seed yield (Table 2). Perusal of data indicates that, variety LSF-1-28 when fertilized with 150 per cent RDF (V_6F_3) recorded significantly maximum diameter of disc, number of seeds disc^{-1} and produced significantly highest seed yield than other treatment combinations. This can be correlated to significantly highest dry matter production in this combination (V_6F_3) which resulted in formation of larger thalamus, more number of seeds disc^{-1} and consequently significant gain in yield.

Thus, from the study, it is concluded that application of 150 per cent RDF (120:90:00 NPK kg ha^{-1}) to variety LSF-1-28 is optimum for highest seed yield of sunflower.

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Measurement of Risk in Agriculture

Devyanee K. Nemade[1] and S. S. Marawar[2]

ABSTRACT

Vulnerability of agricultural producers arises on account of two types of risk. One is the risk of loss of production due to unfavourable weather and soil conditions (Ramaswami Bharat, 2008). The other is the risk on account of depressed price due to various types of market condition and policy of the government. In the present study, an attempt has been made to measure the risk. The study is based on primary as well as secondary data. A time series data on area, production and productivity for the period 1980-81 to 2004-05 have been used. While primary data are collected from Agricultural Price Cell Scheme for the period from 2000-01 to 2004-05. The analysis of the data was done using trend curve for measurement of risk. Analysis of breakeven yield suggested that with the present productivity and prices of *Kharif* jowar, it is not economical to include Kh. jowar in the cropping pattern. In all highest annual negative deviation with probability of shortfall is observed in soybean followed by kh. jowar. While minimum expected negative deviation is observed in Cotton. Among all crops Cotton (deshi) is most profitable crop with high average return and low level of risk and found suitable for this area.

Indian farmers face various types of risk such as yield, price and technological. The nature of risks and farmer's adaptation to risks are changing with changes in climatic pattern, economic order and technological developments. In the light of a fluctuating economic environment, rational decisions are made possible through an application of breakeven techniques (Dillon, 1993). What is certain, however, is that the existence of potential risks in farming increases the vulnerability of the agricultural producers operating in less favourable production environments. On the basis of existing literature, this study documents the status of our knowledge on risk of agriculture. Indeed, to the best of our knowledge this is the first study of its kind in Vidarbha. The objectives of the study are:

1. To work out the break even yields in different crops.
2. To measure the risk in yields of different crops.

MATERIAL AND METHODS

The study was conducted in Akola district and based on primary as well as secondary data. A time series data on Area, Production and Yield pertaining to the period 1980-81 to 2004-05 have been used. The primary data for the present study were collected from Agricultural prices scheme, Department of Agricultural Economics and Statistics, Dr. P.D.K.V., Akola pertaining to the years 2000-01 to 2004-05.

Break even Yield

To estimate the break-even yield the following formula is used.

$$\text{Break Even Yield} = \frac{F}{(P-V)}$$

Where, F = Fixed Cost in Rs. ha^{-1}
P = Price of Product per quintal
V = Variable Cost per quintal

Break Even analysis for agricultural decision making has been proposed and discussed. Some analysis are i) Maximum potential yield losses due to detrimental weather can be investigated with potential yield analysis. ii) Breakeven output price can be used as a simple impact of marketing decision under price variability. iii) Breakeven analysis is also useful from input side.

Measurement of Risk in Yield

The study was restricted to measurement of yield risk, coefficient of variation was used to quantify the risk. Different types of trend curves were fitted and one i.e. Sinusoidal Curve giving highest R^2 was used for obtaining data adjusted trend and computation of risk. Besides coefficient

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of variation the risk in terms of probability of obtaining yields below 95 per cent of the trend value have been computed with the help of the probability distribution.

1. Normal Distribution

$$\text{Probability Distribution Function} = \frac{1}{(2\Pi\sigma^2)^{1/2}} \; EXP\left[\frac{-(X-\mu)^2}{2\sigma^2}\right]$$

Estimates $\mu = \bar{x}$

σ^2 = Sample Variance(S^2)

2. Lognormal:

$$\text{Probability Distribution Function} = \frac{1}{X\,\sigma\,(2\Pi)^{1/2}} \; EXP\left\{\frac{-[Log\,(X/M)]^2}{2\sigma^2}\right\}$$

$$\mu = \frac{\Sigma Log(X_i)}{N}$$

Estimates, $M = \exp(\mu)$

$$\sigma^2 = \frac{\Sigma Log(X-\mu)^2}{(N-1)}$$

3. Gamma

Probability Distribution Function: $(X/\beta)^{\alpha-1}\,[EXP\,(-X/\beta)]\beta T(\alpha)$

Estimates,

$$\alpha = (\underline{X/S})^2 \qquad \beta = (S^2/\bar{X})$$

4. Beta

Probability Distribution Function: $\frac{X^{m-1}(1-X)^{n-1}}{B(m,n)}$ where $B(m,n) = \int_0^1 X^{m-1}(1-X)^{n-1}$

Estimates,

$$m = \bar{X}[\bar{X}(1-\bar{X})/S^2]-1,\; n = (\bar{X}[\bar{X}(1-\bar{X})/S^2]-1)(1-\bar{X})$$

RESULTS AND DISCUSSION

Break even yield of different crops in Akola district

Break even yield is defined as that yield offsets cost of cultivation of a crop in a unit area. For any enterprise to move in a profitable track, it is necessary to first cover its break even quantity or volume of production to meet its cost and then the excess will lead to profit. In order to know the profitability of various crops grown, the break even yield is calculated.

Table 1 reveals that the break even yield varied from 2.97 q ha^{-1} to 23.82 q ha^{-1} in different crops grown in the district. In most of the crops actual yield is found to be higher than the corresponding break-even yield except *Kharif jowar*. In *Kharif jowar* actual yield was 21 per cent less than break even yield. It is not economical to include *Kharif jowar* in cropping pattern.

Measurement of Risk in Yield

The estimated probabilities of shortfall in realized yields and resulting expected negative deviations are presented in Table 2.

As explained in methodology any deviation by 5 per cent or more of trend values from the actual yield is termed as shortfall and an average probability over the period of study is termed as probability of shortfall.

The probability of shortfall was found to be highest in Soybean to the extent of 0.80 and in remaining crops, it varied between 0.44 in *Tur* to 0.70 in Gram and Cotton. In all, highest annual negative deviation to the extent of 166.02 Kg ha^{-1} with probability of shortfall was 0.80 observed in Soybean and lowest negative deviation was seen in Cotton production (21.10 Kg ha^{-1}).

Risk associated with different crops

Variability has been used as a measure of risk involved in crop production by many researchers over the years. The average net return ha^{-1} and coefficient of variation of net return for various crops grown in is presented in Table 3.

It is seen from Table 3 that the average net return is found to be highest for *Tur* (Rs. 8865.50), followed by Sunflower (Rs. 8050.63) while the average net returns ha^{-1} for Safflower and Hy. Cotton were Rs. 6348.48 and Rs. 5157.92, respectively. The crops which produced net returns below cut off point (Net Income less than Rs. 4000/-) were *Kharif jowar, Mung, Udid*, Groundnut, Soybean, Wheat and Gram.

Table: 1 Break-Even yield of different crops in Akola district.

S.N.	Crops	Total Fixed Cost (Rs ha^{-1})	Price $unit^{-1}$ (Rs. q)	Average variable cost (Rs. q)	Break even yield (q)	Actual yield (q)	Percentage of to Actual Yield
1	Kh. Jowar	1810	459	383	23.82	18.87	—
2	Tur	3510	1511	851	5.34	10.63	50.09
3	Gram	1926	1515	857	2.97	4.65	63.95
4	Soybean	2288	1198	803	7.15	10.14	70.51
5	Cotton	3236	2201	1258	3.43	7.22	47.52

Table:2 Probabilities of Shortfall and Expected Negative Deviations in different Crops.

S.N.	Crops	Average yield (Kg ha^{-1})	Probability of shortfall	Expected negative Deviation (Kg ha^{-1})
1	Kh. Jowar	1409	0.67	118.64
2	Tur	957	0.44	65.80
3	Gram	597	0.70	86.16
4	Soybean	1527	0.80	166.02
5	Cotton	125	0.70	21.10

Table 3 : Average Net return & Coefficient of variation of Net return of different Crop (1995-96 to 2004-05).

S.N.	Crops	Average Net Return (Rs.)	C.V. %
1	Cotton Hy.	5157.92	54.70
2	Cotton local	4728.52	32.56
3	Kh. Jowar	3973.73	31.43
4	Tur	8865.50	41.74
5	Mung	2064.37	62.56
6	Udid	2927.92	56.02
7	Soybean	3717.24	63.38
8	Gr.Nut	3427.11	72.46
9	Sunflower	8050.63	85.24
10	Wheat	2848.86	72.65
11	Gram	3338.94	47.14
12	Safflower	6348.48	98.73

Cut off point: Net return > Rs. 4000 per hectare high.
Risk(CV) > 40 per cent high.

Table: 4 Two way classification of Risk and Net Return of different Crops.

Return	Risk(C.V.)	
	Low	High
Low	Kh. Jowar	Mung, Udid, Soybean, Gr.Nut., Wheat and Gram.
HIgh	Cotton (Deshi)	Cotton (Hybrid), Tur, Sunflower and Safflower.

The coefficients of variation of net returns showed a wide range amongst various crops. The C.V. was highest for safflower (98.73 %), followed by sunflower (85.24 %), wheat (72.65 %) and ground Nut (72.46 %). The C.V. for soybean, *Mung, Udid* and cotton were 63.38 , 62.56, 56.02 and 54.70 per cent, respectively. The low C.V. (less than cut-off point) was obsered in crops like cotton (*Deshi*) and *Kharif jowar.*

While taking any decision regarding crops to be included in the cropping pattern, risk involved and expected return per hectare are considered. Using this, crop of the selected area is classified in to low return – low risk and high return-high risk. For this classification, a net return less than Rs.4000 ha^{-1} was considered as relatively low and more than that as high return, while C.V. less than 40 per cent was considered as low and greater than 50 per cent as high. The classification done in this way is given in Table 4.

Table 4 reveals that the crop like cotton (*Deshi*) was the most profitable crop with high average return and low level of risk. This is the most suitable crop in this area.

Farmers having capacity to bear high risk can go for cotton (hybrid), *Tur*, sunflower and safflower. These crops have high average return but at the same time high risk. The crop like *Mung, Udid*, soybean, ground nut, wheat and gram are low returns and high while *Kharif jowar* shows low returns and low risk crop.

In general, farmers are ready to bear high risk may go for cotton (hybrid), *Tur*, sunflowers and safflower.

CONCLUSION

Analyses of break-even yield suggest that with the present productivity and prices of *Kharif jowar*, it is not economical to include *Jowar* in the cropping pattern. In all highest annual negative deviation with probability of shortfall was observed in soybean, followed by *Kharif jowar*. While minimum expected negative deviation is observed in Cotton. Among all crops, cotton (*Deshi*) is most profitable crop with high average return and low level of risk and found suitable for this area.

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Productivity of Soybean as Influenced by Land Configuration and Nutrient Management

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ABSTRACT

An agronomic investigation was carried out on soybean cv. JS-335 at Agriculture College Farm, Nagpur during *Kharif* season of 2007 to study the influence of different land configuration treatments and fertilizer levels on productivity of soybean. Sowing of soybean on BBF increased growth attributing characters like plant height, number of branches plant^{-1}, mean dry matter accumulation plant^{-1} and yield contributing characters viz., number of pods plant^{-1}, grain yield plant^{-1}, grain yield ha^{-1}, protein and oil yield ha^{-1}. Application of 100 per cent RDF (30 : 75 NP kg ha^{-1}) as well as 75 per cent RDF along with soil application of PSB (3 kg ha^{-1}) gave maximum grain, protein and oil yield ha^{-1}. Total N and P uptake was maximum in BBF and 100 per cent RDF, thus indicating a saving of 25 per cent phosphorus dose due to soil application of PSB.

Soybean, being a rainfed crop suffers greatly due to dry spell (drought) and excessive rains (water logging) during crop-growth period. The extent of yield reduction due to these stresses depends on duration and growth stage of crop at which they occur. Waterlogged soils may reduce growth and development of root system. Without oxygen, seeds will not germinate and roots will not function normally. Flowering and pod development period also have been found most sensitive to drought. To avoid the problem of water stress, it would be necessary to ensure adequate soil moisture. The intermittent dry spell during reproductive stages, particularly at grain filling can be managed by supplementary irrigation. Resorting sowing on land configuration like broad bed and furrow (BBF), ridges and furrow and provision of furrow at regular intervals and reduced tillage are known to help soybean crop during water stress (Chauhan and Joshi, 2005).

Phosphorus plays an important role in growth and development of soybean. it hastens maturity and improves quality of grain. Being an exhaustive crop, its phosphate requirement is greater.

To reduce the expenditure on cost of fertilizers and increase the productivity, technology of use of biofertilizer by inoculating the seed with phosphate solubilizing bacteria is developed and adopted. The species of micro organisms like Bacillus, Penicillum, Psudomonas, Aspergillus posses the ability to convert insoluble phosphorus in soil into soluble form.

MATERIAL AND METHODS

An agronomic investigation was carried out at Agriculture College farm, Nagpur during *Kharif* season 2007. The experiment was laid out in split plot design consisting four treatments of land configuration and three treatments of fertilizer levels. The land configuration consist flat bed, BBF, furrow in every row and furrow after alternate row and fertilizer levels viz. RDF 30:75:0 NP kg ha^{-1}, 30:57 (75%) NP kg ha^{-1} + PSB soil application and 30:37.5 (50%) NP kg ha^{-1}+ PSB soil application. There were twelve treatment combinations replicated three times.

The soil was clayey texture with pH 7.8 indicating slightly alkaline in reaction. it was low in available nitrogen (235.62 kg ha^{-1}), medium in available phosphorus (17.96 kg ha^{-1}) and high in available potassium (415.26 kg ha^{-1}) The seed of soybean cv. JS-335 was drilled at spacing of 45*5 cm on 19th July, 2007. The required quantities of chemical fertilizers and PSB were measured and applied as per the treatments by mixing in soil at the time of sowing. PSB was applied to soil @ 3 kg ha^{-1} as per treatment. The crop was raised as usual on flat bed. when the plants were about 10 cm height the soil was inter cultivated and furrows were opened between the two rows as per treatments with the help of hoe by tying rope to its types. Land configuration treatments were imposed 30 days after sowing. The periodical observations on growth parameters and yield contributing characters were recorded at specific intervals to evaluate the treatment effects. some of the important findings

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emerged from this investigation are summarized as below.

RESULTS AND DISCUSSION

Response to land configuration

Growth attributes

The data in the Table 1 indicated that, various growth characters like height of plant, number of branches plant^{-1} and dry matter accumulation plant^{-1} were significantly increased and were highest in treatment BBF but it remained statistically at par with furrow in every row and furrow after alternate row. The increase in dry matter plant^{-1} might be due to conservation of moisture in the furrow and its availability to crop. These results are in conformity with the findings of Ralli and Dhingra (2003).

Yield attributes and quality parameters

Yield contributing characters viz., number of pods plant^{-1}, grain yield plant^{-1} had also recorded higher value in treatment BBF which was at per with treatments furrow in every row and furrow after alternate row. However, test weight remained uninfluenced. Higher grain (15.96 kg ha^{-1}) and straw yield (27.73 kg ha^{-1}) was recorded in the treatment of BBF and it was statistical at per with treatment furrow in every row and furrow after alternate row. The protein and oil content was not influenced due to various treatments while, maximum protein yield kg ha^{-1} was recorded in the treatments BBF which was at per with treatment of furrow in every row. Oil yield kg ha^{-1} was also maximum in treatment of BBF which was at par with furrow in every row and furrow after alternate row. Maintenance of favourable moisture and avoidance of waterlogging was the principal reason for better performance under these treatments. Similar effects of modified land configuration have also been reported by Desai *et al.*(2000) and Kantwa *et al.* (2005).

Nutrients uptake

Data regarding uptake of nutrients by plant as influenced by various treatments are presented in Table-2. Nitrogen uptake was maximum in the treatment of BBF and at par with treatment of furrow in every row which was also at par with treatment of furrow after alternate row. These results are in close accordance with Tarde (1984) and Vaghasia *et al.* (2007). P-uptake was also higher in the treatment of BBF and at par with treatment of furrow in every row but was significantly superior over treatments of flat bed and furrow after alternate row. These results are in close accordance with Jadhav (1983) and Vagahasia *et al.*(2007).

Residual soil fertility status after harvest

Data regarding residual soil fertility after harvest as influenced by different treatments are presented in Table 2. Though the residual soil fertility in respect of available nitrogen, phosphorus and potassium remained unaffected due to various land configuration treatments, but it definitely improved over the initial status.

Response to fertilizer level

Growth attributes

Hundred per cent RDF recorded maximum height of plant, number of branches plant^{-1} and dry matter accumulation plant^{-1} but was at par with 30:57 NP kg ha^{-1} + PSB soil application. Microbial inoculation seems to have promoted various physiological activities in plant which are considered to be indispensable for proper growth and development. This is in accordance with the findings recorded by Dubey (2001) and Menaria *et al.*(2003).

Yield attributes and quality parameters

Number of pods plant^{-1} (31.13), grain yield ha^{-1} (14.76q) and straw yield ha^{-1} (24.74q) were maximum with application of 100 per cent RDF which was at par with application of 30:57 NP kg ha^{-1} + PSB. This might be due to proper development of root and translocation of photosynthates being the constituent of nucleic acid, phytin and phospholipids, increased the growth and yield attributing parameters in these treatments. (Nayak *et al.* 2006). Data pertaining to oil and protein contents indicated that, none of the treatments influenced the protein and oil content significantly. However, protein and oil yield (567.40 kg ha^{-1} and 287.64 kg ha^{-1}, respectively) was maximum with 100 per cent RDF and was at par with treatment 30:57 NP kg ha^{-1} + PSB. These results are also supported by Sharma and Namdeo (1999). The data thus indicated that, there was a saving of 25 per cent phosphorus due to soil application of PSB @ 3.0 kg ha^{-1}

Nutrient uptake

Nitrogen uptake was significantly highest in the treatment of 100 per cent RDF over rest of the treatments. These results are in conformation with the findings reported by Jat and Nepalia (1992), Dubey (2001) and Govindan and Thirumurugan (2005). Phosphorus uptake was also highest with application of 100 per cent RDF over rest of the

Table 1 : Effect on land configuration and nutrient management on different growth, yield contributing attributes and quality parameters of soybean

Treatments	Plant height (cm)	Branches plant^{-1}	Dry matter weight plant^{-1} (g)	Pods plant^{-1} (No)	100 seed weight (g)	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Protein (%)	Oil (%)	Protein (kg ha^{-1})	Oil (kg ha^{-1})
Land configuration													
Flat bed	38.80	4.30	14.46	21.93	10.80	4.35	9.26	12.02	19.14	33.98	16.96	408.86	204.61
BBF	50.61	5.49	17.10	31.73	11.52	6.30	13.40	15.96	27.73	34.36	17.87	594.85	285.14
Furrow in every row	47.17	5.14	16.40	28.90	11.32	5.70	12.13	15.04	25.10	34.29	17.42	516.83	263.92
Furrow after alternate row	45.67	5.03	15.88	27.70	11.16	5.49	11.68	14.62	24.17	34.08	17.30	500.44	253.92
S.E (m) ±	1.84	0.22	0.40	1.19	0.25	0.29	0.62	0.70	1.27	0.25	0.41	24.99	14.54
C.D. at 5%	6.36	0.76	1.37	4.12	N.S.	1.00	2.12	2.41	4.40	N.S.	N.S.	86.49	43.63
Fertilizer levels													
30:75 NP kg ha^{-1} (100% RDF)	49.21	5.26	16.77	31.13	11.55	6.17	13.12	16.12	27.16	34.00	17.81	567.40	287.64
30:57 NP kg ha^{-1} + PSB	46.78	5.00	16.01	28.48	11.18	5.62	11.96	14.76	24.74	33.86	17.29	500.23	257.00
30:37.5 NP kg ha^{-1} + PSB	40.67	4.72	15.10	23.08	10.87	4.59	9.76	12.35	20.21	33.52	17.06	414.35	211.07
S.E (m) ±	1.36	0.10	0.28	0.99	0.18	0.19	0.40	0.47	0.84	0.23	0.20	17.64	8.48
C.D at 5%	4.09	0.30	0.84	2.99	N.S.	0.57	1.20	1.42	2.52	N.S.	N.S.	52.88	25.42

Table 2 : Initial and residual fertility status of soil, N and P uptake by plant as influenced by various treatments

Treatments	Nutrient uptake(kg ha^{-1})		Residual fertility status of soil (kg ha^{-1})		
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Potassium
Land configuration					
Flat bed	84.60	9.34	243.07	18.33	420.06
BBF	123.89	13.96	235.66	17.96	415.18
Furrow in every row	111.89	12.46	238.58	18.49	420.61
Furrow after alternate row	107.63	11.73	239.09	18.76	418.59
S.E (m) ±	4.26	0.50	1.72	0.47	9.68
C.D. at 5%	14.76	1.74	N. S.	N. S.	N. S.
Fertilizer levels					
30:75 NP kg ha^{-1} (100% RDF)	123.81	14.00	237.85	18.00	422.29
30:57 NP kg ha^{-1} + PSB	109.45	12.05	239.26	19.27	418.42
30:37.5 NP kg ha^{-1} + PSB	87.76	9.58	240.21	17.88	415.12
S.E (m) ±	2.82	0.35	1.43	0.38	6.99
C.D at 5%	8.44	1.05	N. S.	1.13	N. S.

treatments. These results are in tune with the findings reported by Sharma and Namdeo (1999), Dubey (2001) and Govindan and Thirumurugan (2005).

Residual soil fertility status after harvest

Available nitrogen and potassium was not significantly influenced due to fertilizer treatments. However, available phosphorus was significantly higher with application of 30:57 NP kg ha^{-1} + PSB over rest of the treatments.

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Effect of Different Levels of Mango Pulp on the Physico-Chemical Quality of Ice Cream

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ABSTRACT

Ice-cream was prepared by using various ingredients like fresh milk standardized at 10 per cent fat, cream, SMP, sugar, stabilizer (sodium alginate) and different levels of mango pulp i.e. 5, 10, 15 and 20 per cent. Fat content as well as over-run of ice-cream was decreased with the increased levels of mango pulp while total solids, sugar, protein and ash increased with the increased levels of mango pulp.

Milk, an ideal food, is high in body building protein, bone forming minerals, health giving vitamins and furnishes energy giving lactose and milk fat in digestible and assimilable form. All these properties make it an important food for pregnant mother, growing children, adults, invalids and patients. On the other hand milk being a perishable product cannot be stored as in liquid form and therefore, it is required to process into different milk products such as *khoa, peda, dahi, shrikhand,* ghee, ice-cream etc.

Ice-cream is a glamorous, delicious and nutritious frozen milk product prepared from milk, cream, condensed milk and other concentrated dry milk with the addition of sugar. Flavour and colour are also added at the time of air incorporation during freezing. Ice-cream can be mixed with fruits, fruit juices and nuts. It has high palatability which stimulates flow of digestive juices and aids in the digestive process. These two factors with sweet flavour, smooth texture and glistering coolness makes it an ideal food for the person suffering from throat application or stomach ailments (Arbuckle, 1966). On an average a cup (100 g) of good quality ice-cream supplies approximately 200 cals, 0.31 g calcium, 0.104 g phosphorus, 0.14 mg iron, 548 IU vit.A, 0.038 mg riboflavin. It is also rich in amino acids which are lacking in plant proteins. Hence, it is recognized as highly nutritious food item.

Due to the tropical nature, considerable quantity of ice-cream is consumed in India. Ice-cream is consumed as a sweet dish or dessert throughout the year as it is relished in western countries. Indians are habituated particularly to consume ice-cream in hot season i.e. in summer. Still in India, ice-cream is considered as an item of luxury or delux as it is costly product. There are many non-conventional ingredients which can be used in ice-cream such as banana pulp, peaches, cherry, pineapple, raspberry, mango pulp, vegetable oils as substitute of fat, soybean, arrowroot powder and honey, etc. In this list of non-conventional ingredients, mango pulp can be added into ice-cream for value addition.

MATERIAL AND METHODS

Fresh cow milk was obtained from Dairy Farm, College of Agriculture, Nagpur. Cream was obtained by separating the milk through cream separator. BIS grade skim milk powder and cream was used for making the ice-cream mix. Plain ice cream mix formulated had 36 per cent Total solids, 10 per cent Fat, 11per cent MSNF, 15 per cent Sugar and 0.3 per cent Stabilizer (sodium alginate). The various ingredients of ice-cream mix were weighed as per the calculations, mixed in the dry ingredients (sugar, skim milk powder and stabilizer). Then added to liquid ingredients (milk and cream) slowly and gradually with constant stirring so that there would not be formation of lumps of the ingredients. Agitation was continuous till all the solid particles were dissolved. The mixture was finally filtered through clean muslin cloth. The ice-cream mix was heated up to 68°C for 30 minutes with constant stirring avoiding the formation of skim on the top of mix and cooled immediately to room temperature by dipping the container of mix in chilled water with constant stirring. The mix was kept for ageing at 0 to 4°C for 4 h in refrigerator. Mango pulp (Alphanso) was added on weight basis of plain ice-cream mix and stirred thoroughly to secure uniform mixture of plain mix and mango pulp. Composition of Alphanso

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mango on frsh weight basis is given in the following table.

S.N.	Parameters	Composition (%)
1	Moisture	79.2 – 83
2	Total soluble solids	12.9 – 20.8
3	Total sugar	10.0 – 17.3
4	Non reducing sugar	7.27 – 12.35
5	Ash	0.38 – 0.62

The combination of mango pulp and ice-cream mix were as follows:

Treatments	Level of mango pulp (%)	Quantity of pulp (g)	Quantity of plain mix (g)	Total quantity after mixing pulp (g)
T_0	0	—	1000	1000
T_1	5	50	950	1000
T_2	10	100	900	1000
T_3	15	150	850	1000
T_4	20	200	800	1000

Ice-cream mix blended with mango pulp was frozen in wooden hand freezer with uniform revolution speed. Ice-cream pot was fixed in wooden vessel with ice and salt mixture in 5:1 ratio. Afterward, softy drawn out kept for hardening at -23°C to -29°C in refrigerator for 3-4 h.

The product so obtained was analysed for different chemical parameters i.e. Fat, Total solids, Protein, Total sugar and Ash as per the procedure given in BIS Hand Book of food analysis of dairy products, SP:18 (1981) Part XI. Over-run was calculated as per the formula recommended by Arbuckle (1966) and Melting quality was determined as per the method adopted by Thomas and Combs (1944). The data so obtained were analysed by Standard C.R.D.

RESULTS AND DISCUSSION

Effect of different levels of mango pulp on the fat percentage of ice-cream

It is observed that, with the increase in the level of mango pulp there was reduction in fat percentage of the ice-cream (Table 1). This might be due to negligible amount of fat in the mango pulp. Highest fat percentage (10.02) was observed in control treatment T_0 without mango pulp and lowest (8.05) in treatment T_4 having 20 per cent mango pulp. Treatment T_0 was highly significant and superior over rest of the treatments. The order of superiority was followed by treatment T_1, T_2, T_3 and T_4. The results are in agreement with the results stated by Ratnaparkhi (1981) who reported that there was decrease in fat percentage of soft serve ice-cream with increase in the level of mango pulp.

Effect of different levels of mango pulp on the total solids content of ice-cream

It is seen that highest total solids percentage (40.275) was observed in treatment T_4 having 20 per cent mango pulp and lowest (36.025) in treatment T_0 without mango pulp (Table 1). It is further observed that with the increase in the level of mango pulp in the mix there was proportionate increase in the total solids content. This might be due to the higher solid content in mango pulp (12.9-20.8 per cent). Treatment T_4 was superior over rest of the treatments whereas, treatment T_0 was inferior amongst all the treatments. These results are in close relation with the results obtained by Ramasamy et al. (2001) who concluded that with the increase in the level of banana powder, total solids content of ice-cream increased.

Effect of different levels of mango pulp on the protein content of ice-cream :

Highest protein (4.45) per cent was recorded in treatment T_4 with 20 per cent mango pulp while lowest (4.06) per cent in treatment T_0 without mango pulp (Table 1). It was also observed that with the increase in the level of mango pulp there was proportionate increase in the protein content of ice-cream. Treatment T_4 was significantly superior over rest of the treatments while T_0 was inferior.

Effect of different levels of mango pulp on the total sugar of ice-cream

It is observed that there was significant difference in sugar content among the various treatments. Highest sugar (39.25%) was recorded in the treatment T_4 while lowest (26.25 %) in treatment T_0 (Table 1) It was revealed that with the increase in the level of mango pulp in the ice-cream there was proportionate increase in the sugar content. This

Table 1 : Effect of different levels of mango pulp on the chemical qualities of ice-cream (mean score %).

Parameters / Treatments	Fat	Total Solids	Protein	Total Sugar	Ash
T_0	10.02^a	36.025^d	4.06^b	26.25^d	0.84^d
T_1	9.50^b	37.075^c	4.23^a	29.50^c	0.88^c
T_2	9.12^c	38.475^b	4.34^a	33.25^b	0.93^b
T_3	8.45^d	39.200^b	4.39^a	37.00^a	0.95^a
T_4	8.05^e	40.275^a	4.45^a	39.25^a	0.96^a
S.E.±	0.0273	0.0675	0.036	0.622	0.0045
C.D.	0.116	0.290	0.156	2.692	0.019

Values with different superscripts differ significantly (P<0.05)

Table 2 : Effect of different levels of mango pulp on the physical qualities of ice-cream (mean score).

Parameters / Treatments	Over-run (%)	Melting Quality(minutes)
T_0	39.61^a	30.75^e
T_1	38.86^a	34.12^d
T_2	38.21^a	37.50^c
T_3	37.32^a	39.62^b
T_4	37.22^a	44.12^a
S.E.±	0.280	0.434
C.D.	1.214	1.878

Values with different superscripts differ significantly (P<0.05)

might be due to the sugar content (10.0-17.3 per cent.) in mango pulp.

Effect of different levels of mango pulp on the ash content of ice-cream

It indicates that highest ash 0.96 per was recorded in the treatment T_4 having 20 per cent mango pulp while, lowest 0.84 per cent was found in control treatment T_0 (Table 1). It is observed that, with the increase in the level of mango pulp, ash content in the ice-cream increased proportionately. This might be due to 0.38-0.62 per cent ash content in the mango pulp.

Effect of different levels of mango pulp on over-run of ice-cream

It is observed that, highest over-run 39.61 was recorded in control treatment T_0 without mango pulp and lowest 37.22 in treatment T_4 having 20 per cent mango pulp (Table 2). It was also observed that as level of mango pulp was increased, there was decrease in the over-run of ice-cream. The treatments were highly significant with each other. El-sayed, et al. (1995) concluded that increasing the proportion of red sweet potato in the mixer led to decrease in over-run of the product. Bajwa, *et al.* (2003) conducted an experiment by using different levels of strawberry pulp i.e. 10, 15, 20 and 25 per cent and concluded that with the increase in the levels of strawberry there was decrease in the over-run of the product.

Effect of different levels of mango pulp on melting quality of ice-cream

It is seen that highest melting time (44.12 minutes) was required by the treatment T_4 having 20 per cent mango pulp while lowest (30.75 minutes) was recorded for control treatment T_0 without mango

pulp (Table 2). It was noticed that there was increase in melting time with increase in the level of mango pulp. This might be due to increase in the total solids content of ice-cream with the increase in the level of mango pulp. Treatment T_4 was significantly superior over rest of the treatments followed by treatment T_3, T_2, T_1 and T_0. Pinto et al. (2004) stated that increasing level of ginger juice resulted in increasing the melting resistance in the herbal ice-cream. Hassan (2005) reported that the amount of pumpkin added was positively associated with the melting resistance and viscosity of ice-cream.

It was concluded that, fat content as well as over-run of ice-cream decreased while total solids, sugar, protein and ash increased with the increased levels of mango pulp.

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Effect of Integrated Nutrient Management on Growth and Yield of Cotton and Greengram Under Cotton+Greengram Intercropping

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ABSTRACT

A field experiment was conducted during *Kharif* seasons of 2000-2001 and 2001-2002 under rainfed condition at AICRP for Dryland Agriculture, Central Research Station, Dr, PDKV, Akola (M.S.) in Randomized Block design with three replications to study the continuous effect of integrated nutrient management on growth and yield of cotton and greengram under cotton+ greengram intercropping. In respect of various growth characters studied, 25 kg N through fertilizer + 25 kg N through FYM +25 kg P_2O_5 (T_7) treatment recorded maximum height, number of branches and mean total dry mater accumulation of cotton and greengram. Also the same treatment proved to be the best in respect of yield of cotton (6.99 q ha^{-1}, pooled mean) as well as green gram (4.36 q ha^{-1}, pooled mean) under cotton+greengram intercropping, followed by 50 kg N + 25kg P_2O_5 ha^{-1} through inorganic fertilizer i.e. 100 per cent RDF (T_2) treatment .

Cotton "white gold" the king of fibers is a premier cash crop of the central and western part of country with enormous potential in employment generation and economic trade activity. Average productivity of lint, in India, is hardly 300 kg ha^{-1} as compared to the world average of 550 kg ha-1 (Singhal, 2003). In India, Maharashtra is important cotton growing state occupying cotton acreage of about 31.05 lakh hectares with average lint yield of147 kg ha-1 during the year 2001-2002 (Anonymous, 2003}. The productivity is still low (126 kg ha^{-1}) in Vidarbha. The major causes for low productivity of cotton in Vidarbha are erratic rainfall, growing of cotton on marginal and sub marginal land and less adoption of improved technology.

For risk aversion in rainfed farming, intercropping in cotton is recently advocated instead of sole cropping which gives stability in production to augment the monetary returns. Among the various intercrops tried, greengram appears most suitable in Vidarbha under dryland condition. This is because of addition of biomass, mulch ability, least competition and fixation of nitrogen.

Cotton being the cash crop, chemical fertilizer is used in sole as well as intercropping. Fertilizer is costly input and has harmful effect affecting the environment. To handle these anomalies and to maintain sustainability, several workers advocated integrated nutrient management for fertilizer economy and for efficient natural resource management (Pagaria *et al.*, 1995, Nambiar and Abrol, 1989: Padole *et al.*,1998).

Integrated nutrient management has been studied in case of sole crops but the information on integrated nutrient management especially for intercropping system is limited. Considering the importance of integrated nutrient management and alternative to present fertilizer recommendations with economy and sustainability, the present investigation was planned to study the continuous effect of integrated nutrient management on growth and yield of cotton and greengram under cotton greengram intercropping system.

MATERIAL AND METHODS

The field experiment was conducted during the *Kharif* seasons of 2000-2001 and 2001-2002 under rainfed condition at AICRP for Dryland Agriculture, CRS, Dr. PDKV, Akola (M.S.) in Randomised Block design with three replications. The eight treatments consisted were Control i. e. no fertilizer(T_1), 50 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer i.e. 100 per cent RDF(T_2), 25 kg N + 12.5 kg P_2O_5 ha^{-1} through inorganic fertilizer. i.e. 50 per cent RDF(T_3), 25 kg N ha^{-1} through Leucaena lopping(T_4), 25 kg N ha^{-1} through farmyard manure (T_5), 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer + 25 kg N ha^{-1} through *Leucaena* lopping(T_6), 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer+ 25 kg N ha^{-1} through farmyard manure(T_7), 50 kg N ha^{-1} through *Leucaena*

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lopping +25 kg P_2O_5 ha^{-1} through inorganic fertilizer(T_8). Cotton variety PKV- Rajat (AKH-84635) at spacing of 60 X 30 cm and green gram variety Kopergaon at a spacing 30 X 10 cm was used for sowing . Between two rows of cotton one row of greengram was intercropped.

The soil was clay in texture, slightly alkaline in reaction (pH 7.8), available N and P_2O_5 were medium, while available K_2O was moderately high during both the year. The climate of area is semiarid with annual average precipitation of 815 mm in 35 days, major being received in June to September The temperature range of area is 10.7 to 42.4 °C. During 2000-01 total rainfall was 534.3 mm (76 % of normal) in 33 days and during 2001-02 was 619,1 mm (83.5% of normal) in 32 days .

RESULTS AND DISCUSSION

The data in respect of emergence count , plant stand at harvest, growth attributes and yield of cotton as well as greengram are presented in Table 1 and 2, respectively

Effect of INM on cotton as main crop in cotton +greengram intercrop

The emergence count and plant stand at harvest of cotton during both years of experimentation was not influenced significantly (Table 1). Thus, the source of nutrients and dose of nutrient tested did not have adverse effect on plant stand of cotton in cotton+greengram intercropping system. This implies that inorganic fertilizers or N through FYM or *Leucaena* lopping did not have any inhibiting effect on germination.

The height at harvest, mean number of sympodial branches $plant^{-1}$ at harvest and dry matter accumulation of cotton during both years of experimentation was significantly influenced by various INM treatment in cotton+greengram intercropping. Treatment 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer+ 25 kg N ha^{-1} through farmyard manure(T_7) recorded maximum and significantly more height during both years and T_6 was at par with it. In 2000-01 T_8 was also at par with T_7. The mean number of sympodial branches per plant was also reported maximum and significantly more in T_7 except T_6 in 2001-02 and T_5, T_2 in 2000-01 which were at par with 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer+ 25 kg N ha^{-1} through farmyard manure(T_7). The mean total dry matter was also maximum and significantly more in T_7 during both years except T_5 during 2000-01 which was at par.

Thus, in respect of various growth characters studied 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer+ 25 kg N ha^{-1} through farmyard manure(T_7) treatment recorded maximum height, number of branches and mean total dry mater accumulation. This might be due to supply of nutrients in available form throughout growth period and that too 25 kg N from inorganic fertilizer that became available in initial growth and thereafter 25 kg N through FYM. Similar results were also reported by Badole and More (2000) at Parbhani where they found that integrated nutrient management with 50 per cent NPK through chemical fertilizer and 50 per cent through FYM +*Azospirillum* +cow dung urine slurry +PSB recorded significantly higher dry matter yield when compared with inorganic fertilizers alone (i.e. 100 per cent RDF).

The seed cotton yield as well as stalk yield (q ha^{-1}) was influenced significantly in both years and also in pooled analysis. The T_7 treatment recorded maximum and significantly higher seed cotton yield during both the year and also in pooled analysis (6.99 q ha^{-1}). But the treatments T_2, T_4, T_5 and T_6 in 2000-01 and T_2 and T_6 in 2001-02 and in pooled analysis were at par with T_7. The higher response to FYM component obtained in the present investigation than *leucaena* lopping probably be due to fact that FYM was applied as a basal dose at the time of sowing while *leucaena* lopping were incorporated a month after sowing. Obviously, nutrients might have become available from FYM right in the beginning while in case of *leucaena* lopping it might have taken some period for decomposition and liberation of nutrients in absorbable form in addition to a period of one month. It therefore seems reasonable to believe that benefits from *leucaena* lopping are comparatively less. Padole *et al.*(1998) at Akola and Badole and More (2000) at Parbhani also indicated beneficial effect of integrated nutrient management using FYM to that of fertilizer use only. Pagaria *et al.* (1995) found that full dose of recommended NP and half NP +10 cart load FYM were at par in respect of dry matter and seed cotton yield. Similar result also reported by Ravankar *et al.* (1999), Lakhdive *et al.* (2000) and Vats *et al.* (2001).

Table 1: Growth parameters, seed cotton yield and stalk yield of cotton as main crop as influenced by cotton+ green gram intercropping

Treatments	Emergence count ha^{-1}		Plant stand at harvest ha^{-1}		Height at harvest (cm)		Mean number of sympodial branches plant^{-1} at harvest		Mean total dry matter accumulation (g)		Seed cotton yield (q ha^{-1})			Stalk yield(q ha^{-1})		
	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	Pooled	2000-2002	2001-2001	Pooled
T_1	52343	52423	51126	51285	58.18	56.18	9.28	8.40	42.16	46.81	6.03	2.98	4.51	9.40	15.84	12.62
T_2	52409	52423	51285	51034	62.59	65.56	12.95	10.44	46.14	49.86	9.05	3.92	6.49	12.88	18.57	16.23
T_3	52132	52171	51047	50954	61.05	62.80	11.56	9.80	43.78	47.10	7.26	3.00	5.13	10.93	17.82	14.37
T_4	53256	52489	51946	51351	66.35	69.71	12.28	10.23	45.21	49.17	8.80	3.76	6.28	12.16	19.36	15.76
T_5	51973	52568	50848	51457	67.87	72.74	13.33	10.10	46.95	48.25	9.11	3.50	6.18	13.58	18.91	16.24
T_6	52687	52661	51536	51523	71.73	77.11	12.52	10.98	45.89	50.33	8.81	4.03	6.42	12.76	20.89	16.82
T_7	52793	52793	51695	51669	74.52	80.72	14.10	11.41	47.70	51.80	9.60	4.37	6.99	14.03	23.76	18.89
T_8	53018	51880	51814	50756	69.26	73.79	12.07	10.20	44.72	48.88	8.40	3.39	5.90	11.60	19.14	15.37
SE(m)±	634.9	621.7	449.8	502.7	2.53	1.33	0.41	0.14	0.42	0.36	0.28	0.19	0.22	0.27	0.36	0.53
CD at 5%	N.S.	N.S.	N.S.	NS	7.68	4.02	1.25	0.43	1.28	1.09	0.84	0.56	0.63	0.82	1.08	1.58

Table 2: Growth parameters, grain yield and straw yield of green gram as intercrop as influenced by cotton +greengram intercropping

Treatments	Emergence count ha^{-1}		At harvest plant stand ha^{-1}		Height at harvest (cm)		Mean number of branches plant^{1} at harvest		Mean total dry matter accumulation (g)		Grain yield (qha^{-1})			Straw yield (qha^{-1})		
	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002	Pooled	2000-2002	2001-2001	Pooled
T_1	147963	145259	148846	146517	22.69	28.65	3.51	3.75	3.70	3.94	2.27	3.53	2.90	4.74	8.84	6.79
T_2	114852	146520	149987	147527	26.80	33.58	4.29	4.90	5.29	6.20	2.91	5.04	3.98	7.53	12.30	9.92
T_3	147980	145654	149210	147017	24.90	30.86	4.04	4.6	4.81	5.35	2.58	4.05	3.32	5.82	10.95	8.39
T_4	148168	146627	148959	146765	24.46	31.40	3.98	4.59	4.66	5.03	2.50	3.86	3.18	5.38	9.50	7.44
T_5	148120	145867	148883	146582	24.17	31.65	3.82	4.40	4.38	5.16	2.39	3.75	3.07	5.08	9.52	7.30
T_6	149108	146995	149364	147248	25.43	35.13	4.13	4.71	4.93	5.79	2.76	4.48	3.62	5.82	11.64	8.73
T_7	149791	147468	150193	147852	28.52	38.54	4.41	5.02	5.67	6.89	3.17	5.54	4.36	8.52	13.35	10.94
T_8	148584	146117	149566	147345	25.12	32.84	4.09	4.76	5.05	5.87	2.71	4.51	3.61	6.58	11.77	9.18
SE(m)±	791	-	803	-	1.21	0.92	0.041	0.052	0.13	0.23	0.10	0.16	0.18	0.33	0.44	0.50
CD at 5%	NS	-	NS	-	3.60	2.77	0.12	0.16	0.39	0.70	0.30	0.48	0.52	1.01	1.33	1.48

The stalk yield was maximum and significantly more in T_7 treatment during both the years of experimentation and also in pooled results (18.89 q ha^{-1}). But T_5 treatment was at par during 2000-01 with T_7.

Effect of integrated nutrient management on intercrop greengram

Emergence count and plant stand at harvest of greengram during both the years was not influenced significantly (Table 2). Thus there was no adverse effect of integrated nutrient management treatments on germination or shading effect of main crop. The height at harvest of greengram plant, mean number of branches $plant^{-1}$ and mean total dry matter accumulation per plant was maximum and significantly higher in treatment 25 kg N + 25 kg P_2O_5 ha^{-1} through inorganic fertilizer+ 25 kg N ha^{-1} through farmyard manure (T_7 and 100 per cent RDF (T_2) was at par with it. During both years and in pooled analysis the grain and straw yield was maximum and significantly more in T_7 (4.36 and 10.94 q ha^{-1} in pooled results) and T_2 (3.98 and 9.92 q ha^{-1} in pooled results) was at par with it. This might probably be due to initial supply of nutrient in T_7 compared to other treatments. These results are in conformity with those obtained by Lakhdive *et al.* (2000).

Thus in the present investigation treatment 25 kg N+25 kg P_2O_5 ha^{-1} through fertilizer + 25 kg N through FYM (T_7) proved to be the best in respect of growth and yield of cotton as well as greengram under cotton + greengram intercropping.

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Detection of Viruses Under Polyhouse Condition on Capsicum by Host Range, Electron Microscopy and DAC-ELISA

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ABSTRACT

Chilli mosaic virus was successfully transmitted under glasshouse conditions through mechanical sap inoculation using 0.01 M phosphate buffer (PH 7.0) on healthy capsicum test plant cv. California Wonder .Based on host range, the symptoms produced on test plant were grouped into isolate I Cucumber mosaic virus (CMV), isolate II Potato virus Y (PVY), isolate III Tobacco mosaic virus (TMV), isolate IV Cucumber mosaic virus + Potato virus Y (CMV + PVY) and isolate V Cucumber mosaic virus + Tobacco mosaic virus (CMV + TMV). These five virus isolates of capsicum tested during investigation had wide host range distributed in solanaceae, cucurbitaceae, chenopodiaceae, cruciferae, leguminoaceae and compositae families. In electron microscopy, the different virus isolates viz., CMV, PVY, TMV, CMV + PVY and CMV + TMV showed different particle size. In DAC-ELISA ,isolate I, II, III, IV and V positively reacted with antiserum of CMV (I), PVY (II), TMV (III), CMV + PVY (IV) and CMV + TMV (V), respectively.

Capsicum (*capsicum frutescens* L..) is the most important *solanaceous* vegetable cash crop in India. Chilli is vulnerable to several biotic stresses caused by viruses and phytoplasmas (Green and Kim, 1991; Singh, 1993; Singh and Singh, 2000). Its successful cultivation has been mainly hampered due to potyviruses causing severe mosaic along with other symptoms resulting in enormous losses in the form of reduced yield and deformed unmarketable fruits. (Satya Prakash *et al.* 2002). Among all the vegetable crops, sweet paper or bell paper is only cultivated under polyhouse conditions due to the high return through export. Scanning through the literature, as many as 57 viruses have been reported worldwide on capsicum by different workers (Green and Kim, 1991). Among the viral diseases, the viruses affecting chilli in India was chilli mosaic virus and potato virus Y reported by Jeyaranjan and RamKrishnan (1969). Present communication, therefore, includes results of host range, electron microscopy and DAC-ELISA using polyclonal antibodies.

