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Genetic architecture of yield and its components in okra (*Abelmoschus esculentus* L.)

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Abstract

Combining ability for nine characters including green pod yield in okra were studied in a half-diallel crosses of eight diverse lines. General as well as specific combining ability variances were highly significant for all the characters studied. The GCA / SCA ratio signified the predominant role of additive variance for all the characters except internodal length and leaf area. Parents HRB-55 and No. 41 were good general combiners for yield and most of the traits, which can be used in crossing programme to isolate superior segregants. Specific combining ability effects indicated that three top yielding hybrids viz. JNDO-5 x No.41, No.74 x JNDO-5 and No. 129 x HRB-55 expressed average to high specific combining ability effects for yield and other characters. Under such a situation, improvement could be obtained adopting a few cycles of recurrent selection.

Key words : Combining ability, diallel cross, okra

Introduction

Selection of suitable parents is an important step in a crop improvement programme. The success rests upon isolation of valuable gene combinations as determined in the form of lines with good combining ability. The knowledge of gene action and combining ability not only helps in identifying the best combiners which may be hybridized either to exploit heterosis or to accumulate fixable genes through selection but also helps in understanding the inheritance of quantitative traits, so as to choose the proper selection method to be followed in future breeding programme.

Materials and methods

Eight diverse genotypes of okra viz., No.41, No.74, No. 114, No. 117, No. 129, No. 151, HRB-55 and JNDO-5 were selected for the study (Table 1).

Table 1. Salient features of the parents used in diallel crossing programme

Sr.No.	Parent	Characteristic feature
1.	No. 114	Tall with average internodal length, bigger leaves and average pod length.
2.	No. 117	Tall with more number of nodes on main stem, early in flowering and maturity. The fruits are long and slender
3.	No. 129	Medium tall, average number of nodes on main stem and fruits) are medium long.
4.	No.151	Tall, average in number of fruits with medium long fruits and average leaf size.
5.	No.74	Tall early in flowering and maturity, bigger leaves and shorter internodal length.
6.	HRB-55	Tall, early in flowering and maturity, fruits are long and slender and average in leaf size.
7.	JNDO-5	Plants are medium tall, late in flowering and maturity and possess average number of nodes on main stem.
8.	No.41	Tall, fruits are long and slender, more number of nodes on main stem and early in flowering and maturity.

A set of 8 x 8 diallel cross, excluding reciprocals was attempted during summer, 1999. The 36 entries, comprising of eight parents and their Fi's excluding reciprocals, were planted in randomized block design with three replications at Vegetable Research Station, Gujarat Agricultural University, Junagadh during *kharif*, 1999. Each entry was represented by a single row of 3.0 m length. In each row 10 seeds were spaced at 22.5 x 60 cm. The recommended agronomic and plant

Table 2. Analysis of variance for combining ability

Characters	Mean squares			
	gca	sca	Error (Me ₁)	gca / sca
Days to 50 per cent flowering	4.67**	4.09** 1	0.33	1.13
Days to first picking	4.52**	4.27**	0.63	1.05
Pod length	9.24**	2.21**	0.16	4.17
Pod girth	1.17**	0.29**	0.018	4.02
Number of nodes on main stem	10.03**	3.48**	0.32	2.87
Internodal length	0.36**	0.56**	0.02	0.65
Plant height	281.42**	89.49**	18.09	3.14
Leaf area	210.20**	247.91**	25.55	0.87
Yield per plant	2734.66**	1666.32**	126.29	1.64

* Significant at 0.05 probability level; ** Significant at 0.01 probability level

protection practices were followed for raising a good crop. The observations were recorded on five randomly selected plants from each entry per replication for nine different characters viz. days to 50 per cent flowering, days to first picking, pod length (cm), pod girth (cm), number of nodes on main stem, internodal length (cm), plant height (cm), leaf area (cm²), and green marketable pod yield per plant (g). Mean values were used for statistical analysis. The gca and sca variances and effects were estimated according to Model-1, Method-2 of Griffing (1956).

Results and discussion

The mean squares (Table 2) due to general combining ability (gca) and specific combining ability (sca) were highly significant for all the characters, suggesting the role of both additive and non-additive genetic components in the expression of all the characters studied. However, higher magnitude of gca variances over sca variances was noted for all the characters, except internodal length and leaf area, indicating that the additive component of genetic variances was predominantly involved in the expression of yield and its attributing characters. It suggested that directional selection could be highly effective and better homozygous lines could be isolated from the segregating populations. These results are in accordance to the results reported by Poshia and Shukla (1986), Kulkarni et al. (1991), Singh et al. (1996) and Pawar et al. (1999).

The estimates of gca effects (Table 3) indicated that none of the parents proved to be good general combiner for all the traits. However, the parent

HRB-555 appeared to be a good general combiner for days to 50 per cent flowering, days to first picking, pod length, number of nodes on main stem, plant height and yield per plant. Parent No. 41 was a good general combiner for pod length, internodal length and yield per plant. No. 114 proved to be a good general combiner for days to 50 per cent flowering, days to first picking, internodal length and leaf area. No. 129 was a good general combiner for pod length, pod girth, number of nodes on main stem. Parent No. 117 was identified as good general combiner for pod length, number of nodes on main stem and leaf area. Parent JNDO-5 proved to be a good general combiner for pod girth and number of nodes on main stem. No. 74 was identified as good general combiner for pod length and leaf area while, parent No. 151 was good general combiner for internodal length.

The additive and non-additive gene effects could be exploited in okra by the use of good general combining parents in hybridization and selecting desirable segregants from segregating generations.

No cross combination was consistently good for all the characters (Table 4). The cross combination JNDO-5 x No. 41 exhibited significant sca effects in desired direction for days to 50 per cent flowering, days to first picking, pod length, plant height, leaf area and yield per plant. Other two high yielding crosses viz., No. 74 x JNDO-5 and No. 129 x HRB-55 expressed average to high sca effects in desired direction for most of the characters studied.

The present investigation suggested that both additive and non-additive genetic variances were

Table 3. Estimates of general combining ability effects associated with each parent

Parents	Days to 50 per cent flowering	Days to first picking	Pod length (cm)	Pod girth (cm)	Number of nodes on main stem	Inter nodal length (cm)	Plant height (cm)	Leaf area (cm ²)	Yield per plant (g)
No. 114	-0.66 **	-0.61 *	-0.16	-0.32 **	-1.22 **	-0.26 **	5.55 **	4.15 **	-10.69 **
No. 117	0.51 **	0.49 *	0.63 **	-0.38 **	0.95 **	0.05	-0.99	4.22 **	2.78
No. 129	0.41 **	0.46	0.34 **	0.19 **	0.58 **	-0.05	-4.87 **	-3.19 *	-12.49 **
No. 151	-0.06	-0.11	-0.91 **	-0.18 **	1.02 **	-0.28 **	-1.53	-7.05 **	-19.76 **
No. 74	0.24	0.26	-1.46 **	0.55 **	-1.15 **	0.00	-2.40	4.94 **	-8.19 *
HRB-55	-1.19 **	-1.11 **	1.06 **	-0.23 **	1.25 **	0.24	-6.43 **	1.29	24.51 **
INDO-5	0.94 **	0.96 **	-0.88 **	0.39 **	0.62 **	0.18 **	-0.66	-5.07 **	-0.19
No. 41	-0.19	-0.34	1.05 **	-0.03	-0.02	0.13 *	0.57 **	0.72	24.04 **
S.E. (g _i) ±	0.1721	0.2361	0.1194	0.0402	0.1682	0.0504	1.2584	1.4952	3.3242
S.E. (g _i - g _j) ±	0.2602	0.3570	0.1805	0.608	0.2543	0.0762	1.9025	2.2606	5.0258
C.D. at 5 %	0.3436	0.4714	0.2384	0.0803	0.3359	0.1006	2.5130	2.9859	6.6384
C.D. at 1 %	0.4565	0.6263	0.3167	0.1066	0.4460	0.1337	3.3370	3.9653	8.8158
No. 151 x No. 74	0.01	-0.09	-1.05 **	0.52 **	0.30	-0.11	2.00 **	-8.40	-28.56 **
No. 151 x HRB-55	-1.22 *	-1.39	0.51	-0.34 **	0.23	0.02	15.87 **	-3.42	50.74 **
No. 151 x INDO-5	-0.69	-0.79	-1.23 **	-0.53 **	2.86 **	0.65 **	2.27	9.11	5.11
No. 151 x No. 41	-1.56 **	-1.19 *	1.52 **	-0.34 **	1.16 *	-0.07	11.04 **	-5.18	57.87 **
No. 74 x HRB-55	2.14 **	2.91 **	0.39	-0.04	-1.64 *	1.17 **	6.31	7.93	31.51 **
No. 74 x INDO-5	-1.99 **	-2.15 **	1.32 **	0.47 **	3.00 **	-0.17	13.14 **	-5.38	71.54 **
No. 74 x No. 41	2.14 **	2.15 **	0.30	0.00	-0.70	0.51 **	3.24	-8.33	11.31
HRB-55 x INDO-5	1.44 **	1.21	0.37	0.12	-2.74 **	-0.60 **	-13.43 **	4.27	-9.16
HRB-55 x No. 41	0.24	0.18	-0.62	0.57 **	-1.10 *	-0.82 **	-6.89 *	-5.18	-12.39
INDO-5 x No. 41	-2.89 **	-2.89 **	1.65 **	-0.78 **	0.86	1.34 **	13.37 **	18.17 **	40.31 **
S.E. (S _{ij}) ±	0.5276	0.7239	0.3660	0.1233	0.5157	0.1545	3.8575	4.5835	10.1902
S.E. (S _{ij} - S _{ik}) ±	0.7807	1.0710	0.5415	0.1824	0.7630	0.2286	5.7075	6.7818	15.0774
C.D. at 5 %	1.0536	1.4460	0.7310	0.2462	1.0299	0.3085	6.7610	9.1530	20.3500
C.D. at 1 %	1.3990	1.9200	0.9706	0.3269	1.3670	0.4097	8.9790	12.1550	27.0240

*, ** Significant at 5 % and 1 % level, respectively

Table 4. Estimates of specific combining ability effects associated with each hybrid

Crosses	Days to 50 per cent flowering	Days to first picking	Pod length (cm)	Pod girth (cm)	Number of nodes on main stem	Inter nodal length (cm)	Plant height (cm)	Leaf area (cm ²)	Yield per plant (g)
No. 114 x No.117	-1.66 **	-2.11**	-0.97*	-0.02	0.73	-0.01	-1.01	4.45	34.41
No. 114 x No.129	-2.56**	-2.12**	2.82**	0.38**	-1.24*	-0.54**	10.10	-14.07**	13.67
No. 114 x No. 151	0.24	0.78	0.97*	-0.08	-0.30	-0.44**	-7.04*	1.22	18.94
No. 114 x No. 74	-0.39	-0.92	-0.35	-0.48**	1.83**	0.64**	-6.64**	17.73**	-7.96
No. 114 x HRB-55	-0.62	0.11	-0.96**	0.07**	0.76**	0.74**	8.23**	-9.62*	3.34
No. 114 x JNDO-5	-1.42**	-1.62*	2.37**	-0.79**	-0.94	0.26	4.29	-26.93**	37.04**
No. 114 x No. 41	1.38*	1.35	-1.55**	-0.24**	-1.97**	-0.85**	-13.34	-3.15	-70.53**
No. 117 x No.129	2.28**	2.11	0.01**	-0.03	1.60**	-0.99**	16.64**	18.62**	65.54**
No. 117 x No. 151	-2.59**	-2.65**	-2.07**	-0.52**	-2.80**	-0.26	-8.43*	3.65	-24.19*
No. 117 x No. 74	2.44**	2.98**	0.31	-0.49**	-3.34**	-0.21	-5.83	-16.00**	-32.43**
No. 117 x HRB-55	2.54**	2.35**	1.30**	0.22	1.93**	-1.28**	-4.33	-16.19**	-37.46**
No. 117 x JNDO-5	0.74	0.95	-0.17	0.10	-3.10**	0.41**	-7.23*	18.34**	-14.76
No. 117 x No. 41	0.54	0.25	1.81**	-0.34**	0.53	0.73**	0.87	23.05**	33.01**
No. 129 x No. 151	1.18*	1.05	-0.94*	0.41**	-1.77**	-0.62**	-2.49	-16.27**	-42.59**
No. 129 x No. 74	-1.79**	-1.99**	-1.40**	-1.22**	1.03*	-0.04	-2.62	-15.76	-26.49*
No. 129 x HRB-55	-3.02**	-3.29**	-0.08	-0.51**	0.63	0.09	-4.12	29.72**	50.47**
No. 129 x JNDO-5	-1.16*	-0.35	1.52**	0.03	2.26**	0.72**	5.54	17.58**	19.51
No. 129 x No. 41	0.98	0.95	-2.33**	0.29*	-1.10*	-0.23	-15.35**	1.79	-25.06*

important for most of the characters. However, additive genetic variances were important for all the traits except internodal length and leaf area. It is suggested that few cycles of recurrent selection could be adopted for handling such population.

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Combining ability analysis in pigeonpea

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Abstract

A study involving 64 hybrids between four male sterile lines and 16 testers of pigeonpea revealed higher magnitude of sca variance over gca variance for all the traits which indicated preponderance of non-additive gene action. The parents MS 288, MS Pusa 33, MS (P) DT, SKNP 9219, SKNP 9226, SKNP 9231, SKNP 9256 and AL 15 were good general combiners for seed yield and its two or more component traits. Twenty five out of 64 hybrids showed significant positive sca effects for seed yield and its two or more component traits.

Key words : Combining ability, pigeonpea, genetic male sterility

Introduction

Combining ability analysis helps to choose suitable parents for hybridization and provides valuable information regarding cross combinations to be exploited commercially. The identification of genetic male sterility in pigeonpea (Reddy *et al.* 1978 and Wallis *et al.* 1981) has opened new vistas for commercial exploitation of hybrid vigour in this crop. Further, by the use of cytoplasmic genic male sterility (Tikka *et al.* 1997), hybrid seed production will become easier. The environment plays an important role in the expression of a trait and greatly influences combining ability estimates and thus the study in single environment may not provide reliable information. Therefore, present study was undertaken to estimate combining ability for seed yield and other traits in pigeonpea over three environments.

Material and methods

A set of 64 hybrids involving four genetic male sterile lines [MS 288, MS Pusa 33, MS(P)DT and MS T 21] and 16 testers (AT 5, AT 6, SKNP 9204-1, SKNP 9219, SKNP 9226, SKNP 9231, SKNP 9256, SKNP

9260-2, SKNP 9510, SKNP 9512, SKNP 9523, GAUT 90-2, GT 100, AL 15, ICPL 87 and UPAS 120) of pigeonpea was made using line x tester mating design during *kharif* 1991. The trials consisting of 64 hybrids and their 20 parents were raised in randomized block design with three replications at three locations (environments) viz., Sardar Krushinagar, Navsari and Vyara during winter 1997-98. Each entry was sown in 3.0 m long single row plot at 60 x 10 cm spacing. Observations on five randomly selected competitive plants were recorded for days to flower, days to mature, plant height, branches / plant, pods/plant, pod length, seeds/pod, 100 seed weight, seed yield/plant, reproductive period, harvest index and protein content. The data were analysed for combining ability following Kempthorne (1957).

Results and discussion

The analysis of variance for combining ability pooled over environments (Table 1) revealed that mean squares due to environments were highly significant for all the traits, indicating sufficient diversity among environments. The mean squares due to females were significant for most of the traits except branches/plant and seeds/pod, whereas mean squares due males were significant for plant height, branches/plant, pod length and seeds/pod. The mean squares due to females x males were significant for all the traits except pods/plant, which indicated the importance of non-additive gene effects. The interaction mean squares due to females x environments for days to mature, plant height, pods/plant, pod length, seed yield/plant, reproductive period and harvest index, due to males x environments for all the traits except seeds/pod were significant which indicated that the estimates of gca and sca variances were highly influenced by the environments.

The ratio $sgca/ssca$ was less than unity for all the traits which suggested greater role of non-additive gene action in the inheritance of all the traits. Predominance of non-additive gene action has also

Table 1. Estimates of gca effects of parents pooled over environments for different traits in pigeonpea.

Parents	Day to flower	Day to maturity	Plant height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	100 seed weight (g)	Seed yield / plant (g)	Reproductive period	Harvest index (%)	Protein content (%)
<i>Female</i>												
MS288	5.15**	2.90**	6.01**	-0.09**	5.87**	0.16**	0.03	0.64**	1.16**	0.26*	2.16**	-0.52**
MS Pusa 33	-3.40**	-5.19**	-7.13**	-0.12**	-1.82**	-0.12**	-0.05**	-0.26**	0.16**	-2.72**	1.08**	0.07*
MST21	0.83**	3.26**	7.87**	0.11**	-7.22**	-0.01	0.03	0.16**	-1.68**	0.45**	-3.05**	0.24**
MS(P)DT	-2.59**	-0.97**	-6.75**	0.10**	3.17**	-0.02	-0.02	-0.54**	0.35**	2.02**	-0.19	0.21**
SE	0.11	0.07	0.38	0.03	0.47	0.02	0.02	0.02	0.08	0.12	0.15	0.03
<i>Males</i>												
AT5	-0.67**	-4.67**	-16.55**	-0.46**	-5.37**	-0.24**	-0.09*	-0.30**	-0.65**	-2.62**	3.03**	0.08
AT6	1.08**	-1.33**	-8.15**	-0.54**	-3.46**	-0.05	-0.11**	-0.06	-0.65**	-3.12**	-0.86**	0.20**
SKNP9204-1	-2.11**	-1.86**	-1.21	-0.38**	-5.42**	0.05	-0.01	-0.45**	-1.51**	-1.37**	-2.88**	0.27**
SKNP9219	2.75**	1.06**	6.16**	0.48**	9.19**	0.10**	0.00	0.52**	2.10**	-1.92**	-0.68*	0.14*
SKNP9226	-0.56*	0.44**	1.50	-0.09	6.74**	0.21**	0.09*	0.45**	1.53**	-0.45	-1.09**	-0.18
SKNP9231	1.39**	1.92**	17.86**	1.00**	13.57**	0.17**	0.04	-0.21**	3.50**	-1.06**	2.95**	-0.06
SKNP9256	0.11	0.50**	12.89**	0.25**	6.44**	-0.05	0.00	-0.07	1.46**	-1.14**	0.27	0.30**
SKNP9260-2	3.14**	7.25**	13.42**	0.63**	0.15	-0.04	0.05	0.05	-0.24	6.16**	-2.63**	0.04
SKNP9510	2.00**	5.39**	7.37**	-0.05	-1.58	-0.03	0.00	0.52**	-0.45*	3.41**	-0.51	-0.14*
SKNP9512	1.83**	3.36**	5.44**	-0.07	-7.15**	-0.03	-0.07	-0.19**	-2.00**	2.05**	-0.83*	0.49**
SKNP9523	2.03**	4.42**	0.28	0.13	-1.37	0.30**	0.26**	-0.05	-0.46*	2.74**	-3.82**	-0.47**
GAUT90-2	-2.61**	-0.42*	-0.64	0.11	-2.13*	0.07	0.08*	0.59**	-0.18	1.88**	1.80**	-0.53**
GT100	1.69**	0.67**	-6.39**	-0.07	-0.76	-0.03	-0.02	0.41**	-0.03	0.44	2.81**	-0.32**
AL15	-2.09**	-5.97**	-7.21**	-0.11	1.10	-0.13**	-0.05	-0.19**	0.72**	-3.51**	3.30**	-0.02
ICPL87	-4.28**	-6.03**	-16.21**	-0.45**	-9.10**	-0.17**	-0.15**	-0.52**	-2.75**	-1.17**	-2.37**	0.63**
UPAS120	-3.70**	-4.72**	-8.55**	-0.39**	-0.84	-0.13**	-0.02	-0.50**	-0.39*	-0.34	1.51**	-0.44**
SE	0.24	0.17	0.85	0.07	1.05	0.04	0.04	0.05	0.19	0.26	0.33	0.07

Significant at $P = 0.05$ and ** Significant at $P = 0.01$

been reported by Reddy *et al.* (1979 a,b), and Narladkar and Khapre (1997) for days to flowering and maturity, pods/plant and seed yield/plant; Reddy *et al.* (1979 b) and Patel *et al.* (1992) for branches/plant, plant height and 100-seed weight; Reddy *et al.* (1979 a) for pod length; Patel *et al.* (1992) for seeds/pod and Narladkar and Khapre (1997) for harvest index.

The gca effects of parents (Table 2) revealed that the parents MS Pusa 33, MS(P)DT, AT 5, AL 15, ICPL 87 and UPAS 120 were good general combiners for imparting earliness and dwarfness. SKNP 9204-1 and GAUT 90-2 for earliness and AT6 and GT-100 for dwarfness also showed significant gca effects. MS T21, MS(P) DT, SKNP 9219, SKNP 9231, SKNP 9256

and SKNP 9260-2 were good general combiners for branches/plant. Parents MS 288, MS(P)DT, SKNP 9219, SKNP 9226, SKNP 9231 and SKNP 9256 possessed desirable genes for increasing pod number and seed yield. MS Pusa 33 and AL 15 were also good general combiners for seed yield. The parents MS 288, SKNP 9219, SKNP 9226, SKNP 9231 and SKNP 9523 for pod length and SKNP 9226, SKNP 9523 and GAUT 90-2 for seeds/pod had significant positive gca effects. For bolder seeds, MS 288, MS T 21, SKNP 9219, SKNP 9226, SKNP 9510, GAUT 90-2 and GT-100 were good general combiners, whereas for longer reproductive period, MS (P) DT, MS T 21, MS 288, SKNP 9260-2, SKNP 9510, SKNP 9512, SKNP 9523 and GAUT 90-2 were good

general combiners. The parents MS 288, MS Pusa 33, AT 5, SKNP 9231, GAUT 90-2, GT-100, AL 15 and UPAS 120 exhibited significant positive gca effects for higher harvest index. For increased protein content, MS T 21, MS (P) DT, MS Pusa 33, ICPL 87, SKNP 9512, SKNP 9256, SKNP 9204-1, SKNP 9219 and AT 6 were good general combiners.

The estimates of sca effects revealed that 25 out of 64 hybrids showed significant positive sca effects for seed yield/plant. Ten best specific combiners with mean performance, gca effects of parents and their significant response to other traits are presented in Table 3. All these crosses showed significant positive response to pods/plant indicating its direct effect for increasing seed yield. However, five crosses showed significant response to branches/plant and harvest index, four for seeds/pod and reproductive period, three for days to flower, 100-seed weight and protein content, two for days to maturity and one for plant height and pod length. This may be because of very complex nature of seed yield and its dependence on its components.

Out of ten crosses showing high mean and significant positive sca effects for grain yield, three crosses (MS

288 x SKNP 9231, MS 288 x SKNP 9219 and MS Pusa 33 x SKNP 9256) were of good x good, five crosses (MS (P) DT x SKNP 9512, MS 288 x SKNP 9204-1, MS 288 x SKNP 9523, MS (P) DT x SKNP 9510 and MS (P) DT x ICPL 87) of good x poor, one cross (MS T 21 x AL 15) of poor x good and one cross (MS T 21 x GAUT 90-2) of poor x average gca of parents. The good x good gca combination could be due to additive and additive x additive type of gene action which are fixable in nature. The crosses involving one parent with significant high gca effect and other with poor or negative gca effect may throw desirable transgressive segregants if additive genetic system is present in good combiner and complementary epistatic effects in other, resulting F_1 to act in favourable direction (Vankateswarlu and Singh, 1982, Patel *et al.* 1987 and Manivel and Rangasamy, 1998).

The results suggested that the crosses showing high mean performance, sca effects for seed yield and their significant response to other related traits had necessarily involved both or at least one parent as good combiner can be commercially exploited through utilizing male sterile lines by taking advantage of high degree of natural out-crossing (Ariyanayagam, 1976) in pigeonpea.

Table 2. Ten best specific combiners for seed yield/plant and their performance for other traits in pigeonpea.

Crosses	sca effects	Mean seed yield/plant (g)	gca effect of parents		Significant response in other traits for sca effects
			Female	Male	
MS 288 x SKNP 9231	5.45	22.64	1.16	3.50	Pods/plant, Reproductive period, Harvest index and Protein content.
MS 288 x SKNP 9219	4.09	19.87	1.16	2.10	Days to flowering, days to maturity, plant height, branches / plant.
MS(P)DTx SKNP 9512	3.88	14.76	0.35	-2.00	Days to flowering, days to maturity, pods/plant, seeds / pod and harvest index.
MSPusa 33 x SKNP 9256	3.39	17.54	0.16	1.46	Pods/plant and protein content.
MST 21 x GAUT 90-2	2.77	13.44	-1.68	-0.18	Branches / plant, pods/plant, pod length, seeds/pod, 100-seed weight, reproductive period.
MS 288 x SKNP 9204-1	2.67	14.84	1.16	1.51	Branches/plant, pods/plant, 100-seed weight and harvest index.
MST21xAL15	2.26	13.81	-1.68	-0.72	Branches / plant, pods/plant, 100-seed weight and protein content.
MS 288 x SKNP 96-3	2.23	15.46	1.16	-0.46	Branches / plant, pods/plant and seeds/pod.
MS(P)DTx SKNP 9510	1.82	14.26	0.35	-0.45	Days to flowering., pods/plant, reproductive period and harvest index
MS(P)DT x SPL 87	1.70	11.92	0.36	2.75	Pods/plant, reproductive period and harvest index.

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Genetic association and path analysis for seed yield, its components and quality attributes in soybean

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Abstract

Correlation and path analysis was done for seed yield, its components and quality attributes in 55 diverse genotypes of soybean collected from different states of India. The results indicated that genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic correlation coefficients for most of the traits. Seed yield/plant showed significant and positive association with plant height branches/plant, clusters/plant, pods/plant and 100-seed weight and only negatively correlated with oil content and protein content at both levels. Among the component attributes, pods/plant showed significant and positive association with plant height branches/plant and clusters/plant. Likewise, clusters/plant had also significant and positive association with plant height and branches/plant. Days to 50% flowering and days to maturity showed significant and positive association with each other. The path analysts indicated that number of pods/plant had maximum direct effect on seed yield followed by 100-seed weight and number of clusters/plant which appeared to be major yield contributing traits in soybean.

Keywords : Path analysis, associations, soybean

Introduction

Correlation and path coefficient analysis together give a clear cut picture of interrelationships and relative contribution of independent characters on dependent variable which enables to a plant breeder to apply suitable selection procedures for crop improvement. The present investigation was, therefore, conducted to find out the major yield contributing traits in soybean.

Materials and methods

The experimental material comprised of 55 diverse genotypes of soybean, collected from different states viz., Madhya pradesh, Uttar pradesh, Maharashtra, Gujarat, Punjab and New Delhi. The field experiment was laid out in randomised block design with three replications at Instructional Farm, College of Agriculture, Gujarat Agricultural University, Junagadh during *kharif*, 2001. Each entry was planted in a single row of 3 m. length with inter and intra row spacing of 45 cm and 15 cm, respectively. The recommended agronomic practices and plant protection measures were followed for the successful raising of the crop. Five random plants were selected from each plot for recording the observations on seed yield/plant and its components. The data were subjected to association analysis as per method given by Miller *et al.* (1958) and path coefficient analysis according to Dewey and Lu (1959).

Results and discussion

The genotypic and phenotypic correlation coefficients among different pairs of characters are presented in Table 1. Genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic values which indicated strong inherent association between various pairs of traits, as was also observed by Bargale *et al.* (1988) Sunder *et al.* (1996), Ramgiry and Raha (1997) Jain *et al.* (2000) and Agrawal *et al.* (2001). Lower degree of associations between two variables at phenotypic level might be due to the masking or modifying effect of environment on the association of traits. Seed yield per plant had significant and positive correlation with plant height, branches/plant, clusters/plant, pods/plant and 100-seed weight at both genotypic and phenotypic levels indicating that these five traits were main yield attributing traits.

Among the seed yield attributes, days to 50 % flowering had significant and positive association with days to maturity at both genotypic and phenotypic

Table 1. Estimates of genotypic (r_g) and phenotypic (r_p) correlation coefficients for different characters in soybean

Character		Day to Maturity	No. of branches/ plant	Plant height	No. of clusters/ plant	No. of pods/ plant	100 seed weight (g)	Oil content	Protein content	Seed yield/ plant
Days to 50 % flowering	r_g	0.317*	-0.194	0.065	0.107	0.204	0.057	-0.323*	0.094	0.063
	r_p	0.287*	-0.141	0.066	0.089	0.189	0.060	-0.294*	0.075	0.058
Days to maturity	r_g		-0.295*	0.056	0.059	0.192	0.072	0.161	-0.031	0.192
	r_p		-0.256	0.050	0.061	0.180	0.071	0.154	-0.028	0.171
No. of branches/ plant	r_g			0.236	0.465**	0.344*	0.022	0.100	-0.209	0.381**
	r_p			0.211	0.419**	0.304*	0.031	0.090	-0.173	0.314*
Plant height	r_g				0.641**	0.494**	-0.104	-0.107	-0.309*	0.421**
	r_p				0.586**	0.466**	-0.098	-0.103	-0.295*	0.376**
No. of clusters/ plant	r_g					0.889**	0.169	-0.129	-0.170	1318**
	r_p					0.832**	0.162	-0.124	-0.155	0.746**
No. of pods /plant	r_g						0.222	-0.148	-0.147	0.810**
	r_p						0.211	-0.140	-0.144	0.786**
100-seed weight	r_g							-0.153	0.022	0.3288*
	r_p							-0.146	0.021	0.308*
Oil content	r_g								-0.239	-0.056
	r_p								-0.231	-0.052
Protein content	r_g									-0.090
	r_p									-0.083

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

levels. This suggested that flowering time is an important indicator of maturity. This confirmed the earlier finding of Taware *et al.* (1995). While days to 50 % flowering showed significant and negative correlation with oil content. Likewise, number of clusters/plant exhibited significant and positive correlation with plant height and branches/plant. Similar, number of pods/plant also exhibited significant and positive association with plant height, branches/plant and clusters/plant. Similar finding was also reported by Agrawal *et al.* (2001).

The genotype correlation coefficients were further partitioned into direct and indirect effects (Table 2) which revealed that number of pods/plant had maximum positive direct effect on seed yield followed by 100-seed weight and number of clusters/plant. Hence, direct selection on these traits may be effective. Similar finding was also reported by Makadia (1999). On the other hand, negative direct effect was

noticed by days to 50 % flowering (Makadia, 1999). The indirect effects of all the traits except oil and protein content via number of pods/plant was positive and higher in magnitude than the rest of the traits. The unexplained variation in genotypic path was only 0.1911. It predicted that 81.89 per cent variation in seed yield at genotypic level had been determined by study of these nine component traits. This finding is in agreement with the results obtained by Sharma *et al.* (1989), Mehetre *et al.* (1997), Ramgiry and Raha (1997) Das and Harer (1996) and Agrawal *et al.* (2001)

Therefore, it can be concluded from correlation and path analyses together that the emphasis may be given to improve the traits like number of pods/plant, number of clusters/plant and 100-seed weight for genetic improvement of seed yield in soybean.

Table 2. Direct (diagonal and bold) and indirect effects based on genotypic correlation and path coefficients in soybean

Character	Day to 50% flowering	Day to Maturity	No. of branches/plant	Plant height	No. of clusters/plant	No. of pods/plant	100 seed weight	Oil content	Protein content	Genotypic correlation with seed yield/plant
Days to 50% flowering	-0.105	0.029	-0.017	0.001	0.015	0.141	0.009	-0.017	0.008	0.063
Days to maturity	-0.033	0.091	-0.026	0.001	0.008	0.133	0.011	0.009	-0.003	0.192
No. of branches/plant	0.020	-0.027	0.087	0.004	0.067	0.237	0.003	0.005	-0.017	0.381**
Plant height	-0.007	0.005	0.021	0.019	0.092	0.341	-0.016	-0.006	-0.025	0.424**
No. of clusters/plant	-0.011	0.005	0.041	0.012	0.144	0.614	0.026	-0.007	-0.014	0.810**
No. of pods/plant	-0.021	0.018	0.030	0.009	0.128	0.690	0.035	-0.008	-0.012	0.868**
100-seed weight	-0.006	0.007	0.002	-0.002	0.024	0.153	0.156	-0.008	0.002	0.328*
Oil content	0.034	0.015	0.009	-0.002	-0.019	-0.102	-0.024	0.053	-0.019	-0.056
Protein content	-0.010	-0.003	-0.018	-0.006	-0.024	-0.101	0.003	-0.013	0.082	-0.090

*, ** Significant at 5 and 1 per cent probability levels, respectively. R = 0.1911

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An analysis of generation means for yield and its component traits in macaroni wheat (*Triticum durum* Deaf.)

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Abstract

Generation means analysis for yield and its component traits were studied in six crosses of macaroni wheat. Individual scaling tests and chi-square for joint scaling test indicated that an additive-dominance model was adequate for plant height in cross 2, 3 and 5; effective tillers/plant in cross 5; grains/spike in cross 3 and 6; grain yield/plant in cross 1, 3, 5 and 6 as well as 100-grain weight in cross 2. On fitting simple model, both additive (d) and dominance (h) effects were significant for grains/spike in cross 3 and 100-grain weight in cross 2, while only additive (d) gene effect was significant for the rest of the traits. All the characters recorded in six crosses except listed above in simple model showed evidence of digenic non-allelic interactions. On fitting epistatic model, both (d) and (h) effects were significant for plant height in cross 5; length of spike in cross 1; days to maturity in cross 1, 2 and 3; grain yield/spike and 100-grain weight in cross 4 and 5. Only (d) effect was significant for plant height in cross 1; spikelets/spike in cross 3, days to heading in cross 2, 3 and 4, whereas only (h) effect was important for effective tillers/plant in cross 3; days to heading and days to maturity in cross 5. All the three types of digenic interactions were significant for days to maturity in cross 1 and 2 as well as 100-grain weight in cross 1. Duplicate type of gene action was noticed for almost all the traits. Population improvement approach in the form of biparental mating among potentially desirable plants in early segregating generations is suggested.

Key words : Generation means, component traits, macaroni wheat

Introduction

Grain yield is the ultimate product of action and interaction of number of quantitative component traits.

Hence, the knowledge of genetic architecture of breeding materials helps the plant breeders in designing the appropriate breeding methodology that results in substantial genetic gain. The size of population in segregating generations and the selection scheme also depends on the gene actions involved in the inheritance of various traits. In this context, generation mean analysis is a simple and useful technique for characterizing gene effects for quantitative traits (Hayman, 1958 and Gamble, 1962).

Materials and methods

The basic set of six generations viz, P_1 , P_2 , F_1 , F_2 , BC_1 and BC_2 derived from six macaroni wheat crosses namely DWR-2006 x CPAN-6207 (cross 1), GW-1099 x MACS-2884 (cross 2), HJD-90-96-1-1-2-4-1-W x Raj-1555 (cross 3), PDW-275 x PBN-1479 (cross-4), RD45 x MACS-3098 (cross 5) and RYPS-3 x GW-1151 (cross 6) were planted in compact family block design with three replications during Rabi 2001-02. Each plot consisted of a single row of P_1 , P_2 , F_1 ; two rows for each of BC_1 and BC_2 and five rows of F_2 generation. The seeds were sown at a distance of 10 cm in 2.5 m long row plot with inter row spacing of 22.5 cm. Recommended package of practices were followed timely throughout the crop season. The observations were recorded on individual plant basis in each replication on randomly selected five plants from each of P_1 , P_2 and F_1 ; 15 plants from each of BC_1 and BC_2 and 20 plants from F_2 generations for ten characters in each cross (Table 1).

