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Physiological Components of Wheat as Influenced by Seed Treatments During Storage

B. M. Patel, B. A. Patel* and P. D. Vekaria

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ABSTRACT

Seed of four wheat genotypes (Sonalika, Lok-1, Kalyan Sona and GW 496) treated with carbendazim, thiram, methyl parathion and castor oil alongwith a control were stored in polythene bags and evaluated for physical characters (seed index and seed density) and physiological characters (seed moisture and imbibitional rate). Seed moisture fluctuated and followed the pattern of fluctuations of atmospheric RH. A change in seed index followed the pattern of change in seed moisture. Imbibitional rate increased with decrease in seed moisture and seed index. Variety GW 496 recorded lower seed moisture and higher seed index throughout the storage while variety Lok-1 recorded higher imbibitional rate. Seed treatment with thiram was found beneficial as it recorded lower seed moisture and higher seed density as well as imbibitional rate throughout the storage.

(Received on 27th March, 1996)

INTRODUCTION

A seed is most important input in modern agriculture. The crop yields basically depend on quality of seed. The safety of seed in storage is greatly dependent on the level of the moisture content which is closely related to the surrounding relative humidity (Singh, 1986). Cereal seeds loose their viability in a short period if they are stored under improper storage conditions. Under Indian conditions, ideal storage godowns are scarce. So emphasis on alternatives such as seed protectants and seed packaging devices become more suitable and economic substitutes. Seed treatment offers protection during storage, maintains the viability of seeds and in certain cases enhances it. However, information on

changes in treated wheat seeds stored under ambient conditions is scarce. Hence, this experiment was conducted with different wheat varieties and seed treatments under ambient conditions of Sardar Krushinagar.

MATERIALS AND METHODS

Seeds of four wheat varieties viz., Sonalika, Lok-1, Kalyan Sona and GW 496 were cleaned with the help of seed blower and sun dried to adjust the moisture to 10 per cent. Five kg seed of each variety was treated with carbendazim (50%) and thiram (75% WDP) each @ 2 g/kg seed, methyl parathion (2% dust) and castor oil each @ 10 g/kg seed and a control (no seed treatment). Seeds were stored in polythene bags from May, 1992 in the

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laboratory under ambient conditions of Sardar Krishanagar in factorial CRD with four replications for a period of 12 months. Seeds were evaluated for physical (index and density) and physiological (moisture content and imbibitional rate) components at monthly intervals. Seed moisture was determined by hot air oven method on wet weight basis. For seed index, 100 seeds were counted and weighed on electrical balance. Seed density was measured by water displacement method as below :

$$\text{Seed density (g cm}^{-3}\text{)} = \frac{\text{Weight of seed (g)}}{\text{Volume of seed (cc)}}$$

For imbibitional rate, seeds (used for index and density) were placed on three

TABLE 1

Physico-physiological components as influenced by storage period, varieties and seed treatments.

Treatment	Seed moisture (%)	Seed index (g)	Seed density (g cm ⁻³)	Imbibitional rate (cc g ⁻¹)
Storage Period (S) (In months)				
1	10.16	4.99	1.353	0.809
2	10.21	5.05	1.362	0.819
3	10.82	5.12	1.370	0.799
4	11.28	5.19	1.379	0.786
5	11.72	5.14	1.369	0.773
6	11.53	5.87	1.355	0.764
7	11.28	5.82	1.348	0.752
8	11.07	4.99	1.343	0.762
9	10.75	4.97	1.340	0.787
10	10.39	4.95	1.336	0.801
11	0.95	4.92	1.331	0.814
12	9.73	4.90	1.331	0.821
S. Em ±	0.009	0.009	0.004	0.001
C.D. (P=0.05)	0.026	0.026	0.010	0.004

layered blotting paper kept in petri dish. The paper was fully moistened for continuous supply of moisture to seeds. These petri dishes were placed in incubator for 14 hours at $25 \pm 1^\circ\text{C}$. Seeds were removed from the dishes, blotted and then weight and volume was recorded. The imbibitional rate was determined by the following formula (Singh, 1986).

$$\text{Imbibitional rate (cc g}^{-1}\text{)} = \frac{V_2 - V_1}{W_2 - W_1}$$

where, V_1 = initial volume of seeds
 V_2 = volume of imbibed seeds
 W_1 = initial weight of seeds
 W_2 = weight of imbibed seeds

1.	2.	3.	4.	5.
Varieties (V)				
Sonalika	10.80	5.07	1.262	0.803
Lok-1	10.78	5.12	1.190	0.808
Kalyan Sona	10.71	4.91	1.559	0.787
GW 496	10.67	5.00	1.396	0.765
S. Em. $\pm$	0.008	0.007	0.004	0.001
C.D. (P=0.05)	0.023	0.019	0.012	0.002
Seed Treatments (T)				
Carbendazim	10.68	5.01	1.372	0.811
Thiram	10.64	5.01	1.372	0.817
Methyl Parathion	10.74	5.03	1.362	0.780
Castor oil	10.82	5.04	1.328	0.766
Control	10.82	5.04	1.319	0.780
S. Em. $\pm$	0.018	0.017	0.004	0.001
C. D. (P=0.05)	0.051	NS	0.012	0.002
Interaction (V x T)				
S. Em. $\pm$	0.019	—	0.005	0.002
C. D. (P=0.05)	0.052	NS	0.014	0.006

RESULTS AND DISCUSSION

Seed moisture and seed index (Table 1) fluctuated and followed the pattern of fluctuations of atmospheric relative humidity. Highest seed moisture (11.72%) was observed when the seed was tested at the end of September (5 months). The seed stored under ambient conditions passed through high atmospheric relative humidity (RH) of whole monsoon and attained the equilibrium atmospheric moisture. Similarly, lowest seed moisture (9.73%) was

observed after twelve months of storage (April) possibly due to low RH (Fig. 1). Similar trend with respect to seed moisture was reported in triticale and wheat by Agrawal (1978) and in sorghum by Singh (1986). Seed index was highest after six months of storage. The imbibitional rate was lowest (0.752 cc g^{-1}) after seven months of storage and increased with decrease in seed moisture and seed index during storage. It was highest after twelve months of storage. Seed density also increased with increase in seed moisture and

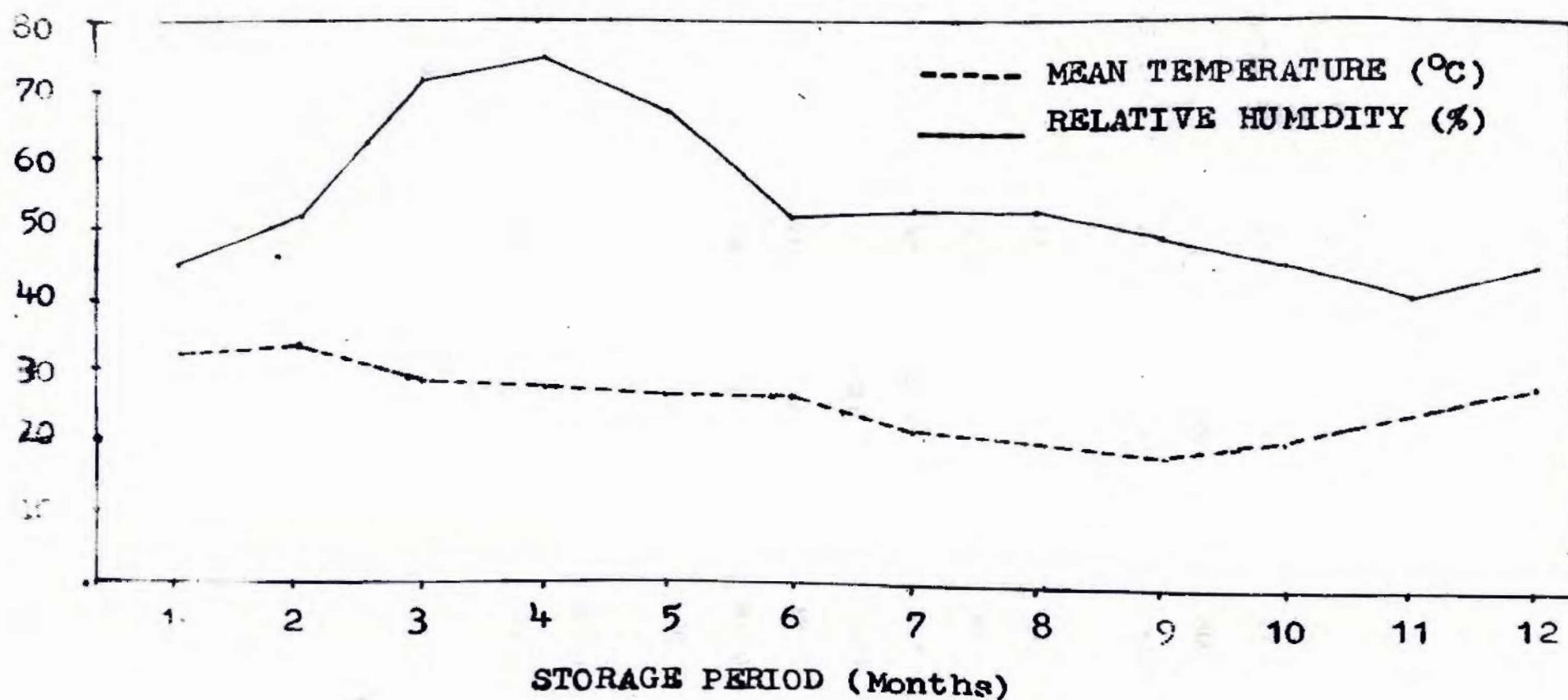


Fig. 1 : The mean monthly temperature and relative humidity recorded during May 1992 to April 1993.

seed index. It increased with storage upto four months and thereafter, decreased upon further storage. Similar results for sorghum have been reported by Singh (1986).

Significant differences in seed moisture, index, density and imbibitional rate due to varieties indicated genotypic variation for these characters. Varieties Sonalika and GW 496 recorded the highest (100.80%) and lowest (10.67%) seed moisture, respectively. But, the magnitude of difference was very small

(0.13%). The genotypic difference in moisture content in the present study may be attributed to the inherent variation in the chemical composition of seeds from different varieties. Present findings supports the findings of Aswathaiah and Murthy (1986) and Parkhe *et al.* (1987). Maximum seed density (1.559 g cm^{-3}) and imbibitional rate (0.808 cc g^{-1}) were recorded in varieties Kalyan Sona and Lok-1, respectively. Genotypic variation for these characters have also been reported by Singh (1986).

TABLE 2

Interaction effect of varieties x seed treatments on seed moisture, seed density and imbibitional rate during storage.

Varities	Seed Treatment				
	T ₁	T ₂	T ₃	T ₄	T ₅
Seed Moisture (%)					
V ₁	10.71	10.66	10.81	10.92	10.93
V ₂	10.70	10.65	10.77	10.89	10.88
V ₃	10.67	10.65	10.71	10.75	10.75
V ₄	10.64	10.62	10.67	10.72	10.72
C. D. (P=0.05) : 0.052					
Seed Density					
V ₁	1.281	1.287	1.267	1.243	1.232
V ₂	1.206	1.207	1.197	1.174	1.165
V ₃	1.585	1.589	1.574	1.524	1.519
V ₄	1.416	1.421	1.407	1.373	1.362
C. D. (P=0.05) : 0.014					
Imbibitional Rate RATE					
V ₁	0.825	0.827	0.793	0.780	0.792
V ₂	0.830	0.849	0.790	0.779	0.789
V ₃	0.810	0.812	0.772	0.765	0.774
V ₄	0.780	0.778	0.764	0.738	0.763
C. D. (P=0.05) : 0.006					

Seed moisture, density and imbibitional rate were influenced significantly by seed treatments. Thiram treated seeds recorded the lowest (10.64%) seed moisture whereas, the highest (10.82%) was recorded in untreated as well as castor oil treated seeds. The beneficial effect of thiram in maintaining lower seed moisture may be attributed to the separation of seeds from the atmospheric condition by forming relatively impermeable barrier by this fungicide (Vyas and Nene, 1975). Similarly, higher seed density 91.372 g cm^{-3} and imbibitional rate (0.817 cc g^{-1}) were recorded by thiram treated seeds. Beneficial effect of thiram have been reported by Dakshinamoorthy and Sivaprakasam (1988).

The interaction (Table 2) revealed that variety $\times$ seed treatment interaction was significant for seed moisture, density and imbibitional rate. Irrespective of varieties, seed treatment with thiram proved its superiority by recording lower seed moisture and higher

imbibitional rate throughout the storage, but was at par with carbendazim treatment. Variety GW 496 recorded the lowest seed moisture, but it was at par with Kalyan Sona. Variety Lok-1 recorded highest imbibitional rate, but was at par with Sonalika variety. Significantly lower (10.62%) seed moisture was recorded by GW 496 when treated with thiram. This combination was at par with that recorded by the seeds of all the varieties treated with thiram indicating superiority of thiram in maintaining lower seed moisture. Irrespective of treatments, variety Kalyan Sona recorded significantly higher seed density. Whereas, thiram recorded higher density which was at par with carbendazim treatment. The seeds of Kalyan Sona variety treated with thiram treatment recorded significantly higher (1.589 g cm^{-3}) seed density but it was at par with that recorded by the seeds of same variety treated with carbendazim. In the case of imbibitional rate, the seeds of Lok-1 variety treated with thiram recorded significantly higher (0.849 cc g^{-1}) value.

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Genetic Architecture of Heading and Maturity in Bread Wheat Under Early and Timely Sown Conditions

K. B. Kathirra*, L. D. Parmar and V. K. Poshya

Department of Agricultural Botany, College of Agriculture, Gujarat Agricultural University, Junagadh-362 001

ABSTRACT

A set of six generations, viz. P_1 , P_2 , F_1 , F_2 , BC_1 and BC_2 derived from the crosses KH Sel-1 x Raj 3077, Kh Sel-1 x Raj 1972, Raj 1777 x GW 496, HJ-72-4-15-2-1 x WH 147 and Raj 1771 x Lok 1 of bread wheat was used to estimate gene effects for days to heading and maturity under early and timely sown conditions. Both additive as well as non-additive gene effects were involved in the inheritance of the traits with preponderance of additive gene effects under early as well as timely sown conditions. Biparental mating approach would be useful for enhancing genetic variability and creation of transgressive segregates.

(Received on 4th Aug., 1995)

INTRODUCTION

In Saurashtra region of Gujarat, wheat is generally grown in early (first week of November) as well as timely sown (mid of November) conditions. In this area, short duration genotypes can be adjusted easily in double cropping and they are also suitable for conditions of short winter and low irrigation water availability. Early heading and maturity are indices of general efficiency of a genotype in terms of maximum returns per unit time. Information on the genetic systems controlling duration would be useful in devising suitable breeding procedures for developing early genotypes. Since information on the genetic architecture of time of heading and maturity is extremely limited, therefore, the present study has been undertaken.

MATERIALS AND METHODS

The experimental material comprised of parents, F_1 , F_2 , BC_1 and BC_2 generations of five crosses, viz. Kh Sel-1 x Raj 3077, KH Sel-1 x Raj 1972, Raj 1777 x GW 496, HJ-72-4-15-2-1 x WH 147 and Raj 1771 x Lok 1. The trial was laid out in compact family block design with three replications at College Farm, Gujarat Agricultural University, Junagadh under early (1st Nov., 1993) and timely (15th Nov., 1993) sown conditions during *rabi*, 1993-94. Parents and F_1 S in single row, BC_1 S and BC_2 S in two rows and F_2 S in four rows of 1.5 m length were sown in each replication. Spacing was kept at 25 cm between rows and 5 cm between plants within the rows. Data on five competitive plants from each plot of parents and F_1 S, 10 plants from

*Present address : Associate Research Scientist (Veg. Breeding), Vegetable Research Station, GAU, Junagadh.

TABLE 1

Scaling tests for days to heading and maturity in the five crosses of bread wheat under early (E_1) and timely (E_2) sown conditions.

Scaling tests	Kh Sel-1 x Raj 3077		Kh Sel-1 x Raj 1972		Raj 1777 x GW 496		HJ-72-4-15-2 x WH 147		Raj 1777 x Lok-1	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
Days to heading										
A	-10.00** ± 2.26	11.87** ± 3.61	-10.07** ± 3.03	5.40 ± 3.05	5.27 ± 2.75	2.40 ± 2.37	7.40** ± 2.75	1.20 ± 2.20	3.47 ± 3.21	-8.40** ± 2.30
B	17.47** ± 2.49	10.80** ± 2.21	10.20** ± 2.28	0.73 ± 1.69	12.00** ± 2.47	3.00 ± 1.98	16.80** ± 2.69	3.70 ± 2.05	10.27** ± 2.68	2.40 ± 2.64
C	-20.13** ± 4.50	0.73 ± 5.10	-10.80** ± 4.86	14.73** ± 2.46	-17.93** ± 4.21	-15.13** ± 3.48	-8.53 ± 4.44	-12.53** ± 3.72	-38.60 ± 2.89	-29.80** ± 3.71
X^2 (3df)	94.20**	34.18**	44.57**	37.36**	53.42**	30.91**	72.37**	19.16**	236.87**	75.62**
Days to maturity										
A	-4.93** ± 1.37	6.93** ± 2.38	-5.47** ± 1.98	14.93** ± 1.52	-3.87* ± 1.75	4.80** ± 1.45	13.60** ± 1.59	10.27** ± 1.83	-2.07 ± 2.67	1.20 ± 1.63
B	15.07** ± 0.89	7.20** ± 1.73	-8.67** ± 1.68	3.87 ± 2.08	7.07** ± 1.98	-1.47 ± 1.79	20.07** ± 1.89	28.80** ± 1.95	-1.33 ± 2.61	17.47** ± 1.84
C	-11.13 ± 20.78	26.27** ± 3.12	-13.67** ± 4.27	55.53** ± 2.28	-27.67** ± 4.10	-55.93** ± 2.56	-9.80 ± 4.20	-2.53 ± 3.14	-51.60** ± 2.86	4.07 ± 2.88
X^2 (3df)	352.52**	86.99**	29.18**	672.31**	91.78**	763.03**	268.17**	312.55**	338.14**	96.98**

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

each plot of BC₁S and BC₂S and 20 plants from each plot of F₂ were recorded on days to heading and maturity. Crosses showing significant variation among generations in compact family block design were subjected to generation mean analysis. Epistatic gene interactions were detected by scaling test of Hayman and Mather (1955) and joint scaling test of Cavalli (1952). Gene effects were estimated as per the Hayman (1958).

RESULTS AND DISCUSSION

The estimates of A, B and C scaling tests and significant χ^2 - values of joint scaling test revealed inadequacy of additive- dominance model for days to heading and maturity in all the five crosses under both the conditions (Table 1).

From the analysis of six-parameter model, it can be inferred that both fixable and non-fixable gene effects were significant in most of the character - cross-environment combinations (Table 2).

Both additive and dominance gene effects were significant for days to heading in Kh Sel-1 x Raj 3077, Raj 1777 x GW 496 and Raj 1771 x Lok 1 under both the conditions as well as in Kh Sel-1 x Raj 1972 and HJ-72-4-15-2-1 x WH 147 under timely sown conditions (Table 2). For days to maturity, both the main gene effects were also significant in Raj 1777 x GW 496 and Raj 1771 x Lok 1 under both the conditions; in KH Sel-1 x Raj 1992 under timely sown condition; and in HJ-72-4-15-2-1 x WH 147 under early sown condition. Preponderance of additive and dominance gene effects for both traits had been reported by Nayeem (1994). The additive component was predominant for days to heading in the cross Kh Sel-1 x Raj 1972 under early sown

condition; and for days to maturity in the cross Kh Sel-1 x Raj 3077 under both the conditions and in Kh Sel-1 x Raj 1972 under early sown condition. The dominance component was negligible in them. Predominance of additive gene effects has been reported by Tandon *et al.* (1989) for days to heading and Sharma *et al.* (1978) for days to maturity. However, the dominance component was predominant for days to heading and maturity in the cross HJ-72-4-15-2-1 x WH 147 under early and timely sown conditions, respectively.

Digenic interactions were significant for most of the cases, however, their magnitude varied depending on the character (s), parent(s) and environment(s) chosen (Table 2). Presence of epistatic effect for the inheritance of days to heading has been reported by Virk *et al.* (1989), while Reghuvanshi *et al.* (1988) reported that the inheritance of days to maturity was controlled due to additive and non-additive gene actions. Epistasis was observed more frequently in the crosses where the parents had greater diversity (Gorsline, 1961), as also observed in this study. Simultaneous occurrence of significant estimates of dominance and epistasis in most cases suggested that both types of gene actions could be due to the action of same gene (s).

It is evident from above results that rapid improvement in these traits under early as well as timely sown conditions through conventional breeding method may not produce quick and desirable results. However, maximum gain could be attained by maintaining considerable heterozygosity through mating of selected plants in early segregating generations. Such an approach would provide transgressive segregates for exploitation of further selection.

TABLE 2

Estimates of gene effects for days to heading and maturity based on digenic epistatic model in five crosses of bread wheat under early (E₁) and timely (E₂) sown conditions.

Gene effects	Kh Sel-1 x Raj 3077		Kh Sel-1 x Raj 1972		Raj 1777 x GW 496		HJ-72-4-15-2-1 x WH 147		Raj 1771 x Lok-1	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
Days to heading										
m	61.53 ± 1.05	60.78 ± 1.24	63.48 ± 0.97	64.72 ± 0.49	58.00 ± 0.95	56.45 ± 6.14	60.61 ± 0.67	56.61 ± 0.60	53.37 ± 0.55	53.33 ± 0.78
(d)	6.87** ± 1.54	13.13** ± 2.07	8.30** ± 1.48	14.40** ± 1.63	11.20** ± 1.72	7.30** ± 0.12	2.33 ± 1.35	10.03** ± 1.08	11.57** ± 1.98	4.77** ± 1.54
(h)	24.87** ± 5.27	13.80* ± 6.49	4.70 ± 5.10	-18.00** ± 3.88	36.23** ± 5.21	15.00 ± 3.65	20.96** ± 4.19	14.50** ± 3.52	53.50** ± 4.63	26.77** ± 4.51
(i)	27.60** ± 5.21	21.93** ± 6.47	10.93* ± 4.89	-8.60* ± 3.81	35.20** ± 5.13	15.73** ± 3.44	17.93** ± 3.79	16.80** ± 3.23	52.33** ± 4.54	23.80** ± 4.40
(j)	-13.73** ± 1.62	0.53 ± 2.10	-10.13** ± 1.71	2.33** ± 1.69	-3.37 ± 1.75	-2.70* ± 1.34	-12.10** ± 1.56	-0.93 ± 1.14	-3.40 ± 1.99	-5.40** ± 1.67
(l)	-35.07** ± 7.64	-44.60 ± 9.70	-11.70 ± 7.65	2.47 ± 6.98	-52.47** ± 8.08	-16.33** ± 5.94	-27.33** ± 6.99	-21.07 ± 5.70	-66.07** ± 8.42	-17.80** ± 7.19
Days to maturity										
m	104.73 ± 5.19	109.90 ± 0.73	102.65 ± 0.91	113.80 ± 0.45	95.98 ± 0.81	87.13 ± 0.41	101.23 ± 0.78	96.90 ± 0.50	92.80 ± 0.60	101.85 ± 0.54
(d)	7.83** ± 0.70	11.93** ± 1.39	17.33** ± 0.97	18.77** ± 1.16	8.53** ± 0.80	8.97** ± 0.97	10.40** ± 0.55	-0.13 ± 1.01	13.90** ± 1.75	3.87** ± 0.95

Gene effects	Kh Sel-1 x Raj 3077		Kh Sel-1 x Raj 1972		Raj 1777 x GW 496		HJ-72-4-15-2-1 x WH 147		Raj 1771 x Lok-1	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
(h)	20.37 ± 20.82	5.87 ± 4.09	-3.13 ± 4.27	-51.23** ± 3.02	34.87** ± 0.38	78.50** ± 2.73	48.83** ± 3.59	48.27** ± 3.09	50.67** ± 4.32	20.40** ± 3.03
(i)	21.27 ± 20.81	-12.13** ± 4.05	-0.47 ± 0.41	-44.46** ± 2.94	30.87** ± 3.63	59.27** ± 2.55	43.47** ± 3.30	41.60** ± 2.84	48.20** ± 4.25	14.60** ± 2.87
(j)	-10.00** ± 0.76	0.13 ± 1.46	1.60 ± 1.09	9.40** ± 1.22	-5.47 ± 0.90	3.13** ± 1.11	-3.23** ± 0.86	-9.27** ± 1.04	-0.37 ± 1.83	-8.13** ± 1.09
(l)	-31.40 ± 20.97	-2.00 ± 6.39	14.60* ± 5.76	33.40** ± 5.17	-34.07** ± 5.21	-62.60** ± 4.64	-77.13** ± 4.74	-80.66** ± 5.11	-44.80** ± 7.55	-33.27** ± 4.79

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

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Genetic Divergence in Blackgram

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ABSTRACT

Genetic diversity in 70 genotypes of Blackgram (*Vigna mungo* (L.) Hepper) estimated using Mahalanobis' D^2 value, indicated considerable diversity in the material studied. The genotypes were grouped in 8 clusters using multivariate analysis. Cluster I was the largest with 55.6% genotypes from different states except Madhya Pradesh, New Delhi and Rajasthan. Cluster VI, VII and VIII were monogenotypic. Genotypes from Gujarat exhibited the maximum diversity and were represented in all the clusters except cluster V. However, no parallelism was observed between geographic diversity and genetic diversity. Cluster I showed much genetic divergence with cluster VI, VII and VIII. It was suggested that the genotypes GU 84-2, Valsad-1 and GU 84-1 can be utilized as parents in the hybridization programme to develop a high yielding blackgram with early maturity.

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INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper) is an important legume crop, receiving importance due to short duration and widely grown as intercrop. A successful breeding programme in the crop would need information on the nature and degree of genetic divergence in the available genetic stocks with plant breeder in choosing the right parents for further improvement.

MATERIALS AND METHODS

Seventy popular geographically diverse genotypes of Blackgram from twelve states of India, were taken for present study. These genotypes were grown during *kharif* 1992-93 at Instructional Farm, Gujarat Agricultural

University, Junagadh, in a randomized block design with three replications. The plot size consisted of single row of 4 m length following a spacing of 30 cm x 10 cm. The recommended agronomical practices and plant protection measures were followed to ensure a normal crop. Observations were recorded on five randomly selected plants in each entry replication wise for twelve characters viz., seed yield per plant (g), days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of pods per plant, number of clusters per plant, pods per cluster, seeds per pod, pod length (cm), 100-seed weight (g) and protein content (%). The analysis was carried out by using Mahalanobis' D^2 statistics. The grouping of the genotypes into clusters was made as per Tocher's method (Rao, 1952).

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TABLE 1

Composition of clusters and origin of blackgram genotypes.

Cluster	Genotypes	Origin
I	UPU 80-56, UPU 80-3-5, UPU 9-40-4, PDU 5,	Uttar Pradesh
	PDU 5, PDU 2, DPU 83-2, P 26, PU 19, PU 30, PDU 10,	
	UG 370, UG 201, UG 378, UG 414, UG 298, UG 407,	Punjab
	UG 301, UG 203,	
	GU 80-1, GU 87-7, GU 87-23,	Gujarat
	UH 80-4, UH 80-7, UH 81-7, UH 82-39, UH 84-39,	Hariyana
	JU 77-41, JU 78-3, JU 78-4, JU 78-27,	Maharashtra
	No. 57, PG 16, RU 2	
	DU 5, DU 2	Bihar
	S 37, Samba 1	Jammu & Kashmir
	B 3-8-8	West Bengal
	NPRB 2	Tamil Nadu
II	GU 84-6, GU 84-8, GU 87-9, GU 87-11,	Gujarat
	GU 87-15, Zandewal	
	L 35-5-2, UG 170, UG 170 UG 218	Punjab
	PDU 319, UPM 79-1-2	Uttar Pradesh
	DB 51	Rajasthan
	C 5-61-1	New Delhi
III	KB 63	Tamil Nadu
	P 16, T 9, UL 222, UPU 2-40-1	Uttar Pradesh
	A 5-31, GU 87-10, GU 87-17	Gujarat
	No 21	Maharashtra
	B 12-4-4	West Bengal
IV	S 10	Jammu & Kashmir
	Shapur 4	Gujarat
	PDU 12	Uttar Pradesh
V	TPU 4	Maharashtra
	PDU 401	Uttar Pradesh
VI	GU 84-2	Gujarat
VII	Valsad	Gujarat
VIII	GU 84-1	Gujarat

TABLE 2

Intra and Inter cluster distance (D^2) for 76 genotypes of blackgram.