MATERIAL AND METHODS

a. Mechanical transmission

Preparation of inocula

The inocula were prepared from virus infected plants of individual isolate by routine crude sap extraction method and used in virus transmission studies. Young leaf tissues showing typical virus symptoms of individual isolate were selected for sap extraction.

Virus infected leaves of capsicum of different isolates maintained in glasshouse were plucked off carefully and carried to the laboratory. The leaves were gently washed in tap water, immediately wiped of excess water with the help of blotting paper and weighed on electronic balance. Leaves were macerated in sterilled and chilled mortar and pestle by adding equal quantity of 0.01 M phosphate buffer (PH 7.0) and diseased leaves on 1:1 (W/V) basis. The crude sap was obtained by squeezing the pulp through a double layered musclin cloth.

Inoculation

Healthy and well grown capsicum seedlings were selected for inoculation. Before inoculation, the carborundum powder an abrasive was dusted on the leaves and inoculated by the inoculum following gentle rubbing method of Holmes (1929) with the help of cotton swab.

The plant species from other families were inoculated at 3-4 leaf stage. Seedlings of *Chenopodium amaranticolor* were inoculated at 5-6 leaf stage. Immediately after inoculation, the leaves were slightly washed in the stream of tap water to remove excess inoculum. The seedlings were labeled properly and kept in the insect proof glasshouse for observations. The inoculated plants were observed

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periodically and observations were recorded as and when the symptoms appeared.

Host range

The different virus isolates were maintained on capsicum cv. California Wonder in an insect proof glasshouse. Six plant species belonging to Solanaceae, Cucurbitaceae, Chenopodiaceae, Leguminoaceae, Compositae and Cruciferae were tested to find out the possible natural reservoirs.

Electron microscopy

The leaf dip preparations were made for detecting virus particles associated with capsicum isolates as per the method described by Brandes (1964).

Direct antigen coating-Enzyme Linked Immunosorbent Assay (DAC-ELISA)

Infected samples (250 mg) of various isolates of chilli mosaic virus were weighed and made in the form of fine powder with the help of liquid nitrogen. Fine sap was prepared with addition of 5 ml coating buffer. One hundred and ninety five microlitre sap of various isolates were added to each well of ELISA plate and was incubated at 37°C for 1 h. After incubation, three washings were given for 3 min with phosphate buffer saline- tween (PBS-T) solution. Then 195 microlitre blocking solution was added to each well and again incubated at 37° C for 1h.

After incubation three washings were given for 3 min each with PBS-T solution and 195 microlitre of enzyme labeled antirabbit IgG/ secondary antibody dilutes in PBS-TPO was added to each well and was incubated for over night at 4°C. Later the plates were washed as described earlier. Then 195 microlitre freshly prepared substrate was added to each well and incubated at room temperature for 1 h. The ELISA plate was put on ELISA reader. The presence or absence of yellow colour to each well was recorded and the quantitative estimation of titre was recorded with ELISA reader.

RESULTS AND DISCUSSION

Host range

On the basis of differential symptoms produced on test plant, virus isolates were categorized into five groups i.e. isolate I, II, III, IV and V (Table 1).

The Isolate-I expressed symptoms like vein clearing, mosaic mottling, blistering, stunting, puckering, distortion on different host plants of family solanaceae, cucurbitaceae, chenopodiaceae and leguminaceae, while the host plants from compositae remained free. Similar symptoms on these hosts are reported by Bidari and Reddy (1990), George *et al.* (1993), Kirmani *et al.* (1997) and Basavarajappa (1997). Hence isolate I expressed symptom like cucumber mosaic virus (CMV).

The virus Isolate II could infect the host plants of *solanaceae* and expressed symptoms as vein clearing, mosaic mottling, chlorotic as well as necrotic local lesions and mild leaf mottling. However, *Datura stramonium* remained free. The host plants of *chenopodiaceae* developed symptoms such as chlorotic and necrotic local lesions, except *Beta vagaries* which did not show any symptom. The plants from family cucurbitaceae, leguminaceae and compositae have not expressed any kind of symptoms and remained free to this isolate even after back indexing. These results are in agreement with the earlier reports of Bidari and Reddy (1990), Elsanusio *et al.* (1991) and George *et al.* (1993). As per symptoms produced by isolate II is called as potato virus Y.

In isolate III,host plants of family solanaceae expressed symptoms like mosaic mottling, stunting, chlorotic as well as necrotic local lesions, necrosis of stem and petioles, vein clearing, blistering etc. Three host plant from *cucurbitaceae* family *viz., Cucumis melo, C. sativus* and *C. pepo* expressed vein clearing, blistering and puckering while others remained free. The host plants from family chenopodiaceae developed chlorotic and necrotic symptoms with local lesions and also blistering and puckering. The hosts *viz., Cajanus cajan* from leguminaceae expressed vein clearing, mottling, banding and severe mosaic, while other hosts remained free. The host *viz., Zinia elegans* from compositae expressed symptoms to this isolate. Similar types of results on these hosts were observed by Bidari and Reddy (1990) and Basavarajappa (1997). Hence isolate III showed tobacco mosaic virus (TMV) type.

Table I. Host range of the virus

S. N.	Family solanaceae	Symptom pattern exhibited by various isolates				
	Plant species	Isolate-I	Isolate-II	Isolate-III	Isolate-IV	Isolate-V
1.	*Capsicum annum* L.	VC. SM	VC, MM	M M	VC, MM	M M
2.	*C.frutescens* L. cv. Orbello	VC, MM	M M	M M	VC, MM	M M
3.	*C.frutescens* L-cv California Wonder	VC, MM	VC, MM	M M	VC, MM	VC, MM
4.	*Nicotiana tabacum* L.cv. White Burley	M M	VC, Vb	Mo, St	CLL	CLL
5.	*N. tabacum* L.cv. Xanthi	VC, Mo	MMo	CLL	SM	CLL
6.	*N. glutinosa* L.	SM, St	VC, MM	CLL	CLL	CLL
7.	*N. robusta*	Mo	CM	CLL	CLL	Mo, CLL
8.	*Datura stramonium* L.	M M	-	CLL	M M	CLL
9.	*Datura metal*	Mo	VC	CLL	VC, Mo	CLL
10.	*Physalis floridana*	SM	CLL	VC, Mo	CLL	VC, Mo
11.	*Petunia hybrid*	CLL, VC, MM	VC, Mo	CLL	CLL, VC, MM, st	CLL, VC, MM, St
12.	*Lycopersicum esculentum*	SM, fL	M M	LD, SM	SM, fL	LD, SM
II	**Cucurbitaceae**					
1.	*Cucumis melo* L.	VC, SM	-	VC, MM, St	VC, Bl, SM	VC, SM, MM, St
2.	*C. sativus* L.	VC, Bl	-	VC, Bl, Mo	VC, Bl, SM	VC, Bl, SM
3.	*Cucurbita pepo.* L	VC, Pu, Mo	-	VC, Bl, Pu	VC, Pu, Mo	VC, Bl
4.	*Cucurbita maxima* Duch ; C	VC, Bl, LD, SM	-	-	VC, Bl, LD, SM	VC, Bl, LD, SM
5.	*Cucurbita moschata* Duch	VC, Bl, Pu, SM	-	-	VC, Bl, Pu, SM	VC, Bl, Pu, SM
6.	*Lufta acutangula* Roxb	VC, MMo	-	-	VC, MMo	VC, MMo
7.	*Lufta cylindrica (l) Roam*	VC, Bl. MMo	-	-	VC, Bl, MMo	VC, Bl, MMo
8.	*Memordica balsamina*	VC, Pu, MMo	-	-	VC, Pu, MMo	VC, Pu, MMo
III	**Chenopodiaceae**					
1.	*Chenopodium album*	CLL	Pp CLL	CLL	CLL	CLL
2.	*Chenopodium amaranticolor*	CLL	CLL	CLL	CLL	CLL
3.	*Chenopodium quoina*	CLL	CLL	CLL	CLL	CLL
4.	*Beta velgaris*	VC, Bl, Pu, SM	-	VC, Bl, Pu, SM	VC, Bl, Pu, SM	VC, Bl, Pu, SM
IV	**Leguminoaceae**					
1.	*Phaseolus mungo*	CLL	-	-	CLL	CLL
2.	*Cajanus cajan*	CLL		VC, MM, Vb, SM	CLL	VC, MM, Vb, SM
3.	*Vigna unguiculata*	CLL, VC, Bl. SM.	-	-	CLL, VC, Bl, SM	CLL, VC, Pu, SM
4.	*V. sinensis*	CLL, VC, Bl, SM	-	-	CLL, VC, Bl, SM	CLL, VC, Bl, SM
V	**Compositae**					
	Zinnia elegans Jacq.	-	-	CLL, VC, Vb, MM	-	CLL, VC, Vb, Mo

- CLL Syst = Systemic chlorotic local lesions, LD = Leaf distortion, Mo = Mosaic, MMo = Mild mosaic, MM = Mosaic mottling, St = stunting,
- VC = Vein clearing, SM = Severe mosaic, Vb = Vein banding, fL = fern leaf, Bl = Blistering, Pu = Puckering, Pp = Pin point

Table 2 : Particle morphology of different capsicum virus isolates.

Virus isolate	Morphology	Size (nm)	Virus identified
Isolate - I	Isometric	28	CMV
Isolate - II	Flexuous	710 X 12	PVY
Isolate - III	Rods	300 X 17	TMV
Isolate - IV	Isometric and Flexuous	28, 710 X 12	CMV + PVY
Isolate - V	Isometric and rods	28, 300 X 17	CMV + TMV

In Isolate IV i.e. the mixture of cucumber mosaic virus and potato virus Y, exhibited symptoms of isolate I and II were observed, in which the host plants from *solanaceae* family expressed vein clearing, mosaic mottling, chlorotic and necrotic local lesions while the host plants from cucurbitaceae expressed blistering, puckering and severe mosaic. Similar types of symptoms were also expressed by chenopodiaceae and leguminaceae to this isolate. However, *Zinnia elegans* from family *compositae* remained free. Similar results have been reported by George *et al.* (1993), Kirmani *et al.* (1997) and Basavarajappa (1997).

A mixture of CMV + TMV was observed in Isolate V. The mixed types of symptoms expressed on all susceptible hosts like mosaic mottling, chlorotic and necrotic local lesions, blistering, distortion, vein clearing, puckering and vein banding on the host belongs to all families *viz.*, solanaceae, cucurbitaceae, chenopodiaceae, leguminaceae and compositae. These results are in agreement with the earlier reports of Bidari and Reddy (1990) and Basavarajappa (1997).

Electron Microscopy :

It is seen from Table-2 that in particle morphology, cucumber mosaic virus was observed singly in isolate I, while in isolate IV it was associated with PVY and in isolate V with TMV. Virus particles of CMV observed under electron microscope were isometric with average size 28nm. The size of this virus particles observed during present investigation was in agreement with the earlier reports of Sherf and MacNab (1997).

The potato virus Y was reported singly in isolate II and in combination with isolate IV. These particles were flexuous with average size of 710 X 12 nm. Similar type of morphological characters has been reported by Nelson and wheeler (1972).

The tobacco mosaic virus (TMV) was observed singly in isolate III and with combination in isolate V. The particles were rod shaped with average size 300 X 17 nm. Similar type of morphological observations were reported by Sherf and MacNab (1997) and George (1997).

Direct antigen coating - Enzyme Linked Immunusorbent Assay (DAC - ELISA)

The comparative efficacy of DAC-ELISA was confirmed using polyclonal antibodies with known positive and healthy samples .The O.D. at 405 nm of various isolates of capsicum were tested; it is evident from Table- 3 that the maximum O.D. i.e. 1.28 was shown by isolate IV, which clearly pointed out, the maximum infection. Minimum O.D. i.e. 0.26 showed by isolate I. Similar type of serological reactions were observed by George *et al.* (1993) and Walky *et al.* (1994).

Table 3. Detection of capsicum virus isolates from various isolates by DAC-ELISA

Isolates	O.D. at 405 nm
Isolate-I	0.26
Isolate-II	1.20
Isolate-III	0.75
Isolate-IV	1.28
Isolate-V	0.88

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Host Range and Physical Properties of Sorghum and Sugarcane Mosaic Virus

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ABSTRACT

Sugarcane and Sorghum mosaic virus was successfully transmitted under glass house condition through mechanical sap inoculation using 0.1 M. Phosphate buffer. Host range of various isolates of sorghum mosaic virus (SrMV) [M-35-1, SPV-504, SPV-1359, RSLG-262 and RSSV-9] and sugarcane mosaic virus [SCMV] (Co-86032, Co-88121, Co-7125, Co-671 and Co-740) was limited to family Graminiaceae. Based on host range, these ten isolates were grouped into two strains i.e. Sugarcane mosaic virus-SC (SCMV-SC) and Sugarcane mosaic virus-JG (SCMV-JG). The SCMV-SC strain was present in four virus isolates *viz*, M-35-1, SPV-504, Co-7125 and Co-740. In another six virus isolates i.e. RSLG-262, RSSV-9, SPV-1359, Co-86032, Co-88121 and Co-671, the SCMV-JG strain was prevalent. The physical properties i.e. TIP (Thermal inactivation point), DEP (Dilution end point) and LIV (Longevity *in-vitro*) of SCMV-JG and SCMV-SC were studied. The TIP, LIV and DEP of SCMV-JG was 55-60°C , 56-60 h and 10^{-3} to 10^{-4} and TIP of SCMV-SC was 50-55°C DEP 10^{-2} to 10^{-3} and LIV 48 to 52 h. Based on host range and physical properties of these isolates of sorghum and sugarcane mosaic virus were reveled into two strains i.e. SCMV-SC and SCMV-JG.

The first virus disease reported in sorghum was sugarcane mosaic virus (SCMV) described by Brandes and Klapack (1923). Moreover, sorghum crop was found to be infected by potyviruses like sugarcane mosaic virus (SCMV), sorghum mosaic virus (SrMV), maize dwarf mosaic virus (MDMV)and johnsongrass mosaic virus (JGMV) belonging to the subgroup of sugarcane mosaic virus. Sugarcane crop grown in the region was reported to be reservoir of sorghum red stripe virus disease (Mali and Garud 1994). The incidence of this virus on sorghum can be as high as 85 per cent and it reduces grain yield to the extent of 53 per cent in *Kharif* and 67 percent in *Rabi* (Vyavahare *et.al.*, 1989).Present paper, therefore includes results of host range and physical properties of various isolates of sorghum mosaic and sugarcane mosaic virus.

MATERIAL AND METHODS

Mechanical sap inoculation

Preparation of inoculum

Inocula prepared from diseased plants of five varieties of sorghum *viz.*, M-35-1, SPV-1359, RSLG-262, SPV-504, RSSV-9 and also five varieties of sugarcane namely Co-86032, Co-88121, Co-740, Co-671 and Co-7125. Routine crude sap extraction methods were used in transmitting the virus. Young leaf tissues showing typical mosaic symptoms were selected for sap extraction. The leaves of various isolates of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV) were used for inoculation to the test plant of most susceptible sorghum variety RSSV-9 for their culture maintenance. The leaves of five varieties of SrMV and SCMV were gently washed in tap water, immediately wiped off excess water with the help of blotting paper and weighted on the chemical weighing balance. Then these leaves were macerated in sterilized and chilled mortar and pestle by adding equal quantity of phosphate buffer. The crude sap were then obtained by squeezing the pulp through a double layered musling cloth. The inocula of all the isolates were kept at 8°C and in some cases the inocula were inoculated immediately.

Inoculation procedure

Before inoculation, the carborundum powder an abrasive was dusted on the leaves to be inoculated. The leaves were then inoculated by the inoculum following gently rubbing method of Holmes (1929) with the help of cotton swab. Immediately after inoculation, the leaves were slightly washed in the stream of tap water to remove excess inoculum. The seedlings were labeled properly and kept in the insect proof glass house for observation.

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The inoculated plants were observed periodically and observations were recorded as and when the symptoms appeared.

Host range

For host range studies, the host of different plant species belonging to various families *viz.* Graminae, Chenopodiacea Solanaceae Compositae, Cucurbitaceae, Cruciferae, Malvaceae and Leguminoaceae were mechanically sap inoculated. Twenty plants of different plant species were inoculated at 3-4 leaf growth stage with sap extracted from different varieties of sorghum (M-35-1, SPV-504, RSLG-262, SPV-1359, RSSV-9) and sugarcane (CO-86032, CO-88121, CO-671,CO-740, CO-7125) by conventional leaf rub method. Inoculated plants were kept in insect proof glasshouse and observations on symptom expressions were carried out at periodical intervals up to one month after inoculation. The plants which did not show any symptom were back indexed on test plants of sorghum variety RSSV-9.

III) Physical property

Total five isolates of sorghum mosaic virus and sugarcane mosaic virus were used in this study. The studies on physical properties *viz.*, TIP (Thermal inactivation point), DEP (Dilution end point), LIV (Longevity *in-vitro*) of various isolates of sorghum mosaic virus and sugarcane mosaic virus were carried out by standard procedure (Noordam, 1973).

i. Thermal inactivation point (TIP)

The five virus isolates of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV) were extracted as per method. In TIP, 4ml sap of these ten isolates were filled in 11th test tubes separately and labeled with respective range of temperature. Each test tube was individually exposed to temperature starting from 40,45,50,55,60,65,70,75,80^{0} C for 10 min. in hot water bath. Immediately after heating period, the test tube was cooled in ice cold water. The sap filled in the 11th test tubes were kept untreated to serve as control. The treated sap from the test tubes along with control were meachanically inoculated on the twenty test plants variety RSSV-9 at three leaf stage. The inoculations were started from highest temperature to lowest temperature i.e. 80^{0} C to 40^{0} C to avoid the contamination. All inoculated plants of above ten isolates were maintained in an insect free glass house. Observations were recorded for number of systemically infected plants.

ii) Dilution end point (DEP)

Crude sap of various isolates of sorghum mosaic virus (SrMV), (M-35-1, SPV-504, SPV-1359, RSLG-262, RSSV-9) and sugarcane mosaic virus (SCMV) (Co-86032,Co-88121,Co-7125,Co-671 and Co-740) were extracted as per method described earlier .A series of dilution *viz*; 1:10, 1:100, 1:1000, 1:10000, 1:100000, 1:1000000, 1:10000000, 1:00000000, 1:000000000 were made from crude sap in distilled water. From the crude sap, 1ml sap was pipetted out and mixed in the next test tube containing 9 ml distilled water. This dilution was made 1:10 (10^{-1}). From this dilution, 1 ml of crude sap was pipetted out and mixed with the next test tube containing 9 ml of distilled water. This dilution was 1:100 (10^{-2}). In this way, other dilutions up to 10^{-9} were prepared. This was done for all isolation of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV). For each dilution, separate pipette was used to avoid contamination and to have accurate results, an experiment was conducted to find out up to what extent sap could be infective. The inoculation was started from highest dilution to lowest dilutions and lastly undiluted sap (control) to avoid contamination. Inoculation was done on twenty test plants of sorghum variety RSSV-9 for each isolates. The all inoculated plants of various isolates of sorghum mosaic virus and sugarcane mosaic virus were maintained in an insect free glasshouse. Observations were recorded for number of systemically infected plants.

iii) Longevity *in-vitro* (LIV)

For longevity *in-vitro* study, the crude sap of various isolates of sorghum mosaic virus (M-35-1, SPV-504, RSLG-252, SPV-1359, RSSV-9) and sugarcane mosaic virus [CO-86032, CO-88121, CO-671, CO-7125, CO-740] were extracted as described earlier.

A quantity of 10 ml sap was filled in each test tube of various isolates of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV). The test tubes were plugged separately for various isolates and stored at room temperature (22-35^{0}C)

Table :1 Host range of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV)

S N.	Family	Various isolates of sorghum & sugarcane mosaic									
		M-35-1	SPV-504	RSLG-262	SPV-1359	RSSV-9	Co-671	Co-740	Co-88121	Co-86032	Co-7125
I	**Graminae**										
	a) Maize (Zea mays)										
	i. Decan double hybrid	+	+	+	+	+	+	+	+	+	+
	ii. Ganga safed	+	+	+	+	+	+	+	+	+	+
	b) Bajara	-	-	+	+	+	+	-	+	+	-
	c) Paddy	-	-	-	-	-	-	-	-	-	*.
	d) Johnsongrass	-	-	+	+	+	+	-	+	+	-
	e) Oat	-	-	+	+	+	+	-	+	+	-
	f) Ragi	-	-	+	+	+	+	-	+	+	-
	g) Sugarcane	+	+	+	+	+	+	+	+	+	+
	h) Sorghum	+	+	+	+	+	+	+	+	+	+
	i) Wheat	-	-	-	-	-	-	-	-	-	-
	j) Barley	-	-	-	-	-	-	-	-	-	-
II	**Solanaceae**	-	-	-	-	-	-	-	-	-	-
	a) Capsicum annum (L)	-	-	-	-	-	-	-	-	-	-
	b) Nicotina tabacum (L)	-	-	-	-	-	-	-	-	-	-
	c) Nicotina glutinosa (L)	-	-	-	-	-	-	-	-	-	-
	d) Lycopersico esculatum	-	-	-	-	-	-	-	-	-	-
	e) Datura metal	-	-	-	-	-	-	-	-	-	-
III	**Chenopodiaceae**	-	-	-	-	-	-	-	-	-	-
	a) Chenopodium amarandicolor	-	-	-	-	-	-	-	-	-	-
	b) Chenopodium album	-	-	-	-	-	-	-	-	-	-
IV	**Cucurbitaceae**	-	-	-	-	-	-	-	-	-	-
	a) Sponge guard	-	-	-	-	-	-	-	-	-	-
	b) Cucumber										
	c) Bottle guard										
	d) Bittle guard										
V	**Leguminoaceae**	-	-	-	-	-	-	-	-	-	-
	a) French bean	-	-	-	-	-	-	-	-	-	-
	b) Cowpea	-	-	-	-	-	-	-	-	-	-
	c) Mungbean	-	-	-	-	-	-	-	-	-	-
VI	**Malvaceae**	-	-	-	-	-	-	-	-	-	-
	a) Abelmoschus esculentum	-	-	-	-	-	-	-	-	-	-

for further studying. Immediately after extraction of sap, inoculations were done mechanically on twenty test plants that served as control, whereas sap from other test tubes stored at room temperature were inoculated at an interval of 4 h that is 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 60, 64, 68, 72, 76, 80, 84 and 88 h on healthy seedlings of sorghum variety RSSV-9. This was done for all isolates of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV). For each inoculation, the sap from various isolates of SrMV and SCMV were used from separate test tubes filled at the same time. The inoculated plants were labelled properly and maintained in an insect free glass house. Observations were recorded for number of systemically infested plants.

RESULTS AND DISCUSSION

I) Host range

The various isolates of sorghum and sugarcane mosaic virus were mechanically sap inoculated to Graminae, Solanaceae, Chenopodiaceae, Cucurbitaceae, Leguminoaceae and Malvaceae family. Under investigation, the various isolates of sorghum and sugarcane mosaic virus had limited host range distributed only in *Graminae* family. (Table 1) These results were in agreement with other worker Tosic *et. al.* (1990), Gopal *et.al.* (1991)and Sibiya *et.al.* (1998). The various host plants from other families namely; solanacece, chenopodiaceae, cucurbitaceae leguminoacae and malvaceae were meachanically inoculated with various isolates of sorghum mosaic virus (SrMV) and sugarcane mosaic virus (SCMV). None of the host plant from these families showed symptom reaction to any of the virus isolates of SrMV and SCMV. The virus was not recovered from inoculated plants of these hosts. A similar result was observed by the Gopal *et.al.* (1991) (Table 1). Based on symptom patterns exhibited by different host plants, various isolates of SrMV and SCMV were grouped into two strains. The virus isolates namely M-35-1, SPV-504, CO-7125, CO-740 showed reaction on maize cvs. Deccan Double hybrid and Ganga safed, sugarcane and sorghum, hence categorized an SCMV-SC. However,virus isolate Co-7125 from SCMV-SC strain was recovered from paddy thereby indicated symptom less carrier of this host. Singh (1983) also noticed paddy act as symptom less carrier of maize dwarf mosaic virus. The virus isolates of CO-671, CO-86032, CO-88121, RSLG-262, SPV-1359, RSSV-9 showed symptoms in *Bajara*, johnsongrass, oat, ragi, sugarcane, maize cvs. Deccan Double Hybrid, Ganga safed and sorghum. Therefore, all six virus isolates categorized into SCMV-JG. Similar observations were reported by Klein *et.al.* (1973).

II) Physical property

Studies on physical properties of ten virus isolates revealed that isolates M-35-1, SPV-504, CO-7125, CO-740 had LIV of 48-52 hr. DEP of 10^{-2} to 10^{-3} and thermal inactivation point of 50-55° C. Hence categorized as SCMV-SC strain. It is clearly evident that the physical properties SCMV-SC strain under study was identical with Sadruddin *et.al.* (1981). While isolates number RSLG-262, RSSV-9, SPV-1359, CO-86032, CO-88121, CO-671 had LIV of 56-60 hr, dilution end point 10^{-3} to 10^{-4} and the thermal inactivation point between 55-60° C. Physical properties of these six virus isolates viz. CO-671, CO-86032, CO-88121 RSLG-262, SPV-1359 and RSSV-9 were categorized as SCMV-JG. These findings are similar with other workers like, Mali and Garud (1978), Garud and Mali (1980). (Table 2)

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Table 2. Physical properties of various isolates of SrMV and SCMV.

S. N.	Virus isolates	LIV	DEP	TIP	Strain identification
1.	M-35-1, SPV-504, CO-7125 & CO-740	48-52 hr	10^{-2} - 10^{-3}	50-55°C	SCMV-SC
2.	RSLG-262, RSSV-9, SPV-1359, CO-86032, CO-88121 & CO-671	56-60 hr	10^{-3} - 10^{-4}	55-60°C	SCMV-JG

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Risk Factors of Suicide and their Correlates

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ABSTRACT

The present investigation was carried out in Akola and Buldana districts of Western Vidarbha region of Maharashtra with descriptive and diagnostic; and experimental design of social research. In this study, respondents were the households of selected victims who committed suicide. In all, 40 victims were selected by proportionate random sampling method. For making comparison between suicidal and non suicidal cases researchers had chosen 40 non suicidal farmers from the same village having similar land holding, irrigation facilities and social conditions. The results of the study revealed that average number of socio-psycho risk factors of suicide was observed higher (5.8) amongst the deceased farmers than non-suicidal farmers (1.5). The result of the 'Z' test inferred that suicidal farmers differed significantly over control group in respect of identified socio-psycho risk factors of suicides. While observing the path analysis results it was revealed that low socio-economic status has not only produced the highest direct effect with identified number of risk factors among the victims but also served as a vehicle/ trigger in both the group through other selected variables. For improving this situation, policy makers have to think critically about the change in socio-economic condition of the farmers of Vidarbha.

Suicide is a complex social and psychological phenomenon. Psychologically, the suicide prone person experiences mental distress because of certain crisis situation. If immediate help is made available to such a person, his suicide could perhaps be avoided. Poverty, unemployment, loneliness, social and economic insecurity, and conflicts in interpersonal relations are the important social factors contributing to suicide. To solve these various problems, appropriate policies and programmes are to be evolved in the country (Phal, 2000). Durkheim (2002) pointed out that the neurobiological and socio-economic dimensions of risk factors are responsible for committing suicide, but the intersection of these two sets, where the relative risk of committing suicide is higher.

Recently farmers' suicides have been receiving public, media, researchers and policy makers' attention in Vidarbha region of Maharashtra. According to various studies/experts, non remunerative prices for crops, indebtedness and crop failures due to monsoon vagaries are, by and large, identified as the core reasons of suicide in Vidarbha region of Maharashtra [Dandekar *et al* (2005), Mishra (2006) and Narayanamoorthy (2006)]. But according to Madan (1980) and Sing (2005), the causes of suicide are complex, many factors combine to cause one particular individual (and not another) to divert his aggression upon himself in the form of suicide. This type of possibilities may not be avoided in Vidarbha region. There may be various reasons behind their act of suicide. Although it is a difficult task to find correct reasons behind act of each victim, but according to Kaplan *et. al.* (1994) the suicidal person sends out signal of distress. Hence, it has been an important question among thinkers/ researchers to find the appropriate signals/stressors of distress among each individual victim. The probable information about these signals/ stressors may be found in secondary material available with each victim's households. Hence, the study pertaining to causes of farmers' suicide was taken by conducting detailed field survey particularly in Buldana and Akola districts of western Vidarbha in Maharashtra with following objectives.

1) To identify the socio-psycho risk factors of suicide which compelled the farmers to commit suicide in western Vidarbha region.
2) To compare the identified socio-psycho risk factors associated with suicidal and control group.
3) To study the relationship between selected characteristics of suicidal and control farmers with their identified socio-psycho risk factors.

MATERIAL AND METHODS

The present investigation was carried out in Akola and Buldana districts of Western Vidarbha region of Maharashtra with descriptive and diagnostic; and experimental design of social research. In this study respondents were the households of selected victims who committed suicide during 1st January 2008 to 31st December 2008 and had declared as legal victims by district level committee headed by Collector of the respective district, for allotting compensation of Rs. 1 lakh and had got Rs. 1 lakh compensation. In all, there were 361 total suicide cases in selected two districts

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during 2008, out of which 242 cases were declared as illegal and 119 cases were declared as legal victims. From the list of 119 legal suicide cases, researcher had selected 40 victims by proportionate random sampling method. For making comparison between suicide and non suicidal cases researcher had chosen 40 non suicidal farmers from the same village and with similar land holding, irrigation facilities and social conditions. It covered 40 villages and 9 *tahsils* of two districts. Data were collected by personal interview method with the help of structured interview schedule.

RESULTS AND DISCUSSION

Socio-psycho risk factors of suicides

The suicide is complex, social and psychological phenomenon. In present research study, it was assumed that the farmers who have committed suicide in Vidarbha region, their social and psychological web might not be sustainable. They might have many social and psychological problems. These problems had created an adverse impact on their well being and impaired the quality of life. In this study, socio-psycho risk factors refers to the aggregation of different socio-psychological risk factors coexisted with an individual respondent externally. For every identified risk factor, one score was allotted. Thus, according to total risk factors identified with each respondent that indicate the total socio-psycho risk factor score of the respondents. The same has been studied and the data have been presented in Table 1.

A critical look of data presented in Table 1 reveals that total 18 socio psychological risk factors were associated with the selected deceased farmers, who committed suicide. A number of risk factors can coexist and one particular individual can come across all or none of the risk factors identified by the researcher. In selected victims, the minimum number of risk factors was two and the maximum 10, as against among control group the minimum number of risk factors was zero and the maximum five. The average number (Mean score) of socio-psycho risk factors of suicide was observed higher (5.8) amongst the deceased farmers than non-suicidal farmers (1.5).The identified risk factors have been presented in a descending order based on frequency of their occurrence in suicidal sample.

Table 1: Distribution of the Suicidal and control farmers according to their identified Socio-psycho Risk Factors

S.N.	Risk factors	Suicidal		Control group	
		No.	%	No	%
1	Indebtedness.	38	95.00	10	25.00
2	Hopelessness due to crops failure	33	82.50	17	42.50
3	Drop in economic status	32	80.00	13	32.50
4	Introvert ness	24	60.00	0	00.00
5	Alcohol use disorder	18	45.00	1	2.50
6	Low social support	17	42.50	5	12.50
7	Having health problem	13	32.50	3	7.50
8	Change in behaviour	11	27.50	0	00.00
9	Family members chronically ill /handicapped	10	25.00	3	7.50
10	Family history of suicide	9	22.50	2	5.00
11	Daughter / sister of marriageable age	7	17.50	5	12.50
12	Disputes/quarrel with the family members	6	15.00	0	00.00
13	Given verbal clues of suicide	5	12.50	0	00.00
14	Depressed due to divorced/disputed, daughter/sister in family	4	10.00	1	2.50
15	Decreased self esteem events	2	5.00	0	00.00
16	Depressed due to no children	1	2.50	0	00.00
17	Depressed due to land disputes in court	1	2.50	0	00.00
18	Death of family member before incident	1	2.50	0	00.00
	Average number of risk factors (Mean)	5.8	580.00	1.5	150.00
	Minimum number of risk factors	02		00	
	Maximum number of risk factors	10		05	

The most common risk factor was indebtedness found in 94.00 per cent deceased farmers, as against in control group it was associated with one fourth (25.00%) households. In more than three fourth of the cases (82.50%) crop failure was mentioned. Mostly the households mentioned that the monsoon vagaries were the main reasons for crop failures. Crop failure can lead to economic downfall and make it difficult to repay the existing loans. Whereas in control group 42.50 per cent households mentioned the problem of crop failure. This was followed by drop in economic position which was noticed in 80.00 per cent of deceased farmers and with 32.50 per cent control group.

Introvert personality was identified in 60.00 per cent deceased farmers as they did not discuss or share their problems with other family members, that led to add more frustration. This factor was not observed in control group.

In sizeable group of the suicidal cases (45.00%) alcohol use disorder was associated, whereas in control group only one (2.50%) had alcohol use disorder. Low social support was noticed with 42.50 per cent victims, as against in control, it was reported by 12.50 per cent of respondents. The personal health problem of the deceased was identified in 32.50 per cent of the cases, while in control group 7.50 per cent family heads had personal health problem. Change in the individuals' behaviour was identified in more than one fourth (27.50%) cases due to stressful life events while this was absent in control group.

In one-fourth (25.00%) deceased farmers, their family member suffered from ill health. It added frustration in those who were not able to fulfill the responsibility of taking care for an ailing parent / spouse / child. More expenses on ill health also lowered the economic position. Whereas this problem was noticed with only three (7.50%) non-suicidal farmers. Family history of suicide was identified in 22.50 per cent of the victims. This could be indicative of genetic factor, while this was also identified with 5.00 per cent control households. Daughter/ sister of marriageable age was found as a risk factor in 17.50 per cent victims, while in control it was also noticed with 12.50 per cent households. In 6 (16.00%) victims disputes/ quarrel was noticed with their family members due to domestic reasons whereas it was absent in control group.

In addition to the above, there were some other risk factors which were identified with the victims but that were not observed in control group.

Testing the significance of difference in the means

In order to test the variability of mean score of identified socio-psycho risk factors of suicidal farmers over control group, the data were subjected to 'Z' test and the results have been presented in Table 2. It is observed from the Table 2 that the mean score of identified socio-psycho risk factors of suicidal farmers was observed higher (5.8) than non-suicidal farmers (1.5). A mere quantitative superiority of the mean score of identified socio-psycho risk factors of the suicidal farmers over mean score of the control group farmers is not conclusive proof of its superiority. Hence the ratio between observed differences was computed as indicated by 'Z' value.

The 'Z' value of identified socio-psycho risk factors (2.12) was found significant at 0.05 level of probability. It could be inferred that suicidal farmers differed significantly over control group farmers in respect of identified socio-psycho risk factors of suicides

Relational analysis

The data were subjected to the statistical tools like correlation and path analysis. This correlation analysis helped in determining the relationship of characteristics of the suicide and control farmers with their identified number of risk factors. The path analysis isolated the direct and indirect effects of the individual independent variables on identified number of socio-psycho risk factors.

Corelational Analysis

The correlation coefficients were computed which indicate the relationship of the selected characteristics of the respondents with their identified number of risk factors. The findings obtained in this regard are depicted in Table 3.

A closer look at the values of correlation coefficient (Table 3) brings into light that the characteristics of the victims namely, family type,

Table 2: Testing the significance of difference in the means of identified Scio-psycho risk factors of suicidal and control group

S.N.	Variable	Mean score		'Z' value
		Suicidal	Control group	
1	Scio-psycho risk factors	5.8	1.5	2.12*

* Significant at 0.05 level of probability

land holding, socio-economic status and annual income were found highly and negatively significant relationship with the identified number of risk factors at 0.01 level of probability. Whereas irrigation facilities had shown negative and significant relation at 0.05 level of probability. This indicates that nuclear type families, lowering land holding, decreasing irrigation facilities, lowering socio-economic status and decreasing annual income of the victims, there was an increase in the risk factors of suicide with the victims.

While in control group, income liability gap and indebtedness had positive and significant relationships with the identified number of risk factors at 0.05 level of probability. This indicates that with the increase in income liability gap and indebtedness with the non-suicidal farmer, there had been an increase in risk factors.

Path analysis

For finding out the influence of the selected independent variables on the identified number of risk factors with the respondents both directly and indirectly and also through other variables, the method of path analysis was used. The results are depicted in Table 4.

1. Direct effects:

Table 3: **Coefficient of Correlation of selected characteristics of the respondents with their identified number of Socio-psycho risk factors**

S. N.	Characteristics	"r" value	
		Suicidal	Control group
1	Age	0.1558	-0.0802
2	Education	-0.2896	0.1529
3	Family type	-0.4742**	0.0185
4	Family size	-0.0321	0.1525
5	Subsidiary occupation	-0.2378	-0.0659
6	Land holding	-0.5533**	-0.0787
7	Type of land	-0.0254	-0.0810
8	Irrigation facilities	-0.3814*	0.0513
9	Socio-economic status	-0.6226**	-0.0989
10	Annual income	-0.4037**	-0.1801
11	Income liability gap	-0.0592	0.3555*
12	Indebtedness	-0.0398	0.3447*

** Significant at 0.01 level of probability

*Significant at 0.05 level of probability

The path coefficients reported in Table 4 revealed that the socio-economic status (-0.7996) had negative and maximum direct effect on the identified number of risk factors with the victims, whereas in control group, indebtedness (0.3785) had positive and maximum direct effect on the identified number of risk factors. Thus it could be inferred that victims with low socio-economic status possessed more risk factors of suicide directly. In this study socio-economic status was multidimensional construct variable having eight important indicators viz. occupation, land holding, family education, annual income, socio-political participation, household possession, material possession and other attributes. That means low level of the above indicators of socio-economic status has exerted maximum direct effect on identified number of risk factors of suicide with the victims. Whereas as in control group increasing obligation of outstanding debts possessed more risk factors directly.

2. Total indirect effects:

It could be noted from table 4 that the variable annual income (-0.8680) exerted negative and maximum total indirect effect on identified number of risk factors with victims. While among control group income liability gap (0.2117) exerted positive and maximum total indirect effect on identified number of risk factors. Thus victims with lower income and in control group increasing income liability gap due to low annual income has exerted maximum total indirect effect on identified number of risk factors.

3. Maximum indirect effects through other variables

Out of 12 variables under study, socio-economic status exerted maximum and negative indirect effect on identified number of risk factors with suicidal and non-suicidal farmers through other variables. Thus low SES has not only produced the highest direct effect with identified number of risk factors among the victims, but it also served as a vehicle for production of indirect effect through other variables for increasing risk factors with the victims as well as with control farmers.

CONCLUSION

In selected victims average number of socio-psycho risk factors of suicide were observed higher (5.8) than non-suicidal farmers (1.5). The result of the 'Z' test inferred that suicidal farmers differed significantly over control group in respect of identified socio-psycho risk factors of suicides

Table 4: Direct and indirect effects of independent variables on identified number of Socio-psycho risk factors

S.N.	Correlates	Suicidal				Control group			
		Coefficient of correlation'r'	Direct effect	Total indirect effect	Maximum indirect effect through other variable	Coefficient of correlation'r'	Direct effect	Total indirect effect	Maximum indirect effect through e other variabl
1	Age	0.1558	0.0492	0.1064	0.1561 (X_9)	-0.0802	0.0575	-0.1377	-0.1457(X_9)
2	Education	-0.2896	-0.0055	-0.2841	-0.3698(X_9)	0.1529	0.5003	-0.3474	-0.4097(X_9)
3	Family type	-0.4742**	-0.2446	-0.2296	-0.3079 (X_9)	0.0185	-0.0966	0.1151	0.0381 (X_2)
4	Family size	-0.0321	-0.0445	0.0124	-0.1022 (X_3)	0.1525	0.0116	0.1409	0.1220 (X_{12})
5	Subsidiary occupation	-0.2378	0.0183	-0.2561	-0.3047 (X_9)	-0.0659	0.2869	-0.3528	-0.5070 (X_9)
6	Land holding	-0.5533**	-0.3190	-0.2343	-0.5924 (X_9)	-0.0787	0.2399	-0.3186	-0.6918 (X_9)
7	Type of land	-0.0254	0.1759	-0.2013	-0.1558 (X_9)	-0.0810	-0.2388	0.1578	-0.1467 (X_9)
8	Irrigation facilities	-0.3814*	0.1151	-0.4965	-0.5501 (X_9)	0.0513	0.1743	-0.1230	-0.5959 (X_9)
9	Socio-economic status	-0.6226**	-0.7996	0.1770	0.3745 (X_{10})	-0.0989	-0.8470	0.7481	0.1959 (X_6)
10	Annual income	-0.4037**	0.4643	**-0.8680**	-0.6449 (X_9)	-0.1801	-0.0984	-0.0817	-0.6670 (X_9)
11	Income liability gap	-0.0592	-0.0746	0.0154	0.0380(X_7)	0.3555*	0.1438	**0.2117**	0.2182 (X_{12})
12	Indebtedness	-0.0398	0.1907	-0.2305	-0.1165(X_9)	0.3447*	**0.3785**	-0.0337	-0.2968 (X_9)

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

Indebtedness, hopelessness due to crops failure, drop in economic status, introvert ness, alcohol use disorder, low social support, self and family members' health problems, change in behaviour due to stressful life events, family history of suicide were the prominent risk factors observed with suicidal farmers, whereas the percentage of the same risk factors with non-suicidal farmers were observed on lower side or nil. While observing the path analysis results it was revealed that low socio-economic status has not only produced the highest direct effect with identified number of risk factors among the victims but also served as a vehicle/ trigger in both the group through other selected variables. For improving this situation, policy makers have to think critically about the change in socio-economic condition of the farmers of Vidarbha. Instantly there is an urgent need to declare remunerative prices for all crops of farmers in consonance with the cost of cultivation. Presently, cost of cultivation has increased by manifolds due to steep rise in the cost of inputs, but prices of farm produce were not rise comparatively. During this field survey, some of the households mentioned that some time they did not get even the cost of cultivation from farm produce. Hence it implies that remunerative prices of farm produce should be declared and paid in consonance with the cost of cultivation. Presently, most of the farmers depend on external input, that needs initial financial provision with farmers, but mostly the farmers of dry land region cannot save the money from their small and marginal holding. Hence for every venture, they have to borrow money. Hence, this study implies measure for reducing the dependency of farmers on external inputs. This can be possible through extensive efforts of extension functionaries by providing information on important low cost-no cost technologies of farm cultivation to farmers like use of own seeds, seed treatment, use of bio-fertilizers, sowing across slope, different land care techniques, etc. This will definitely help farmers to reducing initial cost of inputs to some extent. Provide crop insurance facilities with low premium affordable by the farmers for all crops and to all farmers, and insurance unit should be reduced to Village Panchayat for at least for major crops. Similarly Government should give immediate financial help to affected farmers in natural calamities like flood, drought and in losses by wild animals. In addition to the these short term measures, the policy makers should have to apply long term measures for uplifting the farmers socially and economically like bring more land under irrigation by completing ongoing irrigation projects and plan about the new irrigation projects, increasing network of canals, tanks; wells and micro irrigation systems. This will definitely help in increasing crop production, productivity, and change in cropping pattern, cropping intensity, and increase in the allied occupations in study area. These things are necessary not only for uphold the farmers economically but also for sustaining them socio-psychologically.

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Optimization of Phosphorus Requirement in Soybean with Sulphur and Biofertilizer

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ABSTRACT

A field experiment to evaluate the response of soybean to phosphorus, sulphur and biofertilizer was conducted at the farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2007-08. The result of the field experiment revealed that growth attributes, yield attributes and yield of soybean crop significantly improved with increasing phosphorus levels up to 100 per cent P_2O_5 (75 kg ha^{-1}). Application of 20 kg S ha^{-1} recorded significantly highest values of growth attributes, yield attributes and yield over 0 kg S ha^{-1}. Seed inoculation of *Rhizobium* + PSB proven to be beneficial for soybean crop over no inoculation. However combined application of 75 per cent P_2O_5 (56.25 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation was found to be effective and economical as it was closer to the application of 100 per cent P_2O_5 (75 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation for yield, NMR and B:C ratio.

Intensive crop cultivation requires the use of chemical fertilizers. However, fertilizers are not only in short supply but also very expensive too. Therefore, the current trend is to explore the possibility of supplementing chemical fertilizer with biofertilizers of microbial origin. Microbial processe are not only quick but also consume relatively less energy than industrial processes. Thus, biofertilizers hold a key to the solution of current problem of fertilizer scarcity and expensiveness. Phosphorus is key nutrient which play important role in legumes like soybean. But the efficiency of utilization of added 'P' by plants is very low (15-20%) due to fixation. The phospho bacteria solubilise phosphorus and make it available to plants (Detorja *et al.*, 1997). Besides, the phosphorus, sulphur is the second most essential nutrient in crop productivity. The deficiency of sulphur causes accumulation of nitrate, amides and carbohydrates which retard the formation of proteins (Tondon, 1989). No single source of nutrients is capable of supplying plant nutrients in adequate amount and balanced proportion. Therefore, to maintain soil fertility and to supply plant nutrients in balanced proportion for optimum growth, yield and quality of crop in a specific agro-ecological situation, balanced use of inorganic fertilizer and biofertilizers is indispensable and inter dependable for successful plant nutrient management system. Keeping in view the above situation the present studies were aimed to find out the role of sulphur and biofertilizer in phosphorus economy of soybean crop.

MATERIAL AND METHODS

A field experiment was conducted at farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2007-08. The soil of experimental field was clayey, having pH 8.2 with electric conductivity 0.32 dSm^{-1}, organic carbon 0.53 per cent and available N, P_2O_5, K_2O and Sulphur 283, 20.12, 353 and 12 kg ha^{-1} respectively. The treatment comprising of three phosphorus levels viz., P_1 – 50per cent P_2O_5 (37.5 kg ha^{-1}), P_2 –75per cent P_2O_5 (56.25 kg ha^{-1}), P_3 – 100per cent P_2O_5 (75 kg ha^{-1}) with two sulphur levels viz., S_1 – 0 kg S ha^{-1}, S_2 – 20 kg S ha^{-1} and biofertilizes viz, B_1 – No inoculation and B_2 – Seed inoculation with *Rhizobium* + PSB. Total 12 treatment combinations were laid out in factorial randomized block design and replicated three times. Sowing was done adopting spacing of 45 x 05 cm by drilling method and variety used was TAMS -38. Well decomposed air dried FYM @ 5 t ha^{-1} was applied in experimental plots before last harrowing. The recommended dose of nitrogen @ 30 kg N ha^{-1} was applied through urea and diammonium phosphate to adjust the treatment wise phosphorus requirement. Sulphur was applied as per treatment 15 days before sowing through elemental sulphur and treatment wise *Rhizobium japonicum* and PSB seed inoculation was done @ 20 g of each kg^{-1} of seed just before sowing. The crop was sown on 4th July and harvested on 20th October of 2007. Total 514.2 mm rainfall was received during crop growth period in 30 rainy days.