Individual scaling tests of Mather (1949) and joint scaling test of Cavalli (1952) were employed to detect the presence of epistasis and to obtain weighted least square estimates of additive (d) and dominance (h) gene effects. Whenever this simple additive-dominance model failed to be adequate to explain the variation in generation means, the six parameters perfect fit solution advocated by Hayman (1958) was used to estimate the main and interaction effects. Heterosis over better parent and inbreeding

Table1. Estimates of gene effects, heterobeltiosis and inbreeding depression for different characters in six crosses of wheat

No	Gene effects						Hetero- beltiosis (%)	Inbreeding depression (%)
	(m)	(d)	(h)	(i)	(j)	(l)		
Plant height (cm)								
1	81.96**±1.39	12.80**±2.09	12.57 ±7.17	0.29±6.96	4.01±2.41	14.13*±7.02	3.95*	10.69**
2	64.52**±0.53	-4.59**±0.48	1.01 ±1.03	-	-	-	-5.96**	1.12
3	76.16**±0.82	1.89*±0.81	1.89 ±1.49	-	-	-	-0.09	0.24
5	71.08**±0.52	3.37**±0.98	34.27**±3.12	26.87**±2.89	-1.91±1.18	-3.70±5.05	2.47*	18.57**
6	76.64**±0.95	3.09**±0.91	3.40 ±2.03	-	-	-	2.43	4.74
Length of spike (cm)								
1	6.78**±0.09	0.54**±0.20	2.20**±0.59	1.49**±0.55	-0.15±0.23	0.96±0.98	0.24	16.60**
Spikelets per spike								
3	14.43**±0.16	0.71**±0.25	-0.67±0.91	0.48 ±0.82	0.61*±0.30	1.22±1.42	-8.10**	-0.20
Effective tillers per plant								
3	6.13**±0.27	-0.80 ±0.58	3.63*±1.73	4.00*±1.60	-0.76±0.72	-9.40**±2.90	-6.66**	-9.46**
5	6.03**±0.38	-1.07**±0.33	0.88 ±0.76	-	-	-	1.99**	2.91**
Days to heading								
2	53.15**±0.38	-1.75**±0.45	3.09 ±1.90	4.33*±1.78	-0.25 ±0.53	-0.66 ±2.72	-4.76**	2.53**
3	51.60**±0.43	-3.20**±0.43	0.26 ±1.27	3.20**±0.9	-0.13 ±0.48	-7.20**±2.12	-10.72**	-3.34**
4	62.11**±0.42	2.71**±0.91	4.98 ±2.58	8.15**±2.50	-1.45 ±1.04	-3.51 ±4.24	-10.31**	2.54**
5	62.33**±0.48	0.07 ±0.93	-15.82**±2.71	-14.88**±2.68	0.59 ±0.99	20.44**±4.30	-2.40**	-4.70**
Days to maturity								
1	90.75**±0.19	-0.75*±0.37	5.29**±1.15	6.06**±1.08	-1.05*±0.46	-9.86**±1.86	-1.16*	0.19
2	89.70**±0.28	-2.84**±0.32	7.41**±1.46	8.31**±1.32	-3.21**±0.47	-9.35**±2.15	-1.37	1.50*
3	88.81**±0.19	-1.06*±0.45	6.48**±1.27	6.68**±1.19	-0.29*±0.15	-11.17**±2.17	-1.18*	0.50
5	94.86**±0.40	0.11 ±0.54	-8.23**±1.97	-9.20**±1.93	0.74 ±0.63	11.93**±2.81	0.35	-1.20**
Grains per spike								
3	41.86**±0.68	1.33*±0.56	-3.26*±1.29	-	-	-	-8.67**	-0.67
6	43.76**±0.81	-0.41 ±0.79	-1.00 ±1.36	-	-	-	-2.45	-1.83
Grain yield per spike (g)								
1	1.84**±0.03	0.17 ±0.09	0.41 ±0.22	-0.12 ±0.21	0.13±0.09	0.73* ±0.35	29.47**	17.48**
4	1.75**±0.04	0.12*±0.05	0.78**±0.18	0.46*±0.18	0.01±0.07	-0.21 ±0.28	10.00**	16.26**
5	1.76**±0.03	0.36**±0.07	0.8*±0.20	0.49**±0.18	0.22±0.19	0.26 ±0.35	9.26**	21.42**
Grain yield per plant (g)								
1	13.76**±0.67	2.68**±0.61	0.95 ±1.41	-	-	-	10.15**	25.13**
3	11.09**±0.66	-0.04 ±0.62	0.33 ±1.27	-	-	-	-4.08*	-11.48**
5	10.72**±0.82	-0.69 ±0.74	2.74 ±1.68	-	-	-	32.19**	23.38**
6	9.13**±0.66	-0.15 ±0.59	1.65 ±1.35	-	-	-	14.51**	16.66*
100 -Grains weight (g)								
1	4.23**±0.06	0.19 ±0.13	-0.01 ±0.37	-0.83*±0.35	0.34±0.15	1.31* ±0.62	17.52**	7.02**
2	3.75**±0.07	-0.27**±0.06	0.58**±0.13	-	-	-	5.55**	0.71**
4	6.77**±0.49	0.16*±0.08	-10.66**±1.97	11.28**±1.97	0.01±0.10	11.26**±2.00	12.40**	-58.92**
5	3.81**±0.05	0.40*1)±0.09	2.37**±0.30	1.63**±0.27	0.37±0.33	0.20 ±0.50	16.39**	24.55**

*** Significant at 5 % and 1% probability levels, respectively.

Cross 1 = DWR-2006 x CPAN-6207

Cross 4 = PDW-275 x PEN-1479

Cross 2 = GW-1099 x MACS-2884

Cross 5 = RD-45 x MACS-3098

Cross 3 = HJD-90-I-I-2-4-IWx Raj-1555

Cross 6 = RYPS-3 x GW-1151

depression were also calculated as per standard formula.

Results and discussion

The results revealed that mean square differences among the generation means were significant for fifty per cent of the traits in various crosses. Hence, crosses showing non-significant differences among the generation means for a particular trait were omitted in further analysis. The estimates of genetic parameters for different characters recorded in six crosses of macaroni wheat are presented in Table 1. The non-significant values of all the individual scaling tests and chi-square value of joint scaling test indicated that an additive dominance model was satisfactory for plant height in cross 2, 3 and 6; effective tillers/plant in cross 5; grains/spike in cross 3 and 6; grain yield/plant in cross 1, 3, 5 and 6 as well as 100-grains weight in cross 2 indicating absence of epistasis for these traits in such crosses. On fitting simple additive-dominance model, both additive (d) and dominance (h) effects were significant for grains/spike in cross 3 and 100-grains weight in cross 2 indicating the importance of both additive and dominance gene effects in such cases. While only additive (d) gene effect was significant for plant height in cross 2, 3 and 6; effective tillers/plant in cross 5 and grain yield/plant in cross 1 which were fitted in simple model. Importance of additive gene effect was reported (1998) for plant height and Kapoor and Luthra (1990) for effective tillers/plant. Absence of epistasis was noticed for grain yield/plant and grains/spike by Amawate and Behl (1995).

All the characters recorded in six crosses except listed above in simple mode showed evidence of digenic non-allelic interactions. On fitting interaction model, in addition to significance of both additive (d) and dominance (h) gene effects, additive x additive (i) effect was significant for plant height in cross 5; length of spike in cross 1; grain yield/spike and 100-grain weight in cross 4 and 5 indicating the major role of fixable type of epistasis gene action for these traits in such crosses. All the three types of digenic interactions were significant for days to maturity in cross 1, 2 and 3 besides significance of both (d) and (h) effects indicating the importance of additive, dominance and all the three types of epistasis gene actions for the inheritance of days to maturity. The opposite sign of (h) and (l) indicated the presence of duplicate type of epistasis for days to maturity in cross 1, 2 and 3. Satyavart *et al.* (2001) for plant height and

grain yield/plant; Walia *et al.* (1994) for length of spike; Shekhawat *et al.* (2000) for 100-grains weight and Mishra *et al.* (1996) for days to maturity reported that these traits were under the control of both additive and non-additive gene effects which confirmed the present findings.

Besides significance of only additive (d) gene effect dominance x dominance (i) effect for plant height in cross 1; additive x dominance (j) effect for spikelets/spike in cross 3 and additive x dominance (i) effect for days to heading in cross 2, 3 and 4 were significant. In addition to significance of only dominance (h) effect, (i) and (l) were important for effective tillers/plant in cross 3; days to heading and days to maturity in cross 5. The opposite sign of (h) and (l) indicated the presence of duplicate type of epistasis for these traits in these crosses. It is interesting to note that all the three types of digenic interactions (i, j, l) were significant for 100-grains weight in cross 1. Hence, 100-grains weight in cross 1 could be improved through cyclic method of breeding involving selection of desirable recombinant and *inter-se* mating between desirable individuals keeping large population size.

The heterosis over better parent and inbreeding depression for various traits in six crosses of wheat are also given in Table 1. The heterosis over better parent was significant for all the traits in most of the crosses except a few cases. Negative heterobeltiosis was observed for days to heading, days to maturity, number of grains/spike and number of spikelets/spike, whereas positive heterobeltiosis was found for plant height (except cross 2), length of spike, grain yield/spike, grain yield/plant and 100-grain weight. The maximum positive heterobeltiosis was observed for grain yield/plant in cross 5 (32.19 %) followed by cross 6 (14.51 %) and cross 1 (10.15 %). These three crosses also showed considerable heterotic effect for grain yield/spike and 100-grain weight as reported by Prasad *et al.* (1998). These findings indirectly support the concept that heterosis in grain yield might be due to the heterosis in yield contributing traits. Significant inbreeding depression was observed for most of the traits in majority of the crosses. The crosses showing high heterotic effects also showed high degree of inbreeding depression for most of the traits.

The results of the present investigation showed that different gene effects were responsible for the inheritance of same trait in different crosses and different traits in same cross. The quantitative traits

in present study were governed by both fixable and non-fixable genes. The characters for which additive gene effect was predominant, simple selection method could be used efficiently. However, additive x additive (i) gene effect was also important in some cases and under such circumstances it is possible to get transgrants in advance generations for fixing that particular trait. The presence of dominance gene effect and duplicate type of epistasis for most of the traits would slow down the progress of selection. In such a situation to exploit additive, dominance and epistatic gene effects simultaneously and to breakdown undesirable linkages, biparental mating as well as mating of selected plants in early segregating generations would be advantageous in developing wheat populations.

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Heterosis in Sesame (*Sesamum indicum* L.)

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Abstract

Heterosis in sesame was studied in a set of 10 x 10 diallel cross excluding reciprocals. Analysis of variance indicated highly significant differences for all the characters, suggesting the presence of considerable genetic diversity in the material studied. The magnitude of heterosis varied from cross to cross for all the characters studied. Degree of heterosis was higher for number of effective branches per plant, number of capsules per plant, days to maturity and yield per plant; moderate for days to 50 per cent flowering, number of seeds per capsule and length of capsule, while plant height exhibited low heterosis. Hybrid ABT-13 X ABT-19 manifested maximum heterobeltiosis (56.22 per cent) for seed yield per plant.

Keywords : Heterosis, heterobeltiosis, sesame

Introduction

Sesamum indicum L., one of the important oilseed crops plays an important role in agriculture and industrial economy of our country. Sesame (*Sesamum indicum* L.) ranks second after groundnut. It contains protein (20 %), fat (50 %), carbohydrate (16 %), fibre (5 %) and moisture (5 %). The genetic studies made so far to improve yield potential of this crops are inadequate. Present study was undertaken to determine the magnitude of heterosis in sesame.

Materials and methods

Ten genetically diverse genotypes of sesame, viz., G. Til-1, GTil-2, AHT-79, AHT-118, AHT-121, AHT-108, AST-47, AST-49, ABT-13 and ABT-19, were crossed in all possible combinations excluding reciprocals during *kharif* 1998. The 55 entries, comprising of ten parents and their 45 F_1 hybrids, were planted in a randomized block design with three replications at the Main Oilseed Research Station, Junagadh during *kharif* 1999. Each entry was represented by a single row of 20 plants, spaced at 45 x 15 cm. The normal agronomic and plant protection practices were followed. The observation on

five randomly selected plants in each row, excluding border ones, were recorded for eight characters viz., days to 50 per cent flowering, plant height, number of effective branches per plant, number of capsules per plant/ number of seeds per capsule, length of capsule, days to maturity and yield per plant.

Results and discussion

Significant differences among genotypes, parents and hybrids were observed for all the characters studied. Parents vs. hybrids variance was significant for plant height, number of capsules per plant, number of seeds per capsule and days to maturity. Heterosis in percentage over mid-parent (MP) and better parent (BP) for various characters are presented in Table 1. Those characters and crosses having desirable significant heterosis over mid-parent and significant heterobeltiosis for yield per plant were discussed only for brevity purpose.

Early flowering is a desirable feature in sesame cultivation. With regard to days to 50 per cent flowering, out of 11 crosses, 5 exhibited significant negative heterosis over mid-parent and 2 crosses depicted significant negative heterobeltiosis. The cross combination AHT-118 X ABT-13 (-13.11 per cent) exhibited highest negative heterobeltiosis for days to 50 per cent flowering. Similar results were obtained by Navadia *et al.* (1995) and Alam *et al.* (1999). For plant height, 5 crosses exhibited significant negative heterosis over mid-parents. While none of the crosses depicted significant negative heterobeltiosis. The cross combination AST-49 X ABT-13 (-12.52 per cent) showed the highest significant negative heterosis over mid-parent for plant height. These results are in confirmation with the results of Sodani and Bhatnagar (1990).

In case of number of effective branches per plant, 7 hybrids exhibited significant positive heterosis over mid-parent value and 4 crosses exhibited significant positive heterobeltiosis. Maximum heterobeltiosis was observed for G.Til-2 X AHT-121 (31.91 per cent).

Table 1. Heterosis in percentage over mid parent (MP) and better parent (BP) for various characters in sesame.

Characters	Days to 50 per cent flowering		Plant height		Number of effective branches per plant		Number of capsules per plant		Number of seeds per capsule		Length of capsule		Days to maturity		Yield per plant	
Crosses	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
GTF1x AHT79	233	789**	606**	13.77**	21.43**	18.60**	16.24**	252	-1.13	-3.10*	2.31**	-2.92**	1.37**	2.86**	15.48**	3.66**
GTF1x ABT13	353	789**	5.13*	27.67**	10.00**	-14.29**	8.44**	-8.12**	-2.71*	-7.03**	4.66**	4.08**	-1.45**	2.08**	15.56**	12.03**
GTF1x ABT19	-5.98**	-3.51	1.73	31.13**	7.75	22.73**	18.61**	0.15	2.80*	2.88	0.26	4.38**	6.06**	1.24**	21.39**	13.50**
GTF2x AHT121	-6.90**	-1.82	-3.36	11.14**	34.78*	31.91**	14.31**	9.53**	3.59**	0.87	-3.90**	-5.99**	2.10**	-1.54**	16.67**	14.10**
GTF2x ABT13	2.79	17.27**	-3.85	29.63**	6.45	-14.29**	11.02**	0.82	1.93	-5.12**	1.91*	1.80	0.89**	4.22**	19.54**	16.34**
GTF2x ABT19	5.22*	10.00**	5.75**	36.56**	8.90**	-19.70**	15.28**	2.28	5.44**	-2.91*	1.17	-4.30*	-1.76**	3.00**	13.30**	12.51**
AHT79x AHT121	-3.64	-2.46**	-6.90**	-2.38	15.12**	10.00	5.81**	2.86	8.09**	4.20**	4.48**	2.13*	3.40**	4.02**	7.40**	6.03
AHT118x ABT13	-19.39**	-13.11**	1.73	17.24**	-10.24**	-25.97**	2.91	-5.76*	2.12	-1.86	-0.36	-3.69	-6.24**	-3.79**	5.93**	4.36**
AHT121x ABT13	-9.51**	-2.46	-0.42	14.77**	16.39**	-7.79*	17.01**	8.74*	8.10**	5.01**	-0.12	-2.59**	0.55	3.26**	21.36**	20.75**
AST49x ABT13	-6.77**	6.36*	-12.52**	11.60**	-10.22**	-20.13*	25.70**	18.40**	-2.78*	-6.74**	-6.56**	-11.99**	0.19	5.85**	20.51**	11.08**
ABT13x ABT19	-2.68	5.83*	-3.75**	-0.29	21.02**	7.58*	30.3**	29.29**	0.96	-0.25	5.41**	0.00	-1.42**	0.00	61.62**	56.22**
SE (d.f.)	0.79	0.91	2.17	2.51	0.15	0.18	1.18	1.36	0.73	0.85	0.02	0.02	0.29	0.34	0.08	0.09

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

Positive heterosis for this character in sesame was reported by Navadia *et al.* (1995) and Alam *et al.* (1999). For number of capsules per plant ten hybrids exhibited positive significant heterosis over mid-parent and four crosses depicted significant positive heterobeltiosis. The cross combination ABT-13 x ABT-19 (29.29 per cent) showed the highest significant positive heterobeltiosis. Similar results were obtained by Navadia *et al.* (1995) and Mishra and Yadav (1996) in sesame.

For number of seeds per capsule, out of 11 hybrids, 5 exhibited significant positive heterosis over mid-parental value, of which two AHT-79 x AHT-121 (4.20 per cent) and AHT-121 x ABT-13 (5.01 per cent) showed positive significant heterobeltiosis. The present findings are supported by Mishra and Yadav (1996). With regards to length of capsule, 5 crosses showed significant positive heterosis over mid-parent and only two crosses, namely, G. Til-1 x ABT-13 (4.08 per cent) and AHT-79 x AHT-121 (2.13 per cent) exhibited significant positive heterobeltiosis. Heterobeltiosis observed in most of the crosses was in low magnitude. Sodani and Bhatnagar (1990), in sesame, observed low heterosis for this trait, which is confirmed by the present findings. For days to maturity, 6 crosses exhibited significant negative heterosis over mid-parental value and 3 crosses showed significant negative heterobeltiosis. The cross combination AHT-118 x ABT-13 (-3.79 per cent) exhibited highest negative heterobeltiosis. Results of Navadia *et al.* (1995) and Mishra and Yadav (1996) are in agreement with the result of present study in this respect.

Out of 45 hybrids, 19 expressed significant positive heterosis over mid-parental values for seed yield. Ten hybrids exhibited significant positive heterobeltiosis

for yield per plant. The cross combination ABT-13 x ABT-19 showed the highest heterosis (61.62 per cent). Manifestation of heterosis by this particular cross combination was also realized for days to 50 per cent flowering, plant height, number of effective branches per plant, number of capsules per plant and length of capsule. It was found that the heterosis for yield per plant is mainly due to increased number of effective branches per plant and number of capsules per plant. As and when feasible this hybrid can be commercially exploited in sesame production. Similar results were drawn by Navadia *et al.* (1995), Mishra and Yadav (1996), Baviskar *et al.* (1998) and Alam *et al.* (1999).

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Combining ability analysis in Indian mustard

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Abstract

Ten lines and four testers of the Indian mustard were evaluated for general and specific combining ability through line x tester cross analysis. The gene action was predominantly non-additive for most of the characters under study. Parents RSK 87 and GM 2 were good general combiners for seed yield/plant and siliquae/plant, SKM 9585, B 85 and GM 1 for early flowering and BIO 902 and GM 2 for bolder seed. The crosses RSK 87 x GM 2, SKM 9585 x GM 2 and RSK 87 x Varuna expressed good SCA effect for seed yield and SKM 9628 x Kranti for bolder seed.

Key words : Combining ability, line x tester analysis, Indian mustard

Introduction

Amongst, different oilseed crops, Indian mustard [*Brassica juncea* (L.) Czern & Coss] is the most important oilseed crop. The information about combining ability is of immense help to the plant breeder in the choice of suitable parents for hybridization programme. The nature of gene action has a bearing on development of efficient breeding programme. The general combining ability is attributed to additive and additive x additive gene effects, which are fixable, while specific combining ability is attributed to non-additive gene actions, which may be due to dominance or/and epistasis. Therefore, proper understanding of combining ability of parents and nature of gene effects for yield and its component characters could be of great help in selecting appropriate parents for hybridization and breeding programme.

Material and methods

Ten lines of mustard were crossed with four testers. The resulting 40 hybrids along with 14 parents were grown in single row of 3m length at a spacing of 45 x

15 cm in Randomized block Design with 3 replications. Observations were recorded on 50% flowering, no. of primary branches/plant, no. of secondary branches/plant, siliquae/plant, 1000-seed weight (g), oil content (%) and seed yield/plant from 5 competitive plants selected at random. The combining ability analysis was carried out according to the method given by Kempthorne (1957).

Results and discussion

The analysis of variance (Table 1) for combining ability indicated that the mean squares due to lines were significant for days to 50% flowering, no. of primary branches/plant, oil content and 1000-seed weight, whereas, mean squares due to testers were significant for oil content and 1000-seed weight. Further, the variance due to lines was higher than that of testers for all the characters except oil content. The mean square due to line x tester interactions were significant for all the characters except no. of primary branches/plant, which indicated that the experimental material possessed considerable variability and that GCA and SCA were involved in the genetic control of various characters.

The GCA, GCA ratio was less than one for seed yield, days to 50% flowering, no. of secondary branches/plant, siliquae/plant, 1000-seed weight and oil content. This indicated that non-additive component played greater role in the inheritance of these characters. These results are in accordance with the findings of Yadav *et al.* (1992), Patel and Sharma (1999) and Sheikh *et al.* (1998). The additive gene action played greater role in the inheritance of primary branches/plant. Similar results was also reported by Chaudhary *et al.* (1997).

Estimates of GCA effects revealed that, among the lines good general combiners were RSK 87 for seed yield and siliquae/plant, B 85 and SKM 9585 for early flowering, B 85 for primary branches/plant, Vaibhav for number of secondary branches/plant and BIO 902 for

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bolder seed. Among the testers, GM 2 was the best general combiner for seed yield, siliquae/plant and bolder seed, GM 1 for early flowering and oil content (Table 2). Therefore, it would be worthwhile to use above parental lines in hybridization, aimed at getting desirable segregating generations.

The highest SCA effects for seed yield was observed in cross PM 67 x Kranti (4.05). The SCA effects of

this cross were also high for number of siliquae/plant (53.16). Another important cross was RSK 87 x Varuna, the SCA effects of this cross were significant in desirable direction for seed yield and bolder seed. Likewise, cross Vaibhav x Kranti for days to 50% flowering, Pusa bold x Kranti for siliquae/plant, SKM 9628 x Kranti for bolder seed and SKM 9585 x Varuna for secondary branches/plant (Table 2).

Table 1. Analysis of variance for combining ability estimates of components of variance and their ratios for different characters in Indian mustard

Source of variation	d.f.	Days to 50% flowering	No. of primary branches/plant	No. of secondary branches/plant	Siliquae/plant	1000-seed weight	Oil content	Seed yield/plant
Females	9	17.81**	0.83	4.42	5273.81	1.36**	26.92*	23.89
Males	3	5.92	0.58	0.41	4767.66	1.59*	36.33**	15.26
Females x males	27	4.80**	0.32	3.56*	4679.64**	0.58**	13.41**	17.74**
Error	78	2.17	0.33	2.13	879.05	0.27	4.61	7.39
s^2_{gca}		0.33	0.02	0.05	16.24	0.05	0.09	0.09
s^2_{sca}		0.90	0.01	1.22	1266.86	0.10	2.93	3.46
s^2_{gca}/s^2_{sca}		0.37	1.80	0.04	0.01	0.48	0.03	0.03

*** Significant at P=0.05 and P=0.01 levels, respectively

Table 2. Three top ranking parents with respect to *per se* performance and GCA effects and three top ranking hybrids respects of *per se* performance and SCA effects

Character	Best performing parents	Best general combiners	Best performing hybrids	SCA effects	hybrids with top SCA effects
Days to 50 flowering	SKM 9585 GM 1 Pusabold	B 85 SKM 9585 GM 1	BIO 902 x GM 2 SKM 9585 x GM 1 BIO 902 x Kranti	-1.28* -0.38 -1.24	Vaibhav x Kranti MJ 90-137 x Varuna RSK 87 x Varuna
No. of primary branches/plant	PM 67 RSK 87 Vaibhav	PM 67 B 85 -	PM 67 x Kranti B 85 x Kranti Pusabold x Kranti	0.60* 0.15 0.37	PM 67 x Kranti - -
No. of secondary branches/plant	GM 1 Vaibhav SKM 9585	Vaibhav SKM 9585 -	SKM 9585 x Varuna Vaibhav x GM 1 Vaibhav x Varuna	2.06* 0.65 0.47	SKM 9585 x Varuna Pusabold x Kranti Vardan x Kranti
Siliquae/plant	GM 2 Vardan Vaibhav	RSK 87 GM 2 Vaibhav	RSK 87 x GM 2 Vaibhav x Varuna PM 67 x Kranti	11.67 15.14 53.16**	Pusabold x Kranti Vaibhav x Kranti SKM 9628 x Kranti
1000-seed weight	BIO 902 Pusabold Varuna	BIO 902 GM 2 PM 67	BIO 902 x GM 2 SKM 9628 x Kranti BIO 902 x Varuna	0.41* 0.89** 0.28	SKM 9628 x Kranti RSK 87 x GM 1 Pusabold x GM 1
Oil content	GM 1 Pusabold Kranti	PM 67 MJ 90-137 GM 1	RSK 87 x Kranti MJ 90-137 x Kranti MJ 90-137 x GM 1	3.34** 1.64 0.69	RSK 87 x Kranti B 85 x Kranti SKM 9585 x Varuna
Seed yield/plant	GM 2 RSK 87 PM 67	RSK 87 GM 2 -	RSK 87 x GM 2 SKM 9585 x GM 2 RSK 87 x Varuna	2.31* 2.68* 3.54**	PM 67 x Kranti RSK 87 x Varuna Pusabold x Varuna

*** Significant at P=0.05 and P=0.01 levels, respectively

The crosses which expressed high per se performance and desirable SCA effects for various characters involved either good x good, good x average, average x good and poor x poor combining parents. Thus, crosses expressing high SCA effects did not always involve parents with high GCA effects. It is suggested that inter allelic interactions were also important for these traits. The presence of predominantly large amount of non-additive gene action would necessitate the maintenance of heterozygosity in the population. Breeding methods such as biparental mating followed by reciprocal recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic improvement.

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Genotype-environment interaction in urdbean [*Vigna mungo* (L.) Hepper]

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Abstract

Genotype x environment interaction and stability parameters of seven diverse urdbean genotypes were studied at 8 locations during *kharif* 2003. Highly significant variance due to genotypes against pooled deviation for grain yield, days to maturity, plant height and pods/plant revealed the presence of genetic variability for these traits. The G X E (linear) interaction was significant for traits such as pods/plant and seed/pod indicating that phenotypic performance of the genotypes were predictable for these traits. The pooled deviation, a non-linear component was significant for grain yield, days to maturity, plant height, pods/plant and seeds/pod. It indicated that both linear and non-linear components of genotype x environment interactions were responsible for the differences in the stability of genotypes observed. The genotypes, TPU-4 (584 kg/ha), T-9 (619 kg/ha) and IPU-94-1 (620 kg/ha) exhibited high mean values for grain yield and non-significant regression coefficient (bi) approaching unity with non-significant deviation from regression. Parameters in respect of yield attributing traits revealed that TPU-4 for days to maturity and plant height and T-9 and IPU-94-1 for pods/plant and seeds/pod were stable over environments. SKNU-9703, a high yielding genotype (780 kg/ha) was found stable for plant height and seeds/pod.

Key words : Genotype x environment interaction, stability, urdbean

Introduction

Urdbean (*Vigna mungo* (L.) Hepper) is one of the important pulse crop for arid and semi-arid regions. There is a need to evolve suitable varieties with better buffering capacity against climatic fluctuations. The yield potential of this crop is low due to inefficient plant type and inconsistency in grain yield over environments, particularly with the existing varieties.

It is essential to breed high yielding varieties which may perform consistently better under different environmental conditions. The present investigation was taken up to study the genotype x environments interaction of seven diverse urdbean genotypes.

Material and methods

Seven elite genotypes of urdbean were evaluated in field trials at eight diverse locations viz., GVT farm-Dahod, Farmer's field-Dahod, Bharuch, Tanchha, Mualiya farm-Dahod, Ratanpur, Vanarasi and Navsari during *Kharif* 2003 in randomized block design with three replications. The inter and intra row spacings were 45 cm and 15 cm, respectively. During crop growth period, all the recommended agronomic practices were followed at all the locations. Observations were recorded on different agronomic traits viz., grain yield, days to maturity, plant height, pod/plant and seeds/pod. Grain yield was recorded on plot basis and converted to kg/ha. The Bartlett's test was employed to test the homogeneity of error variance of different environments. The data were analyzed for stability parameters following Eberhart and Russell (1966).

Results and discussion

The results revealed significant variation among genotypes for all traits except seeds/pod (Table 1). Environment (linear) was highly significant, which indicated that environments differed considerably from location to location. The genotype x environment interaction being significant for pods/plant, indicated that the genotypes interacted considerably to different environmental conditions for this trait. The G x E (linear) interaction was significant for traits viz., pod/plant and seeds/pod indicating that phenotypic performance of genotypes was predictable for these characters. Significant variance due to pooled deviation for all the traits studied indicated that the genotypes differed considerably with respect to their stability. It also indicated that both linear and

Table 1. Analysis of variance (mean square) for stability in urdbean

Sources	d.f.	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	Pods /plant	Seeds/pod
Genotype	6	46224.86**	19.29**	105.27**	147.85**	0.067
Environments	7	987349.14**	496.20**	1736.12**	2262.65**	2.74**
Genotype x Environments	42	11557.52	9.17	50.46	88.06*	0.30
Environments (L)	1	6911444.00**	3473.44**	12152.87**	15383.54**	19.23**
Genotype x Environments (1)	6	6500.41	6.27	37.97	289.19**	0.65**
Polled deviations	42	10628.88**	8.27**	45.03**	47.18**	0.21**
Polled error	96	4266.88	1.13	18.76	13.30	0.12

*, ** Significant at 5% and 1% respectively

Table 2. Mean and stability parameters for yield and yield components in urdbean

Sr. No	Geno-type	Grain yield (kg/ha)			Days to maturity			Plant height (cm)			Pods/plant			Seeds/pod		
		xi	b _i	S ² d _i	xi	b _i	S ² d _i	xi	b _i	S ² d _i	xi	b _i	S ² d _i	xi	b _i	S ² d _i
1	TPU-4	584	0.97	-2345.9	86	0.85	1.36	60	1.09	18.21	45	1.36	46.11**	6.25	1.63*	-0.06
2	T-9	619	0.95	-3869.4	82	0.89	2.17*	57	0.93	25.39**	42	0.86	3.25	6.17	1.30	0.16
3	IU8-6	673	1.03	9727.0*	83	1.00	3.57**	55	1.08	-10.81	44	1.35	25.85	6.04	0.28*	-0.0004
4	SKNU-9703	780	1.14	20735.7**	88	1.02	10.74**	54	0.84	14.33	49	1.36*	2.27	6.25	0.91	-0.035
5	TAU-1	563	0.91	-935.8*	86	0.95	10.84**	59	1.13	20.42	39	0.82	2.63	6.29	1.25	0.022
6	IPU-94-1	620	1.05	2000.8	83	1.15	19.17**	52	0.78	64.10**	38	0.72	10.16	6.17	1.17	-0.09
7	RBU-30	571	0.93	12771.3**	85	1.13	0.85	60	1.15	41.16**	37	0.51	77.05**	6.08	0.44	0.33**

N, ** Significant at 5% and 1% respectively.

non-linear components of genotype x environment interactions were responsible for the differences in the stability of genotypes observed. The linear regression (b_i) is regarded as a measure of responsiveness and s^2d_i as a measure of stability for classification of genotypes as suggested by Paroda and Hayes (1971). A genotype with non-significant s^2d_i and b_i was considered as stable genotype.

Mean performance and stability parameters for grain yield and its components traits are given Table 2. The genotypes, TPU-4 (584 kg/ha), T-9 (619 kg/ha) and IPU-94-1 (620 kg/ha) exhibited high mean values for grain yield and non-significant regression coefficient (b_i) approaching unity with non-significant deviation from regression. Parameters in respect of yield attributing traits revealed that TPU-4 for days to maturity and plant height and T-9 and IPU-94-1 for pods/plant and seeds/pod were stable over environments. SKNU-9703, a highest yielding genotype (780 kg/ha) was found stable for plant height and seeds/pod. This indicated that the stability of various components traits might be responsible for observed stability of grain yield. These findings are in

accordance with Perraju et al. (1989) and Mishra et al. (2001).

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Field screening of some sorghum genotypes/varieties for their resistance to armyworm, *Mythimna separata* Walker

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Abstract

A field experiment on screening of some sorghum genotypes/varieties for their resistance to armyworm, *Mythimna separata* Walker was conducted at Forage Research Project farm, Gujarat Agricultural University, Anand Campus during Kharif, 1999 and 2000 with 8 different genotypes/varieties viz., C-10-2, MP Chari, GFS-5, ICSV-745, SR-770-2, SR-833, GJ-36 and GJ-41. Among different genotypes/varieties sorghum C-10-2 had significantly lowest (0.60) *M. separata* larval population with lower (1.66%) damaged plants in comparison to both the checks viz., GJ-36 (1.40 larvae and 3.64% damaged plants) and GJ-41 (1.54 larvae and 4.45% damaged plants). Sorghum genotype ICSV-745 was found equally susceptible to armyworm as sorghum C-10-2 but gave significantly higher grain yield than C-10-2.

Key words : Resistance, army worm, sorghum

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an important food grain as well as a fodder crop cultivated in 0.18 million hectares with an annual production of 0.16 million tonnes in Gujarat (Anon., 1999). It is attacked by more than 150 insect-pests (Sheshu Reddy and Davies, 1979). Amongst them, armyworm (*Mythimna separata* Walker) is very important pest. Desai *et al.* (1983) have reported 80 per cent yield loss of sorghum grain in Ahmedabad district by this pest.

Considering the extent of damage and losses caused by *M. separata*, farmers are using synthetic insecticides indiscriminately for its control which may lead to the problems of 3 Rs i.e. resistance in insect-pests to pesticides, residue deposition on foliage as well as on grain and resurgence of the

minor pests. To avoid all these problems, the safest way is to go for resistant variety to pests. With this in view, eight sorghum genotypes/varieties were evaluated against *M. separata* for finding out a relatively resistant variety.

Material and methods

A field experiment to screen 8 sorghum genotypes/varieties for their resistance to armyworm, *M. separata* was conducted in the Kharif seasons of 1999 and 2000 at Forage Research Project farm, Gujarat Agricultural University, Anand campus- 388 110. The soil of the field was sandy loam. Seeds of all the genotypes/varieties were received from the Research Scientist (Sorghum), GAU, Surat. The genotypes/varieties selected for the study were sown in three replications (Plot size : 3.75 x 1.80) in Randomized Block Design and all the recommended agronomical practices were followed.

The observations on number of larvae and the number of damaged plants per plot were recorded starting from 3 weeks age from to maturity weekly interval. The data on total number of plants in each plot was recorded from 45 days after germination and thus percentage of damaged plants per plot was calculated. The experiment was repeated for two years. At the time of maturity of the crop, ear heads were harvested separately from each net plot for recording the yield data. The data on larval population and percent age of damaged plants were subjected to square root and arcsin transformation, respectively for statistical analysis.

Results and discussion

Larval activity

The data (Table 1) on armyworm population on different sorghum genotypes/varieties including local varieties GJ-36 and GJ-41 revealed significantly lower (0.56) armyworm population on C-10-2 than rest of

the genotypes/varieties during *Kharif* 1999. The genotype ICSV-745 had significantly lower (1.35) larval population of *M. separata* than SR-770-2 (1.90) and SR-833 (2.09) but observed at par to MP Chari (1.60), GFS-5 (1.46), GJ-36 (1.69) and GJ-41 (1.49). During *Kharif*, 2000 also C-10-2 recorded lower (0.67) larval population in comparison to other varieties except ICSV-745 (0.82). Sorghum ICSV-745 (0.82) had lower larval population than GJ-36 (1.14) and GJ-41 (1.60), SR-833 (1.35) and MP Chari (1.69) but remained at par to GFS-5 (0.89) and SR-770-2 (0.94).

The study of two years also showed lower (0.60) larval population on sorghum C-10-2 in comparison to rest of genotypes/varieties except ICSV-745 (1.06) and GFS-5 (1.16). Patel (1988) has reported lower larval population of *M. separata* on sorghum C-10-2 in comparison to sorghum GJ-36 and MP Chari.

Damaged plants

The larval population was reflected on damage to the plants. The C-10-2 had significantly lower (1.84%) damaged plants than rest of the genotypes/varieties including two local varieties GJ-36 (5.27%) and GJ-41

(4.14%) during *Kharif* 1999. Sorghum variety MP Chari (3.89%), GFS-5 (4.19%), ICSV-745 (4.15%) and SR-770-2 (5.09%) did not show significant difference in plant damage. The SR-833 (5.53%) had highest damaged plants. The plant damage during *Kharif* 2000 also remained lowest in sorghum C-10-2 (1.49%) but GFS-5 (1.42%), ICSV-745 (1.82%) and local variety GJ-36 (2.30%) remained at par to C-10-2. The highest damage was registered on sorghum GJ-41 (4.77%) which remained at par to MP Chari (3.73%) and SR-833 (4.19%).