Cluster	I	II	III	IV	V	VI	VII	VIII
I	4.96	57.26	32.06	44.64	49.64	84.45	83.07	76.34
II		5.06	38.51	33.20	33.95	38.45	38.65	39.03
III			4.67	32.39	34.77	64.65	63.24	57.89
IV				4.91	40.17	48.98	57.03	45.37
V					4.50	32.75	42.03	49.40
VI						00.00	29.85	31.63
VII							00.00	40.79
VIII								00.00

TABLE 3

Cluster means for different characters in black gram.

Cluster	Number of population	Seed yield per plant (g)	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Effective number of branches per plant	Number of pods per plant	Number of cluster per plant	Number of pods per cluster	Number of seeds per pod	Pod length (cm)	100 seed weight	Protein content (%)
I	39	1.99	38.40	66.20	14.09	1.58	8.45	4.44	1.95	5.77	3.67	3.90	20.90
II	14	2.52	41.68	70.60	21.82	1.54	12.40	5.73	2.24	6.08	4.09	4.12	20.75
III	9	2.29	39.56	68.56	17.49	1.84	9.98	5.19	1.96	5.70	3.86	4.14	21.40
IV	3	2.88	38.67	68.22	17.26	1.51	13.63	6.30	2.18	5.76	3.55	3.94	19.48
V	2	3.37	43.17	72.50	21.37	2.22	8.22	5.37	1.56	5.85	3.84	4.30	18.39
VI	1	3.82	37.33	65.67	24.63	1.90	16.65	7.53	2.19	5.27	4.09	4.70	18.35
VII	1	3.60	41.67	70.33	27.40	1.53	11.50	5.93	1.94	6.70	4.30	4.50	17.95
VIII	1	3.03	37.33	65.67	23.40	1.77	13.60	10.07	1.35	5.67	3.99	4.20	18.13

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among the genotypes for all the characters studied, indicating existence of genetic diversity among the populations. All the 70 genotypes were grouped into 8 clusters on the basis of D^2 values (Table 1). Among these, cluster I was the largest having 39 genotypes representing Uttar Pradesh, Punjab, Gujarat, Haryana, Maharashtra, Bihar, Jammu and Kashmir, West Bengal and Tamil Nadu. Cluster II included 14 genotypes from six states. Cluster III was represented by 9 genotypes from four states. Cluster IV consisted of 3 genotypes from three states, cluster V possessed two genotypes consisting one each from Maharashtra and Uttar Pradesh. Cluster VI, VII and VIII had only one genotype originating from Gujarat. Thus, clustering pattern showed that genotypes of different states were clubbed into one cluster and also the genotypes of same state were grouped in different clusters. This indicated that there was no correspondence between genetic and geographical diversity. Similar findings were reported by Parameshwarappa *et al.* (1993) in blackgram.

Intra and inter-cluster average D^2 values (Table 2) indicated maximum distance be-

tween cluster I and VI (84.85) followed by cluster I and VII (83.07) and cluster I and VIII (76.34). The criterion used for selection of varieties as parent for hybridization using D^2 analysis is the inter-cluster distances. Those genotypes included in clusters with maximum inter-cluster distance are obviously genetically more divergent. Hence, it would be logical to incorporate genotypes from cluster I and VI, as parents in hybridization to obtain high heterotic combinations.

Cluster mean for different characters (Table 3) showed large differences for various traits. The cluster VI got desirable rating in respect of seed yield, days to 50% flowering, days to maturity, plant height, pods per plant and 100-seed weight whereas cluster VIII was good for earliness and cluster per plant, cluster VII for seeds per pod and pod length and cluster II, III and V for pods per cluster, protein content and branches per plant respectively. Therefore, inter crossing of such genotypes involved in these clusters would be useful for inducing variability in the respective traits. On the basis of genetic divergence and mean performance. The characters viz., plant height, pods per plant, clusters per plant, pod length and 1000-seed weight were found to be the main contributing characters for seed yield and thus are the basic attributes of plant architecture which need greater attention.

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Genetic Variability, Heritability and Genetic Advance of Various Polygenic Traits in *Capsicum*

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ABSTRACT

Genetic variability, heritability and genetic advance among 54 genotypes of *Capsicum* for ten economic traits were studied in *kharif* 1992. A wide range of phenotypic variability was observed for fresh fruits weight/plant, fruit shape index, number of fruits/plant and plant height. The highest genotypic coefficient of variation values coupled with heritability (broad sense) and genetic advance (expressed as per cent of the mean) were exerted by number of fruits/plant followed by fresh fruit weight/plant and length of fruit indicating their importance in selection. The selection based on phenotypic performance for these traits would, therefore, be most effective in yield improvement of this crop.

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INTRODUCTION

Chilli (*Capsicum annum* L. var *annuum*) is an annual and most valuable commercially grown vegetable crop of India. In spite of its importance as a spice in dried form varietal improvement is at a much less advanced stage. Germplasm collections exist in many agricultural stations in India but no systematic records are currently available on extent of variation in economic traits, so that genetic improvement can be achieved either through selection or hybridization. Therefore, information on genetic variation was collected to help the plant breeder in producing cultivars of hot pepper suitable for semi-arid areas of the country.

MATERIALS AND METHODS

The experimental material of 54 diverse accessions of chillies was sown in *kharif* 1992 at the Vegetable Research Station, Gujarat Agricultural University, Junagadh, Gujarat in a Randomized Block Design with 3 replications. The inter and intra-row spacings were 75 and 60 cm, respectively. Each accession was accommodated in a row of 6 m length. Recommended agronomic and plant protection practices were followed to raise a good crop. Five competitive plants from each entry were randomly chosen for recording observations viz., days to first fruit picking, plant height (cm), fruit length (cm), fruit girth (cm), fruit shape index, number of primary branches, number of fruits

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TABLE 1

Analysis of variance for ten polygenic traits of chillies.

Sr. No.	Character	Mean sum of squares		
		Replications (d.f. = 2)	Genotypes (d.f. = 53)	Error (d.f. = 106)
1.	Days to 50% flowering	2.75	14.16**	1.45
2.	Days to maturity	46.00	157.20**	30.41
3.	Days to first fruit picking	17.06	325.22**	6.26
4.	Plant height (cm)	6.91	546.14**	3.66
5.	Number of fruits/plant	4.59	1455.66**	4.15
6.	Number of branches/plant	0.97	2.56**	0.14
7.	Length of fruit (cm)	0.40	22.10**	0.46
8.	Girth of fruit (cm)	0.08	4.87**	0.08
9.	Fruit shape index (%)	33.62	895.16**	130.71
10.	Fresh fruit weight/plant (g)	418.12	4241.55**	259.14

**significant at 1% level.

and fresh fruit weight (g)/plant. Days to 50 per cent flowering and days to maturity were recorded on plot basis. Average values were subjected to standard statistical procedures, namely, analysis of variance (Panse and Sukhatme, 1978), genotypic and phenotypic coefficient of variation (Burton, 1952) and heritability and expected genetic advance (Allard, 1960).

RESULTS AND DISCUSSION

The data revealed highly significant varietal differences for all the ten characters studied (Table 1). The range (Table 2) showed wide variation among the genotypes for the traits, like fresh fruit weight/plant (29.33 to 168.00 g.), fruit shape index (28.69 to 135.78), number of fruits/plant (5.20 to 83.22) and plant height (22.00 to 75.00 cm). The present findings corroborated with result obtained by Padhar (1989).

The estimates of phenotypic and genotypic variance components (Table 2) were high for fresh fruit weight/plant, number of fruits/plant, fruit shape index, plant height and days to first picking indicating good amount of genetic variation for selecting superior genotypes for these characters. Similar findings were also reported by Pandya (1982), Padhar (1989) and Sahoo *et al.*, (1989).

The present study revealed high genotypic and phenotypic coefficient of variation for number of fruits/plant, length of fruit (cm), fresh fruit weight/plant(g) and girth of fruit (cm) (Table 2). The results are akin to those of Pandya (1982), Meshram (1987), Padhar (1989) and Pandita *et al.*, (1991). The closeness of these two parameters further suggested that a major portion of total variation was accounted for by the genetic cause and

TABLE 2

Mean, phenotypic range and variability parameters of ten traits in chillies.

Sr. No.	Character	Mean	Phenotypic range	Variance Components		Coefficients of Variation		Heritability (%)	Genetic advance (per cent of mean)
				Genotypic	Phenotypic	Genotypic	Phenotypic		
1.	Days to 50% flowering	50.74	45.52 — 55.20	5.69	4.24	4.06	4.70	74.51	7.21
2.	Days to maturity	212.47	198.00 — 223.00	72.67	42.26	3.06	4.01	58.15	4.81
3.	Days to first fruit picking	112.75	94.00 — 133.00	108.45	108.38	9.23	9.24	99.94	19.02
4.	Plant height (cm)	45.75	22.00 — 75.00	184.49	180.83	29.39	29.69	98.01	59.94
5.	Fruits/plant	39.98	5.20 — 83.22	487.99	483.84	55.02	55.25	99.15	112.85
6.	Branches/plant	5.74	4.20 — 7.43	1.95	1.81	15.06	16.98	93.00	46.61
7.	Length of fruit (cm)	6.53	2.79 — 12.58	7.67	7.21	41.12	42.41	94.01	82.13
8.	Girth of fruit (cm)	3.98	1.85 — 6.75	1.68	1.60	32.75	32.54	95.20	63.82
9.	Fruit shape index (%)	65.86	28.69 — 135.78	385.53	364.61	27.99	28.81	94.58	58.08
10.	Fresh fruit weight/plant (g)	94.68	29.33 — 168.00	1586.61	1549.00	38.48	42.07	97.67	84.61

thus, selection based on phenotypic performance would be rewarding for improvement in these traits.

The perusal of data (Table 2) further revealed that the heritability values were of higher magnitude in eight traits except days to 50 per cent flowering and days to maturity. *Capsicum* researchers also obtained high value of heritability for major fruit yield and associated traits, like number of fruits/plant (Ramakumar *et al.*, 1981, Pandita *et al.*, 1991 and Varalakshmi and Hari Babu, 1991), fruit size (Padhar, 1989), number of branches/plant (Sahoo *et al.*, 1989), girth of fruit (Ramakumar *et al.*, 1981), fruit length and plant height (Sahoo, *et al.*, 1989 and Varalakshmi and Hari Babu, 1991) and fruit yield (Pandita *et al.*, 1991). Selection criteria for yield and its associated components may be useful in chillies as reflected by very high heritability values. The highest heritability was recorded for days to first picking (99.94%) but low GCV

and PCV values render this character unsuitable for direct selection for further improvement.

The expected genetic gain at 5% selection intensity was highest for number of fruits/plant (112.85%) followed by fresh fruit weight/plant (84.61) and length of fruit (82.13). The results are in accordance with Ramakumar *et al.*, (1981) and Pandita *et al.*, (1991) for number of fruits/plant and Pandya (1982) and Pandita *et al.*, (1991) for fruit yield/plant.

Results of present study indicate that direct selection based on number of fruits/plant, fresh fruit weight/plant and length of fruit having high GCV, high heritability coupled with high genetic advance may be utilized in future capsicum breeding programmes for developing high yielding varieties and also in characterization of germplasm.

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Estimation of Genetic Parameters of Yield Characters in Grain Sorghum (*Sorghum bicolor* (L.) Moench)*

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ABSTRACT

Estimates of additive, dominance and epistatic gene effects for eight quantitative traits, viz., days to flowering, flag leaf area, panicle weight, panicle length, number of primary branches, length of primary branch, yield per plant and grain weight have been obtained in grain sorghum. The material studied included the parental lines and the F_1 , F_2 , B_1 and B_2 derivatives of the crosses SR 388-1 x ICSR 89022-3 and SR 405-1 x ICSR 89022-3. The results revealed that most of the traits are under the control of additive and non-additive genetic components. Preponderance of dominance (h) effect was observed for flag leaf area, number of primary branches, length of primary branch, grain yield and grain weight. The type of gene action appeared to favour the crosses for exploitation of hybrid vigour.

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INTRODUCTION

For the improvement in yield contributing characters studies on nature of gene action governing complex quantitative characters are of great value to the breeder. Information on the presence of type of epistatic gene effects in the inheritance of various quantitative characters to improve the characters is very important for future breeding programme. In the present study, an attempt has been made to know the nature and magnitude of additive, dominance and epistatic gene effects for eight yield characters under summer and *kharif* environments.

MATERIALS AND METHODS

Genotypes SR 388-1, ICSR 89022-3 and SR 405-1 were crossed by hand emasculation and pollination in 1991. Two hybrids SR 388-1 x ICSR 89022-3 and SR 405-1 x ICSR 89022-3 were prepared for generation mean analysis.

In summer 91-92 the F_1 were selfed and F_2 were prepared. The F_1 were crossed with respective P_1 and P_2 for B_1 and B_2 generation. The F_1 , F_2 , B_1 , B_2 and parental generations were grown at the College Farm, College of Agriculture, Junagadh during summer (S) and *kharif* (K) seasons of 1992-93 with three

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replications. Parents and F_{1s} were grown in single-row plots, B_{1s} and B_{2s} were sown in two-row plots and F_{2s} in four row plots. Row length was 5.0 m with spacing of 34 x 15 cm. Observations on 5 random plants in parents and F_{1s} , 10 plants in B_{1s} and B_{2s} and 20 plants in F_{2s} selected per replication were recorded for days to flowering, flag leaf area (cm^2), panicle weight (g), panicle length (cm), number of primary branches, length of primary branch (cm), yield per plant (g) and grain weight (g) in summer (s) and *kharif* (k) seasons.

The gene effects were estimated by 6 - parameter (Hayman, 1958) and 3 - parameter models (Jinks and Jones, 1958) following the weighted least square technique of Cavalli (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed significant generation differences in cross SR 388-1 x ICSR 89022-3 for days to flowering, panicle weight, grain yield per plant and grain weight under both the seasons, whereas for flag leaf area, panicle length, number of primary branches and length of primary branch significant differences were observed only in *kharif* season. In cross SR 405-1 x ICSR 89022-3 significant differences were observed in both the seasons for panicle weight, panicle length, number of primary branches, length of primary branch, grain yield per plant and grain weight, whereas in *kharif* significant differences were observed for days to flowering and flag leaf area.

Non-significant X^2 values for panicle weight and yield per plant under summer environment in cross SR 388-1 x ICSR 89022-3, whereas in cross SR 405 x ICSR

89022-3 for number of primary branches in summer and length of primary branch in *kharif* season indicated the adequacy of additive dominance model. Clear influence of environments was observed for panicle weight and yield per plant in cross SR 388-1 x ICSR 89022-3 as the additive dominance model was adequate for summer season.

For days to flowering in cross SR 405-1 x ICSR 89022-3 additive type of gene action was observed in summer (Table-2). However dominance x deminance effect were observed in cross SR 388-1 x ICSR 89022-3 (Table-1). For flag leaf area dominance and epistatic effects in cross SR 388-1 x ICSR 89022-3 were observed whereas, additive and dominance both the effects were important for the inheritance of this character in cross SR 405-1 x ICSR 89022-3. For the character panicle weight additive and dominance effects were important in cross SR 388-1 x ICSR 89022-3 in both the seasons. Only dominance effect was important for this trait in cross SR 405-1 x SR 89022-3 in summer season. For panicle length in cross SR 388-1 x ICSR 89022-3 in *kharif* additive and dominance both the effects were important, whereas both the effects were important in summer season in cross SR 405-1 x SR 89022-3. In cross SR 388-1 x ICSR 89022-3 for the trait number of primary branches in *kharif* season both the effects additive and dominance were important. In cross SR 405-1 x ICSR 89022-3 during summer both the effects were important, whereas only dominance effect is important in *kharif* season. Additive dominance model is adequate for this trait in summer season (Table-2). For the length of primary branches in cross SR 388-1 x ICSR 89022-3 both effects were important in *kharif* season and also in cross SR 405-1 x

TABLE 1

Estimates of gene effects for yield characters in SR 388-1 x ICSR 89022-3.

Characters	SR 388-1 x ICSR 89022-3							X^2 / type of epistasis
	m	(d)	(h)	(l)	(j)	(l)		
Days to flowering	(S)	80.67	-1.69	-1.23	1.80	-1.39	-26.87**	89.54**
		± 0.49	± 0.96	± 2.93	± 2.72	± 1.29	± 4.81	
Flag leaf area(cm ²)	(K)	155.32	-18.25*	-69.14*	-58.42*	13.11	143.87**	8.66**
		± 4.96	± 8.62	± 31.55	± 26.29	± 11.48	± 52.92	D
Panicle weight (g)	(S)	51.00	-3.77	57.50**	36.20**	-0.67	-38.87	10.38*
		± 2.12	± 4.73	± 13.73	± 12.70	± 5.14	± 23.12	
	(K)	40.63	2.80	2.40	-4.27	2.33	1.73	10.32*
		± 0.69	± 0.91	± 3.44	± 3.32	± 1.00	± 4.93	
Panicle length	(K)	20.00	-4.70**	13.30**	11.40**	-3.20**	-18.07**	30.66**
		± 0.51	± 0.81	± 2.78	± 2.60	± 0.93	± 04.30	D
Number of primary	(K)	50.33	-3.43*	27.23**	11.53*	-2.80	-16.60*	9.52*
		± 0.87	± 1.53	± 4.78	± 4.63	± 1.59	± 7.42	D
Length of primary branch (cm)	(K)	4.88	-0.52**	3.98**	2.53**	-0.10	04.53**	29.64**
		± 0.11	± 0.16	± 0.59	± 0.56	± 0.22	± 0.88	D
Yield per plant (g)	(S)	36.10	6.34*	15.03**	—	—	—	2.17
		± 1.61	± 1.59	± 3.51				
	(K)	32.93	-6.83**	20.50**	3.67	-5.60**	30.20**	205.56**
		± 0.97	± 1.09	± 4.59	± 4.46	± 1.20	± 6.24	C
Grain weight (g)	(S)	31.30	0.30	-7.92**	-10.13**	-0.53**	21.11**	117.52**
		± 0.20	± 0.38	± 1.14	± 1.11	± 0.41	± 1.79	D
	(K)	25.92	0.63	-5.83**	-6.27**	-1.13*	15.73**	78.01**
		± 0.25	± 0.44	± 1.33	± 1.28	± 0.49	± 2.09	D

*, ** significant at 5% and 1% level, respectively.

TABLE 2

Estimates of gene effects for yield characters in SR 405-1 x ICSR 89022-3.

Characters	SR 405-1 x ICSR 89022-3							X^2 /type of epistasis
	<i>m</i>	(<i>d</i>)	(<i>h</i>)	(<i>i</i>)	(<i>j</i>)	(<i>l</i>)		
Days to flowering	(S)	71.75	-7.77**	0.63	1.47	-5.07**	-6.93**	161.11**
		10.33	± 0.37	± 1.55	± 1.51	± 0.46	± 2.09	
	(K)	69.95	-0.39	-0.60	2.20	-0.87*	4.33*	81.72**
		± 0.25	± 0.32	± 1.24	± 1.21	± 0.39	± 1.75	
Flag leaf area (cm ²)	(K)	123.15	11.15	51.24*	60.43*	25.67**	-142.32**	18.66**
		± 4.29	± 8.21	± 25.17	± 23.77	± 8.95	± 40.59	D
Panicle weight (g)	(S)	46.35	7.59**	15.67**	—	—	—	—
		± 1.78	± 1.76	± 3.87				
	(K)	43.05	-6.93**	21.80**	4.73	-5.67**	28.73**	189.41**
		± 0.97	± 1.13	± 4.64	± 4.50	± 1.24	± 6.38	C
Panicle length	(K)	23.68	2.27**	6.30**	2.07	2.17**	-7.33*	23.69**
		± 0.34	± 0.67	± 1.94	± 1.91	± 0.72	± 3.09	D
Number of primary	(S)	45.66	-3.66**	4.98**	—	—	—	7.20
		± 0.83	± 0.75	± 1.68				
	(K)	57.32	0.60	20.70**	13.40**	2.57	-19.20**	10.10*
		± 1.03	± 1.27	± 4.96	± 4.83	± 1.48	± 6.93	D

Characters		SR 405-1 x ICSR 89022-3						X^2 /type of epistasis
		m	(d)	(h)	(l)	(j)	(l)	
Length of primary branch (cm)	(S)	6.85 ± 0.14	-0.58** ± 0.15	3.47** ± 0.65	2.45** ± 0.62	-0.23 ± 1.19	-2.73** ± 0.89	16.56** D
	(K)	5.24 ± 0.10	-0.12 ± 0.10	0.95** ± 0.20	—	—	—	3.61
Yield per plant (g)	(S)	40.98 ± 2.03	-3.53 ± 4.64	55.97** ± 13.30	35.80** ± 12.34	-0.37 ± 5.06	-39.07 122.57	10.66*
	(K)	30.25 ± 0.66	2.57 ± 0.86	2.03** ± 3.25	-3.60 ± 3.15	-2.33** ± 0.94	-1.87 ± 4.61	18.94**
Grain weight (g)	(S)	34.69 ± 0.12	2.91** ± 0.36	-5.92** ± 0.90	-14.22** ± 0.87	1.72** ± 0.39	38.63** ± 1.61	776.26** D
	(K)	24.23 ± 0.384	-1.10 ± 0.51	-4.40* ± 1.97	-9.80** ± 1.81	-1.50* ± 0.67	12.40** ± 2.94	36.79** D

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

ICSR 89022-3 during summer season it was important whereas, during *kharif* only dominance effect is important. For important character yield per plant in cross SR 388-1 x ICSR 89022-3 additive and dominance both the effects were important in both the seasons (Table-1). In cross SR 405-1 x ICSR 89022-3 for this trait dominance effect in summer and additive effect in *kharif* is important for the inheritance. For grain weight in cross SR 388-1 x ICSR 89022-3 dominance effect is important in both the seasons, whereas in cross SR 405-1 x ICSR 89022-3 both additive and non-additive effects were important in summer season and only dominance effect is important in *kharif* season.

A perusal of gene action (Table 1 & 2) revealed that both additive and non-additive gene effects controlled the inheritance of most of the traits under study which suggested the possibility of obtaining transgressive variation in early generations. Rao (1970), Goud (1971), Raju *et al.*, (1980) and Hussain Sahib

et al., (1988) also reported the additive and non-additive type of gene action for grain yield.

In cross SR 388-1 x ICSR 89022-3 duplicate type of epistasis was observed for flag leaf area, panicle length, number of primary branches, length of primary branch and grain weight, whereas complimentary gene action was observed for panicle weight and yield per plant in *kharif* season. In cross SR 405-1 x ICSR 89022-3 duplicate type of gene action was observed for flag leaf area, panicle length, number of primary branches, length of primary branch and grain weight. Goyal and Joshi (1984) reported duplicate type of epistasis for length of primary branches.

In general, the studies indicated that maximum improvement may be expected through reciprocal recurrent selection, as it will utilize simultaneously both type of genetic components.

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Screening of Chickpea Genotypes for Salinity Tolerance During Germination and Early Seedling Growth

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ABSTRACT

Fifty-eight genotypes of chickpea were evaluated in laboratory under two simulated environments created by applying Hoagland solution ($EC\ 1.8\ dSm^{-1}$) for normal condition and Hoagland solution + NaCl ($EC\ 8.0\ dSm^{-1}$) for salinity condition. The genetic differences were highly significant for all characters under both conditions. Grouping of genotypes on the basis of reduction in germination and seedling growth traits under salinity revealed that the genotypes JCP 27, K 850, AKG 46, DGM 1044, JCP 125, BDNG 154, ICC 4, BKG 45, NDG 861, H-89-11-1, EC 5183, JCP 89 and GNG 752 were salinity tolerant and genotypes RSG 514 was sensitive and performed poorly under salinity condition.

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INTRODUCTION

Early stages of plant growth are most critical as later development and crop production depends on effective germination and early seedling growth. Thus, it could be ideal to study the decrease caused in these parameters due to salinity in comparison to normal conditions. Legumes as a group are very sensitive to salinity and chickpea (*Cicer arietinum* L.) is one of the most sensitive crop to salinity (Johansen, 1984). However, the present study was conducted to generate informations of the relative tolerance of different genotypes of chickpea to salinity. Selection models based on the existence of variability may be proposed even in a susceptible crop like chickpea.

MATERIALS AND METHODS

Fifty-eight genotypes of chickpea were selected for the present study. Genotypes were evaluated at two levels of salinity namely control ($EC\ 1.8\ dSm^{-1}$) and salinity ($EC\ 8.0\ dSm^{-1}$) created by the addition of 0.0 g NaCl and 3.621 g NaCl to a litre of Hoagland solution, respectively. The composition of Hoagland solution as suggested by Johnson *et al.*, (1957) was used. The genotypes were germinated and maintained as per the following procedure.

The germination sheets were used for germination of the genotypes. The sheets which had folds of 2.5 cm to form ridges and furrows were first sterilized in oven at $60^{\circ}C$ for

24 hours. One sterilized germination sheet was spread on each of 16 enamel trays (46 x 30 x 7 cm) which were previously sterilized with 70% ethanol. The seeds were surface sterilized with 0.2% mercuric chloride for 30 minutes followed by thorough washing with sterile distilled water. Twenty-five sterilized seeds of each genotype were placed in the furrows of the germination sheet treating as one replication. Whole set was replicated thrice, using CRD.

For complete germination, trays were continuously kept covered with moistened sheets, using corresponding solutions, and were kept under darkness for the first 3 days at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The trays were then exposed to natural light for 10 hours duration. Each day, each tray was irrigated with respective solution of 10 ml. for first 5 days 15 ml. for 2nd 5 days and 20 ml. for remaining 6 days.

The germination count was recorded each day, upto 4th day. Only such seeds which showed radicle emergence through the protruded inner coat were taken into account for calculating per cent seed germination. After 4 days, out of 25 seeds, 15 germinated seeds from each genotype/treatment/replication were kept for studying seedling growth parameters, namely shoot length (cm), root length (cm), number of leaves/seedling, number of leaflets/seedling, root fresh weight (g) and shoot fresh weight (g) which were recorded on 10 seedlings after 20 days. Shoot dry weight (g) and root dry weight (g) were recorded after drying the seedlings at 70°C for 2 days in oven.

Fifty-eight genotypes were categorised as tolerant (0-30% reduction), semi-tolerant (30-70% reduction) and sensitive ($> 70\%$

reduction) according to the per cent decrease under salinity condition as compared to normal for different traits under study.

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the genotypes for all the characters studied under both environments. It indicated wide variation amongst chickpea genotypes under normal as well as salinity conditions. The phenotypic range of per cent decrease in salinity condition was wider for all the character except shoot length (15.4 to 74.7%) where it was moderate. The lowest and highest mean per cent decrease in salinity condition was observed for number of leaves per seedling (36.3%) and root dry weight (48.7%), respectively (Table 1). Similar findings were also reported for various traits in chickpea (Goel and Varshney, 1987; Maliwal and Paliwal, 1982 and Yadav *et al.*, 1989).

Among all the genotypes (Table 1), six genotypes viz. JCP 27, K 850, AKG 46, DGM 1044 and BDNG - 154 were found tolerant to salinity for germination percentage and all the eight growth characters, except DGM 1044 for number of leaflets per seedling; BDNG 154 for germination percentage and JCP 125 for root fresh weight.

Genotypes JCP 27, AKG 46, K 850, JCP 125 and BDNG 154 were registered as salinity tolerant for shoot length, root length, leaves/seedling (except BDNG 154), shoot fresh weight (except JCP 125 and BDNG 154), root fresh weight (except JCP 27 and JCP 125), shoot dry weight and root dry weight (except JCP 125 and DGM 1044). While DGM 1044 was observed salinity tolerant for germination percentage alongwith shoot and root length and its fresh and dry weight (except root

TABLE 1

Genotypes showing less reduction (< 30%) under salinity stress in comparison to normal environment for different characters.