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Observations on growth attributes were recorded at important growth stages and yield attributes and yield were estimated at harvest and expressed as mean. Economics of treatments were work out and NMR and B:C ratio was calculated to study the economics of the treatments.

RESULTS AND DISCUSSION

The variations imposed through various treatments significantly influenced all growth parameters (Table 1), yield attributes and yield (Table 2).

Growth attributes

Effect of Phosphorus

Plant height, number of branches plant^{-1}, leaf area plant^{-1}, dry matter plant^{-1} and root nodules plant^{-1} were significantly increased with successive increased in phosphorus level up to 100 per cent P_2O_5 (75 kg ha^{-1}). This result illustrate the role of phosphorus in early root ramification and development of nodule bacteria, which resulted in healthy crop growth and higher photosynthetic area due to increased in leaf area thus gain in dry matter plant^{-1}. The significant increase in growth attributes with increase in phosphorus levels were also reported by Mohd. Abbas *et al.* (1994) and Goswami *et al.* (1999).

Effect of Sulphur

Sulphur application resulted in significant influence on growth attributes (Table 1). Application of 20 kg S ha^{-1} recorded highest values of plant height, number of branches plant^{-1}, leaf area plant^{-1}, dry matter plant^{-1} and root nodules plant^{-1} over no application. The significant increase in growth attributes with the application of sulphur may be because of increased chlorophyll synthesis as it is greatly affected by the sulphur content in growing medium. However, increase in nodulation with sulphur is attributed to role of sulphur in formation of ferredoxin, an iron containing plant protein that acts as an electron carrier in photosynthesis process and is involved in nitrogen fixation by nodule bacteria. Sulphur also had indirect effect on nodulation and N fixation, possibly by improving soluble sugar supply and N metabolism. Prasad *et al.* (1991) and Singh and Singh (1995) observed similar response of growth attributes to sulphur. Increase in number of nodules of soybean with the application of sulphur has been demonstrated by Dubey and Billore (1995).

Effect of Biofertilizer

Rhizobium + PSB seed inoculation significantly improved the plant height, number of branches, leaf area, dry matter and root nodules plant^{-1} over no inoculation (Table 1). Beneficial effect of Rhizobium + PSB may be related to increase in nodulation due to Rhizobium bacterium and release of growth promoting substances like cytokinins in the rhizosphere of soybean plant which enhance root growth and nutrient uptake as well as increase in availability of native soil phosphorus and applied phosphorus by phosphate solubilising bacteria. Similar result of combined application of Rhizobium + PSB was reported by Balasubramanian and Pananiappan (1994).

Yield attributes and Yield

Effect of Phosphorus

Every increase in level of phosphorus gave significantly more number of pods plant^{-1}, weight of pods plant^{-1}, test weight and consequently higher seed, straw and oil yield than its preceding lower level (Table 2). Significantly highest values of yield attributes and yield were recorded with application of 100 per cent P_2O_5 (75 kg ha^{-1}). Such significant increase in yield attributes and yield with each increment in phosphorus levels might be due to increase in phosphorus availability, which enhanced food synthesis and its effective translocation to reproductive organs. Similar significant increase in yield attributes and yield with higher level of phosphorus over its lower levels in alkaline soil was quoted by Umale *et al.* (2002) and Kausadikar *et al.* (2003).

Effect of Sulphur

Application of 20 kg S ha^{-1} recorded significantly higher values of number of pods plant^{-1}, weight of pods plant^{-1}, test weight, seed yield, straw yield and oil yield over 0 kg S ha^{-1} (Table 2). This significant gain in yield attributes and yield with the application of 20 kg S ha^{-1} is due to significant increase in vigour, plant growth and dry matter production with efficient translocation of food material from source to sink. The above finding is in close proximity with that of Mishra and Agrawal (1994) and Singh *et al.* (2001).

Table 1: Effect of phosphorus, sulphur and biofertilizer on growth attributes of soybean

Treatments	Plant height at harvest (cm)	No. of branches plant^{-1} at 80 DAS	Leaf area plant^{-1}at 80 DAS (dm^2)	Dry matter plant^{-1} at harvest (g)	Root nodules plant^{-1} at 60 DAS
Phosphorus levels					
P_1 – 50% P_2O_5 (37.5 kg ha^{-1})	56.58	10.82	3.11	12.02	33.81
P_2 –75% P_2O_5 (56.25 kg ha^{-1})	59.81	12.20	3.64	18.12	40.62
P_3 – 100% P_2O_5 (75 kg ha^{-1})	63.16	12.81	4.02	21.14	44.39
SE (m) ±	0.97	0.20	0.10	0.61	0.96
CD at 5%	2.84	0.57	0.30	1.78	2.83
Sulphur levels					
S_1 – 0 kg S ha^{-1}	58.06	11.65	3.37	14.65	37.39
S_2 – 20 kg S ha^{-1}	61.64	12.23	3.81	19.54	41.82
SE (m) ±	0.79	0.16	0.08	0.50	0.79
CD at 5%	2.32	0.46	0.25	1.45	2.31
Biofertilizers					
B_1 – No inoculation	58.31	11.61	3.41	15.71	37.95
B_2 – *Rhizobium* + PSB	61.39	12.27	3.78	18.48	41.26
SE (m) ±	0.79	0.16	0.08	0.50	0.79
CD at 5%	2.32	0.46	0.25	1.45	2.31

Table 2: Effect of phosphorus, sulphur and biofertilizer on yield attributes and yields of soybean

Treatments	No. of pods plant^{-1}	Wt. of pods plant^{-1} (g)	Test weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Oil yield (q ha^{-1})
Phosphorus levels						
P_1 – 50% P_2O_5 (37.5 kg ha^{-1})	16.32	5.25	10.54	16.69	21.61	3.01
P_2 –75% P_2O_5 (56.25 kg ha^{-1})	19.34	6.25	11.26	21.59	28.52	4.20
P_3 – 100% P_2O_5 (75 kg ha^{-1})	21.48	6.87	11.77	24.60	33.52	5.09
SE (m) ±	0.32	0.09	0.03	0.39	0.57	0.10
CD at 5%	0.93	0.26	0.07	1.14	1.67	0.30
Sulphur levels						
S_1 – 0 kg S ha^{-1}	17.62	5.68	11.05	18.99	25.45	3.53
S_2 – 20 kg S ha^{-1}	20.47	6.56	11.32	22.93	30.31	4.68
SE (m) ±	0.26	0.07	0.02	0.32	0.47	0.08
CD at 5%	0.76	0.21	0.06	0.93	1.36	0.24
Biofertilizers						
B_1 – No inoculation	18.48	5.96	11.16	20.07	26.48	3.84
B_2 – *Rhizobium* + PSB	19.61	6.29	11.21	21.85	29.28	4.37
SE (m) ±	0.26	0.07	0.02	0.32	0.47	0.08
CD at 5%	0.76	0.21	NS	0.93	1.36	0.24

Table 3: Interaction effect of phosphorus, sulphur and biofertilizer on yields and economics of soybean

Treatments	seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Net monetary return (Rs. ha^{-1})	B:C ratio
$P_1S_1B_1$	15.42	19.96	13687	2.05
$P_1S_1B_2$	15.81	20.47	14085	2.06
$P_1S_2B_1$	17.64	22.83	17024	2.06
$P_1S_2B_2$	17.90	23.17	17195	2.25
$P_2S_1B_1$	18.98	24.55	19507	2.46
$P_2S_1B_2$	19.43	25.20	20004	2.47
$P_2S_2B_1$	20.89	27.32	22328	2.61
$P_2S_2B_2$	27.08	37.00	32867	3.33
$P_3S_1B_1$	21.94	30.91	24458	2.79
$P_3S_1B_2$	22.37	31.62	24921	2.78
$P_3S_2B_1$	25.57	33.30	30089	3.12
$P_3S_2B_2$	28.51	38.25	34977	3.42
SE (m) ±	0.78	1.14	1358	-
CD at 5%	2.29	3.35	3983	-

Effect of Biofertilizer

Biofertilizer significantly influenced yield attributes and yield, except test weight (Table 2). Seed inoculation of Rhizobium + PSB significantly enhanced the number of pods plant^{-1}, weight of pods plant^{-1}, seed yield, straw yield and oil yield over no inoculation. This beneficial effect of Rhizobium + PSB is attributed to significant increase in number of root nodule in this treatment, which augments nitrogen supply at critical growth stages like flowering and pod development through symbiotically fixed nitrogen as well as more phosphorus availability which resulted significant boom in yield attributes and consequently yield. Similar beneficial effects of combined application of Rhizobium + PSB over no inoculation were reported by Poonam *et.al.* (2003) and More *et.al.* (2008).

Interaction

Interactive effect of phosphorus level, sulphur level and biofertilizer on seed yield, straw yield and net monetary was significant (Table 3). Combined application of 100 per cent P_2O_5 (75 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation ($P_3S_2B_2$) remaining at par with 75% P_2O_5 (56.25 kg ha^{-1}), 20 kg S ha^{-1} and *Rhizobium* + PSB seed inoculation ($P_2S_2B_2$) and recorded significantly higher seed yield of soybean over rest of the combinations of phosphorus, sulphur and biofertilizer. Similar interactive effects of phosphorus, sulphur and biofertilizer were also visible on straw yield.

So far as the economics of treatment is concerned, combined application of 100 per cent P_2O_5 (75 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation ($P_3S_2B_2$) gave highest net monetary return and B:C ratio, which was at par with treatment combination of 75 per cent P_2O_5 (56.25 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation ($P_2S_2B_2$) for NMR and quiet closer for B:C ratio, which indicated 25 per cent saving of P_2O_5 requirement can be achieved in soybean production.

Thus, it can be concluded that combine application of 75% P_2O_5 (56.25 kg ha^{-1}), 20 kg S ha^{-1} and Rhizobium + PSB seed inoculation ($P_2S_2B_2$) is effective and economical to achieve highest yield of soybean crop under rainfed condition.

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Changes in Growth Rate and Cropping Pattern in Yavatmal District of Vidarbha

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ABSTRACT

An attempt has been made to study the changes in growth rate of area, production and yield of major crops and cropping pattern in Yavatmal district of Vidarbha. The study was based on secondary data pertaining to a period of 26 years i.e. from 1980-81 to 2005-06. The compound growth rates of area, production and yield of major crops were estimated for two sub-periods i.e., 1980-81 to 1992-93 (Period I) and 1993-94 to 2005-06 (Period II). The result showed that the area growth rates of major cereal crops declined as well as area, production and yield of pulses also declined during the study period. There existed wide temporal changes in the cropping pattern in Yavatmal district. The proportion of area under cotton and *Kharif jowar* declined, whereas, the area under oilseeds increased over a period of time. Soybean has emerged as an important crop in the Yavatmal district.

Maharashtra is one of the top economic states with respect to per capita income in India. Agriculture is the mainstream of Maharashtra's economy. Analytical studies related to agricultural growth would provide valuable information for future planning and projections of agricultural output. There are many factors that promote agricultural development in a region. The study of cropping pattern is one of them, which assumes a great significance, as it is one of the important paths for balanced development in a region. The adoption of better cropping pattern optimally suited to the technological changes is an important one for augmenting agricultural growth. The study was undertaken with the following objectives:

1) To examine the growth rates in area, production and yield of major crops
2) To examine the changes in cropping pattern.

MATERIAL AND METHODS

The present study pertains to the Yavatmal district in Vidarbha region of Maharashtra state. The required secondary data of major crops were collected from various Government publications for the period 1980-81 to 2005-06.

Analytical Tools

Growth Analysis

In the present study, compound growth rates of area, production and yield of major crops were estimated for two sub-periods i.e., 1980-81 to 1992-93 and 1993-94 to 2005-06 (Pandey and Sharma, 1996). Compound growth rates were estimated with the following exponential model.

$$Y = a.\ b^t$$

Compound Growth Rate = (b-1) * 100

Where,

Y = the dependent variable (area / production / yield)

a and b = parameters of exponential model

Analysis of cropping pattern changes:

The changes in cropping pattern have been studied by tabular analysis for all the major crops. Cropping pattern in terms of percentage share of individual crops on gross cropped area has been worked out at six different points of time i.e., 1980-81, 1985-86, 1990-91, 1995-96, 2000-01 and 2005-06 (Venkataramanan and Prahaladachar, 1980).

RESULTS AND DISCUSSION

Growth rates of area, production and yield of major crops in Yavatmal district:

The compound growth rates of area, production and yield of major crops in Yavatmal district for two sub-periods, period I (1980-81 to 1992-93) and period II (1993-94 to 2005-06) were computed and presented in Table 1. Among cereals, compound growth rates of area significantly declined during period I and period II, except *Bajra* in period I. During period II, the area growth rate of wheat significantly increased by 7.86 per cent. In pulses, growth rates of area significantly increased in period I as compared to period II. Among oilseeds, area growth rates of *Kharif* groundnut declined significantly in both the periods, whereas, in period II safflower and sunflower, registered significant

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Table 1: Compound growth rates of area, production and yield of major crops in Yavatmal District

S.N.	Crops	Area		Production		Yield	
		Period I	Period II	Period I	Period II	Period I	Period II
1.	Rice	-4.95**	-8.10**	-8.18**	-12.16**	5.60**	-4.77*
2.	Wheat	-12.8**	-7.86*	-2.36	-9.53*	1.93	-2.45
3.	Kharif Jowar	-1.64**	-4.62**	2.13	-5.49**	6.48**	-0.79
4.	Bajra	1.95*	-8.37**	2.08	-11.53**	1.35	-3.97
5.	Other Cereals	-5.70	-8.04	5.40	-9.65	5.68	4.41
6.	Tur	5.58**	1.19**	4.51**	-0.01	-1.69	-1.23
7.	Gram	6.56*	-0.25	16.33**	0.49	5.78**	0.14
8.	Other Pulses	17.34**	-2.71*	15.30**	-6.91	7.0**	-4.76*
9.	Sugarcane	0.33	-4.83*	21.31**	-5.28*	24.48**	-0.76
10.	Cotton	-7.62**	-1.84*	2.62	-0.67	2.35	1.46
11.	KharifGroundnut	30.30**	-12.76**	-9.71**	-25.67**	1.72	2.28
12.	Safflower	47.58**	24.99**	26.16	-19.55**	2.14	-2.06
13.	Sunflower	-	-22.15**	11.63**	-13.20	8.16**	-9.59*
14.	Soybean		10.47**	-	15.22**	-	-4.75

Note: Period I 1980-81 to 1992-93, Period II 1993-94 to 2005-06.

*, ** denotes significance at 1 and 5 per cent respectively.

negative growth rate of 24.99 per cent and 22.15 per cent, respectively. Soybean registered significantly positive growth rate of 10.47 per cent during period II. Sugarcane registered non-significant negative growth rate of area 4.83 per cent during period II. Cotton registered significant negative growth rate of 1.84 per cent during period II.

Among cereals, significantly negative growth rate of production was observed in wheat (9.53 per cent), *Kharif jowar* (5.49 %) and *Bajra* (11.53 %). Production growth rates of rice declined significantly in both the periods. In pulses, growth rate of production increased significantly during period I. Among oilseeds, production growth rates of *Kharif* groundnut declined significantly by 9.71 per cent and 25.67 per cent during period I and period II, respectively. Safflower production growth rate declined significantly by 19.55 per cent during period II, whereas, production growth rate of soybean increased significantly by 15.22 per cent during period II.

The growth rates of yield with respect to rice and *Kharif jowar* were higher in period I as compared to period II. Rice recorded negatively significant growth rate of 4.77 per cent during period II. Among pulses, *tur* recorded negative growth rate of yield during both the periods, whereas, gram recorded significant positive growth rate of 5.78 per cent during period I. Among oilseeds, sunflower yield growth rate declined significantly by 9.59 per cent during period II. Sugarcane recorded significant positive growth rate of 24.48 per cent during period I.

Changes in cropping pattern in Yavatmal district

The changes in cropping pattern in Yavatmal district were estimated and presented in Table 2. On examination of data, it showed that the cropping pattern was dominated by cotton and soybean. The proportionate area under cotton and *Kharif jowar* was 43.66 per cent and 31.64 per cent, respectively in the year 1980-81 which was decreased by 12.54 per cent and 58.26 per cent, respectively in the year 2005-06. The proportionate area under pulses i.e. *tur*, gram and other pulses were 5.77 per cent, 0.70 per cent and 5.11 per cent, respectively in the year 1980-81 and showed continuous increasing trend over the entire period of study and it was 15.33 per cent, 1.56 per cent and 5.93 per cent, respectively in the year 2005-06. The proportion of area under *Kharif* groundnut was 3.81 per cent in 1980-81, which decreased by 0.14 per cent in the year 2004-05. Area under soybean was negligible in the 80's and increased to 21.26 per cent of the gross cropped area during 2005-06 (Tingare *et. al.*, 2007). The proportions of area under safflower, sunflower and sugarcane were negligible. In the year 1980-81, the proportion of area under wheat and *Bajra* was 5.90 per cent and 1.32 per cent, which reduced to 0.62 per

Table 2: Changes in Cropping Pattern in Yavatmal District during 1980-81 to 2005-06.

(Area in '00' hectares)

Year	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06
Rice	162	95	88	50	52	24
	(1.86)	(1.07)	(0.94)	(0.52)	(0.55)	(0.29)
Wheat	514	400	192	197	171	51
	(5.90)	(4.49)	(2.05)	(2.02)	(1.80)	(0.62)
Kharif Jowar	2758	2270	2132	1633	1545	1151
	(31.64)	(25.51)	(22.72)	(16.99)	(16.31)	(13.88)
Bajra	115	97	127	99	92	36
	(1.32)	(1.09)	(1.35)	(1.03)	(0.97)	(0.43)
Other Cereals	8	2	2	3	16	1
	(0.09)	(0.02)	(0.02)	(0.03)	(0.17)	(0.01)
Tur	503	691	886	1266	1195	1271
	(5.77)	(7.76)	(9.44)	(13.18)	(12.61)	(15.33)
Gram	61	54	135	170	138	129
	(0.70)	(0.61)	(1.44)	(1.77)	(1.46)	(1.56)
Other Pulses	445	530	789	761	885	492
	(5.11)	(5.96)	(8.41)	(7.92)	(9.34)	(5.93)
Sugarcane	12	12	69	65	74	30
	(0.14)	(0.13)	(0.74)	(0.68)	(0.78)	(0.36)
Cotton	3805	4562	4240	4653	4477	3328
	(43.66)	(51.26)	(45.18)	(48.42)	(47.25)	(40.14)
Kharif Groundnut	332	170	178	99	57	12
	(3.81)	(1.91)	(1.90)	(1.03)	(0.60)	(0.14)
Safflower	1	6	29	10	4	1
	(0.01)	(0.07)	(0.31)	(0.10)	(0.04)	(0.01)
Sunflower	0	10	55	44	10	2
	(0.00)	(0.11)	(0.59)	(0.46)	(0.11)	(0.02)
Soybean	0	0	463	562	759	1763
	(0.00)	(0.00)	(4.93)	(5.85)	(8.01)	(21.26)
Gross Cropped Area	8716	8899	9385	9609	9475	8291
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

cent and 0.43 per cent, respectively in the year 2005-06. The gross cropped area was 8716 hundred hectares in the year 1980-81 and it was decreased by 5 per cent over the period.

CONCLUSION

From this study, it is concluded that, the area growth rates of major cereal crops declined over a period of time in Yavatmal district. The growth rates of area, production and yield of pulses and *Kharif* groundnut declined during the study period. The area under cotton and *Kharif jowar* had declined, whereas, area under oilseeds had increased in Yavatmal district. There existed wide temporal changes in the cropping pattern. Soybean had emerged as an important crop in the Yavatmal district.

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Sustainability of Agriculture in Akola District of Vidarbha

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ABSTRACT

In this study, an attempt has been made to measure the Sustainability of Agriculture with the help of indicators of sustainability in Akola district of Vidarbha region. The study was based on secondary data collected from various Government publications and pertains to a period of 25 years i.e. from 1980-81 to 2004-05. The result showed that the sustainability index of Akola district developed through principal component analysis was seen declining over the years. Higher number of sustainability index represented higher sustainability whereas, lower number represented lower sustainability, which indicated that, the Akola agriculture is tended towards unsustainabilty.

Agriculture is a complex of processes taking place within biophysical, socio-economic and political constraints, which control the sustainability of the farming activities. The concept of sustainable agriculture combines characteristics such as long term maintenance of natural systems, optimal production with minimum input, adequate income per farming unit, fulfillment of basic food needs, and provision for the demands and necessities of rural families and communities. All definitions of sustainable agriculture promote environmental, economic and social harmony in an effort to attain the meaning of sustainability. The most relevant issue today is to design suitable technologies, as well as compatible strategies from the social, economic and ecological viewpoints that will bring about the necessary behavioral changes to achieve the objectives of sustainable agriculture.

Sustainability is a concept and cannot be measured directly. Appropriate indicators must be selected to determine levels and duration of sustainability. An indicator of sustainability is a variable that allows describing and monitoring the processes, states and tendencies of systems at the farm, regional, national or worldwide levels. In the present study, the concept of indicator was extended to measure or reflect system status or change in condition, with emphasis on the agricultural systems. The only one objective of this study was aimed to investigate Sustainability of Agriculture in Akola district of Vidarbha with the help of various indicators of sustainability and develop Sustainability Index of Akola district.

MATERIAL AND METHODS

The study has been confined in the Akola district of Vidarbha. Indicators of sustainability of Akola have been constructed for the period 1980-81 to 2004-05 utilizing the data available through different sources. The study was limited to the principal crops namely cotton, *Kharif jowar*, soybean, *tur*, gram and sunflower cultivated in Akola district of Vidarbha. Data pertaining to area, productivity, population, agricultural population, weather, irrigation, area under high yielding varieties were collected from various Government publications of Maharashtra. The data for computation of indicators cost-benefit ratio for selected crops were adopted from the records of Agricultural Prices Cell, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Analytical Tools

Indicators of Sustainability of Akola district

The various indicators of sustainability (Berroteran and Zinck, 1996) of Akola district were as follows:

a. Index of Surface Percentage of Crops
b. Crop yield
c. Cost-Benefit Ratio
d. Irrigated land / Irrigable land
e. Agricultural population / Total population
f. Per capita production of foodgrains
g. Area under High Yielding Varieties
h. Cropping Intensity
i. Availability of Land per Farmer
j. Rainfall

Development of Composite Sustainability Index:

Composite indices are aggregation of sets of variables for the purpose of meaningfully condensing large amounts of information. Various aggregation methods exist and the choice of an appropriate method depends on the purpose of the composite index as well as the nature of the subject being measured. The method used here was to perform a principal component analysis.

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Principal Component Analysis

Principal component analysis (PCA), a popular multivariate technique, is mainly used to reduce the dimensionality of p multi-attributes to two or three dimensions. PCA summarizes the variation in a correlated multi-attribute to a set of a few uncorrelated components, each of which is a particular linear combination of the original variables. The extracted uncorrelated components are called principal components (PC) and are estimated from the eigenvectors of the covariance or correlation matrix of the original variables. Therefore, the objective of PCA is to achieve parsimony and reduce dimensionality by extracting the smallest number components that account for most of the variation in the original multivariate data to summarize the data with little loss of information (Dunterman, 1989).

Principal component analysis can be performed either on the original variables, or their deviations from the means $x_j = X_j - X_j$ or the standardized variables (measured as the deviations of the X_j's from the means and subsequently divided by the standard deviation);

$$Z_j = x_j / S_{xj}$$

Principal components satisfy two conditions:

a) The principal components are uncorrelated (orthogonal) and

b) the first principal component P_1 absorbs and accounts for the

maximum possible proportion of the total variation in the set of all X's, the second principal component absorbs the maximum of the remaining variation in the X's and so on. In our study, a required number of components that explains at least 86 per cent of total variation were chosen for developing composite Index. SPSS, a standard software package was used for this purpose. A composite index was derived by taking sum of weighted PCA scores with eigen values as weights (Esty, 2001 and Esty *et. al.*, 2005).

RESULTS AND DISCUSSION

Performance of Indicators of Sustainability

The performance of various Indicators of Sustainability of Akola district during different segments of time periods from 1980-81 to 2004-05 is shown in Table 1. From the Table, it can be seen that the Index of Surface Percentage of Crops of Akola district showed an increase by 16.67 per cent from 1980-81 to 2004-05. The yields of major crops in the Akola district had observed a spectacular growth. The yield of sunflower and gram increased by 543.51 and 332.82 per cent from 1980-81 to 2004-05, respectively. During the same period, the yield of cotton, *Kharif jowar* and *tur* had increased by 297.18 per cent, 251.19 per cent and 148.40 per cent, respectively. The yield of soybean increased by 284.06 per cent from 1990-91 to 2004-05.

Regarding profitability of crops, the cost-benefit ratio of sunflower and soybean increased by 65.46 per cent and 15.65 per cent respectively, during the period 1980-81 to 2004-05. The cost-benefit ratio of *Kharif jowar*, gram, cotton and *tur* decreased by 25.85 per cent, 18.75 per cent, 15.57 per cent and 10.29 per cent, respectively during the same period. The ratio of irrigated land to irrigable land, area under high yielding varieties, per capita production of foodgrains and cropping intensity increased by 138.88 per cent, 103.23 per cent, 26.91 per cent and 12.16 per cent respectively, during the period 1980-81 to 2004-05. The availability of land per farmer, ratio of agricultural population to total population and rainfall decreased by 38.27 per cent, 8.17 per cent and 3.62 per cent, respectively, during the period 1980-81 to 2004-05.

Development of Sustainability Index through Principal Component Analysis:

The principal component analysis was carried out and presented in Table 2. The principal component analysis produces components in descending order of their importance i.e., the first component explains the maximum amount of variation, and the last component the minimum.

The first component only accounted for 47 per cent of variation. The second component explained 57 per cent of variation. It took sixth components to produce 86 per cent of variation, and another two for 90 per cent variation. The first six components accounted for a sizeable amount of variation i.e., 86 per cent thus succeeded in effectively reducing the dimension of the problem. The subsequent components contributed very little.

Table 1. Triennium Average of Indicators of Sustainability and Related Agricultural development in Akola

S. N.	Indicators of Sustainability	Unit	1980-83	1990-92	2000-02	2003-05	Percentage increase (+)/ decrease (-)
1.	Index of Surface Percentage of Crops	-	0.40	0.5	0.47	0.47	16.67
2.	Crop yield in kharif jowar	Kg/ha	827.67	1508.33	2784.33	2906.67	251.19
3.	Crop yield in cotton	Kg/ha	71	99	270.0	282.0	297.18
4.	Crop yield in tur	Kg/ha	657	648.67	1901.00	163.00	148.40
5.	Crop yield in gram	Kg/ha	261	484.33	1176.00	1129.67	332.82
6.	Crop yield in sunflower	Kg/ha	416	1754.00	4294.00	2677.00	543.51
7.	Crop yield in soybean	Kg/ha	0	548.00	2341.00	2014.67	254.06
8.	Cost-benefit ratio of Kh.jowar	-	1.47	1.23	0.97	1.09	(-)25.58
9.	Cost-benefit ratio of cotton	-	1.33	0.99	0.98	1.12	15.79
10.	Cost-benefit ratio of tur	-	1.36	1.37	1.21	1.22	(-)10.29
11.	Cost-benefit ratio of gram	-	1.28	1.35	1.16	1.04	(-)18.75
12.	Cost-benefit ratio of sunflower	-	0.83	0.95	1.22	1.37	65.46
13.	Cost-benefit ratio of soybean	-	1.15	1.36	1.12	1.33	15.65
14.	Irrigated land / Irrigable land	-	0.09	0.09	0.171	0.22	138.88
15.	Agricultural population / Total population	-	0.43	0.46	0.39	0.39	(-)8.17
16.	Per capita production of foodgrains	Kg/person/ annum	229.74	385.78	293.70	291.56	26.91
17.	Area under High Yielding Varieties	-	18.91	27.99	33.01	38.43	103.23
18.	Cropping Intensity	Per cent	106.20	115.93	128.05	119.11	12.16
19.	Availability of land per farmer	Ha.	2.75	2.23	1.77	1.70	(-)38.37
20.	Rainfall	mm	781.9	781.9	892.03	746.27	753.57

Table 2: Result of Principal Component Analysis

Set of Components	Cumulative Percentage
1	0.472
2	0.579
3	0.674
4	0.744
5	0.809
6	0.857
7	0.893
8	0.924
9	0.946
10	0.961
11	0.972
12	0.983
13	0.989
14	0.994
15	0.996
16	0.998
17	0.999
18	1.000
19	1.000
20	1.000

Sustainability Index

Table 3 presented the Sustainability Index of Akola district derived from the various indicators of sustainability. It was observed that the results of the principalcomponent analysis were astonishingly clear and appealing from an agricultural perspective. The numerical scores ranging from -0.012 to 0.251, which represented the Sustainability Index, obtained through principal component analysis. Further, it was observed that the index obtained through the principal component analysis was seen declining. Higher numbers represented higher sustainability whereas, lower number represented lower sustainability.

CONCLUSION

The study concluded that the sustainability index of Akola district developed through principal component analysis was seen declining over the years. Higher number of sustainability index represented higher sustainability whereas, lower number represented lower sustainability, which indicated that, the Akola agriculture tended towards unsustainabilty.

Table 3: Sustainability Index of Akola District

Years	Sustainability Index
1980-81	-0.085
1981-82	0.249
1982-83	0.126
1983-84	0.175
1984-85	0.251
1985-86	0.231
1986-87	0.163
1987-88	0.145
1988-89	-0.041
1989-90	0.180
1990-91	0.155
1991-92	-0.091
1992-93	0.110
1993-94	0.154
1994-95	0.054
1995-96	-0.012
1996-97	-0.021
1997-98	-0.357
1998-99	-0.495
1999-00	-0.422
2000-01	-0.100
2001-02	-0.127
2002-03	-0.065
2003-04	0.006
2004-05	-0.184

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Varied Biochemical Content in Different Stages of Host Governing the Infection by *Erysiphe polygoni* DC

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ABSTRACT

Chlorophyll a, b and total chlorophyll was found to increase at flowering in green gram whereas the same decreased at flowering in black gram. Total phenols were reduced at flowering compared to before flowering by 18 to 27 per cent and 7 to 13 per cent in green gram and black gram, respectively. At flowering phenolic acids in green gram and black gram showed reduction by 20 to 23 per cent and 10 to 30 per cent, respectively. High content of sugars was observed in powdery mildew susceptible cultivars than resistant. Its contents were increased by 16 to 38 per cent in green gram and 3 to 9 per cent in black gram at the time of flowering. The leaves contained more protein at flowering than before flowering by 3 per cent in green gram and by 1 to 2 per cent in blackgram. The decreased level of phenols and increased level of sugars in the leaves at the time of flowering was found to be associated with the incidence of powdery mildew pathogen in green gram and black gram.

Green gram (*Vigna radiata*) and black gram (*Vigna mungo*) are widely grown as food legumes in the entire Indian subcontinent during summer and *Kharif* seasons. India is the largest producer of green gram and black gram in the world. Average productivity of 362 ha^{-1} in green gram and 448 ha^{-1} in black gram are very low compared to the genetic potential of 1000-1500 ha^{-1}. The production of pulses has always been low and it has never been parallel to that of population. Its availability has declined from 64.8 g $capita^{-1}day^{-1}$ during 1951-56 to less than 40 g $capita^{-1}day^{-1}$ (Singh, 1995). The projected demand for green gram and black gram upto 2010 are 1.96 and 2.19 million tones, respectively(Anonymous, 2000). Obviously the present level of productivity will have to be enhanced through the adoption of improved agro production and protection technologies. Presently most important constraint in production of these crops are diseases. Among the commonly occurring diseases of green gram and black gram, powdery mildew caused by *Erysiphe polygoni* DC is the most serious and destructive. The spread of the disease is very fast and losses up to 90 per cent in mung bean have been reported by Wanjari and Raut (1997). The Vidarbha and Marathwada regions of Maharashtra are the hot spot of this disease.

Different cultivars of the same crop show different reaction to the disease in the same region where the environmental conditions are uniform to all the cultivars. This indicate that host nutrition plays a vital role in deciding the occurrence and spread of the disease in population. The maximum losses occurs when the powdery mildew occurs at the time of flowering. The resistance of a cultivar depends on the biochemical changes at the time of flowering which offer resistance against disease. Hence the present investigation was undertaken.

MATERIAL AND METHODS

The healthy leaves just before flowering and at flowering of 6 entries of green gram and 2 of black gram showing different reactions to powdery mildew i.e. Kopergaon (Highly susceptible), AKM-8802 (Susceptible), BM-4 and ML-131 (Moderately susceptible) and TARM-18 & AKM-9242 (Resistant) of green gram and No. 55 (Highly susceptible) and TAU-1 (Susceptible) of black gram were collected from the field and analyzed for chlorophyll a, b and total chlorophyll by the method suggested by Arnon (1949). Total phenols were analyzed by the method given by Farkas & Kiraly (1962). Phenolic acids by method described by Bray and Thorpe (1954). Dubois *et.al.* (1956) method was applied for total sugar analysis and the protein content was calculated by analyzing N content (micro Kjeldahl method) and converting it to protein by the formula suggested by Singh (1977).

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Protein % = (T x B) x 5 x N x 1.4 / S x 6.25

where,

T = Sample titration reading (ml)

B = Blank titration reading (ml)

N = Normality of HCl (1/28)

S = Weight of the plant material

T x B was multiplied by 5 because only 10 ml out of 50 ml digest has been used.

The value was multiplied by 6.25 as the amount of N in protein is 1/16 by weight 1.4 is the N factor

RESULTS AND DISCUSSION

Chlorophyll content :

All the cultivars of green gram showed increased content of chlorophyll a, b and total at flowering compared to before flowering (Table 1). But reverse was true in black gram where chlorophyll a, b and total chlorophyll content was more before flowering compared to at flowering. The green gram and black gram cultivars didn't show any correlation with the susceptibility of cultivars to powdery mildew and the content of chlorophyll. The increase in content of chlorophyll in green gram at flowering compared to before flowering was slightly more in resistant and moderately resistant cultivars than the susceptible and highly susceptible, whereas decrease in content of chlorophyll in highly susceptible cultivars of black gram at flowering than before flowering was meager. The susceptible showed slight decrease. Overall chlorophyll a content in green gram ranged from 1.628 to 1.926 mg g^{-1} at flowering than 1.386 to 1.623 mg g^{-1} before flowering thereby increased by 15 to 17 per cent at flowering, whereas in black gram it was reduced by 6 to 8 per cent at flowering i.e. before flowering content ranged from 1.215 to 1.293 compared to 1.110 to 1.208 mg g^{-1} at flowering (Table 2). In green gram chlorophyll b was 0.429 to 0.623 mg g^{-1} at flowering and 0.296 to 0.518 mg g^{-1} before flowering, showing a increase of 20 to 44 per cent at flowering. It was reduced to 0.309 to 0.326 mg g^{-1} from 0.342 to 0.418 in black gram at flowering compared to before flowering showing reduction by 11 to 22 per cent (Table 2). Total chlorophyll content at flowering in green gram ranged from 2.116 to 2.538 mg g^{-1} compared to 1.672 to 2.116 mg g^{-1} before flowering giving a increase of 19 to 26 per cent at flowering whereas in black gram reduced by 6 to 7 per cent i.e. 1.552 to 1.613 mg g^{-1} before flowering and 1.427 to 1.501 mg g^{-1} at flowering.

In this study, chlorophyll a, b and total increased at flowering in green gram whereas decreased at flowering in black gram. The increase or decrease in content was not associated with the reaction of the cultivar. Although Guleria *et. al.* (1997) recorded post

Table 1: Chlorophyll, total phenols, phenolic acid, total sugar and protein content in healthy leaves of different cultivars of green gram before and at flowering.

Crop entries		Chlorophyll (mg g^{-1})			Total phenols (mg g^{-1})	Phenolic acids (mg g^{-1})	Total sugars (mg g^{-1})	Protein (%)
		a	b	total				
Kopergaon (HS)	BF	1.445	0.392	1.813	1.96	0.29	12.6	3.28
	AF	1.628	0.515	2.197	1.32	0.21	14.1	3.45
AKM-8802 (S)	BF	1.386	0.368	1.724	1.82	0.26	13.3	3.38
	AF	1.719	0.438	2.116	1.44	0.20	15.5	3.49
BM-4 (MS)	BF	1.392	0.412	1.792	2.28	0.31	6.2	3.17
	AF	1.636	0.515	2.168	1.96	0.25	8.4	3.26
ML-131 (MS)	BF	1.435	0.296	1.672	2.36	0.30	7.6	3.08
	AF	1.815	0.429	2.219	1.98	0.22	8.2	3.12
TARM-18 (R)	BF	1.623	0.518	2.116	2.54	0.35	5.3	2.96
	AF	1.926	0.623	2.538	2.08	0.28	6.8	2.99
AKM-9242 (R)	BF	1.598	1.467	1.968	2.66	0.32	4.9	2.82
	AF	1.826	0.588	2.397	2.16	0.24	7.3	2.91

BF - Before flowering AF - After flowering

Table 2: Chlorophyll, total phenols, phenolic acid, total sugar and protein content in healthy leaves of different cultivars of black gram before and at flowering.

Crop entries		Chlorophyll (mg g^{-1})			Total phenols (mg g^{-1})	Phenolic acids (mg g^{-1})	Total sugars (mg g^{-1})	Protein (%)
		a	b	Total				
No. 55 (HS)	BF	1.293	0.342	1.552	2.76	0.23	11.5	3.32
	AF	1.208	0.309	1.501	1.92	0.16	12.6	3.41
AKM-8802 (S)	BF	1.215	0.418	1.613	3.08	0.29	10.8	3.08
	AF	1.110	0.326	1.427	2.65	0.26	11.2	3.12

infection decrease in chlorophyll (a,b and total) in leaves of both resistant and susceptible cultivars to powdery mildew, the content of chlorophyll may not be correlated with the occurrence of the disease either on susceptible or resistant cultivars.

Total Phenols

Total phenols were reduced at flowering in all the cultivars of green gram and black gram. Its reduction ranged from 1.82 to 2.66 mg g^{-1} before flowering to 1.32 to 2.16 mg g^{-1} at flowering in green gram (Table 1), thus reduced by 18 to 27 per cent at flowering. In black gran its content was 2.76 to 3.08 mg g^{-1} before flowering which was reduced to 1.92 to 2.65 mg g^{-1} at flowering i.e. by 7 to 30 per cent at flowering (Table 2). Moreover the susceptible and highly susceptible cultivars showed more reduction in content of total phenols compared to resistant or moderately resistant cultivars i.e. highly susceptible Kopergaon showed reduction by 32.6 per cent at flowering (from 1.96 to 1.32 mg g^{-1}) whereas resistant AKM-9242 by only 18.7 per cent at flowering (from 2.66 to 2.16 mg g^{-1}). This shows that the level of phenol at the time of flowering offer resistance against attack of pathogen. More reduction in highly susceptible may expose the cultivar to attack for powdery mildew whereas less reduction in resistant or highly resistant cultivars may sustain the attack for some time. Parashar and Sindhan (1986) reported variation in phenols and sugar content of leaves with age. Total phenols were also high in resistant cultivars than the susceptible i.e. highly susceptible Kopergaon contained 1.96 mg g^{-1} of total phenols whereas resistant AKM-9242 contained 2.66 mg g^{-1} total phenols in leaves at flowering. Higher content of total phenols in leaves of powdery mildew resistant and moderately resistant varieties of pea have been also reported by Sindhan and Parashar (1984), Parashar and Sindhan (1996), Munshi *et. al.* (1987), Sharma *et. al.* (1996) and Rathi *et. al.* (1998). Guleria *et. al.* (1998) opined that increased level of key enzymes of the phenol propanoid pathway and orthodihydroxy phenolic content may confer resistance to infection by *Erysiphe polygoni*.

Phenolic acids : At flowering phenolic acids were reduced. Phenolic acids ranged from 0.34 to 0.47 mg g^{-1} before flowering in green gram which were reduced to 0.26 to 0.38 mg g^{-1} at flowering showing a reduction of 18 to 23 per cent at flowering (Table 1). In black gram it was 0.26 to 0.35 mg g^{-1} before flowering and at flowering 0.20 to 0.28 mg g^{-1}, thus reduced by 20 to 23 per cent at flowering (Table 2). The resistant and highly resistant varieties were found to contain more phenolic acids (0.32 to 0.35 mg g^{-1}) than the susceptible and highly susceptible i.e. 1.82 to 1.96 mg g^{-1}, respectively. A high phenolic content is reported to be generally associated with the resistance of particular variety (Sharma *et. al.*, 1986). But like total phenols its reduction in content at flowering from before flowering was not related with the reaction of the cultivars.

Total Sugars : Total sugars were increased at flowering by 16 to 38 per cent in green gram and by 3 to 9 per cent in black gram (Table 1). In green gram at flowering total sugars ranged from 6.8 to 15.5 mg g^{-1} whereas before flowering it was 4.9 to 13.3 mg g^{-1}. Also the highly susceptible Kopergaon contained more amount of total sugars (12.6 mg g^{-1}) compared to 4.9 mg g^{-1} in highly resistant AKM-9242 before flowering (Table 1). In black gram also the sugar content was more in highly susceptible (11.5 mg g^{-1}) than susceptible (10.8 mg g^{-1}) before

flowering (Table 2) showing high sugar content as the susceptibility increases. Rathi *et. al.*(1998) observed higher content of total and reducing sugars in powdery mildew susceptible cultivars of pea than resistant. The sugar content increased at the time of flowering when the crop becomes more susceptible to attack of powdery mildew pathogen.

Protein : More protein percentage was observed in susceptible, highly susceptible and moderately susceptible varieties of green gram than resistant and highly resistant varieties (Table 1). Also the protein content increased in all the cultivars of green gram at flowering than before flowering. Its increase was marginal i.e. only of 3 per cent (Table 1). Similarly in black gram also a marginal increase of 1 to 2 per cent was observed at the time of flowering than before flowering (Table 2).

The present study showed the increased sugars and protein content and decreased total phenols and phenolic acids in leaves at flowering which probably is a predisposing nutritional conditions for infection by powdery mildew pathogen in green gram and black gram.

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Intensification and Diversification of Established Cropping System of the Central Vidarbha Zone

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ABSTRACT

A field trial to study intensification and diversification of existing cropping system was conducted from 2001-2002 to 2003-2004 under ECF Scheme in Nagpur and Wardha districts of Central Vidarbha Zone of Maharashtra State. The treatment consisted of four crop sequences viz. soybean – wheat, soybean – chickpea, soybean – wheat – fenugreek (*Methi*) and soybean – chickpea - coriander arranged in RBD with 15 replications. Pooled results indicated that the existing cropping system of soybean – wheat could be diversified to soybean – chickpea and existing and diversified cropping system could be intensified by introducing fenugreek and coriander, respectively for getting higher monetary returns and net profit per unit area under irrigated conditions. The soybean – chickpea – coriander sequence recorded highest monetary returns and B:C ratio, followed by soybean – fenugreek – wheat sequence.

In Central Vidarbha Zone (CVZ), soybean – wheat is the predominant cropping system, however wheat crop requires more number of irrigations and high quantity of nutrients whereas chickpea requires less number of irrigations and its nutritional requirement is also less, as compared to wheat crop. Moreover, it also replenishes the soil fertility. Hence, there is a scope for diversification of the existing cropping system by including chickpea in place of wheat and it is also possible to intensify existing and diversified cropping system by introducing vegetable crop in it. In order to find out profitability of diversified cropping system over existing cropping system and feasibility of incorporating vegetable crop in this system. The present investigation entitled 'Intensification and diversification of established cropping system of the Central Vidarbha Zone' was conducted for three years from 2001-2002 to 2003-2004 under 'Experiments on Cultivator's Field Scheme' in Nagpur and Wardha districts of Central Vidarbha Zone of Maharashtra State.

MATERIAL AND METHODS

The cropping sequence experiments were conducted during the year 2001-2002, 2002-2003 and 2003-2004 with 15 replications. Treatments consist of four cropping sequences, T_1: soybean – wheat, T_2: soybean – chickpea, T_3: soybean – wheat – fenugreek and T_4: soybean – chickpea – coriander, tried in randomized block design on a plot size of 20 x 10 m. The crops included in the sequence were raised with recommended package of practices. While calculating monetary returns, the prices of the commodities prevailed during previous year were considered. Production efficiency values were calculated by dividing total grain production in a sequence by total duration of the crop in that sequence (Tomar and Tiwari, 1990).

RESULTS AND DISCUSSION

Data pertaining to yield and monetary returns for individual year along with pooled results are presented in Table 1 to 4.

Crop Productivity

During 2001-2002 to 2003-2004, soybean – fenugreek – wheat crop sequence had recorded highest total yield of the cropping sequences during all the three years, as well as in pooled results while next best sequence was soybean – chickpea – coriander. The lowest productivity was recorded by soybean – chickpea crop sequence. Dahatonde *et al.* (2004), in their three years cropping sequence experiment, observed the highest crop productivity in chilli- groundnut sequence, while next best sequence was soybean- wheat- clusterbean. Lowest productivity was recorded by the existing cotton-groundnut cropping sequence.