Two years study on sorghum plants damaged by *M. separata* (Table 1) indicated the lower damage to sorghum C-10-2 (1.66%) than rest of the genotypes/varieties except GFS-5 (2.63%) and ICSV-745 (2.87%). The GFS-5 (2.63%) and ICSV-745 (2.87%) also remained at par to MP Chari (3.81%), SR-770-2 (3.89%), SR-833 (4.84%), GJ-36 (3.64%) and GJ-41 (4.45%).

Grain yield (Kg/ha)

Sorghum ICSV-745 yielded significantly higher grain during both the years in comparison to rest of the genotypes/varieties which were at par. Same trend was observed in pooled results.

Table 1. Relative susceptibility of sorghum genotypes/varieties to armyworm, *M. separata*

Variety	No. of larvae/plot*			Damaged plants (%)**			Grain yield (kg/ha)		
	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled
C-10-2	1.03 ^d (0.56)	1.08 ^d (0.67)	1.05 ^b (0.60)	7.79 ^d (1.84)	7.01 ^d (1.49)	7.40 ^b (1.66)	1809 ^a	1513 ^a	1661 ^b
MP Chari	1.45 ^{abc} (1.60)	1.48 ^a (1.69)	1.47 ^a (1.66)	11.38 ^c (3.89)	11.13 ^{ab} (3.73)	11.26 ^a (3.81)	1930 ^b	1634 ^b	1782 ^c
GFS-5	1.40 ^{bc} (1.46)	1.18 ^a (0.89)	1.29 ^{ab} (1.16)	11.82 ^{abc} (4.19)	6.85 ^d (1.42)	9.33 ^{ab} (2.63)	1993 ^b	1697 ^b	1845 ^b
ICSV-745	1.36 ^c (1.35)	1.15 ^{cd} (0.82)	1.25 ^{ab} (1.06)	11.75 ^{bc} (4.15)	7.76 ^{cd} (1.82)	9.76 ^{ab} (2.87)	3284 ^a	2988 ^a	3136 ^a
SR-770-2	1.55 ^{ab} (1.90)	1.21 ^{cd} (0.94)	1.38 ^a (1.40)	13.04 ^{abc} (5.09)	9.72 ^{bc} (2.85)	11.38 ^a (3.89)	1943 ^b	1646 ^b	1795 ^b
SR-833	1.61 ^a (2.09)	1.36 ^{bc} (1.35)	1.48 ^a (1.69)	13.60 ^a (5.53)	11.82 ^{ab} (4.19)	12.71 ^a (4.84)	2252 ^b	1956 ^b	2104 ^b
GJ-36(c)	1.48 ^{abc} (1.69)	1.28 ^{cd} (1.14)	1.38 ^a (1.40)	13.27 ^{ab} (5.27)	8.73 ^{cd} (2.30)	11.00 ^a (3.64)	2197 ^b	1901 ^b	2049 ^b
GJ-41(c)	1.41 ^{bc} (1.49)	1.45 ^{ab} (1.60)	1.43 ^a (1.54)	11.74 ^{bc} (4.14)	12.61 ^a (4.77)	12.18 ^a (4.45)	2049 ^b	1753 ^b	1901 ^b
S.Em.+V	0.05	0.03	0.08	0.53	0.66	1.08	247	246	156
W	-	-	0.04	-	-	0.60	-	-	247
C.V. %	17.46	12.90	15.60	23.49	36.33	29.37	1959	2267	21.01

* $\sqrt{X + 0.5}$ transformed values., ** Arcsin transformed values. Figures in parentheses are retransformed values.

Note: Treatment means with the common letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance.

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Initial evaluation for photosensitivity in Pearl millet

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Abstract

A long term experiment spread over 9 years from 1990 to 1998. In all 26 plantings were done to create varied photoperiodic conditions and a total of 39 parental lines of pearl millet were evaluated. The data were subjected to linear correlation and regression analysis between photoperiod and degree -days to flower. In general pearl millet exhibited a quantitative short day response. Individual lines were identified and categorized for their response to photoperiod. Time to flower (early or late) did not show any specific relationship with photoperiodic response.

Key words : Photosensitivity, Photoperiod,
Pearl Millet.

Introduction

Pearl millet is a highly cross-pollinated crop. For commercial hybrid seed production, synchronization in flowering of both the parents is an essential requirement. Knowledge of photoperiodic response of parental lines and identification of photo-insensitive lines would be an asset in commercial hybrid seed production programme in pearl millet. A low degree of photoperiodic sensitivity is also essential for broad adaptation of pearl millet (Bidingar and Rai, 1989).

Material and methods

In a long term experiment spread over nine years from 1990 to 1998 with split plot design and three replications each of single row of 5 m, in all 26 plantings employing recommended package of practices were done at Jamnagar location to create different photoperiodic conditions ranging from 12 hours and 1 minute to 14 hours and 13 minutes, and 39 parental lines were evaluated for their photoperiodic response.

The photoperiodic sensitivity was defined as delay in flowering due to increasing day length depending on planting dates. The influence of temperature was nullified by expressing the flowering period in terms of degree-days. These were calculated by summing up the mean daily temperature minus base temperature (12° C in pearl millet) of the flowering period. Flowering was recorded when stigmas on 50% of the main panicles per plot had emerged.

The data were subjected to linear correlation and regression analysis between photoperiod and degree- days to flower (Gomez and Gomez, 1984). The list of entries is given in Table 1, along with various components of regression analysis.

Results and discussion

In an overall response a significant positive correlation (r) was obtained between degree-days to flower and photoperiod, signifying that with the increase in photoperiod there was a delay in flowering. This indicates that in general pearl millet exhibited a quantitative short day response (Table 1). These results are in conformation with the earlier work (Begg and Burton, 1971, Ong and Everard, 1979).

Genotypic differences in response to photoperiods were observed. Non-significant values of r indicated a poor photoperiodic response or photo-insensitive nature of the entry. Accordingly, these parental lines are categorized as low photoperiodic responsive photo-insensitive lines. Such lines are of particular interest to breeders as a matter of requirement of synchrony in flowering of parental lines for hybrid seed production programme. Out of 39 lines 24 entries were assessed as low photoperiodic-responsive / photo-insensitive lines, which may be useful for breeding purpose. However, some entries with limited plantings (less number of observations- n) require further confirmation and two entries viz. PNMS-3A

Table 1. Correlation and regression analysis between photoperiods (in hours) and flowering time (in degree days) of different entries

Sl. No.	Name of entry	n	r	r ²	t	F	Regression equation	Mean photo period[h]	Mean time [deg.day]
1.	S1-A	27	0.45*	0.2	2.54*	6.45*	y=47.55 +192.57	13.32	826.07
2.	S41-A	48	0.16	0.02	1.1	1.21	y=28.63 x-384.71	13.33	766.73
3.	ICMR-88088	6	0.92*	0.84	4.62**	21.39*	y=85.05 x370.98	13.14	746.67
4.	214-2	6	0.48	0.34	1.43	2.04	y=29.31x+372.36	13.14	757.5
5.	PPMI-301	42	-0.39*	0.15	-2.66*	7.07*	y=84.42x+2002.5	13.21	886.98
6.	77-273-3-2	6	0.57	0.32	1.37	1.88	y=121.26x-778.58	13.14	814.83
7.	AIB-23	12	0.54	0.29	2	4.02	y=45.92x+145.84	12.73	730.42
8.	PN-2A	24	0.15	0.02	0.71	0.5	y=22.80x+476.34	13.24	778.46
9.	PPNBV-8	24	0.14	0.02	0.65	0.42	y=21.23x+368.36	13.43	653.58
10.	RIB-20K-86	21	0.61*	0.37	3.35**	11.22**	y=67.75x219.49	13.4	688.38
11.	AER-49	12	0.06	0.003	0.19	0.04	y=2.97x+698.94	13.31	738.5
12.	J-108	12	-0.08	0.006	-0.25	0.06	y=6.99x+786.13	13.31	693.08
13.	RP-3414	12	0.26	0.068	-0.86	0.73	y=21.59x+928.07	13.31	640.67
14.	843-A	39	0.61*	0.37	4.74**	22.47**	Y=82.96x-429.82	13.39	681.56
15.	1009	12	-0.15	0.02	-0.48	0.23	Y=31.42x+1213.1	13.31	794.92
16.	2059	12	0.04	0.001	0.12	0.01	y=4.73x+752.13	13.31	815.08
17.	J-2289	12	-0.25	0.06	-0.8	0.64	y=13.31x+663.42	13.31	663.42
18.	J-2296	21	0.42	0.18	2.04	4.19	y=49.25x+58.77	13.4	71876
19.	5054-A	12	-0.44	0.19	-1.55	2.41	y=-79.03x-1771.4	13.31	719.33
20.	ICMR-87003	33	-0.22	0.05	-1.28	1.64	y=-52.92x+1514.9	13.34	80869
21.	ICMR-88088	57	0.69*	0.45	7.20**	51.83*	y=166.49x-1446.5	13.37	77969
22.	ICMR-89951	12	-0.13	0.016	-0.41	0.17	y=-9.97x+775.64	13.31	64292
23.	Pb-111-A	33	0.17	0.03	0.98	0.96	y=45.59x+274.49	13.4	885.73
24.	J-2290	36	0.28	0.07	1.67	2.78	y=65.07x-34.69	13.35	83436
25.	D-23	39	-0.02	0.005	-0.14	0.02	y=-4.19x+886.52	13.42	830.2
26.	ICMP-85410-E1E1	12	0.94*	0.89	9.06**	81.99*	y=200.39x-1680.4	13.38	1001.33
27.	ICMP-85410-e1e1	12	0.71*	0.51	3.23*	10.42*	y=188.21x-1829.3	13.38	689.42
28.	BSECTCP-2/C2	15	0.64*	0.4	3*	9*	y=80.57x-291.49	13.35	78393
29.	PNMS-3A	3	-	-	-	-	-	12.5	63833
30.	PNBM-90001	15	0.05	0.002	0.18	0.03	y=5.61x+873.13	13.35	88806
31.	PNMS-8A	12	-0.38	0.15	-1.32	1.74	y=-48.17x+1597.3	13.48	94792
32.	PNBM-89053	15	0.66*	0.44	3.19*	10.19*	y=162.01x-1319.5	13.35	84307
33.	886-A	12	0.55	0.3	2.09	4.35	y=93.08x-436	13.19	791.25
34.	89-1 11-A	9	0.94*	0.89	7.55**	5704**	y=105.29x-601.12	13.45	815.56
35.	ICMP-451	9	0.62	0.39	2.11	4.43	y=45.63x+130.22	13.45	744.12
36.	RIB-335/74	18	0.56*	0.32	2.73*	7.4*	y=55.96x-32.61	13.49	722.06
37.	G-73-107	9	0.78*	0.6	3.27*	10.69*	y=103.63x-570.48	13.45	823.89
38.	77/29-3	3	-	-	-	-	-	14.16	791
39.	H-77/833-2	9	-0.73	0.54	-2.84	8.09	y=-220.76x+3765	13.33	822.44
Overall responses		732	0.17*	0.03	4.7*	22.09*	y=38.45x+271.27	13.34	784.32

Table 2. Categorization of different parental lines for flowering time [degree days]

Sr. No.	Early flowering entries [<700 degree days]	Mid-late entries [<700 degree days]	Late entries [>800 degrees days]
1.	PNBVS	841-A	81-A
2.	RIB-20K-86	ICMR-88088	PPMI-301
3.	J-108	214-2	77/273/3-2
4.	RP-3414	AIB-23	2069
5.	843A	PN-2A	ICMR-87003
6.	J-2289	AER-49	Pb-111-A
7.	ICMR-89951	1009	J-2290
8.	ICMP-85410e1e1	J-2296	D-23
9.	PNMS-3A	5054-A	ICMP-85410E1E1
10.	-	ICMR-58004	PNBM-90001
11.	-	BSECTCP-C2	PNMS-8A
12.	-	886-A	PNBM-89053
13.	-	ICMP-451	89-111-A
14.	-	RIB-335/74	G-73-107
15.	-	77/29-3	-
16.	-	H77/833-2	-

and 77/29-3 are totally excluded from the discussion. The response of a hybrid to day-length has been shown to be closely related to that of their parents and that the adaptive range of the breeding material can be broadened (Bidinger and Rai, 1989).

The parental lines are also categorized (Table 2) for their flowering behavior as early, mid-late and late flowering entries depending on their mean flowering time (Table 1). However, photoperiodic response was not found to be associated with earliness or lateness of the entry. Nevertheless, once we know the

temperature regime of a location and degree-days to flower of any entry, the number of days required for flowering can be predicted. This is very helpful in synchronization of flowering time of two parental lines by staggered sowing in commercial hybrid seed production programme.

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Studies on intercropping in rainfed cotton

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Abstract

A field experiment was conducted during for three consecutive years in the month of July, August, September 1997-2000 rainy season of 1997-98 to 1999-2000 on medium black soil to select a suitable rainy season crop for intercropping with cotton. The highest mean seed cotton equivalent yield (695 kg ha⁻¹) and monetary advantage (Rs 13900 ha⁻¹) were obtained by intercropping one row of soybean [*Glycine max* (L.) Merr] between two rows of cotton sown at 240 cm inter row spacing. This was followed by cotton + green gram (*Phaseolus radiatus* L) and cotton + sesame (*Sesamum indicum* L.).

Keywords : Intercropping, rainfed cotton, seed cotton yield equivalent

Introduction

Cotton is the predominant monsoon crop of Bhal and Coastal Agro-climatic Zone of Gujarat state. Due to its adaptability for wider spacing and slow initial growth, quick growing *Kharif* crops can be taken as inter crop particularly when cotton is grown in 240 cm wide rows. Earlier studies indicated that intercropping of cotton with short duration legumes, cereals and oilseeds was more remunerative than sole crop of cotton (Giri and Upadhyay, 1979; Tomer *et al.* 1994 and Sharma *et al.* 1997). The present study was undertaken for assessing the possibilities of an intercropping *Kharif* crops with cotton to increase productivity.

Materials and methods

A field experiment was conducted in three consecutive monsoon (1997-98 to 1999-2000) on medium black soil under dry land conditions of Bhal and Coastal Agro-climatic Zone at Regional Research Station, Gujarat Agricultural University, Arnej. The

treatments consisted of intercropping of green gram, soybean, sesame and fodder sorghum with cotton sown at 240 cm spacing in the row ratio of 1 : 1. In addition to this, sole crop of cotton was also grown at 120 cm and 240 cm row spacings. In all, 6 treatments were tried in a RBD with four replications. The soil was medium black, containing 124.66, 45.52 and 678.00 kg available N, P₂O₅ and K₂O kg/ha, respectively. The rainfall received during the crop growth period was 995.0, 768.4 and 700.6 mm during 1997-98, 1998-99 and 1999-2000 in 44, 36 and 24 rainy days, respectively. All crops were sown on 11th, 1st and 15th July in the respective years. To compare the intercropping treatments, the yield of all the crops was converted into seed cotton yield equivalents.

Results and Discussion

Effect of intercrops on yield of main crop

The effect of intercrops on seed cotton yield of main crop was found significant during two out of three years and also in pooled analysis. In first year and in pooled all the intercrops except fodder sorghum significantly reduced the seed cotton yield of main crop whereas during 1999-2000 sesame and fodder sorghum adversely affected the cotton yield. In general, the magnitude of reduction was more with soybean. This was due to the smothering effect of soybean. (Shaktawat and Singh, 1985 and Chelamuthu *et al.* 1989 and Babu, 1998).

Results revealed that effect of different treatments on seed cotton equivalent was significant during all the years and also in pooled analysis (Table 1). All the intercropping treatments showed significantly higher seed cotton equivalent over sole crop of cotton sown at 120 cm inter row spacing. However, they were almost comparable to sole crop of cotton sown at 240 cm spacing with some exception. In 1998-99, sesame and green gram and in 1999-2000 soybean showed higher seed cotton equivalent as compared to that of sole crop of cotton sown at 240 cm spacing. Among the different treatments, cotton + soybean recorded

Table 1. Yield of main and intercrop (kg ha⁻¹) and cotton equivalent yield (kg ha⁻¹) and gross income (Rs. ha⁻¹) as influenced by different treatments

Treatment	1997-98		1998-99		1999-2000		2000-2001						Gross income Rs. ha ⁻¹
	Seed cotton yield of main crop, kg ha ⁻¹	Yield of inter crop kg ha ⁻¹	Seed cotton equi- valent yield kg ha ⁻¹	Seed cotton yield of main crop, kg ha ⁻¹	Yield of inter crop kg ha ⁻¹	Seed cotton equi- valent yield kg ha ⁻¹	Seed cotton yield of main crop, kg ha ⁻¹	Yield of inter crop kg ha ⁻¹	Seed cotton equi- valent yield kg ha ⁻¹	Seed cotton yield of main crop, kg ha ⁻¹	Yield of inter crop kg ha ⁻¹	Seed cotton equi- valent yield kg ha ⁻¹	
1. Cotton sole (120 cm)	479	-	479	485	-	485	265	-	265	409	-	409	8180
2. Cotton sole (240 cm)	678	-	678	573	-	573	429	-	429	560	-	560	11280
3. Cotton-Green green (1:1)	518	191	661	538	364	811	385	102	432	480	205	634	12680
4. Cotton + Soybean (1:1)	475	368	751	441	335	692	387	337	640	434	348	695	13903
5. Cotton + Sesame (1:1)	550	52	615	554	214	822	340	83	444	481	117	627	12540
6. Cotton + Fodder sorghum (1:1)	589	1187*	678	552	1907*	695	373	1533*	488	505	1547*	621	12420
S. Em. +	38	-	41	42	-	44	17	-	15	20	-	43	-
C.D.0.05	115	-	125	NS	-	133	51	-	46	58	-	136	-
C.V. %	14	-	13	16	-	13	9	-	7	14	-	12	-

*Dry fodder yield

the maximum seed cotton equivalent during two out of three years as well as in pooled analysis. In general, the highest mean seed cotton equivalent yield (695 kg ha⁻¹) and monetary advantage (Rs. 13900 ha⁻¹) were obtained by intercropping one row of soybean [*Glycine max* (L.) Merr] between two rows of cotton sown at 240 cm inter row spacing. This was followed by cotton + green gram (*Phaseolus radiatus* L.) and cotton + sesame (*Sesamum indicum* L.) cropping sequence.

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Production potential of forage maize (*Zea mays* L.)-cowpea cropping systems as influenced by row ratios

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Abstract

A field experiment was conducted during rainy seasons of 1999 and 2000 to evaluate the production potential of forage maize-cowpea cropping systems. Inter cropping of maize + cowpea in 4:1 row ratio gave significantly higher green forage yield than maize or cowpea grown alone during 1999, while mixed cropping of maize and cowpea in same row was found to significantly superior in green forage and dry matter yields to all the other treatments during 2000. On an average of two years, the highest green forage (544 q/ha) and dry matter yield (79.6 q/ha) were produced by the treatments of maize + cowpea sown in row ratio 4:1 and mixed sowing of maize + cowpea in same row, respectively. Inclusion of cowpea as intercrop or mixed crop also improved the quality of forage by giving higher crude protein yield compared to maize crop grown alone.

Keywords : Cropping system, intercropping, forage crop

Introduction

Maize is an ideal forage crop having quick growing habit, high yielding ability, palatability, nutritive value and acceptable to the cattle at any stage of growth, while cowpea is used as green fodder, converted into hay or preserved as silage. Quality forage production plays an important role in the dairy industry. Growing cereal forages and legumes together either mixed or in various row ratios is a perspective way to get quality forage in appreciable quantities with added advantage of soil enrichment. The present experiment was conducted to evaluate the forage productivity of maize alongwith cowpea in intercropping and mixed cropping systems, since information on these aspects is not available for middle Gujarat region.

Materials and Methods

The experiment was conducted during rainy (Kharif) seasons of 1999 and 2000 at Forage Research Project, Anand. The sandy-loam soil of the experimental plot had organic carbon 0.31 %, available nitrogen 235.0 kg/ha, available phosphorus 97.9 kg (P_2O_5)/ha and available potassium 271.0 kg (K_2O) /ha. with pH 7.8. Twelve treatments of maize-cowpea cropping systems including sole crops (Table 1) were replicated four times in randomized block design. The crops were sown at 30 cm spacing as sole crop, in row proportion or mixed in same row as per the treatments during second week of July during both the years. Maize variety African tall and cowpea variety EC-4216 were fertilized with 80 kg N/ha + 30 kg P_2O_5 /ha and 20 kg N/ha + 40 kg P_2O_5 /ha, respectively. Other practices recommended were adopted for cultivation of both the fodder crops. Both maize and cowpea were harvested at 70 days after sowing for green forage yield. The green fodder was oven dried and weighed as dry matter. The forage quality was also estimated at harvest by taking crude protein content.

Results and discussion

Green forage and dry matter yields

The total green forage and dry matter yields were significantly affected by various treatments except dry matter yields in 1999 (Table 1). Maize + cowpea in 4:1 row ratio recorded the highest green forage and dry matter yields (506 and 74.3 q/ha, respectively) during 1999 and being statistically at par with other treatments. It was significantly superior in green forage yield than sole cropping of maize or cowpea in 1999. However, mixed cropping of maize + cowpea sown in same row was found significantly superior in green forage and dry matter yields (625 and 100.8 q/ha, respectively) than all the other treatments during 2000.

Production potential of maize as influenced by row ratios

Table 1. Effect of maize-cowpea cropping systems on total green forage, dry matter and crude protein yield and net returns.

Treatment	Green forage yield (q/ha)			Dry matter yield (q/ha)			Crude protein yield (q/ha)			Net returns (Rs/ha)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Sole Maize	357	510	464	61.9	76.6	69.3	2.77	4.39	3.58	9920	18600	14260
Sole Cowpea	403	346	375	60.9	49.7	55.3	11.01	7.24	9.12	18725	13950	16388
Maize + Cowpea (1:1)	481 (380)	483 (133)	482	65.0 (52.6)	68.6 (22.1)	66.8	8.19	6.07	7.13	21320	18976	20148
Maize + Cowpea (1:2)	493 (396)	488 (199)	491	66.9 (56.9)	71.3 (30.5)	69.	13.00	7.17	10.08	22520	20325	21423
Maize + Cowpea (2:1)	504 (339)	503 (132)	503	73.8 (45.1)	73.8 (21.4)	73.8	11.89	5.35	8.62	23825	20160	21993
Maize + Cowpea (3:1)	496 (304)	576 (81)	536	67.9 (38.9)	69.6 (12.7)	68.7	9.83	4.18	7.00	22820	23835	23328
Maize + Cowpea (1:3)	458 (400)	414 (241)	436	60.7 (55.2)	64.8 (36.6)	62.7	9.70	6.81	8.26	20660	16455	18558
Maize + Cowpea (1:4)	497 (430)	419 (234)	458	61.5 (56.9)	61.3 (33.5)	61.4	11.17	6.46	8.82	22370	16590	19480
Maize + Cowpea (4:1)	506 (220)	582 (90)	544	74.3 (27.8)	84.3 (14.0)	79.3	5.78	7.04	6.41	22160	24270	23215
Maize + Cowpea (2:3)	487 (362)	548 (159)	517	66.8 (46.2)	87.4 (21.3)	77.1	8.64	7.07	7.85	23150	23205	23178
Maize + Cowpea (3:3)	473 (333)	514 (158)	494	64.4 (41.3)	83.2 (23.4)	73.8	9.73	6.56	8.14	21875	21210	21543
Mixed in same row	449 (382)	625 (146)	537	58.4 (47.2)	100.8 (21.0)	79.6	6.79	7.43	7.11	21170	27630	24400
S.E.m. ±	26.92	11.41	--	3.64	1.64	--	0.65	0.15	--	--	--	--
C.D. at 5 %	78.94	33.46	--	NS	4.81	--	1.89	0.43	--	--	--	--

* Figures in parentheses indicate yield of cowpea

Selling price of green fodder of maize and cowpea were considered Rs. 0.60 and 0.75, respectively.

Table 2. Effect of maize-cowpea cropping systems on crude protein content and other ancillary observations of maize and cowpea (Mean of 1999 to 2000).

Treatment	Av. crude protein (%)		Av. plant height (cm)		Av. No. of plants/m. row	
	maize	cowpea	maize	cowpea	maize	cowpea
Sole Maize	5.10	--	218.2	--	9.0	--
Sole Cowpea	--	16.30	--	121.5	--	12.0
Maize + Cowpea (1:1)	6.50	14.53	200.0	158.5	7.2	9.9
Maize + Cowpea (1:2)	6.22	18.40	205.7	151.8	6.3	9.6
Maize + Cowpea (2:1)	5.13	18.56	207.0	165.8	8.3	10.5
Maize + Cowpea (3:1)	5.63	17.26	226.8	164.0	9.2	10.6
Maize + Cowpea (1:3)	6.94	15.32	187.5	143.8	6.5	11.1
Maize + Cowpea (1:4)	6.06	16.81	188.0	147.0	6.5	8.7
Maize + Cowpea (4:1)	6.18	13.85	229.3	167.0	9.2	9.9
Maize + Cowpea (2:3)	6.13	14.86	207.2	174.8	8.3	9.2
Maize + Cowpea (3:3)	6.05	17.29	213.7	175.2	7.6	8.7
Mixed in same	5.53	13.26	211.8	171.5	4.6	6.9

On an average, maize + cowpea (4:1) recorded the highest green forage yield (544 q/ha) and it was 17.24 and 45.07 per cent higher over yield of sole maize and sole cowpea, respectively. The maize + cowpea sown mixed in same row recorded the highest dry matter yield (79.6 q/ha) on average of two years and the increase was 14.86 and 43.94 per cent over yield of sole maize and sole cowpea, respectively. Barik and Tiwari (1996) and Patel and Rajagopal (2001) also noted superiority of intercropping of maize + cowpea over sole cropping, while Krishna *et al.* (1998) reported superiority of mixed cropping of maize + cowpea sown at 30 cm row spacing over maize alone in forage yields. The increase in forage yield in the intercropping and mixed cropping systems might be due to the nutrient sparing effect of leguminous fodder crop. The atmospheric nitrogen fixed in the cowpea import nitrogen enrichment to maize grown in combination, increasing the forage yield. The results support the observations of Gill and Verma (1993).

Crude protein yield

Crude protein yield was significantly affected by different treatments during both the years (Table 1). Maize + Cowpea in 1:2 row ratio produced the highest crude protein yield during 1999 (13.00 q/ha) and on mean basis (10.08 q/ha), while mixed cropping of maize and cowpea in same row recorded maximum crude protein yield (7.43 q/ha) during 2000.

Sole crop of maize gave the lowest crude protein yields and it was significantly inferior than all the other treatments during both the years. Higher crude protein yield under mixed or intercropping was due to inclusion of cowpea crop with maize. Similar results were reported by Rao *et al.* (1976) and Tiwari *et al.* (1978).

Economics

The net return was maximum in mixed cropping of maize and cowpea in same row during 2000 and in average of two years. The net returns obtained from sole crop (maize or cowpea) was lower than all the other maize + cowpea cropping systems grown for fodder purpose in average of two years (Table 1). The results support those of Patel and Rajagopal (2001).

Yield attributes

The crude protein content estimated at harvest showed that being a cereal forage crop, maize recorded lower crude protein content than cowpea (Table 2). The average crude protein content in maize ranged from 5.10 per cent in maize alone to 6.94 per cent in maize + cowpea in row ratio 1:3, while in cowpea, it varies from 13.26 per cent in mixed sowing in same row to 18.56 % in the treatment of maize + cowpea (2:1). Krishna *et al.* (1998) also reported that intercropping of maize and cowpea increased crude protein content in both the crops.

Maize grown under maize + cowpea line ratio of 4:1 recorded the tallest plants (229.3 cm), while cowpea grown as sole crop recorded the lowest plant height of 121.5 cm among the treatments.

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Studies on the efficacy of composts and chemical fertilizers in sunflower (*Helianthus annuus* L.) production and soil NPK status

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Abstract

Compost produced from the mixture of one part crop residue and one part poultry waste on weight basis has the highest N, P_2O_5 and K_2O content (3.50, 4.94 and 2.10 per cent respectively) with the lowest carbon to nitrogen ratio (5.6 : 1). Application of this compost at 3 t ha^{-1} significantly improved the growth and yield parameters, chlorophyll (a, b and total) content, seed and oil yield of sunflower over other types of compost. The benefit-cost ratio (1.72 : 1), the NPK uptake by the crop and soil available NPK status was also improved with use of the compost prepared with 1:1 ratio of crop residue and poultry waste. Recommended fertilizer use ($60 : 75 : 60\text{ kg N} : P_2O_5 : K_2O/\text{ha}$) established its superiority over the 75 and 50 per cent in respect of growth in height, dry matter production, yield parameters, yield and NPK uptake by the crop and soil NPK status. The benefit-cost ratio was 1.98: 1 with recommended NPK.

Key words: Crop residues, poultry waste, compost, soil fertility status

Introduction

India has large potential (185.3 mt) of crop residues and poultry wastes. The poultry industry is growing at the rate of 5 to 20 per cent per annum. The nutrient potential of crop residues is estimated at 3.32 mt (Bharadwaj and Gaur, 1985). But the temporal and spatial nonavailability of the nutrients of crop residues, phytotoxic effects of undecomposed poultry waste inspite of its high nutrient value are the inherent drawbacks for direct use in crop production. Sustained crop production is possible through the integrated use of quality organics in conjunction with chemical fertilizer. Hence the experiment was conducted to produce compost of improved nutrient value from crop

and poultry wastes and to study its efficacy on growth and productivity of sunflower and soil fertility status.

Material and methods

Four types of composts using crop residues and poultry waste at 4:1 (P_2), 2:1 (P_3), 4:3 (P_4) and 1:1 (P_4) were prepared. Residues of finger millet and maize and poultry waste (faeces and litter) were filled in alternate layers in the vats. Phosphorus solubilizers viz., *Aspergillus awamorii* and *Bacillus megaterium* were sprinkled along with dung slurry. The materials were turned for aeration at 20 days interval. Moisture content of the material was maintained at 50-60 per cent. The compost was ready in 90 days. They were analyzed for NPK and carbon content.

The field experiment was conducted at Gandhi Krishi Vignana Kendra Farm, Bangalore in red sandy clay loam grouped under *Kandic paleustalfs* during the rainy season of 1999. Soils are slightly acidic (pH 6.0), low in available N (186 kg ha^{-1}), medium in P_2O_5 (38 kg ha^{-1}) and K_2O (209 kg ha^{-1}). The treatments comprised of 4 types of composts (P_1 , P_2 , P_3 and P_4) and 4 fertility levels (0, 50, 75 and 100 per cent recommended fertilizers of $60:75:60\text{ kg N} : P_2O_5 : K_2O$ per ha respectively) laid out in factorial randomized block design replicated thrice. The net plot size was $3.9\text{ m} \times 3.6\text{ m}$. Composts were added at 3 t ha^{-1} . Fifty percent of N as per the treatments and complete dose of P and K were applied before sowing in seed rows. The seeds were sown on 1st August 1999. Remaining N as per the treatments was top dressed at 30th day of sowing. Leaf area index (LAI) and leaf area duration (LAD) were determined (Power *et al.* 1967). Leaf chlorophyll content was estimated at 60th day of sowing (Arnon, 1949). Seed oil content was estimated by nuclear magnetic resonance (NMR) spectrometer. Nutrient uptake by the crop and soil NPK status were analyzed (Piper, 1966). Benefit-cost ratio was worked out using the prevailing prices of inputs and the produce.

Results and discussion

Nutrient value of the composts

The N, P_2O_5 and K_2O content of the compost produced from decomposition of one part of residue (P_4) was the highest (3.5, 4.94 and 2.10 per cent) with least C:N (5.6 : 1) which was followed by P_3 (3.36, 4.83 and 2.06 per cent) and P_2 (3.08, 3.59 and 1.76 per cent). The higher nutrient content of P_4 compost may be attributed to higher quantity of poultry waste used. In P_1 compost the quantity of the poultry waste used was 25 per cent as a consequence the nutrient content was 2.80, 1.78 and 1.57 per cent with highest C:N ratio (10.3 : 1).

Effect of type of composts

Dry matter production per plant and its distribution into leaves and capitulum was significantly higher with the use of compost of 1:1 proportion of crop residue and poultry waste (P_4) over 4:1 (P_1) compost. The plant height was highest with P_4 followed by P_3 , P_2 and P_1 . However the values did not differ significantly. Improvement in dry matter production and its accumulation in different parts of the plant may be attributed to the improvement in leaf area index and total leaf area duration, which reflected the trend of dry matter production. The chlorophyll a, b and the total chlorophyll content of the leaves at 60 DAS was significantly higher with P_4 as compared to P_1 while P_3 and P_2 were intermediate. Higher chlorophyll

Table 1. Growth parameters and chlorophyll content of sunflower as influenced by types of composts and fertilizer levels

Treatment	Plant height (cm)	LAI	Total LAD (d)	Dry matter distribution (g/pl.)			Total DM (g/pl.)	Chlorophyll at 60 DAS (mg/g FL.)		
				Leaves	Stem	Capitulum		a	b	Total
Composts										
P ₁	146	1.59	68.93	9.9	37.0	40.5	87.4	0.80	0.59	1.57
P ₂	150	1.81	77.43	11.3	39.4	43.9	94.6	0.86	0.69	1.72
P ₃	152	1.91	81.41	12.2	40.5	47.1	99.8	0.92	0.77	1.92
P ₄	155	1.97	85.93	13.2	42.4	50.4	106.0	0.99	0.83	1.99
CD at 5%	NS	0.26	8.59	2.2	NS	7.1	10.4	0.12	0.14	0.26
% RFD										
0	203	1.21	52.99	6.3	28.8	26.6	61.7	0.80	0.56	1.56
50	156	1.71	74.32	10.6	37.8	39.9	88.3	0.89	0.69	1.77
75	167	2.02	91.11	13.1	45.8	52.0	110.9	0.91	0.78	1.88
100	178	2.33	105.55	16.7	51.8	63.4	131.9	0.97	0.84	2.03
CD at 5%	13.3	0.26	8.59	2.2	5.8	7.1	10.4	0.12	0.14	0.26

P_1 , P_2 , P_3 and P_4 are the composts of crop residues and poultry waste in 4:1, 2:1, 4:3 AND 1:1 Proportions respectively. RFD-60, 75 and 60 kg N, P_2O_5 and K_2O ha⁻¹ respectively.

Table 2. Effect of types of composts and fertilizer levels on yield parameters and yield of sunflower

Treatment	Days to 50 % flowering	Diameter of capitulum (cm)	Filled seeds per capitulum	Chaffiness (%)	1000 seed Wt. (g)	Seed yield (Kg/ha)	Seed oil content (%)	Oil yield (Kg/ha)	Harvest index	B.C
Composts										
P_1	62.3	11.6	517	21.0	38.62	1027	41.72	440	0.41	1.57
P_2	62.1	11.9	546	19.1	39.70	1072	42.14	454	0.41	1.62
P_3	61.8	12.3	565	18.4	40.40	1115	42.32	471	0.41	1.68
P_4	61.5	12.5	593	16.9	41.14	1155	42.52	490	0.42	1.72
CD at 5%	NS	NS	37	2.8	1.82	85	NS	35	NS	
% RFD										
0	63.3	8.3	321	31.3	32.56	644	40.96	263	0.40	1.21
50	62.4	11.5	491	22.3	34.85	981	41.51	408	0.41	1.54
75	62.0	13.1	632	13.8	34.46	1283	42.78	549	0.42	1.86
100	60.0	15.4	778	8.0	48.01	1462	43.45	636	0.42	1.98
CD at 5%	1.64	2.1	37	2.8	1.82	85	1.46	35	0.01	

Table 3. Nutrient uptake by sunflower and residual nutrient status (kg/ha) in soil as influenced by types of composts and fertilizer levels

Treatment	Nutrient uptake						Residual NPK		
	Nitrogen (kg/ha)		Phosphorus		Potassium		N	P ₂ O ₅	K ₂ O
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest			
Composts									
P ₁	21.1	88.6	3.3	12.6	19.1	79.9	149	30	170
P ₂	22.9	90.9	3.8	13.6	20.3	83.4	159	31	174
P ₃	25.1	94.7	4.1	14.0	21.2	86.4	163	33	183
P ₄	27.8	99.6	4.3	14.7	22.8	90.9	164	37	184
CD at 5%	2.9	7.9	0.4	1.4	2.4	6.8	6.4	3.9	NS
% RFD									
0	15.8	59.6	2.6	8.8	13.8	55.1	144	26	171
50	21.7	83.8	3.5	12.7	18.8	76.5	152	30	175
75	27.6	107.8	4.3	15.4	23.7	97.4	164	34	179
100	31.8	122.4	5.1	17.8	27.0	111.7	176	40	184
CD at 5%	2.9	7.9	0.4	1.4	2.4	6.8	6.4	3.9	NS

content, more leaf area index and total leaf area duration may be the possible reason for better growth in dry matter and plant height Maskina *et al.* (1985) and Madhavi *et al.* (1995) found improvement in the growth of rice and maize respectively with the addition of poultry manure.