	Germina- tion (%)	Shoot length (cm)	Root length (cm)	Leaves/ seedlings	Leaflets/ seedling	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
Overall mean	37.5	45.0	41.5	36.3	36.5	42.7	44.6	47.0	48.7
Range	03.0 to 80.0	15.4 to 74.7	04.6 to 74.7	03.2 to 65.9	00.5 to 73.3	01.0 to 74.6	005.7 to 85.7	02.8 to 83.7	02.7 to 87.0
Best 10 genotypes showing minimum reduction (< 30%)	DGM-285 (3.0)	JCP-27 (15.4)	AKG-46 (4.6)	K-850 (3.2)	BG-385 (0.5)	DGM-1044 (1.0)	EC-5183 (5.7)	JCP-125 (2.8)	BDNG-154 (2.7)
	ICCC-4 (8.8)	PG-88-6 (15.5)	JCP-27 (10.5)	JCP-89-1 (10.0)	K-850 (1.0)	JCP-141 (8.1)	GNG-752 (7.4)	PG-88-6 (6.1)	GNG-752 (8.4)
	Dohad yellow (15.6)	K-850 (19.8)	EC-5183 (10.8)	BG-385 (11.1)	JCP-27 (4.3)	JCP-27 (11.1)	K-850 (9.2)	DGM-1044 (7.1)	K-850 (10.8)
	BCP-41 (16.2)	BDNG-154 (20.1)	NDG-8601 (16.9)	H-89-11-1 (13.8)	RSG-286-1 (7.4)	AKG-46 (20.4)	AKG-46 (14.1)	JCP-27 (8.5)	JCP-27 (11.0)
	DGM-1044 (18.1)	JCP-125 (21.1)	JCP-124 (17.4)	JCP-125 (14.0)	NDG-8601 (10.7)	BKG-45 (21.0)	JCP-141 (17.3)	ICCC-4 (14.7)	NDG-8601 (11.4)
	H-89-11-1 (18.1)	Chaffa (23.5)	K-850 (18.2)	DCP-8 (14.2)	H-89-11-1 (14.9)	K-850 (22.5)	DGM-352 (18.9)	BDNG-154 (15.7)	BG-360 (15.4)
	Chaffa (18.1)	AKG-5173 (23.8)	EC-5173 (19.9)	764-594 (14.3)	PG-88-6 (17.4)	Chaffa (24.6)	JCP-271 (19.3)	AKG-46 (21.1)	JCP-188 (16.3)

Germination (%)	Shoot Length (cm)	Root length (cm)	Leaves / seedlings	Leaflets / seedling	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
EC-5183 (19.0)	JCP-124 (24.5)	BDNG-154 (20.6)	JCP-27 (14.4)	Saradpuri (17.9)	BM-76 (25.5)	DGM-1044 (20.5)	ICCV-10 (22.8)	AKG-46 (18.6)
JCP-89-1 (19.9)	DGM-1044 (24.6)	JCP-125 (21.4)	EC-6617 (16.6)	AKG-46 (18.7)	H-89-11-1 (27.7)	ICCV-10 (20.7)	JCP-39 (25.4)	EC-5183 (19.0)
DGP-8 (20.4)	BG-360 (26.4)	DGM-1044 (22.6)	AKG-46 (16.8)	JCP-125 (19.4)	GNG-752 (28.7)	BDNG-154 (23.1)	K-850 (25.8)	ICCC-4 (20.2)

Values in parenthesis indicate the % reduction under salinity as compared to normal condition.

dry weight). The genotype EC 5183 showed less than 30% reduction for the germination per cent, root length, root fresh weight and root dry weight under salinity condition. The other widely adapted varieties which found tolerant at germination stage were ICCC 4, Dohad yellow and Chaffa. These genotypes may perform better under salinity areas of Bhal and Ghad regions of the Gujarat State due to higher germination rate which will result in better plant population at initial stage.

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Combining Ability in Wheat (*Triticum aestivum* L.)*

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ABSTRACT

Studies on combining ability were conducted in wheat using 8 x 8 diallel set in three environments. Yield and its component characters were studied. The mean squares due to GCA x environments and SCA x environments were highly significant for all the characters studied in all the generations. The estimates of GCA x environment variances were generally higher than those of the SCA x environment Variances. It showed that the additive variance x environment interaction was more as compared to the non-additive variance x environment interaction. Raj 1777 was good combiner for grain yield/plant, productive tillers/plant, length of main spike, number of spikelets/spike and number of grains/spike. The crosses pitic 62/Raj 1777 and Pitic 62/GW 496 exhibited positive sca effects for grain yield/plant and other yield attributing characters over generations. Diverse good combiners should be used for hybridization and the resultant material should be exposed to different environments for identifying the stable high yielding genotypes.

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INTRODUCTION

It is being realised that the genetic potential of present day cultivars of wheat appears to be fast reaching plateau. Thus there is need to improve the yield potential of wheat varieties. Therefore, testing of new segregants and lines from germplasm for their usefulness in breeding programme would be the first step leading to development of superior varieties. The success of a breeding procedure is determined by the useful gene combinations organised in the form of high combining lines isolated from germplasm. Therefore, information on general and specific combining ability would be very useful to the plant breeders.

MATERIALS AND METHODS

Eight parents namely, K 65, Pitic 62, Raj 1777, HD 2189, GW 173, GW 496, HI 1077 and Lok 1 were crossed in all possible combinations excluding reciprocals to make a diallel set during 1992-93. A few F_1 seeds of each of the crosses were grown at Wellington, Nilgiris, Tamil Nadu in off season wheat nursery during Summer 1993 for generation advancement. Eight parental lines, their 28 F_{1s} and 28 F_{2s} were studied during Rabi 1993-94, under three environments as follows :

Environment 1 : Early sown (1st November, 1993)

*Part of the Ph.D. thesis submitted by author to Gujarat Agricultural University, Sardar Krushinagar.

Environment 2 : Timely sown (15th November, 1993)

Environment 3 : Late sown (1st December, 1993)

The experiment was laid out in randomised complete block design (RBD), with three replications under each environment. Each plot of homogeneous (Parents and F_{1s}) and segregating (F_2) material was consisted of 2.5 m long single and four row respectively. The row-to-row and plant-to-plant distances were kept at 22.5 cm and 5 cm, respectively. Five competitive plants from parental lines and F_1 and 20 plants from each F_2 were randomly selected for recording observations. The combining ability analysis was carried out according to the procedure given by Griffing (1956, Moel I, Method 2) which was further extended by Singh (1973) for pooled analysis.

RESULTS AND DISCUSSION

Pooled analysis for combining ability for parents and F_1S as well as parents and F_2S was carried out separately. The variances due to general and specific combining abilities were significant for all the characters in both the generations. This indicated that both additive and non-additive gene effects played important role in the inheritance of the characters. The GCA x environment interaction was significant for all the characters in F_1 and F_2 except 1000-grain weight in F_2 generation. The SCA x environment interaction was significant for most of the characters in both the generations except productive tillers/plant and 1000-grain weight in F_2 generation (Table 1). The mean squares due to GCA x environment were higher than the SCA x environment for most of the characters. The higher value of GCA x environment over SCA x environment for majority of the cases suggested that GCA was more susceptible to

environmental changes. Significant sensitivity of GCA x environment and SCA x environment interactions for different traits have also been reported earlier by Narula (1987) and Srivastava (1992).

General Combining Ability Effects

Significant negative GCA effects revealed that GW 173, Lok 1, GW 496 and HI 1077 were good general combiners for early flowering and maturity in both the generations (Table 2). The parents K 65, HD 2189, Raj 1777 and Pitic 62 were desirable combiners for tallness, while parents GW 173, Lok 1, GW 496 and HI 1077 were desirable combiners for dwarfness, Raj 1777 recorded to be good general combiner for productive tillers/plant in both the generations. HD 2189 and Pitic 62 in F_1 generation and Pitic 62 in F_2 generation were identified as good general combiners for productive tillers/plant. In respect of length of main spike, number of grains/spike and number of spikelets/spike, Raj 1777, HD 2189 and Pitic 62 were identified as good general combiners over both the generations. Lok 1 and K 65 over both the generations were identified as good general combiners for 1000-grain weight. HD 2189 and Pitic 62 in F_1 generation and K 65 in F_2 generation were identified as good general combiners for grain yield/plant. Raj 1777 was good general combiner for grain yield/plant, which means that these parents transmitted additive genes for yield and component characters in their progeny.

Specific Combining Ability Effects

Specific combining ability effects (SCA) presented in Table 3 revealed that out of 28 crosses only six crosses over generations were significant for sca effects for grain yield/plant. In the present study none of the

TABLE 1

Analysis of variance for combining ability over environments in wheat.

Item	d.f.	Days to flowering		Days to maturity		Plant height		Productive tillers per plant	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
GCA	7	492.14**	398.63**	268.03**	470.56**	1030.06**	1123.29**	7.79**	4.18**
SCA	28	24.61**	24.33**	29.49**	20.86**	22.15**	17.36**	7.74**	1.47**
Environment (E)	2	203.78**	30.41*	723.85**	648.65**	405.61**	411.08**	26.38**	2.69
GCA x E	14	109.08**	13.24**	23.94**	42.31**	32.68**	22.06**	3.17**	1.35**
SCA x E	56	6.36**	36.30*	11.34**	5.12**	10.99**	15.85**	2.22**	0.34
Error	210	0.38	1.02	0.44	0.90	1.04	2.83	0.19	0.25

Item	d.f.	Length of main spike		No. of spikelets per spike		No. of grains per spike		1000 grain weight		Grain yield per plant	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
GCA	7	17.15**	11.99**	53.62**	39.86**	654.21**	412.71**	229.26**	177.90**	39.85**	12.72**
SCA	28	0.92**	0.23**	2.06**	0.94**	104.68**	17.61**	18.83**	11.43**	23.76**	5.73**
Environment (E)	2	9.42**	7.78*	11.62*	27.21*	64.05*	23.25	1.71	11.95	100.12**	8.40
GCA x E	14	0.89**	0.59**	3.49**	1.69**	24.98**	11.89*	4.42**	3.89	16.20**	2.85**
SCA x E	56	0.17**	0.28**	0.71**	1.05**	7.54**	8.45**	4.25**	2.86	12.40**	1.17**
Error	210	0.07	0.10	0.16	0.30	1.63	4.12	0.35	2.13	0.19	0.54

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

TABLE 2

Estimates of the general combining ability effects for different characters studied in wheat.

Parents	Days to flowering		Days to maturity		Plant height		Productive tillers per plant		Length of main spike	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
K 65	3.51**	4.34**	3.04**	6.47**	9.06**	8.67**	0.01	0.50**	0.42**	0.62**
Pitic 62	2.56**	2.35**	2.31**	1.89**	1.91**	2.51**	0.32**	0.02	0.60**	0.45**
Raj 1777	6.56**	5.22**	4.37**	3.62**	2.91**	3.51**	0.86**	0.55**	0.50**	0.22**
HD 2189	0.13	-0.69**	0.33**	-0.71**	4.39**	5.14**	0.33**	-0.15	0.59**	0.46**
GW 173	-5.88**	-5.23**	-3.80**	-6.41**	-10.13**	-10.09**	-0.77**	-0.48**	-1.49**	-1.16**
GW 496	-2.09**	-2.29**	-1.96**	-2.52**	-3.06**	-3.97**	-0.21**	-0.37**	-0.04	-0.12*
HI 1077	-1.26**	-0.96**	-1.37**	-0.63**	-1.55**	-0.91**	-0.04	-0.16*	0.19**	0.26**
Lok 1	-3.53**	-2.73**	-2.93**	-1.73**	-3.52**	04.86**	-0.49**	0.08	-0.77**	-0.73**
SE (g) ±	0.11	0.17	0.11	0.16	0.17	0.29	0.07	0.08	0.05	0.05
SE (g — g) ±	0.16	0.26	0.17	0.24	0.26	0.43	0.11	0.13	0.07	0.08

Parents	No. of spikelets per spike		No. of grain per spike		1000 grain weight		Grain yield per plant	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
K 65	0.62**	0.80**	-1.15**	0.45	1.47**	1.37**	0.03	0.86**
Pitic 62	1.16**	1.03**	1.62**	1.13**	0.88**	1.24**	0.41**	0.21
Raj 1777	1.71**	1.06**	7.75**	5.12**	-4.13**	-3.60	1.44**	0.75**
HD 2189	1.14**	1.06**	4.50**	3.77**	0.20*	-0.15	1.48**	0.16
GW 173	-1.82**	-1.47**	-6.40**	-4.51**	-3.30**	-2.89**	-2.02**	-1.06**
GW 496	-0.67**	-0.80**	-1.10**	-1.24**	-0.03	-0.34	-0.59**	-0.64**
HI 1077	-0.54**	-0.08	-0.03	0.90**	0.16	0.31	-0.06	-0.10
Lok 1	-1.59**	-1.60**	-5.54**	-5.62**	4.75**	4.06**	-0.67**	-0.18
SE (g) ±	0.07	0.09	0.22	0.34	0.10	0.25	0.07	0.12
SE (g—g) ±	0.10	0.14	0.33	0.52	0.15	0.38	0.11	0.20

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

TABLE 3

Specific combining ability effects for different traits in wheat.

Genotypes	Days to flowering		Days to maturity		Plant height		Productive tillers per plant		Length of main spike	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
K 65/HD/2189	0.34	1.63**	1.82**	2.99**	-0.86	-0.19	2.58**	1.57**	-0.21	0.28
Pitic 62/Raj 1777	-3.57**	-2.62**	0.40	-1.75**	-3.48**	7.31**	0.35	-0.15	0.63**	0.47**
Pitic 62/GW-496	-0.15	1.78**	0.29	1.94**	1.41**	0.35	1.53**	0.59*	0.40**	0.35*
Pitic 62/Hi 1077	2.69**	1.00	0.37	2.83**	1.62**	0.94	1.62**	0.61*	0.24	-0.20
Raj 1777/HD 2189	2.97**	0.09	-0.18	-0.37	2.34**	-0.21	1.00**	1.08**	0.36**	0.10
Raj 1777/GW 496	-0.26	-0.42	1.56**	1.21*	-0.86	-0.54	1.90**	0.52*	0.27*	-0.04
SE (Sij) ±	0.32	0.53	0.35	0.50	0.53	0.88	00.23	0.26	0.14	0.17
SE (Sij-Sik) ±	0.48	0.78	0.51	0.74	0.79	1.30	0.34	0.37	0.20	0.25

Genotypes	No. of spikelets per spike		No. of grains per spike		1000 grain weight		Grain yield per plant	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
K 65/HD 2189	0.25	-0.45	-0.32	1.80	0.94**	0.13	1.93**	3.13**
Pitic 62/Raj 1777	0.35	0.19	4.77*	2.60*	1.01**	1.12	2.43**	0.77**
Pitic 62/GW 496	0.92**	0.71*	5.45**	3.30**	1.30**	0.92	1.11**	1.28**
Pitic 62/Hi 1077	0.27	-0.01	2.36**	0.62	0.29	0.76	3.80**	1.16**
Raj 1777/HD 2189	0.59**	-0.24	5.51**	4.40**	1.21**	1.27	3.16**	1.57**
Raj 1777/GW 496	0.95**	0.09	5.56**	-0.08	0.60*	0.22	5.70**	0.77**
SE (Sij) ±	0.21	0.28	0.67	1.06	0.31	0.76	0.23	0.38
SE (Sij-Sik) ±	0.31	0.42	0.99	1.57	0.46	1.13	0.34	0.57

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

crosses showed significant positive sca effects for all the traits in both the generations. The cross Pitic 62/Raj 1777 showed desirable specific combining ability for early flowering in both the generations. Crosses Pitic 62/Raj 1777 and Pitic 62/GW 496 exhibited significant and positive sca effects for grain yield/plant over generations with positive sca effects for length of main spike, number of spikelets/spike, number of grains/spike and 1000-grain weight (Table 3). The inconsistency in sca effects observed over generations can be attributed to dominance x dominance interaction and genotype x environment interaction. Most of the cross combinations in F_1 and F_2 generations which exhibited high sca effects for different traits involved one

good general combiner as either parent, it is expected that such a cross combination would throw transgressive segregants in later generations.

Keeping in view the findings of present investigation it is concluded that the choice of the parents to be used in breeding programme should be based on the combining ability tests over different environments. In a wheat breeding programme aiming to improve yield and other traits, a three-way or complex crosses involving good combiners should be produced and resulting material should be handled through intermating (biparental crosses) of the selects in the early generation.

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Genetic Analysis of Yield and Yield Components Over Environments in Pigeonpea

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ABSTRACT

The combining ability analysis of 50 hybrids based on five genetic male sterile lines and ten short duration testers over four environments for nine characters in pigeonpea revealed a significant role of additive and non-additive gene action; the former being predominant for days to maturity, pod length and seeds/pod, and the later for days to flowering, plant height, branches/plant, pods/plant, seed yield/plant and 100-seed weight. The parents were classified for their genetic worth in respect of different characters and prospects for use in hybridization programme. In general, hybrids having high heterotic estimates for seed yield included both or at least one good combiner parent. The high degree of heterosis and non-additive gene action observed for seed yield and its contributing traits favouring hybrid breeding programme when male sterility is available in pigeonpea.

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INTRODUCTION

The selection of suitable parents is important in a breeding programme, particularly if the aim is to improve a quantitative character such as yield. The *per se* performance of a parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on the nature of gene effects and their expression in terms of combining ability is necessary. The scope of such studies was limited as they were mostly based on one year/locations of testing. Hence, the present study was undertaken to analyse combining ability of parents and hybrids in pigeonpea over four environments.

MATERIALS AND METHODS

In the present investigation, five genetic male sterile lines and ten short duration testers (Table 2) were crossed in a line x tester fashion. The 50 hybrids and their 15 parents were evaluated alongwith Pusa Ageti as standard check in Randomized Block Design with three replications in four environments created by combinations of two spacing (30 x 10 and 45 x 15 cm) in two *kharif* seasons (1991 and 1992). The fertile sibs in the male sterile lines were used to represent female lines. Each entry was planted in a single row plot of 15 plants. The observations were recorded on five randomly selected competitive plants of each entry in respect of

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TABLE 1

Analysis of variance (mean squares) and estimates of combining ability variance for nine characters in pigeonpea pooled over environments.

Source	d.f.	Days to flowering	Days to maturity	Plant height	Branches/ plant	Pods/ plant	Pod length	Seeds/ pod	Seed yield/ plant	100-seed weight
Environments	3	8488.20**	8125.29**	709.32**	117.39**	10549.63**	1.69**	2.42**	1951.45**	25.36**
Rep. x environment	8	2.65	5.33	120.59*	0.65	157.27	0.21**	0.09**	16.78	0.14
Genotypes	64	165.20**	261.30**	582.03**	20.90**	3214.34**	5.21**	3.06**	218.59**	15.71**
Parents	14	181.28**	399.73**	845.92**	15.21**	2477.06**	14.28**	8.89**	174.65**	39.05**
Hybrids	49	153.88**	175.37**	435.65**	18.97**	3021.11**	2.45**	1.41**	183.23**	6.89**
Females	4	982.88**	1150.72**	2788.57**	77.26**	6218.07**	1.07*	0.53*	616.40**	13.10**
Males	9	273.28**	303.31**	806.89**	52.61**	10871.97**	11.63**	6.88**	522.23**	25.90**
Females x males	36	31.92**	35.08**	81.40	4.08**	703.18**	0.30**	0.14**	50.34**	1.45**
Females x environment	12	36.35**	14.06	111.93	1.66	193.94	0.15	0.06	14.96	0.82*
Males x environment	27	21.43*	33.98**	128.90	2.15*	252.45	00.10	0.008	21.47	0.57
Females x males x environment	108	12.40**	14.24**	118.91**	0.87	280.66**	0.14**	0.06**	25.39**	0.37**
Pooled error	392	2.21	4.36	52.48	1.28	138.11	0.06	0.02	9.99	0.14
σ^2 gca		6.44	7.58	19.05	0.66	87.77	0.07	0.04	5.85	0.20
σ^2 sca		6.51	6.95	—	1.08	140.84	0.05	0.03	8.31	0.35
σ^s gca/ sca		0.99	1.09	—	0.61	0.62	1.40	1.33	0.70	0.57

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

nine characters (Table 1). Observations on days to flowering and maturity were recorded on plot basis. The combining ability analysis and estimation of variance components were done as per line x tester mating design (Kempthorne, 1957). The mean values over replications over environments for different traits were used for estimation of pooled heterosis.

RESULTS AND DISCUSSION

Analysis of variance for combining ability over environments (Table 1) revealed that the mean squares due to females, males and females x males interaction were significant for all the traits except plant height in respect of female x male interaction, indicating importance of both additive and non-additive gene effects. The mean squares due to environments were highly significant for all the traits, suggesting sufficient diversity among environments. The mean squares due to females x environments for days to flowering, and 100-seed weight, and males x environments interactions for days to flowering, days to maturity and branches/plant were significant, indicating that general combining ability (gca) of these parents were influenced by environments for these characters. Further, the mean squares due to females x male x environment interactions showed that the specific combining ability (sca) effects of hybrids for all the characters except branches/plant were not consistent over environments (Table 1).

The high ratios (> 1) of gca : sca variances were recorded for days to maturity, pod length and seed/pod indicating that these characters were governed predominantly by additive component of heritable variance. The gca : sca variance ratios were less than unity

for days to flowering, branches/plant, pods/plant, seed yield/plant and 100-seed weight suggesting that these traits were governed predominantly by non-additive components. These results are in agreement with Patel (1990) for days to maturity, pod length and seeds/pod; and Patel *et al.*, (1992) for plant height, branches/plant, pods/plant and seed yield.

The gca effects for parents (Table 2) revealed that among the females, MS Prabhat-DT was the best general combiner for seed yield, branches/plant, pods/plant, pod length and seeds/pod. MS Prabhat-NDT showed significant and desirable gca effects for seed yield, branches/plant and pods/plant. On the contrary, IMS 1, QMS 1 and QMS 2 among females and ICPL 83006 and ICPL 312 among males were good general combiners for earliness and dwarfness. The pollinators viz., ICPL 87, AL 15, Manak and BDN 31 were the best general combiners for seed yield as well as pods/plant. The former two male parents also showed significant and desirable gca effects for branches/plant. The parents QMS 2, ICPL 87109, ICPL 87091 and ICPL 312 were found to be good source of genes for increasing pod length, seeds/pod and 100-seed weight.

The yield superiority of hybrids over best cultivated variety is essential from commercial point of view. Hence, Pusa Ageti, an early maturing variety released for general cultivation in Gujarat State was sown in the experiment in order to obtain information on superiority of hybrids over this belt check variety. The fifteen promising hybrids which significantly exceeded Pusa Ageti in respect of seed yield and heterosis are listed in Table 3. All the promising hybrids depicted positive

TABLE 2

Estimates of general combining ability (gca) effects of parents for nine characters pigeonpea pooled over environments.

Parents	Days to flowering	Days to maturity	Plant height	Branches/ plant	Pods/ plant	Pod length	Seeds/ pod	Seed yield/ plant	100-seed weight
Lines									
MS Prabhat-NDT	4.61**	4.90**	6.13**	0.56**	5.99**	-0.02	0.02	1.56**	-0.33**
MS Prabhat-DT	0.61**	0.53**	3.33**	1.01**	9.11**	0.10**	0.07**	2.62**	-0.13**
IMS 1	-2.51**	-3.32**	-6.26**	-0.99**	-7.16**	-0.11**	-0.05**	-3.00**	-0.10**
QMS 1	-2.12**	-1.68**	-1.59*	-0.46**	-5.04**	-0.06**	-0.08**	-1.47**	0.01
QMS 2	-0.59**	-0.42*	-1.62*	-0.14	-2.30**	0.09**	0.05**	0.29	0.55**
S.E. ±	0.136	0.191	0.661	0.103	1.073	0.022	0.013	0.288	0.034
Testers									
ICPL 87104	0.78**	1.46**	-0.09	-0.65**	-11.95**	0.10**	0.00	-3.49**	0.38**
ICPL 87109	3.58**	3.24**	1.71	-0.07**	-7.62**	0.57**	0.43**	0.70	0.63**
ICPL 87091	1.08**	1.61**	-1.46	-0.66	-15.94**	0.81**	0.69**	-2.00**	1.11**
ICPL 88027	-0.02	-0.02	-1.56	-1.21**	-12.92**	-0.10**	-0.06**	-3.62**	-0.09*
ICPL 83006	-4.14**	-3.84**	-3.23**	-0.20	4.08**	-0.46**	-0.32**	-0.61	-0.82**
ICPL 87	0.06	-0.51	-0.06	1.26**	15.89**	-0.02	0.00	4.78**	-0.22**
ICPL 312	-0.99**	-0.91**	-5.33**	-0.74**	-10.32**	0.22**	0.09**	-2.20**	0.56**
Manak	-2.11**	-3.32**	3.40**	0.21	12.58**	-0.43**	-0.34**	1.08**	-0.93**
BDN 31	-0.19	0.53	-1.24	0.24	4.96**	-0.18**	-0.15**	1.10**	-0.42**
AL 15	1.96**	1.76**	7.85**	1.81**	21.23**	-0.51**	-0.35**	4.25**	-0.19**
S.E. ±	0.192	0.270	0.935	0.146	1.517	0.032	0.018	0.408	0.048

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

TABLE 3

Promising hybrids for seed yield per plant with heterosis over Pusa Ageti and better parent (BP), and thier specific combining ability (sca) effect based on combined analysis in pigeonpea.

Sr. No.	Hybrids	Seed yiled per plant	Heterosis over		sca effects
			Pusa Ageti	BP	
1.	MS (P)@ DT x ICPL 87	27.69	58.05**	39.40**	2.57**
2.	MS (P) NDT x AL 15	26.29	50.05**	44.83**	2.75**
3.	MS (P) DT x AL 15	25.83	47.43**	35.82**	1.23
4.	QMS 2 x BDN 31	23.73	35.44**	52.30**	4.62**
5.	MS (P) DT x Manak	22.83	30.31**	20.03**	1.41
6.	MS (P) NDT x ICPL 87	22.57	28.82**	13.62*	-1.49
7.	QMS 2 x AL 15	21.61	23.34**	19.05**	-0.66
8.	MS (P) NDT x ICPL 83006	21.50	22.72**	30.13**	2.83**
9.	QMS 1 x ICPL 87	21.21	21.06**	6.77	0.18
10.	IMS 1 x ICPL 87	20.98	19.75**	5.63	1.48
11.	MS (P) DT x BDN 31	20.76	18.49**	9.14	-0.69
12.	QMS 2 x ICPL 87109	20.21	15.35*	42.17**	1.50
13.	QMS 2 x ICPL 87	20.06	14.50*	0.99	-2.73**
14.	MS (P) DT x ICPL 83006	20.04	14.38*	5.38	0.31
15.	MS (P) NDT x Manak	19.90	13.58*	20.47**	-0.46
16.	Pusa Ageti	17.52	—	—	—
S. E ±		1.20	1.20	1.20	0.65
C.D. at 5%		2.38	2.38	2.38	1.79
C. D. at 1%		3.14	3.14	3.14	2.35

*, ** = Significant at 5% and 1% levels, respectively. MS (P)@ = MS Prabhat.

heterosis over better parent which was significant in ten crosses. Of course, ten high yielding hybrids showed positive sca effects for seed yield, indicating the importance of non-additive gene effects in the heterotic response of these hybrids. It is evident that hybrids having high heterotic estimates for

seed yield involved both or at least one good combiner for seed yield and its components. Seven hybrids (Table 3) involved one good general combiner indicating an additive x dominance type of gene interaction. These crosses could be utilized to produce desirable transgressive segregants in subsequent

generation. QMS 2 x ICPL 87109 involved both parents with low gca effects indicating a dominance x dominance type of gene action. Two crosses showing high sca effects, i.e. MS (P) NDT x AL 15 and MS (P) DT x ICPL 87 involved both high general combiners suggesting additive x additive gene effects, and could be exploited by conventional breeding methods.

A substantial degree of hybrid vigour and non-additive effects for seed yield and related traits reflected that development of hybrids would be beneficial using genetic male sterile lines available in this crop (Reddy *et al.*, 1978 and Wallis *et al.*, 1981) or by converting one of the parents of promising hybrids into male sterile line by restoring to back crossing.

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Effect of Nitrogen, Phosphorus and Sulphur on Yield and Chemical Composition of Blackgram (*Phaseolus mungo*)

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ABSTRACT

A field experiment was conducted during the rainy seasons (*kharif*) of 1990 and 1991 on sandy loam soil to select the suitable levels of N, P and S for maximum production of Blackgram. Application of N, P_2O_5 and S significantly increased the grain and stover yields upto their maximum levels. Increase in seed yield of blackgram over control was 217, 273 and 109 kg ha⁻¹ in mean yield at 30 kg N, 60 kg P_2O_5 and 60 kg S ha⁻¹ respectively. The application of nitrogen in combination of sulphur significantly enhanced the yield. Significantly highest seed weight was recorded under the maximum limit of nutrient applications except in case of nitrogen where the difference between 15 and 30 kg N ha⁻¹ was at par. Increasing levels of N, P_2O_5 and S significantly increased the total uptake of N, P and S. Further, continuous fertilizer application built up the fertility status of the soil. The maximum net return (Rs. 3893 ha⁻¹) and BCR (2.01) was gained under $N_{30}P_{60}S_{60}$ kg ha⁻¹.

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INTRODUCTION

The farmers of Northern Madhya Pradesh are adopting double cropping on their fields because of introduction of irrigation facilities. Sharma *et al.*, (1992) reported that adoption of blackgram - mustard crop sequence may help in increasing the cropping intensity under northern region of Madhya Pradesh where irrigation facilities exist. Being a pulse crop, blackgram builds up a mechanism of fixing atmospheric nitrogen into their root nodules. It provides about 40 kg N ha⁻¹ to the succeeding crop (Patel *et al.*, 1981). The average yield of blackgram in Madhya Pradesh is much below (300 kg ha⁻¹) the national average. Efficient use of fertilizer help in enhancing the production and

productivity of the crop. Therefore, it was considered important to find out proper combination of fertilizer nutrients like N, P and S to boost the productivity of blackgram.