Gross monetary returns

Soybean – chickpea – coriander crop sequence had recorded significantly higher GMR per hectare in pooled results (Table 1). Pooled data

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Table 1: Grain, straw and vegetable yields, gross monetary returns, cost of cultivation, net benefit, B:C ratio and production efficiency of different cropping sequences (2001-2002)

S. N.	Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
1	T_1 Soybean- Wheat						
	Soybean	20.21	19745	—	—	—	
		(29.60)	2960	17013	—	—	
	Wheat	23.70	17894	—	—	—	
		(35.50)	17755	13501	—	—	
	Total	**43.91**	**42374**	**30514**	**11860**	**1.39**	**20.90**
2	T_2 Soybean – Chickpea						
	Soybean	20.19	19726	—	—	—	
		(29.20)	2920	17013	—	—	
	Chickpea	15.46	28647	—	—	—	
		(16.30)	1630	12426	—	—	
	Total	**35.65**	**52923**	**29439**	**23484**	**1.80**	**17.83**
3	T_3 Soybean- Fenugreek - Wheat						
	Soybean	20.05	19589	—	—	—	
		(29.10)	2910	17013	—	—	
	Fenugreek	77.00	30800	8835	—	—	
	Wheat	21.96	16580	—	—	—	
		(32.80)	1640	13501	—	—	
	Total	**119.01**	**71519**	**39349**	**32170**	**1.82**	**47.60**
4	T_4 Soybean – Chickpea – Coriander						
	Soybean	20.29	19823	—	—	—	
		(29.75)	2975	17013	—	—	
	Chickpea	14.31	26516	—	—	—	
		(14.93)	1493	12426	—	—	
	Coriander	38.70	23220	8818	—	—	
	Total	**73.30**	**74027**	**38257**	**35770**	**1.93**	**29.32**
	SE (m)±		3417		2310		
	CD at 5%		9815		6267		

Rates (Rs/q)							
	Grain	Soybean	977/-	Wheat	755/-	Chickpea	1853/-
	Straw	Soybean	100/-	Wheat	50/-	Chickpea	100/-
		Fenugreek	400/-	Coriander	600/-		

Figure in parenthesis indicate straw yield.
Total productivity is excluding straw yield.
Yield of Fenugreek and Coriander are as green vegetables

Table 2: Grain, straw and vegetable yields, gross monetary returns, cost of cultivation, net benefit, B:C ratio and production efficiency due of different cropping sequences (2002-2003)

S. N.	Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
1	T_1 Soybean- Wheat						
	Soybean	17.86	21250	—	—	—	
		(27.18)	2718	9627	—	—	
	Wheat	25.82	20656	—	—	—	
		(38.77)	1938	9614	—	—	
	Total	**43.68**	**46562**	**19241**	**27321**	**2.41**	**20.80**
2	T_2 Soybean – Chickpea						
	Soybean	17.83	21396	—	—	—	
		(26.79)	2679	9627	—	—	
	Chickpea	17.03	25649	—	—	—	
		(20.21)	2021	8417	—	—	
	Total	**34.86**	**51745**	**18044**	**33701**	**2.86**	**17.43**
3	T_3 Soybean- Fenugreek - Wheat						
	Soybean	17.90	21480	—	—	—	
		(26.81)	2681	9627	—	—	
	Fenugreek	69.54	27680	9070	—	—	
	Wheat	27.07	21656	—	—	—	
		(40.89)	2044	9614	—	—	
	Total	**114.51**	**75541**	**28311**	**47230**	**2.66**	**45.80**
4	T_4 Soybean – Chickpea – Coriander						
	Soybean	18.19	21986	—	—	—	
		(27.27)	2727	9627	—	—	
	Chickpea	17.84	26760	—	—	—	
		(21.10)	2110	8417	—	—	
	Coriander	53.75	32250	8612	—	—	
	Total	**89.78**	**85833**	**26656**	**59177**	**3.22**	**35.91**
	SE (m) ±		2388		2399		
	CD at 5%		6889		6919		

Rates (Rs/q)								
	Grain	Soybean	1200/-	Wheat	800/-	Chickpea	1500/-
	Straw	Soybean	100/-	Wheat	50/-	Chickpea	100/-
		Fenugreek	400/-	Coriander	600/-		

Figure in parenthesis indicate straw yield,
Total productivity is excluding straw yield.
Yield of Fenugreek and Coriander are as green vegetables

Table 3: Grain, straw and vegetable yields, gross monetary returns, cost of cultivation, net benefit, B:C ratio and production efficiency of different cropping sequences (2003-2004)

S. N.	Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
1	T_1 Soybean- Wheat						
	Soybean	20.83	24996	—	—	—	
		(30.14)	3014	11306	—	—	
	Wheat	26.63	21304	—	—	—	
		(40.22)	2011	10239	—	—	
	Total	**47.46**	**51325**	**21545**	**29780**	**2.38**	**22.60**
2	T_2 Soybean – Chickpea						
	Soybean	21.34	25608	—	—	—	
		(31.05)	3105	11306	—	—	
	Chickpea	14.74	22110	—	—	—	
		(16.09)	1609	7496	—	—	
	Total	**36.08**	**52432**	**18802**	**33630**	**2.79**	**18.04**
3	T_3 Soybean- Fenugreek - Wheat						
	Soybean	21.65	25980	—	—	—	
		(31.41)	3141	11306	—	—	
	Fenugreek	59.99	29995	6891	—	—	
	Wheat	27.02	21616	—	—	—	
		(40.80)	2040	10239	—	—	
	Total	**108.66**	**82772**	**28436**	**54336**	**2.91**	**43.46**
4	T_4 Soybean – Chickpea – Coriander						
	Soybean	21.46	25752	—	—	—	
		(31.40)	3140	11306	—	—	
	Chickpea	15.22	22830	—	—	—	
		(16.38)	1638	7496	—	—	
	Coriander	52.37	41896	10029	—	—	
	Total	**89.05**	**95256**	**28831**	**66425**	**3.30**	**35.62**
	SE(m)±		1117		1607		
	CD at 5%		3139		4514		

Rates (Rs/q)							
	Grain	Soybean	1200/-	Wheat	800/-	Chickpea	1500/-
	Straw	Soybean	100/-	Wheat	50/-	Chickpea	100/-
		Fenugreek	500/-	Coriander	800/-		

Figure in parenthesis indicate straw yield,

Total productivity is excluding straw yield.

Yield of Fenugreek and Coriander are as green vegetables

Table 4: Grain, straw and vegetable yields, GMR, cost of cultivation, NMR, B:C ratio and production efficiency of different cropping sequences (Pooled of three years)

S. N.	Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
1	T_1 Soybean- Wheat						
	Soybean	19.63	—	—	—	—	
		(28.97)	24894	12649	12245	—	
	Wheat	25.38	—	—	—	—	
		(38.16)	21859	11118	10741	—	
	Total	**45.01**	**46753**	**23767**	**22986**	**1.97**	**19.55**
2	T_2 Soybean – Chickpea						
	Soybean	19.79	—	—	—	—	
		(29.00)	25144	12649	12495	—	
	Chickpea	15.74	—	—	—	—	
		(17.53)	27222	9446	17776	—	
	Total	**35.53**	**52366**	**22095**	**30271**	**2.37**	**17.76**
3	T_3 Soybean- Fenugreek - Wheat						
	Soybean	19.87	—	—	—	—	
		(29.11)	25261	12649	12612	—	
	Fenugreek	68.84	29492	8265	21227	—	
	Wheat	25.35	—	—	—	—	
		(38.16)	21859	11118	10741	—	
	Total	**114.06**	**76612**	**32032**	**44580**	**2.39**	**45.62**
4	T_4 Soybean – Chickpea – Coriander						
	Soybean	19.89	—	—	—	—	
		(29.47)	25467	12649	12818	—	
	Chickpea	15.79	—	—	—	—	
		(17.47)	27116	9446	17670	—	
	Coriander	48.27	32455	9153	23302	—	
	Total	**84.04**	**85038**	**31248**	**53790**	**2.72**	**33.62**
	SE (m) ±		2308		2105		
	CD at 5%		5610		5900		

Rates (Rs/q)								
Grain	Soybean	1126/-	Wheat	785/-	Chickpea	1618/-		
Straw	Soybean	100/-	Wheat	50/-	Chickpea	100/-		
	Fenugreek	433/-	Coriander	667/-				

Figure in parenthesis indicate straw yield,

Total productivity is excluding straw yield.

Yield of Fenugreek and Coriander are as green vegetables

further revealed that the GMR from soybean – chickpea cropping system recorded 12 per cent increase over soybean – wheat system. Gross monetary returns due to intensification of existing cropping system (soybean - wheat) by including vegetable (fenugreek) crop after soybean were increased by about 64 per cent and that of proposed diversified system (soybean - chickpea) by about 62 per cent due to inclusion of coriander after harvest of chickpea crop over the existing cropping system. Nandurkar *et al.* (1998) and Dahatonde *et al.* (2004) reported higher GMR with soybean- gram-groundnut and chilli- groundnut crop sequence, respectively.

Net monetary returns

The higher NMR was obtained by soybean-chickpea- coriander cropping sequence followed by soybean- fenugreek- wheat sequence. The net monetary return due to proposed diversification (soybean - chickpea) was higher by about 32 per cent than the existing cropping system (soybean - wheat). Intensification of these cropping systems by including fenugreek in soybean – wheat system and coriander in soybean – chickpea system recorded increase in net monetary returns by about 94 and 78 per cent, respectively over the existing cropping system. Bhagat *et al.* (1995) and Deshpande and Jadhav (1996) recorded higher NMR in groundnut – wheat cropping sequence.

Benefit: Cost ratio

The B:C ratio of existing cropping system (soybean – wheat) was found to be 1.97 and increased to 2.37 due to proposed diversification (soybean - chickpea). The B:C ratio of existing cropping system (soybean - wheat) increased from 1.97 to 2.39 due to intensification by way of inclusion of fenugreek crop. The B:C ratio was raised from 2.37 to 2.72 due to intensification of soybean – chickpea system by inclusion of coriander crop. Nandurkar *et al.* (1998) and Dahatonde *et al.* (2004) recorded the higher B:C ratio with soybean- gram- groundnut and chilli-groundnut crop sequence, respectively.

Production efficiency

The production efficiency was maximum (45.62 kg day^{-1} ha^{-1}) in soybean- fenugreek- wheat system, followed by soybean- chickpea- coriander (33.62 kg day^{-1} ha^{-1}). Soybean- chickpea system recorded the lowest production efficiency of 17.76 kg day^{-1} ha^{-1}. Nandurkar *et al.* (1998) observed the higher production efficiency of 29.32 kg day^{-1} ha^{-1} in rice- fallow- groundnut sequence, followed by rice-fallow- rice sequence (26.43 kg day^{-1} ha^{-1}).

On the basis of three years data, it can be recommended to adopt soybean – chickpea cropping system instead of soybean – wheat system and for intensification of both these systems, include fenugreek crop in soybean – wheat system and coriander crop in soybean – chickpea system and take respectively as soybean – fenugreek – wheat and soybean – chickpea – coriander in order to get higher monetary returns and net profit from unit area under irrigated conditions in the CVZ of Maharashtra state.

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Integrated Nutrient Management in Semirabi Pigeonpea

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ABSTRACT

A Field experiment was conducted on ICPL-87119 (Asha) pigeonpea during semi *Rabi* 2007-2008 at Agriculture College Farm, Nagpur to study the integrated nutrient management in semi *Rabi* pigeonpea. Pigeonpea feritilized with 100 per cent RDF (25:50:00 kg NPK ha^{-1}) recorded significantly higher grain yield (11.51 q ha^{-1}) with hight cost benefit ratio of 3.42 Uptake of nitrogen (78.96 kg ha^{-1}) and Phosphorus (5.76kg ha^{-1}) was higher in 100 per cent RDF treatment, while higher residual of N (216.99 kg ha^{-1}) and P (26.33 kg $^{-1}$) was observed in treatment of 5 ton FYM ha^{-1}.

Pigeonpea (*Cajanus cajan* L. Millsp.) is one of the important tropical pulse crops of India and ranks second after chickpea in area and production. It is one of the main sources of protein (22.3%). The availability of pulses in India is about 42 g day^{-1} $head^{-1}$ is against 80g day^{-1} $head^{-1}$, therefore, to meet the national short fall, the production of pulses needed to be enhanced. Besides production, maintenance of self health is also important which can be achieved by adopting suitable packages under INM system with judicious utilization of biofertilizer, bioformulation and chemical fertilizers. Foliar application of nitrogen fixing bacteria (NFBs) is more effective than field inoculation as the energy for efficient fixation of atmospheric nitrogen is provided by the photosynthesis present in the leaf leachates hydrolysis of leaf polymers (Sudhakar, 2001).

Bioformulation like Amrutpani is an organic formulation having large population of plant growth promoting rhyzobia known to colonize the root system of plant by beneficial micro organisms and can modulate plant growth by enhancing the availability of nutrients and certain growth hormones. It is also useful in improving water holding capacity of soil (Rupela *et al.* 2006). It was therefore, thought to study the effect of integrated nutrient management on yield of semi *Rabi* pigeonpea. Var. ICPL 87119 (Asha).

MATERIAL AND METHODS

A field experiment was conducted during semi *Rabi* 2007-2008 at Agriculture College Farm, Nagpur to study the effect of integrated nutrient management in semi *Rabi* pigeonpea. The experimental soil was vertisol with 7.8 pH. The initial soil organic carbon was 5.22 g ha^{-1}. The available N, P and K were 256.70, 16.76 and 402.86 kg ha^{-1}, respectively. The experiment was conducted in Randomized block design and replicated thrice. The treatments consisted were RDF – 25:50:00 kg NPK ha^{-1} (T_1), 75% RDF (T_2), FYM 5 t ha^{-1} (T_3), FYM 3.75 t ha^{-1} (T_4), 75% RDF + Amrutpani at 30 DAS (T_5), 75% RDF + Azotobacter spray at 45 and 60 DAS (T_6), 75% RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS (T_7), FYM 3.75 t ha^{-1} + Amrutpani at 30 DAS (T_8), FYM 3.75 t ha^{-1} + Azotobacter Spray at 45 and 60 DAS (T_9) and FYM 3.75 t ha^{-1} + *Amrutpani* at 30 DAS + Azotobacter spray at 45 and 60 DAS (T_{10}).

Fresh cow dung -10 kg, Fresh cow urine - 10 lit., cow ghee- 500 g and honey – 250 g. above ingredients were thoroughly mixed in 20 liters of water and kept for fermentation for 10 days. After fermentation water was added to make the volume to 200 lit. ICPL – 87119 (Asha) was sown at 45 x 20 cm spacing on 27 Aug. 2007 Recommended fertilizer dose 25: 50:00 kg NPK ha^{-1} was applied at sowing as per treatments. Amrutpani was applied at 30 DAS in between rows of the crop. Liquid Azotobacter was sprayed @ 2 to 4 ml lit^{-1} of water at 45 and 60 DAS.

The soil samples before and after experiment were taken to study the fertility status of soil. Similarly plant samples were analyzed to study the uptake of nutrient by the crop; five random plants were selected for observations on growth and yield contributing parameters. B:C ratio was calculated according to the prevailing marked rates.

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Table 1: Grain Yield , yield parameters and economics as influenced by various treaments

Treatments	No. of Pods Plants^{-1}	No. of grains Pod^{-1}	Grain Yield Plant^{-1} (g)	Straw Yield Plant^{-1} (g)	100 grain wt. (g)	Grain Yield ha^{-1} (q)	Straw yield ha^{-1} (q)	Grain to straw ratio	Harvest Index	Cost of cultivation (Rs. ha^{-1})	NMR (Rs.ha^{-1})	B:C Ratio
T1	56.07	3.81	10.2	38.75	10.23	11.51	41.57	0.27	0.21	9287	22504.00	3.42
T2	45.06	3.37	8.44	31.25	9.91	7.79	27.07	0.27	0.22	9163	12248.00	2.34
T3	43.59	2.94	8.24	30.74	9.85	6.72	26.82	0.25	0.20	11774	7035.00	1.60
T4	40.11	2.67	5.75	22.53	9.75	5.13	22.64	0.23	0.19	10999	3542.00	1.33
T5	46.07	2.96	8.95	33.29	10.01	8.08	32.27	0.25	0.20	10484	12115.00	2.15
T6	46.66	3.28	9.01	34.85	10.09	8.35	33.14	0.25	0.20	9959	13397.00	2.34
T7	55.37	3.68	9.41	36.72	10.13	9.78	36.76	0.26	0.21	11434	14167.00	2.23
T8	41.78	3.01	6.13	25.74	9.59	5.58	23.91	0.23	0.19	12124	3656.00	1.31
T9	42.44	3.15	6.32	26.42	9.77	5.75	24.32	0.23	0.19	11599	4667.00	1.41
T10	43.65	3.36	6.88	27.63	9.82	6.11	25.53	0.23	0.19	13074	4133.00	1.32
SE(m)±	0.29	0.32	0.27	0.91	0.41	0.65	1.63	-	-	-	1566.00	0.15
C.D. at 5%	0.87	N.S.	0.83	2.71	N.S.	1.94	4.84	-	-	-	4654.00	0.46
GM	46.06	3.21	8.05	31.00	9.78	7.42	29.3	0.24	0.19	-	9747.00	1.94
						15.26		-				

Market Rates

Particulars

1. FYM (Rs.q^{-1})	-	500	2. Seed (Rs.Kg.$^{-1}$)	-	25
3. SSP (Rs. Kg^{-1})	-	3.75	4. Urea (Rs.Kg.$^{-1}$)	-	5
5. Grain (Rs. q^{-1})	-	2400	6. Straw (Rs. q^{-1})	-	100
7. Azotobacter liquid (Rs. lit^{-1})	-	250	8. Cowdung (Rs. kg^{-1})	-	5
9. Cow Urine (Rs. lit^{-1})	-	5	10. Cow ghee (Rs.Kg.$^{-1}$)	-	200
11. Honey (Rs.Kg.$^{-1}$)	-	200			

– 25:50:00 kg NPK ha^{-1} (T_1), 75% RDF (T_2), FYM 5 t ha^{-1} (T_3), FYM 3.75 t ha^{-1} (T_4), 75% RDF + Amrutpani at 30 DAS (T_5), 75% RDF + Azotobacter spray at 45 and 60 DAS (T_6), 75% RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS (T_7), FYM 3.75 t ha^{-1} + Amrutpani at 30 DAS (T_8), FYM 3.75 t ha^{-1} + Azotobacter Spray at 45 and 60 DAS (T_9) and FYM 3.75 t ha^{-1} + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS (T_{10}).

Table 2: Available N,P and K kg ha^{-1} and total nitrogen and phosphorus uptake (kg. ha^{-1}) influenced by various treatments

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})
Initial Value	256.7	16.76	402.86	-	-
T1	214.87	26.33	410.49	78.96	5.76
T2	213.1	25.09	409.04	53.19	5.03
T3	216.99	24.33	412.15	50.64	4.87
T4	215.18	23.08	411.66	43.19	4.54
T5	214.06	24.55	409.83	62.31	5.31
T6	213.76	25.91	409.30	66.08	5.35
T7	214.3	25.33	410.4	71.32	5.57
T8	216.03	22.66	411.18	[illegible]14	4.63
T9	215.68	24.03	409.66	45.2[illegible]	4.67
T10	216.32	23.66	411.81	47.43	4.76
SE(m)±	0.29	0.24	0.86	2.57	0.09
C.D. at 5%	0.88	0.72	NS	7.65	0.28
GM	215.03	24.45	410.56	55.56	5.05

RESULTS AND DISCUSSION

Grain yield:

Data presented in Table-1 revealed that, grain yield ha^{-1} was significantly affected by different treatments. Treatments of 25:50:00 kg NPK ha^{-1} and 75 per cent RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS recorded significantly higher grain yield of 11.51 q. and 9.78 q ha^{-1} , respectively as compared to other treatments, except treatment 75 per cent RDF + Azotobacter spray at 45 and 60 DAS and 75 per cent RDF + *Amrutpani* at 30 DAS which were at par with treatment 75 per cent RDF + *Amrutpani* at 30 DAS + Azotobacter spray at 45 and 60 DAS. Treatments 75per cent RDF + *Amrutpani* at 30 DAS + Azotobacter spray at 45 and 60 DAS and 75 per cent RDF + Amrutpani at 30 DAS recorded 17.60 per cent, 7.0 per cent and 3.60 per cent more grain yield, respectively than treatment 75 per cent RDF similar results reported by Paslawar *et al.* (2003) and Sharma and Namdeo (1999).

Straw yield

Straw yield ha^{-1} was significantly affected by various treatments. The treatment of 100 per cent RDF(25:50:00 kg NPK ha^{-1}) recorded significantly higher straw yield as compared to all other treatments except treatment of 75% RDF + *Amrutpani* at 30 DAS + Azotobacter spray at 45 and 60 DAS Treatment FYM 3.75 t ha^{-1} recorded significantly lowest straw yield (22.64 q. ha^{-1}). Higher straw production was recorded in 100 per cent RDF followed by 75 per cent RDF along with biofertilizer and bioformulation treatments which might be due to availability of more nutrients by Sharma and Namdeo (1999).

Grain to straw ratio

The treatments 25:50:00 kg NPK ha^{-1} and 75 per cent RDF recorded highest value of grain to straw ratio than all other treatment. This might have been happened due to the more availability of nutrients for early growth that might have helped to increase the grain to straw ratio by Sharma and Namdeo (1999).

Harvest index

Treatment 75 per cent RDF and 25:50:00 kg NPK ha^{-1} recorded more values of harvest index followed by treatment 75 per cent RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS than other treatment. Nitrogen and Phosphorus supplied through chemical fertilizers helped for the fast development of root and transformation of foods.

Economic

Treatment of 25:50:00 kg NPK ha^{-1} recorded significantly more net monetary returns (Rs. 22504

ha^{-1}) than all other treatments. The treatment FYM 3.75 t ha^{-1} recorded the lowest net monetary returns (Rs. 3542 ha^{-1}). 100 per cent RDF treatment recorded more net monetary returns because of more production and less cost of cultivation than other treatments. The treatment of 25:50:00 kg NPK ha^{-1} registered significantly more B:C ratio (3.42) than other treatments. The treatment of 100 per cent RDF recorded higher B:C ratio as it give more grain yield and comparatively less cost of cultivation as compared to other treatments.

Nutrient Uptake

Table 2 indicated that treatment of 25:50:00 kg NPK ha^{-1} recorded significantly more N uptake (78.96 kg ha^{-1}) than all other treatments except treatment 75 per cent RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS However, treatment of 25:50:00 kg NPK ha^{-1} (5.76 kg ha^{-1}) showed significantly more uptake of P than all other treatment except 75 per cent RDF + Amrutpani at 30 DAS + Azotobacter spray at 45 and 60 DAS (Pawar P.P. and Pawar V.S., 1997).

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Response of Cotton to Different Nutrient Sources and Bioformulation

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ABSTRACT

A field experiment was conducted on response of cotton to different nutrient sources and bioformulation at Agronomy farm, College of Agriculture,Nagpur during *Kharif* seasons of 2006-07 and 2007-08 on cotton hybrid PKV Hy -4. Recommended dose of fertilizer through chemical fertilizer produced significantly more seed cotton yield of 1611 kg ha^{-1}; 50 percent RDF through chemical fertilizer and 2.5 t FYM ha^{-1} was next in order producing 1458 kg ha^{-1} seed cotton yield. Application of bio fertilizer i.e. *Amrutpani* recorded maximum microbial count as compared to other treatments. Gross monetary, net monetary and B:C ratio (3.13)was higher in 100 percent RDF, followed by 50 per cent RDF and 2.5 ton FYM ha^{-1} treatment (2.64).

Cotton is an important cash as well as fiber crop directly affecting the economic status of farmers. There are several reasons for low productivity of cotton. Among them moisture stress, nutrient imbalancing and soil health are the important reasons. Nutrient supply can be done through chemical fertilizer and soil characters can be improved by using organic source and bio formulations. Organic sources help to improve physico-chemical properties of soil and bio-formulations are useful for increasing fungal and bacterial count in the soil which are responsible for making the nutrients available.

Hence to improve the soil condition and micro organism count for sustainable production, an investigation was undertaken to find out suitable combination of various sources of nutrients for cotton production.

MATERIAL AND METHODS

An experiment was carried out to study the response of cotton to different nutrient sources and bioformulation at Agronomy farm, College of Agriculture, Nagpur during *Kharif* 2006-07 and 2007-08 on cotton hybrid PKV Hy -4.The experimental soil was vertisol with 7.6 pH and available nitrogen 248.0 kg ha^{-1}, phosphorus 17.43 kg ha^{-1} and potassium 349.0kg ha^{-1}. Initial bacterial and fungal count were 4.5×10^6 and 8.9×10^5 g^{-1} of soil, respectively. The experiment was conducted in randomized block design with four replications. There were six treatments consisting recommended dose of fertilizer through chemical fertilizer i.e. 100:50:50 kg NPK ha^{-1} (T_1), 5 t FYM ha^{-1}(T_2), *Amrutpani* (T_3), 50 percent RDF + 2.5 t FYM ha^{-1} (T_4), 2.5 t FYM ha^{-1} + two sprays of Azotobactor at square and flowering stage (T_5) and 2.5 t FYM ha^{-1} + application of *Amrutpani* at sowing (T_6). Cotton crop was fertilized with 100:50:50 kg NPK ha^{-1} as per treatments. *Amrutpani* was prepared by using 10 kg cow dung + 10 liters cow urine + 0.500 kg honey + 0.250 kg cow ghee in 200 liters of water for 0.40 ha area. Soil samples were taken for chemical status and micro-organism count during 2006-07. Five plants were selected randomly for recording yield contributing characters.

RESULTS AND DISCUSSION

Recommended dose of fertilizer recorded significantly more seed cotton yield of 1657 and 1564 kg ha^{-1} during 2006-07 and 2007-08, respectively, followed by application of 50 percent RDF + 2.5 t FYM ha^{-1} with seed cotton yield of 1504 and 1412 kg ha^{-1}, respectively as compared to other treatments. Application of bio-formulation i.e. *Amrutpani* did not influence the seed cotton yield significantly and recorded lowest yield. Microbial count was higher in *Amrutpani* treatment. When nutrient source was made available through organic manure i.e. 2.5 t FYM ha^{-1} along with application of *Amrutpani* increased the yield by 9.3 per cent over application of *Amrutpani* alone. On the basis of two years treatments mean, 5.0 ton FYM ha^{-1}, application of *Amrutpani*, 50 per cent RDF + 2.5 t FYM ha^{-1}, 2.5 t FYM ha^{-1} +Azotobactor spray and 2.5 t FYM ha^{-1} + *Amrutpani* recorded reduced yield by 17.8, 27.9, 9.5, 22.7 and 21.1 per cent, respectively over RDF treatment.

Thus, results indicated that supply of nutrients along with application of bio-fertilizer and bio-formulation is essential for sustainable cotton

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Table1. Seed cotton yield, yield parameters and microbial count as affected by different treatments.

Treatments	Seed cotton yield (kg ha^{-1})			% reduction over RDF	Seed cotton yield^{-1} plant	No. of Bolls plant^{-1}	Microbial Count g^{-1}	
	2006-07	2007-08	Mean				Bacte-	Fungal ria
T1 - RDF(100:50:50 kg NPK ha^{-1})	1657	1564	1611	-	195.0	62.7	6.0x10^{7}	9.0x10^{5}
T2 - 5 ton FYM ha^{-1}	1380	126	1324	17.8	161.9	52.7	5.0x10^{7}	7.0x10^{5}
T3 - Amrutpani application at sowing.	1210	1114	1162	27.9	142.1	48.1	9.0x10^{7}	8.0x10^{5}
T4 - 2.5 t FYM ha^{-1} + 50 percent RDF	1504	1412	1458	9.5	178.2	58.1	8.0x10^{6}	7.0x10^{5}
T5 - 2.5 t FYM ha^{-1} Azotobactor sprays at Square and flowering stage	1304	1188	1246	22.7	158.0	50.8	9.0x10^{7}	7.0x10^{5}
T6 - 2.5 t FYM ha^{-1} Amrutpani application at sowing.	1340	1202	1271	21.1	159.9	51.6	1.0x10^{8}	8.0x10^{5}
SE (m)±	58.2	55.6	-	-	-	-	-	-
C.D. at 5%	195.8	172.0	-	-	-	-	-	-
C.V.%	7.6	7.8	-	-	-	-	-	-
Initial value	-	-	-	-	-	-	4.5x10^{6}	8.9x 10^{5}

Table 2. Economics of cotton as affected by different treatments

Treatments	Seed cotton yield (kg ha^{-1}) (Mean)	Gross monetary returns (Rs ha^{-1})	Netmonetary returns (Rs ha^{-1})	Production Cost (Rs ha^{-1})	B:C ratio
T1- RDF(100: 50:50 kg NPK ha^{-1})	1611	32220	21920	10300	3.13
T2- 5 t FYMha^{-1}	1324	26480	14730	11750	2.25
T3- Amrutpani	1162	23240	14340	8900	2.61
T4- 2.5 t FYM ha^{-1} + 50 % RDF	1458	29160	18135	11025	2.64
T5- 2.5 t FYM ha^{-1} + Azotobactor spray	1246	24920	14545	10375	2.40
T6- 2.5 t FYM ha^{-1} + Amrutpani	1271	25420	14645	10775	2.36

production. Prasad *et al.*, (2005) and Anup Das *et al.*, (2004) also reported similar beneficial effect of stimulants only when FYM was applied. Application of 5.0 t FYM ha^{-1} alone did not influence the seed cotton yield.

Higher gross monetary returns (Rs.32220 ha^{-1}), net monetary returns (Rs.20910 ha^{-1}) and B:C ratio (3.13) was recorded in RDF treatment, followed by 50 percent RDF + 2.5 t FYM ha^{-1} treatment. Lowest B:C ratio was observed in application of 5.0 t FYM ha^{-1} (2.25).

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Effect of Land Configuration and Fertilizer on Growth and Yield of Greengram

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ABSTRACT

A field experiment was conducted at Agriculture College farm, Nagpur during *Kharif* 2002 in Factorial Randomised block design with two factors viz., land configuration and fertilizers. The growth and yield contributing characters, yield and economy were not influenced significantly by the land configuration treatment. However, among the fertilizers with biofertilizers treatment application of 40 kg P_2O_5 i.e. 100 per cent recommended dose of phosphorus recorded maximum and significantly higher growth attributes, yield attributes, yield, GMR and NMR, followed by 75 per cent RDP (30 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1}) and 75 per cent RDP (30 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1}) + Rhizobium.

Greengram ranks third among the various pulses grown in India. It is grown on 30.42 lakh hectares area with production of 11.73 lakh tonnes (Anonymous, 2000). In Maharashtra it is grown on 6.62 lakh hectares area with annual production of 3.51 lakh tonnes and productivity is 530 kg per hectare. In Vidarbha region area is 3.09 lakh hectares with production of 0.69 lakh tonnes. Land configuration plays important role in soil moisture conservation in rainfed condition which is useful in conserving the maximum rain water. Slightly modifying the land and soil in crop raising can conserve the moisture, provide better soil-moisture plant atmosphere leading to better yield.

Phosphorus plays an important role in root development, nodulation, flowering and fruiting. But phosphorus after its application gets fixed in soil and becomes available to the crop very slowly. PSB has the capacity to make the phosphorus available through its bacterial action. Rhizobium fix and make available the atmospheric nitrogen to the crop. These fertilizers and biofertilizers if get optimum soil-moisture atmosphere can enhance the yield of greengram due to effect of land configuration and fertilizers with biofertilizers. Therefore, the present investigation was undertaken to study the effect of land configuration and fertilizers on growth and yield of greengram.

MATERIAL AND METHODS

A field experiment was conducted at Agriculture College farm, Nagpur during *Kharif* 2002 in Factorial Randomised block design with three replications and two factors viz., land configuration comprising two treatments (Flat and BBF) and fertilizers with biofertilizers comprising five treatment i.e. F_1- 100 per cent RDP (40 kg P_2O_5 ha^{-1}), F_2-75 per cent RDP (30 kg P_2O_5 ha^{-1})+PSB(2.5 kg ha^{-1}), F_3-50 per cent RDP (20 kg P_2O_5 ha^{-1}) +PSB(2.5 kg ha^{-1}), F_4 - 75 per cent RDP (30 kg P_2O_5 ha^{-1})+PSB(2.5 kg ha^{-1}) + Rhizobium, F_5-50 per cent RDP (20 kg P_2O_5 ha^{-1})+PSB (2.5 kg ha^{-1}) + Rhizobium. The soil of experimental site was clayey in texture, medium in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potash (Table 2). The greengram variety AKM-8802 was used with spacing of 30 X10 cm. The crop was sown on 1 st July, 2002 after receiving the rainfall of 124.6 mm and harvesting was done on 2 nd September, 2002. The common fertilizer dose of 20 kg N ha^{-1} was applied and the phosphorus recommended (RDP) is 40 kg P_2O_5 ha^{-1} for this area was applied as per the treatment. The average annual precipitation is 900-1250 mm receiving mainly in June to September. The rainfall received during crop growth period was 72.9 mm and 398.2 mm in July and August, respectively. The rainfall received in August (late growth to maturity stage) was more than average. The observations on growth, yield contributing characters, yield, nutrient uptake, available residual soil status and economy were recorded.

RESULTS AND DISCUSSION

Effect of land configuration

The data presented in Table 1 and 2 showed that all the growth observations, yield parameters,

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Table 1: Growth, yield contributing characters and yield of greengram as influenced by various treatments

Treatments	Growth characters at harvest				Yield attributes at harvest				Yield			
	Mean plant height (cm)	Mean number of branches	Mean dry matter accumulation (g) plant^{-1}	Number of pods plant^{-1}	Number of grains pod^{-1}	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Grain to straw ratio	Harvest Index (%)
Land configuration												
L_1 - Flat bed	47.57	5.24	11.66	9.16	8.08	2.72	6.69	39.64	7.95	19.84	0.399	28.52
L_2 - BBF	48.19	5.39	11.75	9.30	8.23	2.83	6.78	39.70	8.04	19.97	0.401	28.63
S.E(m)±	0.49	0.06	0.07	0.21	0.05	0.04	0.05	0.05	0.18	0.39	0.003	0.18
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizers												
F_1 - 100 % RDP (40 kg P_2O_5 ha^{-1})	51.61	5.75	12.38	10.27	8.84	3.38	7.32	39.84	8.86	21.05	0.420	29.63
F_2 - 75 %RDP (30 kg P_2O_5 ha^{-1}) + PSB(2.5 kg ha^{-1})	48.89	5.30	11.81	9.54	8.13	2.85	6.95	39.68	8.34	20.38	0.410	29.12
F_3 - 50 %RDP (20 kg P_2O_5 ha^{-1}) + PSB(2.5 kg ha^{-1})	43.83	4.98	10.93	8.06	7.46	2.14	6.07	39.47	6.93	18.49	0.374	27.24
F_4 - 75 %RDP (30 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1}) + Rhizobium	50.35	5.53	12.17	9.95	8.61	3.21	7.14	39.76	8.65	20.95	0.413	29.21
F_5 - 50 %RDP (20 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1}) + Rhizobium	44.74	5.03	11.24	8.33	7.71	2.30	6.20	39.61	7.19	18.77	0.382	27.68
S.E(m)±	0.78	0.10	0.12	0.34	0.09	0.07	0.07	0.09	0.29	0.61	0.005	0.29
C.D. at 5%	2.33	0.29	0.36	1.01	0.27	0.21	0.22	NS	0.88	1.83	0.016	0.86
Interaction												
S.E(m)±	1.11	0.14	0.17	0.48	0.12	0.10	0.10	0.13	0.42	0.87	0.008	0.41
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Moisture content , nutrient uptake, residual available soil nutrients and economy of greengram as influenced by various treatments.

Treatments	Moisture content (%)		Uptake (kg ha^{-1})			Residual available soil nutrient (kg ha^{-1})			Economy			
	Flowering	Pod filling	N	P	K	N	P	K	Cost of cultivation (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
Land configuration												
L_1 - Flat bed	24.70	26.97	51.49	9.99	42.62	224.72	20.21	347.40	6538	14303	7765	2.18
L_2 - BBF	25.98	28.39	52.21	10.16	43.20	227.24	20.57	354.24	6648	14446	7798	2.17
S.E(m)±	-	-	1.12	0.19	0.86	-	-	-	-	293.8	319.8	-
C.D. at 5%	-	-	NS	NS	NS	-	-	-	-	NS	NS	-
Fertilizers												
F_1 - 100 % RDP (40 kg P_2O_5 ha^{-1})	25.67	28.21	59.44	11.37	47.6	218.15	18.50	340.53	6729	15728	8999	2.33
F_2 - 75 %RDP (30 kg P_2O_5 ha^{-1}) +PSB(2.5 kg ha^{-1})	25.45	27.84	54.33	10.40	44.45	225.98	21.30	355.56	6644	14896	8252	2.24
F_3 - 50 %RDP (20 kg P_2O_5 ha^{-1}) +PSB(2.5 kg ha^{-1})	24.93	27.06	43.09	8.66	37.16	222.51	19.60	346.00	6449	12707	6258	1.97
F_4 - 75 %RDP (30 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1})+ Rhizobium	25.56	27.98	57.60	10.93	46.75	233.50	22.05	360.96	6669	15440	8771	2.31
F_5 - 50 %RDP (20 kg P_2O_5 ha^{-1}) + PSB (2.5 kg ha^{-1}) + Rhizobium	25.06	27.31	44.78	9.00	38.56	229.76	20.50	351.08	6474	13101	6627	2.02
S.E(m)±	-	-	1.77	0.31	1.36	-	-	-	-	464.5	505.6	-
C.D. at 5%	-	-	5.27	0.92	4.04	-	-	-	-	1379.4	1501.3	-
Interaction									-			
S.E(m)±	-	-	2.51	0.43	1.92	-	-	-	-	656.93	715.0	-
C.D. at 5%			NS	NS	NS	-	-	-		NS	NS	-
Initial value	-	-	-	-	-	236.24	17.56	365.24	-	-	-	-

yield, moisture content, residual available nutrients in soil, NPK uptake and economy parameters studied recorded higher values due to BBF but the differences were not significant due to land configuration. It is evident from the rainfall data that the rainfall was scattered throughout the initial crop growth stage and therefore there was no stagnation of water. The duration of crop was short. This might have provided similar growth condition in both the land configuration viz., flat bed and BBF which could not influence the various characters. Similar results are also reported by Jogdande (1997), Balki (1998), Jain *et al.* (2000) and Anonymous (2003).

Effect of fertilizers

Application of 40 kg P_2O_5 ha^{-1} i.e. 100 per cent recommended dose of phosphorus recorded maximum and significantly higher values for growth observations viz., mean plant height, mean number of branches $plant^{-1}$, mean dry matter accumulation $plant^{-1}$, yield $plant^{-1}$ (g), grain yield (8.86 q ha^{-1}), straw yield (21.05 q ha^{-1}), nutrient uptake of NPK, GMR and NMR but 75 per cent RDP (30 kg P_2O_5 ha^{-1})+PSB(2.5 kg ha^{-1}) and 75 per cent RDP (30 kg P_2O_5 ha^{-1}) +PSB(2.5 kg ha^{-1}) + Rhizobium, recorded statistically at par values. Thus application of 40 kg P_2O_5 ha^{-1} i.e. 100 per cent recommended dose of phosphorus was optimum to produce maximum yield along with use of PSB alone or PSB + Rhizobium and by which 10 kg P_2O_5 ha^{-1} cauld be saved. Tomer *et al.* (1993), Ardeshna *et al.*(1993), Bhattacharya and Pal (2001), Shukla and Dixit (1996), Kumar *et al.*(2002), Singh *et al.*(1994) also reported maximum yield with application of 40 kg P_2O_5 ha^{-1} in greengram. Test weight was not influenced significantly.

Interaction effect

The interaction effects were found non-significant in respect of various characters, yield attributes, yield, uptake and economy.

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Evaluation of Different Integrated Methods of Weed Control in Chilli

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ABSTRACT

An experiment was conducted during *Kharif* season of 2001 and 2002 at Chilli Vegetable Research Unit, Dr.Panjabrao Deshmukh Krishi Vidaypeeth., Akola. Weed population and their dry matter weight were reduced significantly by weed control treatments and maximum reduction was in cultural treatment two hoeings + two weedings at 30 and 60 DAT of Chilli followed by integrated treatments of PPI of trifluralin @ 1 kg a.i. ha^{-1} + one hoeing and one weeding at 45 and 60 DAT. Among the herbicidal treatment, PPI of trifluralin @ 1 kg a.i. ha^{-1} proved to be the best. Two hoeings and two weedings at 30 and 60 DAT proved to be the best treatment resulting in highest yield.

Chilli plays a vital role in Indian economy. It has become an essential item in our diet. It is a good source of vitamin A, B and C. (Venkateswara, 1969). The Capsaicin content in red chilli varies between 0.7 to 0.9 per cent (Pankar and Mahajar, 1978) . It has significant physiological action, which is used in many pharmaceutical preparation. (Singh and Singh,1980).

A large number of constraints limit the production of chilli. Among them weeds constitutes one of the greatest hazards in the successful chillicultivation. Apart from this weed also harbour some of the insect pests and diseases, which further cause drastic reduction in fruit yield (Mariappan and Narayansamy, 1977, and Alegbejo, 1987). Among the four regions of Maharashtra, Vidarbha grows Chiilli in more than 42 per cent area of State but the productivity of dry Chilli in Vidarbha is very low (4.66 q ha^{-1}) as compared to productivity of Maharashtra (5.35 q ha^{-1}) and also country's productivity (7.53 q ha^{-1}) (More *et al*., 1996). Disparity in productivity of Chilli in Vidarbha is mainly attributed to the lack of appropriate production technologies. Weeds are considered to be one of the major production constraints. Information on weed management in Chilli is limited and no work has been done on weed management in Chilli crop particularly in newly released variety "Jayanti" (AKC 86-39). The present study was, therefore, conducted to Study the integrated weed management in Chilli (*Capsicum annum* L.).

MATERIAL AND METHODS

The design adopted was Randomised Block Design with nine treatments replicated four times. The site of the experiment, the plan of layout and randomization was same for both the years. The seed of Jayanti variety was obtains from Chilli and Vegetable Research Unit and Herbicides, Trifluralin (Treflan 48 %EC) and Fluchloralin (Basalin 45 %EC) were received from Weed Science Laboratory, Department of Agronomy, Dr.PDKV, Akola. Quantity of pre-plant herbicides, Trifluralin, Fluchloralin and Alachlor required for gross plot area (3.6 m x 6.0 m) was calculated as per the treatment and dissolved in 2 litre of water and sprayed uniformly over an area of 21.6 m^2 according to different treatments. Trifluralin, Fluchloralin were applied as pre-plant soil incorporation while, alachlor was sprayed uniformly with knapsack sprayer fitted with flat fan nozzle, one day before transplanting of chilli seedlings with minimum transplanting. The treatment details are given in Table 1. A quadrat of 0.5 m x 0.5 m was placed at random inside the net plot area of each plot. The weeds in the quadrat were removed from each plot at 30,60,90 and 120 days after transplanting and at harvest.The weed samples were first sun dried and oven dried to constant weight at 65°C temperature and weights were recorded. Weed Control Efficiency (Satao ., 1990) was worked out as below:

$$WCE(\%) = \frac{\text{Dry matter of weeds in untreated plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in untreated plot}}$$

Weed index (%) was calculated by the formula proposed by Gill and Vijay Kumar (1969).

$$WI\% = \frac{X-Y}{X} \times 100$$

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Table 1. Treatment details

S.N.	Treatments	Symbol
1	Pre-plant soil incorporation of Trifluralin @ 1Kg a.i. ha^{-1}	T1
2	Pre-plant soil incorporation of Fluchloralin @ 1Kg a.i. ha^{-1}	T2
3	Pre-plant soil incorporation of Alachlor @ 1Kg a.i. ha^{-1}	T3
4	Pre-plant soil incorporation of Trifluralin @ 1Kg a.i. ha^{-1}+ one hoeing at 45 days + one weeding at 60 days after transplanting	T4
5	Pre-plant soil incorporation of Fluchloralin @ 1Kg a.i. ha^{-1}+ one hoeing at 45 days + one weeding at 60 days after transplanting	T5
6	Pre-plant soil incorporation of Alachlor @ 1Kg a.i. ha^{-1}+ one hoeing at 45 days + one weeding at 60 days after transplanting	T6
7	One hoeing at 30 days + one weeding at 45 days after transplanting	T7
8	Unweeded control (Weedy check)	T8
9	Two hoeings at 30 and 60 days followed by two weedings at 30 and 60 days after transplanting	T9

Table 2. Total number of weeds m^{-2} as influenced by different treatment during 2000-01 and 2001-02

Treatments	Total number of weeds m^{-2}							
	2000-01				2001-02			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T1	6.86	7.85	9.40	9.10	7.42	7.95	9.17	9.80
	(47.25)	(62.00)	(89.00)	(83.25)	(55.25)	(63.50)	(84.50)	(96.25)
T2	8.03	9.11	10.57	10.33	8.71	9.50	10.77	10.88
	(65.00)	(83.25)	(112.25)	(107.00)	(76.25)	(90.50)	(116.25)	(118.50)
T3	8.12	9.21	10.85	10.62	9.06	9.95	0.79	11.09
	(66.50)	(85.25)	(118.25)	(113.00)	(82.25)	(99.25)	1(116.50)	(123.00)
T4	6.72	5.69	5.57	6.03	7.31	5.99	4.39	6.48
	(45.75)	(32.75)	(31.25)	(36.50)	(53.75)	(36.50)	(19.50)	(42.00)
T5	8.36	7.74	5.82	6.40	9.21	7.29	4.95	6.99
	(70.25)	(60.25)	(34.25)	(41.25)	(85.00)	(53.25)	(24.75)	(49.00)
T6	8.53	7.85	6.10	6.63	9.22	7.77	4.84	7.31
	(73.00)	(62.00)	(37.50)	(44.25)	(85.50)	(60.50)	(23.50)	(53.50)
T7	10.55	5.22	7.28	7.92	11.97	5.88	7.70	8.45
	(111.75)	(27.50)	(53.50)	(63.00)	(143.50)	(34.75)	(59.50)	(71.50)
T8	10.48	12.09	13.29	12.58	12.18	13.25	13.90	12.97
	(110.25)	(146.75)	(177.00)	(158.75)	(148.50)	(175.75)	(193.25)	(168.25)
T9	10.43	4.48	4.00	5..04	11.82	5.25	3.38	4.63
	(109.50)	(20.25)	(16.25)	(25.75)	(140.00)	(27.75)	(11.50)	(21.50)
S.E.(m)±	0.39	0.37	0.39	0.33	0.32	0.31	0.26	0.21
C.D.at5%	1.15	1.11	1.14	0.97	0.92	0.90	0.76	0.62
Mean	8.67	7.69	8.10	8.32	9.65	8.09	7.76	8.73

N.B.: (i) Figures in parenthesis are original values. (ii) Upper values are transformed values (x).

Where,

WI = Weed index in per cent.

X = Fruit yield from weed-free plot.

Y = Fruit yield under the treatment for which weed index is to be worked out.

RESULTS AND DISCCUSION

Weed Flora

In general, during 2001-02 monocot weeds like *Cyperus rotundus* , *Cynodon dactylon and Echinochloa crusgalli* and dicot weeds Viz., *Psorulea corylifolia* , *Corchorus acutangulas* , *Lagasca mollis* , *Euphorbia hirta* and *Parthenium hysterophorus* were dominant in the experimental plot. During both the years, the proportion of monocot weeds was more than that of dicot weeds. The influence of weather condition and weed competition was probably responsible for low yield.