Improved growth with the use of P₄ type of compost was manifested in production of increased test weight, reduction in chaffs from 21.01 to 16.93 per cent resulting in increase of filled seeds was the manifestation of growth with the use of P₄ compost. However, it was at par with P₃. The seed yield was significantly superior with P₄ over P₁ but was at par with P₃ and P₂. The superiority of the growth parameters may be the cause for higher yields in these treatments. Singh *et al.* (1997), Talshilkar *et al.* (1997) and Ramesh *et al.* (1998) reported increase in seed yield with the application of poultry manure in sesamum, groundnut and soybean respectively. There was an increase of 50 kg oil yield per ha with P₄ compost over P₁. This was related to the higher seed yield per ha. Treatment differences of days to 50 per cent flowering, seed oil content, harvest index were not significant. The return per rupee spent was greater with the use of P₄ compost (1.72).

Uptake of NPK was significantly higher both at 45 and at harvest with P₄ compost and was in the order of P₄ > P₃ > P₂ > P₁. The residual NPK status of the soil followed the order of nutrient uptake. This was attributed to higher content of NPK in P₄ followed by P₃, P₂ and P₁.

Effect of levels of fertilizers

Plant height, total dry matter production and its distribution were significantly improved with the use of 100 per cent recommended fertilizer dose (RFD) which was on par with 75 per cent RFD. Distribution of dry matter into stem, leaves and capitulum was significantly more with 100 per cent RFD. The order of dry matter distribution was capitulum (46.2%) > stem (41.9%) > leaves (11.9%). It was least in control. Improvement in growth of dry matter and plant height may be attributed to increase in leaf area index, leaf area duration and amount of chlorophyll a and b, and total chlorophyll. Leaf area index and leaf area duration was maximum with the use of 100 per cent RFD while application of less than recommended level of fertilizers reduced, LAI, LAD and chlorophyll content. This might have caused reduction in crop growth. The size of the capitulum increased with increase in fertilizer levels. It was larger with 100 per cent RFD as compared to lower levels of RFD. More number of filled seeds per capitulum, seed weight and reduction in chaffs were noticed with 100 per cent RFD. This caused significant increase in seed yield (1462kg/ ha.) with 100 per cent RFD over control (644kg/ ha.). Greater partitioning of dry matter into seed (42%) in this treatment also supports for higher yield. Oil yield increased by 142 per cent with 100 per cent RFD over no fertilizer application. This was caused by higher oil content of seeds as well as seed yield, which were significantly superior at higher level of RFD. The benefit to cost ratio was also more (1.98) with 100 per cent RFD.

Uptake of NPK by the crop both at 45 DAS and at harvest and residual NPK in soil were significantly higher with 100 per cent RFD. It confirms the application of 100 per cent RFD for higher seed yield and nutrient uptake. However N and K status of the soil declined from the initial values of 186 and 209 kg per ha. to 176 and 184 kg per ha., respectively. The P content of the soil did not change significantly from the initial value of 38 kg per ha. This may be attributed to lower crop uptake. There was greater depletion of available NPK in the unfertilized treatment.

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Effect of row spacing and fertilizer doses on growth and yield attributing characters of Cowpea [*Vigna unguiculata* (L.) Walp.] under rainfed conditions

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Abstract

A field experiment was carried out during *kharif* season of 2000 to 2002 on loamy sand soils of Sardarkrushinagar to find out the optimum dose of fertilizer and row spacing for higher productivity of cowpea variety GC-4 under rainfed conditions. Results revealed that the row spacing had no significant effect on seed and straw yields although 45 cm row spacing gave higher seed yield. Application of 25 N + 50 P₂O₅ kg/ha gave significantly the highest seed (1204 kg/ha) and straw (1863 kg/ha) yields being at par with 20 N + 40 P₂O₅ kg/ha.

Key words : Row spacing, yield attributing characters

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important pulse crop grown in Gujarat under rainfed condition both for its grain and vegetable purpose. This crop seldom receives manuring and hence the yield level is low. It contains 24.6% protein in seed and plays an important role in maintaining soil fertility. Increase in yield of cowpea with application of nitrogenous fertilizer has been reported by Rao and Patel (1975). Cowpea being a legume, fixed atmospheric nitrogen and improves the soil fertility. Phosphorus fertilization in legumes is of great importance, as it affects the nodulation, growth and yield (Thakuria and Khan, 1991). Row spacing is a non-monetary input and optimum plant spacing is of considerable importance for newly released variety Gujarat Cowpea - 4. Keeping this in view, the present study was carried out to study the effect of row spacing and fertilizer doses on growth and yield of cowpea under rainfed conditions in North Gujarat Agro-climatic region.

Material and methods

The field experiment was conducted during *kharif* from 2000 to 2002 at Main Pulses Research Station, Gujarat Agricultural University, Sardarkrushinagar on sandy loam soil having 0.29% organic carbon, 42 kg/ha available phosphorus, 291 kg/ha available potassium and 7.1 pH. Treatments included three row spacings (30, 45 and 60 cm) as main plot and four doses of fertilizers (15 N + 30 P₂O₅, 20 N + 40 P₂O₅ and 25 N + 50 P₂O₅ kg/ha and control) as sub-plots in a split plot design with four replications. All the requisite quantity of N and P were applied as basal on 17th, 5th and 1st July in 2000, 2001 and 2002 at the time of sowing, respectively. Newly released cowpea variety Gujarat Cowpea - 4 was used in the study. A common seed rate of 20 kg/ha was used. The rainfall was received during crop season was 398.6 mm in 13 rainy days during 2000, 570.7 mm in 30 rainy days during 2001 and 206.5 mm in 16 rainy days during 2002. Other agronomic practices were carried out as and when required as per recommendation.

Results and discussion

In general, the seed and straw yields of cowpea in 2001 remained higher than that observed in 2000 and 2002 because of higher and well distributed rainfall during 2001.

Effect of row spacing

The row spacing had no significant effect on the seed yield during 2000 and 2001 as well as in pooled, while it was significant only during 2002 (Table 1). Significantly higher seed yield was recorded with 45 cm row spacing than 30 and 60 cm row spacing during 2002. However, on the basis of pooled data, crop sown at 45 cm row spacing recorded higher seed yield than that of 30 and 60 cm row spacings, where number of pods per plant and seeds per pod increased significantly. However, the increase in pods per plant

and seeds per pod could not increase the seed yields. 100-seed weight was not affected significantly. The yield contributing characters increased with increased row spacing was attained from 30 to 60 cm. Increased values of growth and yield attributing characters under 60 cm row spacing due to lower competition among plants for moisture, nutrient and sunlight. The results were in conformity with those of Jain *et al.* (1984) and Rajesh Kumar *et al.* (1997).

Straw yield was not affected significantly by different row spacings during all individual as well as in pooled analysis (Table 1). Similar trend was observed with respect to plant height in pooled data. Significantly the highest number of branches per plant was recorded with 60 cm row spacing followed by 45 and 30 cm row spacing.

Effect of fertilizer doses

The effect of different doses of fertilizer on seed yield was significant during individual year as well as in the pooled data. Application of fertilizer doses increased the seed yield and yield attributing characters of cowpea. The seed yield increased significantly with increasing fertilizer doses upto 20 N + 40 P₂O₅ kg/ha

during individual years as well as in pooled. However, seed yield recorded with application of 20 N + 40 P₂O₅ kg/ha and 25 N + 50 P₂O₅ kg/ha remained at par (Table 1). Similar trend was observed in yield attributing characters, viz., pods per plant, seeds per pod, 100-seed weight and number of branches per plant (Table 2). The application of 20 N + 40 P₂O₅ kg/ha increased the seed yield by 18.0 and 7.0 per cent, respectively over control and 15 N + 30 P₂O₅ kg/ha on the basis of pooled analysis. The increase in seed yield was clearly reflected in terms of increasing values of yield attributing characters like number of pods per plant, seeds per pod, 100-seed weight and number of branches per plant by application of fertilizer doses. The results were in conformity with those of Mohan Kumar and Pillai (1979) and Jain *et al.* (1984).

During individual year, straw yield of cowpea was not significantly affected by different doses of fertilizer but was significant in pooled data. The role of fertilization on promotion of vegetative growth is well established. A perusal of the data on number of branches per plant and plant height indicated significant improvement of these growth attributes due to addition of fertilizers. The excessive vegetative

Table 1. Effect of different row spacings and fertilization on seed and straw yields, growth and yield attributing characters of cowpea

Treatments	Seed yield (kg/ha)				Straw yield (kg/ha)				No. of pods per plant	Seeds per pod	100-seed weight (g)	No., of branches per plant	Plant height (cm)
	2000	2001	2002	Pooled	2000	2001	2002	Pooled					
Row spacing													
30 cm	1013	1746	475	1078	1395	2528	1462	1795	9.0	10.5	13.85	2.2	61.5
45 cm	1007	1879	561	1149	1349	2344	1395	1696	10.7	10.7	14.40	2.7	62.7
60 cm	1022	1810	509	1113	1433	2162	1283	1626	11.8	11.2	14.89	3.0	63.0
S. Em. ±	37	63	16	25	40	122	73	49	0.4	0.1	0.21	0.1	0.7
C.D. at 5%	NS	NS	55	NS	NS	NS	NS	NS	1.2	0.4	NS	0.2	NS
CV %	14.6	13.8	13.3	15.4	11.5	20.8	21.0	19.9	26.7	9.0	4.6	20.4	7.8
Fertilizer doses													
15N+30P ₂ O ₅ kg/ha	1009	1776	500	1095	1379	2291	1311	1160	10.1	10.5	14.16	2.5	62.0
20N+40P ₂ O ₅ kg/ha	1027	1901	573	1167	1395	2439	1477	1770	11.3	11.0	14.75	2.7	63.3
25N+50P ₂ O ₅ kg/ha	1085	1960	569	1204	1451	2541	1598	1863	11.6	11.2	15.04	3.0	64.6
Control	936	1609	419	988	1345	2108	1135	1529	9.0	10.5	13.55	2.2	59.7
S. Em±	31	58	19	23	39	141	56	35	0.4	0.1	0.16	0.1	0.6
C.D. at 5%	91	169	55	65	NS	NS	NS	99	1.1	0.4	0.55	0.4	2.0
CV%	10.7	11.1	12.8	12.4	9.6	12.0	14.0	12.4	21.8	7.8	2.8	16.8	4.9
Interaction													
S. Emi	55	101	33	40	67	141	97	61	0.7	0.2	0.12	0.13	0.9
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

growth even at the expense of seed production would have resulted in higher yield of straw. Interaction effect between row spacing and fertilizer doses was not significant in any of the years.

It can be concluded that cowpea variety GC-4 should be sown at 45 cm row spacing and fertilized with 20 N + 40 P₂O₅ kg/ha to obtain higher seed and straw yields under rainfed conditions of North Gujarat.

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Feasibility and economics of cotton (*Gossypium hirsutum* L.) based cropping systems

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Abstract

A field experiment was conducted during *kharif-rabi* seasons of 1996-97 to 1998-99 to study the feasibility and economics of cotton based cropping systems under different sowing dates. Results revealed that advanced sowing of cotton on 15th May or 30th May increased the seed cotton yield under irrigated conditions. Cotton crop sown on 15th May followed by cabbage in *rabi* was proved to be the most suitable cropping system for getting higher yields and monetary returns (Rs. 85,644/ha) and next *kharif* was the cotton sown on 30th May or 15th May followed by onion in *rabi* season. The cotton sown on 30th June followed by wheat in *rabi* season registered the minimum net return of Rs. 6,574/ha.

Key words: Feasibility, Economics, Cotton based cropping System.

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important *kharif* season crops grown in Gujarat. With the advent of short duration cotton varieties, double cropping has become a popular practice among the farmers. Although wheat remains the major crop in *rabi* season, the productivity and monetary return can be increased through the highly remunerative vegetable crops like onion, potato and cabbage in this system.

If cotton crop is grown before onset of monsoon with some adjustment in sowing time, it could avail full benefit of monsoon rain and also can provide a scope for cultivation of *rabi* crops. As the land holdings of the farmers are very small, there is a need to evolve a suitable and more profitable cotton based cropping system which may increase productivity per unit area and per unit time. Hence, the present study was carried out to study the production potential and

economics of cotton based crop sequences under different sowing dates in middle Gujarat condition.

Materials and Methods

The field trial was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand from 1996-97 to 1998-99 on sandy loam soil under irrigated condition. The soil of the experimental site was low in total nitrogen (0.036 %) and medium in available phosphorus (39.5 kg/ha) and potassium (260.6 kg/ha) having pH 7.7. The experiment was laid out in split plot design with 4 replications, keeping the layout undisturbed throughout the course of investigation. Sixteen treatments comprised of the combinations of four sowing dates of cotton viz., 15th May, 30th May, 15th June and 30th June with four *rabi* crops viz., cabbage, onion, potato and wheat grown after harvesting of cotton crop. Cotton was grown in main plots using four sowing dates in *kharif* season, while four *rabi* crops were raised as sub-plots. The plot size was 6.0m x 4.5 m. Cotton hybrid-8 was dibbled at 90 x 60 cm spacing using seed rate of 4.0 kg/ha in *Kharif* season. The seedlings of cabbage variety Pride of India and onion variety Pusa Red were transplanted at a spacing of 45 x 30 cm and 15x10 cm, respectively, while potato variety Kufri Badshah was sown at 45 x 15 cm with seed rate of 3000 kg/ha and Wheat variety GW 503 was sown at 22.5 cm row spacing by using seed rate of 120 kg/ha during *rabi* season. The recommended dose of N, P₂O₅ and K₂O, kg/ha applied to cotton, cabbage, onion, potato and wheat were 320:0:0, 75:37.5:37.5, 75:25:75, 220:110:220 and 120:60:0, respectively. Irrigations were applied as per requirements, while weeds were controlled by hand weeding and interculturing operations. Other management practices were adopted as per recommendations of the crops. The prevailing market price of various crop produce and inputs used were considered to work out the cotton equivalent yield and economics of different systems.

Results and discussion

Seed cotton yield

A perusal of data given in Table 1 reveal that dates of sowing had significant effect on seed cotton yield during all the three years as well as pooled analysis. The sowing of cotton crop on 15th May or 30th May were found at par and produced significantly higher seed cotton yield (1496 and 1363 kg/ha, respectively) over 15th and 30 June dates of sowing. The higher yield in early dates of sowing may be attributed to favourable climatic conditions and better utilization of rain water resulting into increased growth and development by early sown crop. The highest values of growth and yield attributes viz., plant height, no. of bolls/plant and boll weight were recorded by the cotton crop sown on 15th May and it was significantly superior in Plant height during 1996-97 and 1997-98 (129.4 and 119.3, respectively) and significantly increased no. of bolls/ plant (29.1) and boll weight

(4.36 g) during 1997-98 than other sowing dates except sowing on 30th May. The advantage of early sowing of cotton was also reported by Singh (1979), Dhoble *et al.* (1987) and Dhoble *et al.* (1990). The lowest seed cotton yield from 30th June sown crop may be due to reduced vegetative and reproductive growth periods. Sharma *et al.* 1992 also reported similar findings in cotton.

The results (Table 1) showed that cotton crop grown after potato registered maximum seed cotton yield during 1996-97, 1997-98 and in pooled results. However, the differences due to *rabi* crops were not found significant during 1996-97, 1998-99 and in pooled analysis. During 1997-98, cotton crop sown after potato produced significantly higher seed cotton yield (1341 kg/ha) than cotton crop grown after wheat. Growth and yield attributes were also not affected significantly due to different *rabi* crops except boll weight during 1997-98.

Table 1. Growth, yield attributes and yield of cotton as influenced by sowing dates and subsequent *rabi* crops

Treatment	Plant height (cm)		No. of bolls/plant		Boll weight (g)		Seed cotton yield (kg/ha)			
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1998-99	Pooled
<i>Sowing dates</i>										
15 th May	129.4	119.3	39.3	29.1	4.72	4.36	1677	1485	1328	1496
30 th May	125.8	112.6	36.1	27.5	4.60	4.23	1521	1347	1221	1363
15 th June	105.1	107.1	33.0	24.2	4.21	4.05	1117	1179	1041	1112
30 th June	79.8	102.4	33.0	21.6	3.97	3.81	808	989	868	888
CD at 5 %	15.4	10.5	NS	3.6	NS	0.21	314	249	207	145
<i>Rabi crops</i>										
Cabbage	112.9	109.4	37.0	25.1	4.42	4.12	1325	1253	1152	1243
Onion	106.9	112.0	35.1	26.4	4.38	4.28	1242	1324	1171	1246
Potato	112.4	112.1	34.4	26.4	4.44	4.26	1336	1341	1152	1276
Wheat	107.8	107.9	34.8	24.5	4.26	3.79	1219	1082	983	1095
CD at 5%	NS	NS	NS	NS	NS	0.15	NS	192	NS	NS

Rabi crop yield

It is evident from the data presented in Table 2 that early sowing of *rabi* crops under advanced sowing of cotton had beneficial effects on *rabi* crop yields. It was found that transplanting of cabbage and sowing of potato after 15th May sown cotton recorded higher yields of cabbage (46730 kg/ha) and potato tuber (23722 kg/ha) than later sowing dates. The

highest bulb yield of onion (30256 kg/ha) was recorded when it was sown after 30th May sown cotton followed by onion grown after 15th May sown cotton. Likewise, wheat sown after 30th May sown cotton gave the highest grain yield (4975 kg/ha). All the *rabi* crops registered the lowest yields under late sown conditions, when they were grown after 30th June sown cotton (Table 2). Similar results were observed by Tomar and Tiwari (1990) and Maliwal *et al.* (1999).

Seed cotton equivalent yield

It was found that there was a significant variation in seed cotton equivalent yield during 1996-97, 1997-98 and in pooled analysis (Table 2). Early sowing of cotton on 15th May followed by cabbage in *rabi* season recorded the highest seed cotton equivalent yield during 1996-97 and in pooled analysis (7704 and 6177 kg/ha, respectively). The said treatment of cotton sown on 15th May followed by cabbage in *rabi* season was significantly superior than all the other treatments during 1996-97, however it was at par with the treatments of cotton sown on 30th May followed by onion in *rabi* and cotton sown on 15th May followed by onion in *rabi* in pooled results. Such advantage of early sowing was also reported by Dhoble *et al.* (1987). Significantly the lowest seed cotton equivalent yield was recorded under the treatment of cotton crop sown on 30th June followed by wheat grown in *rabi* season. Thus cropping systems involving vegetable crops like cabbage or onion gave higher total yields and gave higher seed cotton equivalent yield than cropping system with wheat. Similar results were also reported by Chaudhary *et al.* (2000).

Economics

Among different cropping systems, cotton sown on 15th May followed by cabbage grown in *rabi* season

was the most beneficial and recorded maximum net return of Rs. 85644 ha⁻¹ followed by the cropping systems of cotton sown on 30th May with onion in *rabi* and cotton sown on 15th May with onion in *rabi* season (Table 3). Cotton sown on 15th May followed by cabbage grown in *rabi* season also gave the highest benefit: cost ratio (2.21). Higher values of net return and benefit: cost ratio from these cropping systems were due to the higher yield realized from cotton crop and higher seed cotton equivalent yield. The cotton sown on 30th June followed by wheat in *rabi* season recorded the lowest net returns (Rs. 1254 ha⁻¹) and minimum values of benefit: cost ratio (0.05). Dhoble *et al.* (1990) showed that cotton crop was not suitable for late sowing due to heavy reduction in the monetary returns, while Chaudhary *et al.* (2000) showed that inclusion of vegetables in maize-based crop sequences gave higher net return than cereal-cereal sequences.

The study indicated that 15th May to 30th May is the optimum sowing time for cotton crop grown under irrigated conditions of Middle Gujarat. Cotton crop sown on 15th May followed by cabbage or onion crops in *rabi* season are the most suitable cropping systems for getting higher yields and monetary returns in cotton based cropping system.

Table 2. Seed cotton yield, *rabi* crop yield and seed cotton equivalent yield as influenced by sowing dates and subsequent *rabi* crops

Cropping system	Yield (kg/ha)* Seed cotton equivalent yield (kg/ha)					
	Seed cotton	<i>Rabi</i> crop	1996-97	1997-98	1998-99	Pooled
15 th May -Cabbage	1554	46730	7704	6437	4391	6177
15 th May -Onion	1543	27777	5580	7078	4475	5711
15 th May -Potato	1551	23722	4774	5559	4678	5004
15 th May -Wheat	1336	4230	3012	2656	2414	2694
30 th May -Cabbage	1318	37615	6295	4868	3424	4864
30 th May -Onion	1411	30257	6018	7352	4478	5949
30 th May -Potato	1437	22260	4838	5158	4333	4776
30 th May -Wheat	1284	4975	2929	2964	2790	2894
15 th June -Cabbage	1156	40447	6044	5269	4297	5203
15 th June -Onion	1017	26616	4565	6311	4153	5009
15 th June -Potato	1210	14029	3743	2824	3378	3315
15 th June -Wheat	1065	3449	2294	2185	2090	2186
30 th June -Cabbage	943	21197	3129	3150	2912	3064
30 th June -Onion	1010	13831	2499	3956	2787	3080
30 th June -Potato	905	12023	2502	2756	2860	2709
30 th June -Wheat	692	2156	1286	1271	1194	1250
CD at 5 %	--	--	655	907	NS	680

* Mean data of three years

Table 3. Economics as influenced by sowing dates and subsequent *rabi* crops
(Mean of 1996-97 to 1998-99)

Cropping system	Cost of cultivation (Rs. / ha)			Net return (Rs. / ha)			Benefit cost ratio
	Seed cotton	Rabi crop	Total	Seed cotton	Rabi crop	Total	
15 th May -Cabbage	19000	19800	38800	12080	73564	85644	2.21
15 th May -Onion	19000	21800	40800	11860	60811	72611	1.78
15 th May -Potato	19000	30000	49000	12020	41166	53186	1.09
15 th May -Wheat	19000	12600	31600	7720	14895	22615	0.72
30 th May -Cabbage	19000	19800	38800	7360	55432	62792	1.62
30 th May -Onion	19000	21800	40800	9220	68971	78191	1.92
30 th May -Potato	19000	30000	49000	9740	36783	46493	0.95
30 th May -Wheat	19000	12600	31600	6680	19737	26417	0.84
15 th June -Cabbage	17000	17800	34800	6120	63098	69218	1.99
15 th June -Onion	17000	19800	36800	3340	60048	63388	1.72
15 th June -Potato	17000	28300	45300	7200	13787	20987	0.46
15 th June -Wheat	17000	10600	27600	4300	11818	16118	0.58
30 th June -Cabbage	16500	17000	33500	2360	25394	27754	0.83
30 th June -Onion	16500	19400	35900	3700	21991	25691	0.72
30 th June -Potato	16500	27500	44000	1600	8569	10169	0.23
30 th June -Wheat	16500	10100	26600	-2660	3914	1254	0.05

Selling price (Rs./kg) :Cotton-Rs.20.00, Cabbage-Rs.2.00, Onion-Rs.3.00, Potato-Rs.3.00
and Wheat- Rs. 6.50

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Characterization and classification of cultivated salt affected soils of north-west agroclimatic zone of Gujarat

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Abstract

The dominance of Ca^{2+} 16.05 (cmol (P^+) / kg) and Mg^{2+} 8.12 (cmol (P^+)/kg) among the exchangeable cations, while Na^+ (11.8 me/l) and Cl^- (10.7 me/l) among the water soluble ions were found in soils of North-West agroclimatic arid zone of Gujarat. The soils of zone are poor in organic carbon (range 0.053 to 0.86, mean 0.312 per cent) alkaline in reaction (pH mean 8.03) and calcareous in nature (CaCO_3 range 0.3 to 25.0 per cent).

The results further showed that half (49.7 %) of the cultivated soils of this zone are having salinity problem, followed by saline-sodic (31.2%) and sodic (19.1%) problem. The problem of salinity is acute in Lakhpat, Rapar, Nakhtrana, Bhachau and Anjar talukas of Kutch district and Vav, Tharad and Santalpur talukas of Banaskantha district. On other hand, the soils of Mandvi, Halwad, Dasada, Harij, Deodar and Kankrej talukas have twin problems of salinity as well as sodicity.

Key words : Characterization, salt affected soils, North-West zone of Gujarat.

Introduction

In India about 10.0 million ha. and in Gujarat about 1.2 million ha. of land are estimated to be affected by the problems of soil salinity and alkalinity (Bhargava, 1989), which is spread on coastal and inland areas of Gujarat. The North - West agro climatic arid zone have severe salinity/ sodicity problem (0.575 million ha.) restricting agricultural production.

Better crop production can be had if the nature and extent of salinity problems are diagnosed and managed appropriately. The characterization of this potential resource has not been done and map showing occurrence of saline, sodic and saline-sodic soils is not available for this zone. Hence the present study was taken up.

Materials and Method

The North-West agroclimatic zone is situated between 22°66' N and 24°66' N latitude and 68°60' E and 72°60' E longitude. This zone has geographic area of 35 lakh hectares, which is about 17.8 per cent of the state. This zone comprises 22 talukas of six districts which include Viramgam taluka of Ahmedabad district, Malia taluka of Rajkot district, Sami and Harij talukas of Mehsana district, Halwad, Dhrangadhra and Desada talukas of Surendranagar district ; Satalpur, Radhanpur, Kankrej, Deodar, Vav and Tharad talukas of Banaskantha district and all nine (Bhuj, Nakhtrana, Mandvi, Abdasa, Anjar, Bhachau, Mundra, Lakhpat and Rapar) talukas of Kutch district.

The climate of entire zone is arid with frequent occurrence of drought and maximum monthly average temperature 42.2° C and annual average rainfall 320 mm. The major crops in this region are pearl millet, cotton and sorghum. This zone have variety of soils. Some soils are residual, while others are resultant of the aeolian and alluvial activity, still others are hydromorphic in nature. Generally, the soils are sandy to sandy loam in texture. This zone have a vast stretch of salt affected soils (0.575 M ha). Large number of cultivated fields also have salinity/sodicity problems.

Twenty surface (0-0.30 m) soil samples from each of the 22 talukas of this zone having salinity/sodicity problems were collected from the farmers' cultivated fields. In all 440 soil samples were collected, prepared and analysed. The pH, EC and water soluble ions were estimated in 1:2.5 soil:water ratio extract methods (Jackson, 1973). For predicting EC_e from $\text{EC}_{2.5}$ extract, 75 soil samples were so selected as to cover a wide range of EC, textural class and different geographical locations in the zone, so the equation developed can be of use for the zone as a whole. These soil samples were analysed for EC and pH of saturation extract, 1:2.5 and 1:5 soil water ratio extracts. Soils were analysed for their EC, pH and exchangeable cations

as per standard methods (Richards, 1954 and Jackson, 1973). The soil organic carbon, CaCO_3 and sulphate were determined by Walkley and Black's rapid titration (Jackson, 1973), rapid titration (Piper, 1950) and turbidity method (Williams and Steinberg, 1950), respectively.

Results and discussion

Water soluble and exchangeable ions

The range and mean values (Table 1) of water soluble cations (Ca^{2+} , Mg^{2+} , Na^+ and K^+) and anions (CO_3^{2-} , HCO_3^- , Cl^- and SO_4^{2-}), show that among the cations, a higher proportion of Na^+ (mean 11.8 me/l), was observed, which was followed by Ca^{2+} (2.13 me/l), Mg^{2+} (1.36 me/l) and K^+ (0.20 me/l). In case of anions, the highest overall mean value of 10.73 me/l was noted for Cl^- and it was followed by combined values of $\text{CO}_3^{2-} + \text{HCO}_3^-$ (2.77 me/l) and SO_4^{2-} (1.64 me/l). The presence of large proportion of Na^+ in most of the area indicates that a potential danger for the development of alkali soils. The higher values of all the ions were registered with Nakhtrana taluka barring $\text{CO}_3^{2-} + \text{HCO}_3^-$ which were highest in the inland area of Viramgam taluka. These are in conformity with an earlier report of Palkhiwala and Shah (1975), Kanzaria *et al.* (1982) and Dubey and Sharma (1987).

A critical look on the overall ranges and mean values (in bracket) of exchangeable cations of 0.7 - 34.0 (16.05) of Ca^{2+} , 0.5 - 21.4 (8.12) of Mg^{2+} , 0.18 - 8.85 (3.02) of Na^+ and 0.04 - 0.99 (0.39) of K^+ cmol (P^+) / kg revealed that in the soils of Malia taluka, Ca^{2+} content (24.6 cmol (P^+) / kg) was higher as compared to that noted in the soils of other talukas. Like wise the Na^+ content in soil of Viramgam taluka having clayey soils registered the highest value of 4.47 cmol (P^+) / kg.

Soil pH, EC and ESP

The pH value of the soils varied from 7.00 to 9.00 with a mean value of 8.03 for the entire zone indicating the soils of this zone are alkaline in reaction (Table 2). The lowest pH value of 7.00 was recorded in soil samples collected from Lakhpat, Nakhtrana and Mandvi talukas of Kutch and Radhanpur talukas of Banaskantha districts. However, highest value of 9.00 was registered in soil samples of Dhrangadhra taluka of Surendranagar district. The distribution of soil samples into different pH classes (< 8.4, 8.4 - 8.8 and 8.9 - 9.4) as suggested by CSSRI, Karnal (Anon, 1974) show that 79.8 per cent of the

soil samples had pH less than 8.4. Almost all soil samples collected from Kutch (all nine talukas) and Banaskantha (all six talukas) districts were covered under this pH range. In Malia and Dasada talukas, 75 and 70 per cent samples were categorized in moderate alkali group (pH 8.4-8.8). Palkhiwala and Shah (1975) reported similar pH range in saline and alkali soils of Saurashtra region of Gujarat.

The values of $\text{EC}_{2.5}$ varied widely between 0.19 to 8.20 dS/m with mean value of 1.29 dS/m (Table 2). The lowest value of 0.19 dS/m was obtained in soils of Abdasa taluka and highest mean value of 2.36 dS/m was registered in soils of Nakhtarana taluka (Kutch). The wide variation in $\text{EC}_{2.5}$ could be due to the influence of sea water or shallow water table or poor quality of ground water (Anon., 1989) prevailing in a particular location. The distribution of EC values into five classes suggested by USDA (Richards, 1954) utilising the regression equation $\text{EC}_e = -0.723 + 5.495^{**} \times \text{EC}_{2.5}$ developed in the present study showed that 27.0 per cent samples were less than EC_e of 2.0 dS/m, another 23 per cent were of low salinity group (2.0 to 4.0 dS/m), the rest of the 50 percent samples had EC_e greater than 4.0 dS/m.

The highest ESP (Table 2) value of 33.9 was registered in Mandvi taluka (Kutch) and that of lowest value of 2.98 was obtained in Sami taluka (Mehsana). The overall ESP value ranged from 2.96 to 33.9 with a mean value of 11.7. The distribution of the samples into various ESP classes as suggested by CSSRI (Anon., 1974) that 44 per cent samples were categorised in safe group (<10 ESP) and 47 per cent into moderate group (10-20 ESP).

The clay content of the soils ranged from 1.80 to 46.25 per cent with a mean value of 13.5 for the entire zone indicating the soils of this are sandy to sandy loam in texture (Table 2). The free lime content varied from 0.3 to 25.0 per cent with a mean value of 7.0 per cent indicating the calcareous nature of soil. In most of the talukas, the average value was above 5 per cent and only few talukas it was between 3 to 5 per cent. This might be due to impregnation of lime in the transported materials and accumulation of shells in the marine alluvial soils. High content of CaCO_3 in salt affected soils of coastal area were observed by Palkhiwala and Shah (1975) and Kanzaria *et al.* (1982). The data in Table 2 showed that the soils of this zone were poor in organic carbon status having most of the mean values below the limit of 0.5 per cent. The overall range was 0.053 to 0.859 per cent with mean value of 0.312 per cent. Such low values are expected because of

Table 1. Talukawise range and mean values of content of water soluble (1:2.5) and exchangeable ions in soils.

Sr.	District and Taluka	Water Soluble ions (me/l)							Exchangeable Cations (cmol(P ⁺)/kg)			
		Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻ +HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺
1	2	3	4	5	6	7	8	9	10	11	12	13
Kutch												
1.	Bhuj	0.40-6.0	0.20-7.6	3.86-51.0	0.07-0.79	1.40-4.80	1.5-49.1	0.23-8.60	2.55-26.6	2.20-13.9	0.39-5.50	0.07-0.71
		243	208	1530	0.30	261	14.50	263	14.70	7.73	259	0.26
2.	Nakhtana	0.80-17.2	0.40-12.8	3.74-74.6	0.16-0.55	1.70-5.3	2.80-83.5	0.09-15.3	3.40-26.9	1.25-21.4	1.20-4.64	0.05-0.48
		421	303	21.70	0.35	251	22.50	363	13.10	9.57	2.15	0.33
3.	Lakhpur	0.3-12.5	0.24-5.1	2.00-44.0	0.15-0.51	1.2-2.9	1.00-50.5	0.18-8.60	0.70-29.3	0.50-17.9	0.18-2.89	0.10-0.55
		248	162	11.00	0.32	202	10.70	236	11.50	7.47	1.42	0.35
4.	Abdasa	0.30-6.5	0.20-4.3	2.00-30.5	0.05-0.21	1.3-3.8	1.00-28.5	0.09-9.10	5.85-29.9	3.95-13.5	1.25-5.39	0.18-0.99
		123	0.79	882	0.19	230	6.78	1.63	17.90	8.09	2.91	0.53
5.	Mandi	0.40-4.4	0.20-2.8	3.44-70.8	0.03-0.65	2.0-6.6	0.80-66.4	0.33-8.03	6.30-31.3	3.45-14.7	2.02-6.71	0.19-0.72
		1.50	0.94	17.00	0.21	336	13.70	231	17.30	8.79	4.45	0.48
6.	Munda	0.40-2.2	0.20-2.4	4.54-25.4	0.05-0.33	2.0-5.4	2.6-25.1	0.32-3.15	7.80-24.7	3.15-15.0	1.50-6.51	0.21-0.74
		1.03	0.74	10.80	0.21	341	7.76	1.21	18.20	9.12	3.53	0.41
7.	Anjar	0.20-6.0	0.30-16.8	27.5-26.0	0.08-0.44	1.8-4.4	1.00-28.0	0.12-6.08	2.85-30.4	3.60-17.03	0.62-8.85	0.11-0.53
		1.78	1.25	11.00	0.23	3.13	9.50	1.58	19.10	8.53	3.82	0.37
8.	Bhadrau	0.20-25.6	0.30-16.8	2.35-45.4	0.08-0.48	1.5-3.7	0.85-74.3	0.12-9.71	6.00-27.8	2.02-13.4	1.07-3.36	0.11-0.53
		341	260	10.40	0.26	232	12.00	1.77	17.70	7.68	2.29	0.30
9.	Papar	0.3-10.1	0.2-8.0	2.57-45.8	0.05-0.45	1.0-4.5	0.80-50.0	0.08-9.40	2.27-28.6	1.48-14.2	0.56-4.93	0.06-0.55
		402	292	17.10	0.24	281	17.70	3.00	11.70	6.39	1.63	0.23
	District average	0.20-25.6	0.20-16.8	2.00-74.6	0.05-0.79	1.0-6.6	0.80-74.3	0.08-15.3	0.70-31.3	0.50-21.4	0.18-8.85	0.05-0.99
		245	1.77	13.70	0.25	272	12.80	2.23	15.70	8.15	2.76	0.36
10.	Malia (Rajkot)	0.40-3.9	0.20-2.3	2.57-20.6	0.05-0.30	1.8-5.8	1.50-18.0	0.10-3.15	16.3-34.0	7.2-12.8	2.63-6.26	0.28-0.92
		1.00	0.41	4.48	0.17	2.65	3.15	0.52	24.60	9.70	4.36	0.57
Surendranagar												
11.	Halvad	0.30-6.4	0.20-3.8	2.62-40.4	0.05-0.30	2.0-7.5	0.80-36.11	0.25-4.50	10.5-23.8	4.35-11.6	2.00-6.58	0.14-0.78
		2.00	0.86	11.30	0.11	3.40	9.21	1.40	15.40	9.97	4.16	0.35
12.	Dhrangadhra	0.40-4.4	0.20-3.2	2.25-26.7	0.05-0.48	2.0-4.2	0.60-27.8	0.36-2.39	7.85-31.8	3.08-16.9	1.98-6.79	0.09-0.59
		2.03	0.99	10.60	0.17	3.04	8.88	1.70	19.30	9.99	4.06	0.28
13.	Desada	0.45-2.0	0.20-1.8	2.28-15.7	0.05-0.23	1.0-3.9	0.40-13.5	0.27-2.88	7.73-31.7	4.90-17.0	2.67-6.50	0.12-0.95
		0.91	0.51	5.44	0.11	2.45	3.59	0.86	21.60	10.70	4.36	0.48
	District average	0.30-6.4	0.20-3.8	2.25-26.7	0.05-0.48	1.0-7.5	0.40-36.1	0.25-4.50	7.73-31.8	3.08-17.0	1.98-6.39	0.09-0.95
		1.65	0.78	9.10	0.11	2.96	7.22	1.15	18.70	10.22	4.20	0.37
14.	Viamgam (Ahmedabad)	0.50-13.6	0.30-17.8	2.14-69.0	0.05-0.27	2.2-8.9	0.60-80.2	0.04-8.55	4.67-32.4	1.40-17.00	1.32-6.29	0.15-0.95
		2.61	2.20	17.20	0.13	4.02	15.80	1.84	18.80	9.00	4.47	0.47

Table 1. (Contd.)