MATERIALS AND METHODS

A field experiment was conducted during 1990 at the research farm of Agriculture College, Gwalior (M.P.) which was continued for two years. The experiment was laid out in split plot design with three replications. The treatments consisted of combination of 3 levels, each of N (0, 15 and 30 kg ha⁻¹) and P_2O_5 (0, 30 and 60 kg ha⁻¹) in main plots and 2 levels of S (0 and 60 kg ha⁻¹) in sub plots. After harvesting of blackgram, mustard was grown during *rabi* with three levels, each of

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nitrogen and phosphorus and two levels of sulphur keeping the same randomisation of treatments from 1 to 9 in both crops. The soil of experimental field was sandy loam having pH 7.8, organic carbon 0.37 per cent with available nitrogen 120 kg ha^{-1} , phosphorus 14.67 kg ha^{-1} , potassium 225 kg ha^{-1} and sulphur as SO_4 6.69 ppm prior to the start of the trial. The rainfall of 867.3 and 439.2 mm was received in respective seasons. Jawahar Urd 2 was inoculated with rhizobium and sown 30 cm apart with a seed rate of 20 kg ha^{-1} on 5th August 1990 and 31st July 1991. Full dose of N, P_2O_5 and S according to treatment and a uniform dose of $25 \text{ kg K}_2\text{O ha}^{-1}$ in the form of urea, triple super phosphate, pyrite and muriate of potash respectively were applied as basal. Estimation of N, P and S in seeds of blackgram was done by the procedures of Chopra and Kanwar (1980). Partial budgeting procedure was followed to workout the economics of the crop.

RESULTS AND DISCUSSION

Yield

Grain and stover yields of blackgram were significantly increased with each treatment in the dose of nitrogen upto 30 kg ha^{-1} (Table 1). Application of 15 and 30 kg N ha^{-1} increased the mean grain yield over control by 19.2 and 40.6 per cent, respectively. This might be due to proper N availability at an early growth stage which results in vigorous growth of the crop and adequate supply of photosynthetes for the formation of branches and seed development.

Significant increase in blackgram seed and stover yields (Table 1) were recorded with the application of phosphorus. Application of $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ gave the highest yield which was significantly more than other rates. The

increase in seed and stover yield over control being 55.6 and 30.9 per cent respectively. The increase in grain yield may be due to vigorous growth which helped the plants in absorption of higher amount of nutrients from the soil.

Perusal of data of grain and stover yield (Table 1) indicated that addition of 60 kg S ha^{-1} significantly enhanced the grain as well as stover yield. The grain yield of blackgram increased by 20.4 per cent with the application of 60 kg S ha^{-1} over control. The increase in blackgram yield may be due to increase in availability of this nutrient as soils of experimental area were deficient in available sulphur content. Similar results were also observed by Singh *et al.*, (1992).

Grain weight

Highest 1000 grain weight of 38.90 g was recorded with 30 kg N ha^{-1} in mean value (Table 1). The N application @ 15 and 30 kg ha^{-1} caused significant increase in grain weight as compared to control but difference between two levels was not significant. This may be due to better built up of N in soil with regular use of N in blackgram.

Among different levels of phosphorus, application of 60 kg ha^{-1} resulted into highest significant test weight of 39.34 g (Table 1). The difference between 0 and $30 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ was also significant. The increase in test weight may be due to higher availability of nutrients through better root growth and metabolic role played by P in energy transfer system.

Addition of sulphur was also recorded to be effective at 60 kg ha^{-1} (Table 1). Increased sulphur supply might have favourably influenced the carbohydrate metabolism. This favourable effect led to an

TABLE 1

Effect of N, P and S on the yields, 1000 seed weight and total nutrient uptake of N, P and S by blackgram and soil fertility changes after harvest of crop.
(Mean of two years)

Treatments (kg ha ⁻¹)	Yield (q ha ⁻¹)		1000 seed weight (g)	Total nutrient uptake (kg ha ⁻¹)			Soil fertility changes			
	Grain	Stover		N	P	S	O.C. (%)	Av. N. (kg ha ⁻¹)	Av. P. (kg ha ⁻¹)	Av. S. ppm
Nitrogen										
0	5.34	23.39	37.81	52.41	8.92	4.57	0.40	173	17.8	8.5
15	6.37	26.91	38.46	66.32	11.02	5.75	0.43	173	20.7	9.4
30	7.51	29.64	39.90	78.90	13.25	6.92	0.48	177	21.7	9.8
C. D. (P=0.05)	0.14	1.44	0.61	3.68	0.78	0.40	0.05	NS	NS	0.6
Phosphorus										
0	4.91	23.12	37.42	46.27	6.30	4.26	0.41	154	12.6	9.6
30	6.68	26.70	38.42	67.95	11.67	5.86	0.44	174	21.9	9.3
60	7.64	30.27	39.34	80.69	15.41	7.12	0.46	195	25.8	8.9
C. D. (P=0.05)	0.14	1.44	0.61	3.68	0.78	0.40	NS	4.8	3.8	NS
Sulphur										
0	5.81	25.84	38.10	60.12	10.19	4.65	0.42	169	19.5	5.4
60	7.00	27.54	38.69	75.57	12.06	6.85	0.45	180	20.6	8.0
C. D. (P=0.05)	0.10	1.28	0.42	3.36	0.70	0.32	NS	3.8	NS	0.6
Initial soil status							0.34	120	14.6	6.7
Interactions (C. D. P=0.05)										
For N x P	0.25	NS	NS							
N x S	0.19	NS	NS							
P x S	NS	NS	NS							

NS : Not Significant.

increase in translocation of photosynthesis resulting into the formation of bold seed.

Nutrient uptake

It is evident from the data that total uptake of N, P and S was significantly

affected due to application of nitrogen, phosphorus and sulphur (Table 1). It was noted that increasing levels of nitrogen, phosphorus and sulphur increased the total uptake of N, P and S. The maximum values was obtained at higher levels of these nutrients.

TABLE 2

Effect of different combinations of N, P and S levels on economics of blackgram production.

Treatments (kg ha ⁻¹)	Yield (ha ⁻¹)			Total cost (Rs ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs ha ⁻¹)	B.C.R.
	1990	1991	Mean				
N ₀ P ₀ S ₀ 1	1.11	6.59	3.85	2925	3080	115	1.06
N ₀ P ₀ S ₆₀ 2	1.41	7.51	4.48	3283	3584	301	1.09
N ₀ P ₃₀ S ₀ 3	1.44	8.34	4.89	3197	3912	715	1.22
N ₀ P ₃₀ S ₆₀ 4	1.83	9.90	5.86	3479	4688	1209	1.33
N ₀ P ₆₀ S ₀ 5	1.86	10.59	6.22	3397	4976	1579	1.46
N ₀ P ₆₀ S ₆₀ 6	2.11	11.39	6.75	3679	5400	1721	1.46
N ₁₅ P ₀ S ₀ 7	1.28	7.13	4.20	3031	3360	329	1.10
N ₁₅ P ₀ S ₆₀ 8	2.50	8.00	5.25	3349	4200	851	1.25
N ₁₅ P ₃₀ S ₀ 9	1.58	10.90	6.24	3267	4992	1721	1.52
N ₁₅ P ₃₀ S ₆₀ 10	2.99	11.41	7.20	3545	5760	2215	1.62
N ₁₅ P ₆₀ S ₀ 11	2.00	12.27	7.13	3467	5704	2237	1.64
N ₁₅ P ₆₀ S ₆₀ 12	3.29	13.26	8.28	3749	6624	2875	1.76
N ₃₀ P ₀ S ₀ 13	1.53	8.53	5.03	3101	4024	923	1.29
N ₃₀ P ₀ S ₆₀ 14	3.66	9.73	6.69	3419	5352	1933	1.58
N ₃₀ P ₃₀ S ₀ 15	1.72	12.27	6.99	3337	5592	2255	1.67
N ₃₀ P ₃₀ S ₆₀ 16	3.99	13.65	8.82	3619	7056	3437	1.94
N ₃₀ P ₆₀ S ₀ 17	2.02	13.52	7.84	3537	6272	2735	1.77
N ₃₀ P ₆₀ S ₆₀ 18	4.38	14.90	9.64	3819	7712	3893	2.01

Note : (1) Cost of nutrient applied to the crop was worked out @ Rs. 4.05, P₂O₅ Rs. 6.69 and S Rs. 4.77 ha⁻¹.

(2) Sale price of grain produce of blackgram was Rs. 800/- q⁻¹.

(3) Economics was worked out on pooled data (1990 and 1991).

Soil fertility changes

The data (Table 1) on soil fertility status at harvest showed that application of nitrogen @ 30 kg ha⁻¹ significantly improved the organic carbon and available sulphur content of soil as compared to control. Application of phosphorus @ 60 kg ha⁻¹ markedly increased the available nitrogen and phosphorus content of the soil. While application of sulphur significantly improved the available nitrogen and sulphur content of the soil. The maximum value was obtained at highest dose i.e. 60 kg ha⁻¹. Data further revealed that after harvest of blackgram the organic carbon, available N, P and S content of soil improved due to application of fertilizers as compared to initial soil fertility status. This built up of soil fertility

may be attributed to addition of biomass in the form of roots and plant residues due to blackgram crop and manuring. Similar results were also reported by Ghosh (1987).

Economics

Economics of different treatments shows that highest net profit of Rs. 3893 ha⁻¹ was obtained with the use of N₃₀P₆₀S₆₀ treatment followed by N₃₀P₃₀S₆₀ (Rs. 3437. ha⁻¹). The highest B.C.R. (2.01) was also recorded under N₃₀P₆₀S₆₀ treatment. The minimum net profit was recorded under control (Table 2). A heavy rainfall of 462.2 mm during the month of September 1990 caused a reduction on seed and straw yields of blackgram during first year.

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Determination of Economic Threshold Level for Rice Leaf Folder, *Cnaphalocrocis medinalis* Guen. in Gujarat

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ABSTRACT

A field experiment to assess the economic threshold level (ETL) for rice leaf folder (*Cnaphalocrocis medinalis* Guen.) was conducted during 1990-91, 1991-92 and 1992-93 at the Main Rice Research Station, GAU, Nawagam (Gujarat). The results revealed that the differences in grain yields were significant due to control measures adopted at different levels (0%, 2%, 5%, 10%, 20%, 30%, 40% and 50% damaged leaves) of infestation. Yearwise fodder yield data showed non-significant difference, however, pooled analysis revealed significant difference. Maximum (4807 kg/ha) grain yield was recorded when control measures were initiated at zero per cent leaf damage and it was on par with 2 and 5% leaf damage. Significant yield reduction due to leaf folder was obtained at 5% damaged leaves. Maximum (1:10.14) ICBR was recorded at the infestation level of 20% damaged leaves.

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INTRODUCTION

Leaf folder (*Cnaphalocrocis medinalis* Guen.) is recorded as minor pest of rice in Gujarat, but now it has almost reached the status of a major pest. Patel *et al.*, (1964) for the first time recorded the pest as a damaging pest for rice crop in Gujarat. According to Upadhyay *et al.*, (1975), *C. medinalis* is the most destructive pest of rice in the State. A sudden outbreak of this pest was recorded during 1971. For every unit of increase in infestation, yield decreased by 1.40% during summer and 1.46% during *kharif* (wet) seasons (Pandya *et al.*, 1987).

economic injury level (EIL) for *C. medinalis*. In successful pest management programme economic threshold levels (ETL) are used for planning chemical and biocontrol strategies.

In India, no detailed work has been done on assessment of ETL for *C. medinalis*, except some little work undertaken by All India Co-ordinated Rice Improvement Programme. However, none of the workers have tried to determine the ETL considering the yield as well as ICBR value for *C. medinalis* in case of rice. Hence, it was felt necessary to work out ETL for this valuable pest in middle Gujarat, so that farmers can be advised at which level of infestation, control measures should be initiated to manage the pest effectively and economically.

Some of the workers (Dyck *et al.*, 1983 and Baustista *et al.*, 1984) have established

MATERIALS AND METHODS

The field experiment was carried out for three successive seasons during 1990-91, 1991-92 and 1992-93, at the Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat). The experiment was laid-out in Randomized Block Design with eight treatments (different level of infestation) replicated thrice. The gross and net plot size was 6.9 m x 4.00 m and 5.7 m x 2.8 m respectively. The seed of susceptible variety (GR-11) of paddy were sown on 27-6-90, 12-7-91 and 26-6-92 and seedlings were transplanted at 20 cm x 15 cm spacing on 6-8-90, 29-8-91 and 3-8-92 during 1990-91, 1991-92 and 1992-93, respectively. The crop was fertilized with 100 kg N and 50 kg P_2O_5 per hectare. All the other recommended agronomic practices, except plant protection, were followed for raising the healthy crop. Uniform plant population was maintained in all the experimental plots.

The leaf folder damage was assessed in all the treatments at 3-5 days interval starting from 20 days after transplanting by counting total number of leaves and leaf folder damaged leaves on 10 plants selected at random. Different levels (0%, 2%, 5%, 10%, 20%, 30%, 40% and 50% damaged leaves-DL) of infestation were maintained by adopting control measures using insecticides. As soon as, the leaf folder damage reached to a desired level, suitable insecticidal applications were made in the respective treatment. The insecticides viz., carbofuran (furadan) 3 G was used at the rate of 0.750 kg a.i./ha, whereas monocrotophos (nuvacron) 36 wsc, methyl parathion (metacid) 50 EC, phosphamidon (Dimecron) 85 EC and fenitrothion (Folthion) 50 EC were used at the rate of 0.50 kg a.i./ha to manage the leaf folder damage at a desired level of infestation. A common spray of phos-

phamidon 85 EC at the rate 0.50 kg a.i./ha was given in all the experimental plots to protect the crop from white backed plant hoppers on 18-10-91 and 19-10-92 during 1991-92 and 1992-93, respectively. The cost of crop protection required in each treatment during first, second and third year of experimentation is given in Table 1.

The crop was harvested on 13-11-90, 22-11-91 and 19-11-92 during 1990-91, 1991-92 and 1992-93, respectively. Grain and fodder yields corresponding to different infestation levels were recorded separately from net plot area and converted into kg/ha. The yield data thus obtained were subjected to statistical analysis.

Economics of each of the insecticidal applications was worked out on the basis of return from grain and fodder yields. The Incremental Cost Benefit Ratio was worked out and economic threshold level (ETL) was calculated based on I.C.B.R. value.

RESULTS AND DISCUSSION

To initiate control measures at lowest (0% DL) level of leaf folder damage, more (5 to 6) number of insecticidal applications are needed which resulted in the highest (Rs. 1886.24/ha) cost for plant protection measures and thereafter the amount invested for crop protection decreased progressively with the increase in infestation level (Table 1).

Year wise as well as pooled data of grain yield, revealed significant differences due to control measures adopted at different levels of leaf damage caused by leaf folder (Table 2). Fodder yield data for individual years of experimentation, showed non-significant difference, however, pooled analysis indicated significant difference. Maximum grain yield (4807 kg/ha) was recorded when control measures were adopted prior to any damage caused by leaf folder and it was on par

TABLE 1

Cost of plant protection measures adopted at various threshold leaves of rice leaf folder.

Sr. No.	Treatments (damaged leaves %)	Cost of insecticide (Rs./ha)				Av. No. of insecticidal application required	Labour* charge (Rs./ha)				Cost of plant protection (Rs./ha)
		1990-91	1991-92	1992-93	Mean		1990-91	1991-92	1992-93	Mean	
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	0	1907.94	1315.75	1795.04	1672.91	5.33	240	200	200	213.33	1886.24
2.	2	1607.94	929.64	1027.31	1188.30	4.00	200	160	120	160.00	1348.30
3.	5	582.94	774.64	1111.11	822.90	2.67	120	120	80	106.67	929.57
4.	10	300.00	549.64	555.55	468.40	1.33	40	80	40	53.33	521.73
5.	20	300.00	163.53	555.55	339.69	1.00	40	40	40	40.00	379.69
6.	30	—	—	—	—	—	—	—	—	—	—
7.	40	—	—	—	—	—	—	—	—	—	—
8.	50	—	—	—	—	—	—	—	—	—	—

* Labour charge Rs.20/- per day.

TABLE 2

Effect of various threshold levels of rice leaf folder on yield of rice.

Sr. No.	Treatments damaged leaves (%)	Grain yield (kg/ha)				Fodder yield (kg/ha)			
		1990-91	1991-92	1992-93	Pooled	1990-91	1991-92	1992-93	Pooled
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	0	5587 a	2882 a	5952 a	4807 a	4741	3759	6840	5114 a
2.	2	5472 a	2088 b	5190 ab	4250 ab	4303	4282	6318	4967 ab
3.	5	5201 a	1607 a	5075 ab	3961 b	4804	3864	6527	5065 ab
4.	10	4271 b	1170 d	4490 b	3310 c	4135	3906	6475	4839 ab
5.	20	4407 b	1065 d	4334 bc	3269 c	4323	3864	6161	4783 ab
6.	30	3603 c	926 d	3102 bc	2541 d	4282	3697	6161	4713 bc
7.	40	3864 c	794 d	2506 c	2388 d	4344	3906	6109	4786 ab
8.	50	3394 c	940 d	2245 c	2193 d	4511	3759	6427	4932 ab
S. Em.		169.68	130.43	428.03	194.81	—	—	—	130.43
C. D. at 5%		514.63	395.60	1298.22	590.86	NS	NS	NS	395.60
C. D. (%)		6.57	15.76	17.93	10.08	—	—	—	4.66

NS = Not Significant.

Means followed by the same letter in each column are not statistically different.

TABLE 3

Economics of threshold level of rice leaf folder and ICBR.

Sr. No.	Treatment damaged leaves (%)	Yield (kg/ha)		Gross income (Rs./ha)	Gross realization after deducting cost of plant protection (Rs./ha)	Net realization over control (Rs./ha)	ICBR
		Grain	Fodder				
1.	2.	3.	4.	5.	6.	7.	8.
(1)	0	4807	5114	21785	19899	8661	1:4.59
(2)	2	4250	4967	19484	18136	6998	1:5.12
(3)	5	3961	5065	18377	17447	6209	1:6.68
(4)	10	3310	4839	15660	15138	3900	1:7.48
(5)	20	3269	4783	15468	15088	3850	1:10.14
(6)	30	2541	4713	12521	12521	1283	—
(7)	40	2388	4786	11945	11945	707	—
(8)	50	2193	4932	11238	11238	—	—

Market Price : Grain Rs. 400/- qt.
Fodder Rs. 50/- qt.

with at 2 and 5% leaf damage. Significant yield reduction due to leaf folder was obtained at 5% damaged leaves. Anonymous (1990) also recorded similar results which supports the above findings. However, significant yield reduction at 10% damaged leaves was reported at Coimbatore (Anon. 1989) and at 20% at Ludhiana (Anon. 1992). This variation may be due to intensity of pest infestation in different environments.

By regression the data, the equations computed was $Y_1 = 4271.27 - 47.46 x$ and $Y_2 = 4984.39 - 4.31 X$, where, Y_1 and Y_2 indicate grain and fodder yield, respectively, while X indicate infestation level. It explains that increase in leaf folder damage level by one unit, would result in decrease in grain and fodder yield by 47.46 and 4.31 times, respectively.

Though, the gross income from grain and fodder yield was maximum (Rs. 21785/ha) in the treatment of 0% damaged leaves (DL), the higher cost involved in plant protection resulted lower (1:4.59) ICBR value (Table 3). Maximum

(1:10.14) ICBR was recorded in the treatment where control measures were initiated at 20% damaged leaves. However, grain yield obtained from plots protected at 2 and 5% damaged leaves yielded significantly higher than the plots protected at 10% and above damage level. Considering the grain yield and ICBR value, it can be judged that for harvesting the optimum yield of rice control measures for leaf folder should be initiated at 5% damage level. Therefore, the economic threshold value for the pest could be fixed as 5% damage leaves. These findings are in partial agreement to those reported by Baustista *et al.*, (1984) who established economic injury level at 4.2% damaged leaves, which is always above the economic threshold level.

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Bionomics of Mealybug, *Coccidohystrix insolita* (Green) on Pigeonpea*

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ABSTRACT

The life cycle of *Coccidohystrix insolita* (Green) was studied in laboratory and field conditions in Junagadh. The eggs were dirty white, oval and found within the protective cottony ovisac. The male and female bugs passed through four and three nymphal instars, respectively. The total life span for male and female was 25.92 ± 1.38 and 42.89 ± 2.88 days, respectively, at an average laboratory temperature of $29.42 \pm 1.20^{\circ}\text{C}$ and 82.64 ± 5.48 per cent relative humidity and 42.14 ± 1.46 and 59.49 ± 2.14 days for male and female at the field temperature of $24.94 \pm 2.27^{\circ}\text{C}$ with 70.11 ± 13.10 per cent relative humidity, respectively. The sex ratio of male to female was 2.07 in field conditions.

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INTRODUCTION

Pigeonpea, *Cajanus cajan* (L.) Millsp. is an important legume crop and various insect-pests reduced the yield by 33.47 per cent in Saurashtra region of Gujarat State (Bhalani and Parsana, 1991). Among the 200 insect-pests (Lateef and Reed, 1990), the mealybug, *Coccidohystrix insolita* (Green) has been observed recently and severely infesting pigeonpea in South Gujarat and in Saurashtra region (Patel *et al.*, 1985; Bhalani, 1990). Considering the importance of the pest and no information of its bionomics, attempts were made to investigate the same.

MATERIALS AND METHODS

Bionomics of the pest was studied under laboratory and field conditions, during 1991

and 1992, respectively. Initial culture was maintained on the pigeonpea (variety BDN 2) seedlings grown in the plastic pots and on plants raised in the fields. The newly emerged nymph was transferred on to a leaf of 21 days aged potted plant. In this way 100 nymph was transferred on a leaf of 100 different potted plants. The plants were covered with glass chimneys having top end covered with muslin cloth and secured in position with the rubber bend. The seedlings were observed daily till the completion of life cycle. The duration of various stages, fecundity, etc. were noted. Observations were also made under microscope for colour, shape and morphological characters of various stages of the pest. The measurements of each stage were taken under microscope. During the study period, the temperature and relative

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humidity was $29.42 \pm 1.20^{\circ}\text{C}$ and 82.64 ± 5.48 per cent, respectively in laboratory, while it was $24.94 \pm 2.27^{\circ}\text{C}$ and 70.11 ± 13.10 per cent respectively, under field condition.

RESULTS AND DISCUSSION

Ovisac : The female laid eggs within the protective cottony ovisac on lower surface of the leaf. Similar observations were also reported by Patel (1990). The length and width of ovisac were 6.51 ± 0.99 and 1.95 ± 0.09 mm, respectively.

Egg : The newly laid eggs were smooth, translucent, bright, dirty white which became creamy to light yellow before hatching. It was oval with tapering ends, kidney or round shaped. The length and breadth were 0.30 ± 0.02 and 0.16 ± 0.01 mm, respectively. The present observations are in agreement with Patel (1990). The incubation period was 6.08 ± 0.78 days and hatching percentage was 90.02 in laboratory. It was 10.26 ± 0.99 days and 87.79 per cent in field condition (Table 1). Rawat and Modi (1969), however reported 4.4 days incubation period from Madhya Pradesh. Patel (1990) reported 7.03 ± 0.27 days as egg period and 89.37 ± 4.23 per cent hatching in laboratory at $29.65 \pm 1^{\circ}\text{C}$ temperature and 84.93% R. H.

Nymph : The male and female nymphs moulted 3 and 4 times, respectively before attaining adult stage.

First Instar : Freshly emerged nymphs were oval in shape, light yellow in colour having a pair of 6-segmented short filiform antennae and bright red eyes. The colour

changed to pale white within two days after hatching. A pair of long filaments was observed at posterior end of the body. The length and breadth were 0.35 ± 0.02 and 0.17 ± 0.01 mm, respectively. Ghosh and Ghose (1988) reported 0.59 and 0.27 mm of body length and width, respectively. The slight differences in body size from the present findings might be due to variation in host plant.

Second instar : The morphology of the second instar nymphs was same as that of first instar. Within one day of the first moult, nymphs secreted white waxy powder and fibres on dorsal as well as on lateral sides of the body. Length and breadth were 0.64 ± 0.03 and 0.32 ± 0.02 mm, respectively. Similar observations were recorded by Ghosh and Ghose (1988) and Patel (1990).

Third instar : Sexual dimorphism was evident from this stage. The male nymph formed a white silken cocoon before one of two days of second moult, whereas it was absent in female. After formation of cocoon male passed through two moults before reaching adult stage. Similar observations were also reported by Rawat and Modi (1969). Mean length and breadth was 1.75 ± 0.15 and 0.61 ± 0.07 mm, respectively.

Male : The nymphs were elongated and pale yellow in colour. It possesses well developed legs and a pair of wing buds on the dorso-lateral margin of the meta-thoracic region. A pair of 9-segmented filiform antennae was directed backward from the first apical end.

Female : The nymphs were smaller in size than male and oval in shape with light

TABLE 1

Incubation period, hatching percentage, duration of nymphal instars and growth index of *C. insolita* under laboratory and field conditions.

Condition	Incubation period (days)	Percentage egg hatching	Sex	Duration of nymphal instars (days)					Nymphs survived (%)	Growth index value
				1st	2nd	3rd	4th	Total		
Laboratory	6.08 ± 0.78	90.02	Male	5.8 ± 0.9	5.1 ± 0.7	3.5 ± 0.7	2.8 ± 0.6	17.2 ± 1.1	92.68	5.39
			Female	5.7 ± 0.7	5.1 ± 0.9	5.4 ± 0.9	—	16.2 ± 1.5	96.49	5.96
Field	10.26 ± 0.99	87.79	Male	10.5 ± 1.1	9.1 ± 1.1	5.6 ± 0.9	3.9 ± 0.8	28.9 ± 1.4	69.70	2.41
			Female	10.5 ± 1.2	8.8 ± 1.2	8.1 ± 1.4	—	27.5 ± 2.0	74.13	2.70

yellow colour. Two pairs of dark brown spots were evident on dorsal side of the body. It possesses a pair of 7-segmented filiform antennae. Number of clusters having 4 to 6 glossy waxy short hairs were also present on the dorsal and lateral sides of each thoracic and abdominal segments.

Length and breadth of third instar nymphs of male were 1.12 ± 0.03 and 0.43 ± 0.02 mm, whereas in case of female, it was 0.90 ± 0.03 and 0.42 ± 0.02 mm, respectively. Ghosh and Ghose (1988) and Patel (1990) recorded similar measurements.

Fourth instar : The male was pale yellow in colour having wing pads on dorso-lateral margins of the metathorax. It possesses a pair of 10-segmented antennae. Length and breadth were 1.17 ± 0.04 and 0.43 ± 0.02 mm, respectively. The reports of Ghosh and Ghose (1988) and Patel (1990) regarding measurements of fourth instar strongly supported the present findings.

The durations of first, second, third and fourth instars of male (Table 1) were $5.8 \pm$

0.9 , 5.1 ± 0.7 , 3.5 ± 0.7 and 2.8 ± 0.6 days, respectively, whereas the first, second and third instar of female took 5.7 ± 0.7 , 5.1 ± 0.9 and 5.4 ± 0.9 days, respectively. The total nymphal period of male and female was 17.2 ± 1.1 and 16.2 ± 1.5 days, respectively in laboratory. Patel (1990) reported total nymphal duration of male and female as 17.02 ± 1.08 and 15.50 ± 1.83 days, respectively on pigeonpea. Under field conditions, the mean duration of first, second, third and fourth instar of male (Table 1) was 10.5 ± 1.1 , 9.1 ± 1.1 , 5.6 ± 0.9 and 3.9 ± 0.8 days, respectively, whereas in case of female, the first, second and third instar duration was 10.5 ± 1.2 , 8.8 ± 1.2 and 8.1 ± 1.4 days, respectively. The total nymphal period of male and female was 28.9 ± 1.4 and 27.5 ± 2.0 days, respectively. Thus, the duration of nymphal instar increased with decreased in temperature.

Growth Index : Growth index values of male and female nymphal instars were 5.39 and 5.96 in laboratory, while it was 2.41 and 2.70 under field conditions, respectively (Table 1). Thus, an average temperature of $29.42 \pm 1.20^\circ\text{C}$ with 82.64

TABLE 2

Pre-oviposition, oviposition, post-oviposition period and fecundity of *C. insolita* under laboratory and field conditions.