In both the years (Table 2), total weed population m^{-2} was affected significantly due to pre-plant herbicidal treatments at early stages of crop growth (30 DAT). There was highest reduction in total weed population in treatments of PPI of trifluralin @ 1 Kg a.i. ha^{-1} with or without hoeing + weeding at 45 and 60 DAT (T4 and T1), followed by PPI of fluchloralin @ 1 Kg a.i. ha^{-1} and pre plant soil application of alachlor @ 2 Kg a.i. ha^{-1} each supplemented with or without one hoeing + one weeding at 45 and 60 DAT (T5, T6, T2 and T3). This may be due to better performance of these herbicides probably due to their ability to control both monocot and dicot weeds effectively, especially at the early stage of crop growth. Similar effect on weed population was reported earlier by Stoian *et al.*(1984), Singh *et al.* (1985) and Joshi *et al.*(1995).

Further, the cultural treatment of two hoeing + two weedings at 30 and 60 DAT (T9) caused maximum reduction in the total weed population at all the growth stages which could be attributed to the removal of both monocot and dicot weeds. Similar results were observed by Labrada and Paredes (1983).

During both the years, dry weed biomass was significantly affected due to pre plant herbicides

Table 3. Dry weed biomass (g/ m^2) at different growth stages of chilli as influenced by different treatments during 2000-01 and 2001-2002

Treatments	Dry weed biomass (g/ m^2)							
	2000-01				2001-02			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T1	2.56	5.82	8.07	8.68	2.88	5.71	8.01	8.91
	(6.70)	(34.15)	(65.85)	(75.70)	(8.35)	(32.95)	(64.40)	(79.55)
T2	3.21	6.80	9.20	9.91	3.71	7.04	9.28	10.16
	(10.40)	(46.55)	(84.90)	(98.45)	(13.85)	(49.75)	(86.25)	(103.35)
T3	3.34	6.89	9.40	10.24	4.03	7.40	9.51	10.61
	(11.30)	(47.75)	(88.65)	(105.10)	(16.35)	(54.85)	(90.50)	(112.80)
T4	2.51	4.12	4.44	5.61	2.69	4.32	3.84	5.83
	(6.35)	(17.25)	(20.00)	(31.75)	(7.35)	(18.90)	(14.75)	(34.00)
T5	3.43	5.67	4.71	6.01	4.03	5.34	4.50	6.55
	(11.95)	(32.50)	(22.60)	(36.30)	(16.25)	(28.70)	(20.70)	(42.90)
T6	3.40	5.76	4.94	6.22	4.14	5.62	5.62	7.05
	(11.70)	(33.45)	(24.75)	(38.90)	(17.30)	(31.65)	(17.75)	(49.80)
T7	4.47	3.76	6.16	7.78	5.07	4.15	6.53	8.06
	(20.10)	(14.30)	(38.20)	(60.75)	(25.75)	(17.25)	(42.65)	(65.40)
T8	4.30	9.04	11.64	12.46	5.28	10.01	12.28	12.72
	(18.75)	(82.15)	(136.30)	(155.60)	(27.95)	(100.40)	(150.90)	(161.90)
T9	4.29	3.21	3.20	4.71	4.87	3.87	3.07	4.32
	(18.60)	(10.50)	(10.40)	(22.40)	(23.75)	(15.25)	(9.55)	(18.75)
S.E.(m)±	0.21	0.30	0.37	0.29	0.18	0.26	0.25	0.25
C.D.at 5%	0.61	0.89	1.09	0.85	0.54	0.75	0.75	0.74
Mean	3.50	5.68	6.86	7.96	4.08	5.94	6.80	8.24

N.B.: (i) Figures in parenthesis are original values. (ii) Upper values are transformed values (x).

at 30 DAT (Table 3). In general, dry weed biomass under pre plant soil incorporation (PPI) of trifluralin @ 1 Kg a.i. ha^{-1} with or without one hoeing + weeding at 45 and 60 DAT (TI and T4) were significantly lowest than rest of the treatments at 30 DAT. This could be attributed to inhabitation of growth of weeds during early crop growth period and more reduction in weed population under PPI of trifluralin as compared to other herbicidal treatments, application of fluchloralin @ 1 Kg a.i. ha^{-1} and alachlor @ 2 Kg a.i. ha^{-1}. It has also reported by Rajender Singh *et al.*, (1993) and Joshi *et al.*, (1995)Further, the cultural method, two hoeings + two weedings at 30 and 60 DAT (T9) brought about significant reduction in dry weed biomass and recorded the leaf dry weight of weeds after subsequent days 60,90,120 DAT and at harvest. Treatment T9 was followed by pre plant soil incorporation (PPI) of trifluralin @ 1 Kg a.i. ha^{-1} (T4), PPI of fluchloralin @ 1 Kg a.i. (T5) and pre plant soil application of alachlor @ 2 Kg a.i. ha^{-1} (T6) each treatment supplemented with one hoeing + one weeding at 45 and 60 DAT.

From the table 4, revealed that during both the years the cultural treatment two hoeings + two weedings at 30 and 60 DAT (T9) recorded highest weed control efficiency. The next higher WCE was obtained in case of PPI of trifluralin @ 1 Kg a.i. ha^{-1} supplemented with one hoeing and one weeding at 45 and 60 DAT (T4). Among the herbicides, pre plant soil incorporation of trifluralin @ 1 Kg a.i. ha^{-1} showed high value of WCE followed by PPI of fluchloraline @ 1 kg a.i. ha^{-1} and pre plant soil application of alachor @ 2 Kg a.i. ha^{-1}. Similar results were obtained by Irfan Raza (1998) and Anonymous (2001b)

Table 4. Weed control efficiency (%) as influenced by different treatments during 2000-01 and 2001-02.

Treatments	Weed control efficiency (%)	
	2000-01	2001-02
T_1	48.74	44.68
T_2	35.33	33.39
T_3	31.17	31.95
T_4	73.49	76.46
T_5	66.50	66.61
T_6	63.41	63.72
T_7	55.79	52.13
T_8	-	-
T_9	81.23	80.54

Table 5. Weed index (%) as influenced by different treatments during 2000-01and 2001-02

Treatments	Weed index (%)		
	2000-01	2001-02	Pooled mean
T_1	40.91	42.71	41.81
T_2	48.03	52.37	50.20
T_3	48.64	54.32	51.48
T_4	7.68	9.32	8.50
T_5	17.05	19.50	18.28
T_6	17.15	19.90	18.53
T_7	33.03	33.10	33.07
T_8	71.89	70.33	71.11
T_9	-	-	-

Weed index indicated yield reduction as weed competition was highest in unweeded control (T8), which recorded highest weed index 71.89 and 70.33 per cent over cultural treatment (T9) during 2000-01 and 2001-02 respectively (Table 5). This was due to unchecked weed growth, resulting in the highest loss of yield. But lowest 7.68 and 9.32 per cent weed index was recorded in integerated treatment PPI of trifluralin @ 1 Kg a.i. ha^{-1}+ one hoeing and one weeding at 45 and 60 DAT (T4) during first and second season respectively.This may be due to satisfactory control of weeds and reduced crop weed competation which enabled the crop to utilize the available resources effectively resulted in higher yield.

During both the years of experimentation (Table 6), similar trend was noticed in respect of Chilli fruit yield. From the pooled data the differences observed in Chilli fruit yield ha^{-1} due to weed control through cultural, chemical and integrated treatments resulted in an increase in fruit yield significantly over unweeded control (T8). The cultural treatment two hoeings + two weedings at 30 and 60 DAT (T9) was significantly superior over all other treatments and it increased the yield 262.02 per cent over unweeded control (T8) . This could be due to better weed control, higher dry matter production per plant, greater nutrient uptake and improvement in other yield contributory component viz. Number of fruits and their weight per plant. These results are in agreement with those reported by Labrada and Paredes (1983), Lanini and Strange (1994) and Anonymous (2001 b).

Integrated treatment PPI of trifluralin @ 1 Kg a.i. ha^{-1}+ one hoeing and one weeding at 45 and 60 DAT (T4) was the next best treatment recorded

Table 6. Dry Chilli fruit yield (q ha^{-1}) as influenced by various treatments during 2000-01 and 2001-02

Treatments	Dry chilli fruit yield (q ha^{-1})		
	2000-01	2001-02	Pooled mean
T_1	11.54	10.02	10.78
T_2	10.15	08.33	9.24
T_3	10.03	07.99	9.01
T_4	18.03	15.86	16.95
T_5	16.20	14.08	15.14
T_6	16.18	14.01	15.10
T_7	13.08	11.70	12.39
T_8	0.5.49	5.19	5.34
T_9	19.53	17.49	18.51
S.E.(m)±	0.40	0.53	0.38
C.D.at 5%	1.18	1.55	1.10
Mean	13.36	11.63	12.50

significantly more yield than remaining treatments which recorded 233.96 per cent more yield over unweeded control (T8). The higher yield in T4 treatment might be due to better weed control, increased in number and weight of wet red fruits plant^{-1}. It was also evident from the positive correlation obtained between number and weight of fruits per plant and yield of wet red chilli fruit.

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Effect of Some Plant Products and Oils as Surface Protectants on Development of Pulse Beetle Infesting Stored Dolichos Bean

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ABSTRACT

Results of the laboratory experiment conducted to study effect of some plant products and oils on overall development of *C. maculatus* infesting stored dolichos bean revealed that the treatment with neem oil @ 10 ml kg^{-1} of seed recorded significantly shortest survival period of 1.21 days followed by karanj oil (1.34 days) and undi oil (2.29 days) tried at same dose. The total number of eggs laid within treatments with plant products and oils varied between 0.00 to 206.00. No egg laying was observed in dolichos bean treated with undi oil, neem oil and karanj oil tested each at 10 ml kg^{-1} of seed. The developmental period of *C. maculatus* was significantly prolonged on dolichos bean treated with neem oil (29.17 days); undi oil (29.19 days) and karanj oil (29.80 days) each at dose of 5 ml kg^{-1} of seed and sweet flag rhizome powder @ 10 gm kg^{-1} of seed (29.05 days). There was absolutely no adult emergence in treatments with undi oil, neem oil and karanj oil tested each at 10 ml kg^{-1} of seed. There was no significant difference between the longevity of pulse beetle emerged from various treatments with surface protectants tested during present study. The female adults lived relatively longer than male.

India produces around 14.11 million tonnes of different pulses $year^{-1}$ but nearly 8.5 per cent of the same is lost during post harvest handling and storage (Agarwal *et al.* 1988; Anonymous, 2007). The pulse beetle, *Callosobruchus maculatus* (Fab.) (Colcoptera: Bruchidae) is the major pest of various stored pulses including dolichos bean causing severe damage and great economic loss. Dolichos bean is traditionally grown over 8185 hectares during rabi season on resudial soil moisture after rice in Konkan region of Maharashtra (Anonymous, 2007). Many workers have reported earlier, various plant materials including oils, plant extracts and plant powders effective in checking the multiplication of pulse beetle in storage (Ali *et al.* 1983; Sawant, 2001). An attempt was therefore made to study the effect of some plant products and oils as surface protectants on overall development of *C. maculatus* infesting stored grains of dolichos bean.

MATERIAL AND METHODS

(i) Maintenance of culture:

The seed of dolichos bean *Lablab purpureus* (L.) infested by pulse beetle was procured from the Department of Agronomy, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri 415 712 (Maharashtra). The taxonomic key given by Haines (1989) was used for identification and isolation of desired species of pulse beetle *i.e, C. maculatus*. About three kg healthy seed of dolichos bean free from infestation of pulse beetle was kept uniformly in three glass jars (19 cm height and 12.5 cm diameter) containing five pairs of male and female beetles of *C. maculatus* isolated from original culture. The top of the each glass jar was covered with muslin cloth secured firmly with rubber bands. The newly emerged adults were transferred into similar sized glass jars containing uninfested and healthy seed of dolichos bean in order to maintain the culture of test insect throughout the period of study. The freshly emerged adults of appropriately uniform age were selected from the culture thus maintained and used for further studies.

(ii) Details of plant material used:

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

(iii) Method of treatments

A statistically designed experiment was laid out during the year 2008-09 in the laboratory of

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Department of Entomology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli- 415 712, Dist. Ratnagiri (Maharashtra) using Completely Randomized Design comprising of fifteen treatments replicated twice. In case of plant powders, 100 g healthy seed of dolichos bean was weighed and placed in each transparent glass bottle (8 cm in height and 7 cm in diameter). The required quantity of powders (5 or 10 g kg^{-1} seed) of four plant species *viz.*, rantulas, karanj, neem and sweet flag was measured using high precision electronic balance and mixed thoroughly into the seed of dolichos bean placed in a glass bottle. In case of treatments with various oils *viz.*, undi oil, neem oil and karanj oil, the respective doses (5 or 10 ml kg^{-1} seed) were measured by using 10 ml capacity pipette and poured on 100 g healthy seed of dolichos bean, mixed thoroughly and dried under shade for two hours. These grains were then kept separately in similar sized transparent glass bottles with plastic lids having four small holes for aeration and labelled accordingly. The untreated control was also maintained. Three pairs of freshly emerged male and female adults of *C. maculatus* were released in each glass bottle including control. The date and time of release of beetle/ treatment were marked on the glass bottle using marking pencil.

RESULTS AND DISCUSSION

(i) Effect of surface protectants on survival of *C. maculatus*

Data recorded on effect of surface protectants on survival of adults of pulse beetle, *C. maculatus* (Table 2) revealed that the survival period of *C. maculatus* varied significantly within the treatments with surface protectants. In case of survival of male adults, the treatment with neem oil @ 10 ml kg^{-1} of seed recorded significantly shortest survival period of 1.21 days, followed by treatments with karanj oil and undi oil each at 10 ml kg^{-1} of seed.

Amongst all treatments with plant products, karanj seed powder @ 5g kg^{-1} of seed and rantulas leaf powder (@ 10 and 5 g kg^{-1} seed) were found ineffective in reducing the survival of male adults. In case of survival of female adults, the shortest survival of 1.34 days was recorded in treatment with neem oil @ 10 ml/kg of seed which was significantly shorter than karanj oil @ 10 ml kg^{-1} of seed (1.71 days) and undi oil @ 10 ml/kg of seed (2.04 days) which were on par with each other. The sweet flag rhizome powder tested at 10 g kg^{-1} of seed was the next best treatment in order of efficacy. The rantulas leaf powder tested at both dosages of 5 g and 10 g kg^{-1} of seed showed very little effect on survival of female adult. The female beetle survived for 9.88 days on untreated seeds of dolichos bean. The effect of neem oil and sweet flag rhizome powder on survival of adults of *C. maculatus* obtained during present investigation is in close agreement with Sawant (2001) who recorded shortest survival period of one day on green gram seed treated with neem oil and sweet flag rhizome powder @ 3g, 4g and 5g 100 g^{-1} of seed. Waryam Singh (1976) found neem oil to be effective in minimizing the survival of pulse beetle.

(ii) Effect of surface protectants on oviposition of *C. maculatus*

The perusal of data (Table 2) indicated that all the treatments with surface protectants were found significantly effective over untreated control

Table 1. Details of plant material tested during present investigation

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

in reducing egg laying. The total number of eggs laid within the treatments with surface protectants varied between 0.00 to 206.0. No egg laying was observed in dolichos bean treated with undi oil, neem oil and karanj oil tested each at 10 ml kg^{-1} of seed. The treatment with sweet flag rhizome powder @ 10 g kg^{-1} of seed was the next best treatment in order of merit which recorded significantly lowest number or eggs (64.50) deposited on dolichos bean than all remaining treatments. The maximum number of eggs laid were found on dolichos bean treated with rantulas leaf powder (206.0) and karanj seed powder (189.50) both tested @ 5 g kg^{-1} of seed. The plant oils (undi oil, neem oil and karanj oil) were found relatively more effective than the powders of various plants like rantulas, karanj and neem tested during present investigation. The present findings in respect of neem oil and karanj oil are in conformity with Ali *et al.* (1983) who also recorded adverse effect of same on deposition of eggs. Naik (1980) noticed reduction in egg laying in cowpea treated with undi oil at the dose of 10 ml kg^{-1} of seed.

(iii) Effect of surface protectants on developmental period of *C. maculatus*:

Observations recorded on effect of surface protectants on developmental period of *C. maculatus* (Table 2) indicated that the treatments with some of the oils and powders showed marked effect on prolongation of developmental period of *C. maculatus* from egg laying to adult emergence. The development of beetle on untreated grains of dolichos bean required a total mean period of 24.05 days. However, the developmental period was significantly prolonged on the dolichos bean treated with neem oil (29.17 days), undi oil (29.19 days) and karanj oil (29.80 days) each at dose of 5 ml kg^{-1} of seed and sweet flag rhizome powder at 10 g kg^{-1} of seed (29.05 days). The high dose (10 ml kg^{-1}) of plant oils *viz.*, neem, karanj and undi oil etc. caused cent per cent mortality of beetles within exposure period of 2 to 3 days. The treatment with rantulas leaf powder @ 5 g kg^{-1}, karanj seed powder @ 5 g kg^{-1} and rantulas leaf powder @ 10 g kg^{-1} did not show any significant effect on developmental period of *C. maculatus* over untreated control.

In general, the treatments with plant oils were found more effective than the powders in prolonging the development of pulse beetle. Observations recorded during present investigation in respect of karanj oil, undi oil and neem oil are in agreement with Naik (1980) who also reported the prolonged development of pulse beetle on cowpea seed treated with plant oils of karanj, undi and neem.

(iv) Effect of surface protectants on adult emergence of *C. maculatus*

Observations recorded on effect of surface protectants on adult emergence of *C. maculatus* (Table 2) indicated that the mean number of adults emerged was significantly low in all the treatments as compared to untreated control (200.50) There was no adult emergence in treatments with undi oil, neem oil and karanj oil tested each at dose of 10 ml kg^{-1} of seed. Neem oil @ 5 ml kg^{-1} of seed was found next best treatment in order of merit. The maximum adult emergence of 144.50 was noticed in the treatment with 5 g of rantulas leaf powder kg^{-1} of seed as compared with other species of plant products. It was noticed that as the dose of plant products increased, the adult emergence was decreased considerably. Present finding corroborates with Khaire *et al.* (1992) who recorded no adult emergence from pigeon pea seed treated with neem and karanj oils at all concentrations of 0.50, 0.75 and 1.00 per cent. Bhatnagar *et al.* (2001) also recorded similar observations in cowpea treated with neem oil @ 10 ml kg^{-1} of seed.

(v) Effect of surface protectants on adult longevity of *C. maculatus*:

Observations recorded on longevity of male and female beetles of *C. maculatus* with and without healthy grains of dolichos bean indicated that no significant difference was noticed in longevity of pulse beetles emerged from various treatments with surface protectants. The longevity of male beetle with and without food was ranged between 7.31 to 7.69 days and 7.31 to 7.63 days, respectively. In case of female, it was varied from 9.38 to 9.75 days with food and 9.37 to 9.69 days without food. The female beetles with and without food survived relatively longer than male beetle. The maximum life span of male (7.69 days) and female (9.75 days) beetle was noticed in untreated control. The higher and lower dosages of plant products and oils were not found to have any deleterious effect on adult longevity. Naik (1980) obtained no any significant differences in the longevity of *C. maculatus* exposed to fourteen

Table 2. Effect of surface protectants on development of pulse beetle, *C. maculatus* infesting stored dolichos bean

Treatments	Dose (g or ml kg^{-1} of seed)	Survival period (days)		Total no. of eggs laid/ treatment	Mean developmental period (days)	Mean number of adults emerged / treatment	Adult longevity (days)			
							With grain		Without grain	
		Male	Female				Male	Female	Male	Fem-ale
Rantulas leaf powder	5	7.46	9.58	206.00	24.50	144.50	7.50	9.62	7.50	9.63
Karanj seed powder	5	7.25	8.25	189.50	24.80	112.50	7.56	9.62	7.50	9.63
Neem seed kernel powder	5	6.92	7.29	187.50	25.47	108.50	7.38	9.50	7.38	9.44
Sweet flag rhizome powder	5	4.25	4.88	110.00	28.15	13.00	7.50	9.40	7.44	9.50
Undi oil	5	3.92	4.71	87.00	29.19	11.00	7.38	9.50	7.38	9.44
Neem oil	5	2.88	3.88	66.00	29.17	8.50	7.31	9.38	7.31	9.38
Karanj oil	5	3.29	4.13	81.00	29.80	10.50	7.38	9.50	7.38	9.44
Rantulas leaf powder	10	7.38	8.92	181.00	25.05	117.50	7.44	9.56	7.44	9.44
Karanj seed powder	10	5.92	6.25	143.00	25.80	80.50	7.44	9.44	7.38	9.44
Neem seed kernel powder	10	5.92	7.25	138.50	26.38	70.50	7.38	9.44	7.38	9.50
Sweet flag rhizome powder	10	2.42	2.92	64.50	29.05	9.00	7.44	9.50	7.38	9.44
Undi oil	10	2.29	2.04	0.00	0.00	0.00	—	—	—	—
Neem oil	10	1.21	1.34	0.00	0.00	0.00	—	—	—	—
Karanj oil	10	1.34	1.71	0.00	0.00	0.00	—	—	—	—
Untreated control	—	7.71	9.88	268.00	24.05	200.50	7.69	9.75	7.63	9.69
S.E. (m) ±	—	0.26	0.33	2.50	0.38	2.24	—	—	—	—
C.D. at 5 %	—	0.78	1.01	7.54	1.16	6.75	—	—	—	—
							NS*	NS	NS	NS

* Non Significant

different vegetable oils. Singh *et al.*(1978) also recorded similar observations with *C. maculatus* exposed to cowpea seed treated with groundnut oil.

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Seasonal Incidence, Host Preference and Host Shifts of *Helicoverpa armigera* (Hubner) in Pulse Based Cropping System

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ABSTRACT

More than 200 species of insect pests are reported in pigeonpea and more than 50 are recorded on chickpea. Among these, insect pests associated with reproductive phase of crop specially, the pod borer, *Helicoverpa armigera* Hub. cause huge economic losses and also elucidates the root cause for low productivity of pulses. The present study was framed to study the seasonal incidence of *Helicoverpa* in pigeonpea and chickpea and its correlation with weather parameters and pheromone trap catches. The data on incidence pattern of *Helicoverpa* larvae as per crop phenology and shift over in hosts was also recorded for its use as an input in the management strategies of pest. In pigeonpea, *Helicoverpa* larvae attained the peak in 45th meteorological week with 2.2 larvae plant-1. In chickpea it attained ETL in 43rd, 44th and 45th meteorological week with 1.4, 2.0 and 2.2 larvae plant-1. The maximum temperature (r value = 0.722**) and evaporation (r value = 0.830**) had significantly positive correlation with the larval population whereas, morning (r value = - 0.896**) and evening relative humidity (r value = - 0.686**) had significantly negative correlation with the *Helicoverpa* larval counts in the pigeonpea crop. The maximum temperature (r value = - 0.549*) and evaporation (r value = - 0.540*) had significantly negative correlation with the larval population in chickpea. The correlation of weather parameters did not reveal significant relation with the trap catches. Two peaks of pheromone traps in terms of male moths trapped in 44th (Year 2009) and 3rd (year 2010) meteorological week coincided with flowering phase of pigeonpea in kharif and semi rabi crop, respectively. Significantly positive correlation of pheromone trap catches with *Helicoverpa* larval incidence was observed in pigeonpea (r value = 0.570*) but correlation with larval incidence in chickpea was statistically non significant. The data on shift in crop by *Helicoverpa* in kharif and rabi pulses with reference to crop phenology reveals shift from mungbean and urdbean (with higher preference to sunflower in flowering stage) to pigeonpea and towards chickpea in later phase. The semi rabi pigeonea in flowering phase was preferred over chickpea towards pod formation and maturity.

Pigeonpea, *Cajanus cajan* and Chickpea, *Cicer arietinum* are most important kharif and rabi season pulse crop, respectively of Vidarbha (MS). Pulses not only improves the soil fertility by fixing the atmospheric nitrogen but also adds large quantity of organic matter to the soil (Nene and Sheila, 1990).

Although, the area and production of pigeonpea and chickpea is more in Maharshtra, the productivity is a matter of concern. The ravages of more than 200 species of insect pests in pigeonpea and more than 50 insect pests in chickpea elucidate the root cause for low productivity. Amongst these insect pests, insect pests associated with fruiting phase of crop specially, the pod borer (*Helicoverpa armigera* Hub.) is the major bottle neck in achieving higher productivity. In Maharashtra losses up to 46 per cent have been reported in pigeonpea but in certain regions and years it can cause losses in grain yield ranging from 60 per cent to complete loss of crop (Singh, 2005). In chickpea the incidence of *Helicoverpa* in vegetative stage seldom inflicts economic losses but under higher level of infestation in flowering and pod formation stage more than 50 per cent pod damage is not uncommon. (Durairaj *et al*, 2005).

The present study was framed to study the seasonal incidence of *Helicoverpa* in pigeonpea and chickpea and its correlation with weather parameters and pheromone trap catches. The data on incidence pattern of *Helicoverpa* larvae as per crop phenology and shift over in hosts was also recorded for its use as an input in the management strategies.

MATERIAL AND METHODS

Seasonal incidence of *Helicoverpa armigera* on pigeonpea and chickpea, was recorded at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) in 2009-10. The incidence of pod borer was recorded on medium duration pigeonpea variety, PKV TARA under

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rainfed condition from 40th to 5th meteorological week, whereas, the seasonal incidence of *Helicoverpa* on chickpea was recorded on Jaki – 9218 under rainfed condition from 42nd to 5th meteorological week. The observations were recorded on randomly selected plants in meter row of large plots of pigeonpea (15 rows of 4m length: 9.0 X 5.0 m) and chickpea (15 rows of 4m length : 4.5 X 5.0 m) under pesticide free conditions.

The pheromone traps were installed near the experimental plots to monitor the male moth catches. Thus, pheromone traps were rendered suitable for monitoring of *Helicoverpa* moths at central location. The correlation of trap catches and larval incidence was estimated as per Verma and Sankhyan (1993), who reported that pheromone trap catch in the (n-1)th week best coincided with larval activity on different hosts in the following week (n)th. The data on weather parameters was procured from Meteorology Observatory, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (n-1)th week observations of standard meteorological weeks were correlated with larval counts per plant on pigeonpea and chickpea in the following week (n)th.

The supporting data from major oilseed crop, kharif sunflower was also included as it supported the hypothesis of host shift over of *Helicoverpa*. The study of host preference behavior by *Helicoverpa* forms an important constituent of this study. The host selection preference was estimated on the basis of the larval incidence intensity.

RESULTS AND DISCUSSION

Seasonal incidence of *Helicoverpa* in pigeonpea

The *Helicoverpa* larval population on pigeonpea (Table 1) was recorded from 42nd meteorological week that increased gradually and attained a peak in 45th meteorological week with 2.2 larvae plant-1. The larval population then declined and was 0.2 larva plant-1 in 52nd meteorological week and no larval population from 1st meteorological week till maturity of the crop. Extended maturity period by 10-15 days was observed in medium duration pigeonpea variety on account of rains in 40th Meteorological week (67.8 mm) and 46th Meteorological week (97.8 mm). The incidence of *Helicoverpa* was low to moderate and it attained ETL in 43rd, 44th and 45th meteorological week with 1.4, 2.0 and 2.2 larvae plant-1. Almost steady declining population pattern was observed, except in 49th meteorological week may be on account of new flush induced as a result of showers in 46th meteorological week.

Seasonal incidence of *Helicoverpa* in chickpea

The larval population on chickpea (Table 1) was recorded from 48th meteorological week that increased gradually and attained a peak on 2nd meteorological week with 1.2 larva plant-1. The larval population then declined with no larval population in 5th meteorological week.

Correlation of weather parameters and larval incidence in pigeonpea

Data in Table 2 reveals simple linear correlation for association of weather parameters and *Helicoverpa* larval counts on pigeonpea. The maximum temperature (r value = 0.722**) and evaporation (r value = 0.830**) had significantly positive correlation with the larval population whereas, morning (r value = - 0.896**) and evening relative humidity (r value = - 0.686**) had significantly negative correlation with the *Helicoverpa* larval counts on pigeonpea. The findings of Yadava *et al* (1991) regarding abundance of *H. armigera* during 47th – 51st standard weeks and its significant positive correlation with maximum and minimum temperatures and significantly negatively correlation with relative humidity was in corroboration with the present findings.

Correlation of weather parameters and larval incidence in chickpea

Simple linear correlation was calculated for association of weather parameters and *Helicoverpa* larval counts on chickpea (Table 3). The maximum temperature (r value = - 0.549*) and evaporation (r value = - 0.540*) had significantly negative correlation with the larval population. Rains in 40th Meteorological week (67.8 mm) followed by dry spell may have favoured for larval population build up of *Helicoverpa*.

Pheromone trap catches and correlation with weather parameters

In case of male moth catches in standard meteorological weeks (Table 4) first peak was observed in 44th meteorological week coinciding with flowering phase of pigeonpea. There was decline in

Table : 1 - Seasonal incidence of *Helicoverpa* larvae on Pigeonpea (Kharif) and chickpea (Rabi) 2009-10.

Met Week	Dates	Weather Parameters at Agromet Observatory, Dr. PDKV, Akola									Helicoverpalarvae/ Plant	
		T max	T min	BSH	WS	RH I	RH II	Ev	RF	RD	Pigeonpea	Chickpea
40	01-07 Oct	34.3	24.5	5.6	5.5	83.0	49.0	6.5	6.8	2.0	0.0	0.0
41	08-14	32.2	23.7	4.1	4.3	90.0	60.0	4.3	67.8	4.0	0.0	0.0
42	15-21	32.9	19.8	8.1	4.4	90.0	33.0	5.1	0.0	0.0	0.4	0.0
43	22-28	34.9	17.8	7.8	1.5	81.0	23.0	5.7	0.0	0.0	1.4	0.0
44	29-04 Nov	33.8	14.7	6.7	1.6	74.0	19.0	5.6	0.0	0.0	2.0	0.0
45	05-11	34.4	14.3	6.8	1.6	70.0	17.0	6.4	0.0	0.0	2.2	0.0
46	12-18	31.0	19.1	4.1	2.1	81.0	50.0	4.9	5.0	1.0	0.6	0.0
47	19-25	29.3	21.7	3.6	1.6	92.0	58.0	3.5	97.8	3.0	0.6	0.0
48	26-02 Dec	27.5	13.1	7.9	1.1	89.0	35.0	3.8	0.0	0.0	0.2	0.2
49	03-09	28.8	12.2	7.2	1.3	82.0	29.0	4.0	0.0	0.0	0.8	0.2
50	10-16	29.6	13.5	5.4	1.0	85.0	33.0	3.5	0.0	0.0	0.4	0.4
51	17-23	30.5	15.1	4.9	0.8	88.0	34.0	3.4	0.0	0.0	0.2	0.4
52	24-31	29.0	14.7	5.1	2.1	86.0	36.0	3.3	0.7	0.0	0.2	0.2
1	01-07 Jan	27.4	12.2	4.8	1.7	76.0	33.0	3.8	14.0	1.0	0.0	0.4
2	08-14	27.2	10.8	6.8	1.2	85.0	34.0	4.0	0.0	0.0	0.0	1.2
3	15-21	28.2	13.5	5.1	2.4	86.0	37.0	3.3	3.9	0.2	0.0	1.0
4	22-28	27.5	10.8	7.3	1.0	85.0	30.0	3.5	0.0	0.0	0.0	0.4
5	29 Jan-04	29.4	10.2	7.6	0.9	69.0	22.0	4.7	0.0	0.0	0.0	0.0

Table 2. Seasonal incidence of *Helicoverpa* larvae on Pigeonpea and simple linear correlation with weather parameters.

T max	1									
T min	0.411	1								
BSH	0.173	-0.488	1							
WS	0.360	0.710	-0.063	1						
RH – I	-0.532	0.383	-0.285	0.295	1					
RH – II	-0.354	0.678	-0.749	0.396	0.705	1				
Ev	0.841	0.117	0.434	0.220	-0.746	-0.512	1			
RF	-0.063	0.721	-0.638	0.311	0.476	0.779	-0.252	1		
RD	0.003	0.786	-0.676	0.482	0.436	0.850	-0.179	0.925	1	
Ha	**0.722****	-0.144	0.345	-0.190	**-0.896****	**-0.686****	**0.830****	-0.266	-0.324	1
r value	T max	T min	BSH	WS	RH - I	RH - II	Ev	RF	RD	Ha

T max : Maximum temperature (°C), T min : Minimum temperature(°C), BSH : Bright Sunshine Hours, WS : Wind Speed (km/hr), RH – I : Morning Relative Humidity (%), RH – II : Evening Relative Humidity (%), Ev : Evaporation, RF : Rainfall (mm), RD : Rainy Days, Ha : Helicoverpa larvae per plant.

Table 3 : Seasonal incidence of *Helicoverpa* larvae on Chickpea and simple linear correlation with weather parameters

T max	1									
T min	0.323	1								
BSH	-0.121	-0.813	1							
WS	0.185	0.425	-0.514	1						
RH – I	-0.609	0.321	-0.357	-0.065	1					
RH – II	-0.399	0.720	-0.721	0.272	0.728	1				
Ev	0.816	0.015	0.264	0.123	-0.825	-0.544	1			
RF	-0.059	0.727	-0.539	0.115	0.404	0.686	-0.210	1		
RD	-0.025	0.814	-0.614	0.177	0.386	0.786	-0.136	0.959	1	
Ha	**-0.549***	-0.470	0.147	-0.054	0.304	-0.024	**-0.540***	-0.229	-0.310	1
r value	T max	T min	BSH	WS	RH – I	RH - II	Ev	RF	RD	Ha

T max : Maximum temperature (°C), T min : Minimum temperature(°C), BSH : Bright Sunshine Hours, WS : Wind Speed (km/hr), RH – I : Morning Relative Humidity (%), RH – II : Evening Relative Humidity (%), Ev : Evaporation, RF : Rainfall (mm), RD : Rainy Days, Ha : Helicoverpa larvae per plant.

the male moths trapped up to 51st meteorological week and again a peak of trapped moths was recorded in 3rd meteorological week with pigeonpea crop towards maturity and chickpea crop in pod formation stage. The second peak did not translate in higher incidence on chickpea but was justified in terms of higher level of incidence on semi rabi pigeonpea in flowering phase. Thus, the pheromone trap catches are indicative enough of the larval incidence in the next meteorological week.

The correlation of weather parameters did not reveal any significant relation with the *Helicoverpa* male moth trap catches in pulses (Table 5) and sunflower (Table 8). Choosang, (1994) also did not observe any correlations between moth catches and weather data thus, the results are in line of the present findings.

Correlation of pheromone trap catches and larval incidence:

Pheromone trap catches from 40th to 5th meteorological week (Table 5) values were correlated with *Helicoverpa* larval counts. The correlation of

Table 4 : Crop phenology, pheromone trap catches and incidence of *Helicoverpa* larvae on Pigeonpea (Kharif) and chickpea (Rabi) 2009-10.

Met Week	Crop Stage		Pheromone trap catches for Helicoverpa	Helicoverpa larvae/ Plant		
	Pigeonpea	Chickpea		Pigeonpea	Chickpea	Mean
40	Vegetative	-	3	0.0	0.0	0.0
41	Vegetative	-	5	0.0	0.0	0.0
42	Flowering	-	9	0.4	0.0	0.2
43	Flowering	Vegetative	11	1.4	0.0	0.7
44	Flowering	Vegetative	16	2.0	0.0	1.0
45	Flowering	Vegetative	12	2.2	0.0	1.1
46	Pod formation	Vegetative	17	0.6	0.0	0.3
47	Pod formation	Vegetative	12	0.6	0.0	0.2
48	Pod formation	Flowering	9	0.2	0.2	0.2
49	Pod formation	Flowerin	11	0.8	0.2	0.5
50	Pod formation	Flowerin	7	0.4	0.4	0.4
51	Pod formation	Pod formation	5	0.2	0.4	0.3
52	Pod formation	Pod formation	12	0.2	0.2	0.2
1	Maturity	Pod formation	15	0.0	0.4	0.2
2	Maturity	Pod formation	13	0.0	1.2	0.6
3	Maturity	Pod formation	22	0.0	1.0	0.5
4	Maturity	Maturity	11	0.0	0.4	0.2
5	Maturity	Maturity	5	0.0	0.0	0.0

Table 5 : *Helicoverpa* male moth catches in pheromone trap in pulses based cropping system and simple linear correlation with weather parameters.

T max	1									
T min	0.725	1								
BSH	0.447	-0.057	1							
WS	-0.142	0.404	-0.294	1						
RH I	0.845	0.666	0.325	-0.222	1					
RH II	0.423	0.784	-0.353	0.257	0.659	1				
Ev	-0.200	-0.018	0.030	0.524	-0.623	-0.430	1			
RF	0.019	0.477	-0.533	0.202	0.167	0.646	-0.177	1		
RD	-0.771	-0.189	-0.682	0.547	-0.742	-0.040	0.442	0.429	1	
TC	-0.048	-0.209	-0.111	-0.246	-0.006	-0.099	-0.167	-0.090	-0.155	1
r value	Tmax	T min	BSH	WS	RH I	RH II	Ev	RF	RD	TC

T max : Maximum temperature (°C), T min : Minimum temperature(°C), BSH : Bright Sunshine Hours, WS : Wind Speed (km/hr), RH – I : Morning Relative Humidity (%), RH – II : Evening Relative Humidity (%), Ev : Evaporation, RF : Rainfall (mm), RD : Rainy Days, Ha : Helicoverpa larvae per plant.TC : Pheromone trap catches of Helicoverpa.

pheromone trap catches with the larval population in peak incidence period shows significantly positive correlation in pigeonpea (r value = 0.570*) as well as chickpea, though statistically not significant (r value = 0.230) at p = 0.05.

Higher incidence of *Helicoverpa* on semi *Rabi* pigenpea in flowering while the chickpea attained pod maturity justifies the absence of strong correlation of pheromone trap catches with larval incidence on chickpea. Gupta *et al.*, 2002 reported insignificant (p=0.05) coefficient of correlation between the mean larval count on chickpea and weekly catch data in light and pheromone traps attributed it to the polyphagous nature of the pest. Though, on average larval counts plant-^{1} basis (pigeonpea and chickpea) had strong positive correlation with pheromone trap catches (r value = 0.502*).

Seasonal incidence and correlations trends of *H. armigera* on Sunflower

The data on incidence of *Helicoverpa armigera* on kharif sunflower (Table 7) was recorded in Oilseeds Research Unit field. The pheromone trap catches of male moths and weather parameters had weak correlation pattern with larval incidence (Table 8).

The increase in larval population during flowering stage clearly indicates the preference of *Helicoverpa* towards sunflower in flowering stage. Similar trend of higher ovipostion and larval abundance was reported by Ravi *et al.*, (2005).

Host behaviour

The study of host preference behavior by *Helicoverpa* forms an important constituent of this study. The host selection preference was estimated on the basis of the larval incidence intensity. It can be inferred from the present study that the host preference of *Helicoverpa* was pigeonpea> sunflower> chickpea> mungbean and urdbean in the descending order. The larval incidence especially in the flowering phase of different crops has strong correlation pattern, on the contrary it do not show consistent correlation trends with crops, weather parameters and even the pheromone trap catches.

The major external stimuli for incidence of *Helicoverpa armigera* is the flowering in host plants which incline the moths for oviposition. Hopper (1981) reported that the flowering acts as a long range distance attractants. Firempong and Zalucki (1989)reported that the presence of flowers greatly increased a plant's attractiveness to oviposition. Non-hosts, on which larvae did not survive, were readily oviposited on when offered in flower along with known hosts not in flower, support the hypothesis and inferences of the present study.

Association of larval incidence and crop phenology

The *Helicoverpa* larval population build up pattern in pigeonpea was as per the crop phenology (Table 4). Broadly, the incidence was highly correlated with buds and flowering phase of pigeonpea as compared to pod formation. Towards maturity, no population was observed on pigeonpea. Data on similar lines is reported by Rao *et al* (2001) about the higher incidence of pod borer on pigeon pea in flowering stage.

On account of rains in 40th Meteorological week (67.8 mm), the sowing was delayed in chickpea. In case of chickpea, the vegetative stage had literally no *Helicoverpa* infestation. There was slight increase in the *Helicoverpa* larval counts from flowering stage and it crossed ETL only during pod formation stage (2nd meteorological week).

First peak of larval incidence of *Helicoverpa* was observed in 36-40th meteorological week, next peak was recorded during 42-45th meteorological week and third peak was recorded in 51-03rd meteorological week. The first peak was associated with flowering stage in kharif sunflower, second peak was correlated with flowering in pigeonpea, whereas, third peak had influence of pod formation stage of chickpea. Also, the higher percentage of pod borer damage in semi rabi pigeonpea crop is indicative of the fact that the *Helicoverpa* incidence was higher on semi rabi pigeonpea crop in the later phase.

Shift in host

Helicoverpa completes 5-6 generations in a year. In case of pulses the *Helicoverpa* larval incidence (Table 6) was observed firstly on mungbean and urdbean in pod formation stage (Data not included) while, the pigeonpea crop was in the vegetative phase, indicating the preference of noctuid towards fruiting bodies with higher protein content. While the incidence on mungbean and urdbean was low to moderate, the incidence on sunflower was on the higher side indicating higher

Table 6 : Crop phenology based shift in incidence of *Helicoverpa* larvae from Pigeonpea (Kharif) to chickpea (Rabi) 2009-10.

Crop Stage						Helicoverpa larvae/ Plant		
Met. Week	Sunflower	Met. Week	Pigeonpea	Met. Week	Chickpea	Sunflower	Pigeonpea	Chickpea
30-34	Vegetative	40 – 41	Vegetative	43 – 47	Vegetative	-	-	-
35	Star Bud	42 – 45	Flowering	48 – 50	Flowering	-	++	+
36-40	Flowering	46 – 52	Pod formation	51 – 03	Pod formation	++	+	++
41-42	Maturity	01 – 05	Maturity	04 – 05	Maturity	+	-	+

+: Presence and intensity of *Helicoverpa* larval incidence and -: Absence of larval incidence

Table: 7 - Seasonal incidence of Helicoverpa on sunflower crop Variety – Modern in kharif 2009-10.

Met. Week	Temp (Max)	Temp (Min)	RH - I	RH - II	RF mm	Trap catches	Larva/ plant	Crop Phenology
34	32.8	24.9	77	49	0.0	0	0	Vegetative
35	31.1	22.8	94	73	65.7	0	0	Star bud stage
36	30.2	23.5	91	68	2.9	2	0	Flowering
37	30.3	23.3	93	67	30.2	3	0	Flowering
38	33.2	22.9	85	43	0.0	2	0	Flowering
39	35.2	22.8	81	34	2.1	0	1.1	Flowering
40	34.3	24.5	83	49	6.8	0	1.6	Flowering
41	32.2	23.7	90	60	67.8	2	1.2	Maturity
42	32.9	19.8	90	33	0.0	3	0	Maturity

Table 8 : *Helicoverpa* larval incidence and male moth pheromone trap catches in sunflower and simple linear correlation with weather parameters.

Ha	1							
Met. Week	0.544	1						
RF	0.123	-0.023	1					
RH - I	-0.316	0.093	0.598	1				
RH - II	-0.234	-0.535	0.654	0.625	1			
T Max	0.619	0.448	-0.415	-0.743	-0.837	1		
T Min	0.325	-0.509	0.095	-0.424	0.394	-0.016	1	
TC	-0.399	0.380	-0.007	0.575	0.047	-0.486	-0.527	1
r value	Ha	Met Week	RF	RH - I	RH - II	T Max	T Min	TC

T max : Maximum temperature (°C), T min : Minimum temperature(°C), RH – I : Morning Relative Humidity (%), RH – II : Evening Relative Humidity (%), RF : Rainfall (mm), Ha : Helicoverpa larvae per plant. TC : Pheromone trap catches of Helicoverpa.

pheromone trap catches with the larval population in peak incidence period shows significantly positive correlation in pigeonpea (r value = 0.570*) as well as chickpea, though statistically not significant (r value = 0.230) at p = 0.05.

Higher incidence of *Helicoverpa* on semi *Rabi* pigenpea in flowering while the chickpea attained pod maturity justifies the absence of strong correlation of pheromone trap catches with larval incidence on chickpea. Gupta *et al.*, 2002 reported insignificant (p=0.05) coefficient of correlation between the mean larval count on chickpea and weekly catch data in light and pheromone traps attributed it to the polyphagous nature of the pest. Though, on average larval counts plant-^{1} basis (pigeonpea and chickpea) had strong positive correlation with pheromone trap catches (r value = 0.502*).

Seasonal incidence and correlations trends of *H. armigera* on Sunflower

The data on incidence of *Helicoverpa armigera* on kharif sunflower (Table 7) was recorded in Oilseeds Research Unit field. The pheromone trap catches of male moths and weather parameters had weak correlation pattern with larval incidence (Table 8).

The increase in larval population during flowering stage clearly indicates the preference of *Helicoverpa* towards sunflower in flowering stage. Similar trend of higher ovipostion and larval abundance was reported by Ravi *et al.*, (2005).

Host behaviour

The study of host preference behavior by *Helicoverpa* forms an important constituent of this study. The host selection preference was estimated on the basis of the larval incidence intensity. It can be inferred from the present study that the host preference of *Helicoverpa* was pigeonpea> sunflower> chickpea> mungbean and urdbean in the descending order. The larval incidence especially in the flowering phase of different crops has strong correlation pattern, on the contrary it do not show consistent correlation trends with crops, weather parameters and even the pheromone trap catches.

The major external stimuli for incidence of *Helicoverpa armigera* is the flowering in host plants which incline the moths for oviposition. Hopper (1981) reported that the flowering acts as a long range distance attractants. Firempong and Zalucki (1989)reported that the presence of flowers greatly increased a plant's attractiveness to oviposition. Non-hosts, on which larvae did not survive, were readily oviposited on when offered in flower along with known hosts not in flower, support the hypothesis and inferences of the present study.

Association of larval incidence and crop phenology

The *Helicoverpa* larval population build up pattern in pigeonpea was as per the crop phenology (Table 4). Broadly, the incidence was highly correlated with buds and flowering phase of pigeonpea as compared to pod formation. Towards maturity, no population was observed on pigeonpea. Data on similar lines is reported by Rao *et al* (2001) about the higher incidence of pod borer on pigeon pea in flowering stage.

On account of rains in 40th Meteorological week (67.8 mm), the sowing was delayed in chickpea. In case of chickpea, the vegetative stage had literally no *Helicoverpa* infestation. There was slight increase in the *Helicoverpa* larval counts from flowering stage and it crossed ETL only during pod formation stage (2nd meteorological week).