Sr.	District and Taluka	Water Soluble ions (me/l)							Exchangeable Cations (cmol(P)/kg)			
		Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻ +HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺
1	2	3	4	5	6	7	8	9	10	11	12	13
Mehsana												
15	Sam	0.35-1.6	0.20-0.6	2.43-6.4	0.05-0.25	1.0-4.0	1.00-4.20	0.30-1.77	4.55-32.9	3.00-19.8	1.34-5.42	0.22-0.78
		0.86	0.38	4.12	0.11	2.34	2.45	0.58	20.90	10.50	3.04	0.43
16	Harj	0.50-12.4	0.20-8.4	2.72-32.8	0.05-0.45	1.0-4.4	2.00-44.5	0.15-4.63	4.52-31.3	1.24-8.9	0.88-4.09	0.29-0.94
		2.14	1.05	12.70	0.17	2.47	11.66	1.62	12.20	5.34	2.17	0.54
	District average	0.35-12.4	0.20-8.4	2.43-32.8	0.05-0.45	1.0-4.4	1.00-44.5	0.15-4.63	4.52-32.9	1.24-19.8	0.88-5.42	0.22-0.94
		1.50	0.71	8.41	0.14	2.41	7.06	1.10	16.40	7.92	2.61	0.48
Banaskantha												
17	Tharad	0.35-3.0	0.15-1.8	2.87-24.7	0.07-0.28	1.1-3.6	2.0-20.1	0.30-1.55	2.58-12.5	1.72-10.2	0.50-3.04	0.06-0.45
		1.32	0.70	10.32	0.17	2.30	8.90	0.83	5.48	3.84	1.10	0.21
18	Vav	0.50-3.8	0.20-3.2	2.71-40.0	0.13-0.38	1.4-3.9	1.60-40.0	0.06-1.96	3.67-28.5	1.23-15.1	0.46-4.29	0.04-0.56
		1.15	0.91	8.40	0.25	2.24	7.50	0.68	8.92	4.61	1.36	0.28
19	Santalpur	0.60-3.2	0.30-1.8	3.54-20.6	0.06-0.27	1.3-5.35	2.80-16.0	0.30-2.84	6.0-32.7	1.98-13.1	1.06-7.30	0.19-0.64
		1.75	0.93	9.64	0.16	2.84	8.50	1.70	19.50	7.85	3.32	0.43
20	Rathapur	0.60-15.3	0.30-8.0	3.86-47.5	0.15-0.38	1.3-5.0	1.30-52.1	0.36-15.50	13.5-30.9	6.20-19.4	1.61-8.31	0.16-0.79
		3.82	2.12	13.01	0.25	2.89	13.30	2.61	21.60	10.40	3.75	0.52
21	Deodar	0.40-5.6	0.20-4.3	2.88-30.0	0.13-0.30	1.1-4.6	2.00-28.8	0.34-5.35	4.05-22.2	1.05-12.9	1.26-5.35	0.04-0.84
		2.11	1.30	14.78	0.23	2.93	13.70	1.42	9.20	5.66	2.46	0.26
22	Kankrej	0.60-19.6	0.30-7.1	3.29-38.7	0.10-0.33	1.7-6.8	1.80-52.3	0.40-5.38	8.25-24.5	3.00-11.2	1.07-5.78	0.14-0.80
		3.15	1.44	14.16	0.20	2.95	14.40	1.29	14.70	7.85	3.05	0.42
	District average	0.35-19.6	0.15-8.0	2.87-47.5	0.07-0.38	1.1-6.8	1.60-52.3	0.06-15.50	2.58-32.7	1.23-19.4	0.46-8.31	0.04-0.84
		2.21	1.23	11.77	0.21	2.69	11.05	1.33	13.24	6.70	2.51	0.35
	Overall	0.20-25.6	0.20-17.8	2.00-74.6	0.05-0.79	1.0-8.85	0.40-83.5	0.04-15.50	0.70-34.0	0.50-21.4	0.18-8.85	0.04-0.99
	Zone	2.13	1.35	11.78	0.20	2.77	10.73	1.64	16.05	8.12	3.02	0.29

the arid climate and practically negligible replacement of organic matter. These results are in tune with the results obtained by Kanzaria *et al.* (1982).

Soil Categorization

Of the 440 samples 49.7 per cent samples were grouped as saline soils followed by 31.2 as saline-sodic and 10.1 as sodic soil group (Fig. 1) using the criteria suggested by Richards (1954). This clearly showed that saline soils are dominant in the zone followed by saline-sodic soils. As described earlier, 65 per cent samples had < 15 ESP and 78.4

per cent had pH < 8.4 and these ranges support this categorization.

Taluka wise distribution of the three groups of salt affected soils shows that within Kutch district, the three talukas on the coast of Arabian Sea viz., Abdasa, Mandvi and Mundra had salinity less than 50 per cent. Other six talukas of the district lying relatively on the northern interior side had salinity in more than 50 per cent samples. Lakhpat taluka registered cent per cent saline group. The cause of saline soils in these talukas are attributed to the arid climate of the region, their proximity and shallow water table (Dubey *et al.* 1986).

Table 2. Talukawise range and mean values of some chemical parameters of the soils

Sr.	District and Taluka	pH _{2.5}	EC _{2.5} (dSm ⁻¹)	ESP	CaCO ₃ (%)	Organic C (%)	Textural Class
1	2	3	4	5	6	7	8
Kutch							
1.	Bhuj	7.45-8.45	0.36-4.70	3.69-17.2	0.40-15.50	0.157-0.897	S
		7.89	1.61	10.40	3.88	0.45	
2.	Nakhtrana	7.00-8.40	0.46-8.10	3.37-30.6	0.30-22.8	0.114-0.903	LS
		7.71	2.36	10.70	3.76	0.52	
3.	Lakhpat	7.00-8.20	0.23-5.60	4.10-13.2	0.30-25.0	0.080-0.691	S
		7.71	1.28	8.20	6.93	0.35	
4.	Abdasa	7.20-8.63	0.19-3.10	3.73-28.2	2.00-15.5	0.058-0.592	SL
		7.89	0.91	11.30	7.22	0.30	
5.	Mandvi	7.00-8.65	0.25-7.20	4.48-33.9	1.70-12.3	0.133-0.802	LS
		8.04	1.65	15.70	5.44	0.40	
6.	Mundra	7.43-8.60	0.35-2.33	5.92-21.3	3.75-18.7	0.133-0.591	SL
		8.14	0.99	12.20	9.46	0.38	
7.	Anjar	7.65-8.80	0.28-3.20	4.62-25.1	1.35-22.3	0.115-0.955	LS
		8.10	1.23	12.40	9.24	0.46	
8.	Bhachau	7.20-8.70	0.26-7.50	3.58-19.1	1.60-24.5	0.053-0.663	SCL
		8.05	1.37	9.60	6.90	0.26	
9.	Rapar	7.30-8.60	0.20-5.70	3.7-22.8	1.85-12.2	0.076-0.592	LS
		8.00	2.08	10.80	4.16	0.23	
	District average	7.00-8.80	0.19-8.10	3.37-33.9	0.30-25.0	0.058-0.859	--
		7.95	1.50	11.30	6.33	0.37	
10.	Malia (Rajkot)	7.92-8.70	0.25-2.55	7.15-17.8	4.60-18.0	0.152-0.632	C
		8.46	0.51	11.00	10.10	0.36	
Surendranagar							
11.	Halwad	7.70-8.80	0.28-4.20	7.20-20.9	3.80-20.9	0.105-0.592	SCL
		8.25	1.20	13.90	6.50	0.34	
12.	Dhrangadhra	7.65-9.00	0.26-3.00	4.96-25.9	3.10-24.2	0.118-0.687	SCL
		8.27	1.17	12.90	10.63	0.37	
13.	Dasada	8.00-8.75	0.25-1.55	7.19-18.2	3.50-20.8	0.114-0.420	LS
		8.43	0.58	12.20	13.30	0.24	
	District average	7.65-9.00	0.25-4.20	4.96-25.9	3.10-24.2	0.105-0.687	--
		8.32	0.98	13.00	10.20	0.32	
14.	Viramgam (Ahmedabad)	7.10-8.65	0.30-8.20	8.90-23.1	1.65-17.0	0.114-0.668	SCL
		8.10	1.95	15.00	9.14	0.29	

Table 2. (Contd.)

Sr.	District and Taluka	pH ₂₅	EC ₂₅ (dSm ⁻¹)	ESP	CaCO ₃ (%)	Organic C (%)	Textural Class
1	2	3	4	5	6	7	8
Mehsana							
15.	Sami	8.10-8.66	0.23-0.78	2.96-18.7	1.40-19.8	0.133-0.480	SCL
		8.35	0.42	9.50	9.49	0.25	
16.	Harij	7.20-8.40	0.25-4.70	4.83-22.2	1.35-11.5	0.133-0.553	SCL
		7.88	1.46	11.70	4.30	0.32	
	District	7.20-8.66	0.23-4.70	2.96-22.2	1.35-19.9	0.133-0.553	-
	average	8.12	0.94	10.60	6.89	0.29	
Banaskantha							
17.	Tharad	7.35-8.30	0.25-2.55	5.30-25.2	1.75-5.2	0.076-0.286	S
		7.86	1.01	11.00	3.50	0.17	
18.	Vav	7.15-8.35	0.25-3.90	3.26-17.8	1.10-18.7	0.058-0.404	S
		7.87	0.88	9.60	4.22	0.19	
19.	Santalpur	7.55-8.40	0.30-2.00	4.22-21.4	3.50-11.6	0.076-0.325	SL
		8.02	1.03	11.20	8.70	0.20	
20.	Radhanpur	7.00-8.45	0.30-6.50	5.45-18.8	3.25-16.4	0.133-0.744	SCL
		7.96	1.55	10.30	8.50	0.31	
21.	Deodar	7.30-8.48	0.25-2.65	5.85-29.3	0.35-7.5	0.114-0.544	LS
		7.75	1.55	15.70	3.38	0.24	
22.	Kankrej	7.35-8.60	0.30-6.10	3.33-30.8	0.50-9.5	0.114-0.496	SCL
		7.92	1.67	12.40	5.00	0.26	
	District	7.15-8.60	0.25-6.50	3.26-30.8	0.35-18.7	0.058-0.744	-
	average	7.90	1.28	11.70	5.53	0.23	
	Overall	7.00-9.00	0.19-8.20	2.96-33.9	0.30-25.0	0.053-0.993	-
	Zone	8.03	1.29	11.70	7.00	0.32	

Among the remaining cluster of 13 talukas adjoining Rann of Kutch, 7 talukas on the northern side (Tharad, Vav, Santalpur, Radhanpur, Deodar, Kankrej and Harij) registered 41 to 75 per cent under saline group in each taluka. This might be due to aridity of climate, poor quality of ground water and high water table. Rivers, Banas, Saraswati and Rupen extinct in this Rann, the salts carried by these rivers might have deposited in this area (Harij and Santalpur talukas). In Deodar, Dasada and Kankrej talukas were predominantly (> 50 %) saline-sodic in nature. Dubey *et al.* (1984) attributed topography and aridity as the major causes for the formation of the salt affected

soils in this region. In the six talukas on the southern side (Malia, Halvad, Dhrangadhra, Dasada, Viramgam and Sami), 30 to 100 per cent of the samples of each taluka were of sodic group. These soils have a relatively heavier texture (Kanzaria and Patel, 1985) and are located in low lying area with poor drainage and water logging and their higher cation exchange capacity could have increased the ESP in these soils. The information generated could be utilized for the development of management practices for the utilization of these salt affected cultivated lands on long term basis.

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Effect of mixed industrial effluents on properties of ground water and irrigated soils

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Abstract

Field survey of assessing ground water quality and irrigated surface soils of Nandesari to Jambusar area of Vadodara and Bharuch districts as influenced by irrigation with mixed industrial effluents of various industries was carried out during December 2000. Samples of effluents, underground tube well water and irrigated surface soils were collected and analyzed for different characteristics. It is inferred that indiscriminate use of effluent for irrigation since last 20 years has contaminated with Co and Cd even up to 2 km distance from disposable effluent channel. The soil has been also contaminated with DTPA extractable Pb in the fields near to effluent channel (5 to 15 m).

Keywords : Industrial effluents, soil properties, ground water

Introduction

Rapid industrialization and urbanization have created enormous problems of environmental pollution in terms of generating the variable quantity and quality of effluents. Reports indicated that the untreated and contaminated industrial effluents increased the concentration of Cd, Pb, Zn, Cu, Mn and Fe in surface layers of irrigated soil (Sakal *et al.* 1992, Adhikari *et al.* 1993) and in nearby water bodies (Totawat, 1993 and Ashok Kumar *et al.* 1998). However, the information available is mainly related to a specific type of industrial effluent, but most of the drains in industrial complexes carrying the mixed effluent of various industries and studies on this aspect are lacking. Keeping this in view present investigation was undertaken to assess the effect of mixed effluent of more than 300 industries located in the area on soil properties and ground water quality in Nandesari to Jambusar area of Vadodara and Bharuch districts (Gujarat).

Materials and Methods

The Nandesari to Jambusar industrial complex has more than 300 industries of dyes, chemicals, fertilizers, petrochemicals, pharmaceuticals, gelatin, resins, polymers, agro-industries, plastic, industrial hazardous chemicals and industrial gases. All the industries discharge their effluents of varying quality into a *pakka* channel which flows along with agricultural lands of 55 km long, covering 24 villages and finally join the bay of Khambhat. The effluents are intercepted and used for irrigation by the farmers on the both sides of channel for irrigating bajra, pigeonpea, paddy, wheat, sorghum (fodder), tobacco and vegetables viz., brinjal, cabbage, cauliflower and tomato. Effluent samples (28) from the various points at mid depth of drain were collected in the month of December, 2000. Soil samples and underground water samples (15) were collected along with effluent samples. The farmers are using effluent water since last 20 years. Water and effluent samples were analyzed for EC, pH, cationic and anionic composition as per methods outlined by Richards (1954) and toxicant build up (metallic cations) by using Atomic Absorption Spectrophotometer (AAS). Soil samples were processed and analyzed for their characteristics as per standard methods. DTPA extractable micro and heavy metals in soil samples were determined using AAS (Lindsay and Norvell, 1978). The total micro and heavy metals in effluents and water were analyzed after acid digestion on AAS (APHA, 2000).

Results and Discussion

Characteristics of the effluents (Table 1) vary over a wide range and this is quite expected as the effluents come from all sorts of industries. Similar results were also observed by Patel and Pandya (1997) in the effluents of Vadodara, Bharuch and Ankleshwar areas of Gujarat state, and Ashok Kumar *et al.* (1998) for Sikandarabad industrial complex.

Table 1. Chemical characteristics of the mixed industrial effluents

Characteristics	Range	Characteristics	Range
pH	2.6 to 8.7	F ⁻ (mg L ⁻¹)	0.17 to 14.3 (0.73 to 16.6)
EC (dSm ⁻¹)	2.3 to 10.5	Mn (mg L ⁻¹)	0.08 to 8.8 (0.08 to 8.86)
SAR	1.6 to 19.3	Zn (mg L ⁻¹)	0.10 to 1.02 (0.10 to 31.2)
RSC	0.0 to 53.9	Cu (mg L ⁻¹)	0.02 to 2.14 (0.03 to 2.25)
Cr (c mol L ⁻¹)	100 to 115	Cd (mg L ⁻¹)	Tr to 0.901 (0.02 to 1.35)
CD ₃ ⁻² (c mol L ⁻¹)	0.0 to 5.09	Pb (mg L ⁻¹)	Tr to 6.30 (0.08 to 6.50)
HCO ₃ ⁻ (c mol L ⁻¹)	0.0 to 53.5	Ni (mg L ⁻¹)	Tr to 0.78 (Tr to 2.32)
Ca ⁺² (c mol L ⁻¹)	0.5 to 41.5	Co (mg L ⁻¹)	0.02 to 0.53 (0.05 to 1.80)
Mg ⁺¹ (c mol L ⁻¹)	2.5 to 21.5		
K ⁺² (c mol L ⁻¹)	2.0 to 6.9		
Na ⁺² (c mol L ⁻¹)	3.2 to 70.1		
F ⁻ (mg L ⁻¹)	Tr to 3.0		

Figures in parenthesis are total contents.

Like effluents, water samples collected from underground tube well waters also exhibited wide range in different chemical characteristics (Table 2). The pH ranged from 7.6 to 8.3 and EC from 1.2 to 5.0 dSm⁻¹. Amongst the cations, Na⁺ and Mg⁺² are the dominant cations; this showed that there is contamination of tube well water with respect to Na⁺ and Mg⁺². Similar findings regarding the salt contamination of water bodies with factory effluent have also been reported by Joshi *et al.* (1994) and Ashok Kumar *et al.* (1998). Concentration of heavy metals (Cd, Pb, Ni, Co) in water samples was within the permissible limit except Co and Cd, which were detected in higher concentration than permissible limit. The reference sample of tube well water collected from 2 km distance from left side of effluent channel also showed the contamination of heavy metals while right side of effluent channel tube well water samples were free from contamination of industrial effluents. Based on these results, it may be inferred that the tube well water have been contaminated with respect to salts Na and Mg and heavy metals viz., Co and Cd by the effluent of factories. In general, water samples are moderately saline.

Data on surface as influenced by effluent contaminated tube well waters are presented in Table 3. The data on EC showed that the soils contain soluble salts within safe limit except site No. 10 and

15 which have higher salt contamination and saline. The pH of surface soils was below 8.00. The content of trace elements revealed that the soils were found marginal to sufficient in available Zn, Mn and Cu whereas, Fe content ranged from deficient to marginal. Further, it revealed that the Cu content showed accumulation of site No. 6, 7, 11, 12 and 14. In case of heavy metals, DTPA extractable Pb was higher where the well sites are near to effluent disposable channel (5 to 15 m) and content ranged from 0.20 to 17.44 mg L⁻¹. The other heavy metals were found within the safe limit. Higher amount of heavy metals in irrigated soils near an industrial complex have also been reported by Adhikari *et al.* (1993). Based on these observations, it is inferred that soils have been infested with moderate salinity problem.

The DTPA extractable metals are subjected to correlation with different soil properties viz. EC, pH, organic carbon and calcium carbonate (Table 4). The correlation showed that EC has positively correlated with Ni and Cd while pH negatively correlated with Mn. The organic carbon has positively correlated with Mn, Ni and Cd while CaCO₃ has negatively correlated with Cu. This showed that the soil properties EC, pH, CaCO₃ and organic carbon have significant effect on accumulation of heavy metals in soil. The similar results were also reported by Williams *et al.* (1980); and Adhikari and Singh (2000).

Table 2. Chemical composition of tube well water

Sr. No.	Location	Side of the channel	Horizontal distance from effluent channel	EC dSm ⁻¹	pH	Cations (mol L ⁻¹)				Anions (mol L ⁻¹)			Micronutrients and heavy metals (mg L ⁻¹)							
						Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	K ⁺	Ca ²⁺	Mg ²⁺	Zn	Fe	Fe	Fe	Fe	Fe	Fe	Fe
1	Kevadi	R	500m	1.2	8.0	6.6	1.6	1.2	3.1	3.6	1.8	4.0	0.007	0.06	0.015	0.005	0.04	0.03	0.15	0.01
2	Nani Serkhi	R	1 km. (Ref.)	1.3	7.9	4.3	1.0	1.2	10.8	3.6	3.6	4.5	0.005	0.06	0.007	0.001	0.00	0.01	0.00	0.00
3	Nani Serkhi	L	500 m	1.1	8.1	6.8	1.6	0.5	6.9	1.8	7.2	2.0	0.001	0.01	0.007	0.011	0.02	0.00	0.00	0.00
4	Nani Serkhi	L	<100 m	1.1	8.3	4.9	1.3	0.7	7.4	3.6	1.8	6.0	0.018	0.01	0.015	0.011	0.01	0.01	0.20	0.00
5	Moti Serkhi	L	10 m	1.2	8.0	5.1	1.3	1.0	5.4	3.6	1.8	5.0	0.016	0.01	0.00	0.001	0.07	0.00	0.17	0.02
6	Moti Serkhi	R	1 km	2.9	7.6	13.3	3.5	1.7	5.9	Tr	7.2	2.0	0.009	0.02	0.015	0.001	0.06	0.07	0.20	0.03
7	Ampad	L	5 m	1.9	8.0	9.8	2.2	0.7	6.7	3.6	3.6	8.0	0.016	0.01	0.001	0.001	0.05	0.01	0.19	0.04
8	Ampad	R	500 m	2.3	8.0	17.2	3.8	0.7	3.4	3.6	3.6	10.0	0.012	0.03	0.001	0.017	0.05	0.03	0.14	0.05
9	Jaspur	R	5 m	2.4	8.1	11.3	9.1	0.7	3.1	5.4	3.6	12.5	0.014	0.03	0.015	0.001	0.08	0.02	0.09	0.03
10	Luna	L	15 m	1.3	8.1	5.5	2.2	0.7	5.3	3.6	3.6	4.5	0.011	0.06	0.001	0.011	0.08	0.01	0.19	0.04
11	Mujpur	L	500 m	1.3	8.0	3.3	0.9	1.0	3.4	1.8	3.6	5.5	0.016	0.07	0.001	0.005	0.06	0.00	0.09	0.04
12	Mujpur	R	500 m	5.0	8.0	32.0	10.5	6.0	12.1	7.2	3.6	33.5	0.020	0.06	0.001	0.023	0.11	0.05	0.27	0.04
13	Narsipura	L	5 m	4.1	7.9	30.8	9.8	3.1	11.2	5.4	3.6	29.0	0.007	0.03	0.001	0.001	0.05	0.02	0.21	0.08
14	Mazalan	L	2 km (Ref.)	1.9	8.3	9.3	4.2	1.0	4.0	3.6	7.2	9.0	0.014	0.06	0.007	0.001	0.07	0.04	0.13	0.06
15	Karkhad	R	25 m	2.9	8.1	18.5	5.2	1.2	3.4	7.2	3.6	16.0	0.012	0.06	0.015	0.011	0.05	0.00	0.15	0.05

Table 3. Characteristics of surface soils irrigated with well water around industries

Location	EC _d dSm ⁻¹	pH _d	Soluble cations & anions, c mol L ⁻¹ (1:2)								Micro and heavy metals (mg kg ⁻¹)						
			Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	HCO ₃ ⁻	CO ₃ ²⁻	Fe	Mn	Zn	Cu	Ni	Co	Pb	Cd
1	0.42	7.7	23	1.0	1.0	1.9	44	0.36	0.52	121	104	25	20	0.30	0.35	1.50	0.15
2	0.62	7.9	21	1.3	1.40	1.3	104	0.36	0.52	51	98	32	21	0.35	0.40	2.01	0.17
3	0.35	7.8	33	2.2	1.0	2.4	72	0.36	0.52	121	121	33	23	0.48	0.37	1.54	0.13
4	0.65	7.6	29	1.4	3.4	3.1	56	0.36	0.52	51	164	26	1.9	0.26	0.47	1.72	0.13
5	0.44	7.6	20	1.0	3.8	3.8	64	0.36	0.52	5.7	150	33	64	0.38	0.45	0.22	0.05
6	0.50	7.8	23	1.1	1.2	2.2	36	0.36	0.52	29	103	20	8.6	0.30	0.33	3.84	0.11
7	0.50	7.7	19	0.8	1.2	1.9	32	0.36	0.52	20.7	152	4.6	10.5	0.50	0.55	7.38	0.11
8	0.35	7.7	14	0.8	2.2	1.4	34	0.36	0.52	7.1	153	22	4.9	0.40	0.49	2.52	0.09
9	0.55	7.9	36	1.4	1.0	0.7	56	0.36	0.52	152	135	4.9	1.4	0.36	0.39	17.44	0.11
10	1.00	7.9	56	2.1	1.0	1.0	7.0	Tr	0.72	113	133	5.0	2.2	0.58	0.43	1.92	0.13
11	0.98	7.8	24	1.2	3.4	4.8	7.8	0.36	0.72	134	206	6.1	7.4	0.72	0.47	5.78	0.21
12	0.55	7.8	26	1.2	0.7	1.4	5.2	0.36	0.72	4.1	9.7	3.1	15.9	0.28	0.57	3.34	0.11
13	0.90	7.7	43	1.6	1.4	1.9	7.2	0.72	0.72	183	15.8	3.0	3.8	0.76	0.41	3.04	0.13
14	0.45	7.8	30	1.2	0.7	2.2	5.0	1.08	0.72	5.4	12.8	2.1	8.2	0.50	0.45	1.98	0.11
15	1.15	7.9	6.8	2.5	1.4	0.7	10.8	0.36	0.36	8.3	11.3	1.7	2.1	0.46	0.45	1.26	0.15

Table 4. Correlation coefficient values (r) between soil properties and DTPA extractable trace and heavy metals

Soil characteristics	DTPA extractable trace and heavy metals							
	Fe	Mn	Zn	Cu	Ni	Co	Pb	Cd
EC	0.239	0.222	0.244	-0.294	0.533*	-0.007	-0.078	0.671**
pH	0.125	-0.478*	-0.007	-0.088	0.138	-0.229	0.357	0.324
CaCO ₃	0.075	0.181	0.221	-0.546*	-0.048	-0.281	0.205	0.449
Organic carbon	0.250	0.626**	0.452	-0.116	0.722**	-0.281	-0.120	0.552**

* = Significant at 5 % ; ** = Significant at 1 %

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Field Evaluation of chlorpyrifos 10G against rice pests

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Abstract

A field trial on evaluation of chlorpyrifos (Dursban) 10G at low (0.50 kg a.i./ha), medium (0.75 kg a.i./ha) and high (1.0 kg a.i./ha) doses along with phorate 10 G and Carbofuran 3 G was carried out at the Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat) during 1997 and 1998 *Kharif* season. Results revealed that high and medium doses of chlorpyrifos 10 G suppressed the leaf folder, *Cnaphalocrocis medinalis* Guen, incidence equal to that of carbofuran 3G (1.0 kg a.i./ha). Similarly high dose of chlorpyrifos 10G was equally effective to phorate 10 G (1.0 kg a.i./ha) in reducing white backed planthopper, *Sogatella furcifera* (Horv.) population, but proved inferior to carbofuran 3 G. Chlorpyrifos 10 G performance was poor in controlling stem borer, *Scirpophaga incertulas* (Walker) incidence. Though the grain yield was highest (37.12 qt/ha) in carbofuran treatment followed by higher dose of chlorpyrifos treatment (23.07 qt/ha). The highest benefit cost ratio (BCR) was computed in chlorpyrifos (1kg a.i./ha).

Key words : Chlorpyrifos, rice pests, benefit cost ratio (BCR)

Introduction

Rice is the most important cereal crop for more than half of the world population. It plays a prime role in our national economy. Like other crops, rice also suffers from severe incidence of insect pests. Among these, stem borer, leaf folder and hoppers are of economic importance in all the rice growing regions of the country. To combat these pests, several insecticidal sprays and granules are recommended (Dhaliwal *et. al.* 1986 ; Rajendran, 1993 and Saroja, 1989). In the present investigation, an attempt has been made to evaluate the three different doses of chlorpyrifos

10 G along with commonly used (Phorate 10 G and carbofuran 3 G) insecticides against insect pests of rice under field conditions.

Materials and methods

A field experiment was conducted at Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat) during 1997 and 1998 *Kharif* seasons. The trial was laid out in Randomized Block Design with six treatments repeated four times. The treatments comprising low (0.50 kg a.i./ha), medium (0.75 kg a.i./ha) and high (1.0 kg a.i./ha) doses of chlorpyrifos 10 G, two commonly used granular insecticides (Phorate 10 G and Carbofuran 3 G both a 1.0 kg a.i./ha) and untreated control. Gross and net plot size was 6.9 x 4.0 m. and 5.7 x 2.8 m. respectively. The seedlings of susceptible cultivar (GR-11) were transplanted at 20 x 15 cm. spacing on 16-8-97 and 5-8-98 during first and second year of experimentation, respectively. A thick mud boundary of 20 cm wide was made around each plot to avoid intermixing of water/granular insecticides. Two applications of each granular insecticides were given, first at threshold level of rice pests and second at 15 days after first application. All agronomic practices, except plant protection were followed to raise the crop.

Observations of leaf folder (LF), *Cnaphalocrocis medinalis* Guen. and white backed planthopper (WBPH), *Sogatella furcifera* (Horv.) were recorded twice during its peak incidence. The leaf folder incidence was assessed by counting total and LF damaged leaves from 10 hills selected randomly from net plot area and reported as percentage affected leaves. The WBPH population was assessed by recording total number of hoppers present on 10 hills from net plot.

Similarly, the damage of stem borer, *Scirpophaga incertulas* (Walker) was recorded by counting total number of white earheads (WE) per plot (27.6 m² area), at heading stage. At the time of harvest grain and

fodder yield was weighed separately from net plot area of each treatments. The data obtained were subjected for statistical analysis.

Results and discussion

Perusal of Table 1 indicates the impact of granular insecticides on leaf folder incidence during both the years of experimentation. It was minimum (5.55%) in carbofuran treated plots followed by high (6.07%) and medium (7.28%) doses of chlorpyrifos. These treatments were at par and superior to the treatments of phorate 10G and control. Different doses of

chlorpyrifos 10 G, were more or less equally effective in controlling the leaf folder attack. The present finding is in agreement with those of other workers (Anonymous, 1999). No significant difference was also observed by Sharma and Krishnamurthy (1999) at 1 and 1.5 kg a.i./ha doses of chlorpyrifos. The LF damage was relatively higher (24.34%) than control (18.13%) during 1998 in phorate treatment indicating resurgence of LF. This resurgence was also reported (Anonymous, 1995) in other places but only in one season out of two. However, this phenomenon was not observed in chlorpyrifos treatments.

Table 1. Effect of various insecticidal treatments on the incidence of major insect pests of rice

Sr. No.	Treatments	Dose (Kg a.i./ha)	Mean** (%) LF damage			Mean** No. of WBPH/hill			WE/Plot (27.6 m ²)		
			1997	1998	Average	60 DAT	65 DAT	Mean	1997	1998	Average
1.	Chlorpyrifos 10G	0.50	5.78	11.39	8.58ab.	2625	4095	33.60c	36.50(5.98)*	3425 (5.84)	3538 (5.91)bc
2.	Chlorpyrifos 10G	0.75	4.29	10.27	7.28a	2523	4060	32.91c	21.00(4.53)	3225 (5.66)	2663 (5.10)bc
3.	Chlorpyrifos 10G	1.00	3.70	8.45	6.07a	2248	3658	29.53b	18.75(4.24)	2900 (5.31)	2388 (4.77)b
4.	Phorate 10G	1.00	10.35	24.34	17.34c	955	4595	27.75b	40.00(6.31)	3525 (5.93)	3763 (6.12)bc
5.	Carbofuran 3G	1.00	3.47	7.82	5.55a	443	283	3.63a	11.75(3.35)	800 (2.79)	988 (3.07)a
6.	Control	-	11.88	18.13	15.01bc	3430	4575	40.03d	44.25(6.60)	3550 (5.94)	3988 (6.27)c
	S.E.m+	-	0.60	0.77	1.81	1.95	1.96	0.92	0.44	0.33	0.41
	C.D.at 5%	-	1.79	2.33	6.56	5.88	5.89	2.77	1.33	0.99	1.48
	C.V.(%)	-	18.11	11.59	13.86	19.17	11.04	6.59	17.14	12.53	14.98
	T x Y	-	-	-	Sig	-	-	-	-	-	NS

* Figures in parenthesis are $\sqrt{X}$ transformed values, ** Mean of 2 observations, DAT = Days After Transplanting
LF = Leaf folder WBPH = White backed plant hopper WE = White earhead

Incidence of WBPH was observed during 1998 season only. Significantly least (3.63 hoppers/hill) number was observed in carbofuran treated plots. Phorate and chlorpyrifos at high doses performed equally in suppressing hopper incidence. Both the treatments were at par and differed significantly from medium and low doses of chlorpyrifos.

Average data indicated that chlorpyrifos granules proved inferior to carbofuran granules in checking stem borer incidence. The performance of chlorpyrifos was similar to that of phorate. However, significantly lower incidence of the pest was found in plots treated with high dose of chlorpyrifos 10 G than untreated check. The present results are in

accordance with that of Sharnia and Krishnamurthy (1999). The poor performance of chlorpyrifos 10 G in controlling stem borer incidence reported elsewhere (Anonymous, 1999) strongly supports the above findings.

Grain yield (Table 2) was considerably reduced during 1998 owing to the severe outbreak of WBPH in later part of crop period. Significantly highest yield was recorded in carbofuran treated plots. In terms of grain production chlorpyrifos and phorate were equally effective. Impact of different granular treatments on fodder yield was also significantly different during both the years, however, pooled data revealed non-significant effect. Relatively more fodder was harvested from the plots treated with chlorpyrifos and carbofuran.

Highest (4.70) benefit cost ratio was found with high dose of chlorpyrifos followed by carbofuran (3.58).

In spite of high grain productivity observed in carbofuran, it ranked second, because of its high cost (Rs. 3691 /ha) of treatment. Medium doses of chlorpyrifos and phorate exhibited poor economic return. Whereas low doses of chlorpyrifos showed negative value of BCR.

Based on the above results, it can be concluded that high and medium doses of chlorpyrifos 10 G suppressed the leaf folder incidence equal to that of carbofuran 3 G. Similarly, high dose of chlorpyrifos 10 G found poor in controlling stem borer damage.

In respect to grain yield, high dose of chlorpyrifos 10 G was less effective than carbofuran 3 G, but was more effective than phorate 10 G. Highest economic return was achieved with chlorpyrifos 10 G. (1.0 kg a.i./ha.) followed by carbofuran 3 G.