Condition	Duration (days)			No. of eggs laid per female
	Pre-oviposition	Oviposition	Post-oviposition	
Laboratory	$13.09 \pm$	$3.09 \pm$	$4.58 \pm$	$163.04 \pm$
	2.55	0.62	1.58	43.90
Field	$14.21 \pm$	$4.04 \pm$	$3.79 \pm$	$147.93 \pm$
	2.23	0.81	1.08	38.37

± 5.48 per cent relative humidity were found to be more suitable for pest multiplication.

Adult

Male : It was slender, delicate and elongate in shape. Head, thorax, legs and antennae were yellowish, whereas abdomen was pale yellow in colour. They possessed a pair of well developed meta-thoracic milky white wings and three pairs of legs. The antennae was 10-segmented and much longer than the female. Two pairs of tail-like waxy filaments were present at the anal end of the body. The mean length and breadth with expanded wing was 1.18 ± 0.04 and 2.35 ± 0.09 mm, respectively. Almost similar measurements were recorded by Patel (1990). The male survived for 2.95 ± 0.84 and 2.70 ± 0.76 days under laboratory and field conditions, respectively (Table 2). Patel (1990) reported 1.44 ± 0.65 days longevity of male.

Female : Female was light yellow in colour having a greenish strip on the dorsal side and a yellowish green strip with two small greenish spots plural sides of the body. It was apterous, elongated oval in shape, soft bodies

insects and having clusters of glossy waxy hairs over the body. Each cluster of waxy hair consists of 4 to 6 and 6 to 10 hairs on dorsal and lateral surfaces of the body, respectively. They possessed a pair of brownish short filiform 9-segmented antennae. Length and breadth were 1.41 ± 0.04 and 0.67 ± 0.05 mm, respectively, while the body measured 2.74 ± 0.16 mm in length and 1.46 ± 0.08 mm in breadth at the time of egg laying. Similar observations were also reported by Patel (1990).

Under the laboratory conditions, pre-oviposition, oviposition and post-oviposition periods were 13.09 ± 2.55 , 3.09 ± 0.62 and 4.58 ± 1.58 days, respectively. These periods were 14.21 ± 2.23 , 4.04 ± 0.81 and 3.79 ± 1.08 days in the field studies. Patel (1990) reported 6.68 ± 1.22 , 3.12 ± 0.73 and 3.32 ± 1.03 days, respectively as preoviposition, oviposition and post-oviposition periods on pigeonpea. A single female laid 163.04 ± 43.90 and 147.93 ± 38.37 eggs in the laboratory and field, respectively (Table 2). Rawat and Modi (1969) observed 199 eggs/female on brinjal and Patel (1990) reported 142.28 ± 46.85 eggs/female on pigeonpea.

TABLE 3

Longevity of adult and entire life span of *C. insolita* under laboratory and field conditions.

Conditions	Sex	Longevity of adult (days)	Entire life period (days)
Laboratory	Male	2.95 ± 0.84	25.92 ± 1.38
	Female	20.76 ± 2.78	42.89 ± 2.88
Field	Male	2.70 ± 0.76	42.14 ± 1.46
	Female	22.06 ± 2.51	59.49 ± 2.14

The female survived for 20.76 ± 2.78 and 22.06 ± 2.51 days in the laboratory and field, respectively (Table 3). Patel (1990) reported female longevity of 15.12 ± 1.88 days in laboratory.

Entire life span : The mean entire life period of male and female was 25.92 ± 1.38 and 42.89 ± 2.88 days in laboratory and 42.14 ± 1.46 and 59.49 ± 2.14 days in the field, respectively (Table 3).

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Influence of Weather Factors on the Pheromone Trap Catches of Cotton Bollworm Moths*

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ABSTRACT

The influence of weather parameters on pheromone trap catches of cotton bollworm moths was studied at Main Research Station (MRS) and Agricultural Research Station (ARS), U.A.S., Dharwad, Karnataka during 1989-90 and 1990-91. Maximum temperature had negative relationship on trap catches of *Pectinophora gossypiella* (Saunders) moths. Significant negative ($r = -0.506^*$) correlation was found between these two variables at M.R.S., Dharwad during 1990-91. Maximum temperature had no definite influence on trap catches of *Heliothis armigera* (Hubner) & *Earias* spp. Significant negative ($r = -0.555^*$) correlation was noticed between trap catches of *H. armigera* and minimum temperature at M.R.S., Dharwad during 1990-91. This weather parameter did not influence the trap catches of other two species of bollworm moths. No definite relationship existed between trap catches of *Earias* spp. and both the levels of temperature. *P. gossypiella* trap catches was positively influenced by morning and evening R. H. Negative relationship was observed between trap catches of *H. armigera* and morning R. H. Highly positive and significant ($r = -0.726^{**}$) correlation was evident between weekly total rainfall and trap catches of *P. gossypiella* moths at M.R.S., Dharwad during 1990-91. Wind velocity exhibited negative influence on trap catches of all the three species of bollworms.

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INTRODUCTION

Synthetic sex pheromone of cotton bollworms viz., pink bollworm, [*Pectinophora gossypiella* (Saunders)], gram pod borer, [*Heliothis armigera* (Hubner)] and spotted bollworm, [*Earias* spp.] are being investigated and extensively used in pheromone traps for monitoring of the moths. Trap catches are greatly affected by many abiotic and biotic factors. Among the various factors, weather is one of the most important and major factor influencing the trap catches of these noctuid

moths. Insect emergence and their flight activity are mainly determined by various weather parameters and thus affect trap catches.

Conflicting views on the influence of weather factors on trapping of bollworm moths have been placed on record. Person (1976) stated that the weather factors have a long term and permanent effect on insect population, whereas according to Verma *et al.*, (1982), weather factors have no significant effect on flight activity of moths. In the present

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TABLE 1

Correlation coefficient (r) between trap catches of cotton bollworms and weather factors at MRS, Dharwad during 1989-91.

Year	Bollworm species	Weather factors					
		Minimum Temp. °C	Maximum Temp. °C	Morning R. H. (%)	Evening R. H. (%)	Rainfall (mm.)	Wind speed km/hr
1989-90	<i>Pectinophora gossypiella</i>	-0.178	-0.284	+0.087	+0.287	+0.148	-0.240
	<i>Heliothis armigera</i>	-0.147	+0.559	-0.333	-0.413	-0.399	-0.635
	<i>Earias</i> spp.	—	—	—	—	—	—
1990-91	<i>Pectinophora gossypiella</i>	+0.088	-0.506**	0.458	+0.347	+0.726**	-0.012
	<i>Heliothis armigera</i>	-0.555**	0.007	-0.074	+0.049	-0.214	-0.155
	<i>Earias</i> spp.	-0.330	+0.131	-0.084	-0.016	-0.368	-0.542

— Tapping was not successful.

* : [P < 0.05]

** : [P < 0.01]

study an attempt was made to determine the effect of various weather parameters on trap catches of bollworm moths. The results obtained are presented in this paper.

MATERIALS AND METHODS

The present study was undertaken at two different locations viz., at the Main Research Station (MRS) and Agricultural Research Station (ARS), University of Agricultural Sciences, Dharwad, Karnataka during 1989-90 and 1990-91. Monitoring of cotton bollworm moths was done during the entire cotton growing seasons. For the purpose, delta sticky traps were used to monitor the pink bollworm (PBW), while polythene sleeve traps were used for *Heliothis* and *Earias* spp. Five pheromone traps each for all the three species baited with respective sex lures were installed at appropriate distance in general cotton fields and operated as per normal routine practices.

Weather data such as minimum and maximum temperature ($^{\circ}\text{C}$), morning and evening relative humidity (%), rainfall (mm.) and wind speed (km/hr) were obtained from meteorological laboratory located at respective trapping places. Mean value of trap catches and weather data were calculated for each week. The relationship between weather factors and trap catches of cotton bollworm moths was computed by using multiple correlation and the data thus obtained are presented in Table 1 and 2. Correlation coefficient (r) was worked out taking the mean trap catches as dependent (x) variable and means of weather factors as independent (y) variables.

RESULTS AND DISCUSSION

The analyses of data revealed that maximum temperature had negative effect on trap catches of PBW moths at both the seasons and locations, significant negative ($r=-0.506^*$) correlation was found between these two variables at MRS, Dharwad during 1990-91 (Table 1). This is in accordance with the report of Lingren *et al.*, (1989) who recorded lower catches of PBW moths at higher temperature. However, this environmental factor no definite influence on trap-catches of *H. armigera* and *Earias* spp.

Earlier reports of Sundarmurthy (1985) and Naik (1988) about negative association between trap catches of *H. armigera* and minimum temperature agreed with the present findings, where significant negative ($r=-0.555^*$) relationship between these two variables was noticed at former location during second year of experimentation (Table 1). Conversely, this weather parameter did not affect the trapping of other two species of bollworm moths. No precise relationship existed between trap catches of *Earias* spp. and both the levels of temperatures, which is corroborated by the findings of Marks (1977) in the case of red bollworm *Diparopsis custanea* Hampson.

According to Gupta and Khurana (1971) and Sukhija *et al.*, (1985). PBW moth activity was proportional to atmospheric Relative Humidity (RH). In the present study also trap catches of PBW was positively related to both morning and evening RH. On the other hand, Regupathy (1985) observed negative association with these two factors. Negative relationship though not significant was observed between trap

TABLE 2

Correlation coefficient (r) between trap catches of cotton bollworms and weather factors at ARS, Dharwad during 1989-91.

Year	Bollworm species	Weather factors					
		Minimum Temp. °C	Maximum Temp. °C	Morning R. H.(%)	Evening R. H. (%)	Rainfall (mm.)	Wind speed km/hr
1989-90	<i>Pectinophora gossypiella</i>	+0.294	-0.188	+0.128	+0.455	+0.487	-0.127
	<i>Heliothis armigera</i>	-0.824	+0.477	-0.832	-0.830	-0.287	-0.641
	<i>Earias</i> spp.	+0.349	-0.076	-0.625	+0.069	+0.274	-0.080
1990-91	<i>Pectinophora gossypiella</i>	++	-0.111	+0.052	+0.143	+0.127	-0.109
	<i>Heliothis armigera</i>	++	-0.140	-0.096	+0.036	-0.334	-0.024
	<i>Earias</i> spp.	++	-0.014	-0.454	-0.162	-0.263	-0.587

++ Minimum temperature data not available.

* : [P < 0.05]

** : [P < 0.01]

catches of *H. armigera* and morning RH is in agreement with the findings of Sundarmurthy (1985).

In present study, high rainfall resulted in increased activity of PBW moths. Highly positive and significant ($r=+0.726^{**}$) correlation was evident between weekly total rainfall and trap catches at MRS, Dharwad during the second year of study (Table 1). This finding strongly agreed with the report of Sukhija *et al.*, (1985). However, Naik (1988) failed

to notice any influence of rainfall on the activity of three species of bollworm moths.

Wind velocity exhibited negative influence on trap catches of all the three species as is evident from the results of two seasons and two locations (Table 1 & 2). However, statistically the relationship was not significant. This finding is in conformity with Marks (1977), Rothschild *et al.*, (1981), Wardhaugh *et al.*, (1981) and Sundarmurthy (1985).

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Studies on Seasonal Cyclicity of *Bactocera correctus* Bezzi in Mango and Sapota Orchards Using Methyl Eugenol Trap

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ABSTRACT

This paper provides an analysis of data on seasonal incidence of *Bactocera correctus* Bezzi (Tephritidae : Diptera) infesting Mango and Sapota orchards, recorded during 1992-94 using Methyl Eugenol as sex attractant (a naturally occurring chemical in 'black Tulsi') in South Gujarat at Agricultural Experimental Station, Gujarat Agricultural University, Paria, District Valsad, Gujarat. Fruit flies were trapped throughout the year in experimental Mango and Sapota orchards. In Mango, maximum trappings were recorded during second fortnight of April (453 fruit flies/trap) and during second fortnight of May (483 fruit flies/trap), thereafter, it declined gradually. Major activity of the pest occurred from March to June coinciding with the fruiting period of the crop. The population variations were positively correlated with temperatures (maximum, minimum and average) and other factors did not show any significant impact on population variation. In Sapota, major activity of the pest was noticed from April to September coinciding with fruiting period of the crop. The highest peak was noticed during first fortnight of June (580 fruit flies/trap) and the minimum during second fortnight of December. The trapped population variations exhibited significantly positive correlation with temperatures (minimum and average), relative humidities (Evening and average) and negative with Sun shine hours.

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INTRODUCTION

Mango, *Mangifera indica* Linn. is extensively grown in Gujarat occupying 26000 hectares, of which 70 per cent of area and 85 per cent of production is concentrated in Valsad district. Similarly, Chiku (Sapota) *Manilkera achraes* (Mill) (Forsberg) occupies 4700 hectares in Gujarat State, of which 80 per cent of area is in Valsad district. Thus, these two fruit crops are economically important fruit crops paying very good revenue in this region. Mango trees are prone to the attack of more

than 350 species of insects, 8 species of mites and 13 species of nematodes reported from all over the world (Anonymous, 1985, Tandon and Verghese, 1985). Over 175 species of insects have been reported damaging Mango trees in India, however, insects which cause serious losses are hoppers, mealy bugs, fruit flies, shoot and stem borers, scale insects, stone weevil, gall midge and termites (Butani, 1979). Similarly, Chiku trees are attacked by about 25 insect pests, of which Chiku bud borer, fruit flies, scales and mealy bugs are important pests (Butani, 1979).

Fruit fly, *Bactocera Dacus correctus* (Bezzi) is a serious pest of Mango and Chiku causing qualitative loss (Shah and Vora, 1974). Since, in South Gujarat, separate as well as mixed plantation of Mango and Chiku orchards are there, the pest survives throughout the year particularly on Chiku trees having continuous habit of flowering and fruit bearing. Before developing insect pest management programme for specific agroecosystem, it is necessary to have the basic information on abundance and distribution of pest in relation to weather parameters, as it helps in determining appropriate time of action and suitable effective method of control. It was therefore felt necessary to study the population rhythms of this pest throughout the year with regards to abiotic factors in the region.

MATERIALS AND METHODS

The plastic bait traps (Length 25 cm : Diameter 15 cm.) containing Methyl Eugenol and Fenthion (Lebaycid) in petri dishes were used for the fruit fly survey. A piece (3 x 3 cm) of synthetic sponge was wetted with 2-3 drops of each chemical and it was placed in glass petri dish (5 cm diameter). Five such traps were placed separately in Mango and Chiku orchards and trap to trap distance was kept 100 metres. The total number of fruit flies were recorded at regular interval of 15 days during 1992-94. The traps were replenished after each observation. In order to study the instantaneous effect of weather parameters viz., maximum temperature (X_1), minimum temperature (X_2), average temperature (X_3), morning relative humidity (X_4), evening relative humidity (X_5), average relative humidity (X_6), Sun shine (X_7), rainfall (X_8) and rainy days (X_9) as independent variables on population of the pest. Correlation coefficients were worked

out by taking average population as dependent variable (Y). Meteorological data were recorded from meteorological observatory at Agriculture Experimental Station, Paria during the period under study.

RESULTS AND DISCUSSION

Population dynamics

It can be seen from Table 1 and figure 1 that the fruit fly population in Mango and Chiku orchards in South Gujarat remained considerably high during April, May and June. In case of Mango, the fruit fly was trapped throughout the year, but its population remained considerably higher during March to June exhibiting highest peak in second fortnight of May (483.50 fruit flies/trap), thereafter, it declined gradually. Similarly, in Chiku also fruit flies were trapped throughout the year. But, population started increasing considerably from first fortnight of April and reached to the peak in first fortnight of June (580 fruit flies/trap) and afterwards a decreasing trend in later period of the year was observed. It was observed that the flies were concentrated in higher numbers in Mango orchard than in Chiku orchard during March to May. While they were higher in Chiku orchard than in Mango orchards during June to December which were the ripening periods of respective crops in the region. There are few reports available on seasonal incidence of fruit fly in Mango as well as Mango Chiku mixed plantation. Patel (1973) and Jhala (1989) made similar observation on seasonal incidence of *D. correctus* and *D. dorsalis* respectively in mixed plantation (Chiku and Mango), wherein they also found major active period of the pest coinciding with ripening period of the fruit.

TABLE 1

Population of *Bactocera correctus* (Bezzi) during different months in Mango and Sapota orchards (1992-94).

Month	Fortnight	Average number of fruit flies per trap					
		Mango			Sapota		
		1992-93	1993-94	Pooled	1992-93	1993-94	Pooled
Jan.	II	18	22	20	16	19	17.50
	IV	34	36	35	19	26	22.50
Feb.	II	41	43	42	23	33	28
	IV	46	50	40	26	36	31
March	II	66	63	64	43	48	45.50
	IV	131	159	145	45	51	48
April	II	384	364	374	148	164	156
	IV	501	405	453	285	301	293
May	II	435	405	420	285	434	359.50
	IV	456	481	483.50	389	476	432.50
June	II	471	284	377.50	589	571	580
	IV	286	290	288	322	422	372
July	II	210	178	194	178	184	181
	IV	130	94	112	163	166	164.50
August	II	83	66	74.50	146	140	143
	IV	74	64	69	132	130	131
Sept.	II	28	23	25.50	130	129	127
	IV	36	36	36	89	78	82.50
Oct.	II	39	43	41	56	58	57
	IV	44	49	46.50	45	47	46
Nov.	II	43	53	48	40	39	39.50
	IV	28	37	32.50	40	30	34.50
Dec.	II	23	23	23	21	24	22.50
	IV	17	19	18	14	17	15

Fig.1 Meteorological data of ABS Paria during 1992-94

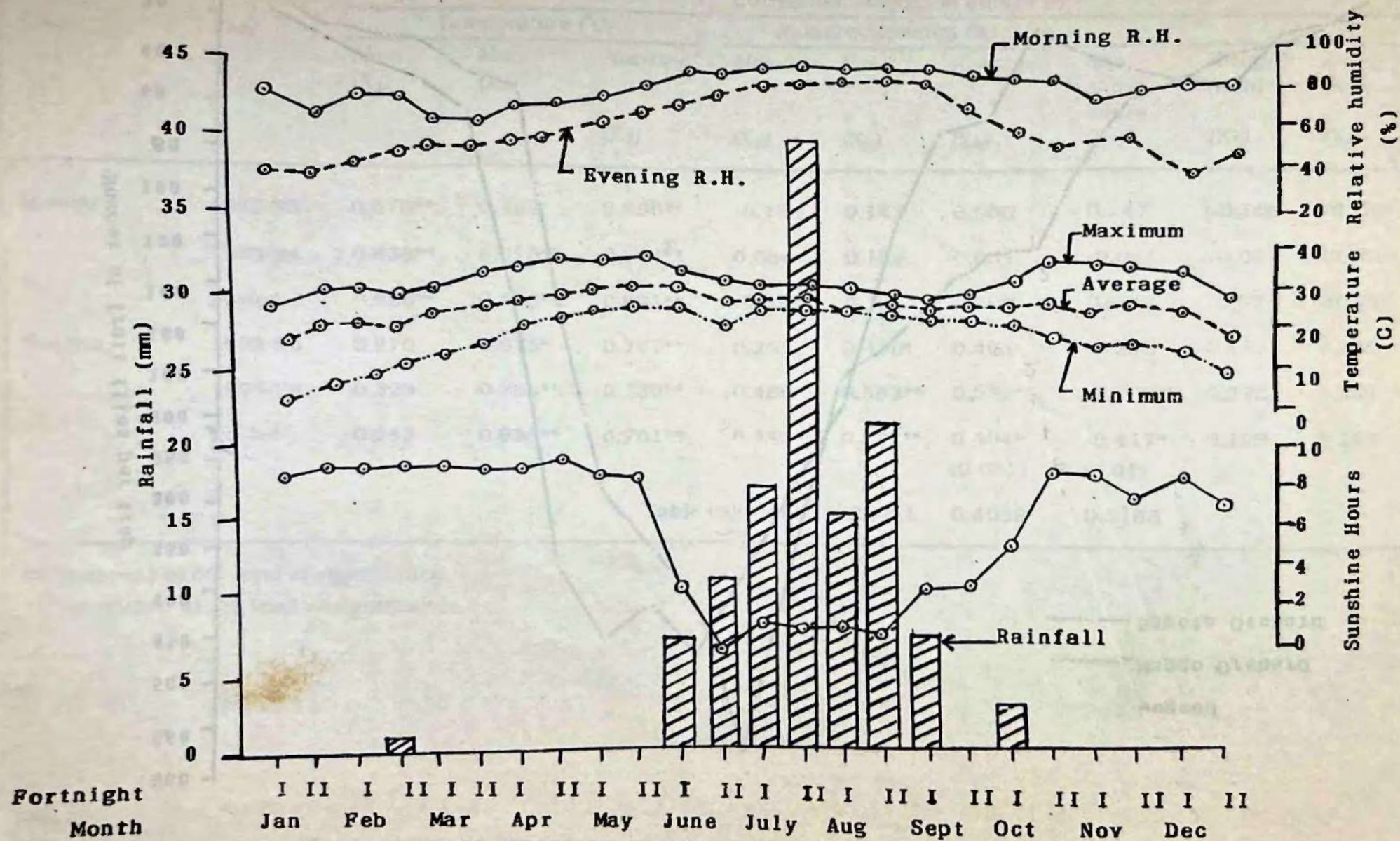


Fig.2. Relative abundance of fruitflies in Mango and Sapota Orchards.

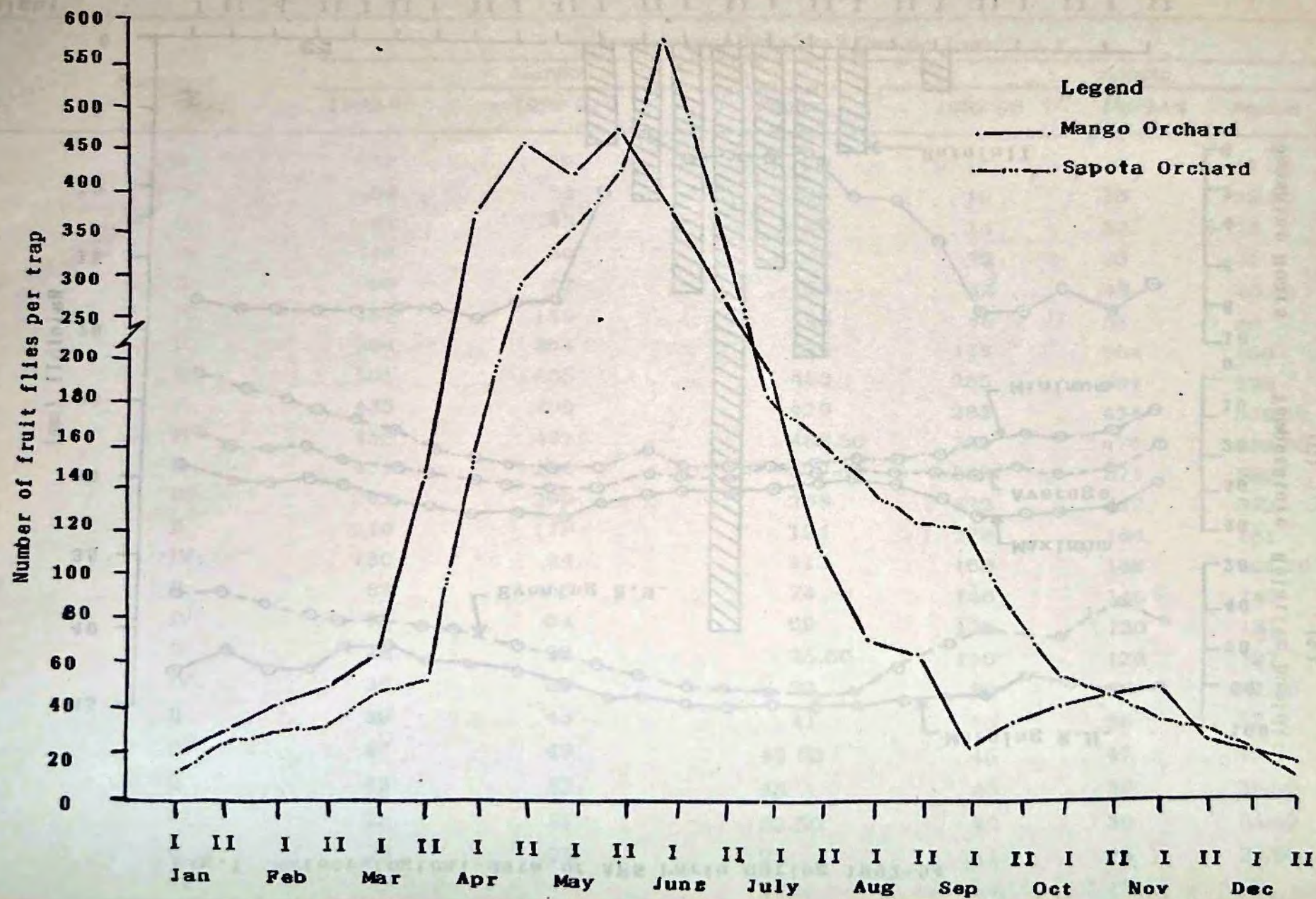


TABLE 2

Correlation between fruit fly population (Mango and Sapota) and weather factors.

Crop	Year	Correlation coefficient values (r)								
		Temperature (°C)			Relative humidity (%)			Sun shline hours (X ₇)	Rainfall (mm) (X ₈)	Rainy days (X ₉)
		Max. (X ₁)	Min. (X ₂)	Average (X ₃)	Mor. (X ₄)	Eve. (X ₅)	Average (X ₆)			
Mango	1992-93	0.570**	0.499*	0.698**	-0.154	0.147	0.060	0.147	-0.108	-0.108
	1993-94	0.636**	0.615**	0.714**	0.064	0.159	0.031	-0.044	-0.060	-0.069
	Pooled	0.600**	0.553**	0.691**	-0.035	0.156	0.099	0.063	-0.074	-0.085
Sapota	1992-93	0.270	0.675*	0.747**	0.200	0.470*	0.403	-0.200	0.151	0.205
	1993-94	0.329	0.764**	0.739**	0.488*	0.563**	0.552**	-0.609**	0.213	0.362
	Pooled	0.265	0.696**	0.701**	0.342	0.542**	0.494* (0.05)	-0.417* (0.01)	0.198	0.297
Table value of 'r' at 22 d.f.							0.4059	0.5168		

*Significant at 5% level of significance.

** Significant at 1% level of significance.

Influence of abiotic factors on Incidence of fruit fly

The data presented in Table 1 and Table 2 indicated that dependent variable viz., fruit fly population in Mango (Y) had significant positive correlation with temperatures (Maximum and average). It is also evident that the average temperature during March to June (the period of higher activity of the pest) was on an average 28°C while during October to February (the period of low activity of the pest) it was on an average 22.97°C. Thus, when the temperature was more than 28°C the pest population was found to increase but when the temperature was decreasing below 22°C the pest population was found to decrease. Other factors showed no any significant impact on population variation. Similarly, in Chiku the pest

population (Y) apart from showing positive correlation with temperatures (minimum and average) also showed significant positive correlation with relative humidities (Evening and average) and negative correlation with Sun shine hours. The pest population was maximum during second fortnight of June when the temperature (average) was 28.5°C and average relative humidity (84.25%) was considerably high. In Karnataka, higher population of *Dacus dorsalis* (Hendel) on Mango has been reported in the month of April-June and indicated positive correlation with maximum temperature during July 1975 to December 1978 (Bagle *et al.*, 1983). Seo *et al.*, (1982) also recorded almost similar pattern of incidence of Papaya fruit fly *D. dosalis* showing positive impact of temperature in Hawaii island.

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Field Evaluation of Some Brinjal Varieties for Resistance to Insect Pests and Little Leaf Disease

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ABSTRACT

Studies carried out on resistance to insect pests and disease in various brinjal varieties at Gujarat Agricultural University, Campus Anand during *kharif* 1992 to 1994 revealed low susceptibility of Suphal to *Bemisia tabaci* G. and Punjab Barsati to *Leucinodes orbonalis* G. Gujarat Brinjal Hybrid-1 (ABH-1) and Chaklasi Doli were proved higher marketable fruit yielder than Suphal, Punjab Barsati, GB-6, Ravedi, Round-14 and Long-13.

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INTRODUCTION

Brinjal (*Solanum melongena* Linnaeus) is the most popular and principal vegetable crop grown throughout the year in India. In Gujarat it is cultivated in 15500 hectares with production of 233000 metric tonnes (Gill and Tomar 1991). Such an important vegetable crop is found infested with 14 pests in Gujarat (Patel *et al.*, 1970). The approach of developing multiresistant crop variety is highly essential because it is inexpensive in long run and would avoid problem of pesticide hazards. In view of this experiment were conducted to screen out the resistant/tolerant brinjal varieties to insect pests and little leaf disease at Gujarat Agricultural University, Campus Anand during *kharif* 1992 to 1994.