First peak of larval incidence of *Helicoverpa* was observed in 36-40th meteorological week, next peak was recorded during 42-45th meteorological week and third peak was recorded in 51-03rd meteorological week. The first peak was associated with flowering stage in kharif sunflower, second peak was correlated with flowering in pigeonpea, whereas, third peak had influence of pod formation stage of chickpea. Also, the higher percentage of pod borer damage in semi rabi pigeonpea crop is indicative of the fact that the *Helicoverpa* incidence was higher on semi rabi pigeonpea crop in the later phase.

Shift in host

Helicoverpa completes 5-6 generations in a year. In case of pulses the *Helicoverpa* larval incidence (Table 6) was observed firstly on mungbean and urdbean in pod formation stage (Data not included) while, the pigeonpea crop was in the vegetative phase, indicating the preference of noctuid towards fruiting bodies with higher protein content. While the incidence on mungbean and urdbean was low to moderate, the incidence on sunflower was on the higher side indicating higher

Table 6 : Crop phenology based shift in incidence of *Helicoverpa* larvae from Pigeonpea (Kharif) to chickpea (Rabi) 2009-10.

Crop Stage						Helicoverpa larvae/ Plant		
Met. Week	Sunflower	Met. Week	Pigeonpea	Met. Week	Chickpea	Sunflower	Pigeonpea	Chickpea
30-34	Vegetative	40 – 41	Vegetative	43 – 47	Vegetative	-	-	-
35	Star Bud	42 – 45	Floweing	48 – 50	Floweing	-	++	+
36-40	Floweing	46 – 52	Pod formation	51 – 03	Pod formation	++	+	++
41-42	Maturity	01 – 05	Maturity	04 – 05	Maturity	+	-	+

+: Presence and intensity of *Helicoverpa* larval incidence and -: Absence of larval incidence

Table: 7 - Seasonal incidence of Helicoverpa on sunflower crop Variety – Modern in kharif 2009-10.

Met. Week	Temp (Max)	Temp (Min)	RH - I	RH - II	RF mm	Trap catches	Larva/ plant	Crop Phenology
34	32.8	24.9	77	49	0.0	0	0	Vegetative
35	31.1	22.8	94	73	65.7	0	0	Star bud stage
36	30.2	23.5	91	68	2.9	2	0	Flowering
37	30.3	23.3	93	67	30.2	3	0	Flowering
38	33.2	22.9	85	42	0.0	2	0	Flowering
39	35.2	22.8	81	34	2.1	0	1.1	Flowering
40	34.3	24.5	83	49	6.8	0	1.6	Flowering
41	32.2	23.7	90	60	67.8	2	1.2	Maturity
42	32.9	19.8	90	33	0.0	3	0	Maturity

Table 8 : *Helicoverpa* larval incidence and male moth pheromone trap catches in sunflower and simple linear correlation with weather parameters.

Ha	1							
Met. Week	0.544	1						
RF	0.123	-0.023	1					
RH - I	-0.316	0.093	0.598	1				
RH - II	-0.234	-0.535	0.654	0.625	1			
T Max	0.619	0.448	-0.415	-0.743	-0.837	1		
T Min	0.325	-0.509	0.095	-0.424	0.394	-0.016	1	
TC	-0.399	0.380	-0.007	0.575	0.047	-0.486	-0.527	1
r value	Ha	Met Week	RF	RH - I	RH - II	T Max	T Min	TC

T max : Maximum temperature (°C), T min : Minimum temperature(°C), RH – I : Morning Relative Humidity (%), RH – II : Evening Relative Humidity (%), RF : Rainfall (mm), Ha : Helicoverpa larvae per plant. TC : Pheromone trap catches of Helicoverpa.

preference for sunflower in flowering phase and shift over in population after sunflower maturity to pigeonpea. This shift over can be inferred from no larval population on sunflower in 42nd meteorological week to higher incidence on pigeonpea in flowering phase (48th meteorological week).

Higher incidence of pod borer on pigeonpea in flowering and early pod formation stage was observed from 42nd to 45th meteorological week with apparently no incidence on chickpea, the later being in vegetative phase. There was gradual decrease in larval counts on pigeonpea from 46th to 52nd meteorological week whereas, chickpea in flowering phase had reverse trend. Gradual increase in *Helicoverpa* incidence on chickpea was observed in pod formation while pigeonpea towards maturity had no incidence. Mundiwale *et al* (1978) reported migrating pattern of *H. armigera* from sunflower to cotton which supports the present findings. Venugopal Rao *et al* (1992) reported shift in *H. armigera* population from mungbean to cotton and towards pigeonpea and chickpea in later phase supporting the findings of present studies.

At the same phase the semi rabi pigeonpea sowned in second fortnight of September (Data not included) had higher *Helicoverpa* incidence which falls in line with the findings of Firempong and Zalucki (1990) reported positive influence of flowers presence on account of its increased attractiveness in oviposition by *H. armigera*.

There is evident shift in larval counts per plant from pigeonpea to chickpea as the former crop was towards maturity stage and the chickpea being more lucrative option. Also, higher level of per cent pod damage in semi rabi pigeonpea plots is indicative of the fact that the flowering and early pod formation stage received more incidence as compared to maturing pods of the pigeonpea. There seems to be a pattern of *Helicoverpa* shift in pulses from mungbean and urdbeans to pigeonpea and towards chickpea in later phase with initial population built up from kharif sunflower. Even the semi rabi pigeonea in flowering phase was more attractive to *Helicoverpa* as compared to chickpea towards pod formation or maturity. Overall pigeonpea was the most preferred host amongst the pulses. Similar type of results were reported by Ramnath *et al* (1992).

Management

The management strategies presently in use seldom address the issue of behavioural manipulation methods for the management of *Helicoverpa armigera* but concentrates on use of transgenic crops, conventional host plant resistance, and use of pesticides on a large scale (White *et al*, 1996). A considerable potential exists for the manipulation of cropping systems to incorporate diversionary hosts (a trap crop), thus maximising the difficulty of *Helicoverpa* populations invading valuable crops, and providing refuges for beneficial organisms (Fitt, 1989). On similar lines possibility of utilization of semi rabi pigeonpea as a trap crop for chickpea can help in behavioural manipulation and management of the pest. Also, calendar based management strategy of *Helicoverpa* targeting the higher incidence in flowering phase can certainly reduce the cost of plant protection and improve the level of management.

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Evaluation of Insecticides Against Pink Bollworm

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ABSTRACT

Popular insecticides used in cotton ecosystem were evaluated against pink bollowrm during *Kharif* 2006-2007 at Cotton Research Station, Nanded, Maharashtra. The experiment was laid- out in RBD with variety PHH-316 and replicated thrice with seven treatments. Twenty green bolls were split open and observed for pink bollowrm larvae on 110 125 and 135 days after sowing. The lowest incidence of 0.33 pink bollworm larvae 20^{-1} green bolls was observed in thiodicarb 75 SP@ 750 g a.i. ha^{-1} . The next best treatmet lambda-cyhalothrin 5 EC @ 25 g a. i. ha^{-1} recorded 1.11 larvae 20^{-1} green bolls which was at par with the treatment thiodicarb.

The lowest per cent of green boll damage, open boll damage and higher yields were recorded in thiodicarb 75 SP @ 750 g a. i. ha^{-1}. The next effective treatments were lambdacyhalothrin, profenofos, cypermethrin and chlorpyriphos.

Cotton is an important fibre crop of global significance, cultivated in more than seventy countries. It is an important raw material for the Indian textile industry and plays a key role in the national economy in terms of both employment generation and foreign exchange earnings.

In India, the area under cotton crop is 9.60 million hectare with production of 310 lakh bales and the productivity is 555 kg lint ha^{-1} as against the world average of 794 kg lint ha^{-1} (Anonymous, 2008). Insect pest attack is the most serious limiting variable in the successful cultivation of cotton crop (Agarwal, 1978). Cotton jassids, whiteflies, aphids, thrips and three bolloworms are serious pests which cause 50 to 60 per cent loss in seed cotton (Dhawan *et al.*, 1998). Among the bollworms, the pink bollworm, Pectinophora gossyiella saundersm activity has become more pronounced in the recent ast. It is one of the most destructive and serious pests of cotton, The pest activity was reported to be continouing even after harvet causing upto 35 per cent yield loss, while country' loss due to this pest was estimated at 6535 metric tones of lint worth Rs. 1,216 million (Agarwal and Katiyar, 1979). The insecticides sprayed for the control of other bollworms, notabley American bollowrm are found to be inadequate to suppress the pink bollworm incidence.

The present investigation was undertaken with a view to study the relative bio-efficacy of popular insecticides against pink bollworm.

MATERIAL AND METHODS

A field experiment was conducted at Cotton Research Station, Nanded during 2006-07 with seven treatments replicated thrice in RBD. The Cotton hybrid PHH-316 was sown at 60 x 60 cm spacing under rainfed condition. Spraying of insecticide treatments was commenced when the pink bollworm (PBW) infestation reached the econmic threshold level (ETL) of 10 per cent incidence on fruiting bodies.

For recording PBW incidence, five plants were selected at random from each treatment and the observations on green boll damage, loculii damage green bolls and PBW larvae in 20 green bolls were recorded 110, 125 and 140 days after sowing (DAS) and means were worked out.

Observations on open boll damage and locule damage were recorded at harvest and percentages were worked out. The seed cotton yield was recorded plot-wise in separate pickings and worked out as q ha^{-1}. The experimental data were subjected to statistical analysis.

RESULTS AND DISCUSSION

The data persented in Table 1 indicated significant differnt among the insecticide treatments in reducing pink bollworm incidence and increasing the seed cotton yield.

PBW larvae 20 green bolls $^{-1}$

The data indicated that the mean number of PBW larvae 20^{-1} green bolls varied from 0.33 to 2.89 in all the treatments including control. The least incidence of PBW larvae (0.33 lavae 20^{-1} green bolls) was observed in thiodicarb @ 750 g a.i. ha^{-1} which was follwed by λ - cyhalothrin @ 25 g a .i. ha^{-1} (1.11

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Table 1: Effect of different insecticides on pink bollworm infestation

S.N.	Treatments	PBW larvae 20^{-1} green bolls*	% Green boll damage*	% Locule Damage*	GOB 5^{-1} Plants	Bob 5^{-1} plants	Open boll Damage	Locule Damage	Yield (q ha^{-1})
1	Profenofos 50 EC500 g a i. ha^{-1}	1.78	5.56	2.23	105.67	14.33	11.00	6.15	11.00
		(1.50)**	(13.60)	(8.52)	(10.29)	(3.80)	(19.29)	(14.32)	
2	Chloropyriphos 20EC 500 g a i. ha^{-1}	2.00	6.11	2.50	102.00	20.00	13.28	7.08	10.07
		(1.57)	(14.20)	(9.01)	(10.10)	(4.50)	(21.35)	(15.39)	
3	Quinalphos 25 EC500 g a i. ha^{-1}	2.33	7.78	2.93	109.00	18.67	12.71	6.63	10.60
		(1.68)	(16.04)	(9.86)	(10.45)	(4.34)	(20.86)	(14.90)	
4	Thiodicarb 75 SP750 g a i. ha^{-1}	0.33	1.11	0.42	121.67	16.33	7.28	3.90	16.00
		(0.91)	(4.94)	(3.71)	(11.04)	(4.09)	(15.61)	(11.37)	
5	λ-cyhalothrin 5 EC25 g a i. ha^{-1}	1.11	3.33	1.40	112.00	17.00	9.91	5.25	14.07
		(1.25)	(10.51)	(6.67)	(10.59)	(4.15)	(18.34)	(13.20)	
6	Cypermethrin 25 EC 120 g a i. ha^{-1}	1.33	4.44	1.67	107.00	15.33	11.65	5.93	12.60
		(1.32)	(9.97)	(7.03)	(10.35)	(3.92)	(10.90)	(14.09)	
7	Control	2.89	8.89	3.62	85.67	19.33	15.93	9.16	7.87
		(1.83)	(17.32)	(10.94)	(9.25)	(4.45)	(23.49)	(17.57)	
	F test	Sig	Sig	Sig			Sig	Sig	Sig
	SE(m)±	0.11	2.38	0.85	0.40	0.35	0.88	0.62	1.35
	CD at 5%	0.34	7.32	2.64	1.24	1.09	2.71	1.93	4.18
	CV%	13.31	33.32	18.67	6.81	14.80	7.69	7.54	20.04

PBW larvae 20^{-1} green bolls). Both these treatments were at par with each other. The next treatments in order of relative efficacy were by permethrim @ 120 g a. i. ha^{-1}, profenofos @ 500 g a i. ha^{-1} and chloropyriphos @ 500 g a i. ha^{-1} in which 1.33, 1.78 and 2.00 PBW larvae 20^{-1} green bolls were observe, respectively and all of these treatments were found at par with each other.

Per cent green boll damge

The lowest per cent green boll damage was recorded in thiodicarb @ 750 g a i. ha^{-1} (1.11 %). It was followed by cypermethrim 10 EC @ 120 g a i. ha^{-1} and λ-cyhalothrin @ 25 g a i. ha^{-1} in which the green boll damage was 4.44 per cent and 3.33 per cent, respectively. Maximum per cent green boll damage (8.89%) was observed in untreated control plot.

Per cent locule damage in green bolls

The results of mean loculii damage in green bolls indicated that the treatment thiodicarb @ 750 g a i. ha^{-1} was found to be the most effective against pink bollworm by recording lowest damage of 0.42 per cent and was found at par with cypermethrin, λ-cyhalothrin and profenofos in which 1.67, 1.40 and 2.23 per cent loculii damage was recorded.

Good opened bolls 5 plants $^{-1}$

Though, the differences found were non significant, the treatment thiodicarb @ 750 g a i. ha^{-1} recorded the highest of 121.67 good opened bolls 5 $plants^{-1}$, followed by λ-cyhalothrin @ 25 g a i. ha^{-1} which recorde 112 good opened bolls 5 $plants^{-1}$. The lowest of 45.33 good opened bolls 5 $plants^{-1}$ were observe in control plot.

Bad opened bolls 5 plants $^{-1}$

Maximum of 19.33 bad opened bolls 5 $plants^{-1}$ were observed in the untreated control whereas the last bad opened bolls (14.33 5 $plants^{-1}$) were observed in profenofos @ 500 g a i. ha^{-1}. All the treatments includ in untreated control found at par with each other for this parameter.

Open boll damage

The treatments thiodicarb @ 750 g a i. ha^{-1} was found most effective by recording least open boll damage (7.28 %), followed by λ-cyhalothrim @ 25 g a i. ha^{-1} which recorded 9.91 per cent open boll damage. The next best treatments in order to effectiveness were profenofos @ 500 g a i. ha^{-1} (11.00 %), cypermethrin @ 120 g a i. ha^{-1} (11.65%) and quinalpohos @ 500 g a i. ha^{-1} (12.71%). Maximum of 15.93 per cent open boll damage was observed in the untreated control.

Locule damage

The treatment with thiodicarb @ 750 g a i. ha^{-1} proved to be highly effective in pink bollworm management by recording least locule damage locule damage of 3.90 per cent and was at par with λ-cyhalothrin @ 25 g a i. ha^{-1} which recorded 5.25 per cent locule damage. The next promising treatments were cyhalothrim @ 120 g a i. ha^{-1}, profenofos @ 500 g a i. ha^{-1}, quinalphos @ 500 g a i. ha^{-1} and chloropyriphos @ 500 g a i. ha^{-1} which were at par with each other by recording 5.93, 6.15,6.63 and 7.08 per cent locule damage.

Effect on seed cotton yield

All the insecticide treatments recorded significantly higher seed cotton yield in the range of 10.07 to 16.00 q ha^{-1} than that of untreated control (7.87 q ha^{-1}). The treatmenht with was at par with @ 500 g a i. ha^{-1} recorded the highest seed cotton yield of 16.00 q ha^{-1} which was at par with λ-cyhalothrim 5 EC @ 25 g a i. ha^{-1} (14.07 q ha^{-1}). The next best treatments in the order of effectiveness were cypermethrin 25 EC @ 120 g a i. ha^{-1} and profenofos 50 EC @ 500 g a i. ha^{-1} in which seed cotton yield of 12.60 and 11.00 q ha^{-1} was obtained, respectively.

It clearly indicates effectiveness of insecide treatment in controlling bollworm of cotton which results in higher seed cotton yield.

Bioefficacy of λ-cyhalothrin, thiodicarb and profenofos against pink bollworm on cotton was reportedby several workers. Vadodaria *et al.* (2000) observed that profenofos 50 EC @ 1000 g a i. ha^{-1} and thiodicarb 75 WP @ 750 g a i. ha^{-1} was found effective in reducing damage to squares, bolls and ocules and thereby producing higher seed cotton yield. Lavekar (2001) reported that λ-cyhalothrin 5EC @ 15 and 20 g a i. ha^{-1} and profenofos 50 EC @ g a i. ha^{-1} were most effective in controlling bollworms and recorded higher seed cotton yield. Kalaiselvi *et al.* (2006) reported that λ-cyhalothrin 5 CS formulation @ 20, 25 and 30 g a i. ha^{-1} was found to be effective in reducing the cotton bollworm incidence. The present findings are in conformity with the reports on effectiveness of λ-cyhalothrin 5 EC, profenofos 50 EC and thiodicarb 75 WP against bollworms as reported by Martin *et al.* (1988), Gopala Swamy *et al.* (2000) and Patil *et al.* (2004).

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Land Utilization and Cropping Pattern Followed by the Farmers Those Committed Suicide in Vidarbha Region

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ABSTRACT

Majority of area under cultivation was concentrated under rainfed condition and a negligible area was observed under irrigation, Rabi cropping and horticultural crops. Majority of the victim's households had taken only single rainfed crops during Kharif season and probably having the greater risk of yield uncertainty due to monsoon vagaries. Low production and productivity of almost all crops was recorded by suicide victims of Vidarbha. This was due to rainfed farming coupled with repeated crop failure. The monsoon vagaries were blamed for crop failures. Lack of remunerative prices in market for obtained produce was also recorded and found closely linked with farmer's distress in Vidarbha region of Maharashtra.

Farmers' suicide has become a major issue of our time, even though both state and central governments tried to sweep the crisis. This is now public policy concern and has been scholarly attention. As per Government record, total 5036 farmers, committed suicide during 2001 to 2008 in suicide hit six districts of Vidarbha, where PM's Package is going to implement. These districts are Yavatmal, Buldana, Amravati, Akola, Washim from Amravati revenue division and Wardha from Nagpur revenue division. Durkhem (2002) pointed that the neurobiological and socio-economic dimensions of risk factors are responsible for committing suicide but the intersection of these two sets where the relative risk of committing suicide is higher.

Suicide is a complex and multifaceted phenomenon. Some important correlates can be identified either in the neurobiologi-cal domain [Mann 2002] or in the socio-economic domain (Durkheini 2002 (1897)]. The former are predisposing in nature. They are internal factors that exist in the individual. All those identified with these factors do not commit suicide. The presence of additional factors that are external to the individual becomes crucial. This takes us to the socio-economic factors that are precipitating in nature – they can act as a trigger. These can be either systemic or idiosyncratic. The current research exercise identifies the land use pattern, cropping pattern and productivity of victims' households from last two years of incidence because all these factors contribute directly to gross income and social web of the farmer.

MATERIAL AND METHODS

The study was conducted in highly suicide concentrated six districts of Vidarbha namely Yavatmal, Washim, Buldana, Akola, Amravati and Wardha by conducting field survey with exploratory design of social research. In this study the respondents were the households of selected victims, those who committed suicide during January 2006 to December 2006 and had been declared as legal victims. In all, 200 legal victims' households constituted the sample of the study. Victims were selected with the help of proportionate random sampling method, which covered 178 villages and 34 *tahsils* of six districts. As suicide is a sensitive social issue and thus the investigation has to be made with very guarded and careful manner, and without hurting the sentiments of the family. Data were collected by personal interview method with the help of structured interview schedule.

RESULTS AND DISCUSSION

Production and productivity of farm crops have direct relation with annual gross income of an individual farmer. In present study, it was assumed that in most of the deceased farmers heavy losses were occurred in annual gross income due to low productivity or crop failures during preceding years, due to monsoon vagaries and absence of irrigation facilities. Hence, productivity of different crops, grown by the victim's households during 2004-2005 and 2005-2006 has been studied.

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Before exploring the productivity of the selected households, it is quite essential to understand the information about the land utilization pattern and cropping pattern of the selected victims.

Land Utilization Pattern

The land utilization pattern indicates the area of land actually utilized by the selected households for different purposes and under different type of cultivation like crop production, rainfed or irrigated, double or multiple cropping, etc. The land utilization of selected victim's households during 2005-2006 has been presented in Table 1. From Table 1, it is observed that the net sown area to total land-holding area was 98.18 per cent, while fallow land was only 1.82 per cent. While studying land utilization pattern of selected victims it was surprisingly noted that 88.56 per cent of total land holding area were observed under rainfed condition. Whereas, the contribution of irrigated area was noted as negligible i.e. 9.03 per cent area under seasonable and 0.59 per cent area under annual irrigation. The percentage of irrigated area was observed to be negligible among the selected households and hence cropping intensity was only 105.00 per cent.

The area sown more than once was noted only 8.68 per cent of total land holding area. It might be due to absence of irrigation facilities that restricted the respondents from double and triple cropping.

Cropping pattern

Cropping pattern of selected victims' household during the year 2004-2005 and 2005-2006 has been worked out in terms of percentage share of individual crops in gross cropped area and presented in Table 2.

An examination of data presented in Table 2 shows that *Kharif* cotton and soybean crops dominated the cropping pattern of selected households. The proportion of area under *Kharif* cotton and soybean was 41.89 per cent and 32.51 per cent, respectively during the year 2004-2005. While the proportion of area under *Kharif* cotton was decreased in 2005-2006 by 5.35 per cent, whereas the area under soybean was slightly increased by 1.17 per cent during 2005-2006. The data also point out that although overall cotton area was decreased by 5.35 per cent during 2005-2006, but area under Bt cotton was increased by 2.64 per cent over previous year.

Next to cotton and soybean nearly equal proportion of area (nearly 10.00 %) under *Jowar* crop was observed, followed by *Tur* (approximately 6.00 to 8.00 %). Whereas share of *Udid*, *Mung*, Maize added a negligible area in total gross cropped area during both the years.

The proportion of total area under *Kharif* crops was 95.15 and 91.60 per cent during 2004-2005 and 2005-2006, respectively. While the area under *Rabi* crop was very meager (1.79 %) during the year 2004-2005, it might be due to drought year and the same was slightly increased by 3.57 per cent in next year i.e. during 2005-2006. The share of horticultural crops was also negligible (nearly 3.00 %) during both the years in total gross cropped area.

Thus it could be concluded that over 70.00 per cent area was cultivated by taking only rainfed

Table 1: Land utilization pattern of selected victims' households (2005-06)

S.N.	Particulars	Total areain ha.	Average area in ha. household^{-1}
1.	Total land holding	439.19 (100.00)	2.20
2.	Total fallow land	8.00 (1.82)	0.04
3.	Total net sown/ cultivated area	431.19 (98.18)	2.16
4.	Total irrigated area (annual)	2.60 (0.59)	0.01
5.	Total irrigated area (seasonal)	39.64 (9.03)	0.20
6.	Total rain fed area	388.95 (88.56)	1.94
7.	Total area sown more than once	38.10 (8.68)	0.19
8.	Total gross cropped area(Area under *Kharif, Rabi,* Summer and Horticultural crops)	453.64 (103.29)	2.27
9.	Cropping intensity (%)	105.00 %	

(Figures in parenthesis indicate the percentage to total land holding.)

Table 2 :Cropping pattern of selected victims' households during 2004-05 and 2005-06

S.N.	Particulars	Area in ha.2004-05	Area in ha.2005-06
	A. *Kharif*		
1.	Cotton	183.24 (41.89)	165.80 (36.54)
	i) Bt. cotton	8.40 (1.92)	20.70 (4.56)
	Ii) Non Bt. cotton	174.84 (39.97)	145.10 (31.98)
2.	Soyabean	142.20 (32.51)	153.60 (33.68)
3.	*Jowar*	42.30 (9.67)	42.64(9.40)
4.	*Tur*	30.30(6.93)	35.00 (7.72)
5.	*Mung*	7.30(1.67)	6.40(1.41)
6.	*Udid*	5.50(1.26)	4.80(1.06)
7.	Maize	2.20(0.50)	5.70(1.26)
8.	Sunflower	1.60(0.36)	—
9.	*Til*	0.40(0.09)	—
10.	Groundnut	—	0.40(0.09)
11.	Sugar-cane	1.20(0.27)	1.20(0.26)
	Total *Kharif*	416.24(95.15)	415.54(91.60)
	B. Rabi		
12.	Wheat	2.00(0.46)	11.70(2.58)
13.	Gram	5.20(1.19)	8.70(1.92)
14.	Onion	0.60(0.14)	1.60(0.35)
15.	Safflower	—	2.30(0.51)
	Total *Rabi*	7.80(1.79)	24.30(5.36)
	C. Horticultural crops		
16.	Orange (mandarin)	10.80(2.47)	10.80(2.38)
17.	Floriculture	1.40(0.32)	1.40(0.31)
18.	Vegetables	1.20(0.27)	1.60(0.35)
	Total Horticultural crops	13.40(3.06)	13.80(3.04)
	Gross cropped area	437.44 (100.00)	453.64 (100.00)

(Figures in parenthesis indicate the percentage to total gross cropped area.)

cotton and soyabean crops in *Kharif* season, by selected deceased farmers. While a negligible area was under *Rabi* and horticultural crops, it might be due to lack of irrigation facilities.

Productivity

Productivity refers to the agricultural production per unit area. The average crops yield of victims' households in q /ha during 2004-2005 and 2005-2006 has been computed along with number of households who cultivated that particular crops and has been presented at a glance in Table 3.

It is quite evident from Table 3 that the average productivity of all crops during 2004-2005 was very low, it might be due to the drought year. The individual crop wise productivity of the victims' household in terms of yield in q/ha during the year 2004-2005 and minimum and maximum expected yield level of respective crops under rainfed condition as per the recommendations published in *Krushi Sanwadini* 2007 by Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola were presented in bracket as : Cotton: 2.39 q ha^{-1} (7 to 15 q ha^{-1}), Soybean : 3.17 q ha^{-1} (15-25 q ha^{-1}), *Jowar* : 4.63 q ha^{-1} (35-50 q ha^{-1}), *Tur* : 1.96 q ha^{-1} (8-15 q ha^{-1}), *Mung* : 2.23 q ha^{-1} (6-12 q ha^{-1}) and in *Udid* : 1.50 q ha^{-1} (8 -12 q ha^{-1}).

During 2005-2006 yields were: Cotton: 4.38 q ha^{-1}, Soybean: 6.42 q ha^{-1}, *Jowar*: 7.85 q ha^{-1}, *Tur*: 5.86 q ha^{-1}, *Mung*: 1.67 q ha^{-1} and in *Udid*: 3.59 q ha^{-1}.

Table 3: Average Productivity of major crops of selected victims' households during 2004-05 and 2005-06

S.N.	Crops	No. of households taken crop		Area in ha.		Production in q.		Productivity q. / ha.	
		2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
1.	Cotton(Bt.&non Bt)	126(63)	129(64.50)	183.24	165.80	437.80	726.70	2.39	4.38
	i) Bt.cotton	5(2.50)	20(10.00)	8.40	20.70	32.00	123.00	3.81	5.94
	ii) Non Btcotton	121(60.50)	109(54.50)	174.84	145.10	405.80	603.70	2.32	4.16
2.	Soybean	93(46.50)	100(50.00)	142.20	153.60	451.00	986.50	3.17	6.42
3.	Jowar	68(34.00)	68(34.00)	42.30	42.64	195.70	334.80	4.63	7.85
4.	Tur	56(28.00)	59(29.50)	30.30	35.00	59.35	205.16	1.96	5.86
5.	Mung	15(7.50)	13(6.50)	7.30	6.40	17.00	10.70	2.33	1.67
6.	Udid	12(6.00)	11(5.50)	5.50	4.80	8.25	17.25	1.50	3.59

(Figures in parenthesis indicate the percentage to total victim's households.)

The data also indicated that, area under Bt cotton was increased during 2005-2006 than previous year. Secondly, average yield of Bt cotton was higher as compared to non-Bt cotton.

Thus, a perusal of the results concluded that almost in all crops productivity was very low during 2004-2005 whereas, for the year 2005-2006 productivity was more than the year 2004-2005 but it was quite less than even minimum expected yield level in almost all crops. Hence, here lower production and productivity on the farms of the victims have been proved as one of the causes of farmers' suicide in Vidarbha region. At the time of data collection, the most of the family members of the deceased farmer suggested for remunerative prices to their farm produce and creation of irrigation facilities as the important measures to be taken by the policy makers to prevent the recurrence of suicide tragedies. As per the group discussion with farmers agriculture is no longer a profitable enterprise in Vidarbha; income from crop cultivation is not enough to meet the annual cultivation expenditure.

The above findings are in conformity with the findings of Assadi (1998) that heavy losses incurred by victims due to crop failure. Deshpande (2002) also observed the lower production and productivity on victims' farms in Karnataka.

CONCLUSION

The agrarian crisis and farmers' suicide in Vidarbha region of Maharashtra are closely linked to low productivity of almost all crops due to rainfed farming of Vidarbha. The cropping pattern of the selected deceased farmers was dominated by *Kharif* Cotton and Soybean crops. While a negligible area was observed under *Rabi* and horticultural crops due to lack of irrigation facilities. In such a scenario, for increasing the production and productivity of all crops there is a need to provide high quality seeds to the farmers, timely credit, better irrigation facilities, better extension services, better prices for their produce and involve the farmers in subsidiary occupation with farming to support their livelihood.

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Comparative Economics of Soybean Based Cropping Sequence in Eastern Vidarbha Zone

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ABSTRACT

There is a substantial change in the cropping pattern in Nagpur and Chandrapur districts of Eastern Vidarbha Zone. Soybean has attained important position in the cropping pattern of the area. In an attempt to increase the net profit per unit area with limited irrigation facility, four soybean based cropping sequences were studied during 2004-2005 by diversification of the existing cropping system (soybean- chickpea) by introducing non-conventional rajmash in place of chickpea, and by intensification of the existing and the diversified cropping system by incorporation of vegetable crop, spinach. The GMR, NMR and C:B ratio were maximum under diversified intensive cropping sequence (soybean- rajmash- spinach), followed by intensified existing cropping system (soybean- chickpea- spinach).

In country like India, agriculture sector have great impact on the per capita income as it contributes the major share of the income and plays an important role in raising the living standard. Adoption of modified cropping sequence, suited to the technological changes, is also an important factor for augmenting growth of agriculture. An attempt has been made to find out the scope for diversification of the existing soybean- chickpea cropping system to soybean- rajmash sequence and intensification of these existing and diversified systems by introducing spinach as vegetable crop in these sequences as soybean- chickpea- spinach and soybean- rajmash- spinach, respectively, in Nagpur and Chandrapur districts of Eastern Vidarbha Zone of Maharashtra state, for increasing the net profit per unit area under limited irrigation.

MATERIAL AND METHODS

The field experiment was conducted on four cropping sequences viz. soybean- chickpea, soybean- rajmash, soybean- chickpea- spinach and soybean- rajmash- spinach, at twelve locations treating locations as replications during the year 2004-2005. Bhivapur, Warora and Chimur block of Nagpur and Chandrapur districts were selected with four replications in each block. Thus, total four sequences were tested in randomised block design on 12 locations. The plot size of each treatment was 20 x 10 m. Soils of the experimental field were mostly light in texture, having pH range of 6.8 to 7.5, low in organic carbon (<0.28 %) and nitrogen (<240 kg ha^{-1}), medium in available phosphorus (<38.24 kg ha^{-1}) and fairly rich in available potash (>333 $kgha^{-1}$).

All the crops in the sequences were raised with the recommended package of practices. One irrigation was given to all *Rabi* crops except rajmash which was given two to three irrigations. The duration of soybean and chick pea was 100 days each, whereas it was 84 and 45 days for rajmash and spinach, respectively. In addition to the grain, straw and vegetable yields of various crops, economic parameters were calculated on the basis of prevailing market prices of the produce. Production efficiency values were calculated by dividing total grain production in a sequence by total duration of the crops in that sequence (Tomar and Tiwari, 1990).

RESULTS AND DISCUSSION

Crop productivity

Soybean- rajmash- spinach cropping sequence has recorded the highest total productivity (108.29 q ha^{-1}), followed by soybean- chick pea - spinach (94.13 q ha^{-1}). However, the existing cropping sequence (soybean- chick pea) recorded the lowest total crop productivity of 55.75 q ha^{-1}. Dahatonde *et al.* (2004), in their three years cropping sequence experiment, observed the highest crop productivity in chilli- groundnut sequence while next best sequence was soybean- wheat- cluster bean. Lowest productivity was recorded by the pre-existing cotton- groundnut cropping sequence.

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Table : Grain, straw and vegetable yields, gross monetary return, cost of cultivation, net benefit , B:C ratio and production efficiency of different cropping sequences (2004-05)

S. N. Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
T_1, Soybean- Chickpea						
Soybean	27.37	32844	11418.50	25525.50		
	(41.00)	(4100)				
Chickpea (SYE)	28.38	34056	8628.00	28028.00		
	(26.00)	(2600)				
	55.75	**73600**	**20046.50**	**53553.50**	**3.67**	**27.87**
T_2, Soybean- Rajmash						
Soybean	27.16	32592	11418.50	25173.50		
	(40.00)	(4000)				
Rajmash (SYE)	45.81	54972	11062.00	44910.00		
	(10.00)	(1000)				
	72.97	**92564**	**22480.50**	**70083.50**	**4.11**	**39.44**
T_3, Soybean- Chickpea- Spinach						
Soybean	27.20	32640	11418.50	25321.50		
	(41.00)	(4100)				
Chickpea (SYE)	29.64	35568	8628.00	29740.00		
	(28.00)	(2800)				
Spinach (SYE)	37.29	44748	7806.00	36942.00		
	94.13	**119856**	**27852.50**	**92003.50**	**4.34**	**38.42**
T_4, Soybean- Rajmash- Spinach						
Soybean	28.20	33840	11418.50	26621.50		
	(42.00)	(4200)				
Rajmash (SYE)	43.68	52416	11062.00	42356.00		
	(10.02)	(1002)				
Spinach (SYE)	36.41	43692	7806.00	35886.00		
	108.29	**135150**	**30286.50**	**104863.50**	**4.46**	**47.08**
SE (m)±	29.82					
CD at 5%	89.17					

Rates (Rs q^{-1})							
	Grain	Soybean	1200/-	Chickpea	1400/-	Rajmash	2300/-
	Straw	Soybean	100/-	Chickpea	100/-	Rajmash	50/-
		Spinach	600/-				

Yield of chick pea, rajmash and spinach is given as **'Soybean Yield Equivalent'**.

Total productivity is excluding straw yield, Figure in parenthesis indicate straw yield,

Yield of spinach is as green vegetables.

Gross Monetary Returns

Data presented in the Table indicated that gross monetary return from soybean- rajmash system recorded about 26 per cent increase over existing soybean- chickpea system. The gross monetary return due to intensification of the existing cropping system (soybean- chickpea) by including spinach crop was increased by 63 per cent and that of the proposed diversified system (soybean- rajmash) by 46 per cent.

Net Monetary Return

Net monetary return due to proposed diversification (soybean- rajmash) was higher by about 31 per cent than existing soybean- chickpea sequence. Intensification by way of including spinach in soybean- chickpea and in soybean-rajmash system also recorded an increase in net return by about 72 and 50 per cent, respectively.

B:C ratio

Benefit: Cost ratio of the existing cropping system (soybean- chickpea) was found to be 3.67 and increased to 4.11 due to proposed diversification (soybean- rajmash). It was further increased to 4.30 due to intensification of the existing cropping system by way of inclusion of spinach crop. It was also raised from 4.11 to 4.46 due to intensification of the diversified soybean- rajmash system by inclusion of vegetable crop, spinach.

Bhagat *et al.* (1995) and Deshpande and Jadhav (1996) recorded highest NMR in groundnut-wheat cropping sequence. Nandurkar *et. al.* (1998) recorded the highest GMR, NMR and B:C ratio with soybean- gram- groundnut sequence followed by rice- fallow- groundnut. Dahatonde *et al.* (2004) reported the highest GMR, NMR and B:C ratio with chilli- groundnut crop sequence, followed by cotton-groundnut sequence.

Production efficiency

The production efficiency was maximum (47.08 kg day^{-1} ha^{-1}) in soybean- rajmash- spinach sequence followed by soybean- rajmash (39.44 kg day^{-1} ha^{-1}). Nandurkar *et al.* (1998) observed the highest production efficiency in rice- fallow-groundnut sequence (29.32 kg day^{-1} ha^{-1}) followed by rice- fallow- rice sequence (26.43 kg day^{-1} ha^{-1}).

Thus, it was inferred that there is a significant scope for diversification of the existing soybean- chickpea cropping system to soybean-rajmash, and both the systems (existing and diversified) can be intensified significantly by introducing spinach as vegetable crop in it.

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Biology and Establishment of *Zygogramma bicolorata* Pallister a Biocontrol Agent on *Parthenium hysterophorus* Linn.

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ABSTRACT

The present investigations were carried out to study the biology of *Zygogramma bicolorata* Pallister in laboratory and its establishment on *Parthenium hysterophorus* Linn under field cage at Entomology Section, College of Agriculture, Nagpur during 2006-07. It was observed that *Zygogramma bicolorata* laid eggs singly or in groups of 2-6 mostly on ventral surface of leaves of *Parthenium hysterophorus*. Incubation period was 4.83 days. The larvae passed through four instars. The total larval period, pupal period and total development period were 11.23, 10.67 and 26.53 days, respectively. Pupation took place 1-3 cm below the soil surface. The viability of eggs was 78.20 per cent, pupation was 78.77 percent and adult emergence was 97.73 percent. Female-male sex ratio was 1 : 0.43. Pre-mating, mating, pre-oviposition and oviposition period upto diapause lasted for 4.80 days, 2.49 h, 6.30 days and 34.60 days, respectively. The mean fecundity upto diapause was 759.40 and average eggs laid per female per day was 21.95. Adult longevity upto diapause was 45.70 days in female and 46 days in male. Two hundred twenty five *Zygogramma* beetles released on 1042 *Parthenium* plants mass multiplied and stages of beetle completely defoliated 1042 plants in 8.5 days under field cage conditions. Ten pairs of beetles released on *Parthenium* plant under cage completed life cycle and 322 adult beetles of new generation recovered from the site of release. Beetles completely established on *Parthenium* plants.

Parthenium hysterophorus L. (Family - Asteraceae) is an obnoxious weed, commonly called carrot weed or *Gajar Gawat*. It is a native of Mexico and neighbouring USA. This weed contain allelochemicals which suppress the growth of local vegetation. It posed severe threat to crops and pastures. The sesquiterpene lactones contained in *Parthenium* cause severe dermatitis and pollens causes asthma and allergic bronchitis (Chandra and Vartak, 1970). Biological control of this weed is gaining the importance.

The studies showed *Zygogramma bicolorata*, a chrysomelid beetle, as a potentially effective host specific biocontrol agent for *Parthenium* in Bangalore and surrounding area (Jayanth, 1987). Shinde (1990) studied biology of *Zygogramma bicolorata* and also reported its successful establishment on *Parthenium* plants under field cage conditions at Parbhani, Maharashtra. Considering the importance of the biological control of *Parthenium* weed under Nagpur conditions, the present study on the biology and establishment of *Zygogramma bicolorata* was undertaken.

MATERIAL AND METHODS

a) Biology

The present studies were carried out under laboratory conditions in the insectary of Entomology Section, College of Agriculture, Nagpur, at room temperature 26°±2°C and R.H. 62 percent during the year 2006-07. *Zygogramma bicolorata* Pallister was procured from Department of Entomology, MAU, Parbhani. The beetles were reared on *Parthenium* plants in a clean plastic container of 18 x 21 cm (oviposition cage) covered with muslin cloth. Experiment was initiated with 50 freshly laid eggs. Fifty small plastic containers of 5 x 4 cm size with pin holes on the lids for aeration, were used for rearing the first and second instar larvae. One freshly laid egg was transferred in each rearing cage using moist fine camel hair brush and accordingly 50 such cages were maintained. Third and fourth instar larvae were reared in 11x14 cm plastic containers with plastic wire mesh windows. After each moulting the larvae were transferred to separate rearing cages for ascertaining the larval duration. Duration and length of each instar larva was measured by binocular microscope, lens and oculometer calibrated with

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stage micrometer. The percentage of viable eggs were calculated by collecting 100 eggs on different dates during the months of August, September and October, 2006. Pupal studies were carried out in a pupation cage prepared by providing 5 cm layer of a mixture of fine, moist sterilized 70 per cent sand and 30 per cent soil in a glass vials of 10 x 3.5 cm size. Sex ratio of beetles was monitored by using 50 adults collected every month from August to October, 2006. The sex was determined by observing the last abdominal sternite as described by McClay (1980).

The newly emerged adults were paired and ten pairs were used for fecundity studies, keeping one pair in each fecundity chamber. Daily observations on the eggs laid per female were recorded till the female beetles entered into diapause.

b) Establishment

Parthenium hysterophorus seeds were collected from the plants in the vicinity of College of Agriculture, Nagpur. Three raised seed beds of 2.5x2.5 m each were prepared and the seeds were broadcast on these beds in the month of June 2006. *Parthenium* plants produced profused flowering in the month of August. These beds were covered with cages of mosquito curtain net of size 3 m x 3 m x 2.5 m LBH. On plants under two cages, 225 *Z. bicolorata* adult beetles were released in each cage which were used to study the establishment of beetles on *Parthenium*. The observations on the stages of beetle were recorded on 15 *Parthenium* plants within each cage. Number of days required for complete defoliation of *Parthenium* plants within a cage were recorded from the date of release of adult beetles. For the study of recovery of adults ten pairs of freshly emerged beetles were released on the *Parthenium* plants under the third cage. Observations on the oviposition, larval and pupal population and the adults developed from the new generation were recorded till their diapause.

RESULTS AND DISCUSSION

a) Biology

Zygogramma bicolorata laid their eggs singly or in a small groups of 2-6 eggs mostly on the ventral surface of leaves, also on the dorsal surface of the leaves and occasionally on the stems and even flowers. The eggs were oblong, yellowish and measured 1.22 mm long and 0.56 mm wide. Incubation period ranged from 4 to 6 days with an average of 4.83 days.

The larvae passed through four instars moulting three times. The newly hatched first instar larvae were yellowish, turned creamy white as they grew. The body of larva was found to be slightly curved with a protrusible proleg-like structure at the posterior end which was used for locomotion. The newly hatched larvae initially fed on adjoining area and then moved to other site. The second instar larvae looked like first instar larvae except in the size. The third instar was differentiated from the earlier instars by their spiracles which were seen as clear dark spots. The four larval instars lasted for 3.25, 2.21, 2.36 and 3.41 days, respectively (Table 1). The mean body length of four instars was 1.79 mm, 2.98 mm, 4.75 mm and 6.95 mm, respectively (Table 2). The full grown larvae stopped feeding and entered in the soil for pupation. This was the pre-pupal stage and lasted for few hours to one day. The total average larval period lasted for 11.23 days + 1 day pre-pupal stage. The pupation took place 1 to 3 cm below the surface of soil in the chamber formed by pre-pupal stage. The mean pupal period was 10.67 days. The total average developmental period was found to be

Table 1. Life-history of *Zygogramma bicolorata* P.

S. N.	Stage	Days	
		Average	Range
1.	Incubation period	4.83	4-6
2.	Larval instar - I	3.25	2-4
3.	Larval instar - II	2.21	2-3
4.	Larval instar - III	2.36	2-3
5.	Larval instar - IV	3.41	3-5
6.	Total larval period	11.23	10-12
7.	Pupal period	10.67	10-12
8.	Total development period (upto adult emergence)	26.53	26-27

Table 2. Measurement of larval instars of *Zygogramma bicolorata

Instars	Maximum body length (mm)
1	1.79 ± 0.07
2	2.98 ± 0.12
3	4.75 ± 0.13
4	6.95 ± 0.31

*n = 50

Table 3. Percentage of viable eggs, percentage of pupation and adult emergence.