Table 2. Effect of various insecticidal treatments on yield of rice and its economics

Sr. No.	Treatments	Dose (Kg a.i./ha)	Yield (Kg./ha.)						Gross income (Rs/ha)	Gross income (Rs/ha)	Net gain (Rs/ha)	Net profit over control (Rs/ha)	BCR
			Grain			Fodder							
			1997	1998	Average	1997	1998	Average					
1.	Chlorpyrifos 10G	0.50	1872	1136	1504	5733	6454	6088	14327	578	13749	280	Negative
2	" "	0.75	2032	1457	1754	5555	6736	6195	16253	848	15405	1376	1.62
3	" "	1.00	2843	1770	2307	5482	6924	6203	20404	1118	19286	5257	4.70
4.	Phorate 10G	1.00	2162	1018	1590	5201	6798	5999	14925	878	14047	18	0.02
5.	Carbofuran 3G	1.00	3518	3866	3712	5271	7033	6152	30916	3691	27225	13196	3.58
6.	Control	-	1817	1159	1488	5099	6375	5737	14029	-	14029	-	-
	S.E.m _t		108.9	119.0	237.9	149.3	143.7	187.8					
	C.D.at 5 %		328.3	368.7	865.3	450.0	433.1	NS					
	C.V.(%)		9.1	13.8	11.1	5.5	4.3	15.8					
	Interaction (T×Y)		-	-	Sig	-	-	Sig					

Price :	Grain	Rs. 7.50 / Kg.	Chlorpyrifos.	10 G	Rs. 54.00/Kg.	Sig = Significant
	Fodder	Rs. 0.50 / Kg.	Phorate	10 G	Rs. 42.00/Kg.	NS = Not significant
	Labour charge	Rs. 38 / day	Carbofuran	3 G	Rs. 54.80/Kg.	

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Bioefficacy and ovipositional deterrent effect of some insecticides against *Liriomyza trifolii* (Burgess) infesting castor

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Abstract

Field and laboratory experiments were carried out at B. A. College of Agriculture, Gujarat Agricultural University, Anand during 1998-99 to find out the bio-efficacy and ovipositional deterrent effect of some insecticides against *Liriomyza trifolii* (Burgess) on castor. Cyromazine 0.045%, abamectin 0.009% and monocrotophos 0.04% were found effective in controlling the *L. trifolii* and reducing the oviposition. The effectiveness of these insecticides was reflected on seed yield of castor recording 12.80 to 13.50 q/ha. The avoidable loss in yield was up to 5.32% as against 27.14% in untreated plots. The highest Net Incremental Cost Benefit Ratio was 1 : 3.75 in monocrotophos.

Key words : Bioefficacy, *Liriomyza trifolii* (Burgess), castor.

Introduction

Among the various existing pest control tactics, the use of chemicals is one of the most popular methods because of its easy application and speedy action. It is an integral part of pest management programme and hence the evaluation of newer chemicals is a continuing process. A variety of chemicals are available in market with different chemical properties and modes of action. Very little work has been done on the evaluation of such newer chemicals against the serpentine leafminer, *Liriomyza trifolii* (Burgess) which was introduced in our country in 1990-91 and assumed the status of serious pest on many agricultural crops (Viraktamath *et al.* 1993) especially castor. Keeping this in view, an attempt was made to determine the bioefficacy and ovipositional deterrent effect of some insecticides against this pest.

Materials and methods

The bioefficacy of nine (Table 1) insecticides was evaluated against *L. trifolii* on castor in field and laboratory condition at B. A. College of Agriculture, Gujarat Agricultural University, Anand during 1998-99. In field trial, each treatment was replicated thrice in randomized block design. First spray was given 45 days after germination and second spray was applied 20 days after first spray. Five plants were randomly selected in each plot for recording the observation. Larval population was recorded from fully expanded three leaves of each castor plant. Observations were recorded prior and 1, 3, 7 and 10 days after each spray. Yield of castor seeds was recorded treatment wise and avoidable losses were calculated (Poul, 1976). Economics of various insecticidal treatments was also worked out.

Twenty-five days old castor (GCH-4) plants raised in earthen pots were used for laboratory experiments. These plants were brought into the laboratory, kept inside the wooden cage (75x75x75 cm) and covered with muslin cloth. Newly emerged 100 adults of *L. trifolii* were released in to each cage. After observing sufficient larval population, each plant was sprayed with insecticides. Each treatment was replicated three times. Observations on number of larvae per plant were recorded before and 12, 24 and 48 hrs of application. Mortality per cent was calculated and corrected by using Abbott's formula (Abbott, 1925). Similarly, to know the ovipositional deterrent effect of these insecticides, a separate laboratory trial was carried out in which 100 adults of *L. trifolii* were released after treating the plants with test insecticides. As the eggs of this pest are invisible, the observations on number of live larvae per plant were recorded five days after application.

Results and discussion

Data (Table 1) on larval population recorded after first spray indicated that cyromazine and abamectin were

Table 1. Bio-efficacy of some insecticides against *Liriomyza trifolii* (Burgess) infesting castor and its effect on yield and economics.

Insecticide	Larvae/leaf ⁺			Yield (q/ha)	Avoidable loss (%)	Economics	
	Before spray	After				Net realization (Rs/ha)	NICBR
		I spray	II spray				
Abamectin (0.009 %)	8.01a (64.28)	3.46*a (12.02)	3.47*a (12.05)	13.01ab	3.77	5545	-
Cypermethrin (0.01 %)	7.78a (60.50)	4.94 bcd (24.46)	4.49b (20.16)	11.43cd	15.45	2773	1:1.11
Quinalphos (0.05 %)	7.69a (59.27)	4.81bc (23.20)	5.16bc (26.62)	12.68b	6.21	4996	1:0.58
Cyromazine (0.045%)	7.91a (62.59)	2.93a (8.60)	2.67a (7.13)	13.52a	0.00	6441	-
Monocrotophos (0.04 %)	8.25a (68.21)	4.50b (20.26)	4.70bc (22.15)	12.80ab	5.32	5177	1:3.75
Methyl-o-demeton (0.025%)	7.95a (63.29)	5.43 cde (30.88)	5.41c (29.26)	11.85c	12.35	3510	1:2.79
Fenvalerate (0.01 %)	7.41a (54.95)	5.59de (31.51)	4.95bc (24.55)	11.53cd	14.71	2948	1:3.41
Endosulfan (0.07%)	8.08a (65.30)	5.32cde (28.87)	4.56bc (20.86)	11.67cd	13.68	3194	1:0.85
Dimethoate (0.03 %)	8.10a (65.61)	5.78e (34.60)	5.06bc (25.64)	11.00d	18.63	2018	1:1.07
Control	8.03a (64.62)	7.98f (63.68)	7.60d (57.89)	9.85e	27.14	-	-
S.Em. +	0.17	0.24	0.29	0.24	-	-	-
CD at 5 %	NS	0.71	0.85	0.71	-	-	-
CV %	3.73	7.42	8.50	3.49	-	-	-

* $\sqrt{x}$ transformed values.
+ Mean of four observations.

Figures in parentheses are original values.
NICBR : Net Incremental Cost Benefit Ratio

significantly more effective than rest of the insecticides. Monocrotophos also had effective control of the pest and was at par with quinalphos and cypermethrin. Among the test insecticides, dimethoate was least effective against leaf miner and registered highest larval population (34.60/leaf). Similarly, after second spray, cyromazine and abamectin were equally effective against this pest and were superior to rest of the insecticides. Cypermethrin was at par with monocrotophos, quinalphos, fenvalerate, endosulfan and dimethoate in suppressing the leaf miner population. Methyl-o-demeton was the least effective.

The highest (13.52 q/ha) yield was obtained from the plots treated with cyromazine followed by abamectin (13.01 q/ha) and monocrotophos (12.80 q/ha). The dimethoate treated plots recorded the lowest yield (11.00 q/ha) followed by cypermethrin (11.43 q/ha) and fenvalerate (11.53 q/ha). The lowest (3.77%) avoidable loss was found in the treatment of abamectin followed by monocrotophos (5.32%) and quinalphos (6.21%), whereas in untreated plots it was 27.14 per cent (Table 1). Maximum net realization (Rs. 6441/ha) was obtained from cyromazine treated plots. The net realization values corresponding to the abamectin,

monocrotophos, quinalphos and methyl-o-demeton were Rs. 5545, 5177, 4996 and 3510 /ha, respectively. The highest (1 : 3.75) Net Incremental Cost Benefit Ratio was registered in the treatment of monocrotophos followed by fenvalerate (1 : 3.41) and methyl-o-demeton (1 : 2.79).

In the laboratory study, cyromazine caused the highest (77.44%) mortality of *L. trifolii* larvae followed by abamectin (68.41%) and monocrotophos (63.87%). Endosulfan, cypermethrin, methyl-o-demeton and quinalphos were at par with each other causing 48 to 54 per cent mortality. Dimethoate and fenvalerate caused less than 46 per cent mortality.

Both the field and laboratory experiments indicated that cyromazine (0.045%), abamectin (0.009%) and monocrotophos (0.04%) were found highly effective against serpentine leaf miner infesting castor. The higher efficacy of cyromazine and abamectin was also

reported by Makvana (1997), Undurraga and Dybas (1988) and Jyani (1999). The effectiveness of monocrotophos against *L. trifolii* infesting castor reported by Kapadia and Parmar (1993) is in accordance with the present findings. The poor performance of dimethoate (0.03%) and fenvalerate (0.01%) observed in the present study is in conformity with the findings of Makvana (1997) and Alverson and Gorsuch (1982).

Data (Table 2) on ovipositional deterrent effect of various insecticides revealed higher impact of cyromazine (12.33 larvae/plant) in reducing the oviposition by *L. trifolii* followed by endosulfan, monocrotophos and abamectin. Schuster and Everett (1983) and Schuster and Taylor (1987) reported that cyromazine and abamectin reduced the oviposition by *L. trifolii* on tomato. The maximum larval mines were recorded in dimethoate treated plants followed by fenvalerate and cypermethrin. It indicates the

Table 2. Bioefficacy and ovipositional deterrent effect of some insecticides against *Liriomyza trifolii* (Burgess) in laboratory

Insecticide	Mortality (%) +	Larvae/plant
Abamectin (0.009 %)	55.81*b (68.41)	4.27**b (18.33)
Cypermethrin (0.01 %)	44.46c (48.96)	4.65c (21.67)
Quinalphos (0.05 %)	27.22e (53.83)	4.39bc (19.33)
Cyromazine (0.045 %)	61.64a (77.44)	3.51a (12.33)
Monocrotophos (0.04 %)	53.03b (63.87)	4.24b (18.00)
Methyl-o-demeton (0.025 %)	44.55c (49.10)	4.61c (21.33)
Fenvalerate (0.01 %)	42.34cd (45.57)	4.65c (21.67)
Endosulfan (0.07 %)	44.12c (48.47)	4.19b (17.67)
Dimethoate (0.03 %)	39.60d (40.66)	5.28d (28.00)
Control	---	7.70e (59.33)
S.Em. +	1.10	0.10
CD at 5 %	3.40	0.30
CV %	4.25	3.70

* Arcsin transformed values.

Figures in parentheses are original values.

** $\sqrt{x}$ transformed values.

+ Mean of three observations.

maximum oviposition made by *L. trifolii* females in these treatments. Schuster and Everett (1983) have expressed similar opinion, in which cypermethrin and fenvalerate were found least effective in reducing the oviposition by this pest on tomato.

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A Study of some selected aspects of women engaged in bidi making occupation

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Abstract

The present study was carried out in Sangamner tahsil of Ahaiednagar district of Maharashtra State in 1999, to know the extent of involvement of women engaged in *Bidi* occupation and their role in decision making about the family affairs. The results revealed that majority of women respondents had high extent of involvement in *Bidi* making occupation, perform all the *Bidi* making practices by themselves. There was equal participation alongwith other family members in all other aspects of family affairs. The respondent women played a significant role in making decisions with respect to family affairs.

Key words : Socio-economic characteristics, respondents, decision making

Introduction

The major proportion of women population in India lives in rural areas. In unorganised sector they are large in number and lack opportunities to aquire skills and subjects to prejudices of low productivity and compulsion to supplement family income. However, development planners and administrators have failed to recognise the diversity of economic and other roles played by women in unorganised sector. They are only recognised as target group for social welfare services. Women are the starting point for all development. Since they play the key role in shaping the young generation. If the nation is to move ahead, women need to be helped to develop their capabilities and inherent potentials.

Bidi making is an important industry in the state of Maharashtra in which large number of women are engaged. Though predominantly unorganised, *Bidi* industry providers employment to over 50 lakh people in India. Next to agriculture, this industry is the single largest provider of employment. In *Bidi* industry

participation of female workers is more than male workers. In order to know the present situation of women engaged in *Bidi* making occupation, as a component in the main stream of economic development, the present investigation was undertaken with the following specific objectives.

1. To study the personal and Socio-economic characteristics of rural women engaged in *Bidi* making.
2. To know the extent of involvement of women engaged in *Bidi* occupation and
3. To study the role of women in decision making about the family affairs.

Material and methods

The present investigation was conducted in Sangamner block of Ahmednagar district of Maharashtra State in 1999. There are five *Bidi* making industries in Sangamner tahsil. Out of these Langer Bidi Udyog is the largest one which has more than 3500 workers, mostly women. This industry was purposiveiy selected for the study. The *Langer Bidi Udyog* is spread over twenty villages in Sangamner block. From among them ten villages were selected randomly. The lists of women engaged in *Bidi* making industry from the selected villages were obtained from the manager of the *Langer Bidi Udyog*, situated at main branch at Sangamner. Then each list was arranged alphabetically and fifteen women respondents were selected randomly from each village. Thus, in all 150 women respondents were selected from these ten villages. The data were collected with the help of well constructed interview schedule by interviewing women respondents personally.

Results and discussion

Characteristics of women engaged in Bidi making occupation

The study revealed that 62.66 per cent women respondents belonged to small size of family having

upto 5 members. Majority of women respondents had nucleated family system (76.00 per cent). In 74.00 per cent families wife was enjoying the status next to the head of family. Majority of the women respondents were married (86.66 per cent) but were illiterate, having no formal education (56.00 per cent). More than half of the women respondents belonged to low income group i.e. upto Rs. 2000/- Most of the women respondents belonged to upper castes (74.00 per cent) and were having medium level of economic motivation (62.66 per cent). Women engaged in Bidi making had low to medium level of aspirations about children. Most of women respondents had low level of cosmopoliteness (71.33 per cent). Nearly half of the women respondents had low to medium level of social values. Further, it was observed that 64.00 per cent of the women respondents had *Bidi* making as their main occupation.

Regarding beliefs, it was observed that majority of women respondents believed that medical treatment was necessary for the cure of disease (85.33 per cent) and 68.67 per cent of them believed that the birth of child on *Mul Nakshatra* was inauspicious. Almost all (98.00 per cent) women respondents expressed that *Ekadashi* should be observed to maintain the purity

of mind and performing holy rituals and *pujas* are essential for maintaining the peace in family.

Regarding number of children in the family 34.66 per cent women respondents believed that there should be only one child in family. While 51.34 per cent and 14.00 per cent of them were in favour of two and three children respectively.

Extent of involment of women in Bidi making occupation

Extent of involvement of women engaged in *Bidi* making occupation was decided on tile basis of their actual participation in individual *Bidi* making practices. Data presented in Table 1 clearly revealed that there was regular involvement of women respondents in almost all the *Bidi* making practices, viz., collecting wages (100.00 per cent). Bringing *tendu* leaves and tobacco from *Bidi* industry (98.00 per cent), sending *Bidi* bundles to *Bidi* industry (98.00 per cent), keeping account of whole *Bidi* making occupation (96.66 per cent), counting *Bidis* for packing in bundles (96.00 per cent), Soaking of leaves in water (95.33 per cent), rolling *bidis* (93.33 per cent), tying thread to *Sidis* (93.33 per cent) and cutting leaves in definite shape for rolling *Bidis* (84.66 per cent).

Table 1. Nature of involvement of women respondents in individual *Bidi* making practices

Sr. No.	<i>Bidi</i> making practices	Occasional		Frequent		Regular	
		Number	Percentage	Number	Percentage	Number	Percentage
1.	Bringing Indu leaves and tobacco from <i>Bidi</i> industry.	1	0.66	-	-	147	98.00
2.	Soaking of leaves in water	2	1.33	3	3.33	143	95.33
3.	Cutting of leaves in definite shape for rolling <i>Bidi</i>	2	1.33	22	14.66	127	84.66
4.	Rolling <i>Bidis</i>	-	-	10	6.66	140	93.33
5.	Tying thread to <i>Bidis</i>	-	-	10	6.66	140	93.33
6.	Counting <i>Bidis</i> for packing in bundles	-	-	6	4.00	144	96.00
7.	Tying thread to <i>Bidi</i> bundles	-	-	6	4.00	144	96.00
8.	Sending <i>Bidi</i> bundles to <i>Bidi</i> industry	3	2.00	-	-	147	98.00
9.	Collecting wages	-	-	-	-	150	100.00
10.	Keeping account of whole <i>Bidi</i> making occupation	4	2.66	1	0.66	145	96.66

According to extent of involvement of women in *Bidi* making occupation, they were categorised into three group. From the data in Table 2, it is observed that 92.77 per cent women respondents belonged to the category of high extent of involvement in *Bidi* making occupation while 6.67 per of them belonged to the category of medium extent of involvement. Only one (0.66 per cent) women respondent belonged to low group of extent of involvement in *Bidi* making occupation.

Table 2 Distribution of women respondent by their extent of involvement in *Bidi* making occupation.

Sr. No.	Extent of involvement in <i>Bidi</i> making occupation	Frequency	Percentage
1.	Low	1	0.66
2.	Medium	10	6.6
3.	High	139	92.77

From above data it is concluded that women engaged *Bidi* making occupation perform all the *Bidi* making practices by themselves which consumed a greater portion of their time. These results are supported by Shashikala *et al.* (1990) who reported that considerable percentage farm women of rainfed and irrigated areas performed the activities both at home and on the farm which consumed a greater portion of their time.

Extent of role performance in decision making about various aspects of family affairs

Making decisions on different aspects of family affairs is important for the success of family, as a right decision at right time is key to success in any enterprise. The data presented in Table 3 show that proportion of women respondents taking self decisions was more than half with respect of own occupation (62.67 per cent) and purchase of house hold grossary (55.33 per cent).

Table 3. Role of women respondents in decision making about family affairs

Sr. No.	Particulars (Decision regarding)	Self decision		Equal participation		Partial Participation		Not involved in decision making	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1	Purchase of household grossary	83	55.33	51	34.00	13	8.67	3	2.00
2.	Purchase of costly items (e.g. T.V..Refrigerator)	16	10.67	112	74.67	16	10.66	6	4.00
3.	Purchase of minor/small household items.	48	32.00	85	56.66	11	7.34	6	4.00
4.	Purchase of cloths	28	18.67	105	70.00	11	7.33	6	4.00
5.	Education of children	17	11.33	111	74.00	13	8.67	9	6.00
6.	Marriage of children	15	10.00	112	74.67	11	7.33	12	8.00
7.	Occupation/business of children	17	11.34	109	72.66	12	8.00	12	8.00
8.	Health of family	22	14.67	110	73.34	11	7.34	7	4.66
9.	Own occupation	94	62.67	52	34.67	4	2.66	-	-

The proportion of women respondents taking self decision was less than one fifth with respect to purchase of cloths (13.67 per cent), occupation/ business of children (11.34 per cent), education of children (11.33 per cent), purchase of costly items like television, refrigerator (10.67 per cent) and marriage of children (10.00 per cent).

As regards participation of women engaged in *Bidi* making occupation in decision making along with other family members i.e. equal participation, it was observed that the proportion of women respondents was more than 70.00 per cent with respect to purchase of costly items, purchase of cloths education of children, marriage of children, occupation/ business of children and health of family members. The proportion of respondents taking equal part in decision making with respect to purchase of minor/small household items was 56.66 per cent, own occupation was 34.67 per cent and purchase of household glossary was 34.00 per cent. Proportion of women respondents participating partially in taking decisions and of those who were not involved in decision making in different aspects of family affairs was negligible or less than one fifth.

It is thus clear that women engaged in *Bidi* making occupation either take self decisions or have equal participation with other family member with respect to decisions regarding family affairs.

Women engaged in *Bidi* making occupation are the earners in their family and hence they are considered important persons in the family. This might be reason why they are consulted in decision making different aspects of family. The present findings are in line with those of Craven and Ruby (1963), Bhagat (1986) and Kadlag (1994).

Distribution of women engaged in *Bidi* making with respect to their role in decision making in the family affairs is presented in Table 4.

Table 4 Distribution of women respondent by their role in decision making about family affairs.

Sr. No.	Role in decision making	Frequency	Percentage
1.	Low	25	16.66
2.	Medium	105	70.00
3.	High	20	13.34

From the data in Table-4 it is clear that majority of women respondents (70.00 per cent) had medium level of participation in decision making followed by low (16.66 per cent) and high (13.34 per cent) level of participation. Thus it is clear that, more than 4/5th of women respondents had medium (83.34 per cent) of women respondents had medium to high level of participation in the decision making about family affairs.

It can be concluded that women engaged in *Bidi* making occupation play a significant role in making decisions with respect of family affairs. Singh (1988) reported that 80.00 per cent of the women were of the view that they played an important role in decision making related to household activities.

Wairagade (1988) found that farm women either took self decision or participated in decision making along with other family members with respect to most of the farm operations and related activities.

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Factors associated with net income from mixed farming of different categories of farmers of south Gujarat.

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Abstract

With a view to know correlation between annual net income of crop and dairy farming with independent variables and to predict the extent of variation on dependent variables caused by selected independent variables this study was undertaken. Out of 23 independent variables only 18 variables namely, operational land holding, herd size, gross income from mix farming, attitude towards dairy farming, management orientation, use of bullock labour, manual labour, FYM use, expenditure in crop enterprise, manual labour in livestock enterprise, milk yield in livestock enterprise, milk consumption in livestock enterprise, marketed milk, expenditure in livestock enterprise, gross income in crop enterprise, net income in crop enterprise, gross income in livestock enterprise and net income in livestock enterprise showed positive and significant correlation with net income of crop +dairy farming system for marginal, small, medium and pooled sample of farmers. Education and extension contact variables showed positive and significant relationship for medium and pooled sample of farmers. It means these variables play an important role in enhancing the productivity and in increasing the annual net income of this farming system. Operating land holding, cowdung used as FYM, management orientation and bullock labour were found contributing positively and significantly to the annual net income from mixed farming of pooled sample of farmers.

Key words : Mixed farming, net income, independent variables,

Introduction

The crop and livestock enterprise as mixed farming in Indian situation are highly interrelated and symbiotically co-existing since long. They are considered to be complementary and supplementary

to each other. Net return of a farm is influenced by several components of the system. To find out the relationship and prediction of these sub components with farm return, the present study was conducted with specific objectives viz., correlation between annual net income of crop and dairy farming with independent variables and to predict the extent of variation in dependent variables caused by selected independent variables.

Material and methods

The present study was conducted in South Gujarat. It has six districts viz, Bharuch, Narmada, Surat, Valsad, Navsari and Dangs. All these districts were included in the present study. These districts are located mainly in three parts of South Gujarat. viz., upper, middle and lower parts. Bharuch and Narmada districts are in the upper parts of South Gujarat. Surat district is in the middle part and Valsad, Navsari and Dangs districts are located in the lower part of South Gujarat. These districts have tribal people in all talukas. The highly tribal populated talukas were selected from these districts. Three villages from each talukas were purposively selected on the basis of concentration of tribal population. From each village 10 respondents were randomly selected. Thus, total 180 respondents were selected for the study.

Results and discussion

To get a comprehensive idea of the inter - correlation between annual net income from crop + dairy farming system, 23 independent variables of Bharuch, Narmada, Swat, Valsad, Navsari and Dangs district's farmers were studied. These variables were grouped in to four categories.

Socio-Economic Variables

It was found that annual net income from crop + dairy farming system was positively and significantly correlated with operational land holding, herd size and

gross income from mixed farming by marginal, small, medium and pooled sampled farmers. Education of only medium and pooled sampled farmers was positively and significantly with annual net income. Age and family size of all marginal, small, medium and pooled sampled farmers was not found correlated with annual net income. (Table 1) The present findings confirm with findings of Singh(1992)., Thakor (1992), Shete (1992), Muchenu *et. al.* (1995) and Islam *et. al.* (1996).

Socio-Psychological Variables

It was found that annual net income from crop + dairy farming system was positively and significantly correlated with attitude towards dairy farming and management orientation by marginal, small, medium and pooled sampled farmers. Extension contact of only medium and pooled sampled farmers was positively and significantly correlated with annual net income. Extension participation of all marginal, small, medium and pooled sampled farmers was not found

Table 1. Relationship of annual net income of different categories of farmers from mixed farming with independent variables.

Independent Variables	Zero order correlation			
	Marginal (N=60)	Small (N=60)	Medium (N=60)	Pooled (N=60)
Socio-economic variables				
Age	0.16600	0.03495	-0.07105	-0.17448
Education	0.20905	-0.16143	0.563378**	0.35041**
Family Size	-0.05083	-0.08968	-0.05844	-0.01289
Operational land holding	0.72455**	0.41672**	0.84029**	0.43704**
Herd Size	0.88479**	0.83836**	0.70122**	0.35418**
Gross Income from mixed farming	0.99199**	0.98002**	0.94971**	0.97339**
Socio - psychological variables				
Extension participation	-0.35749	0.03692	-0.00144	0.03957
Extension contact	-0.30117	0.17046	0.46787**	0.45181**
Attitude towards dairy farming	0.82612**	0.77600**	0.68242**	0.79333**
Management Orientation	0.97207**	0.95552**	0.85805**	0.93815**
Crop enterprise related variables				
Use of bullock labours	0.93235**	0.90889**	0.83684**	0.76782**
Manual labour	0.90032**	0.94426**	0.80575**	0.89692**
FYMuse	0.94801**	0.93137**	0.84674**	0.89672**
Expenditure (crop)	0.96538**	0.91558**	0.79804**	0.89709**
Gross income crop	0.98418**	0.96568**	0.95116**	0.96801**
Net income	0.98389**	0.97265**	0.96763**	0.97873**
Livestock enterprise related variables				
Manual labour	0.87358**	0.84598**	0.79089**	0.84166**
Milk yield	0.96581**	0.94510**	0.87526**	0.93632**
Milk consumption	0.80408**	0.95454**	0.86496**	0.88470**
Marketed milk	0.96590**	0.94259**	0.87590**	0.93551**
Expenditure (livestock)	0.94727**	0.91483**	0.77575**	0.88197**
Gross income (livestock)	0.98645**	0.97906**	0.92140**	0.96414**
Net income (livestock)	0.96905**	0.94618**	0.93235**	0.95601**

** Significant at 0.01 level of probability.

correlated with annual net income. The findings get the support from the findings of Singh (1992) and Islam (1996).

Crop Enterprise Variables

All six variables viz., use of bullock labour, manual labour, FYM use expenditure in crop enterprise, gross income in crop enterprise and net income in crop enterprise showed a positive and significant correlation with annual net income from crop + dairy farming system. This finding was in line with the findings of Shete (1992) and Singh (1992).

Dairy Enterprise Variables

All seven variables, namely, manual labour, milk yield, milk consumption, marketed milk, expenditure in livestock enterprise, gross income in livestock enterprise and net income in livestock enterprise were positively and significantly correlated with annual net income from crop + dairy farming system. This finding is supported by the findings of Singh (1992) and Ly and Diaw (1996).

Prediction of annual net income from mixed farming of marginal, small, medium and pooled sample of farmers with independent variables

As indicated in Table 2, out of total of 11 independent variables entered in a regression mode, two variables viz., management orientation and manual labour in crop enterprise were found contributing positively and significantly to the annual net income from mixed farming of marginal farmers.

The multiple R (0.9857) value indicated greater interdependence of the annual net income of marginal farmers on all these independent variables. The F ratio indicated significant effectiveness of these independent variables in predicting the annual net income from mixed farming of marginal farmers when all of them were considered. The multiple regression analysis with respect to marginal farmer is presented in Table 2, revealed that as much as 97.16 percent of the variation in mixed farming was through eleven variables.

Table 2. Multiple regression analysis of the annual net income of different categories of farmers from mixed farming with independent variables

Independent Variables	Marginal farmers		Small farmers		Medium farmers		Pooled	
Education	--	--	- 0.773	(1355.70)	-0.638	(510.05)		
Operational land holding	-0.914	(775.73)	-1850 ^{NS}	(4954.52)	2.124*	(7028.81)	2.198*	(2703.67)
Extension Contact			-0.762	(1056.18)	-1.261	(446.44)		
Herd Size	-0.236	(854.09)	-0.698 ^{NS}	(897.37)	0.712	(1405.01)	0.154	(683.58)
Milk production	0.476	(36.24)	0.620 ^{NS}	(50.26)	1.785	(294.08)	0.558	(46.74)
Milk consumption	-0.103	(36.22)	1.641 ^{NS}	(64.15)	-3.562**	(304.90)	-0.148	(48.53)
Milk marketing	-0.451	(38.09)	-0.853 ^{NS}	(49.70)	-1.348	(300.73)	-0.516	(46.88)
FYM used	-0.538	(44.70)	1.125 ^{NS}	(42.97)	1.76	(84.75)	2.009	(27.28)
Dairy farming attitude	-0.691	(402.60)	0.296 ^{NS}	(588.57)	0.492	(1139.95)	0.110	(435.37)
Management Orientation	4.480**	(176.84)	1.431 ^{NS}	(335.41)	-0.600	(487.51)	3.230*	(184.43)
Manual labour (crop)	2.406* ^{NS}	(27.42)	1.651 ^{NS}	(61.08)	-0.681	(88.73)	0.744	(31.71)
Bullock labour (crop)	-2.102	(38.81)	1.503 ^{NS}	(40.39)	2.135*	(78.44)	2.309*	(25.34)
Manual labour (livestock)	0.121	(37.39)	-0.583 ^{NS}	(39.59)	-0.749	(83.86)	-0.630	(33.12)
R squared = 0.9716		R squared = 0.9325		R squared = 0.8941				
Multiple R = 0.9857		Multiple R = 0.9721		Multiple R = 0.9499				
F ratio = 149.393 (H.S.)		F ratio = 75.06 (H.S.)		F ratio = 108.893 (H.S.)				

(Figures in the parentheses indicates standard error)

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability, NS = Non - Significant

Prediction of annual net income from mixed farming of small farmers

Data presented in Table 2 reveal that 11 independent variables were entered in a regression model to predict the annual net income of small farmers. None of these variables was found independently contributing significantly to the annual net income from mixed farming of small farmers.

The higher multiple R value (0.9721) indicated greater interdependence of the annual net income of small farmers on all these independent variables. The F ratio (75.06**) indicated significant effectiveness of these independent variables in predicting the annual net income from mixed farming of small farmers when all of them were taken combinedly.

The regression analysis as reported in Table 2 indicate that all eleven independent variables together effected change in the dependent variable to the extent of 93.25 per cent.

Prediction of annual net income from mixed farming of medium farmers

Data presented in Table 2 reveal that, out of the 13 independent variables entered in a regression model, two variables, namely, operational land holding and bullock labour were found contributing significantly to the annual net income of medium farmers. The multiple R value (0.9127) indicated greater interdependence of the annual net income of medium farmers on all these independent variables. The 'F' ratio (17.648**) also indicated significant effectiveness of these independent variables in predicting the annual net income of medium farmers when all of them were taken combinedly.

The multiple regression value ($R^2 = 0.8330$) indicated that all thirteen independent variables contributed jointly to the extent of 83.30 per cent of the variation in mixed farming productivity of the medium farmers.

Prediction of annual net income from mixed farming of pooled sample of farmers

Data presented in Table 2 reveal that, out of a total of 13 independent variables entered in a regression model, four variables, namely, operational land holding, cow dung used as FYM, management orientation, and bullock labour were contributing positively and significantly to the annual net income from mixed farming of pooled sample of farmers.

The multiple 'R' value (0.9499) indicated greater inter-dependence of the annual net income from mixed farming of pooled sample of farmers on all these independent variables. The 'F' ratio (108.893) also indicated significant effectiveness of these independent variables in predicting the annual net income of pooled sample of farmers when all of them were taken combinedly.

The multiple regression analysis with respect to all the farmers i.e. irrespective of tier is presented in Table 2 revealed that much as 89.41 per cent of the variation in mixed farming productivity is explained by thirteen variable.

Conclusions

Out of 23 independent variables only 18 variables namely, operational land holding, herd size, gross income from mixed farming, attitude towards dairy farming, management orientation, use of bullock labour, manual labour, FYM use, expenditure in enterprise, manual labour in livestock enterprise, milk yield in livestock enterprise, consumption in livestock enterprise, marketed milk, expenditure in livestock enterprise, gross income in crop enterprise, net income in crop enterprise gross income in livestock enterprise and net income in livestock enterprise showed positive and significant correlation with net income of crop + dairy farming system for marginal, small and pooled sample of farmers. Education and extension contact independent variables showed positive and significant relationship for medium and pooled sample of farmers. It means these variables play an important role in enhancing the productivity and in increasing the annual net income of this farming system.

Management orientation and manual labour in crop enterprise were found independently contributing positively and significantly to the annual net income from mixed farming of marginal farmers. None of the variable was found independently contributing significantly to the annual net income from mixed farming of small farmers but variables like milk production, milk consumption, cow dung used as FYM, management orientation, manual labour for crop enterprise and bullock labour jointly contributed to the annual net income of small farmers. Operational land holding and bullock labour had contributed significantly in increasing the annual net income from mixed farming of medium farmers. Operational land holding cow dung used as FYM, management orientation and

bullock labour were found to be contributing positively and significantly to the annual net income from mixed farming of pooled sample of farmers.

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Adoption pattern of hybrid tobacco growers

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Abstract

The study concluded that overwhelming number of the respondents had knowledge about various recommended cultivation practices of GTH1, but green manuring, control measures of stem borers and nematode were known by few tobacco growers. In case of adoption, majority had adopted recommended time and spacing of transplanting and topping practice, very few had adopted recommended dose of FYM, inorganic fertilizers and pest control measures, majority of them had done four to five times desuckering and given four times irrigation. The majority of the GTH 1 growers had given favourable opinion for GTH 1 in terms of production, size, colour, quality and smoking taste of leaves. Unfavorable marketing policy created by tobacco merchants, low market prices of product, high rate of labour, labour crises, high cost of fertilizers and seeds, poor involvement of co operatives were major constraints experienced by GTH 1 growers. Thus, efforts should be done to motivate farmers to adopt practices like, fertilizer management and plant protection measures to improve per unit production of tobacco.

Key words : Adoption, tobacco, respondents

Introduction

Gujarat is leading state for the cultivation of bidi tobacco with an area of 1.06 lakh hectares, whereas, it is first in both production and productivity. Kheda, Anand, Vadodara and Panchmahals are the major tobacco growing districts in the state, covering about 85 to 90 percent of the total area of tobacco cultivation. Anand 119, Anand 2 and GT 5 are the important varieties developed and recommended by GAU to the farming community for higher production. Hybrid tobacco GTH-1 is developed by BTRS, GAU, Anand and recommended for cultivation in 1995. It gives 48 and 36 percent higher yield over

recommended varieties Anand 119 and GT 5, respectively. It contains 9 per cent nicotine, good smoking taste, and good qualities of leaves with more thickness, length and width. It is also resistant to stem-borer. A considerable time of 6 years has been elapsed after its recommendation. It is high time to examine its performance among the farmers because the success of any new technology depends on the degree of its adoption by its real users. Thus, present study was undertaken with following objectives.

1. To study the profile of hybrid tobacco growers.
2. To study the extent of adoption of hybrid tobacco cultivation by the tobacco growers.
3. To study the constraints faced by the farmers in adoption of hybrid tobacco cultivation.
4. To get suggestions of tobacco growers to overcome constraints.

Present study was undertaken in Kheda and Anand District of the state. Six to ten farmers from five villages of each district, thus a random sample of total 100 respondents from ten villages were selected for the study. The data were collected with the help of personal interview schedule, which was specially constructed in accordance with the objectives of study.

Findings and discussion

Personal and socio-economic characteristics of the respondents

The data residing Personal and socio-economic characteristics of respondents are presented in Table 1. Results indicate that majority of Hybrid Tobacco adopters had middle age (55%), high school level of education (65%), large size of family (79 %), up to 2 ha. of land holding (80%), up to two numbers of animal possession (60%), agriculture and animal husbandry as major sources of income (64 %), below one ha. of hybrid tobacco cultivation area (63 %) from their total land holding and up to four years of experience (90 %).