MATERIALS AND METHODS

Field experiment were conducted in randomised block design with three replications. The plot size was 4.2 x 3.6 m. The row to row and plant to plant spacing was 90 and 60 cm respectively. Ten brinjal varieties (Table 1) were evaluated for their relative resistance to aphid (*Aphis gossypii* (G)), jassid (*Amrasca biguttula biguttula* Ishida), white fly (*Bemisia tabaci* Genn.), shoot and fruit borer (*Leucinodes orbonalis* Guen.) and little leaf disease. The nymphal and adult populations of sucking pests were recorded on three leaves at different heights of each of five tagged plants selected at random from each of the plots. The population counts were made at an interval of one week starting after four weeks of transplanting of brinjal seedlings till the last picking of fruits. The damage caused

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TABLE 1

Susceptibility of various brinjal varieties to insect pests and little leaf disease (1992 to 1994 pooled).

Variety	Av. No. per leaf*			Damage (%) of**		Plant (%) Infected with little leaf disease	Marketable fruit yield (q/ha)
	Aphid	Jassid	White Fly	<i>L. orbonalis</i> Shoot	Fruit		
Suphal	1.53 (2.61)	1.10 (0.97)	0.93 (0.38)	13.52 (5.87)	25.32 (18.52)	34.26 (35.35)	45.65
Long-13	1.49 (2.19)	1.07 (0.67)	0.96 (0.46)	6.92 (1.93)	20.32 (12.14)	41.83 (46.44)	56.05
Round-14	1.56 (2.39)	0.99 (0.52)	1.06 (0.69)	10.73 (4.19)	19.66 (11.52)	41.71 (43.87)	56.39
Punjab Barsati	1.36 (1.66)	0.95 (0.40)	1.09 (0.76)	7.70 (2.31)	11.56 (4.18)	42.35 (45.98)	68.70
ABH-1	1.70 (2.98)	0.99 (0.52)	1.23 (1.17)	9.08 (2.89)	16.34 (8.12)	32.34 (27.82)	112.19
ABH-2	1.39 (1.89)	0.97 (0.49)	1.23 (1.17)	8.30 (2.66)	18.56 (10.33)	32.55 (31.99)	103.62
GB-6	1.35 (1.56)	0.96 (0.43)	1.17 (0.96)	8.67 (3.01)	17.77 (9.42)	32.57 (31.17)	78.12
Doli-5	1.34 (1.60)	0.90 (0.44)	1.22 (1.11)	8.96 (2.98)	15.21 (6.93)	32.22 (29.72)	105.30
Chaklasi Doli	1.37 (1.61)	1.02 (0.93)	1.20 (1.06)	10.07 (3.50)	15.47 (7.18)	25.22 (20.24)	121.76
Ravedi	1.25 (1.26)	0.94 (0.36)	1.06 (0.69)	10.41 (4.79)	13.89 (5.82)	39.06 (43.43)	46.51
S. Em.	0.11	0.04	0.07	1.07	1.11	3.71	13.10
C. D.	NS	NS	0.19	3.18	3.31	NS	38.92
C. V. %	19.69	7.64	11.64	13.39	12.30	10.83	24.10

* $\sqrt{x + 0.5}$ transformed values.

** Arcsin transformed values.

Figures in parentheses are original values.

by *L. orbonalis* to shoots was also recorded at weekly interval starting from four weeks after transplanting till fruit formation by counting the total number of shoots and the number of withered shoots in the entire plot. The fruit

damage by *L. orbonalis* was recorded by counting number of healthy and damaged fruits at each picking. The little leaf incidence was recorded by observing all the plants of each plot at weekly interval starting after six

weeks of transplanting till the last picking. Yield data of marketable fruit for each variety was recorded during each picking. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Aphid and jassid

Among the ten brinjal varieties none could show superiority in resistance to insect pests and all were found equally susceptible to aphid (*A. gossypii*), jassid (*A. biguttula biguttula*) and little leaf disease.

Whitefly

The plants of brinjal Suphal and Long-13 were found to have significantly lower whitefly (*B. tabaci*) population than the other varieties tested. Higher population of whiteflies was recorded on GB-6, Chaklasi Doli, Doli-5, ABH-1 (Gujarat Brinjal Hybrid-1) and ABH-2 (Anand Brinjal Hybrid-2), which were considered as susceptible varieties against the attack of whitefly. However, Ravedi, Punjab Barsati and Round-14 were found moderately susceptible.

Shoot and fruit borer

The shoots of Long-13 were found to have significantly low infestation of *L. orbonalis* in comparison to shoots of Suphal, whereas rest of the varieties had almost equal shoot damage by shoot borer. The highest shoot damage was found on Suphal.

The fruits of Punjab Barsati showed least susceptibility to *L. orbonalis* and exhibited superiority to rest of the brinjal varieties except Ravedi by yielding higher number of healthy fruits. Ravedi had lower infestation of *L. orbonalis* in fruits than GB-6, ABH-2, Round-14, Long-13 and Suphal. However, Doli-5, Chaklasi Doli and ABH-1 had almost equal fruit damage as Ravedi and GB-6. Suphal had highest fruit damage followed by Long-13 and Round-14.

Yield

ABH-1 and Chaklasi Doli gave higher marketable fruit yield than all the varieties tested except Doli-5 and ABH-2 which showed equal yield potentiality.

Thus, the results indicated that Suphal which was found less susceptible to white fly had higher susceptibility to *L. orbonalis*. Likewise Long-13 showed low susceptibility to whitefly and shoot damage by *L. orbonalis* but had higher susceptibility of fruits to *L. orbonalis*. Punjab Barsati showed low susceptibility in fruit damage in comparison to Chaklasi Doli but due to its low yield potentiality it could give considerably lower marketable fruit yield than Chaklasi Doli. ABH-1 and Chaklasi Doli remained superior among the tested brinjal varieties except Doli-5 and ABH-2 by giving higher marketable fruit yield. Jyani et al., (1995) have also reported higher marketable fruit yield potentiality of Chaklasi Doli and Doli-5 even though they were found susceptible to *B. tabaci*.

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Bioefficacy of Various Insecticides Against *Coccidohystrix insolita* (Green) on Pigeonpea*

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ABSTRACT

Laboratory (1990-91) and field (1991-92 & 1992-93) investigation was carried out to see the bioefficacy and economics of various insecticides against *Coccidohystrix insolita* (Green) on pigeonpea at Junagadh. Out of 18 insecticides, quinalphos and methyl parathion 0.05 per cent; dichlorvos, triazophos and monocrotophos 0.04 per cent and neemark 0.5 per cent were found highly effective against third nymphal instars of *C. insolita* under laboratory condition, whereas quinalphos, triazophos and monocrotophos were found most effective and gave above 98 per cent mortality of this pest within 10 days of application under field condition. The results also indicated that the lowest percentage of loss in grain yield and highest net profit per hectare were recorded from these treatments.

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INTRODUCTION

Recently, the mealybug, *Coccidohystrix insolita* (Green) has been found seriously infesting pigeonpea crop in isolated patches in the Gujarat State. It is commonly known as brinjal mealybug, has been reported by Chaudhary (1976) and Nair and Nair (1976) attacking brinjal. It has been also reported to feed on pigeonpea in Gujarat (Patel *et al.*, 1985b and Bhalani, 1990). Considering the economic importance of the pest, attempts were made to find out the effective and profitable insecticides against mealybug on pigeonpea.

MATERIALS AND METHODS

Laboratory study

Trial was conducted at Department of Entomology, Junagadh during 1990-91, in a completely randomized design with 3 replications and 18 different insecticides including botanical materials (Table 1) and water treated control. A laboratory reared third nymphal instar of *C. insolita* were used as test insects. Leaves of pigeonpea were placed in Petri dishes (9.0 cm x 9.0 cm) having moist blotting paper. Each insecticidal suspension was applied @ 2 ml per Petri dish with the help of atomizer and was dried under room

*Part of Ph. D. thesis submitted by senior author.

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TABLE 1

Per cent mortality of nymphs of *C. insolita* by insecticides at different hours on pigeonpea in laboratory.

Treatment	Concentration (%)	Per cent mortality of <i>C. insolita</i> hours after application					
		3	6	12	24	48	72
Acephate	0.04	17.70 (9.24)	20.26 (11.99)	26.88 (20.44)	28.92 (23.39)	33.47 (30.42)	33.97 (31.22)
Dichlorvos	0.04	25.56 (18.62)	38.67 (39.04)	54.25 (65.87)	84.23 (98.99)	84.23 (98.99)	84.23 (98.99)
Dimethoate	0.03	17.70 (9.24)	21.63 (13.59)	34.06 (31.37)	39.36 (35.20)	45.78 (51.36)	53.31 (64.30)
Endosulfan	0.07	20.08 (11.79)	28.60 (22.91)	35.81 (34.23)	36.06 (34.65)	39.36 (35.20)	41.68 (44.22)
Malathion	0.05	30.98 (26.50)	41.03 (43.09)	51.75 (61.67)	68.43 (86.48)	84.23 (98.99)	84.23 (98.99)
Methyl parathion	0.05	36.79 (35.87)	46.58 (56.23)	63.02 (79.42)	84.23 (98.99)	84.23 (98.99)	84.23 (98.99)
Monocrotophos	0.04	11.23 (3.79)	38.67 (39.04)	51.93 (61.98)	72.10 (90.55)	80.42 (97.23)	80.55 (97.30)
Phosphamidon	0.03	16.07 (7.66)	32.82 (29.38)	38.04 (37.97)	49.78 (58.30)	60.12 (75.18)	64.60 (81.60)
Triazophos	0.04	5.74 (1.00)	40.34 (41.90)	60.39 (75.59)	84.23 (98.99)	84.23 (98.99)	84.23 (98.99)
Chinalphos	0.05	39.16 (39.88)	54.50 (66.28)	73.41 (91.85)	84.23 (98.99)	84.23 (98.99)	84.23 (98.99)
Cartap	0.05	14.14 (5.97)	22.36 (14.47)	28.84 (23.27)	33.47 (30.42)	41.72 (44.29)	41.77 (44.37)

1.	2.	3.	4.	5.	6.	7.	8.
Indiara	0.50	5.74 (1.00)	17.26 (8.80)	26.88 (20.44)	30.88 (26.34)	33.53 (30.51)	34.09 (31.42)
Mint oil	0.50	11.23 (3.79)	19.92 (11.61)	38.26 (39.34)	52.53 (62.99)	68.43 (86.48)	69.17 (87.36)
Neemark	0.50	14.79 (6.52)	27.70 (21.61)	46.16 (52.02)	48.18 (55.54)	73.55 (91.98)	80.42 (97.23)
Neemgaurd	0.50	16.42 (7.99)	19.53 (11.18)	29.50 (24.25)	45.78 (51.36)	54.74 (66.67)	63.41 (79.97)
Neem seed kernel suspension	3.00	11.23 (3.79)	16.62 (8.18)	22.81 (15.03)	28.92 (23.39)	36.06 (34.65)	40.66 (42.45)
Nicotine sulphate	0.05	11.23 (3.79)	22.55 (14.71)	47.80 (54.88)	53.93 (65.33)	64.97 (82.10)	68.09 (86.08)
Repelin	0.50	17.70 (9.24)	25.73 (18.85)	31.47 (27.25)	33.47 (30.42)	39.36 (40.22)	40.04 (41.39)
S. Em. $\pm$		2.44	3.20	2.82	2.57	1.92	1.98
C. D. at 5%		6.98	9.14	8.06	7.35	5.49	5.66
C. V. %		22.66	18.64	11.54	8.37	5.48	5.45

Figures in parentheses are retransformed values.

TABLE 2

Pooled mean per cent reduction of *C. insolita* at different intervals after first and second sprays on pigeonpea in field (1991-92 and 1992-93).

Treatment	Concentration (%)	Mean per cent reduction of <i>C. insolita</i> days after spray									
		First spray					Second spray				
		1	2	3	7	10	1	2	3	7	10
Dichlorvos	0.04	44.72 (49.51)	50.85 (60.14)	54.31 (65.96)	57.42 (71.00)	58.17 (72.18)	45.99 (51.73)	53.38 (64.42)	59.44 (74.15)	65.04 (82.19)	67.74 (85.65)
Malathion	0.05	61.58 (77.35)	68.18 (86.18)	72.56 (91.02)	75.41 (93.65)	75.96 (94.11)	55.68 (68.21)	64.86 (81.95)	70.16 (88.48)	72.56 (91.02)	74.38 (92.75)
Methyl parathion	0.05	63.27 (79.77)	70.56 (88.92)	73.70 (92.12)	76.70 (94.71)	78.01 (95.68)	56.28 (69.18)	63.20 (79.67)	69.93 (88.22)	71.32 (89.74)	74.42 (92.79)
Monocrotophos	0.04	62.67 (78.92)	72.02 (90.47)	78.24 (95.85)	81.80 (97.97)	82.24 (98.18)	57.75 (71.53)	71.73 (90.17)	77.60 (95.39)	82.17 (98.14)	83.30 (98.64)
Phosphamidon	0.03	64.25 (81.13)	68.00 (85.97)	69.74 (88.01)	74.30 (92.68)	75.48 (93.71)	56.31 (69.23)	61.83 (77.71)	66.98 (84.71)	69.09 (87.26)	71.35 (89.77)
Triazophos	0.04	66.55 (84.16)	76.84 (94.82)	78.22 (95.83)	83.59 (98.75)	84.16 (98.96)	60.51 (75.77)	73.05 (91.50)	77.56 (95.36)	81.99 (98.06)	83.30 (98.64)
Quinalphos	0.05	70.99 (89.39)	80.94 (97.52)	82.45 (98.27)	83.50 (98.72)	84.66 (99.13)	70.60 (88.97)	75.83 (94.01)	78.05 (95.71)	80.90 (97.50)	82.50 (98.30)
Endosulfan	0.07	31.83 (27.82)	36.84 (35.95)	40.55 (42.26)	42.01 (44.79)	42.27 (45.24)	31.08 (26.65)	38.76 (39.20)	40.07 (41.44)	41.56 (44.01)	42.42 (45.50)
Mint oil	0.50	37.38 (36.86)	48.11 (55.42)	50.56 (59.64)	51.13 (60.62)	56.95 (70.26)	35.16 (33.16)	42.16 (45.05)	48.15 (55.49)	49.71 (58.18)	50.08 (58.82)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Neemark	0.50	52.51 (62.96)	63.02 (79.42)	65.94 (83.38)	70.34 (88.68)	72.32 (90.78)	44.63 (49.35)	52.83 (63.50)	58.15 (72.15)	62.11 (78.12)	64.43 (81.37)
Neemgaurd	0.50	29.44 (24.16)	45.45 (50.79)	49.02 (56.99)	55.14 (67.33)	55.98 (68.70)	29.05 (23.58)	39.14 (39.84)	47.00 (53.49)	53.52 (64.65)	55.29 (67.58)
Nicotine sulphate	0.05	36.67 (35.67)	47.04 (53.56)	48.56 (56.20)	51.15 (60.65)	51.48 (61.21)	35.84 (34.28)	45.57 (50.99)	50.54 (59.61)	53.73 (65.00)	54.22 (65.82)
Control	—	9.68 (2.83)	11.79 (4.17)	12.61 (4.77)	14.56 (6.32)	14.76 (6.49)	7.13 (1.54)	10.30 (3.12)	11.64 (4.07)	13.09 (5.13)	13.71 (5.62)
S. Em. ±		3.12	2.92	2.81	2.72	3.05	2.77	3.23	2.94	3.11	2.80
C. D. at 5%		8.66	8.08	7.80	7.54	8.47	7.69	8.94	8.14	8.62	7.76
C. V. %		15.29	12.49	11.22	10.80	11.79	16.09	15.62	12.80	12.68	11.15

Figures in parentheses are retransformed values.

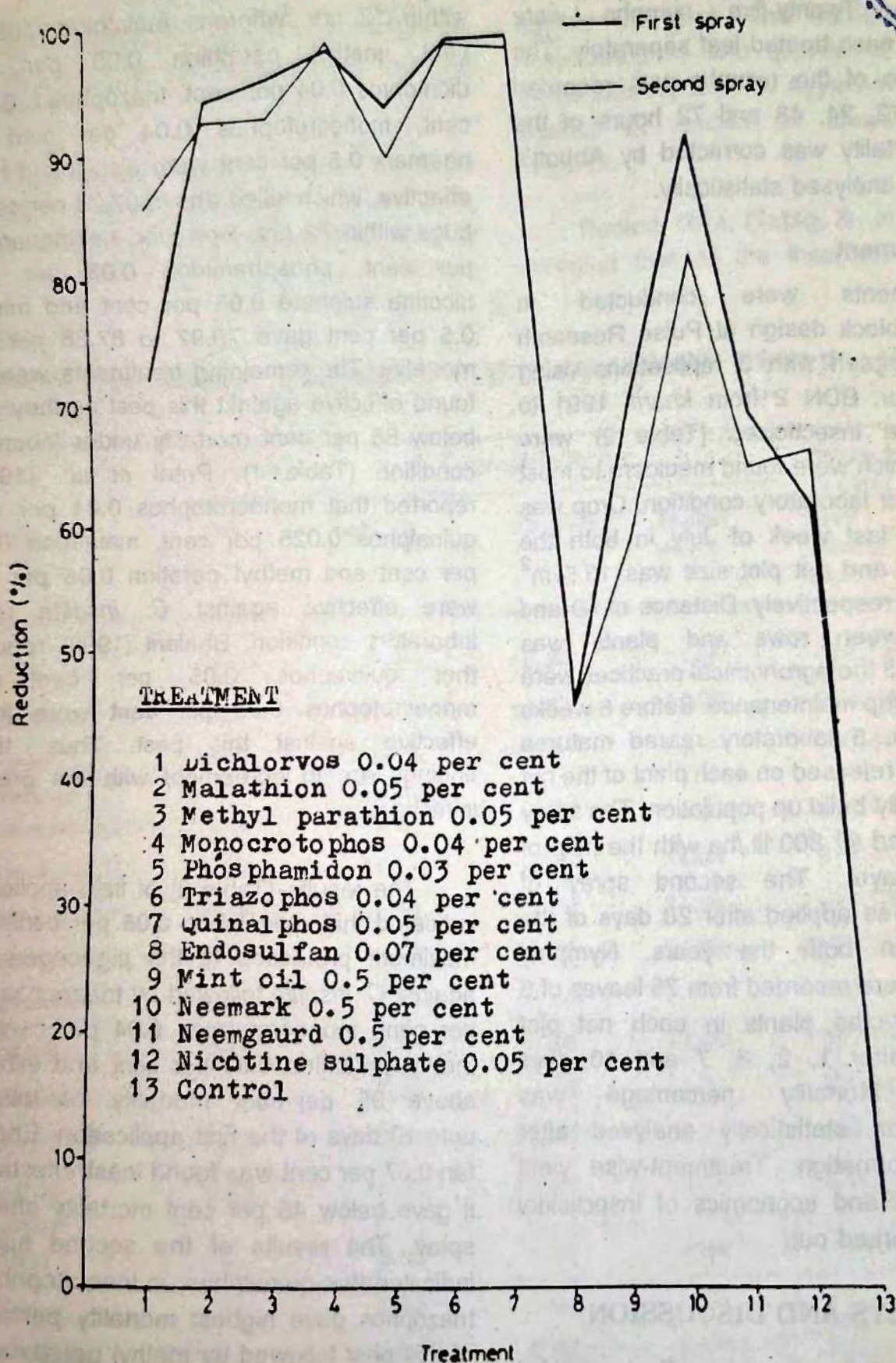


Fig. 1 : Pooled mean per cent reduction of *C. insolita* ten days after spraying of insecticides

temperature. Twenty-five nymphs were released on each treated leaf separately. The mortality rate of the nymphs was recorded after 3, 6, 12, 24, 48 and 72 hours of the release. Mortality was corrected by Abbott's formula and analysed statistically.

Field experiment

Experiments were conducted in randomised block design at Pulse Research Station, Junagadh with 3 replications using pigeonpea c.v. BDN 2 from *kharif*, 1991 to 1993. Twelve insecticides (Table 2) were evaluated, which were found mediocre to most effective under laboratory condition. Crop was sown during last week of July in both the years. Gross and net plot size was 13.5 m² and 4.86 m², respectively. Distance of 60 and 30 cm between rows and plants was maintained. All the agronomical practices were followed for crop maintenance. Before 6 weeks of application, 5 laboratory reared matured females were released on each plant of the net area for equally build up population. The spray liquid was used @ 800 lit./ha with the help of knapsac sprayer. The second spray of insecticides was applied after 20 days of the first spray in both the years. Nymphal populations were recorded from 75 leaves of 5 randomly selected plants in each net plot before and after 1, 2, 3, 7 and 10 days application. Mortality percentage was calculated and statistically analysed after arcsin transformation. Treatment-wise yield was recorded and economics of insecticidal treatments worked out.

RESULTS AND DISCUSSION

The quick knock down effect on third nymphal instar of *C. insolita* was obtained with the application of quinalphos 0.05 per cent, which registered 91.85 per cent mortality

within 12 hrs, whereas malathion 0.05 per cent, methyl parathion 0.05 per cent, dichlorvos 0.04 per cent, triazophos 0.04 per cent, monocrotophos 0.04 per cent and neemark 0.5 per cent were also found highly effective, which killed above 97.23 per cent of bugs within 72 hrs. However, neemgaud 0.5 per cent, phosphamidon 0.03 per cent, nicotine sulphate 0.05 per cent and mint oil 0.5 per cent gave 79.97 to 87.36 per cent mortality. The remaining treatments were not found effective against this pest as they gave below 65 per cent mortality under laboratory condition (Table 1). Patel *et al.*, (1985a) reported that monocrotophos 0.04 per cent, quinalphos 0.025 per cent, malathion 0.05 per cent and methyl parathion 0.05 per cent were effective against *C. insolita* under laboratory condition. Bhalani (1990) reported that quinalphos 0.05 per cent and monocrotophos 0.05 per cent were found effective against this pest. Thus, these findings are in agreement with the present investigation.

The results (Table 2) of field application indicated that quinalphos 0.05 per cent gave maximum protection to the pigeonpea crop against *C. insolita* followed by triazophos 0.04 per cent, monocrotophos 0.04 per cent and methyl parathion 0.05 per cent and exhibited above 95 per cent mortality of this pest upto 10 days of the first application. Endosulfan 0.07 per cent was found least effective, as it gave below 45 per cent mortality after first spray. The results of the second spraying indicated that quinalphos, monocrotophos and triazophos gave highest mortality percentage of this pest followed by methyl parathion upto 10 days after application in second spraying too. Whereas, endosulfan and mint oil were observed least effective in controlling the pest.

at all the intervals. The results are in conformity with the results obtained in first spraying (Fig. 1).

Looking to the above results, it can be concluded that the quinalphos 0.05 per cent, triazophos 0.04 per cent and monocrotophos 0.04 per cent were found most effective

against this pest. The maximum effect of monocrotophos and quinalphos @ 0.25 kg a.i./ha was reported by Ayyanna *et al.*, (1976) against *C. insolita* on brinjal in Andhra Pradesh.

Pooled data (Table 3) on grain yield revealed that all the insecticidal treatments

TABLE 3

Effect of insecticides on pigeonpea grain yield and avoidable losses due to mealybug, *C. insolita*.

Treatment	Concentration (%)	Grain yield (q/ha)			Increased in yield over control (%)	Avoidable loss (%)
		1991-92	1992-93	Pooled mean		
Dichlorvos	0.04	13.61	16.36	14.99	693.12	30.79
Malathion	0.05	14.57	12.52	13.55	616.93	37.44
Methyl parathion	0.05	14.95	18.83	16.89	793.65	22.02
Monocrotophos	0.04	16.17	23.15	19.67	940.74	9.18
Phosphamidon	0.03	13.99	15.29	14.64	674.60	32.41
Triazophos	0.04	16.80	25.93	21.36	1030.15	1.39
Quinalphos	0.05	16.56	26.75	21.66	1046.03	0.00
Endosulfan	0.07	9.77	10.15	9.96	426.98	54.02
Mint oil	0.50	11.66	13.20	12.43	557.67	42.61
Neemark	0.50	15.09	16.15	15.62	726.46	27.89
Neemguard	0.50	12.76	13.79	13.27	602.12	38.73
Nicotine sulphate	0.05	11.83	14.37	13.10	593.12	39.52
Control	—	2.06	1.72	1.89	—	91.27
S. Em. ±	—	0.92	1.99	1.84		
C. D. at 5%		2.69	5.81	5.66		
C. V. %		12.22	21.54	18.48		

TABLE 4

Net realisation (Rs/ha), net profit (Rs/ha) and NICBR of insecticides sprays for the control of *C. insolita* in pigeonpea.

Insecticide	Concentration (%)	Quantity of insecticide required for two spraying (l/ha)	Total cost of treatments for two application (Rs/ha)	Grain yield of pigeonpea (q/ha)	Gross realisation (Rs/ha)	Net realisation (Rs/ha)	Net profit (Rs/ha)	Net incremental cost benefit ratio (NICBR)
Dichlorvos	0.04	0.843	352.00	14.99	11243	9825	9473	1:26.91
Malathion	0.05	1.600	344.00	13.55	10163	8745	8401	1:24.42
Methyl parathion	0.05	1.600	480.00	16.89	12668	11250	10770	1:22.44
Monocrotophos	0.04	1.600	576.00	19.67	14753	13335	12759	1:22.15
Phosphamidon	0.03	0.565	295.00	14.64	10980	9562	9267	1:31.41
Triazophos	0.04	1.600	744.00	21.36	16020	14602	13858	1:18.63
Quinalphos	0.05	3.200	952.00	21.66	16245	14827	13875	1:14.57
Endosulfan	0.07	3.200	728.00	9.96	7470	6052	5324	1:7.31
Mint oil	0.50	8.000	2520.00	12.43	9323	7905	5385	1:2.14
Neemak	0.50	8.000	1120.00	15.62	11715	10297	9177	1:8.19
Neemgaurd	0.50	8.000	976.00	13.27	9933	8535	7559	1:7.44
Nicotine sulphate	0.05	2.000	500.00	13.10	9825	8407	7907	1:15.81
Control	—	—	—	1.89	1418	—	—	—

Labour charges Rs. 20.00/labour/day. Market price of pigeonpea grains Rs. 750.00/q.

were significantly better than the control. The highest grain yield (21.66 q/ha) was obtained in the plot sprayed with quinalphos followed by triazophos (21.26 q/ha), monocrotophos (19.67 q/ha) and methyl parathion (16.89 q/ha). Among the insecticidal treatments, the lowest grain yield (9.96 q/ha) was recorded from endosulfan treated plot.

The maximum percentage increase in grain yield was noted from the plot treated with quinalphos (1046.03 per cent) followed by triazophos (1030.15 per cent) and monocrotophos (940.74 per cent) over control (Table 3). However, the percentage of avoidable loss in yield was the lowest in treatment of triazophos (1.39 per cent) followed by monocrotophos (9.18 per cent), whereas in water sprayed pigeonpea

plot, it was 91.27 per cent over maximum yield recorded with spray of quinalphos (Table 3).

The maximum NICBR is found in the sprays of phosphamidon followed by dichlorvos and malathion. Though, the highest net profit per hectare was recorded, when the crop was protected by quinalphos (Rs. 13875/-) followed by triazophos (Rs. 13858/-), monocrotophos (Rs. 12759/-) and methyl parathion (Rs. 10770/-) and they gave 1:14.57, 1:18.67, 1:22.15 and 1:24.42 NICBR, respectively. Thus, it can be inferred from these results that the insecticides, quinalphos, triazophos and monocrotophos were found to be the most effective and profitable against *C. insolita* on pigeonpea.

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Response of Plant Growth Regulators on Flowering and Fruiting in Alphonso Mango Trees

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ABSTRACT

Field studies to evaluate the relative effectiveness of various plant growth regulators and other chemicals viz., KNO_3 (2%), Urea (2%), Gibbrellic acid (100 ppm) and Paclobutrazol (cultar at 2.5, 4 and 7.5 g. a.i. per tree as soil drench) were carried out at Agricultural Experimental Station, Gujarat Agricultural University, Paria during 1990-93. Out of four plant growth regulators tested, paclobutrazol (cultar) at the rate of 4 g. a.i./tree in 5 litres of water, applied as soil drench twenty five years old mango trees CV. Alphonso during rainy season (August end), recorded highest flowering (85.82%), fruit bearing (322.66 fruits/tree) and yield (80.88 kg/tree) and lowest fruit dropping (17.08%). There was significant interaction of growth regulators with various stages of shoots with respect to flowering and yield. Highest flowering (69.16%), fruit setting (21.23 fruits set/20 shoots at marble stage) and yield (3.88 kg/20 shoots) and least fruit dropping (28.87 per cent) was recorded on current year mature shoots. Paclobutrazol at the rate of 4 g. a.i./tree resulted in maximum economic realisation over control (Rs. 500.88/tree), thereby giving cost benefit ratio of 1:12.52. However paclobutrazol (cultar) at 2.5 g. a.i./tree reported higher CBR i.e. 1:15.16/tree. Cultar application tended to reduce vegetative growth in extent and number, thereby induced early flowering being 8-9 days as compared to control.