S. N.	Date	No. of eggs kept for hatching	No. of eggs hatched	Per cent egg hatching	No. of Larvae pupated	Percent pupation	No. of adults emerged	Percent adult Emergence
1.	19.8.06	100	81	81	66	81.48	64	96.96
2.	23.8.06	100	80	80	64	80.00	63	98.43
3.	5.9.06	100	78	78	61	78.20	59	96.72
4.	18.9.06	100	77	77	59	76.62	59	100.00
5.	1.10.06	100	75	75	58	77.33	56	96.55
Total		500	391	78.20	308.00	78.77	301.00	97.73

Table 4. Sex ratio of *Z. bicolorata* adults collected from field during 2006

S. N.	Date of observation	No. of adults observed	No. of females	No. of males	Sex ratio female : male
1.	19.8.2006	50	32	18	1 : 0.56
2.	23.8.2006	50	33	17	1 : 0.52
3.	5.9.2006	50	36	14	1 : 0.38
4.	18.9.2006	50	38	12	1 : 0.32
5.	1.10.2006	50	35	15	1 : 0.428
6.	14.10.2006	50	35	15	1 : 0.428
	Total	300	209	91	
	Average	-	-	-	1 : 0.43

Table 5. Fecundity of female beetle upto diapause and logevity of adult beetles upto diapause

S. N. of beetle pairs	Pre-mating period (days)	Mating period in h.	Pre-ovi-position period (days)	Oviposition period up to diapause (days)	No. of eggs laid per female	Average No. of eggs laid per day per female	Adult beetle longevity upto diapause	
							Female	Male
1	5	2.45	6	34	760	22.35	45	46
2	5	3.12	7	34	684	20.12	46	47
3	5	2.33	5	34	718	21.12	44	44
4	4	2.41	7	34	753	22.15	45	45
5	5	2.49	7	34	740	21.76	46	44
6	5	2.27	6	34	828	24.35	45	47
7	5	2.38	7	35	785	22.43	47	47
8	4	2.50	5	35	779	22.26	44	45
9	5	2.48	7	36	740	20.56	48	49
10	5	2.52	6	36	807	22.42	47	46
Average	4.80	2.49	6.30	34.60	759.40	21.95	45.70	46.00

* Date of release of pairs of female x male beetles in fecundity chambers - 14th, 15th, 16th Sept. 06

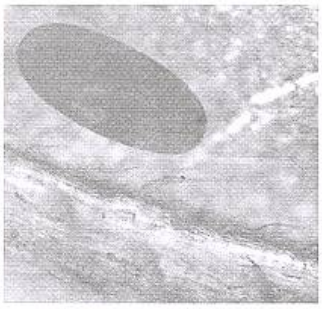

Fig. 1. Close view of egg under microscope

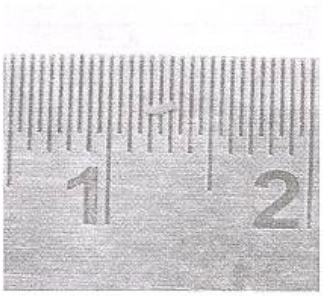

Fig. 2. First instar larva

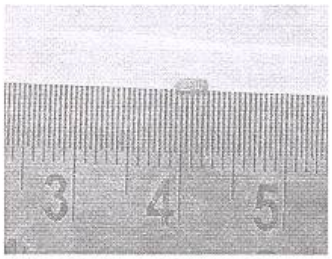

Fig. 3. Second instar larva

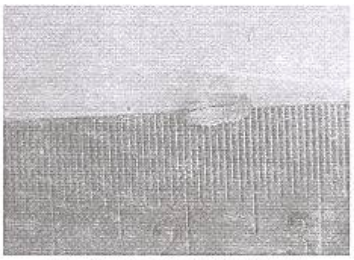

Fig. 4. Third instar larva

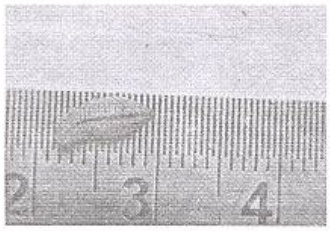

Fig. 5. Fourth instar larva

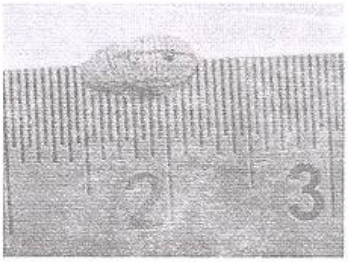

Fig. 6. Pre pupal stage

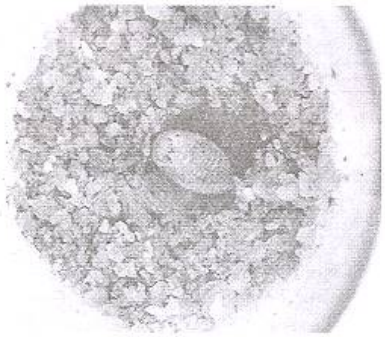

Fig. 7. Pupal stage

Fig. 8. Adult stage

Table 6. Study of establishment of *Z. bicolorata* under field cages

S. N. of cage	Area of *Parthenium* bed under cage	Plants in 0.3m x 0.3m area	Approximate plants bed^{-1} of 6.25 sq.m	*Z. bicolorata* adults released	No. of larvae and beetles on 15 plants (0.3mx0.3m)	Average larvae and adults beetles recorded /Plant	Period required for complete defoliation (days)
1. 2.5m x 2.5m (6.25 sq.m.)	15	1042	225	181	12.60	8	
2. 2.5m x 2.5m (6.25 sq.m.)	15	1,042	225	167	11.13	9	
Average				174	11.59	8.5	

* Date of release of adults- 19-8-2006.

Table 7. Field cage release and recovery of *Z. bicolorata* adult beetles, beetles released 10 Pairs (Female-male).

S. N.	Date of recovery	No. of beetles recovered	No. of days required for recovery	Period of entering in diapauses
1.	27-9-2006	61	30	
2.	29-9-2006	16	32	
3.	01-10-2006	15	34	
4.	3-10-2006	29	36	
5.	5-10-2006	23	38	Adult beetles entered in the soil for diapause on dt. 26th October to 30th Oct. 2006
6.	7-10-2006	17	40	
7.	9-10-2006	13	42	
8.	11-10-2006	17	44	
9.	13-10-2006	18	46	
10.	15-10-2006	21	48	
11,	17-10-2006	20	50	
12.	19-10-2006	24	52	
13,	21-10-2006	19	54	
14.	23-10-2006	17	56	
15.	25-10-2006	12	58	
	Total	322		

Date of release of beetles- 29-8-2006,

26.53 days. The mean per cent viability of eggs was 78.20, mean per cent pupation of larvae was 78.77 and average per cent adult emergence from pupae was 97.73 (Table 3). The mean female-male sex ratio was 1 : 0.43 (Table 4). The average pre-mating period, mating period, pre-oviposition period and oviposition period upto diapause were found to be 4.80 days, 2.49 h, 6.30 days and 34.60 days, respectively. The mean fecundity per female upto diapause was 759.40 eggs and average eggs laid per female per day was 21.95. Average adult longevity upto diapause was female 45.70 days and male 46.0 days (Table 5).

Jayanth (1987) reported incubation period of 4-5 days. Shinde (1990) reported that eggs were laid on the ventral surface of leaves, singly on in groups of 2-6 eggs and total larval period of 8-10 days. Pande *et al.* (2001) reported larval 4 instars, 1st, 2nd, 3rd and 4th instar larvae measured 1.7 mm, 2.8 mm, 4.5 mm and 6.8 mm in length and the instarwise duration was 2-3 days, 2-3 days, 2-3 days and 3-4 days, respectively.

Dhiman and Bhargawa (2005) reported that the total larval period was 12-19.5 days which differed greatly with the present results.

The present findings were in general agreement with those of the above workers.

b) Establishment

A number of 225 adult beetles of *Zygogramma bicolorata* released on about 1042 plants in each of the two field cages oviposited and larvae and adult completely defoliated all the *Parthenium* plants in 8.5 days (Table 6). Later on these plants dried completely. Pande *et al.* (2001) reported that *Z. bicolorata* was found feeding on *P. hysterophorus*, completely defoliating these plants leading to their drying. The present findings are in conformity with the findings of the above worker.

Table 7 revealed that 10 pairs of adult beetle of *Z. bicolorata* released on *Parthenium* plants under field cage on dated 29th August, 2006, laid eggs on *Parthenium* plants. Larval and pupal stages were observed and 322 adult beetles were recovered from the release site upto diapause.

Shinde (1990) reported that *Z. bicolorata* was established on *Parthenium* plants under field cage, and 1706 adult beetles were recovered from 100 beetles released initially. The results of present studies are in conformity with those of the above worker.

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Enhancement of Soybean Yield through Biofertilizers and Fertilizers

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ABSTRACT

A field experiment was conducted at the farm of University Department of Agronomy, Dr. P.D.K.V., Akola during *Kharif* season of 2007-08, to study the enhancement of soybean yield through biofertilizers and fertilizer. The study revealed that combined or integrated inoculation of biofertilizers i.e. Rhizobium + PSB + *tricoderma* culture, Rhizobium + PSB culture, PSB + *tricoderma* culture or Rhizobium + *tricoderma* culture, recorded higher values for growth characters, yield attributes, grain yield, straw yield, oil and protein content over single seed inoculation and no culture treatments. Similarly, 100 per cent RDF (30:75:30 kg NPK ha^{-1}) proved significantly superior over 50 per cent RDF (15:37.5:15 kg NPK ha^{-1})

Soybean is a leguminous crop having high oil content in its seeds, in addition to the high protein content. These characteristics make soybean the most important oil and protein crop in the world. In India, it covers an area of about 7.7 m ha with 6.1 m t of annual production. However, productivity is low (0.8 t ha^{-1}) than world average of 2.3 t $ha^{-1}$and Asian average of 1.9 t ha^{-1} (Anonymous, 2006). Under intensive agriculture, indiscriminate and imbalanced fertilizer use results in deterioration of soil fertility and poses a serious threat to long term sustainability of crop production, and also due to high cost of inorganic fertilizer, farmers are unable to supply recommended dose of fertilizers to the crop. So, in soybean, there is a wide scope to use biofertilizers like Rhizobium, PSB and *tricoderma* which maintain the soil health, sustain production, check pollution, reduce the fertilizer dose and improve fertilizer use efficiency. Hence, keeping in view these facts, the present study was undertaken to explore the effect of different biofertilizers and fertilizers on the yield of soybean.

MATERIAL AND METHODS

The field experiment was conducted during *Kharif* season of 2007-08 at the Agronomy Farm, University Department of Agronomy, Dr. P.D.K.V., Akola. The experiment was conducted on clay loam soil, slightly alkaline in reaction, moderate in organic carbon, medium in available N, low in available P and fairly high in available K. The experiment was laid out in Factorial Randomised Block Design with 16 treatment combinations, replicated thrice. These 16 treatments consisted of eight treatments of biofertilizers, alone or in combination or no inoculation (B_1- *Rhizobium japonicum* @ 25 g kg^{-1} seed, B_2- Phosphorus Solubilising Bacteria @ 25 g kg^{-1} seed, B_3- *Tricoderma viride* @ 4 g kg^{-1} seed, B_4-(B_1+B_2), B_5-(B_1+B_3), B_6-(B_2+B_3), B_7-(B_1+B_2+B_3) and B_8- no biofertilizers) with two levels of chemical fertilizer (F_1-100 per cent and F_2- 50 per cent of RDF i.e. 30:75:30 and 15: 37.5:15 kg NPK ha^{-1}, respectively). Rhizobium, PSB and *tricoderma* were applied to seed before sowing and fertilizer was applied as basal dose through urea, single super phosphate and murriate of potash as the sources of N, P and K. FYM @ 5 t ha^{-1} was applied in the field and mixed thoroughly in the soil before sowing.

Observations on growth viz. plant height, branches $plant^{-1}$, number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$ were recorded periodically whereas yield attributes like number of pods $plant^{-1}$, seed yield $plant^{-1}$, seed and straw yield ha^{-1}, oil and protein content were recorded at harvest. The grain and straw yields were recorded from net plot basis and converted into q ha^{-1}.

RESULTS AND DISCUSSION

Growth Characters

The data on growth characters of soybean as influenced by different treatments are presented in Table 1. Seed inoculation with Rhizobium + PSB + *tricoderma* (B_7) registered significantly highest plant height, number of branches and number of leaves

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Table 1. Growth characters of soybean as influenced by various treatments.

Treatments	Plant height at harvest (cm)	No. of branches plant^{-1} at harvest	No. of functional leaves plant^{-1} at 60 DAS	Leaf area plant^{-1} (dm^2) at at 60 DAS	No. of root nodules plant^{-1} at 60 DAS	Total dry matter accumulation plant^{-1} (g)
Biofertilizers						
B_1–Rhizobium	60.37	5.80	46.74	22.44	34.00	31.20
B_2–PSB	60.67	5.90	46.80	22.62	33.16	31.83
B_3–Tricoderma	58.08	5.73	46.60	22.23	34.13	30.58
B_4–Rh + PSB	62.60	6.25	51.14	26.55	36.00	35.66
B_5–Rh + trico	61.18	6.20	49.08	24.81	36.33	31.83
B_6–PSB + trico	62.07	6.23	50.43	26.58	35.33	33.16
B_7–Rh + PSB + trico	62.09	6.63	52.98	26.61	37.00	36.00
B_8–No inoculation	58.00	5.52	43.30	22.02	32.83	26.80
SE(m)±	0.60	0.25	0.94	0.56	0.85	1.46
CD at 5%	1.73	0.74	2.71	1.72	2.46	4.24
Fertilizer levels						
F_1 –50 % RDF	60.05	5.69	43.95	22.41	34.20	30.66
F_2 –100 % RDF	61.41	6.35	53.04	26.58	35.54	33.67
SE(m)±	0.30	0.12	0.70	0.66	0.43	0.73
CD at 5%	0.86	0.37	2.04	1.92	1.23	2.12

Table 2. Yield attributing characters, yield and quality parameters of soybean as influenced by various treatments.

Treatments	No. of pods plant^{-1}	Seed yield plant^{-1} (g)	Test weight (g)	Seed yield (qha^{-1})	Straw yield (qha^{-1})	Oil content (%)	Protein content (%)
Biofertilizers							
B_1–Rhizobium	38.38	8.36	11.81	19.42	29.70	18.35	37.41
B_2–PSB	38.41	8.51	11.83	19.44	29.61	18.33	37.42
B_3–Tricoderma	38.35	8.25	11.80	18.50	28.09	18.18	36.91
B_4–Rh + PSB	41.45	9.15	12.26	20.92	31.35	18.60	41.50
B_5–Rh + trico	40.25	9.08	12.16	20.25	28.16	18.55	40.87
B_6–PSB + trico	40.28	9.12	12.21	20.30	28.68	18.58	40.95
B_7–Rh + PSB + trico	41.50	9.31	13.25	20.98	32.52	18.70	41.67
B_8–No inoculation	37.87	8.01	11.53	17.40	27.43	18.03	36.56
SE(m)±	0.94	0.09	0.48	0.49	0.90	0.11	1.46
CD at 5%	2.72	0.27	N. S.	1.41	2.60	0.34	4.24
Fertilizer levels							
F_1 -50 % RDF	38.32	8.37	11.82	18.55	28.14	18.25	36.62
F_2 -100 % RDF	40.80	9.00	12.40	21.01	31.13	18.57	41.70
SE(m)±	0.47	0.05	0.24	0.24	0.45	0.05	0.73
CD at 5%	1.36	0.13	N. S.	0.70	1.30	0.17	2.12

plant^{-1} at harvest over the treatments B_1, B_2, B_5 and B_8 and was at par with B_3, B_5 and B_6. Similarly, treatment F_2 (100 per cent RDF) produced significantly highest plant height, number of branches and number of leaves plant^{-1} over 50 per cent RDF (F_1) because of more and easy availability of nutrients to the plants. Similar findings were recorded by Ghosh *et al.* (2005), Khutate *et al.* (2005) and Paratey and Wani (2005)

Treatment B_7 consisting seed inoculation with Rhizobium + PSB + *Tricoderma* recorded significantly maximum leaf area plant^{-1} over treatments B_1, B_2, B_3 and B_8 and was at par with B_4, B_5 and B_6. Similar results were also obtained by Kanase *et al.* (2006). Significant increase in leaf area due to full RDF (F_2) over half RDF (F_1) was recorded. The findings are in accordance with Ghosh *et al.* (2005). Similar trend was also noticed in respect of maximum number of root nodules. Increase in nodule numbers was found in combination of biofertilizers. This conforms the findings of Sharma and Namdeo (1999). Application of full RDF (F_2) produced significantly highest root nodules plant^{-1}. This might be due to the fact that application of fertilizers in balanced form increased nutrient uptake which in turn might have resulted in increased number of root nodules. Similar results were obtained in dry matter accumulation plant^{-1} (Sheerin, 1998).

Yield and yield attributes

The results presented in Table 2 indicated that the combined application of Rhizobium + PSB + *Tricoderma* (B_7) recorded significantly highest number of pods plant^{-1} over the treatments B_1, B_2, B_5 and B_8 and was at par with B_4, B_5 and B_6. Full RDF (F_2) recorded the highest number of pods plant^{-1}. This might be due to vigorous growth of the plant because of easy availability of nutrients leading to more accumulation of carbohydrates and proteins and their translocation to respiratory organs. Similar findings were reported by Bothe *et al.* (2001). Same trend was also observed regarding seed yield plant^{-1}. Combined inoculation of biofertilizers (B_7) mainly increased availability of nutrients like N and P_2O_5 while *Tricoderma* reduced the seedling rot which help in improving the uptake by plants. Optimum dose of fertilizer (F_2) was utilised for reproductive growth, ultimately increased the grain yield plant^{-1}. Govindan and Thirumurugan (2005) also recorded the similar results.

The test weight of soybean was not influenced due to biofertilizer treatment but increased with application of full dose of fertilizer (F_2) as compared to half dose. Treatment B_7 registered significantly maximum seed yield (20.98 q ha^{-1}) as compared to treatments B_1, B_2, B_3 and B_8 and was statistically similar with treatment B_4, B_5 and B_6. Grain yield increased significantly with increasing fertilizer level to 100 per cent RDF (F_2). This result is in conformity with the findings of those recorded by Dubey (1996).

The increase in grain yield could be attributed to cumulative effect of better growth which produced more number of pods plant^{-1} and seed yield plant^{-1} and ultimately resulted in increased seed yield ha^{-1}. The higher grain yield due to biofertilizer and inorganic fertilizer alone might be due to sustained nutrient supply and also as a result of better utilization of applied nutrient through improved microbial activity that involved in nutrient transformation and fixation.

Quality parameters

The quality parameters (Table 2) revealed that the average oil and protein content of soybean was found to be increased with combination of different biofertilizers (B_7) and it was significantly more than treatments B_1, B_2, B_5 and B_8 and was at par with B_4, B_5 and B_6. Similarly, application of 100 per cent RDF (F_2) increased the oil and protein content significantly over half RDF (F_1).

Phosphorus directly involves in the oil synthesis, particularly in formation of phospholipids and esterrification of fatty acids, which might have caused an increase in oil content. Similarly, more uptake of nitrogen increases the amino acid content in seed Amino acids, being the structural unit of protein, result in increase in protein content in seed. This type of result was also recorded by Singh and Sharma (2001) and Deshmukh *et al.* (2005).

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Integrated Nutrient Management in Summer Sesame

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ABSTRACT

An experiment was conducted at farm of Agronomy section, College of Agriculture, Nagpur during summer season of 2006-07, in Randomized Block Design with eleven treatments replicated thrice, to study the effect of integrated nutrient management in summer sesame. The 100 per cent recommended dose of fertilizer recorded maximum growth attributing characters like plant height, number of branches plant^{-1}, mean dry matter accumulation plant^{-1}, as well as yield contributing characters viz., number of capsules plant^{-1}, number of grains capsule^{-1}, grain yield plant^{-1}, grain yield ha^{-1}, oil yield ha^{-1}, residual available N, P and K content and GMR, NMR and B : C ratio, followed by 75 per cent RDF + *Azotobacter* and PSB soil application with or without 1 or 2 spray of *Azotobacter*. *Azotobacter* count was found more in treatment of 75 per cent recommended dose of fertilizer with biofertilizer treatments.

Sesame is an important oilseed crop cultivated throughout the year. It is quite nutritious containing 48-52 per cent oil, 18-20 per cent protein, rich in vitamin E. Our annual per capita consumption of oil and fat remained only 4-6 kg against 26 kg in developed countries (Shrivastav *et al.,* 1985).In Maharashtra area under oilseed crops was 1.38 lakh ha with production of 5.88 lakh metric tonnes in 2006-07. In Maharashtra, Vidarbha region comprising Nagpur and Amravati revenue divisions are the most important sesame growing area. Nagpur division having sesame area 3800 ha, production of 600 mt with average production of 158 kg ha^{-1} in 2006-07. The area and production of sesame are less in *Rabi* and summer than *Kharif* (Anonymous, 2007). Sesame as an oilseed crop requires less cost of cultivation, low water requirement but higher market rate and thus becomes a good substitute for summer groundnut. Sesame is cultivated with traditional package of practices and inadequate level of inputs which limits the full expression of sesame yield potential. Intensive cultivation of sesame requires use of chemical fertilizer, which are not only short in supply but also expensive. Several workers have noticed the favorable responses of *Azotobacter* and PSB. *Azotobacter* fixes 10 to 40 kg nitrogen per hectare and showed increased yield in sesame as it fixes nitrogen in soil (Jaipurkar *et al.,* 1980). Therefore, to explore the possibility of supplementing chemical fertilizers with organic ones more particularly biofertilizers of microbial origin, present study was undertaken.

MATERIAL AND METHODS

A field experiment was conducted during summer season of 2006-07 at Agriculture College Farm, Nagpur (M.S.) in Randomized Block Design with three replications and eleven treatments, viz. T_1 - 100 per cent RDF, T_2 - 75 per cent RDF, T_3 - 50 per cent RDF, T_4 - 75 per cent RDF + *Azotobacter* soil application, T_5 - 50 per cent RDF + *Azotobacter* soil application, T_6 - 75 per cent RDF + *Azotobacter* and PSB soil application, T_7 - 50 per cent RDF + *Azotobacter* and PSB soil application, T_8 - 75 per cent RDF + *Azotobacter* and PSB soil application + 1 spray of *Azotobacter*, T_9 - 50 per cent RDF + *Azotobacter* and PSB soil application + 1 spray of *Azotobacter*, T_{10} - 75 per cent RDF + *Azotobacter* and PSB soil application + 2 sprays of *Azotobacter* and T_{11} - 50 per cent RDF + *Azotobacter* and PSB soil application + 2 sprays of *Azotobacter*. The experimental soil was vertisol with low in available nitrogen, low in available phosphate , and medium in available potash. Sesame variety AKT - 101 was sown with 2.5 kg ha^{-1} seedrate and fertilized with 25 : 25 : 0 NPK Kg ha^{-1} as full RDF. Chemical fertilizers and biofertilizers were given as soil application at the time of sowing. The first spray of *Azotobacter* was given at flowering and second spray after 15 days of first spray. Gap filling and thinning was done whenever necessary. Harvesting was done when crop was fully matured. Observations on growth characters viz., plant height, number of branches, dry matter accumulation, yield contributing characters viz., number of capsules plant^{-1}, number

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of grains capsule^{-1} and grain yield, oil percent, oil yield, soil analysis and *Azotobacter* count were recorded.

RESULTS AND DISCUSSION

Growth attributes

The data in the Table 1, indicated that plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} were significantly influenced by various treatments. The 100 per cent recommended dose of fertilizer was significantly superior over other treatments except 75 per cent RDF + *Azotobacter* and PSB soil application + 2 spray of *Azotobacter* (T_{10}); 75 per cent RDF + *Azotobacter* and PSB soil application + 1 spray of *Azotobacter*(T_8); 75 per cent RDF + *Azotobacter* and PSB soil application(T_6) which were at par with 100 per cent RDF(T_1).

The results are in agreement with the results of research work conducted at Agriculture College and Research Institute, Madurai by Arunachalam and Venkatesan, 1984, who reported that Urea at 30 kg N ha^{-1} recorded the highest growth and yield of sesame and was at par with urea 15 kg N ha^{-1} + *Azotobacter* and *Azotobacter* alone.

Yield and yield components

The results (Table 1) revealed that 100 per cent RDF had pronounced effect on yield and yield components. Hundred per cent RDF recorded significantly higher number of capsules plant^{-1} and number of grains capsule^{-1}. Similarly, it recorded significantly higher seed yield, oil yield, except 75 per cent RDF + *Azotobacter* and PSB soil application + 2 sprays of *Azotobacter*(T_{10}); 75 per cent RDF + *Azotobacter* and PSB soil application + 1 spray of *Azotobacter*(T_8); 75 per cent RDF + *Azotobacter* and PSB soil application(T_6) which were at par with 100 per cent RDF(T_1). Thus, with the use of Azotobacter and PSB, 25 per cent RDF caould be reduced as it did not reduce the yield significantly, because the microbial action of *Azotobacter* and PSB supplied might have compensated the nutrient balance. Reddy *et al.* (2000) reported the higher seed yield and oil yield in sesame due to 60 kg N ha^{-1} which was more or less similar with 30 kg N ha^{-1} + biofertilizers.

Fertility status and Azotobacter count

The data recorded in Table 2 showed that the residual fertility status i.e. N, P and K content in soil was increased with the application of 100 per cent RDF in soil. Hundred per cent RDF recorded higher N, P and K as compared to rest of treatments except 75 per cent RDF + *Azotobacter* and PSB soil applications + 2 sprays of *Azotobacter* (T_{10}); 75 per cent RDF + *Azotobacter* and PSB soil application + 1 spray of *Azotobacter* (T_8); 75 per cent RDF + *Azotobacter* and PSB soil application (T_6) which were at par with 100 per cent RDF. Thus, the residual fertility status was statistically similar even with 25 per cent less RDF application supplemented with *Azotobacter* and PSB. This might be due to similar supply or release of nutrients by the .treatments T_6, T_8, and T_{10} compared to T_1 due to microbial action in soil. These results are in tune with those obtained by Ghosh and Patra (1994), El-habhasha *et al.*(2007).

Compared to initial *Azotobacter* count of 1.4 x 10^7 CFU g^{-1} soil, the bacterial count increase was more with *Azotobacter* inoculation or 100 per cent RDF. Without inoculation the rate of increase was less.

This might be due to the fact that initial Azotobacter present in the soil multiplied rapidly with initial starter nutrient and then fixed the atmospheric nitrogen which might have happened with initial higher grade of RDF. Also with artificial inoculation the increased *Azotobacter* population might have acted in increased nitrogen fixation and supply to sesame crop spplemented by PSB activity.This revealed that the natural occurrence and further multiplication of *Azotobacter* was due to the inoculation of microbes and increasing level of nitrogen. Paul *et al.* (2003) reported that 50 per cent N + biofertilizers influenced more on *Azotobacter* population than 30 kg N ha^{-1} as urea.

ECONOMICS

Data in Table 2 indicated that 100 per cent RDF recorded significantly higher gross monetary returns, net monetary returns and B: C ratio which was at par with 75 per cent RDF + *Azotobacter* and PSB soil application (T_6), T_8 and T_{10}. These results are in conformity with those obtained by Narkhede *et al.* (2001).

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Table 1 : Growth, yield attributes & yield of summer sesame as influenced by different treatments

Treatments	Plant height (cm)	No. of branches plant^{-1}	Dry matter accumulation plant^{-1} (g)	No. of capsules plant^{-1}	No. of grains capsule^{-1}	1000 seed wt. (g)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
T_1 - 100 % RDF	121.93	4.54	24.70	84.03	53.68	3.00	518.84	223.20
T_2 - 75 % RDF	114.05	3.98	22.42	71.11	45.98	2.95	443.45	189.04
T_3 - 50 % RDF	101.36	3.20	19.60	58.76	35.18	2.90	378.96	161.55
T_4 - 75 % RDF + *Azotobacter* soil application	114.81	4.08	22.86	75.07	47.16	2.96	455.35	194.98
T_5 - 50 % RDF + *Azotobacter* soil application	103.12	3.34	20.32	60.16	37.23	2.94	388.88	166.63
T_6 - 75 % RDF + *Azotobacter* and PSB soil application	117.90	4.20	23.50	79.10	49.45	2.97	477.19	202.51
T_7 - 50 % RDF + *Azotobacter* and PSB soil application	108.37	3.76	21.58	68.10	43.01	2.92	415.67	176.70
T_8 - 75 % RDF + *Azotobacter* and PSB soil application + 1 spray of Azotobacter	120.01	4.47	24.10	81.50	52.03	2.95	501.98	214.54
T_9 - 50 % RDF + *Azotobacter* and PSB soil application + 1 spray of Azotobacter	111.63	3.83	21.85	69.90	44.32	2.93	427.57	182.52
T_{10} - 75 % RDF + *Azotobacter* and PSB soil application + 2 spray of Azotobacter	121.20	4.51	24.38	82.84	52.66	2.98	508.92	216.29
T_{11} - 50 % RDF + *Azotobacter* and PSB soil application + 2 spray of Azotobacter	112.61	3.89	22.08	69.37	45.28	2.94	437.49	186.06
SE (m) ±	1.63	0.12	0.43	2.43	1.87	0.09	13.88	6.8
CD at 5%	4.80	0.35	1.30	7.20	5.62	N. S.	41.66	20.69

Table 2 : Fertility status, Azotobacter count and economics of summer sesame as influenced by different treatments

Treatments	N (kg ha^{-1})	P (kg ha^{-1}) count. CFU X 10^{-7} g^{-1} soil)	K (kg ha^{-1}) (Rs ha^{-1})	*Azotobacter* (Rs ha^{-1})	GM.R	N.M.R	B:C ratio
Initial	274.20	25.57	406.05	1.4×10^7	-	-	-
T_1 - 100 % RDF	285.56	32.82	419.20	1.9×10^7	18160	10258	2.29
T_2 - 75 % RDF	277.53	29.95	410.06	1.6×10^7	15521	7709	1.98
T_3 - 50 % RDF	274.72	25.85	409.20	1.5×10^7	13264	5549	1.71
T_4 - 75 % RDF + *Azotobacter* soil application	281.93	30.34	416.38	2.0×10^7	15937	8005	2.00
T_5 - 50 % RDF + *Azotobacter* soil application	276.13	26.67	411.53	1.8×10^7	13610	5776	1.73
T_6 - 75 % RDF + *Azotobacter* and PSB soil application	283.07	30.77	416.64	2.1×10^7	16701	8649	2.07
T_7 - 50 % RDF + *Azotobacter* and PSB soil application	276.29	28.34	414.20	1.7×10^7	14548	6594	1.82
T_8 - 75 % RDF + *Azotobacter* and PSB soil application + 1 spray of Azotobacter	283.69	31.77	418.67	2.2×10^7	17569	9264	2.11
T_9 - 50 % RDF + *Azotobacter* and PSB soil application + 1 spray of Azotobacter	277.30	28.52	414.37	1.8×10^7	14964	6757	1.82
T_{10} - 75 % RDF + *Azotobacter* and PSB soil application + 2 spray of Azotobacter	284.23	31.99	418.92	2.2×10^7	17812	9254	2.08
T_{11} - 50 % RDF + *Azotobacter* and PSB soil application + 2 spray of Azotobacter	278.43	28.72	414.50	1.9×10^7	15312	6851	1.80
SE (m)±	2.37	0.93	4.52	-	487	540	-
CD at 5%	7.11	2.76	N. S.	-	1461	1622	-

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Determination of Proper Isolation Distance for Seed Production of Soybean

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ABSTRACT

An efforts were made to determine the proper isolation distance for seed production of soybean in order to maintain the genetic purity. The presently recommended isolation distance of 3.0 m is inadequate and needs revision urgently. The two varieties i.e. PK-1029 (tester) and JS-335 (contaminator) were grown at 3.0 m and 5.0 m isolation distance at Seed Technology Research Unit, Dr. PDKV, Akola. Flower colour used as morphological marker in this study and the result indicated that the percent of contamination i.e. off type was upto an extent of 0.87 percent at 3.0 m isolation distance which is above the minimum acceptable limit i.e. 0.10 percent for foundation and 0.50 percent for certified seed production where as there was no off type plant observed in the field of 5.0 m isolation distance. Hence it is recommended to use 5.0 m isolation distance in place of 3.0 m for seed production of soybean.

Soybean known as golden bean grown on a large area in India in general and Maharashtra in particular. In 2006-07 under seed production and produced 6,09,421qt of seed. From these only 3,88,807qt seed could able to meet the seed certification standards (Ananymous, 2007). Thus a large quantity fails because of not meeting the required seed and field standards as prescribed by Indian Minimum Seed Certification Standard and followed all over the country. One of the main reason of this failure is increased amount of contaminants which directly responsible for decrease in genetic purity.

Cultivar purity determines the success of entire seed production programme. If the genetic purity of seed is not maintained during seed multiplication, the contaminants present get multiplied several times in the succeeding generation. Thus, not only the chances of rejection of foundation and certified seed increases due to high percentage of contaminants but the cost and effort involved in rouging become prohibitive.

To maintain the genetic purity in Soybean is not difficult job due to it predominantly self pollinating. It has small flowers with entomophilous characteristics. Erickson (1975) showed an increase in seed yield and outcrossing rate by caging honeybees. "The Central Seed Certification Board" of the Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India has published 'Indian Minimum Seed Certification Standards' in July, 1988. The manual provides the guidelines for minimum isolation distance to be maintained, minimum permitted cross pollination and maximum genetic purity standards to be maintained for foundation and certified seeds for each crop. These standards are based on nearly one and half decade old varieties which are out of cultivation chain. To maintain the genetic purity in a present position these recommendations need to be revised by generating the scientific data based on crop varieties which are under cultivation and future needs.

As per the present standards prescribed by Indian Minimum Seed Certification Standards the isolation distance for seed production of soybean is 3.0m. Hence the present study was undertaken to find out the current status of natural cross pollination in soybean and to suggest proper isolation distance for maintaining the genetic purity in seed production of soybean.

MATERIAL AND METHODS

This experiment was conducted at Seed Technology Research Unit, Dr. PDKV, Akola during the year 2006-07, 07-08 and 08-09. Two soybean cultivars, PK-1029 having white colour flower and pod pubescence present whereas JS-335 having violet colour flower and pod pubescence absent were used for this study and flower colour was used to separate the two cultivars. Morphological markers such as color of flowers, hypocotyl, pubescence and seed coat were used to identify hybrid seeds in estimating the rate of outcrossing in soybean (Culter,

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1934, Garber and Odland, 1926, Woodworth, 1922). Two sets of trials were grown (in three replication) considering the isolation distance of 3.0m in one set and 5.0m in second set of trial. In both the trials the seed of PK-1029 were sown as a central plot (Tester Plot) on a plot size of 5m x 5m and seed of JS-335 were sown as contaminator on all the four side i.e. N-E-W-S of central plot at a spacing of 45 x 10 cm. Efforts were made to take all cares to avoid any mechanical mixture during post harvest operations.

The observations on days to flowering initiation, days to 50 percent flowering, style length (mm), plant height at maturity, flower colour, pod pubescence, seed colour and hilum colour were recorded and given in Table 1, 2, and 3. The central plot of PK-1029 was allowed for natural cross pollination during the season of 2006-07, 07-08 and 2008-09. The seed obtained from the central plot i.e. PK-1029 were examined for natural cross pollination in the next generation. The grow out test was conducted by growing 2500 plants with 45 x 10 cm spacing and following the recommended cultural practices. The presence of off type plants i.e. contamination were determined by examining the individual plant during flowering and on the basis of flower colour and present or absent of pubescence. The grow out test was conducted in normal growing season during three years.

RESULTS AND DISCUSSION

The pooled data obtained are presented in Table no. 1 and 2. The results indicated that during 2006-2007 out of 2472 plants, 18 off-type plants (0.72 %) was observed at an isolation distance of 3 m where as at 5 m isolation distance no plant was found off-type, i.e. 0.0 % off-type. Similarly during 2007-2008 & 2008-2009 about 21 off-type plants (0.87 %) & 9 off-type plants (0.47 %) respectively was observed in seed produced with 3m isolation, while that the seed produced from 5m isolation was free from off type. This data give the support with the finding of Ananymous (2008). Similarly, Ray et.al.(1994) studied the natural cross pollination in soybean and reported that decreasing the percent of contamination by increasing the distance of pollen source.

The results of pooled data indicated that the off-type is seen to occur in higher numbers, which lead to rejection of the seed due to genetic impurity above the permissible limit i.e. 0.5 % in certified seed as mentioned in Indian Minimum Seed Certification Manual. Hence, the isolation distance of 3 m is inadequate for maintaining the genetic purity. Under isolation distance of 5 m there was no contamination and was effective for maintaining the genetic purity in seed production of soybean. Surendra Prakash and Singhal (2003) also studied the natural cross pollination in self pollinating crop like bread wheat and suggested to increase the isolation distance from 3 m to 5 m for cultivar purity in seed production plots. The present result emphasized the need of isolation and rouging during seed production and cultivar maintenance to keep it as pure as it was released. Hence, an isolation

Table- 1 : Observation flowering habit, floral characters, plant height and seed characters of PK-1029 and JS-335 (Mean value).

S.N.	Observations to be recorded	3 m Isolation Distance		5 m Isolation distance	
		PK-1029	JS-335	PK-1029	JS-335
1	Days to flowering initiation	37.67	37.33	37.67	37.33
2	Days to 50% flowering	43.33	42.33	43.33	42.33
3	Style length (mm)	1.92	2.61	1.94	2.58
4	Anther size (mm)	0.283	0.312	0.282	0.323
5	Plant height at maturity (cm)	36.2	45.2	36.27	45.1
6	Flower colour	White	Violet	White	Violet
7	Pod pubescence	Present	Absent	Present	Absent
8	Seed colour	Dark Yellow	Yellow	Dark Yellow	Yellow
9	Hilum colour	Black	Brown	Black	Brown
10	No. of pod/Plant	81	97	84	97.33
11	Pod weight/Plant (g)	125.67	142	129	146.33

Table 2 : Effect of isolation distance on the genetic purity of Soybean. (Results of grow out test conducted for three year i.e. 2006-07, 07-08 and 08-09)

Year	Number of plant	Number of off type plant	% of off type plant
3 m Isolation			
2006-07	2472	18	0.728
2007-08	2392	21	0.87
2008-09	2300	9	0.47
Mean	**2388**	**16**	**0.68**
5 m Isolation			
2006-07	2500	0.0	0.0
2007-08	2385	0.0	0.0
2008-09	2386	0.0	0.0
Mean	**3323.66**	**0.0**	**0.0**

distance in soybean of 5 meters be used in place of presently recommended 3 meters to minimize the frequency of out crossing and maintaining the genetic purity in succeeding generation.

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Effect of Nitrogen Levels and Azospirillum on Growth and Yield of Safflower

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ABSTRACT

A field experiment was carried out during *Rabi* season of 2007-08 at Agronomy Farm, College of Agriculture, Nagpur to study the effect of nitrogen levels and ozospirillum on growth and yield of safflower in RBD with seven treatments. Application of 50 kg N ha^{-1} (125 % RDN) recorded significantly highest seed yield and harvest index over other treatments exeept 40 kg N ha^{-1} (100% RDN) + *Azospirillum* seedinoculation of soil application which were at par with it. Similar trend was observed in respect of residual fertility status, gross monetary returns, net monetary returns and benefit cost ratio. Thus, seed treatment (250 g 10 kg^{-1} seed) or soil application (3 kg ha^{-1}) with *Azospirillum* could reduce nitrogen requirement by 10 kg.

Safflower is an important oilseed crop of Vidarbha. It is grown under rainfed condition in vertisols during *Rabi* season. The productivity of safflower is low and unstable. Nutrient management plays an important role among the various factors that are responsible for the yield of safflower. The high cost of fertilizers, nutrient imbalance and adverse effect on soil physicachemical properties are some of the factors which limit the use of chemical fertilizers. therefore, efforts are now being made to find out low cost alternatives by making nutrients available from natural source i.e. almosphere or through soil by use of biofertilizer. *Azospirillium* have been found more effective in increasing the yield of safflower, sorghum, maize and wheat through nitrogen fixation. The *Azospirillium* inoculation observed a wide variation in increasing the yield (0-64%) which was up to 2-3 q ha^{-1} (Sharma, 2000). *Azospirillium* treatment can supplement the Nitrogen requirment of the safflower.Cost can be reduced to 50 per cent due to seed treatment with *Azospirillium* and give more economic returns (Hajare, *et. al.*, 2003). considering this view, the present investigation was carried out with the objective to find out suitable combination of nitrogen fertilizer and *Azospirillium* for better growth and yield of safflower.

MATERIAL AND METHODS

The field experiment was conducted during *Rabi* season of 2007-08 at Agronomy Farm, College of Agriculture, Nagpur. The soil of the experimental field was clayey in texture having 0.53 per cent organic carbon, available N 248 kg, 16 kg available P_2O_5 nd 390 kg available K_2O ha^{-1} with pH 7.2. the experiment was laid out in randomized block design with seven treatments replicated four times. The treatments were T_1-50 kg N ha-1 (125% RDN), T_2 -40 kg N ha^{-1} (100% RDN), T_3 - 30 kg N ha^{-1} (75%RDN), T_4 - 40 kg N ha^{-1} (100% RDN) + *Azospirillium* seed treatment, T_5 - 30 kg N ha^{-1} (75% RDN) + *Azospirillium* seed treatment, T_6 - 40 kg N ha^{-1} (100% RDN) + *Azospirillium* soil application and T_7 - 30 kg N ha^{-1} (75% RDN) + *Azospirillium* soil application.

Safflower seed of variety AKS-207 was dibbled at 45 x 20 cm spacing. Fertilizer was applied as per the treatments. Seed treatment and soil application was done with *Azospirillium* @ 250 per 10 kg seed and 3 kg ha^{-1} , respectively. The recommended doe of fertilizer for the irrigated safflower was 40 kg N + 40 kg P_2O_5 ha^{-1} with half N and full P_2O_5 as basal and half N at 30 days after sowing. The observation on growth viz., height of plant, number of branches $plant^{-1}$, dry matter accumulation on growth viz., height of plant, number of branches $plant^{-1}$, dry matter accumulation $plant^{-1}$ at harvest and yield attributes viz., number of capitulum $plant^{-1}$, number of seeds $capitulum^{-1}$, weight of seed $capitulum^{-1}$, seed yield $plant^{-1}$ and seed yield ha^{-1} were recorded. The soil anslysis was done for assessing nutrient status before sowing and at harvest.

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Table 1. Growth and yield attributes as influenced by various treatments

Treatments	Growth attributes			Yield attributes				
	Plant height (cm)	No. of branches plant^{-1}	Dry matter (g plant^{-1})	No. of capitulum plant^{-1}	No. of seeds capitulum	Weight of seeds capitulum	Test weight (g)	Seed yield plant^{-1}
T_1 - 50 kg N ha^{-1} (125% RDN)	96.16	10.25	50.15	15.25	16.32	1.18	5.25	976
T_2 - 40 kg N ha^{-1} (100% RDN)	94.63	8.95	49.00	14.88	15.70	1.01	4.24	8.97
T_3 - 30 kg N ha^{-1} (75% RDN)	93.10	7.52	48.10	14.28	14.80	0.91	4.00	7.60
T_4 - 40 kg N ha^{-1} (100% RDN) + Azo. seed	95.85	10.10	50.02	15.20	16.16	1.12	4.85	9.47
T_5 - 30 kg N ha^{-1} (75% RDN) + Azo. seed	93.83	8.40	48.96	14.73	15.50	0.94	4.21	8.75
T_6 - 40 kg N ha^{-1} (100% RDN) + Azo. soil	95.05	9.90	49.85	15.10	16.05	1.08	4.72	9.34
T_7 - 30 kg N ha^{-1} (75% RDN) + Azo. soil	93.42	8.22	48.55	14.56	15.45	0.92	4.11	8.68
S.E. (m) $\pm$	0.53	0.25	0.18	0.11	0.10	0.04	0.50	0.16
CD at 5% level	1.52	0.77	0.52	0.34	0.29	0.11	N.S.	.48

Azo. seed = *Azospirillium* seed treatment @ 250 g 10 kg^{-1} seed

Azo. soil = *Azospirillium* seed treatment @ 3 kg ha^{-1}

Table 2. Seed yield, residual fertility status of soil and economics as influenced by various treatment

Treatments	Yield		Available NPK kg ha^{-1}			Economics of treatment			
	Seed (q ha^{-1})	Harvest index, %	N	P	K	Cost of cultivation	GMR Rs. ha^{-1}	NMR Rs. ha^{-1}	B:C ratio
T_1 - 50 kg N ha^{-1} (125% RDN)	9.76	19.33	264.42	20.10	400.52	9610	20496	10886	2.13
T_2 - 40 kg N ha^{-1} (100% RDN)	8.97	18.65	263.48	18.72	398.54	9500	18920	9420	1.99
T_3 - 30 kg N ha^{-1} (75% RDN)	7.60	18.11	262.58	17.04	397.88	9390	15960	6570	1.69
T_4 - 40 kg N ha^{-1} (100% RDN) + Azo. seed	9.47	19.08	264.23	19.88	400.38	9520	19887	10367	2.09
T_5 - 30 kg N ha^{-1} (75% RDN) + Azo. seed	8.75	18.55	263.62	18.14	398.45	9410	18375	8718	1.95
T_6 - 40 kg N ha^{-1} (100% RDN) + Azo. soil	9.34	18.97	264.10	19.12	400.20	9620	19614	10114	2.04
T_7 - 30 kg N ha^{-1} (75% RDN) + Azo soil	8.68	18.48	263.09	17.75	398.26	9510	18228	8755	1.92
SE(m)±	0.16	0.17	0.16	0.34	0.15	-	549	478	-
CD at 5% level	0.48	0.50	0.48	1.08	0.46	-	1678	1468	-

RESULTS AND DISCUSSION

Growth attributes :

Data presented in Table 1 indicated that, plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} at harvest was significantly higher with application of 50 kg N ha^{-1} (125% RDN) among all and at par with 40 kg N ha^{-1} (100 % RDN) + *Azospirillium* seed treatment and 40 kg N ha^{-1} (100 % RDN) + *Azospirillium* soil application. This might be due to sufficient availability of nutrient which resulted in better growth of crop. This is in tune with the findings reported by Ahmad *et. al.*, (2003) and Bhongle *et. al.*, (2003).

Yield and Yield Attributes

The data from the table 1 revealed that application of 50 kg N ha^{-1} (125% RDN) recorded maximum and significantly higher number of capitulum plant^{-1} , number of seeds capitulum^{-1} , weight of seed capitulum^{-1} , seed yield plant^{-1} and seed yield ha^{-1} (9.79 q ha^{-1}) over all other treatments but was at par with application of 40 kg N ha^{-1} (100% RDN) + *Azospirillium* seed treatment and 40 kg N ha^{-1} (100% RDN) + *Azospirillium* soil application. Patel *et. al.*, (1994) nd Papi Reddy *et. al.*, (1994) also reported similar findings.

Residual Soil Fertility

As could be seen from the data presented in Table 2 that available N, Available P_2O_5 and Available K_2O (kg ha^{-1}) at harvet found increased with application of higher dose of inorganic fertilizer and in combination with biofertilizer. Available N, Available P_2O_5 and Available K_2O (kg ha^{-1}) in soil were significantly maximum with application of 50 kg N ha^{-1} (125% RDN) amongst all but at par with 40 kg N ha^{-1} (100 % RDN) + *Azospirillium* seed treatment and 40 kg N ha^{-1} (100% RDN) + *Azospirillium* soil application. This might be due to balanced supply of nutrient in maintaining right level of residual nutrient status. Similar results were reported by Ekshinge *et. al.*, (1995) and Papi Reddy *et. al.*, (1994).

Economic Study

Data presented in Table 2 indicated that gross monetary returns (Rs. 20496), net monetary returns (Rs. 10886) and B:C ratio (2.13) were highest with application of 50 kg N ha^{-1} (125% RDN) over all other treatments but at par with application of 40 kg n ha^{-1} (100% RDN) + *Azospirillium* seed treatment and 40 kg N ha-1 (100 % RDN) + *Azospirillium* soil application. This is in accordance with the findings reported by Makhawara *et. al.* (1996).

Thus, from the present investigation it can be concluded that either seed treatment @ 250 g 10 kg^{-1} seed or soil application @ 3 kg ha^{-1} with *Azospirillium* can reduced the nitrogen requirement of safflower.

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Research Notes

Effect of Pendimethalin and Different Doses of Acetolactate Synthase Inhibitor on Growth, Yield and Economics of Groundnut

Groundnut *(Arachis hypogaea* L.) is one of the most important oil seed crops of India. India ranks first in the world in groundnut with an area of 7.3 million ha and ranks second in production of about 8.3 million tonne. India accounts for 40 per cent of world area and 30 per cent of world out put of groundnut (Anonymous, 2000). Weed infestation is a limiting factor in the production of groundnut, being a dwarf nature of crop and with slow growing habit in initial stages making the weeds to quickly dominate groundnut. During flowering stage, the weeds create problem to pegging in groundnut. The weeds directly compete groundnut crop for nutrients, space, water and solar radiation. Hence present investigation was carried out.