Table 1. Personal and socio-economic characteristics of the respondents (N=100)

S.N	Characteristic	No	Percent	S.N	Characteristic	No	Percent
1.	Age			2.	Education		
	Young	28	28		Illiterate	00	00
	Middle	55	55		Primary	16	16
	Old	17	17		High school	65	65
3.	Family Size				Above h. school	19	19
	Small (Up to 5)	21	21	4.	Land holding		
	Large (Above 5)	79	79		Up to 1.0 ha.	08	08
5.	Herd Size				1.1 to 2.0 ha.	72	72
	No animals	16	16		2.1 to 4.0 ha.	20	20
	Up to two	60	60	6.	Income Sources		
	3 to 4 animals	24	24		Only agriculture	28	28
7.	Area under GTH1				Agri. and A.H.	64	64
	Up to 1.0 ha.	63	25		Agri. and others	08	08
	1.1 to 2.0 ha.	63	25	8.	Experience of GTH1		
	Above 2.0	12	12		Up to 2 years	58	32
					Above 2 to 4 years	58	32
					Above 4 years	10	10

Table 2. Distribution of GTH-1 growers according to their knowledge (N=100)

Sr. No.	Techonologies	No.	Percent
1.	Land preaparation	100	100
2.	Time of transplanting	100	100
3.	Transplanting spumji	70	70
4.	Fertilizer application		
	I. Organic Manures		
	a.FYM	87	87
	b. Green manuring	20	20
	II. Inorganic Fertilizers		
	a. Basal application	56	56
	b. Top dressing	74	74
5.	Irrigation applied		
	a. Number	88	88
	b. Interval between two irrigations	74	74
6.	Topping	100	100
7.	Desuckering	100	100
8.	Knowledge of major harmful insect-pests		
	a. Stem borer	60	60
	b. Spodoptera (leaf eating caterpillar)	85	85
9.	Knowledge of control measures of insect-pests		
	a. Stem borer	28	28
	b. Spodoptera (Leaf eating caterpillar)	54	54
10.	Knowledge of major diseases		
	a. Nematode	32	32
	b. Leaf curl	100	100
11.	Knowledge of diseases control		
	a. Nematode	18	18
	b. Leaf curl	58	58
12.	Harvesting		
	a. Leaf by leaf method	100	100
	b. Stalk cut method	100	100
	c. Priming method (Gugra)	84	84

Knowledge of tobacco growers regarding GTH 1 cultivation

It is evident from the Table 2 that among different practices of GTH1 cultivation, overwhelming number of the respondents had knowledge about various recommended cultivation practices. Farming practices like green manuring was known only by for stem borer pest by 28 % and nematode control was known by 18 % respondents only.

Table 3. Distribution of GTH1 Growers According to their Adoption (N=100)

Sr. No.	Technology	No.	Percent
1	Transplanting		
	1. Early (before 1 st August)	00	00
	2. Timely (1st to 15th August)	68	68
	3. Late (15th to 3 1st August)	32	32
2	Spacing		
	1. Recommended (90 cm. x 75 cm.)	60	60
	2. Narrow (75 cm. x 75 cm.)	25	25
	3. Wider (90 cm. x 90 cm.)	15	15
3	Fertilizer application		
	I Organic		
	a. FYM		
	1. Recommended (25 cartloads/ha)	12	12
	2. Less	79	79
	3. More	09	09
	b. Green manuring		
	1. Adopted	07	07
	2. Not adopted	93	93
	II Inorganic		
	1. Recommendation (260 Kg N/ha)	27	27
	2. Less	38	38
	3. More	35	35
4	Topping		
	1. At 22 to 24 leaves (As per recommendation)	78	78
	2. At 18 to 20 leaves (Lower)	22	22
	3. More than 24 leaves (Higher)	00	00
5	Irrigation		
	1. Three irrigations	10	20
	2. Four irrigations	62	62
	3. Five irrigations	28	28
6	Desuckering		
	1. Three times	15	15
	2. Four times	50	50
	3. Five times	35	35
7	Plant Protection Measures		
	I Insect control (Stem borer, Spodoptera, etc.)		
	1. As per recommendation	03	03
	2. Lower	06	06
	3. Not adopted	91	91
	II Diseases control		
	a. Nematodes		
	1. As per recommendation	14	14
	2. Lower	12	12
	3. Higher	00	00
	4. Not adopted	74	74
	b. Leaf curl		
	1. As per recommendation	03	03
	2. Lower	06	06
	3. Higher	00	00
	4. Not adopted	91	91

Adoption of GTH 1 Tobacco Cultivation

As far as adoption of improved practices of GTH-1 cultivation was concerned (Table 3) majority of GTH-1 cultivators adopted recommended time (68 %) and spacing (60 %) of transplanting. Great majority (93 %) of farmers had not adopted green manuring. Only 12 and 27 % had adopted recommended dose of FYM and inorganic fertilizers respectively. It was also revealed that majority (78 %) had followed the toppings as per recommendation and given irrigation four times (62 %) during crop period. As far as adoption of plant protection measures were concerned, very few tobacco growers had adopted practices for the control of various insect-pests and diseases.

Opinion of tobacco growers for GTH1

As far as opinion of tobacco growers for GTH 1 was concerned (Table 4), it can be realized that nearly cent per cent growers had given favourable opinion in terms of production, size, colour, quality, quantity and smoking taste of GTH 1 tobacco.

Table 4. Opinion of Tobacco Growers of GTH-1 (N=100)

Sr.No.	Opinion	No.	Percent
1.	Yield over other varieties		
	Higher	100	100
	lower	00	00
2.	Leaf quality		
	Good	54	54
	Medium	27	27
	Poor	19	19
3.	No of leaves		
	More	100	100
	Less	00	00
4.	Size of leaves over other varieties		
	Larger	100	100
	Smaller	00	00
5.	Colour of dry leaves		
	Good (Parrot green)	87	87
	Dull	13	13
6.	Smoking test		
	Strong	89	89
	Mild	11	11

Constraints

The results (Table 5) indicated that the major problems faced by GTH-1 growers in descending order of ranks were unfavorable marketing policy

created by tobacco merchants, low market prices of product, high rate of labour wages, labour crises at transplanting, high cost of fertilizers and seeds, poor involvement of co-operative organizations, etc.

Table 5. Constraints faced by farmers in adoption of GTH-1 cultivation (N=100)

Sr. No.	Constraint	Mean Score	Rank
1.	Unfavorable marketing policy created by tobacco merchants	3.00	I
2.	Low market prices of the product	2.81	II
3.	High rate of labour wages	2.79	III
4.	Labour crises at transplanting	2.61	IV
5.	High cost of fertilizers	2.58	V
6.	High cost of seeds	2.51	VI
7.	Poor involvement of co operatives in marketing of tobacco	2.40	VII
8.	Lake of knowledge of recommendations	2.10	VIII
9.	Non availability of seedlings as required	1.80	IX

Suggestions offered by GTH-1 growers to improve their level of adoption

The suggestions offered by the GTH1 tobacco growers are presented in Table 5 with their mean score values and ranks. At present due to dormancy of co-operative sectors, private traders have become dominant in the tobacco market. As a result farmers are not receiving cash payment of their product immediately after selling. Thus, respondents suggested that marketing facility should be improved for the cash payment of products for that, tobacco co-operatives should be initiated at village level.

Table 6. Suggestions offered by GTH 1 growers to improve their level of adoption

Sr. No.	Suggestion	Mean value	Rank
1.	Marketing facility should be improved for the cash payment of products	3.00	I
2.	Tobacco Co operatives should be initiated at village level	2.80	II
3.	Seeds should be made available in required quantity at reasonable rate.	2.71	III

Conclusion and Implication

It can be concluded that overwhelming number of respondents had knowledge about various recommended cultivation practices of GTH-1. The practices like green manuring control measures for stem borers and nematodes were known by limited number of the tobacco growers. As far as adoption of improved practices of GTH-1 was concerned, majority of farmers had adopted recommended time and spacing of transplanting and topping practices, whereas, very few of them had adopted recommended doses of FYM, inorganic fertilizers and control measures of pest and diseases control measures. The results further indicated that majority of farmers had undergone four to five times desuckering and given four irrigations to the crop. The majority of the GTH-1 growers had opined favourably for GTH-1 with respect to production, size, colour, quality, quantity and smoking taste of leaves. From this study it is suggested that more efforts should be made to solve constraints faced by farmers and motivate them to adopt more recommended practices such as fertilizer application and plant protection measures to improve per unit production of tobacco.

Distribution of coefficient of variation of agricultural field experiments

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Abstract

Coefficient of variation expressed in per cent (C.V.%) is a good index of reliability of the results of any kind of field experiment Plot-wise yield data of 906 experiments conducted in Randomised Complete Block Design (RCBD) on six pulse crops, viz. arhar, cowpea, urid, mung, guar and gram at 25 research stations of Gujarat Agricultural University were collected and analysed by analysis of variance technique. The results revealed that the C.V.% of agricultural field experiments followed positive skewed distribution.

Key words : Coefficient of variation, skewed distribution, frequency distribution

Introduction

The precision of the treatment estimates depends on the magnitude of experimental error which is usually expressed in term of coefficient of variation (C.V.%). The C.V.% is a ratio of standard are deviation to the mean, expressed in per cent. Lot of information is available on the distributions of mean and standard deviation singly. However, no work on distribution of C.V. % of agricultural field experiments is seen in literature (Patel, 1994). Therefore, present study was taken up to study the distribution of C.V.% of field experiments conducted over space and time.

Results and discussion

The frequency distribution of C.V.% is presented in Table 1 along with Chi-square values for goodness of fit. The frequency distribution (Table 1 and Figure 1) showed that the C.V.% followed skewed distribution. The calculated χ^2 (210.77) was highly significant, indicating thereby that the goodness of fit to normal distribution was poor.

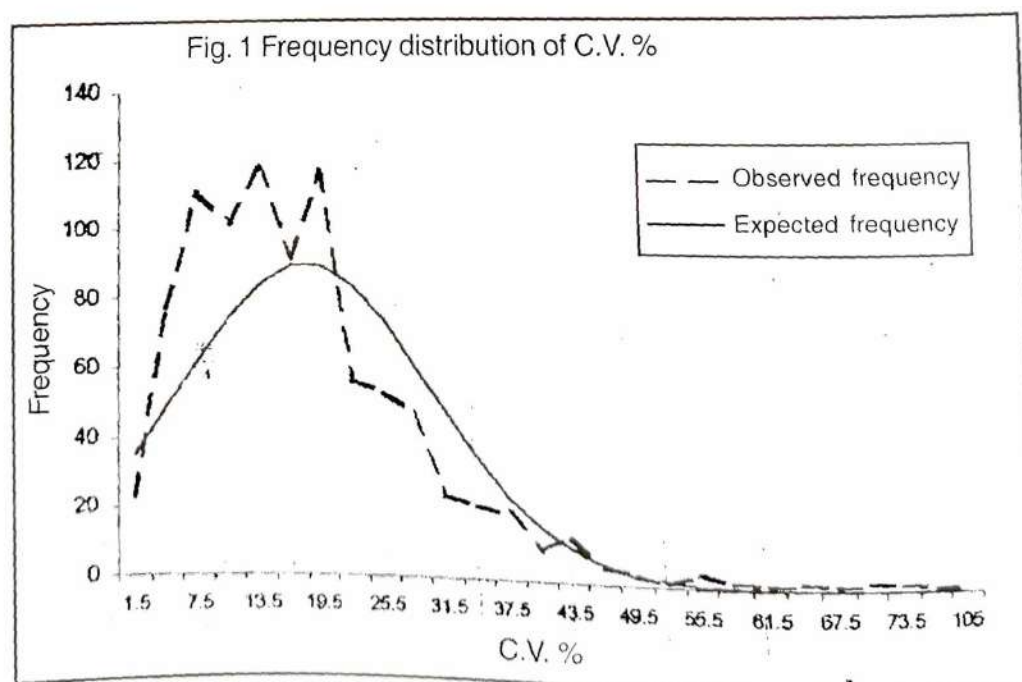


Table 2. Frequency distribution of C.V.% and Chi-square test for goodness of fit

Sr. No.	Class (C.V.%)	Observed frequency No. of experiments	Z	P	Expected frequency	Chi-square
1	<3					
2	3-6	23	-1.2442	0.0389	35.26	4.26
3	6-9	77	-0.9942	0.0534	48.37	16.94
4	9-12	111	-0.7441	0.0683	61.86	39.04
5	12-15	102	-0.4941	0.0823	74.52	10.13
6	15-18	118	-0.2441	0.0930	84.24	13.53
7	18-21	91	0.0060	0.0988	89.51	0.02
8	21-24	117	0.2560	0.0986	89.37	8.54
9	24-27	56	0.5061	0.0926	83.89	9.27
10	27-30	53	0.7561	0.0816	73.93	5.92
11	30-33	47	1.0061	0.0676	61.24	3.31
12	33-36	24	1.2562	0.0527	47.74	11.83
13	36-39	21	1.5062	0.0385	34.87	5.52
14	39-42	19	1.7563	0.0265	23.97	1.03
15	42-45	9	2.0063	0.0171	15.50	2.73
16	45-48	13	2.2563	0.0104	9.43	1.35
17	48-51	5	2.5064	0.0059	5.38	0.03
18	51-54	3	2.7564	0.0031	2.84	0.01
19	54-57	1	3.0065	0.0016	1.48	77.31
20	57-60	4	3.2565	0.0007	0.63	
21	60-63	2	3.5066	0.0004	0.36	
22	63-66	1	3.7566	0.0001	0.09	
23	66-69	2	4.0066	0.0001	0.09	
24	69-72	1	4.2567	0.0000	0.00	
25	72-75	2	4.5067	0.0000	0.00	
26	75-78	2	4.7568	0.0000	0.00	
27	78-81	1	6.4237	0.0000	0.00	
28	81-84	1	8.0906	0.0000	0.00	
Total		906			844.59	210.77**

*Legend : ** Significant at 99 % level of confidence.

For confirming the type of distribution, various statistic were worked out. The mean and variance of the distribution obtained were 17.97 and 143.36 respectively. The third and fourth moments about mean were 3235.12 and 200625.27 respectively. If the sample is from a normal distribution, then the coefficient of skewness i.e. $\sqrt{b_1}$ is approximately distributed with mean zero and standard deviation $\sqrt{6/n}$ (Snedecor and Chochran, 1967). For the distribution (Table 2) $\sqrt{b_1}=1.88$ which was about 24 times greater than its standard deviation. The shape as well as $\sqrt{b_1}$ value indicated that the C. V.% followed positive skewed distribution.

The estimate of coefficient of kurtosis g_2 was 9.76. If the sample is from normal distribution, the and is

distributed with mean zero and standard deviation $\sqrt{24/n}$ (Snedecor and Chochran, 1967). Here g_2 was much larger than its standard deviation. This further supported that the C.V.% of experiments on pulse crop followed positive skewed distribution.

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Effect of inter and intra row spacing on yield and quality of castor (*Ricinus communis* L.) Cv.GCH-5

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Castor (*Ricinus communis* L.) is an important cash and non-edible oilseed crop of arid and semi arid region. Non monetary inputs like spacing play an important role for boosting the seed yield depending on growth habits, which is governed by edaphically and climatic factors. GCH 5 is new released castor hybrid and its growth habit is quite different than other cultivated castor hybrids and very meager data on this aspect of the crop cultivars is available under North Gujarat condition. Hence the present investigation was undertaken to find out the optimum inter and intra row spacing for castor Cv. GCH 5.

A field trial was conducted during *kharif* season of 1995-96, 1996-97 and 1997-98 at Main Castor-Mustard Research Station, Gujarat Agricultural University and Sardarkrushinagar. The soil was loamy sand in texture, having low in organic carbon (0.23%) and available nitrogen (176 kg/ha) and high in available P (60 kg/ha) and K (208 kg/ha) with slightly alkaline in reaction (7.7 pH). Treatments comprising three inter row spacings (90, 120 and 150 cm) in Main

plots and three intra row spacings (45.60 and 75 cm) in sub plots were laid out in split plot design with four replications. The new castor hybrid GCH 5 was sown on third week of August during the period of study. All the cultural practices were done as per recommendations and crop requirement. The crop received 582.349 and 810 mm rain in 27.28 and 24 rainy days during the years of 1995-96, 1996-97 and 1997-98 respectively.

Effect of inter row spacing

During 1995-96, wider inter row spacing of 120 and 150 cm produced significantly higher seed yield than narrower spacing of 90 cm. Whereas, during 1996-97, 1997-98 and pooled results, seed yield was not influenced by inter row spacing (Table 1). Oil content with 150 cm inter row spacing was significantly higher than 90 cm, but was at par with 120 cm inter row spacing during individual years and in pooled results except in 1995-96 where effect was non significant.

Table 1. Castor seed quality and seed yield influenced by different inter and intra row spacing

Treatment	100 seed weight (g.)				Oil content (%)			Seed yield (Kg/ha)			
	1995	1996	1997	Pooled	1996	1997	Pooled	1995	1996	1997	Pooled
Intra row spacing (cm)											
90	32.46	33.35	29.94	31.92	44.43	44.58	44.51	2977	3075	3311	3121
120	32.80	33.34	30.13	32.22	45.11	45.50	45.30	3230	3116	3098	3148
150	32.99	33.26	31.03	32.43	45.06	46.25	45.65	3405	3108	3013	3175
CD (0.05)	NS	NS	NS	NS	NS	0.49	0.53	306	NS	NS	NS
Intra row spacing (cm)											
45	32.17	33.60	30.24	32.00	44.36	44.97	44.67	2921	2881	2973	2925
60	32.52	33.04	30.45	32.00	44.50	45.66	45.08	3200	3138	3192	3176
75	33.56	33.32	30.81	32.56	45.73	45.70	45.72	3492	3280	3257	3343
CD (0.05)	1.12	NS	NS	NS	1.01	0.58	0.55	320	193	NS	136
Inter x	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Sig.
Intra row spacing interaction											

Effect of intra row spacing

The effect of plant-to-plant spacing (intra row spacing) was found significant in 1995, 1996 and also in pooled analysis. The intra row spacing of 75 cm gave the significantly higher seed yield (3343 kg/ha) in pooled analysis and it was at par with 60 cm intra row spacing in the year 1995 and 1996. Crop sown with 75 cm intra row spacing recorded the significantly highest oil content. Whereas, differences between 45 cm and 60 cm intra row spacing were statistically most similar.

Interaction effect between inter and intra row spacing

Responses on seed yield due to interaction effect between inter and intra row spacing was not positive during individual years, but was positive in pooled results (Table 2). Crop sown by 150 cm x 75 cm spacing recorded the significantly highest seed yield of 3570 kg/ha (Table 2). Similar results were obtained by (DOR, 1997).

Table 2. Interaction table of inter x intra row spacing (Pooled)

Inter row spacing (cm)	Intra row spacing (cm)		
	45	60	75
90	2962	3234	3167
120	2929	3222	3293
150	2853	3073	3570

S.Em+ : 82.51 C.D. (0.05) : 235.84

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Effect of integrated nutrient management on growth, yield and economics of *kharif* pearl millet (*Pennisetum glaucum*)

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The use of organic manures held a prestigious position among the farmers for quality crop produce and sustainable crop production in past before green revolution appeared in the country but introduction of dwarf and nutrient hungry high yielding varieties in the late sixties made a habit to consume huge quantity of chemical fertilizers. Constant use of chemical fertilizers created a problem of soil health and sustainable crop production and even to increasing population. It is well known that addition of organic manures have shown considerable increase in crop yield and exert their significant influence on physical, chemical and biological properties of soil. However, use of organics alone can not feed the hungry mouth of billions unless they form a part of integrated nutrient management. But their use is not significant to meet the requirement of nutrients. Therefore, use of both organic manures and chemical fertilizers in appropriate proportion assume special significance as complementary to each other in crop production. Hence, experimentation was planned to study the effect of organic manures and chemical fertilizers alone and in combinations on pearl millet crop.

A field experiment was conducted at College Agronomy Farm, Gujarat Agricultural University, Anand Campus, Anand during the *kharif* season of 1997. The soil was loamy sand in texture having pH 7.48, low in nitrogen (0.023 %), medium in available phosphorus (51 kg P_2O_5 /ha) and rich in available potassium (338.20 K_2O /ha). The experiment comprised of twelve treatments as given in Table 1. In treatments 1 to 10, nitrogen was applied @ 100 kg/ha from different combinations of organic manures and chemical fertilizers, while in treatment 11, 100 kg N/ha was applied from urea. Treatment 12 was kept as control in which recommended dose of 80 kg N/ha was applied in form of urea. Common dose of phosphorus @ 40 kg P_2O_5 /ha as basal application in form of single superphosphate was given to all the treatments. The

experiment was laid out in randomized block design with four replications. Pearl millet variety GHB-15 was used as test crop and 23 days old seedlings were transplanted on 18th July 1997 after on set of monsoon. Entire quantity of FYM, castor cake, poultry manure and single superphosphate were applied in rows at the time of field preparation for transplanting of the crop. Half quantity of N from urea was applied at the time of sowing and remaining N from urea was applied as top dressing at 30 days after transplanting in respective treatments. The crop was harvested at 90 days when attained maturity.

The growth characters such as plant height and leaf area index at 60 days after transplanting significantly influenced due to different treatments, wherein, plant height recorded under treatment T_5 (100% N from castor cake) was significantly higher than rest of the treatments barring T_4 , which was found to be on par. The leaf area index measured at 60 days after transplanting observed to be higher under T_{11} (100 % N from urea as per soil test) than other treatments, but it was at par with T_5 . The protein content indicated more under treatment T_6 . Similar results were also reported by Patel *et al.* (1995). The values of yield attributes such as number of effective tillers/plant, length of earhead and test weight were recorded maximum under treatment T_{11} . The grain yield was significantly higher under treatment T_{11} , but it was at par with T_6 , while, straw yield was significantly higher under treatment T_5 that was at par with treatments T_{11} and T_4 . The higher straw yield under treatment T_5 might be due to increase in plant height as well as leaf area mobilized more protein pools available through accelerated photosynthetic rate for greater dry matter production. These results are akin to those reported by Verma (1996) and Duivenbeeden *et al.* (1993). The cost-benefit analysis of the treatments indicated that application of nitrogen through urea as per soil test (T_{11}) accrued maximum net realization with BCR of 1.76.

Table 1. Effect of different treatments on growth, yield and economics of *kharif* pearl millet

Treatment No.	Treatment details	Plant height (cm)	Leaf area index (60 DAS)	Effective tiller/Plant	Earhead length (cm)	Test weight (g)	Protein (%)	Grain yield (kg/ha)	Straw Yield (kg/ha)	Net gain/ Loss (Rs/ha)	BCR
T ₁	100 % N from FYM	164	0.46	1.2	17.8	5.25	8.89	945	1895	- 2664	-ve
T ₂	75 % N from FYM + 25 % N from CC	172	0.75	1.4	18.1	5.28	9.33	1089	2417	- 2111	-ve
T ₃	50 % N from FYM + 50 % N from CC	185	1.00	1.5	18.6	6.04	9.04	1251	3347	- 1185	-ve
T ₄	25 % N from FYM + 75 % N from CC	201	1.88	1.2	20.2	5.67	9.04	1506	4207	- 158	1.02
T ₅	100 % N from CC	212	2.00	2.1	21.1	6.13	10.06	1502	4687	- 62	-ve
T ₆	12.5 % N from FYM + 12.5 % N from CC + 75 % N from Urea	187	1.67	2.2	21.4	6.06	10.65	1706	3833	2640	1.40
T ₇	25 % N from FYM + 25 % N from CC + 50 % N from Urea	197	1.42	2.1	20.6	6.37	10.06	1566	3948	1619	1.23
T ₈	37.5 % N from FYM + 37.5 % N from CC + 25 % N from Urea	187	0.99	2.6	20.0	6.22	9.96	1341	3549	- 188	-ve
T ₉	25 % N from FYM + 50 % N from CC + 25 % N from PM	192	0.93	1.8	20.1	6.15	10.35	1352	3733	- 417	-ve
T ₁₀	25 % N from FYM + 25 % N from PM + 50 % N from Urea	190	1.38	2.1	19.7	5.90	9.77	1585	3590	1865	1.28
T ₁₁	100 % N from Urea (As per soil test)	192	2.52	2.9	21.6	6.76	10.06	1976	4219	4666	1.76
T ₁₂	100 % N from Urea (As per RD)	200	1.82	2.1	20.9	6.61	9.04	1631	3979	2948	1.49
	S.E.m. ±	4	0.17	0.06	0.72	0.08	0.33	91	183	-	-
	CD (P=0.05)	12	0.50	0.17	1.93	0.24	0.96	263	528	-	-

NB: FYM= Farmyard manure; CC= Castor cake; PM=Poultry manure; RD=Recommended dose of N, 80 kg/ha

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Effect of plant densities and integrated nutrient supply practices on growth, nutrient uptake and productivity of rice

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Rice is the major food crop of the country which occupies 44.8 m ha with an average productivity of 2929 kg ha⁻¹ against 6321 kg ha⁻¹ in China. In recent years there is stagnation in rice productivity (FAO, 1999). The degradation of soil fertility due to over mining of nutrients and inadequate replenishment through fertilizers are the causes. Supplementary and complementary use of organic manures, green manures and chemical fertilizers, can only sustain soil productivity. China has successfully sustained the productivity level of rice-wheat system by supplementing 50 per cent N requirement of the crop through organic sources which convincingly shows the importance of using organic sources in conjunction with chemical fertilizers (Von Uexkull and Mutert, 1992). In irrigated command areas of our country water, land and solar radiation use efficiency can be achieved by evolving agrotechniques for higher productivity which are sustainable. Hence the present study was conducted to maximise the rice productivity by integrating nutrient sources at higher plant density.

The field experiment was conducted at the Agricultural Research Station, Kathalagere in Davangere district during summer 1999. Soils of the experimental site were sandy clay loam with pH 6.30, electrical conductivity of 0.20 dsm⁻¹ and organic carbon 0.63. The available NPK content of the soil was 249, 12.3 and 135 kg N, P₂O₅ and K₂O per ha respectively. The treatments consisted of two plant densities 5.00 and 6.67 lakh hills per ha planted at 20cm x 10cm and 15cm x 10cm spacing respectively in main plots and six combinations of integrated nutrient sources and levels as detailed in Table 1. Thus there were 12 treatments combinations laid out in split plot design replicated four times. The net plot size was 6.0 m x 2.7 m. Jaya rice cultivar was sown in the nursery on 20th Jan 1998. Seedlings were transplanted in the experimental plot on 13th February 1998. Fifty percent nitrogen, entire dose of phosphorus, potassium, ZnSO₄ and FYM as per the treatments was applied before transplanting. In treatments F₄

and F₅, 40 days aged sunnhemp (*Crotalaria juncea*) raised in situ was incorporated three days prior to transplanting rice. Remaining nitrogen as per the treatments was top dressed at 25 per cent each at 30th and 60th day of Transplanting. The sources of NPK used were urea, single superphosphate and muriate of potash respectively. The crop matured in 140 to 145 days after sowing. The observations on growth, yield parameters and yield per ha. were recorded. Nutrient uptake by the crop was estimated by adopting standard procedure. The net income was computed. The data were analysed statistically and presented at five per cent level of significance.

The grain yield was highest (58.08 q ha⁻¹) with higher plant density of 6.67 lakh hills ha⁻¹ which was significantly superior to lower plant density of 5.00 lakh hills ha⁻¹ (55.12 q ha⁻¹). Grain yield increase was mainly attributed to more number of hills per unit area. Less number of tillers per hill (14.9) shorter panicle length 20.4 cm, lower panicle weight (2.66g) and less number of grains per panicle (87) with higher plant density (6.67 lakh hills ha⁻¹) as compared to lower plant density was compensated by more number of hills per unit area (Table 1). Rao *et al.* (1990) also obtained lower panicle weight, fewer filled grains per panicle at closer spacings while higher number of filled spikelets and panicle weight at wider spacing. Straw yield did not differ significantly due to spacing levels. Higher plant density produced numerically higher straw yield over lower plant density (Table 2). Taller plants (84.9 cm), more number of leaves (58.2) and leaf area index (6.73) with higher plant density as compared to lower plant density (83.7 cm, 56.4 and 4.90 respectively) compensated straw yield. Increased plant height at higher plant density was attributed to competition among plants for solar radiation and space. As a consequence plants grew taller with less tiller production. Thousand grain weight and harvest index were lower with high density population and with increased levels of nutrient supply. Lower 1000 grain weight was compensated by more number of grains per panicle under high plant density (Table 1). Nitro-

Table 1. Effect of dplanting densities and integrated nutrient use on the growth and yield parameters of rice

Treatments	Plant height (cm)	Leaf area index	Tillers hill ⁻¹	Total dry matter Hill ⁻¹	Panicle length (cm)	Penicle weight (g)	Grains panicle ⁻¹	1000 grain weight (g)
Plant density								
5.00 lakh hills per ha (S ₁)	83.7	4.90	16.1	36.46	21.5	2.87	90	28.83
6.67 lakh hills per ha (S ₂)	84.9	6.73	14.9	36.04	20.4	2.66	87	28.35
CD at 5 %	1.1	0.03	0.9	NS	0.49	0.05	1.1	0.20
INM Practices								
100% NPK, 20 Kg ZnSO ₄ , 5 t FYM ha ⁻¹ (F ₁)	82.7	5.36	14.9	35.40	19.9	2.56	84	28.77
125 % NPK, 20 kg ZnSO ₄ , 5t FYM ha ⁻¹ (F ₂)	83.8	5.61	15.4	36.83	20.9	2.54	87	29.02
150 % NPK, 30 kg ZnSO ₄ , 5t FYM ha ⁻¹ (F ₃)	86.5	6.08	16.6	36.94	21.7	3.06	88	27.55
F ₂ + sunhemp green manure (F ₄)	87.5	6.11	16.8	37.82	21.8	3.11	93	28.59
F ₃ - sunhemp green manure (F ₅)	88.0	6.39	16.7	41.06	22.0	3.15	98	28.31
85 : 30 : 50 kg N:P ₂ O ₅ : K ₂ O ha ⁻¹ (F ₆)	77.2	5.35	12.8	29.46	19.3	2.21	81	29.38
CD at 5 %	1.1	0.06	0.7	0.74	0.59	0.14	1.5	0.17

Table 2. Effect of planting densities and integrated nutrient use on the nutrient uptake, harvest index, yield and net income rice

Treatments	Nutrient uptake (Kg ha ⁻¹)			Harvest index	Grain yield (q ha ⁻¹)	Straw yield (t ha ⁻¹)	Net Income (Rs.ha ⁻¹)
	N	P	K				
Plant density							
5.00 lakh hills per ha	114	14.5	127	42.50	55.12	7.54	23748
6.67 lakh hills per ha	127	14.4	135	42.40	58.08	7.89	25075
CD at 5 %	10.4	NS	0.65	NS	0.55	NS	606
INM Practices							
100% NPK, 20 Kg ZnSO ₄ , 5 t FYM ha ⁻¹	114	12.9	114	43.80	52.87	6.79	23245
125 % NPK, 20 kg ZnSO ₄ , 5t FYM ha ⁻¹	125	14.9	126	43.70	57.36	7.40	25012
150 % NPK, 30 kg ZnSO ₄ , 5t FYM ha ⁻¹	114	15.8	140	43.00	59.20	8.02	25385
F ₂ + sunhemp green manure	141	16.6	144	40.40	60.65	8.79	26768
F ₃ - sunhemp green manure	144	14.9	155	40.20	60.55	8.95	25522
85 : 30 : 50 kg N:P ₂ O ₅ : K ₂ O ha ⁻¹	88	11.7	110	43.60	49.00	6.32	20540
CD at 5 %	4.4	1.3	2.9	0.02	1.78	0.32	774

gen and potassium uptake by the crop was significantly higher under high density population as compared to lower density but P uptake did not differ significantly. There was an increase in net income by Rs. 1327 ha⁻¹ with high density population over lower plant population. The increase in net income was due to increase in grain yield in the corresponding treatment.

Grain yield was significantly higher with the use of 150 % recommended NPK 30 kg ZnSO₄ per ha and 10t FYM ha⁻¹ (59.20 q ha⁻¹) (F₃), 125 % recommended NPK, 20 kg ZnSO₄ and 5t FYM ha⁻¹ and sunnhemp *in situ* green manure (F₄) (60.65 q ha⁻¹) and 150 per cent recommended NPK, 30 kg ZnSO₄ per ha and 10 t FYM ha⁻¹ with *in situ* green manure (F₅) (60.55 q ha⁻¹) as compared to 100 or 125 % recommended NPK, farmyard manure and ZnSO₄ use or farmers practice of 85, 30 and 50 kg N, P₂O₅ and K₂O and 2t FYM ha⁻¹. The plant height (86.5 cm to 88.0 cm), number of leaves (58.1 to 62.2) and leaf area index (6.08 to 6.39) in these treatments were superior to rest of the treatments. Hence the active photosynthetic surface is greater. As a consequence tiller number (16.6 to 16.8) and total dry matter per hill (36.94 to 41.06g) were improved. This was reflected in yield parameters viz., panicle length (21.7 cm to 22.0 cm), panicle weight (3.06 g to 3.15 g), grains per panicle (88 to 98). The superiority of these yield attributes as a consequence of adequate availability of nutrients through chemical fertilizers, farmyard manure and green manure and ZnSO₄ was attributed for higher grain yield in F₃, F₄ and F₅. Straw yield also followed the trend of grain yield recording 8.02, 8.79 and 8.95 ha⁻¹ with F₃, F₄ and F₅ treatments respectively. The percent increase in grain and straw yields with F₄ over the farmers practice was 23.8 and 41.6 per cent respectively. Similarly with 100 per cent recommended NPK, ZnSO₄ and FYM. the increase was 12.8 per cent grain and 29.5 per cent straw. The increased yields with 125% recommended NPK, 5t ha farmyard manure and 20 kg ZnSO₄ per ha along with *in situ* green manure may be attributed to adequate supply of nutrients. Sharanappa and Shivaraj (1996) also obtained higher grain yield of rice with the use of green manures. The lower harvest index with increase nutrient supply in F₄ and F₅ treatments was due to

higher accumulation of dry matter in the straw. The possible reasons may be poor sink size or poor translocation of photosynthates to economic plant part. The chemical fertilizers meet the immediate crop nutrient demand while farm yard manure and green manure satisfied the subsequent nutrient demand of the crop. As a consequence N and K uptake was higher in F₄ and F₅, but P uptake was higher in F₄, Sharanappa and Shivaraj (1997) also observed higher NPK uptake and grain yield with *Sesbania rostrata* green manure followed by sunnhemp (*Crotalaria juncea*). The net income with conjunctive use of chemical fertilizers at 125 % recommended NPK, ZnSO₄ at 20 kg ha⁻¹, 5t FYM ha⁻¹ and green manures was higher by Rs. 6228 over farmers practice and Rs. 3523 over 100 per cent recommended NPK, ZnSO₄ and FYM per ha.

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Fertigation study in castor

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Castor is grown under irrigated condition in North Gujarat (AES-1) where the soils are sandy to sandy loam in texture and due to this leaching and volatilization losses of nitrogen fertilizers are high. Earlier study showed that the castor responds to drip irrigation and economically higher yield was obtained with 0.8 ADFPE, which saves 25 per cent water and gives 36 per cent higher yield over surface irrigation (Anonymous, 1996). Use of fertilizer has not been efficient due to higher costs and inefficient management. Therefore, the most important approach to mitigate the fertilizer management problems would be to increase fertilizer use efficiency through adoption of 'fertigation' technique. With this purpose an experiment was planned to workout economic fertilizer schedule through drip for castor.

A field experiment was conducted in randomized block design with six replications during rainy season of 1995-96 to 1997-98 at Main Castor Mustard Research Station, Gujarat Agricultural University, Sardar krushinagar with castor variety GCH-4. The soil is sandy loam in texture with pH 7.9, low in available nitrogen (142 kg/ha), medium in available P_2O_5 (55 kg/ha) and high in available K_2O (244 kg/ha). The crop was sown by adopting recommended package of

practices in the inter and intra row spacing of 90 cm and 60 cm respectively, with basal fertilizer dose of 20-50-00 kg/ha N, P_2O_5 and K_2O (244 Kg/ha). The treatments comprised four nitrogen levels viz.: 40,60,80 and 100 kg N/ha and nitrogen was applied in five splits through drip (fertigation). In surface flood method the recommended irrigation schedule, i.e. 6 cm depth of irrigation at 15-20 days interval and 100 kg N/ha recommended nitrogen dose were followed. The treatments under drip were irrigated at 0.8 pan evaporation fraction on alternate days, a recommendation for castor crop for this region (Anonymous, 1996).

The individual as well as pooled results of castor seed yield presented in Table 1 showed that the seed yield differences due to different nitrogen levels were significant. The significantly higher seed yield was recorded with the application of nitrogen @ 100 kg N/ha through drip in the year 1996 and in pooled analysis and it was at par with 80 kg N/ha applied through drip during 1995 and 1997. The results corroborate the earlier findings in Gujarat in castor (Anonymous, 1999) and in cotton (Vaishnava *et al.* 1995).