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INTRODUCTION

The mango (*Mangifera indica* L.) is an important fruit of tropical and sub-tropical regions with centre of productions in India. It occupies an area of 1.002 million ha, i.e. 40 per cent of the area devoted to fruit crops with a total production of 8.663 million tonnes (Chadha, 1989). In Gujarat the commercial cultivation are confined to the varieties 'Alphonso', 'Kesar', 'Rajapuri' and 'Langra' of which 'Alphonso' occupies about 60 per cent of the area under mango in the State, which is

estimated to be about 25000 hectares. This variety is mainly cultivated in the districts of Valsad and Surat. There are a number of reasons for the dismal performance of Alphonso cultivar of which irregular bearing is most important wherein a vintage year is followed by lean year which may even extend for two or more seasons. Alternate bearing in mango is postulated to have been occurring due to lack or late occurrence of vegetative flush in the fruited shoots resulting in barrenness in the next flowering season, that is, off year (Seri and Mallick, 1941; Naik and

Rao, 1942; Nakasone *et al.*, 1955). Then these shoots, instead of flowering, produce vegetative flush which had sufficient time to mature and build enough reserve carbohydrates to produce heavy flowering in the next spring (on year). To control this alternate bearing habit, it is therefore intended to have as much as vegetative growth soon after the harvest of fruits in May - June that might become fruitful in the next flowering season. In order to boost up an immediate vegetative flush either to fruited shoots or to vegetative spring flush; a quick acting nutrient rich in nitrogen like urea along with strong growth promoting substance with dormancy breaking power like GA and KNO_3 could be used for getting the desired effect. Further, influence of gibberline in growing shoots will have to be checked for flowering in following season (Pandey, 1989; Chadha and Pal, 1993). Paclobutrazol (Cultar), gibberlin biosynthesis inhibitor, has recently been demonstrated to induce flowering in a number of commercially important mango cultivars including 'Alphonso' and in general soil application is more effective. Several scientists tried this chemical and favourable response was observed (Winston, 1989; Tongumpai *et al.*, 1991; Charnavichit, 1991; Burondkar and Gunjate, 1991; Desai and Chundawat, 1994). With this objective in view, the present investigation was taken in 1990-93 in mango cultivar Alphonso to see the effect of various PGR's on the growth and flowering behaviour.

MATERIALS AND METHODS

The experiment was conducted on 25 year old bearing trees of mango CV. Alphonso at Agriculture Experimental Station, Gujarat Agricultural University, Paria, the area known for the cultivation of 'Alphonso' mango during

three cropping seasons (1991, 1992 and 1993). Uniform trees which were maintained under similar cultural practices were included in the trial. In these trees 20 shoots each of various stages viz., current year mature of 6 to 9 months old (S_1), last year flowered (S_2) and current season or 3 to 5 months old (S_3) were selected all over the tree surface. The treatments were T_1 - KNO_3 (2%), T_2 - Urea (2%), T_3 - Gibberlic acid (100 ppm), T_4 - Paclobutrazol (Cultar 25 SC) (2.5 g. a.i./tree), T_5 - Paclobutrazol (Cultar 25 SC) (4 g. a.i./tree), T_6 - Paclobutrazol (Cultar 25 SC) (7.5 g. a.i./tree) and T_7 - Control. Each tree constituted a replication. There were three replications in all which were set up in a R.B.D. A single tree was taken as a unit for a treatment in a replication. KNO_3 Urea and GA were applied as foliar spray during last week of November. Treatments of cultar were applied by trunk soil line pour method at collar-region to Alphonso mango trees in different doses mixed with 5 litres of water during middle of September each year. The effect of these treatments was observed on flowering, fruit setting, dropping and production. The trees received uniform recommended dose of nutrition and plant protection measures during the experimental period.

RESULTS AND DISCUSSION

Amongst various stages of shoots selected for recording observations with respect to various parameters (Table 1) viz., flowering (%), fruit dropping (%), fruit setting at marble stage/20 shoots and yield (kg)/20 shoots, current year mature shoots (S_1) recorded highest flowering (69.16%), fruit setting (21.23), yield (3.96) and lowest dropping (28.87), whereas, current season shoots (S_2) recorded minimum flowering, fruit setting and yield. This has resulted in due to

TABLE 1

Effect of plant growth regulators on various stages of shoots with respect to on flowering, fruit setting, dropping and yield during 1990-93 in mango CV. 'Alphonso'.

Stages of shoots	Flowering (%)	Fruit setting No. of fruits set at marble stage/ 20 shoots	Fruit dropping (%)	Yield / 20 shoots (kg)
S ₁	53.32* (69.16)	4.44** (21.33)	31.81* (28.87)	1.96** (3.88)
S ₂	45.12 (50.18)	3.51 (14.04)	35.04 (35.02)	1.59 (2.41)
S ₃	51.77 (60.25)	4.12 (18.00)	35.21 (33.73)	1.78 (3.07)
S. Em. ±	0.697	0.138	0.524	0.034
C. D. at 5% (V.C. %)	11.41 2.149	0.427 11.57	1.616 31.92	0.105 11.03

*Figures in parenthesis are original values and those outside are ARC Sine values.
 **Figures in parenthesis are original values and those outside are Sq. foot transformed values.

physiological maturity of vegetative growth causing higher flower bud initiation in the shoot (S₁). This has been further helped by higher fruit set and better retention (lowest fruit dropping) and increased production.

Data (Table 2) show that at the time of all the treatments including cultar (paclobutrazol), all the trees possessed similar number of shoots. All the cultar treatments induced better flowering, than other plant growth regulators and control, however, cultar (paclobutrazol) at 4 g. a.i./tree produced more panicles in extent and proportion (85.82%). Cultar has also helped in better fruit retention (lowest fruit dropping 17.08% was recorded in cultar at 4 g. a.i./tree). It was also observed that differences due to paclobutrazol on various floral and fruiting characters were non-significant among the various concentrations of the chemical. Therefore, it may not be necessary to go for concentration higher than 4 g. a.i./tree and the

quantity of chemical may further be standardised based on age and canopy size of the tree. The cultar treatments also improved fruit set in panicles which was more than those of other PGR's and control. Cultar at 7.5 g. a.i./tree was responsible for highest fruit set (24.66/20 shoots) i.e. about 3 times higher than control.

Similar results were also brought out by Voon *et al.*, (1991) and Winston (1989) while reporting manipulation of mango cropping through cultar.

Cultar also affected fruit bearing and yield without any adverse affect on fruit quality. Trees treated by cultar at 4 g. a.i./tree produced 322.66 fruits as well as 80.88 kg. yield which was not only higher than those of other PGR's but also 8 times higher than control (Table 2). Looking to the economics of plant growth regulators (Table 3), cultar

TABLE 2

Effect of various plant growth regulators on flowering, fruit dropping and production in mango CV. 'Alphonso'.

Treatments (Growth regulators)	Flowering (%)	Fruit dropping (%)	No.. of fruits set/20 shoots at marble stage	No. of fruits/ tree	Yield in kg/tree
T ₁	46.82* (53.05)	43.32* (44.35)	3.65** (14.47)	129.88	31.94
T ₂	38.25 (38.54)	38.48 (38.95)	3.52 (13.18)	108.22	25.57
T ₃	49.96 (58.21)	34.33 (32.60)	4.12 (18.47)	164.22	40.20
T ₄	56.61 (68.31)	29.47 (24.94)	4.37 (19.96)	261.88	65.65
T ₅	72.06 (82.82)	22.22 (17.08)	4.65 (24.40)	322.66	80.88
T ₆	65.57 (80.76)	29.40 (25.10)	4.83 (24.66)	301.66	75.21
T ₇	35.24 (34.07)	42.34 (44.62)	2.94 (9.22)	68.00	10.27
S. Em. ±	2.382	3.575	0.174	59.93	14.01
C. D. at 5%	7.340	11.016	0.537	NS	43.197
C.V. (%)	11.41	31.92	11.57	10.48	14.15

Figures in parenthesis are original values.

* : Indicate ARC sine transformed values.

** : Indicate Sq. root transformed values.

treated trees at 2.5, 4 and 7.5 g. a.i./tree were responsible for higher economic realisation over control i.e. Rs. 379.04, 500.88 and 455.52/tree, respectively and reported CBR 1:15.16, 1:12.52 and 1:6.07/tree, respectively. The effect of cultar on suppression of growth and increase in flowering, fruiting and yield without loss of fruit quality have been reported in mango by other workers also (Burondkar and Gunjate, 1991; Hillar, 1991; Tongumpai, *et al.*, 1991; Desai and

Chundavat 1994; Sant Ram and Tripathi, 1993) as well as in other fruit crops (Arun *et al.*, 1983; Copas *et al.*, 1985; Curry and William, 1986).

Consequently, in the present investigation, paclobutrazol treatment not only induced profuse flowering but advanced flowering i.e. date of flowering initiation (8-9 days) and date of full bloom (9-14 days) and contributed to higher production which was not only regular

TABLE 3

Economics of various plant growth regulators in mango CV. 'Alphonso'.

Treatment	Quantity of PGR used/tree	Cost/tree (Rs)	Yield/tree (kg)	Increase in yield over control (kg)	Economic realisation over control/tree (Rs)	Cost benefit ratio/tree
KNO ₃ 2%	400 g/20 Lit. water	36	31.94	13.67	109.36 (+)	1:3.04
Urea 2%	400 g/20 Lit. water	64	25.57	7.30	58.40 (—)	1:0.91
Gibberlic acid 100 ppm spray	2 g/20 Lit. water	130	40.20	21.93	175.44 (+)	1:0.97
Cultar 2.5 g.a.i./tree	10 ml	25	65.65	47.38	379.04 (+)	1:15.16
Cultar 4 g.a.i./tree	16 ml	40	80.88	62.61	500.88 (+)	1:12.52
Cultar 7.5 g.a.i./tree	30 ml	75	75.21	56.94	455.52 (+)	1:6.07
Control	—	—	18.27	—	—	—

Average price of mango produce = Rs 160/20 kg
 Price of cultar = Rs 2500/litre.

TABLE 4

Effect of various plant growth regulators on flowering in mango CV. 'Alphonso' (Date of flower initiation).

Treatment	Date of flower initiation in other PGR treated trees			Treatment	Date of flower initiation in Paclobutrazol treated trees		
	First year	Second year	Third year		First year	Second year	Third year
T ₁ -KNO ₃ 2%	18-1-91	13-1-92	20-1-93	T ₄ -Cultar 2.5 g.a.i./tree	12-1-91	7-1-92	12-1-93
T ₂ -Urea 2%	18-1-91	13-1-92	20-1-93	T ₅ -Cultar 4 g.a.i./tree	12-1-91	7-1-92	12-1-93
T ₃ -GA 100 ppm	18-1-91	13-1-92	20-1-93	T ₆ -Cultar 7.5 g.a.i./tree	12-1-91	7-1-92	12-1-93
T ₇ -Control	20-1-91	15-1-92	21-1-93	—	—	—	—

TABLE 5

Effect of various plant growth regulators on flowering in mango CV 'Alphonso' (Date of full bloom).

Treatment	Date of full bloom in other PGR treated trees			Treatment	Date of full bloom in Paclobutrazol treated trees		
	First year	Second year	Third year		First year	Second year	Third year
T ₁ -KNO ₃ 2%	1-3-91	28-2-92	26-2-93	T ₄ -Cultar 2.5 g.a.i./tree	24-2-91	19-2-92	14-2-93
T ₂ -Urea 2%	1-3-91	28-2-92	26-2-93	T ₅ -Cultar 4 g.a.i./tree	24-2-91	19-2-92	14-2-93
T ₃ -GA 100 ppm	28-2-91	28-2-92	26-2-93	T ₆ -Cultar 75 g.a.i./tree	24-2-91	19-2-92	14-2-93
T ₇ -Control	1-3-94	28-2-92	28-2-93	—	—	—	—

but considerably greater over control (Table 2, 3, 4 and 5). This has been further helped by higher fruit set and better fruit retention under paclobutrazol (Table 2). Such an induction of regularity in bearing and improvement in production has been reported by several workers (Burondkar *et al.*, 1991; Hillar *et al.*, 1991) in mango, apple and other fruits.

The effect of other plant growth regulators viz., KNO_3 (2%), Urea (2%) and GA (100 ppm) as foliar spray was not so pronounced with

respect to all the floral, fruit dropping and fruiting characters studied as those of cultar in mango C. 'Alphonso'.

Almost all those flowering and fruiting parameters of mango which were significantly influenced favourably by cultar also significantly varied the influence of season. Cultar induced tendency of regular cropping in mango could not fully mask the favourable or unfavourable effect of season on mango fruiting. Therefore, to achieve total control over cropping in mango, integrated approach which may include cultar needs to be worked out.

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Factors Associated with Pattern of Source Utilisation Among Cumin Growers

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ABSTRACT

The present study was carried out in five talukas of Bhavnagar district to study the factors associated with pattern of source utilization among cumin growers. The results indicated that the source utilization pattern among the respondents having different levels of personal socio-economic characteristics was different at initial stage. While the respondents possessing different personal socio-economic characteristics (except education) had same pattern of information source utilization at detailed information seeking as well as decision taking stage.

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INTRODUCTION

The information sources utilized by the farmers play an important role in adopting the new technology thereby increasing farm production and improving farmers' conditions. Farmers of different categories differ in their utilization of information sources.

Singh and Singh (1976) reported that small farmers mostly used the localite sources such as progressive farmers, neighbours relatives and friends. Chole and Rahudkar (1978) found that education and social participation were found to be associated with source utilization. It has been observed from the previous studies that different socio-economic characteristics of farmers are important factors influencing utilization of different information sources. Therefore, it is necessary to know the

association of socio-economic characteristics with utilization of information sources. Hence, the present investigation was planned and undertaken to study the factors associated with pattern of source utilization among cumin growers.

MATERIALS AND METHODS

This investigation was carried out in five talukas of Bhavnagar district of Gujarat State during the year 1990-91. Two stage random sampling design was used to select a sample for the study. Thus, 205 respondents were randomly selected and the data were collected by arranging personal interview.

The sources of information utilized by the respondents at various stages of adoption process viz., initial detailed information seeking and decision taking stage were worked out. To

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determine the relationship between sources of information utilized at initial, detailed information seeking and decision taking stages of adoption and the selected personal socio-economic characteristics of the cumin growers, spearman correlation (r_s) was worked out by using the following formula of George W. Snedecor and William G. Cochran :

$$R_s = 1 - \frac{6 \sum d^2}{n (n^2 - 1)}$$

where,

r_s = Ordinary correlation co-efficient rank value between different categories of farmers.

d = Difference between ranking of two pairs.

n = Number of pairs.

RESULTS AND DISCUSSION

(a) Initial stage of adoption

The information regarding association of some selected personal socio-economic characteristics and sources of information used by cumin growers at initial stage of adoption is presented in table 1.

The rank co-relation co-efficient (r_s) was computed on the basis of rank assigned to each source of information according to its frequency in different categories of farmers. Therefore, value of r_s provides a means which is generally accepted for the measurement of relationship between different categories of farmers.

Thus, it is evident from the non-significant values of r_s presented in table 1 that there existed no co-relation

TABLE 1

Relationship between some personal socio-economic characteristics and sources of information used at initial stage.

Relationship	r_s Value
Sources of information and age	0.524 N.S.
Sources of information and education	0.601 N.S.
Sources of information and highest level of education in family.	0.345 N.S.
Sources of information and average educational level of family	0.452 N.S.
Sources of information and size of family	0.458 N.S.
Sources of information and type of family	0.452 N.S.
Sources of information and social participation	0.351 N.S.
Sources of information and size of land holding	0.327 N.S.
Sources of information and economic status	0.595 N.S.

N. S. = Non Significant.

between the respondents of different categories in their source utilization at initial stage of adoption. In this way, the respondents of different age groups having different levels of education, different average educational level of the family, different sizes of family, different types of family, differential social participation, different sizes of land holding, different categories of economic did differ in source utilization for information at initial stage of adoption.

(b) Detailed Information seeking stage of adoption

The data (table 2) reveal that 'rs' value (0.434) for relationship between sources of information and education was found non-significant. It means the farmers having different levels of education did differ regarding the rank order of information

sources used by them at detailed information seeking stage.

It is also indicated from the data presented in table 2 that 'rs' values (0.705, 0.835, 0.668, 0.912, 0.820, 0.686 and 0.874) were found highly significant at 0.01 level of significance. It means that greater similarity between two groups of respondents of different age having different average educational level of family, different sizes of family, differential social participation and different sizes of land holding regarding their source utilization at detailed information seeking stage.

Moreover, it is obvious from the data (Table 2) that the respondents possessing different categories of economic status (i.e. below and above mean score) had used almost similar sources of information at detailed information seeking stage.

TABLE 2

Relationship between some socio-economic characteristics and sources of information used at detailed information seeking stage.

<i>Relationship</i>	<i>rs Value</i>
Sources of information and age	0.705**
Sources of information and education	0.434 N.S.
Sources of information and highest level of education in family.	0.835**
Sources of information and average educational level of family.	0.668**
Sources of information and size of family.	0.912**
Sources of information and type of family.	0.820**
Sources of information and social participation	0.686**
Sources of information and size of land holding	0.874**
Sources of information and economic status	0.515*

N.S. — Non Significant.

* — Significant.

** — Highly Significant.

(c) Decision taking stage of adoption

The findings obvious from the data presented in Table 3 are as under :

- (i) The calculated 'rs' value (0.767) was found to be highly significant, indicating thereby similarity between two different age groups of the respondents (i.e. below and above mean age) in their pattern of source utilization at decision taking stage.
- (ii) The computed 'rs' value (0.883) highly significant reflecting that the respondents having different levels of education did not differ in their source utilization at decision taking stage.
- (iii) It can be said from the highly significant 'rs' (0.883) that the source utilization pattern was similar among two groups of respondents having highest level of education in the family upto primary and above primary at decision taking stage.
- (iv) The computed 'rs' value (0.862) was found to be highly significant stating source utilization pattern was almost similar between the two groups of respondents having different levels of average education of the family.
- (v) The calculated 'rs' value (0.854) was found to be highly significant indicating the respondents having different sizes of family did not differ in their source utilization at decision taking stage.
- (vi) The rank co-relation co-efficient value (0.967) was found to be highly significant, stating thereby high closeness between two different groups of respondents.

TABLE 3

Relationship between some personal socio-economic characteristics and sources of Information used at decision taking stage.

<i>Relationship</i>	<i>rs Value</i>
Sources of information and age	0.767**
Sources of information and education	0.883**
Sources of information and highest level of education in family.	0.883**
Sources of information and average educational level of family.	0.862**
Sources of information and size of family	0.854**
Sources of information and type of family	0.967**
Sources of information and social participation	0.971**
Sources of information and size of land holding	0.867**
Sources of information and economic status	0.950**

**Highly significant.

dents (i.e. nucleous and joint type of family group) in source utilization at decision taking stage.

- (vii) The 'rs' values (0.971, 0.862, 0.950) were also found to be highly significant indicating similarity between two groups of respondents having different levels of social participation (i.e. no participation and participation group), different sizes of land holding and different economic status (i.e. below and above mean score) in their source utilization at decision taking stage.

Implication

The pattern of source utilization was similar among the respondents having different

levels of personal and socio-economic characteristics at detailed information seeking and decision taking stage. Hence, the counselling agencies should approach uniformly to all types of farmers and should not make any discrimination between groups of farmers while working out the plan for providing information and guidance to them. Moreover, the variation in the selected personal socio-economic characteristics had caused variation in the information sources utilized by the respondents at initial stage of adoption. Therefore, it is desirable for counselling agencies to consider the differentiative effects of personal socio-economic characteristics of farmers during planning for dissemination of information at initial stage of adoption.

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Short Communications

Effect of Phosphatic Biofertilizers on Conjunction with Manure and Fertilizer on Pearlmillet

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A field experiment was conducted at Agronomy Farm, Gujarat Agricultural University, Junagadh during *kharif* season of 1991. The soil was clayey in texture, medium in nitrogen (0.064%), phosphorus (30.8 kg/ha) and potassium (156 kg/ha) and slightly alkaline in reaction (pH 7.9) with normal E.C. (0.27 ds/m). The treatments consisting two levels of FYM (0 and 10 t/ha) as main plots and combinations of three levels of biofertilizer (control, *Pseudomonas striata*, inoculant and *Paecilomyces fussisporus* inoculant) and four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 /ha) as subplots were tried in a split plot design with four replications. Half dose of N and full dose of P in form of urea and SSP, respectively were applied at the time of sowing and remaining half dose of N was top-dressed at tillering stage. The crop was sown on July 4, 1991 and harvested on October 19, 1991. Pearlmillet variety GHB-181 was sown at

row spacing of 45 cm using seed rate of 3.750 kg/ha.

Higher grain and stover yields of pearlmillet were recorded with application of FYM @ 10 t/ha which were 17.5 and 31.6% higher over control respectively. The results are in agreement with those reported by Kala *et al.*, (1988). Significantly higher protein content and uptake of N, P_2O_5 and K_2O by pearlmillet were observed under application of FYM @ 10 t/ha. Addition of FYM in soil having medium status of nutrients might have increased availability of macro and micro nutrients by improving root rhizosphere which ultimately enhanced removal of N, P and K as well as crop yield. The findings are in agreement with those of Sharma *et al.*, (1988). Application of FYM recorded lower net realization and B:C ratio as compared to no application of FYM.

Significantly higher grain and stover yields were recorded under inoculation with *P. striata* which were 13.00 and 11.6% higher over uninoculated control, respectively. Similar results were reported by Gaur (1990). Significantly the highest protein content was recorded under seed inoculation with *P. striata*. The uptake of N and P_2O_5 was significantly influenced by seed inoculation with *P. striata*. However, uptake of K_2O remained unaffected

TABLE 1

Effect of different treatments on yield, quality nutrient uptake and economics of pearl millet.

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Protein content (%)	N uptake (kg/ha)	P ₂ O ₅ uptake (kg/ha)	K ₂ O uptake (kg/ha)	Net return (Rs/ha)	Net B:C ratio
FYM (t/ha)								
0	16.49	38.71	11.93	59.66	6.60	42.03	3515	1.33
10	19.38	46.48	12.06	<u>73.36</u>	8.12	<u>56.23</u>	3404	0.89
C.D. at 5%	0.96	5.41	0.07	9.13	0.97	4.19	—	—
Biofertilizer								
Control	17.14	41.00	11.95	62.45	6.77	47.33	3766	1.42
Pseudomonas striata	19.37	45.74	12.05	<u>71.87</u>	8.36	<u>51.81</u>	4563	1.71
Paecilomyces fussisporus	17.30	41.04	11.98	<u>65.21</u>	<u>6.97</u>	<u>48.23</u>	3791	1.42
C. D. at 5%	1.26	2.29	0.06	3.58	0.54	NS	—	—
Phosphorus (kg P₂O₅/ha)								
0	14.41	35.81	11.90	53.99	5.01	35.67	2758	1.04
20	17.14	40.99	11.94	63.26	6.77	45.25	3577	1.26
40	19.77	46.49	12.03	73.10	8.77	57.70	4365	1.45
60	20.43	47.49	12.10	75.69	8.90	57.88	4414	1.38
C. D. at 5%	1.46	2.64	0.07	4.14	0.63	4.63	—	—

due to inoculants. Maintenance of higher population of efficient P solubilizers in rhizosphere might have produced chelating compounds which remove cations from insoluble phosphate and release soluble P and thereby increased uptake of P as well as N due to balanced nutrition resulting in higher dry matter production. The results are in line with the reports of Mohod *et al.* (1991). Biofertilizer *P. striata* recorded the maximum net realization of Rs. 4563/ha and B:C ratio of 1.71 which were Rs. 797/ha and 0.29 higher over uninoculation, respectively.

The application of P significantly increased grain and stover yields. The highest grain and stover yields were recorded with 60 kg P_2O_5 /ha which remained at par with 40 kg

P_2O_5 /ha. This finding is in agreement with that reported by Keshwal and Jat (1992). Significantly the highest protein content as well as uptake of N, P_2O_5 and K_2O were recorded with the highest level of P, however remained at par with 40 kg P_2O_5 /ha. The results are in accordance with those of Pareek and Shaktawat (1988). P application might have increased root density leading to higher absorption of nutrients by plant and thereby improved quality and yield of the crop. The highest net realization of Rs. 4414/ha was recorded with 60 kg P_2O_5 /ha closely followed by 40 kg P_2O_5 /ha which recorded Rs. 4365/ha of net realization with the highest B:C ratio of 1.45.

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Effect of Harvesting Stages and Levels of N and P on Yield, Quality and Uptake of Nutrients by Fodder Maize (*Zea mays*)

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A field experiment was conducted at the Agronomy Farm, Gujarat Agricultural University, Junagadh during *rabi* season 1992-93. The soil was clay loam in texture and slightly alkaline in reaction (pH 7.8) with normal E.C. (0.29 dS/m) and having total N 0.07%, available P 34 kg/ha and available K 303 kg/ha. Twenty four treatment combinations consisting of two stages of harvesting (silking and milking) as main plots, four levels of N (0, 40, 80 and 120 kg N/ha) and three levels of P (0, 40 and 80 kg P₂O₅/ha) as sub-plots were tried in split plot design and replicated thrice. The maize cv Ganga Safed-2 was sown at row spacing of 30 cm with seed rate of 60 kg/ha on October 22, 1992 and harvested on December 20, 1992 and January 2, 1993 at silking and milking stages, respectively. Treatment-wise half dose of N and full dose of P in form of urea and SSP, respectively were applied at sowing

and remaining half dose on N was top-dressed at 25 DAS.

Green and dry fodder yields recorded at milking stage were significantly higher than that recorded at silking stage. Milking stage recorded higher green and dry fodder yield to the tune of 13.9 and 22.8% over silking stage, respectively. Nitrogen and crude protein contents were low in milking stage of harvesting as compared to silking stage. This might be due to fact that at milking stage, consumption of N and protein increase with rapid cell division and multiplication resulting in low N and protein in plants. The findings are in accordance with those of Tiwana *et al.* (1983). There was no significant difference between the two stages of harvesting in respect of P content. Crude fibre content was more in delayed harvesting. Delayed harvesting significantly increased the uptake of N and P also. Similar results are also reported by Patel and Saiyed (1990).

Application of 120 kg N/ha significantly increased the contents of N, crude protein and crude fibre, while decreased the P content. Increase in level of N significantly increased the uptake of N and P as well as protein yield. The observations are in line with those of Singh *et al.* (1989) and Dodia (1991).

TABLE 1

Effect of different treatments on forage yield, quality and nutrient uptake by maize.

Treatments	Fodder yield (q/ha)		N content (%)	P content (%)	Crude protein content (%)	Crude fibre content (%)	N uptake (kg/ha)	P uptake (kg/ha)	Protein yield (kg/ha)
	Green	Dry							
Harvesting stages									
Silking	280.6	66.9	1.06	0.14	6.62	26.92	72.49	9.43	442.2
Milking	319.5	82.1	1.01	0.13	6.32	27.48	85.04	11.38	519.1
C. D. at 5%	23.1	7.9	0.05	NS	0.28	0.41	12.25	0.95	72.9
Nitrogen (kg/ha)									
0	191.7	47.2	0.91	0.15	5.68	26.67	42.57	6.93	266.7
40	294.6	72.8	0.96	0.14	5.98	27.03	69.29	10.34	430.4
80	333.3	82.2	1.07	0.14	6.69	27.38	87.84	11.31	549.7
120	380.6	95.6	1.21	0.13	7.54	27.72	115.36	12.73	675.6
C. D. at 5%	14.8	4.2	0.03	0.01	0.17	0.23	5.68	0.56	46.1
Phosphorus (kg P ₂ O ₅ /ha)									
0	266.7	66.3	1.03	0.10	6.42	27.35	69.61	6.65	434.8
40	314.2	78.0	1.03	0.14	6.46	27.20	82.46	10.82	492.0
80	319.2	79.2	1.05	0.18	6.53	26.92	84.22	13.73	515.2
C. D. at 5%	12.8	3.6	NS	0.01	NS	0.20	4.91	0.48	39.9

Application of 40 and 80 kg P_2O_5 /ha being at par recorded significantly higher green and dry fodder yields over control. P application did not exert significant influence on N and protein contents. P fertilization significantly increased the content of P, while decreased the fibre content. Application

of 80 kg P_2O_5 /ha recorded significantly higher uptake of N and P as well as protein yield but remained at par with that of 40 kg P_2O_5 /ha in respects of N uptake and protein yield. The findings corroborates the reports of Dodia (1991).