Field study was conducted on the experimental farm of the Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2002 on the clay loam soil, low in organic carbon (0.36%), total nitrogen (0.038%) and available phosphorus (16.96 kg ha^{-1}) but high in potash (291.50 kg ha^{-1}). The soil pH was slightly alkaline in reaction.

The experiment consisting of eleven treatments (Table I) laid out in a randomized block design with three replications. The net plot size was 4.2 x 3.0 in. Groundnut (Var. TAG -24) was sown on 29 June 2002 using a seed rate of 100 kg Kernels ha^{-1}. The crop was sown by dibbling method keeping row to row distance 30 cm and 10 cm plant to plant. Before sowing, seeds were treated with Thirum @ 3 g kg^{-1} seed and soon before the seed were treated with Rhizobium culture @ 250 g per 15 kg. The recommended dose of nutrients (25 kg N, 50 kg P_2O_5) to groundnut was uniformly applied to all the treatments. Other agronomic operations and plant protection measures were followed as per recommendations. The crop was harvested on 22 October 2002. Yield and yield contributing characters along with economics in term of net returns were studied.

The prominent weeds observed in the experimental field mainly comprised of *Euphorbia geniculata, Physalis minima, Digera arvensis, Lagasca mollis, Acalypha indica, Phyllanthus niruri* among the dicot and *Denebra arabica, Commelina*

Table I : Treatment Details

S.N.	Treatments
T_1	ALS 37.5 g a-i.ha^{-1} spray 5 DAS fb IH + IHW at 35 DAS
T_2	ALS 50 g a-i.ha^{-1} spray 5 DAS fb 1H+ IHW at 35 DAS
T_3	ALS 62.5 g a.i.ha^{-1} spray 5 DAS fb IH + IHW at 35 DAS
T_4	ALS 75 g a.i.ha^{-1} spray 5 DAS fb IH +1HW at 35 DAS
T_5	ALS 100 g a.i.ha^{-1} spray 5 DAS fb IH +1 HW at 35 DAS
T_6	ALS 50 g a.i.ha^{-1}, Pendimethalin @ 250g. a.i.ha^{-1} spray 5 DAS fb IH + IHW at 35 DAS
T_7	ALS 50 g a.i.ha^{-1}, Pendimethalin @ 500g. a.i.ha^{-1} spray 5 DAS fb IH + IHW at 35 DAS
T_8	PE Application of Pendimethalin @ 1 kg a.i.ha^{-1}
T_9	Recommended Practice (2H + 2HW at 20 and 40 DAS)
T_{10}	Weed free check (without chemical)
T_{11}	Weedy check (control)

***ALS-Aceto Lactate Synthase, DAS = Days after sowing, H = Hoeing, HW = Hand weeding, PE = Pre-emergence**

Table 2: Growth, yield and Economics of groundnut as influenced by different weed control treatments

Treatments	At harvest		pod yield	Haulm	GMR	NMR	B:Cratio
	Plant height (cm)	Dry matter plant^{-1}(g)	(q ha^{-1})	yield(q ha^{-1})	(Rs ha^{-1})	(Rs ha^{-1})	
T_1 - ALS 37.5 g a.i.ha^{-1} spray 5 DAS fb 1H + 1HW at 35 DAS	22.40	12.83	10.37	18.78	20543	10906	2.13
T_2 - ALS 50 g a.i.ha^{-1} spray 5 DAS fb 1H+ 1 HW at 35 DAS	22.53	15.00	11.00	20.10	21842	12209	2.26
T_3 - ALS 62.5 *g* a.i.ha^{-1} spray 5 DAS fb 1 H + ! HW at 35 DAS	23.33	16.10	12.38	21.16	24196	14559	2.51
T_4 - ALS 75 g a.i.ha^{-1} spray 5 DAS fb 1 H +1 HW at 35 DAS	22.93	15.50	11.53	19.84	22574	12933	2.35
T_5 - ALS 100 g a.i.ha^{-1} spray 5 DAS fb 1H +1 HW at 35 DAS	22.60	14.10	10.85	19.57	21468	11969	2.26
T_6 - ALS 50 g a.i.ha^{-1}, Pendimethalin @ 250g.a.i.ha^{-1} spray 5 DAS fb 1H + 1HW at 35 DAS	22.73	15.30	11.22	18.78	21820	12059	2.24
T_7 - ALS 50 g a-i.ha^{-1}, Pendimethalin @ 500g. a.i.ha^{-1} spray 5 DAS fb 1H + 1HW at 35 DAS	23.00	15.50	12.01	20.11	23368	13480	2.37
T_8 - PE Application of Pendimethalin @1 kg a.i.ha^{-1}	21.73	11.02	.7.83	16.40	16088	7051	1.79
T_9 - Recommended Practice (2H + 2HW at 20 and 40 DAS)	24.33	17.82	14.95	22.08	28312	18063	2.77
T_{10} - Weed free check (without chemical)	25.80	19.35	16.14	23.54	30488	19329	2.74
T_{11} - Weedy check (control)	21.33	7.52	3.12	11.38	7674	665	0.93
S. E (m) ±	0.73	0.66	0.63	1.16	1215	591	0.15
C. D. at 5%	2.15	1.98	1.86	3.43	3584	1770	0.46

Wages of male / female Labour Charges - Rs. 47 day^{-1}.

Value of produce / herbicides Pod - Rs. 1510 q^{-1}, Haulm - Rs. 260 ALS inhibitor herbicides - Rs. 300 lit^{-1}, Pendimethalin - Rs. 480 lit^{-1}

benghalensis, Poa annua, Cyperus rotundus and Cynodon dactylon among the monocots. (Bhagat, 1997) also noticed this type of weed flora.

It is evident from Table 2 that weed free check (T_{10}) recorded highest plant height (25.80 cm) and it was followed by T_9 i.e. recommended practice (24.33 cm) and were at par. In control treatment (T_{11}) recorded lowest plant height. Among herbicides application of ALS inhibitor herbicide @ 62.5 g ha^{-1} spray 5 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_1) recorded highest plant height 23.33 cm which was at par with treatment T_7, T_4, T_6, T_3, T_2 and T1 Similar observations were also reported by *Brar et al.* (1980).

All treatments were significantly superior in dry matter production over check. Among treatments, weed free check (Tio) recorded 19.35g dry matter yield, followed by treatment recommended practice (T_9). Treatment Ti i.e. application of ALS inhibitor herbicide @ 62.5 g ha^{-1} spray 5 DAS + one hoeing + one hand weeding at 35 DAS was also proved best in increasing dry matter (16.10g) was at par with treatment T_4, T_7, T_6 and T_2. Similar results have been reported by Chaudhari and Mankar (1991).

Maximum dry pod yield was obtained with treatment T_{10} i.e. weed free treatment (16.14q ha^{-1}) which was statistically at par with treatment T_9 (14.95 q ha^{-1}). Among the herbicidal treatments, Treatment T_3 recorded significantly superior dry pod yield (12.38 ha^{-1}) over weedy check which was at par with treatment T_7, T_4, T_6, T_2 and T_5 Results are in conformity with those by Brar *et al.* (1980) and Attarde *et al.* (2001).

Highest GMR was obtained with treatment TIO i.e. weed free treatment (Rs.30488 ha^{-1}) which was statistically at par with treatment T_9 (Rs. 28312 ha^{-1}). Among herbicides application of ALS inhibitor herbicide @ 62.5 g ha^{-1} spray 5 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_1) recorded significantly superior GMR (Rs.24196 ha^{-1}) over weedy check which was at par with treatment T_7, T_4, T_2, Tg and TS Results are in conformity with those reported by Attarde *et. al.*, (2001), Parbhakaran *et. al.* (1996) and Suryawanshi *et. al.*, (2001).

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Ergonomical Assessment of Hand Operated Rotary Maize Shelter for Farm Women

At present maize shelling has been improved by the use of tubular maize shellers and hand operated rotary maize shellers. Tubular maize shelling is done by holding the sheller in one hand and gradually inserting the cob into the sheller by the other hand with clockwise and anticlockwise rotation. The tubular maize sheller is getting popularity among the small and marginal farmers (Agrawal and Satapathy, 2006). Removing grain from the cob by hand operated rotary maize sheller is preferred for seed production due to less damage to the grain during the shelling operation.

As the hand operated rotary maize sheller is manually operated tool, its work performance depends not only on the equipment but also on the operator. If ergonomic aspects are not given due consideration, performance of the man-machine equipment system will be poor, resulting in lower work output, because the worker may have to take frequent rests or a long rest and the effective working time would reduced (Gite and Yadav, 1982). Hence the study was undertaken to evaluate the performance of hand operated rotary maize sheller from ergonomic point of view.

A study on hand operated rotary maize sheller was conducted at CIAE, Bhopal for maize shelling operation with farm women subjects to assess the physiological work load based on heart rate data during maize shelling operation. The performance evaluation was measured in terms of output capacity, shelling efficiency and unthreshed grain. Hand operated rotary maize sheller is manually operated equipment consisting of a flywheel, a frame, a hopper and three shelling gears. With one hand a person operates the equipment by hand cranking whereas with the other hand he feeds the cobs into the machine one by one. The shelled cobs come out through the port on opposite side. Hand operated rotary maize sheller is shown in fig. 1.

A healthy age group ranging from 20-35 years was randomly selected as subjects for the present study. The measured body dimensions of selected female agricultural workers have been presented in Table 1. All subjects were agricultural workers and were familiar with the use of maize shellers. Initially the subjects were briefed about the experiment and the procedure to be-followed so as to enlist their full cooperation.

The heart rate was taken as an evaluating measure. For measurement of heart rate Polar heart rate monitor (Polar Vantage NV) was used and were fitted on the subjects. The duration of each trial was 15 minutes. Shelling operation was carried out at constant speed of 50 rpm.

Performance evaluation of hand operated rotary maize sheller

Fourteen body dimensions involved in maize shelling operations of 6 female agricultural workers of Bhopal district were measured. The consolidated data of these dimensions are presented in Table 1, from this table it can be seen that the statures of female subjects were ranged from 152.50 cm to 160.00 cm. The weights of subjects ranged from 41.00 kg to 66.00 kg. In maize shelling operation, the man and machine interaction is through hand; therefore dimensions related to hand were measured. It includes hand length, grip diameter (inside), grip

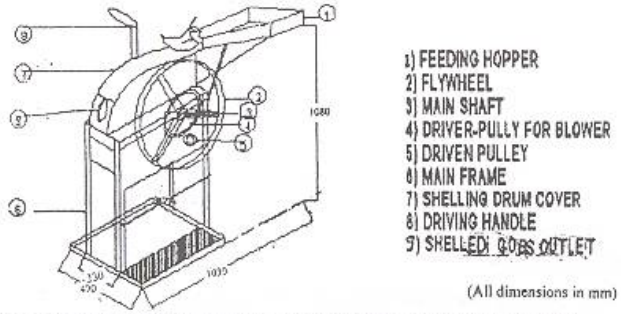

Fig. 1 : Schematic diagram of handoperated rotary maize shellar

Table 1. Anthropometric data of selected female workers (N=6) study.

(All dimensions in cm except otherwise mentioned)

S.N.	Body Dimensions	S1	S2	S3	S4	S5	S6	Mean
1	Age, (years)	33.0	32.0	35.0	30.0	33.0	30.0	32.16
2	Weight, (kg)	56.0	44.0	41.0	44.0	66.0	54.0	50.83
3	Stature	155.4	155.0	153.0	160.0	154.0	152.5	154.98
4	Acromial height	127.6	127.4	122.0	133.8	128.0	126.7	127.58
5	Elbow height	98.5	96.9	93.5	101.1	94.0	93.0	96.18
6	Olecranon height	94.5	93.9	90.6	98.5	93.5	92.2	93.86
7	Tochanteric height	79.0	80.1	84.7	83.1	85.0	83.2	82.51
8	Arm reach from wall	75.1	74.7	77.4	77.9	77.0	73.5	75.93
9	Shoulder grip length	66.0	66.1	67.0	68.6	68.0	64.3	66.66
10	Metacarpal III height	67.9	66.8	65.1	66.9	63.0	63.3	65.50
11	Hand length	17.3	16.5	18.1	17.3	16.7	16.6	17.08
12	Palm length	9.8	9.4	10.7	10.1	9.3	9.6	9.81
13	Grip diameter (outside)	8.0	7.7	8.4	7.4	8.0	8.0	7.9
14	Grip diameter (inside)	4.8	4.6	5.4	4.5	4.6	4.6	4.75

Table 2. Performance evaluation and Heart rate response of subjects

S.N.	Sub. No	Replications	(%) Unshelled grain	Shelling efficiency (%)	Output Capacity (kg h^{-1})	Heart Rate (beats/min)	AHR (beats min^{-1})
1	S_1	1	3.23	96.77	93.60	134	63
		2	2.55	97.45	90.24	129	60
2	S_2	1	3.76	96.24	80.60	136	56
		2	2.86	97.14	86.60	141	60
3	S_3	1	4.23	95.77	78.28	135	53
		2	2.25	97.75	83.98	137	58
4	S_4	1	2.98	97.02	85.23	139	58
		2	3.55	96.45	90.00	143	60
5	S_5	1	4.25	95.75	87.50	140	62
		2	4.00	96.00	81.20	138	57
6	S_6	1	3.08	96.92	83.58	145	51
		2	3.96	96.04	91.77	141	52
Av			3.39	96.60	86.06	138.2	57.5

diameter (out side), maximum grip length, grip span, middle finger palm grip diameter, palm length and arm reach.

Experiments were carried out to measure physiological responses in terms of heart rate of female agricultural workers during maize shelling operation with hand operated rotary maize sheller. The mean (±S.D) dry bulb temperature, wet bulb temperature, relative humidity was observed as 36.45+1.21 °C, 20.7+0.823 °C, 22+2.58 percent respectively during the period of experiment.

The mean working heart rate (HR) and increase in heart rate over rest i.e. delta heart rate (AHR) during maize shelling operation with hand operated rotary maize sheller is shown in Table 2. The mean working heart rate (HR) and increase in heart rate over rest (AHR) during maize shelling operation with hand operated rotary maize sheller was observed as 138.2 beats per min and 57.5 beats per min. According to classification suggested by Varghese *et al.*, (1994), the maize shelling operation with hand operated rotary maize sheller was scaled in "Very heavy" category of workload.

Mechanical evaluation of maize shelling operation was carried out to evaluate the shelling operation in terms of output capacity, shelling

efficiency and unthreshed grain. Performance evaluation is shown in Table 2

The mean heart rate and increase in heart rate over rest (AHR) during maize shelling operation with hand operated rotary maize sheller was observed as 138.2 beats per min and 57.5 beats min^{-1}. The maize shelling operation with hand operated rotary maize sheller was scaled in "Very heavy" category of workload. The performance evaluation of hand operated rotary maize sheller in terms of output capacity, percentage of unshelled grain, shelling efficiency was observed as 86.06 kg h^{-1}, 3.39 and 96.60 per cent, respectively.

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Biorational Management on Cauliflower

Diamondback moth *Plutella xylostella* (L.) is the most noxious pest of cauliflower recording almost 52 to 80 per cent losses in marketable curds alongwith other pests (Cheliah and Srinavasan, 1986). Indiscriminate and unjustified use of conventional insecticides resulted in adverse changes in the biotic balance and led to the development of resistance in *Plutella xylostella* (Linnaeus) (Deshmukh and Saramma, 1973).

It has therefore, become the need of the day to formulate biointensive pest management (BIPS) system for minimising the use of chemical pesticides and promoting the application of eco-friendly insecticides. Hence this experiment was conducted to determine the comparative efficacy of eco-friendly biopesticides to recommended insecticide quanolphos 0.05 per cent at the experimental field of College of Agriculture, Nagpur during *Rabi* season of 2006-07. The experiemnt was conducted on cauliflower variety Snowball in RBD with 11 treatments replicated thrice to study the efficacy of biopesticides viz., *Bacillus thuringiensis* (liquid form), *Metarhizium anisopliae* $1x10^8$ conidia ml^{-1} and $1x10^6$ conidia ml^{-1}, *Beauveria bassiana* $1x10^8$ conidia ml^{-1} and $1x10^6$ conidia ml^{-1} and parasitoid *Trichorgammatoidea bactrae* and neem based pesticides, neem seed extract 5 per cent and Neemark 1500 ppm in comparison with recommended insecticide quinalphos 25 EC 0.05 per cent to search out most economically viable tool for management of Diamondback moth.

Five plants per plot were selected randomly from each plot. As soon as 1 larva/plant was noticed, the treatments were initiated. Pre-treatment observations on larvae/plant were recorded on 5 selected observational plants 24 hours before the spray. Post treatment observations on larval count were recorded on 3rd, 5th, 7th and 14th day after application of treatments. The release of *Trichogrammatoidea bactrae* was carried out under muslin cage conditions. In all, two sprays were undertaken during the experiment at an interval of 17 days as second spary could not be undertaken at 15 days interval due to rains. On the basis of population in pre-treatment observations, the percent reduction in larval population of DBM was computed.

The results clearly indicated that recommended insecticide quinalphos 0.05 per cent

offered maximum percent mean reduction in the larval population to the extent of 74.21 per cent with maximum yield 232.93 q ha^{-1} and higher ICBR 1:95.96. *Trichogrammatoidea bactrae* at both release rates (1.5 and 1 lakh eggs ha^{-1}) registered second rank in reducing the per cent larval population to the tune of 50.39 and 45.22 per cent respectively and registered yield of 190.72 and 188.69 q ha^{-1}, respectively with maximum ICBR of 1:139.92 and 1:132.75, respectively. The result revealed that the *Bacillus thuringiensis* @ 1000 mgha^{-1} recorded mean larval reduction of 47.81 per cent and registered second rank position in respect of yield (191.14 q ha^{-1}) with ICBR 1:42.35 and was found costly as compared to other biopesticides tested. The performance of *Metarhizium aniscopliae* at both the concentrations ($1x10^5$ and $1x10^6$ conidia ml^{-1}) as well as *Beauveria bassiana* at both the concentrations ($1x10^8$ and $1x10^6$ conidia ml^{-1}) was superior to control in respect of reduction of percent larval population in range of (42.88 and 36.86 per cent) respectively and yield upto (187.74 and 177.18 q ha^{-1}) and (181.55 q ha^{-1} and 173.55 q ha^{-1}), respectively and ICBR of (1:79.85 and 1:75.56) and (1:74.69 and 1:72.23, respectively. In the present investigations the neem products, Neemark and Neem seed extract of 5 per cent performed well in respect of percent larval reduction 31.28 and 29.09, respectively as compared to control (12.84 %) and yield 158.28 q ha^{-1} and 142.9 q ha^{-1} respectively and ICBR is 1:87.85 and 1:41.31, respectively. Justin and Nirmala (2002) obtained the highest yield of cauliflower curds (27.4 t ha^{-1}) with the treatment of quinalphos 250 g a.i. ha^{-1}. Singh *et al.* (2004) found that *Trichogammatoidea bactrae* reduced larval population to 4.89 larvae $plant^{-1}$. Biradar and Dhanorkar (2001) reported that *Bacillus thuringeinsis* reduced the Diamondback moth (DBM) population and increased curd yield. Similarly Fernandez *et al.* (2003) stated that *Beauveria bassiana* caused mortality of *Plutella xylostella* under field conditions. While, Santigo (1991) found *Metarhizium anisopliae* effective against DBM on the basis of larval mortality and increased yield which support the present findings.

Table 1. Showing effect of different treatments on percent reductions of larval population, yield and incremental cost benefit ratio

S.N.	Treatments	Average percent reduction in larval population of DBM (pooled mean)	Yield(q ha^{-1})	Incremental cost benefit ratio(C/A)
1.	*Bacillus thuringiensis* (liquid form) Dr. PDKV formulation @ 1000 ml ha^{-1}	47.81(43.73)	191.4	1:42.35
2.	*Metarhizium anisopliae* Dr. P.D.K.V. @ 1000 ml ha^{-1} ($1x10^6$ conidia ml^{-1})	36.86(37.38)	177.18	1:75.56
3.	*Metarhizium anisopliae* Dr. P.D.K.V. @ 1000 ml ha^{-1} ($1x10^8$ conidia ml^{-1})	42.88(40.90)	184.74	1:79.85
4.	*Beauveria bassiana* Dr. P.D.K.V. @ 1000 ml ha^{-1} ($1x10^6$ conidia ml^{-1})	36.23(37.00)	173.55	1:72.23
5.	*Beauveria bassiana* Dr. P.D.K.V. @ 1000 ml ha^{-1} ($1x10^8$ conidia ml^{-1})	38.91(38.58)	181.55	1:74.69
6.	*Trichogrammatoidea bactrae* @ 1 lakh eggs ha^{-1}	45.22(42.25)	188.69	1:132.75
7.	*Trichogrammatoidea bactrae* @ 1.5 lakh eggs ha^{-1}	50.39(45.21)	190.72	1:139.92
8.	Neemark (3 ml $lit.^{-1}$)	31.28(34.60)	158.28	1:87.85
9.	Neem seed extract 5%	29.09(32.63)	142.90	1:41.31
10.	Quinalphos 25EC 0.05%	74.21(59.47)	232.94	1:95.96
11.	Control (Water spray)	12.84(20.99)	93.67	
	SE(m)±	0.98	1.52	
	CD at 5%	2.90	4.49	

Figures in parenthesis are corresponding arc-sin transformed values.

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Evaluation of Chickpea Genotypes Against Metabolite Produced by *Fusarium oxysporum* f. sp. ciceri

Chickpea wilt caused by *Fusarium oxysporum. f.sp.ciceri* is one of the major diseases affecting production of this pulse crop. The fungus is soil borne as well as seed borne in nature. It is impracticable to control the disease by using fungicides and crop rotation. Development of resistant varieties is thought to be the most viable strategy to overcome this problem.(Ravikumar and Ratna Babu ,2007).For this purpose, it is necessary to have a full knowledge about the disease, fungus, mode of resistance in host and screening technique. However, difficulties associated with the development and maintenance of uniform wilt sick plot for screening have hindered the process of developing resistant cultivars. Thus, there is a need for more efficient methods for screening cultivars against the disease. Toxic metabolite has been reported to play an important role in pathogenesis. Most of the toxins are low molecular weight compounds, which may cause necrosis, chlorosis, wilting or combination of these symptoms (Scheffer, 1983).Thus, the sensitivity of the host plant to the toxin was correlated with the pathogenicity of the isolates (Iftikhar *et.al.*2001). Therefore, the study was undertaken to evaluate the chickpea genotypes against metabolite produced by *Fusarium oxysporum. f.sp. ciceri*

The highly virulent isolate of *Fusarium ciceri* was grown in six conical flasks of 1000 ml containing 500 ml of sterilized potato dextrose broth at room temperature for 30 days and one flask was kept as uninoculated control. The experiment was conducted during 2007-08 in Seed Pathology Laboratory, Seed Research Unit, MPKV, Rahuri. The content of the flasks were filtered through triple layered Whatman No. 42 filter paper. The filtrate was observed under microscope for presence / absence of conidia. The culture filtrate without conidia was centrifuged at 12000 rpm for 20 minute. The supernatant was pooled as the culture filtrate as such and 50 per cent, 25 per cent and 10 per cent dilutions were made with distilled water. The seeds of 31 chickpea genotypes were sown in autoclaved sand and FYM mixture (1:1) placed in pro-trays. Fifteen seeds of each genotype were used. The 15 days old seedlings were uprooted carefully, the roots were washed in running water and then rinsed with sterilized distilled water. These seedlings were placed into sterilized glass test tubes containing 20 ml undiluted and diluted culture filtrate. Five seedlings

of each genotype of chickpea was tested with two replications in test tube containing culture filtrate and seedlings were held upright in position by cotton plugs. The roots of seedlings were dipped in culture filtrate and incubated at room temperature for four days.

Observations in respect of epinasty and wilting were recorded after 24,48, 72 and 96 h of inoculation.

The seedlings of all chickpea genotypes (resistant and susceptible) were wilted within a period of 48 h after dipping roots of seedlings in undiluted culture filtrate. It indicated that culture

Table 1 Evaluation of chickpea genotypes at 10% concentration of *Fusarium ciceri* culture filtrate.

Genotypes	No. of plants tested	Progressive no. of plants wilted after h			No. of seedings wilted	Percent wilt (%)	Disease reaction
		48	72	96			
			Desi				
Chafa	10	6	4	-	10	100	S
Vishal	10	-	-	-	0	0	R
Digvijay	10	-	3	7	10	100	S
Vijay	10	2	8	-	10	100	S
Rajas	10	4	6		10	100	S
PG-5	10	3	7		10	100	S
PG-007-3-	10	6	3	1	10	100	S
PG-97084	10	-	-	1	1	10	R
PG-0001-15-2	10	4	6	-	10	100	S
PG-9409-1	10	-	-	1	1	10	R
SAKI-9516	10	-	-	1	1	10	R
PG-9621-8	10	7	3	-	10	100	S
PG-9758-6-2	10	-	8	2	10	100	S
PG-0001-14-3	10	2	8	-	10	100	S
PG-96006	10	-	8	2	10	100	S
PG-03110	10	6	4	-	10	100	S
PG-00103	10	2	8	-	10	100	S
JAKI-9218	10	3	7	-	10	100	S
PG-0008-8-1	10	2	7	1	10	100	S
PG-00109	10	2	8	-	10	100	S
PG-0010-6-1	10	1	9	-	10	100	S
PG-9915-6	10	-	9	1	10	100	S
PG-0202-5-1	10	-	7	3	10	100	S
PG-0002-12-4	10	3	7	-	10	100	S
JG-62	10	8	2	-	10	100	S
			Kabuli				
Mexigold	10	2	8	-	10	100	S
PG-9924-5	10	3	7	-	10	100	S
Vihar	10	-	-	1	1	10	R
Virat	10	-	9	1	10	100	S
BGD-2045	10	8	2	-	10	100	S
BGD-1040	10	9	1	-	10	100	S

Where, R : Resistant (< 10 % wilting) S : Susceptible (> 20.1 % wilting)

filtrate of isolates contained metabolites, which were toxic to cause seedling mortality within 48 h. Similarly, all these genotypes of chickpea wilted within 72 h when evaluated in 50 per cent and 25 per cent dilution of culture filtrate.

Observations on effect of culture filtrate of *Fusarium oxysporum f. sp. ciceri* on wilting of 31 chickpea genotypes at 10 per cent dilutions of culture filtrate was presented in (Table 1).The variety JG-62 highly susceptible to *Fusarium* wilt and other susceptible varieties showed necrotic lesions and death of seedlings. *Fusarium oxysporum f. sp. ciceri* was reported to produce a pterocarpan toxic compounds which leads in wilting of chickpea (Alam *et.al.*, 2000). The seedlings of *Desi* genotypes *viz.*, Vishal, PG-97084. PG-9409-1 and SAKI-9516 and kabuli genotype 'Vihar' showed no wilting even after 96 hrs indicating that these varieties were resistant to *Fusarium* wilt at 10 per cent dilution of metabolite. Therefore, 10 per cent dilution of culture filtrate can be used to screen the chickpea genotypes for wilt resistance.

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Evaluation of *Trichoderma* Spp. Against *Fusarium oxysporum f. sp ciceri* Isolates Infecting Chickpea

Wilt of chickpea *(Fusarium oxysporum* f.sp. *ciceri)* is an important constraint in higher production of chickpea in Maharashtra and several other states of country. Chickpea wilt was widely distributed in 32 countries (Haware *et.al.* 1986 and Nene and Kannaiyan, 1996). Various factors were responsible for reduction of yield in chickpea, among them wilt incited by F.O.C is important one.

The disease is soil borne in nature therefore difficult to control. Seriousness of this disease can be imagined by the fact that during last decades several good cultivars developed, had been thrown out of cultivation, only due to their susceptibility to *Fusarium* wilt. Some cultivars like Phule G-5, Vijay and Annigeri have been identified as resistant source against *Fusarium* wilt at the centre of its development and found susceptible at other centers because of break down in their resistance which happens due to variability in the pathogen.

Effectiveness of *Trichoderma viride* and *T.harzianum* as biocontrol agents in controlling chickpea wilt was reported earlier (Shinde *et.al* 2005).

The chickpea samples infected with wilt were collected from chickpea growing areas of Maharashtra *viz.* Ahmadnagar, Dhule, Pune, Nashik, Satara, Solapur, Kolhapur,Parbhani, Nanded, Akola, Nagpur, Amravati, Latur and Jalna districts during the year 2007-08. A study was undertaken to evaluate *Trichoderma* spp. *viz. T. viride, T.harzianum, T.koningii, T. hamatum and T. logispoum* against 20 isolates of *F.O.C in-vitro.* Efficiency of these isolates were tested by growth inhibition study. The radial mycelial growth of each isolate with each

Table 1: *In-vitro* evaluation of *Trichoderma* spp. against isolates of *Fusarium oxysporum of f.sp.ciceri*

Isolate No	Place of collection and district	Mean Colony dia(mm)	%inhibition by *T.harzianum*	Mean Colony dia(mm)	%inhibition by *T.harzianum*	Mean Colony dia(mm)	%inhibition by *T.harzianum*	Mean Colony dia(mm)	%inhibition by *T.harzianum*	Mean Colony dia(mm)	%inhibition by *T.harzianum*
I_1	Mohol(Solapur)	5.0	94.44	22.5	75.00	17.5	80.55	60.0	33.33	40.0	55.55
I_2	Pandharpur(Solapur)	25.0	72.22	25.0	72.22	20.0	77.77	48.0	46.66	55.0	38.88
I_3	Sangli (Sangli)	30.0	66.66	35.0	61.11	16.0	82.22	30.0	66.66	45.0	50.00
I_4	MPKV,Rahuri(Ahmednagar)	30.0	66.66	35.0	61.11	15.0	83.33	45.0	50.00	15.0	50.00
I_5	Sinnar(Nashik)	35.0	61.11	40.0	55.55	36.0	60.00	60.0	33.33	52.0	42.22
I_6	Gadhinglaj(Kolhapur)	30.0	66.66	35.0	61.11	25.0	72.22	22.5	75.00	45.0	50.00
I_7	Vathar (Satara)	40.0	55.55	42.5	52.77	40.0	55.55	35.0	61.11	20.0	22.22
I_8	Malegaon(Nashik)	15.0	83.33	25.0	72.22	15.0	83.33	22.5	75.00	25.0	72.22
I_9	NARP, Kolhapur(Kolhapur.)	10.0	88.88	30.0	66.66	15.0	83.33	25.0	72.22	25.0	72.22
I_{10}	Nira (Pune)	35.0	61.11	40.0	55.55	25.0	72.22	25.0	72.22	40.0	55.55
I_{11}	Agril.College, Dhule (Dhule)	40.0	55.55	42.5	52.77	25.0	72.22	35.0	61.11	40.0	55.55
I_{12}	Devulagaon (Akola)	15.0	83.33	20.0	77.77	18.0	80.00	17.5	80.55	42.0	53.33
I_{13}	Dr.PDKV,Akola, (Akola)	20.0	77.77	30.0	66.66	15.0	83.33	25.0	72.22	45.0	50.00
I_{14}	Shegaon (Akola)	30.0	66.66	36.0	60.00	30.0	66.66	35.0	61.11	40.0	55.55
I_{15}	Agril.College,Nagpur (Nagpur)	15.0	83.33	28.5	68.33	15.0	83.33	30.0	66.66	35.0	61.11
I_{16}	Amravati(Amravati)	30.0	66.66	26.0	71.11	18.0	80.00	22.5	75.00	35.0	61.11
I_{17}	Parbhani(Parbhani)	28.0	68.88	30.0	66.66	20.0	77.77	30.0	66.66	40.0	55.55
I_{18}	Latur (Latur)	26.0	71.11	22.5	75.00	25.0	72.22	40.0	55.55	40.0	55.55
I_{19}	ARS, Badnapur (Jalna)	48.0	46.66	35.0	61.11	42.0	53.33	40.0	55.55	50.0	44.44
I_{20}	Nanded (Nanded)	36.0	60.00	35.0	61.11	5.0	94.44	37.5	58.33	70.0	22.22
	Control	90.0		90.0		90.0		90.0	-	90.0	-
	S.E ±	1.24		1.15		1.25		1.52	-	1.34	-
	Test at 1%	3.53		3.47		3.57		4.33	-	3.82	-
	C.V(%)	7.16		5.77		8.68		7.15	-	5.02	-

Trichoderma spp. (antagonist) was measured for every 24 hrs up to seven days .The per cent inhibition of F.O.C by *Trichoderma* spp. was calculated as per the formula (Arora and Upadyay, 1978)

The results presented in Table-1 indicated that all *Trichoderma* spp. significantly inhibited the growth of FOC isolates.The growth of F.O.C in control was 90 mm.

Trichoderma harzianum inhibited the growth of FOC isolates by 46.66 to 94.44 per cent .The higher inhibition (94.44 %) was observed in the Mohol isolate (Isolate I_1) followed by NARP,Kolhapur isolate I_9(88.88 %). Isolate 8, 12 and 15 showed 83.33 per cent inhibition. Similar results were obtained earlier by Singh *et. al.* (1977) indicating inhibition of *Fusarium ciceri* by *T. harzianum*.

The per cent inhibition of FOC by *T. viride* ranged from 52.77 to 77.77 per cent. The growth of FOC isolates I_1,I_2 ,I_8, I_{12} ,I_{16} and I_{18} inhibited percentage to the extent of 75.00, 72.22, 72.22, 77.77, 71.11 and 75.00 per cent, respectively. Effective control of chickpea *Fusarium* wilt by *T. harzianum and T. viride* was reported earlier by Kolte *et.al.*(1998), Prasad *et.al.*, (2002), Shinde *et.al.*, (2005) and Mandhare and Suryawanshi (2008). Similiarly *Trichoderma koningii* inhibitied the growth of FOC in the range of 53.33 to 94.44 per cent. The maximum inhibition (94.44%) was noted in the Isolate 20 collected from Nanded . The isolates I_4, I_8,I_9,I_{13} and I_{15} showed 83.33 percent inhibition by *T. koningii*.

T.hamatum inhibited the growth of FOC isolates in the range of 33.33 to 80.55per cent .The Isolate I_{12} was inhibitied upto 80.55per cent by *T.hamatum*.The other isolates, I_6, I_8, I_9, I_{10}, I_{13} and I_{16} were suppressed to 75.00,75.00,72.22,72.22,72.22 and 75.00 per cent,respectively

Trichoderma longisporum found less effective for controlling FOC isolates. The percent inhibition was ranged from 22.22 to 72.22.These result clearly indicated that all the *Trichoderma* spp.inhibited the growth of FOC isolates in chickpea.

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Intensification and Diversification of Rice Based Cropping System of Eastern Vidarbha Zone

Rice- fallow- rice, rice- wheat and rice-chickpea are the most common cropping patterns in the double cropped areas of Eastern Vidarbha Zone of Maharashtra State, but these have certain disadvantages. Rice- fallow- rice crop sequence is the most dreadful for the build up of disease and pest complex on the rice crop. The rice- wheat crop sequence could not cover large area due to limited availability of irrigation facility during the *Rabi* season, whereas, rice- chickpea cropping sequence is not remunerative. Hence, it was felt worthwhile to find out the most suitable and economically viable cropping system for the zone to divert the available irrigation water towards other remunerative cropping sequences, after *Kharif* rice.

Four cropping sequences, viz. rice-chickpea, rice-mustard, rice- chickpea- amaranthus and rice- mustard- amaranthus were tested for their suitability and economic viability in the EVZ, treating locations as replications. Different villages in Sindewahi, Brahmpuri and Paoni block of Chandrapur and Bhandara districts was selected, with four replications in each block. Thus, there were total 12 replications analysed in Randomised Block Design. The size of each treatment plot was 20 x 10 m. Soil of the experimental fields were mostly light in texture, medium deep, having pH range of 6.8 to 7.5, low in organic carbon (<0.28 %) and nitrogen (<240 kgha^{-1}), medium in available phosphorus (<38.24 kgha^{-1}) and fairly rich in available potash (>333 kgha^{-1}).

All the crops inc' ded in the experiment were raised with the recommended package of practices. In addition to grain, straw and vegetable yields of various crops, economical parameters were also calculated on the basis of market prices of the produce prevailing at that time. Production efficiency values were calculated by dividing total grain production in a sequence by total duration of the crops in that sequence (Tomar and Tiwari, 1990).

Rice- mustard- amaranthus cropping sequence has recorded the highest total productivity (72.65 q ha^{-1}) followed by rice- chickpea- amaranthus (71.17 q ha^{-1}). However, the diversified cropping sequence (rice- mustard) recorded the lowest total crop productivity of 40.56 q ha^{-1}.

Data presented in the Table indicated that GMR in rice- mustard system was reduced by 4.73 per cent as compared to rice- chickpea system. The GMR due to intensification of existing rice- chickpea cropping system and that of proposed diversified system (rice- mustard) was increased by about 44 and 52 per cent, respectively, due to inclusion of amaranthus. The NMR due to proposed diversification (rice- mustard) was lowed by about 0.52 per cent than existing rice- chickpea cropping system. Intensification by way of inclusion of amaranthus in rice- chickpea system and rice-mustard system recorded increase in NMR by about 65 and 78 per cent, respectively, over the traditional rice- chickpea cropping system. Bastia *et al.* (2008) stated that rice – maize – cowpea had registered the highest net return of Rs 40,415 ha^{-1}. Alok Kumar *et al.* (2008) reported highest net return of Rs 43,100 ha^{-1} year^{-1} provided by rice – potato – green gram sequence, followed by rice – onion sequence (Rs 36,40^ ha^{-1} year^{-1}).

B:C ratio of the existing rice- chickpea cropping system was found to be 1.71 and increased to 1.77 due to rice- mustard diversification. The B:C ratio of existing rice - chickpea cropping system increased from 1.71 to 1.91 due to intensification by way of inclusion of amaranthus crop. The B:C ratio was raised due to intensification of rice- mustard system due to inclusion of amaranthus from 1.77 to 2.04.

Nandurkar *et. al.* (1998) recorded the highest GMR, NMR and B:C ratio with soybean-gram- groundnut sequence, followed by rice- fallow-groundnut. Kharub *et al.* (2003) reported that inclusion of vegetable and legume crops in rice based crop sequences improved the productivity and net returns. The production efficiency was maximum (27.41 kg day^{-1} ha^{-1}) in rice - mustard - amaranthus sequence, followed by rice - chickpea - amaranthus (27.37 kg day^{-1} ha^{-1}). Nandurkar *et al.* (1998) observed the highest production efficiency in rice - fallow-groundnut sequence (29.32 kg day^{-1} ha^{-1}), followed by rice- fallow- rice sequence (26.43 kg day^{-1} ha^{-1}).

Thus, it is inferred that there is a significant scope for diversification from the existing cropping

Table : Grain, straw and vegetable yields, GMR, COC, net benefit, B:C ratio and production efficiency of different cropping sequences (2004-05)

Treatments	Yields & total productivity (q ha^{-1})	Gross Monetary Returns (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Benefit (Rs ha^{-1})	B: C ratio	Production efficiency (kg day^{-1} ha^{-1})
T_1, Rice- Chickpea						
Rice	35.60	23140	13709	12116		
	(53.70)	(2685)				
Chickpea	6.02	8428	6653	2470		
	(6.95)	(695)				
	41.62	**34948**	**20362**	**14586**	**1.71**	**18.92**
T_2, Rice – Mustard						
Rice	36.06	23439	17709	12384		
	(53.08)	(2654)				
Mustard	4.50	7200	5074	2126		
	40.56	**33293**	**18783**	**14510**	**1.77**	**18.03**
T_3, Rice – Chickpea – Amaranthus						
Rice	37.67	24485	13709	13598		
	(56.45)	(2822)				
Chickpea	6.21	8694	6653	2732		
	(6.91)	(691)				
Amaranthus	27.29	13645	5954	7691		
	71.17	**50337**	**26316**	**24021**	**1.91**	**27.37**
T_4, Rice – Mustard – Amaranthus						
Rice	39.45	25642	13709	14803		
	(57.41)	(2870)				
Mustard	5.00	8000	5074	2926		
Amaranthus	28.20	14100	5954	8146		
	72.65	**50612**	**24737**	**25875**	**2.04**	**27.41**
SE(m)±	18.41					
CD at 5%	54.18					

Rates (Rs q^{-1})							
	Grain	Rice	650/-	Chickpea	1400/-	Mustrard	1600/-
	Straw	Rice	50/-	Chickpea	100/-		
		Amaranthus	500/-				

Total productivity is excluding straw yield,
Figure in parenthesis indicate straw yield,
Yield of Amaranthus is as green vegetables

system (rice- chickpea) to rice- mustard. The existing and the diversified systems can be intensified significantly by introducing amaranthus in rice - chickpea and rice - mustard cropping system

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Studies on Intercropping in Relation to Planting Pattern of Bt Cotton Hybrid Under Rainfed Conditions

Bt cotton area has increased upto 53 per cent of the total area in Maharashtra (Anonymous 2006-07). But cotton productivity was stagnating at 330 kg lint ha^{-1} in Maharashtra, which is low as compared to national productivity of 560 kg lint ha^{-1}. Intercropping in cotton is giving yield stability and more returns per unit area even under adverse climatic conditions. Many research workers reported higher returns of intercropping in non Bt cotton (Kaynande and Narnawre, 1995) than sole cropping. The canopy architecture of Bt cotton is differed by virtue of its resistance to bollworms and crop attending maturity earlier than that of non Bt hybrids. Considering the above facts, field experiment was conducted to find out suitable intercrop in relation to planting pattern in Bt cotton under rainfed condition.

A field experiment was conducted during 2008-09 at Akola (MS). The soil was clayey, having PH 7.60, available NPK 142.3, 22.2 and 322.7 kg ha^{-1}, respectively. Bt cotton hybrid (NCS 145) was intercropped with soybean (JS-335), greengram, (Kopergoan), Sesame, (AKT-64) cowpea (Komal Sadan) and clusterbean (Nirmal) in 1:1 (90 x 60 cm spacing) and 2:2 row proportion in paired row planting (60 x 60 – 120cm) along with sole crop of cotton in RBD and replicated thrice. Sowing was done on 4th July 2008 along with intercrops. Common dose of 50:25:25 NPK was applied to all plots. Total rainfall received at Akola was 528.2 mm in 42 rainy days as against normal rainfall of 762.8 mm in 40.7 rainy days.

Sole cotton with 90 x 60 spacing (T_1) recorded highest number of bolls plant ha^{-1} which was at par with paired row (T_2), cotton + greengram (T_9 and T_4) but significantly superior to remaining treatments. Cotton with soybean and sesame (T_3, T_8 and T_5, T_{10}) had adverse effect on number of bolls plant ha^{-1}. Significantly highest seed cotton yield ha^{-1} was recorded in sole cotton (T_1) as compared to other treatments. Maximum boll weight (4.96 g) was recorded in cotton + cowpea intercropping treatment (T_{11}) ,which was significantly higher than all other treatments. Significant reduction in boll weight was observed when soybean and sesame were grown as intercrops in cotton .

Cotton + greengram intercropping (T_4) recorded highest seed cotton yield which was at par with sole cotton (T_1) but significantly higher than all treatments. Kayande and Narware (1995) also reported higher yield in cotton + greengram intercropping . Similarly sole cotton (T_1) recorded significantly higher seed cotton yield than paired row cotton (T_2) and other treatments except cotton + cowpea (T_6) intercropping system. Significant reduction in seed cotton yield was observed with soybean (T_3) and sesame (T_5) grown as intercrops in cotton as compared to other intercrops. Similar results were also observed by Deoche (2001).

As regards to cotton equivalent yield, cotton + clusterbean (T_9) intercropping recorded significantly highest yield than other treatments. Chellamuthu et. al. (1987) found out that in low rainfall year inclusion of clusterbean as intercrop in cotton

Table 1: Yield attributes, seed cotton and cotton equivalent yield of cotton as influenced by various treatments

S. N. Treatments	No. of bolls plant^{-1}	Boll weight (g)	Seed cotton yield plant^{-1} (g)	Seed cotton yield (kg ha^{-1})	Intercrop yield (kg ha^{-1})	Equivalent yield (kg ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C ratio
T_1 Sole (cotton)	25.5	4.33	80.8	1252	-	1252	35050	14831	1.73
T_2 Paired row	23.4	4.27	67.5	1039	-	1039	29101	9521	1.49
T_3 C + Soybean 1:1	16.2	3.56	60.0	649	788	1156	32369	12759	1.65
T_4 C + G. gram 1:1	22.6	4.10	68.6	1293	139	1441	40359	19857	1.97
T_5 C + Sesame 1:1	15.3	2.83	41.5	740	293	1368	38311	19528	2.04
T_6 C + Cowpea 1:1	20.7	4.20	61.6	1175	1628	1524	42674	20658	1.94
T_7 C+Clusterbean 1:1	20.9	4.10	65.8	1071	3651	1853	51886	28159	2.19
T_8 C + Soybean 2:1	17.3	3.56	59.2	938	412	1203	33678	13601	1.68
T_9 C + G. gram 2:1	22.9	4.20	67.5	966	123	1099	30768	11287	1.58
T_{10} C + Sesame 2:1	12.9	3.80	42.8	923	215	1383	38714	19432	2.01
T_{11} C + Cowpea 2:1	15.9	4.96	60.7	968	840	1148	32144	11737	1.58
T_{12} C+Clusterbean 2:1	21.2	4.43	66.0	862	2835	1469	41138	19054	1.86
S.E. m±	1.30	0.14	3.18	37.79	-	42.14	1179.9	-	-
CD at 5%	3.81	0.39	9.33	110.86	-	123.61	3460.8	-	-
CV%	11.51	6.10	8.92	6.61	-	5.49	5.49	-	-

Yield of cowpea and cluster bean (green pod yield) Market rates (Rs/qtl) – 1) seed cotton 2800/-
2) Soy – 1800/- 3) Sesame – 6000/- 4) Mungbean 3000/- 5)Cowpea–600/- 6)Clusterbean-600/-

was better than other intercrops. Sole cotton with 90 x 60 cm spacing (T_1) was recorded significantly higher equivalent yield than cotton + green gram in paired row system (T_9) and paired row cotton (T_2) but it was at par with cotton + soybean (T_5 and T_8) and cotton + cowpea (T_{11}) intercropping systems.

Significantly highest GMR (RS. 51886 ha^{-1}) were found in cotton + clusterbean (T_7) as compared to other treatments. Cotton + cowpea treatment (T_6) being at par with cotton + clusterbean (T_{12}) and cotton + green gram (T_4) recorded significantly higher GMR than all remaining treatments. It is concluded from the study that cotton + clusterbean intercropping in 1:1 row proportion gave higher yield, GMR,NMR, and B:C ratio under rainfed condition .

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