Table 1. Yield and economics as influenced by different N levels through fertigation in castor

Treatment	Seed yield (kg/ha)				Additional Yield over lower level (kg/ha)	Add. Income over lower level (Rs./ha)	Add. Cost over lower level (Rs./ha)	Net income over lower level (Rs./ha)	Net ICBR
	1995	1996	1997	pooled					
40% N through drip	2435	2495	3466	2799	-	-	-	-	-
60% N through drip	2659	2712	3677	3016	217	3146	185	2961	1:16.00
80% N through drip	3013	3219	3825	3352	553	8019	370	7649	1:20.67
100% N through drip	3239	3577	4160	3655	856	12412	555	11857	1:21.36
100% N soil application (Traditional method)	2592	2966	3749	3013	214	3103	555	2548	1:04.59
SE m ±	153	112	148	78					
CD (0.05)	452	329	437	220					

Selling price of castor Rs. 1450/q, Urea Rs. 425/q

The results further indicated that application of 60 kg N/ha through drip gave seed yield comparable to the conventional method with 100 kg N/ha (soil application). This may be due to better utilization of N owing to good development of root system of castor crop. The results are in agreement with the earlier findings at Navsari, Gujarat in late sown castor in clayey soil (Anonymous, 1999). Thus, this study revealed that through fertigation about 40 per cent nitrogen fertilizer can be saved without any ill effect on castor seed yield. Fertigation, thus, increased the fertilizer use efficiency as compared to the normal fertilizer technique.

The economical analysis showed that the additional net income of Rs.1 1857/ha over lower level of 40 kg N/ha through drip was maximum in application of 100 kg N/ha through drip with net incremental cost benefit ratio of 1:21.36. Thus, these results showed that the farmers who have their own drip irrigation set, can apply 100 kg N/ha through drip (fertigation) for maximum yield, maximum net return and increased nitrogen use efficiency. Application of nitrogen through drip (fertigation) save 40 kg N/ha as the compared to traditional method.

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Effect of mulching on soil moisture conservation and fruit drop of *Ambia bahar* in Nagpur mandarin

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The fruits of Nagpur mandarin in *Ambia bahar* (January-February) drop down at various stages of fruit development due to many causes. The continued fruit drop results in considerable reduction in total yield, affecting the profit of the mandarin grower. Mulching is known to increase the yield of the mandarin because it helps in conservation of the soil moisture and regulate soil temperature (Lohar *et al.* 1995). Therefore, present investigation elucidates the response of various mulches on soil moisture status and fruit drop of *Ambia bahar* in Nagpur mandarin.

The experiment was conducted in the orchard of All India Coordinated Research Project (T.F), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 1996-97. The uniform trees (12 years age) were selected to the experiment. Uniform cultural practices were adopted for all the treatments. The experiment consisted of five mulching treatment viz., dry grass mulch (wheat straw), leaf mulch (subabul), soil mulch (hand digging), weed mulch (dicot weeds) and untreated control. Two trees were kept as a treatment unit and replicated four times in a Randomized Block Design. All the treatments were applied before the onset of summer i.e. first week of February. In each treatment surface area under tree was covered with mulching material. Field capacity was worked out before the starting of experiment. The soil moisture percentage has been worked out on oven dry basis at 30 cm depth at 15 days interval. The observation of fruit drop was recorded at 15 days interval.

Data presented in Table 1 shows that highest available soil moisture was recorded with dry grass mulch which was at par with leaf mulch treatment. The percentage increase in moisture conserved is 28.15% over control, whereas least moisture percentage was recorded with control except weed mulch treatment. Morimoto and Ozawa (1991) reported that mulching increase the soil moisture in oranges. Bal and Sandhu (1999) also found that paddy straw mulch was beneficial to maintain soil moisture and reduce the soil temperature in lemon. Minimum fruit drop was observed with dry grass mulch followed by leaf mulch, whereas maximum was with control. Results are in close conformity with the findings of Lohar *et al.* (1995) who noticed reduced fruit drop in mandarin with leaf mulch.

The data on fruit drop studies presented in Table 2 revealed that maximum fruit drop was observed in the month of May and August. Two definite major waves of fruit drop in Nagpur mandarin during the months of May and October have been reported by Tayde and Ingle (1997). The fruit drop in the month of May was observed due to low soil moisture, high temperature and low relative humidity. The fruit drop in August was found to be associated with higher relative humidity, saturated moisture condition and favourable climatic conditions for occurrence of pests and diseases.

Table 1. Effect of various mulches on conservation of soil moisture and fruit drop in Nagpur mandarin

Treatment	Soil moisture (%)	Fruit drop (%)
1. Dry grass mulch	16.16	71.14
2. Leaf mulch	15.70	72.64
3. Soil mulch (hand digging)	14.64	76.72
4. Weed mulch	13.37	79.89
5. Control (no tillage)	12.61	82.12
'F' test	Sig.	Sig.
SE (m) ±	0.261	0.741
CD at 5 %	0.805	2.22

Table 2. Effect of various mulches on fruit drop (%) and available soil moisture (%) in Nagpur mandarin

Month	T ₁		T ₂		T ₃		T ₄		T ₅	
	Fruit drop	ASM	Fruit drop	ASM	Fruit drop	ASM	Fruit drop	ASM	Fruit drop	ASM
Feb.	-	18.10	-	18.01	-	17.41	-	16.84	-	15.80
March	5.82	17.92	5.91	17.65	6.13	16.34	6.47	15.02	6.93	13.21
April	8.15	16.21	8.26	15.42	8.67	14.10	8.92	13.26	9.34	11.29
May	11.36	14.28	11.47	13.69	12.12	12.61	12.60	10.81	12.86	10.19
June	6.74	19.29	6.76	13.76	6.31	12.74	7.26	10.92	7.86	10.26
July	5.61	-	5.68	-	5.83	-	5.16	-	5.92	-
Aug.	13.48	-	14.22	-	15.46	-	16.77	-	17.14	-
Sept.	9.14	-	9.26	-	10.14	-	10.91	-	10.96	-
Oct.	6.16	-	6.37	-	6.54	-	6.82	-	6.30	-
Nov.	4.68	-	4.71	-	4.92	-	4.98	-	4.81	-
Total	71.14	-	72.64	-	76.72	-	79.89	-	82.12	-

ASM - Available soil moisture

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Okra - a new host of *Fusarium solani* in Gujarat

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Okra (*Abelmoschus esculentus* Lin Moench, family : Malvaceae) is locally known as Bhindi. It is an important vegetable crop of South Gujarat. It occupies substantial area amongst vegetable crop in India and is grown during rainy season (July-October) in black clay-loamy soils. The crop has been observed to suffer from important wilt disease. The wilt of okra caused by *F. oxysporum* f. sp. *Vasinfestum* was reported by Chattopadhyay and Basu (1975), Rao (1963), Grover and Singh (1969) and Chohan and Singh (1972) from West Bengal, Maharashtra, Haryana and Punjab respectively.

The wilt caused by *Fusarium solani* (Mart.) App and Wr. was recorded during the survey conducted in South Gujarat. The pathogen isolated from the wilted okra plant closely resembled the description of *Fusarium solani* (Mart.) App and Wr. The pure culture sent to Indian Type Culture Collection, Division of Mycology and Plant Pathology, I A.R.I., New Delhi for identification and same was identified as *Fusarium solani*.

The diseased seedlings showed sudden dropping and drying of the apical region and the leaves. In the hypocotyl region at the ground level, deep brown to black discoloration and decay of the cortical tissues was noticed. Due to death of the laterals, the root system was adversely affected. The attacked seedlings in most of the cases, die within a very short time of the appearance of the symptoms.

Mycelium hyaline, conidia loosely arranged in heads, Macroconidia thick walled with rounded ends or straight with pointed ends measuring 10.9-36.3 x 65 mm with 1-3 septa; microconidia, oval shaped measuring 2.8 - 5.3 x 5.5-6.5 mm; chlamydospores were round, terminal or inter calary, single or in chains and measuring 10.1 - 11.1 mm.

A perusal of literature showed no previous record of okra as host of *Fusarium solani* in Gujarat.

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Efficacy of insecticides against citrus pests

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Citrus, *Citrus aurantifolia* Swingle is one of the most important fruits of the world. Lime fruit is the cheapest among all citrus fruits and a good source of vitamin-C. Field trials were conducted with citrus variety 'Kagzi lime' in a randomized block design at the Horticultural Instruction Farm, C. P. College of Agriculture, Gujarat Agricultural University, Sardar Krushinagar. Insecticidal spray fluid was applied on the citrus trees with the help of a foot sprayer @ 5 litre per tree. For citrus blackfly nymph and puparia, twelve treatments were replicated three times. For citrus leaf miner, eleven treatments were replicated three times. Number of nymphs and puparia of blackfly and leaves with live leaf miner larva were recorded from each twig before and 3, 7 and 14 days after spraying. From these observations, mortality rate of blackfly nymph and puparia and leaf miner larva were worked out separately. The data were analysed statistically after adopting angular transformation.

From the results, it was evident that all the insecticidal treatments were found significantly superior (Table 1). Two weeks after the spray, monocrotophos 0.04 per cent recorded the highest nymphal mortality (93.74 %) although it was at par with dimethoate 0.03 (90.03 %) and phosphamidon 0.03 per cent (87.19 %). Neem oil @ 5 ml / lit. (42.11 %) was the least effective treatment, however, it was on par with tobacco snuff decoction @ 20 gm / lit. (42.95 %), fenvalerate 0.01 (53.29 %) and endosulfan 0.07 per cent (55.19%). The remaining treatments viz., quinalphos, acephate and dichlorvos were moderately effective and recorded more than 60 per cent mortality of *A. woglumi* nymphs. The present studies were in conformity with Makar *et al.* (1982) who reported that monocrotophos was the most effective treatment followed by phosphamidon and dimethoate against blackfly nymph. Katole *et al.* (1996) and Jadhav *et al.* (1997b) also reported that monocrotophos was the most effective insecticide against blackfly nymph. Two weeks after spraying, monocrotophos 0.04 per cent (74.99%) recorded the highest mortality of blackfly puparia, however, it was

at par with dimethoate 0.03 (73.36%) and phosphamidon 0.03 per cent (70.10%). Neem oil @ 5 ml/lit. (40.10%) was the least effective and at par with tobacco snuff decoction 20 gm/lit. (41.21 %) but better than control (21.80 %). Amongst remaining treatments, quinalphos, chlorpyrifos, endosulphan, fenvalerate and were moderately effective as they registered more than 50 per cent control of blackfly puparia. In past, Katole *et al.* (1994) reported effectiveness of monocrotophos, dimethoate and phosphamidon against citrus blackfly puparia supporting the present findings.

The results (Table 2) indicated that all the insecticidal treatments exhibited persistent toxicity against *P. citrella* larva and were significantly superior over control. Two week after the spray, monocrotophos 0.04 per cent was the most effective treatment (94.27 %), however it was at par with phosphamidon 0.03 (90.80%) and methyl - o - demeton 0.05 per cent (84.71%) larval mortality and also at par with each other. Among the remaining treatments dimethoate 0.03 (82.11%), quinalphos 0.05 (79.15%), chlorpyrifos 0.03 (76.89%), fenvalerate 0.01 (72.68%) and dichlorvos 0.03 per cent (68.17 %) showed very good control being at par with each other. The lowest larval mortality was recorded in the treatment of tobacco snuff decoction @ 20 gm/lit. (46.13 %) but showed good result than control (8.15%). Earlier to this Reddy and Savitri (1988) and Jadhav *et al.* (1997a) reported that monocrotophos was the most effective insecticide against citrus leaf miner.

From the above results, it can be concluded that monocrotophos 0.04 per cent was the most effective treatment followed by dimethoate 0.03, phosphamidon 0.03, methyl o demeton 0.05, quinalphos 0.05 and chlorpyrifos 0.03 per cent against citrus blackfly and leaf miner. The botanical preparation like neem oil and tobacco snuff decoction proved less effective against these pests.

Table 1. Effectiveness of insecticides tried against blackfly on Kagzi lime

Treatments	Concentration (%)	Cumulative per cent mortality 14' DAS	
		Nymph	Pupa
Neem oil	0.5	40.75 (42.11)	39.58 (40.10)
Tobacco decoction	20g/l	41.24 (42.95)	40.23 (41.21)
Acephate	0.05	56.72 (69.40)	50.12 (58.39)
Chlorpyrifos	0.03	63.05 (77.53)	51.29 (60.39)
Dichlorvos	0.03	51.71 (61.10)	46.28 (51.73)
Dimethoate	0.03	72.09 (90.03)	59.22 (73.36)
Endosulfan	0.07	48.26 (55.19)	47.30 (53.51)
Fenvalerate	0.01	47.17 (53.29)	47.00 (52.99)
Monocrotophos	0.04	76.11 (93.74)	60.32 (74.99)
Phosphamidon	0.03	69.46 (87.19)	57.17 (70.10)
Quinalphos	0.05	60.15 (74.73)	51.69 (61.06)
Control (Water spray)	-	30.74 (25.63)	28.18 (21.80)
S.E.m. $\pm$		3.29	2.85
C.D. at 5 %		9.65	8.35
C.V.%		10.40	10.23

*Figures in the parentheses are retransformed values Indicate $\arcsin \sqrt{\text{Per cent} + 0.5}$ transformed values
 DAS=Days after spraying

Table 2. Effectiveness of insecticides tried against blackfly on Kagzi lime

Treatments	Concentration (%)	Mean percentage larval mortality	
		7th day	14th day
Tobacco decoction	20g/l	39.89 (39.63)	46.13 (51.48)
Chlorpyrifos	0.03	51.95 (61.51))	61.61 (76.89)
Dichlorvos	0.03	46.43 (52.00)	55.96 (68.17)
Dimethoate	0.03	56.05 (68.31)	65.36 (82.11)
Endosulfan	0.07	42.38 (44.93)	50.26 (58.63)
Fenvalerate	0.01	49.17 (56.75)	58.80 (72.68)
Methyl-o-demeton	0.05	57.55 (70.71)	67.38 (84.71)
Monocrotophos	0.04	63.02 (78.91)	76.79 (94.27)
Phosphamidon	0.03	59.98 (74.48)	72.84 (90.80)
Quinalphos	0.05	52.99 (63.27)	63.19 (79.15)
Control (Water spray)	-	16.38 (7.45)	17.10 (8.15)
S.E.m. $\pm$		2.40	3.53
C.D. at 5 %		7.08	10.41
C.V.%		8.53	10.58

*Figures in the parentheses are retransformed values Indicate $\arcsin \sqrt{\text{Per cent} + 0.5}$ transformed values
 DAS=Days after spraying

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pest reaction and yield potential of some pre-release rice cultures

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Host plant resistance and need based chemical control are the two chief components of Integrated Pest Management. Although good progress has been made to develop varieties resistant to insect pests/ use of insecticides in a limited way would continue as one of the components of IPM (Kalode *et al.* 1977). Frequency of pesticide application must be based on population levels of pests (Mishra, 1977). Gangwar and Basgupta (1986) opined that routine chemical protection was uneconomic and therefore advocated supervised need based control measures. Hence, it is essential to generate information on the cultures reaction against pest and yield performance prior to their release. With this view, present study was undertaken to evaluate the level of resistance of some selected pre-release cultures against major pests of rice, which ultimately determine the degree of plant protection to be offered for obtaining maximum yield.

For the purpose, a field trial was laid-out in split plot design with four replications at Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat) during Kharif 1998. Need based plant protection (P) and no protection (NP) throughout the crop period were the main plot treatments. The sub-plot treatments comprised of six pre-release (Table 1) cultures ; alongwith Jaya as susceptible check and GR-11 a local high yielding cultivar (susceptible check).

Gross and net plot size were 5.0 m x 4.95 m and 4.2 m x 4.45 m. respectively. Seedlings of respective cultures were transplanted at spacing of 20 cm x 15 cm. during second week of August. Need based application of carbofuran 36 (0.75 kg a.i./ha) was applied during first week of September, whereas monoerotophos 36 WSC (0.75 kg a.i./ha). was applied during fourth week of September and second week of October.

Table 1. Details of cultures used in the study

Culture / variety	Cross	Duration (Days)	Grain type
IET-12150	BP-1105 X East	135	LB
IET- 12537	Ratna X ARC 10654	150	LS
IET- 14074	Ratna X ARC 10654	150	LS
SKL-11-28-29-65	Phalguna X Eswarakora	140	LS
RP- 3179-1462	RYT-372 X RP- 1579-1	150	LS
RP- 3174-1631	IET-8655 X IET-8642	140	LS
Jaya	T.N-1 X T-141	135	LB
GR-II	Z-31 X IR-8-246	125	LS

LB= Long and bold

LS= Long and slender

Table 2. Pest incidence and yields recorded in different cultures/varieties of rice

Treatments	Mean (%) LF Damage	WBPH/ Hill	WE/ plot	Yield (kg/ha)	
				Grain	Fodder
Main Plots					
P	6.09	13.86	2.72 (1.55)*	3112	7046
NP	10.26	31.28	4.75 (2.04)	1805	6422
S.Em. ±	0.22	0.41	0.05	59.59	90.55
C.D. at 5%	1.01	1.85	0.20	268.17	407.97
C.V.(%)	14.70	10.42	14.30	13.71	7.61
Sub- Plots					
IET-12150	5.97	35.65	5.80 (2.46)	2672	6240
IET- 12537	8.27	12.78	0.0 (0.71)	2321	7384
IET- 14074	9.07	23.08	0.0 (0.71)	1338	7494
SKL-11-28- 29-55	8.67	12.39	4.38 (2.09)	3230	6227
RP-3179-1462	9.00	22.06	0.75 (0.99)	2525	6401
RP-3174-1631	8.94	20.54	2.30 (1.58)	2869	7611
Jaya	9.08	24.82	8.38 (2.95)	2638	6173
GR-11	10.01	27.27	8.13 (2.87)	2077	8253
S.Em. ±	0.27	0.60	0.17	138.99	335.39
C.D. at 5%	0.78	1.72	0.49	397.07	958.12
C.V.(%)	8.99	7.62	26.80	15.99	14.09

* Figures in parenthesis are $\sqrt{X + 0.5}$ transformed values.

Observations on leaf folder (LF), *Cnaphalocrocis medinalis* Guen. and white backed plant hopper (WBPH) *Sogatella furcifera* (Horv.) were recorded when the incidence was at peak level. For the purpose, total number of leaves and LW damaged leaves were counted in 10 hills selected at random from net plot. Similarly, WBPH population was recorded from 10 hills in net plot. Stem borer (SB), *Scirpophaga incertulas* (Walker) incidence appeared during heading stage, was assessed by counting total number of white earheads (WE) per plot. At harvest, grain and fodder yields were recorded separately from net plot area. Data thus obtained were statistically analysed and presented in Table 2.

Results revealed that the reaction in pest incidence due to need based plant protection was significant (Table 2). Among the cultures evaluated, significantly least (5.97 %) incidence of leaf folder was registered in IET-12150. The culture IET-12537 ranked second by exhibiting significantly low (8.27 %) damage than both the susceptible checks (Jaya and GR-11). Rest of the cultures were at par with Jaya. White backed planthopper population was significantly low (12.39 to 12.78 hoppers/hill) in IET-12537 and SKL-11-28-29-55 compared to all other cultures evaluated, IET-14074, RP-3179-1462 and RP-3174-1631 cultures recorded moderately lower level (20.54 to 23.08 hoppers/hill) of hoppers than the susceptible checks (24.82 to 27.27

hoppers/hill). As per the report of Korat et al. (1998), significantly low (8.96 hoppers/hill) population of WBPH was recorded in IET-12537 than the susceptible checks (Jaya and GR-11) strongly support the present findings.

Stem borer incidence was relatively low during the study period. However, its damage assessed at heading stage revealed that IET-12537, IET-14074 and RP-3179-1462 cultures remained free from borer attack.

Grain and fodder yield was significantly enhanced following need based application of insecticides. Increase in grain and fodder yield irrespective of cultures/varieties owing to plant protection measures was about 13.07 (72.4 %) and 6.24 q/ha (9.7 %) respectively. Increase in yield from 16.74 to 31.32 q/ha with chemical protection as compared to that of without protection has been reported by Yein and Rahman (1984). Similarly, Korat et al. (1998) recorded 12.7 and 3.51 q/ha yield enhancement in case of grain and fodder respectively, due to need based plant protection. These reports are in accordance with the present findings.

The highest (3230 kg/ha) grain yield was registered in SKL-11-28-29-55 followed by RP-3174-1631 (2869 kg/ha) and IET-12150 (2672 kg/ha). These three cultures produced significantly higher grain yield over local check GR-11 (2077 kg/ha). Relatively better performance of SKL-11-28-29-55 with regard to grain yield reported (Anonymous, 1999) is akin to the above results. With respect to fodder yield the highest (7611 kg/ha) yield was harvested in RP-3174-1631 followed by IET-14074 (7494 kg/ha) and IET-12537 (7384 kg/ha).

From the overall results based on pest incidence and yield potential, it can be concluded that the cultures IET-12537 and SKL-11-28-29-55 could be judged as high yielding pest resistance genotypes. These can be utilised as donors for developing resistant breeding lines in varietal improvement programme.

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Bionomics of painted bug, *Bagrada hilaris*. (Burmeister)

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The painted bug, *Bagrada hilaris* (Burmeister) is found in almost all the mustard growing States and becoming a regular menace to the mustard growers. Due to its heavy attack, mustard crop suffered substantial loss in yield, seed weight and oil content (Bakhetia and Sekhon, 1989; Singh *et al.*, 1980). This pest is the major limiting factor in lowering productivity of mustard crop in Gujarat. No work has been done on biology of this pest except the solitary report of Joshi (1980) who studied the bionomics of *B. hilaris* in Middle Gujarat. Therefore, the study was undertaken on bionomics of this pest under South Gujarat.

Initial culture of *B. hilaris* was raised in the laboratory. The field collected nymphs were released in the glass jar (20 x 15 cm.) and fresh food was supplied everyday until they attained adult stage. The newly emerged adults were separated as male and female and were paired separately in petridish (10 x 1.7 cm.). The fresh food was supplied everyday. The eggs laid by individual female were removed with the help of camel hair brush and kept in petridish. The colour and shape of eggs were recorded. The size was measured under student microscope. In order to study incubation period number of freshly laid eggs were observed daily till hatching. The newly hatched nymphs were transferred individually on the fresh mustard leaves and supplied with fresh food everyday. The moulting was confirmed by presence of exuvium on the leaf. The observations on individual nymphal instar period were recorded. Newly emerged adults were paired separately as described earlier. The pre oviposition, oviposition, and post- oviposition period alongwith fecundity were recorded. Longevity of male and female was also recorded. The colour, shape and size of each nymphal instar and adult were noted. Size was measured with the help of microscope as described earlier. For determining the sex ratio the adults collected from mustard fields were separated on the basis of size and genital aperture. The sex ratio was also determined from the culture raised in the laboratory.

The female of *B. hilaris* laid eggs either singly or in cluster of 2 to 13. The freshly laid eggs were dirty white in colour and changed from orange yellow to onion skin and pink at the time of hatching. The eggs were translucent, hard and more or less cylindrical at both the ends. Similar observations were recorded by Rakshpal (1949) and Joshi (1969). The length of the eggs ranged from 0.806 to 0.917 mm (average 0.875 ± 0.040 mm.) while, the breadth ranged from 0.639 to 0.694 mm (average 0.668 ± 0.022 mm.). The incubation period varied from 4 to 9 days (average 6.54 ± 0.88 days) (Table 1). The incubation period reported by Rakshpal (1949) and Joshi (1968) was in conformity with the present findings.

The nymphal stage passed through 5 instars. The newly hatched nymph was light orange in colour with dark and red eyes, later on turned to reddish brown. It was oval in shape with head more or less elliptical. Antennae and tarsi were 4 and 2 segmented, respectively. The second instar nymph was bright orange in colour with two prominent red eyes. As the nymph developed, colour of the abdominal segments gradually changed into reddish brown whereas, head, antennae, thoracic segments and legs turned blackish in colour. There were three different sized black bands on dorsal as well as on ventral side of the abdomen. The body of third instar nymph was reddish, whereas, head, antennae, thorax, and legs were blackish in colour. One more black band developed on the dorsal abdominal segments. The head was rectangular in shape and two prominent compound eyes present on it. The fourth instar nymph was orange in colour and it turned to black at later stage. The orange and white mixed coloured markings appeared on each side of the head. Wing pads were visible. The fifth instar was orange to reddish in colour and assumed the colouration of the adult. Four prominent black bands were present on the dorsal side. Black, white and yellow spots were seen on the pleural region of the abdominal segments. Developing genital appendages were also visible. The length of first, second, third, fourth and fifth

Table 1. Measurements and duration of different stages of *B. hilaris*

Stage	Length (mm)			Breadth (mm)			Period (days)		
	Min.	Max.	Av. $\pm$ S.D.	Min.	Max.	Av. $\pm$ S.D.	Min.	Max.	Av. $\pm$ S.D.
Egg	0.806	0.917	0.875 $\pm$ 0.040	0.639	0.694	0.668 $\pm$ 0.022	4	9	6.54 $\pm$ 0.88
Nymph									
1 st instar	0.861	1.111	1.016 $\pm$ 0.081	0.722	0.961	0.793 $\pm$ 0.051	3	5	3.60 $\pm$ 0.71
2 nd instar	1.389	1.528	1.454 $\pm$ 0.054	1.000	1.111	1.049 $\pm$ 0.031	3	8	5.60 $\pm$ 1.47
3 rd instar	1.722	1.944	1.820 $\pm$ 0.058	1.388	1.528	1.446 $\pm$ 0.043	4	7	5.76 $\pm$ 1.17
4 th instar	2.806	3.000	2.883 $\pm$ 0.066	1.778	2.139	1.966 $\pm$ 0.104	4	9	6.00 $\pm$ 1.29
5 th instar	4.375	4.813	4.592 $\pm$ 0.125	2.938	3.437	3.155 $\pm$ 0.144	6	9	7.16 $\pm$ 0.80
Total	-	-	-	-	-	-	24	32	28.12 $\pm$ 2.56
Adult									
Male	6.500	6.722	6.599 $\pm$ 0.071	2.861	3.083	2.961 $\pm$ 0.069	6	25	14.68 $\pm$ 4.85
Female	7.839	7.639	7.541 $\pm$ 0.082	3.889	4.194	4.045 $\pm$ 0.089	15	30	21.20 $\pm$ 4.43
Pre-oviposition	-	-	-	-	-	-	3	10	6.52 $\pm$ 2.24
Oviposition	-	-	-	-	-	-	4	21	11.28 $\pm$ 4.63
Post-oviposition	-	-	-	-	-	-	0	9	3.40 $\pm$ 2.80
Total life cycle	-	-	-	-	-	-			
Male	-	-	-	-	-	-	39	63	52.48 $\pm$ 7.08
F-male	-	-	-	-	-	-	44	70	54.72 $\pm$ 7.59

nympal instar ranged from 0.861 to x 1.111 mm (average 1.016 $\pm$ 0.081 mm), 1.389 to 1.528 mm (average 1.454 $\pm$ 0.054mm), 1.722 to 1.944 mm (1.82 $\pm$ 0.058 mm), 2.806 to 3 mm (average 2.883 $\pm$ 0.066 mm) and 4.735 to 4.813 mm (average 4.592 $\pm$ 0.125 mm), respectively. Where as, the breadth varied from 0.722 to 0.861 mm, (average 0.793 $\pm$ 0.051 mm), 1.000 to 1.111 mm (average 1.049 $\pm$ 0.031 mm), 1.388 to 1.528 mm (average 1.446 $\pm$ 0.043 mm), 1.778 to 2.139 mm (average 1.966 $\pm$ 0.104) and 2.938 to 3.437 mm. (average 3.155 $\pm$ 0.144 mm), respectively. (Table 1). The average development period of first, second, third, fourth and fifth instar was 3 to 5 days (average 3.60 $\pm$ 0.71 days), 3 to 8 days (average 5.60 $\pm$ 1.47 days), 4 to 7 days (average 5.76 $\pm$ 1.17), 4 to 9 days (average 6.00 $\pm$ 1.29 days) and 6 to 9 days (average 7.16 $\pm$ 0.80 days), respectively. The total nymph period varied from 24 to 32 days with an average of 28.12 $\pm$ 2.56 days other workers reported it to be 33 to 36 days (Bhai and Singh, 1961) and 14 to 18 days (Rohilla and

Kumar, 1991). This variation might be due to the different climatic conditions prevailing during study period and different host plants used as food.

The adult was quite distinct, beautifully patterned with white, orange and yellow coloured small spots on the wings. There were two whitish orange patches at the upper side of the forewing. The hind wing were transparent with black strip. Two orange coloured bands joint together to form V shaped structure on the head. Antennae was black in colour with five segments and somewhat hairy in structure. Legs were black in colour with whitish line. Tarsi was three segmented. The male was smaller in size than female with a blunt abdomen while, it was developed into a pointed ovipositor in case of female. The body length and breadth of male and female varied from 6.500 to 6.722 mm (average 6.599 $\pm$ 0.071 mm) and 2.861 to 3.083 mm (average 2.961 $\pm$ 0.069mm), whereas female measured 7.839 to 7.639 mm (average 7.541 $\pm$ 0.082 mm) in length and 3.889 to 4.194 mm (average 4.045 $\pm$ 0.098 mm)

in breadth. The morphological character and measurement described above are in concurrence with the findings of Rakshalpal (1949), who reported that the male and female was 6.6mm and 7.5 mm long, respectively. The sex ratio of male to female was 1:1.04 and 1:1.02 for field collected and laboratory reared adults, respectively. The longevity of male varied from 6 to 25 days (average 14.68 ± 4.85 days) whereas, in case of female, it varied from 15 to 30 days (average 21.20 ± 4.43 days) indicating the male life shorter than the females.

Adults started mating soon after emergence and the copulation period was about 2 to 2.5 days. The pre-oviposition, oviposition and post-oviposition period was 3 to 10 days (average 6.52 ± 2.24), 4 to 21 days (average 11.28 ± 4.63 days) and 0 to 9 days (average 3.40 ± 2.80 days), respectively. Almost similar observations were reported by Joshi (1968). The total number of eggs laid by an individual female varied from 53 to 186 with an average of 112.08 ± 34.43 .

Total duration of life cycle of male and female was 39 to 63 days (average 52.48 ± 7.80) and 44 to 70 days (average 54.72 ± 7.59 days), respectively. However, the earlier report on total duration of life cycle (21 to 27 days) by Dhiman and Gandhi, 1988 are not in conformity with the present findings. This might be due to difference in environmental conditions.

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path analysis of independent variables on the level of knowledge of Hybrid-6 cotton growers

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Cotton is one of the most important commercial fiber crop of India. It is one of the prime source of natural fiber. It support to prestigious textile industry and generates employment to millions of people.

Gujarat is one of the major cotton producing state in the country, it covers about 16 lacs hectares area under cotton crop, producing 7.14 lacs MT bales of cotton but production per hectare is very low (453 Kg/ha.) as compared to other states. (Anonyma 2001)

The various reasons for low productivity of cotton in Gujarat and India as compared to world's average are fluctuations in the rainfall pattern, improper management of resources (like soil, water and nutrients), faulty plant protection techniques, weak extension- link denying improved technology to cotton growers who continue to follow traditional methods as well as non acceptance and non-adoption of the cotton cultivation technology by the farmers. Keeping this in view, the present study was conducted to know the influence of independent variable on the knowledge level of the Hybrid-6 cotton growers both directly as well as through other variable present in the situation.

The present study was conducted in Mahuva taluka of Bhavnagar district of Gujarat state during December 1992 to January 1993. This taluka has maximum area under Hybrid-6 cotton cultivation. Out of 134 villages, 16 villages were purposively selected having maximum area under Hybrid-6 cotton cultivation. A sample of 150 hybrid-6 cotton growers was drawn from these selected villages by resorting to proportionate random sampling method. The data were collected from the respondents with the help of interview schedule.

Path effects were obtained by solving simultaneous equations set up for the purpose using the correlation matrix. The path coefficient analysis was carried out as per the formula suggested by Dewey and Lu (1959)

considering X_1 to X_{11} as independent variable to be influencing the dependent variable Y the knowledge level of Hybrid-6 cotton growers.

The data were presented in the Table 1 showed that the variables viz., education (0.680), economic motivation (0.212), size of family (0.119), localite-cosmopolite value orientation (0.069) and extension participation index (0.017) exhibited positive direct effect, whereas age (-0.107), technological gap (-0.057), social participation (-0.048), size of land holding (-0.039), mass media exposure (-0.010) and other occupation (0.009) exhibited negative direct effect on knowledge level of Hybrid-6 cotton growers.

The education had maximum direct effect (Rank-I) followed by economic motivation (Rank-II), size of family (Rank-III), age (Rank-IV), localite-cosmopolite value orientation (Rank-V), technological gap (Rank-VI), social participation (Rank-VII), size of land holding (Rank-VIII), extension participation (Rank-IX), mass media exposure (Rank-X) and other occupation (Rank-XI) in descending order, respectively. The education had taken the positive and first place among the variables having direct effect, probably due to the Hybrid-6 cotton growers acquired more knowledge about Hybrid-6 cotton technology. Education being personal variable associated with an individual any external factors operating this should necessarily be a function of Hybrid-6 cotton growers.

The data revealed that all the variables except age, size of family and technological gap had positive total indirect effect on knowledge level of Hybrid-6 cotton growers. Further, it can be observed that mass media exposure had maximum total indirect effect (0.782), whereas, size of family had minimum and negative indirect effect (-0.054) on knowledge.

The mass media exposure had occupied first rank by contributing maximum to the knowledge level about new technology of Hybrid-6 cotton growers indirectly.

Table 1. Direct and Indirect Effects of Selected Independent Variables on Level of Knowledge of Hybrid-6 Cotton Growers

Independent variables	Direct effect		Total indirect effect		Substantial indirect effect through variable			
	Effect	Rank	Effect	Rank	1		2	
					Effect	Var.	Effect	Var.
X ₁ Age	-0.107	IV	-0.191	VII	-0.216	X ₂	0.054	X ₃
X ₂ Education	0.680	I	0.154	VIII	0.176	X ₈	-0.080	X ₁₀
X ₃ Size of family	0.119	III	-0.054	XI	-0.048	x ₁	-0.017	X ₄
X ₄ Size of land holding	-0.039	VIII	0.144	IX	0.105	X ₂	0.052	X ₃
X ₅ Other occupation	-0.009	XI	0.115	X	0.052	X ₂	0.039	X ₈
X ₆ Social participation	-0.048	VII	0.497	IV	0.375	X ₂	0.103	X ₈
X ₇ Technological gap	-0.057	VI	-0.364	V	-0.355	X ₂	-0.099	X ₈
X ₈ Economic motivation	0.212	II	0.547	II	0.566	X ₂	-0.073	X ₁₀
X ₉ Extension participation	0.017	IX	0.346	VI	0.289	X ₂	0.083	X ₈
X ₁₀ Mass media exposure	-0.010	X	0.782	I	0.559	X ₂	0.160	X ₈
X ₁₁ Localite-cosmopolite value orientation	0.069	V	0.510	III	0.451	X ₂	0.137	X ₈

The probable reason for this might be that higher exposure to various sources of information facilitated farmers to get detailed information, experience and conviction about modern farm technology.

Similar findings were reported by Purohit (1981) and Bhople and Ingle (1990).

The data in Table 1 reported that the first maximum substantial indirect effect was exerted by economic motivation (0.566) followed by mass media exposure (0.559), localite-cosmopolite value orientation (0.451), social participation (0.375), technological gap (-0.355), extension participation (0.289), age (-0.216), size of land holding (0.105) and other occupation (0.052) respectively routed through the variable education. Whereas, education (0.176) and size of family (-0.048) had its positive and negative substantial indirect effect through economic motivation and age respectively.

In case of second largest substantial indirect effects age and size of land holding had their indirect effects through size of family. Education and economic motivation had their indirect effects through mass media exposure; size of family had its indirect effect through size of land holding. Whereas, mass media

exposure, localite-cosmopolite value orientation, social participation, technological gap, extension participation index and other occupation had their indirect effect through economic motivation.

The reason may be that Hybrid-6 cotton growers had first substantial indirect effect of economic motivation for earning income from farming by growing the cash crop of groundnut and cotton as well as their favorable attitude toward new farm technology and large size of land holding.

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