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Relative Contribution of Production Inputs in Groundnut (*Arachis hypogaea* L.)

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Groundnut is one of the important rainfed *kharif* crop of North-Eastern hilly part of Madhya Pradesh. Its average yield (805 kg/ha) is however, low due to poor management. Among different management factors during *kharif* season, fertilizer, weed control and plant protection measures play a vital role in maximising production. The present experiment was, therefore, undertaken to determine the response of groundnut to major production inputs and identify the priority ones.

A field experiment was conducted during *kharif* 1992 at Indira Gandhi Krishi Vishwa Vidyalaya, Zonal Agricultural Research Station, Ambikapur (M.P.). The soil of the experimental plot was Sandy Loam, with available N, P and K, 170, 13 and 270 kg/ha, respectively, with pH 5.9. The experiment was laid out in randomised block design replicated thrice. Treatments comprised absolute control (without fertilizer, weed control and plant protection), F (basal application of recommended dose of fertilizer

i.e. 20:60:20 NPK kg/ha); W (weed control i.e. two hand weeding at 20 and 35 days after sowing); ID (insect and disease control including seed treatment with bavistin @3 g/kg of seed). Besides these treatments, different combinations of F, W and ID, were also made (Table 1). Insecticidal spray was not done as there were no incidence of defoliator pests and aphids at economic injury level, however, incidence of tikka disease caused by *Cercospora* spp. appeared and two sprays of Dithane M — 45 @ 0.2 per cent at 15 days interval was made to manage the crop against this disease as per treatments. Groundnut (cv. JL 24) was sown on 5 July, 1992 at 30 x 15 cm spacing. Weed density at 60 DAS and weed dry matter were collected from a quadrat of 0.25 m² placed randomly at three places in each plot at 90th day crop stage. Crop was raised under rainfed conditions. Total rainfall received during crop season was 965.9 mm and was fairly distributed.

The weed flora associated comprised mainly of *Echinochloa* spp., *Ageratum conyzoides*, *Eclipta alba*, *Celosia argentea*, *Panicum* spp. and *Cyperus rotundus*.

Among production inputs, weed control alone recorded significantly higher pod yields (1615 kg/ha) as compared to plant protection (425 kg/ha), fertilizer application (223 kg/ha)

TABLE 1

Effect of production inputs on yield attributes, pod yield and economics in groundnut.

Treatment	Weed density* (No/m ²)	Weed dry weight (g/m ²)	No. of filled pods per plant	Weight of pods/plant (g)	Pod yield (Kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit-cost ratio
O-O-O	17.66	236	5.6	4.9	410	3333	-1283	0.61
F-O-O	17.56	456	3.1	2.7	223	3830	-2715	0.29
O-W-O	4.41	60	13.2	11.8	1615	4698	3377	1.72
O-O-ID	17.56	261	5.2	4.3	425	3433	-1308	0.62
F-W-O	4.44	63	15.1	11.8	2265	5195	6130	2.18
F-O-ID	17.68	436	3.3	3.6	321	3930	-2325	0.59
O-W-ID	4.53	59	13.8	11.0	1778	4798	1090	1.85
F-W-ID	4.42	63	16.2	11.5	2358	5295	6495	2.23
C.D. (P=0.05)	1.90	71	0.4	0.7	496	—	—	—

*Transformed (Square root $x + 0.5$) values of weeds are presented. F: Fertilizer.

W : Weed control, ID : Insect and disease control, O : Missing the input.

and absolute control (410 kg/ha). Singh and Bajpai (1991) reported a six fold increase in pod yield of groundnut by two hand weedings as compared to unweeded treatment. Application of fertilizer without weed control favoured the luxuriant weed growth and resulted marked increase in crop weed competition and weed dry matter production. Although weed population in absolute control, fertilizer alone, plant protection measures alone and fertilizer with plant protection were at par but weed dry weights were significantly higher under the application of fertilizer alone and fertilizer with plant protection. Alone fertilizer application or plant protection measures did not increase pods/plant and weight of pods/plant. Combining weed control either with fertilizer or plant protection measures increased pod yield by 40 and 10 per cent over weed control alone, respectively.

Combination of all the production inputs under study recorded highest pod yield of 2358 kg/ha which was also higher than the pod yield obtained due to combined effect of fertilizer with weed control (2265 kg/ha). Thus results clearly indicate that all the inputs had contributed to increase groundnut yields in variable magnitude even though among single factors weed control contributed highest to increase pod yields of groundnut. Combination of fertilizer with weed control was also proved important factor for higher productivity. Beneficial effect of fertilizer application under weed control condition have been reported by Singh *et al.* (1994). The contribution from plant protection measures was marginal. Highest net return (Rs. 6495/ha) and cost benefit ratio (1:2.23) was obtained when all the three inputs were applied together.

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Growth and Yield of Safflower (*Carthamus tinctorius* L.) as Influenced by Irrigation, Nitrogen and Phosphorus

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A field experiment was conducted at Agronomy Farm, Gujarat Agricultural University, Junagadh during *rabi* season of 1992-93. The soil was clayey in texture, medium in total nitrogen (0.07 %), medium in available phosphorus (34 kg/ha) and high in available potassium (303 kg/ha) and slightly alkaline in reaction (7.9 pH) with normal E. C. (0.30 dS/m). The treatments comprising three levels of irrigation (0.4, 0.6 and 0.8 IW/CPE) as main plots and three levels each of nitrogen (0, 25 and 50 kg N/ha) and phosphorus (0, 10 and 20 kg P₂O₅/ha) as sub-plots, were tried in split plot design with three replications. Half dose of N and full dose of P were applied in the forms of urea and single super phosphate, respectively at the time of sowing and remaining half dose of N was top-dressed at 40 days after sowing. The safflower variety 'Tara' was sown on October 17, 1992 at inter row spacing

of 45 cm and harvested on February 9, 1993.

Different schedules of irrigation significantly influenced growth and yield of the crop, except seeds/head. Scheduling irrigation at 0.8 IW/CPE recorded significantly higher growth and yield attributes viz., plant height, primary and secondary branches/plant, heads/plant, test weight and seed weight/plant which were ultimately reflected in significantly higher seed and stover yield over 0.4 IW/CPE ratio but 0.6 IW/CPE ratio was on par with 0.8 IW/CPE in respects of growth and yield of the crop, except test weight. The results are in accordance with the findings of Singh and Singh (1989).

Application of 50 kg N/ha significantly improved growth and yield attributes viz., plant height, primary and secondary branches/plant, heads/plant, test weight and seed weight/plant and seed and stover yields over no application of nitrogen. However, 25 kg N/ha was on par with 50 kg N/ha in respects of plant height, primary branches/plant and stover yield. The findings corroborates the report Bhanvadia (1993).

There was significant increase in growth and yield attributes as well as

TABLE 1
Effect of different treatments on growth, yield attributes and yields of safflower.

Treatment	Plant height (cm)	Branches/plant		Heads/ plant	Seeds/ head	1000-seed weight (g)	Seed weight plant (g)	Yield (q/ha)	
		Primary	Secondary					Seed	Stover
Irrigation (IW/CPE)									
0.4	87.11	4.67	6.13	11.78	18.68	43.05	9.64	12.61	37.82
0.6	91.89	5.08	7.56	13.81	17.53	44.19	10.65	14.05	44.50
0.8	94.51	5.46	8.01	14.01	17.46	45.36	11.24	14.80	48.12
C. D. at 5%	5.41	0.55	0.86	1.32	NS	1.02	0.97	1.35	5.53
Nitrogen (kg N/ha)									
0	87.63	4.51	6.37	11.95	18.64	43.36	9.89	12.99	39.38
25	91.98	5.18	7.22	13.25	17.74	44.06	10.53	13.81	44.07
50	93.90	5.52	8.11	14.10	17.29	45.18	11.12	14.66	46.99
C. D. at 5%	3.05	0.38	0.62	0.71	NS	0.61	0.50	0.65	3.39
Phosphorus (kg P₂O₅/ha)									
0	89.43	4.66	6.50	12.12	18.42	43.41	9.86	12.96	39.66
10	91.66	5.05	7.22	13.11	17.85	44.16	10.51	13.83	43.54
20	92.42	5.50	7.98	14.07	17.40	45.03	11.16	14.67	47.24
C. D. at 5%	NS	0.38	0.62	0.71	NS	0.61	0.50	0.65	3.39

yield of the crop with each increment in level of P. except plant height and seeds/head and 20 kg P_2O_5 /ha significantly recorded higher values of growth and yield attributes viz., primary and secondary branches/plant, heads/plant, test weight and

seed weight/plant and seed and stover yields. Similar results were also reported by Singh and Singh (1989) and Bhanvadia (1993).

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Effect of Spacing Planting Pattern and Weed Control in Mustard

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Mustard occupy prime position both in area and production but the productivity is very low in India as compared to West European Countries. Mustard is a C_3 plant subjected to photo-respiration. Photo-respiration can be minimized by adopting proper spacing and planting pattern ultimately increasing the crop yield. The losses due to weeds in mustard yield range from 10 to 70 per cent depending upon the composition and intensity of weed flora. The use of herbicides have revolutionised the conventional weed control practices.

A field experiment was conducted on medium black soil of Instructional Farm, Gujarat Agricultural University, Junagadh to study the response of mustard to spacing, planting pattern and weed management practices during *rabi* season of 1992-93. Twenty four treatments comprising of two levels of row spacing viz., 30 and 45 cm (as main plot) and three levels of planting pattern viz., Uniform sowing (No skipping), one skipped row after three

sown rows (3:1) and one skipped row after two sown rows (2:3) and four levels of weed management practices viz., fluchloralin 1.0 kg ha^{-1} as pre-emergence, one hand weeding at 30 days after sowing, fluchloralin 1.0 kg ha^{-1} as pre-emergence + one hand weeding at 30 days after sowing and unweeded check (as sub plot) were tried in split plot design with three replications.

The results revealed that narrow row spacing (30 cm) significantly recorded higher yield of seed, stover and oil by 19.88, 21.77 and 20.03 per cent respectively as compared to wider row spacing (45 cm). The results obtained are in close proximity of those reported by Chavan *et al.* (1989) in mustard. Uniform sowing (no skipping) recorded significantly higher seed, stover and oil yield by 34.16, 28.64 and 34.33 per cent, respectively as compared to one skipped row after three sown rows (3:1), whereas 14.96, 12.62 and 15.08 per cent, respectively when compared to one skipped row after two sown rows (2:1). Similar results were also observed by Saini and Gupta (1982) who reported that skip row planting pattern of toria produced the lowest seed yield as compared to solid planting. Significantly the highest seed, stover and oil yield were observed with fluchloralin 1 kg ha^{-1} as pre-emergence + one hand weeding at 30 days after sowing.

TABLE 1

Seed, stover and oil yield of mustard (kg ha^{-1}) as influenced by spacing, planting pattern and weed management practices.

Treatment	Yield kg ha ⁻¹			Net realization Rs. ha ⁻¹
	Seed	Stover	Oil	
Spacing				
S ₁ — 30 cm	2008	5364	725	7307
S ₂ — 45 cm	1675	4405	604	5270
S. Em. ±	48	146	16	—
C. D. at 5%	290	887	98	—
C.V. %	15.51	17.90	14.58	—
Planting pattern				
P ₁ Uniform sowing	2113	5498	763	7677
P ₂ One skipped row after three sown rows	1575	4274	568	4864
P ₃ One skipped row after two sown rows	1838	4882	663	6332
S. Em. ±	51	134	18	—
C. D. at 5%	145	383	52	—
C. V. %	13.56	13.46	13.42	—
Weed management practices				
W ₁ Fluchloralin 1 kg ha ⁻¹	2000	5200	722	7266
W ₂ One hand weeding at 30 days after sowing	1650	4472	595	5101
W ₃ (W ₁ + W ₂)	2350	6044	849	8678
W ₄ Unweeded check	1367	3821	493	4115
S. Em. ±	59	155	21	—
C.D. at 5%	145	442	60	—
C.V. %	13.56	13.46	13.42	—

Comparative Evaluation of Direct Seeded Low Land and Transplanted Paddy

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An experiment was conducted on paddy during *kharif* 1991 to 1993 at Regional Rice Research Station, GAU, Vyara, Gujarat to study the comparative performance and economics of two leading varieties under two methods of planting (direct seeding and transplanting). Direct seeding of sprouted seeds in puddled soil on the day of nursery sowing was equally productive and 37% more remunerative than transplanted crop. The differences in varieties were not significant.

Majority of the low land paddy in the country is grown by transplanting method and so is in South Gujarat. Transplanting being a time bound and labour intensive operation, occasionally suffers inordinate delays due to either delayed onset of monsoon or prolonged drought after pre-monsoon rains and because of acute scarcity of labourers during this period, seldom the recommended plant population and spacings are adopted. Transplanting

cost is another serious issue needing attention as the same has risen to Rs. 1300 per hectare. Direct seeding, on the other hand, eliminate nursery raising and transplanting. Besides, the crop matures early (Mitra *et al.*, 1992). Equal performance of direct seeding and transplanting methods has been reported by Kundu *et al.* (1993).

A field experiment was conducted during *kharif* season from 1991 to 1993 at Regional Rice Research Station, GAU, Vyara (Gujarat). The soil of experimental field was clayey containing 0.39% organic carbon, 56 kg/ha available P_2O_5 , 450 kg/ha available K_2O and 7.0 pH. Six treatments comprising of 2 varieties, namely, GR-3 (V_1) and GR-103 (V_2) and two methods of planting viz., transplanting (M_1) and direct seeding of sprouted seeds with 2 dates in case of direct seeding i.e. day of nursery sowing (M_2) and day of transplanting (M_3) were tried in factorial randomized block design with 6 replications.

The nursery for transplanting treatments was sown on 29th, 27th and 30th June in the consecutive years. The corresponding dates of transplanting were 20th, 23rd and 24th July. These dates were considered as base for direct seeding. Transplanting method involved 30 kg/ha seed rate and 20 x 15 cm spacing, while direct sowing

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TABLE 1

Effect of varieties and methods of planting on paddy yield and its economics.

Treatment ,	Grain yld (q / ha)			Pooled	Cost of cultivation	Gross realization (Rs. / ha)	Net realisation (Rs. / ha)
	1991	1992	1993				
Varieties							
GR-3	52.12	28.10	33.24	37.82	8103	13690	5587
GR-103	50.55	32.06	32.01	38.21	8684	15131	6447
C. D. at 5%	NS	2.58	NS	NS	—	—	—
Methods of Planting							
Transplanting	52.38	33.05	34.26	29.90	10057	15155	5098
Direct seeding of sprouted seeds on the day of nursery sowing	45.44	33.48	35.88	38.27	7562	14571	7009
Direct seeding of sprouted seeds on the day of transplanting	56.20	23.73	27.74	35.89	7562	13505	5943
C. D. at 5%	3.69	3.16	3.09	NS	—	—	—

was carried at 30 cm spacing between the rows using 60 kg/ha seed. Recommended doses of fertilizers i.e. 80 kg N and 40 kg P_2O_5 /ha for GR-3 and 120 kg N and 60 kg P_2O_5 /ha for GR-103 were applied through urea and single super phosphate. Nitrogen was applied in 2 equal splits. The crop received 800, 1556 and 1435 mm total rainfall during 1991, 1992 and 1993, respectively.

Grain yield

Effect of varieties

The yield differences between GR-3 (V_1) and GR-103 (V_2) varieties were not significant in first and third years as well as pooled analysis (Table 1).

Effect of methods of planting

The differences in grain yield due to methods of planting were significant in the individual years (Table 1). While in 1991 direct seeding of sprouted seeds in the day of transplanting (M_3) was significantly superior over direct seeding of sprouted seeds on the day of nursery sowing (M_2) and transplanting (M_1), the reverse was true in 1992 and 1993. Poor performance of direct seeding on the day of nursery sowing (M_2) in 1991 was due to setback caused by low rainfall (68 mm) and that of direct seeding on the day of transplanting (M_3) in 1992 and 1993 was because of heavy to very rainfall (383 and 318 mm, respectively) during the

crop establishment period. The pooled analysis, however, indicated no difference among the three methods. These results indicated that direct seeding of sprouted seeds was as good as transplanting. The findings are in accordance with those of Mitra *et al.*, (1992) and Kundu *et al.*, (1993).

The interaction between variety and method was significant in the individual years, but not in pooled analysis.

Economics

GR-103, which is a fine grain variety gave significantly higher net return i.e. Rs. 858/ha more than GR-3. This was basically due to differences in market price. Among the methods of planting, direct seeding of sprouted seeds on the day of nursery sowing (M_2) with net realization of Rs. 7008/ha recorded the highest net profit and was significantly superior over direct seeding of sprouted seeds on the day of transplanting (M_3) and transplanting (M_1). Between the later two, M_3 was significantly superior over M_1 . It can, therefore, be inferred that direct seeding with sprouted seeds is superior than transplanting in terms of net return per hectare. Higher net return in direct seeding could be ascribed to saving of the cost of nursery raising and transplanting, which account for about 30% of the total cost of cultivation in transplanted paddy.

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Effect of Mulches and Antitranspirants on Yield Attributes, Yield and Quality of Safflower

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Major oilseed crops of the Gujarat are roundnut, sesamum and mustard. Whereas safflower is recently introduced crop. To increase the oilseed production in arid and semi-arid conditions with rainfall of scanty, uneven and irregular nature, drought tolerant crop like safflower can be successively grown because of spiny nature of leaves and ability to extract moisture from deeper soil layers through its deep tap root system (Mahapatra *et al.* 1975). Any attempt to minimize the water loss should be diverted to reduction of transpiration by use of antitranspirants and mulches without adverse effect on crop growth (Yadav and Singh, 1981). With this context, the present investigation was undertaken to ascertain the effect of mulches and antitranspirants on yield and quality of safflower.

A field experiment was conducted during the *rabi* season of 1991-92 at the college farm, Gujarat Agricultural University, Navsari

Campus. The soil was clayey in texture, having poor to medium drainage and good water holding capacity with pH 7.9. Total eighteen treatments consisting of combination of three mulches (No mulch, Black polythelene mulch of 50 micron thickness and paddy straw mulch @ 5 t/ha) and six antitranspirants (No antitranspirant, Phenyl Mercuric Acid (PMA) 10^{-4} m, Kaolin (8%), Atrazin (200 ppm), PMA + Kaolin and Kaolin + Atrazin) were accommodated in randomised block design with three replications. Mulches were applied 30 days after sowing, whereas antitranspirants were sprayed twice first at 60 days and second at 90 days after sowing. The safflower variety Bhima was sown in first fortnight of November 1991 and was harvested in April, 1992. Yield and yield attributes were recorded at the time of harvest. The oil content in safflower seeds was determined with the help of Soxhlet apparatus by using petroleum ether as a solvent.

Effect of mulches

Various yield attributes such as heads per plant, number of seeds per head and the test weight in safflower were significantly improved by mulch treatments (Table 1) due to positive effect of mulch in conservation and availability of moisture to the crop for longer period. Such results are also obtained by Bhan *et al.* (1980) in dryland conditions.

TABLE 1

Effect of mulches and antitranspirants on yield attributes of safflower.

Treatments	Heads/plant	Seeds/head	Test weight (g/100 seeds)
Mulches			
M ₀ — No mulch	17.3	23.1	5.02
M ₁ — Plastic mulch	22.6	23.4	5.19
M ₂ — Straw mulch	21.5	24.9	5.18
C. D. (5%)	1.5	0.8	0.09
Antitranspirants			
A ₀ — Water spray	17.4	23.6	5.07
A ₁ — PMA	19.1	24.2	5.08
A ₂ — Kaolin	21.4	24.4	5.10
A ₃ — Atrazin	20.0	23.9	5.17
A ₄ — PMA + Kaolin	22.0	25.6	5.17
A ₅ — Kaolin + Atrazin	22.0	25.0	5.19
C. D. (5%)	2.1	0.1	NS
Interaction	NS	NS	NS
C. V. %	10.6	4.8	2.62

Effect of antitranspirants

Spraying of various antitranspirants alone or in combination found effective in improving different yield attributes in safflower as compared to control (Table 1). Application of PMA + Kaolin and Kaolin + Atrazin increased the seeds per head by 5.92 and 8.21 per cent, respectively over control. Dalvi *et al.* (1991) also observed similar trend in chickpea. Likewise, application of Atrazin and Kaolin alone or in combination increased the number of heads per plant significantly

over control. Sebale and Khuspe (1986) also observed similar results in groundnut. Antitranspirants check the water loss from the plant leaves by reducing transpiration through stomata closer. Reduction in transpiration due to Kaolin is reported to be due to increase in reflectivity of the incident radiation, especially in visible region (Patel and De, 1976). The stomatal closer induced by Phenyl Mercuric Acetate (PMA) also reduces the transpiration. Due to this positive effect of Kaolin and PMA the

TABLE 2

Interaction effect of mulch x antitranspirant on seed yield, oil content and oil yield of safflower.

Mulches	Antitranspirants						Mean
	A ₀	A ₁	A ₂	A ₃	A ₄	A ₅	
Seed yield (q/ha)							
M ₀	10.50	11.25	12.71	12.29	12.64	12.11	11.92
M ₁	13.60	15.31	16.63	15.88	20.80	16.83	16.51
M ₂	13.93	13.00	15.92	15.30	16.74	16.24	15.20
Mean	12.68	13.19	15.09	14.52	16.72	15.06	
	Mulch	Antitranspirant		Interaction			
S. Em. ±	0.28	0.28		0.68			
C. D. (5%)	0.80	1.13		1.96			
Oil Content (%)							
M ₀	33.54	33.71	33.06	32.63	32.99	32.24	33.19
M ₁	32.52	32.75	32.26	33.12	33.45	32.67	32.96
M ₂	32.86	33.27	33.47	33.35	33.14	33.24	33.24
Mean	32.97	33.25	33.26	33.04	33.19	33.08	
	Mulch	Antitranspirant		Interaction			
S. Em. ±	0.05	0.07		0.12			
C. D. (5%)	0.14	0.20		0.36			

Mulches	Antitranspirants						Mean
	A ₀	A ₁	A ₂	A ₃	A ₄	A ₅	
	Oil yield (q/ha)						
M ₀	3.51	3.79	4.20	4.01	4.17	4.02	3.93
M ₁	4.42	5.02	5.54	5.26	6.96	5.55	5.46
M ₂	4.58	4.32	5.33	5.13	5.55	5.42	5.04
Mean	4.16	4.38	5.02	4.80	5.56	5.00	
	Mulch		Antitranspirant		Interaction		
S. Em. ±	0.09		0.13		0.22		
C. D. (5%)	0.26		0.37		0.64		

number of heads per plant and seeds per head were found increased in safflower. However, antitranspirant application did not influence the test weight in safflower significantly.

Interaction effects

The combined effect of mulch alongwith antitranspirants was found significant for seed yield in safflower (Table 2). Outrightly the highest seed yield (20.80 q/ha) was recorded with application of PMA + Kalolin alongwith black polythelene mulch, followed by Kaolin + Atrazin with black polythelene mulch (16.83 q/ha). The increase in seed yield was double than the absolute control (10.50 q/ha). In many other treatment combinations, use of black polythelene or paddy straw mulch increased the seed yield considerably, particularly when accompanied with spray of antitranspirants due to positive effect of

mulches and antitranspirants. Yadav and Singh (1981) also reported that daily ET was reduced significantly with reflecting type of antitranspirants.

The quality of safflower in terms of oil yield was also appreciably improved by combined effect of mulches and antitranspirants compared to absolute control (Table 2). Significantly the highest oil yield (6.96 q/ha) was recorded with application of PMA + Kaolin alongwith plastic mulch due to higher seed yield and better oil content. The increase in oil yield with spraying of antitranspirants in sunflower was also obtained by Mungse and Bhapkar (1979). The oil content in safflower seeds was not improved much with combined effect of mulches and antitranspirants and maximum oil content (33.54%) was registered with absolute control.

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Effect of N and P on Yield, Quality, Uptake of Nutrients and Economics of Fodder Sorghum Varieties

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A field experiment was conducted at the Agronomy Farm, Gujarat Agricultural University, Junagadh during *rabi* season of 1992-93. The soil was clayey in texture and slightly alkaline in reaction (pH 7.8) with normal E.C. (0.33 dS/m) having low available nitrogen (226 kg/ha), medium available phosphorus (28.7 kg/ha) and medium available potassium (210 kg/ha). Two sorghum varieties viz., GFS-4 and Gundari as main plots and four levels of nitrogen viz., 0, 20, 40 and 60 kg N/ha and three levels of phosphorus viz., 0, 20 and 40 kg P_2O_5 /ha as sub-plots were tried in split plot design with three replications. The crop was sown on November 5, 1992 with inter row spacing of 30 cm using 60 kg/ha seed rate.

Green and dry fodder yields were significantly higher in GFS-4 than variety Gundari. Protein yield and uptake of N and

were significantly higher with variety GFS-4, however, contents of protein, N and P remained unaltered among both the varieties. Crude fibre content was lower in GFS-4 than variety Gundari. The variety GFS-4 also secured higher net profit of Rs. 1252/ha over variety Gundari. The findings are in conformity with those reported by Vekaria (1989).

Green and dry fodder yields were significantly increased with each increment in level of N from 0 to 60 kg N/ha. The findings lends support of Vekaria (1989). Protein content, protein yield, content and uptake of N and P uptake were significantly increased with incremental level of N, however, P content remained unaffected. Crude fibre content was significantly decreased with each successive increase in N dose. Similar results were also obtained by Patel (1991). Maximum net return of Rs. 5233/ha was secured under 60 kg N/ha. These results are in complete agreement with the results obtained at Forage Research Station, Dhari (Gujarat).

Application of 40 kg P_2O_5 /ha produced significantly higher green and dry fodder yields over control, but it was at par with 20 kg P_2O_5 /ha. Protein yield, N uptake, P content and P uptake were significantly increased with P application upto 40 kg P_2O_5 /ha, but 40 and 20 kg P_2O_5 /ha levels were at par in respect of

TABLE 1

Effect of different treatments on yield quality, uptake of nutrients and economics.

Treatments	Fodder yield (q/ha)		Protein content (%)	Protein yield (kg/ha)	Crude fibre (%)	N content (%)	N uptake (kg/ha)	P ₂ O ₅ content (%)	P ₂ O ₅ uptake (kg/ha)	Net return (Rs/ha)
	Green	Dry								
Variety										
GFS-4	218	76	6.4	489	31.1	1.020	78.3	0.162	12.3	3951
Gundari	182	63	6.3	397	32.7	1.001	63.5	0.158	10.0	2699
C. D. at 5%	28	8	NS	71	1.3	NS	11.4	NS	2.2	—
Nitrogen (kg/ha)										
0	130	45	5.8	262	33.1	0.930	41.9	0.158	7.2	1192
20	182	63	6.2	388	32.2	0.991	62.1	0.160	10.2	2739
40	226	78	6.5	511	31.5	1.040	81.7	0.161	14.6	4154
60	261	90	6.6	611	30.8	1.081	97.8	0.161	14.6	5233
C. D. at 5%	14	4	0.2	31	0.6	0.030	4.9	NS	0.8	—
Phosphorus (kg P ₂ O ₅ /ha)										
0	166	57	6.3	367	32.0	1.006	58.8	0.144	8.3	2551
20	216	74	6.3	478	31.9	1.010	76.4	0.167	12.5	3952
40	219	75	6.3	484	31.8	1.014	77.5	0.169	12.8	3584
C. D. at 5%	12	3	NS	27	NS	NS	4.2	0.005	0.7	—

N uptake. Protein content, N content and fibre content remained unaffected due to P levels. The results are in harmony with those of Patel (1991). Application of 20 kg

P_2O_5 /ha realised highest net return of Rs. 3852/ha closely followed by 40 kg P_2O_5 /ha (Rs 3584/ha).

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Response of Fodder Sorghum (*Sorghum bicolor*) Varieties to Levels of Nitrogen and Phosphorus

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A field experiment to study the response of fodder sorghum varieties (GFS-4 and Gundari) to nitrogen (0, 20, 40 and 60 kg N/ha) and phosphorus (0, 20 and 40 kg P_2O_5 /ha) was carried out during *rabi* season of 1992-93 at Agronomy Farm, Gujarat Agricultural University, Junagadh. The soil was clayey in texture and slightly alkaline in reaction with low available nitrogen, medium available phosphorus and high available potassium. The experiment was laid out in split plot design with three replications. The crop was sown on November 5, 1992 with inter-row spacing of 30 cm using 60 kg/ha seed rate.

The data presented in Table 1 indicated that growth attributes and fodder yield were significantly differed among both the varieties. The variety GFS-4 was found superior in respects of plant height (at 30 and 45 days after sowing (DAS) as well as at harvest), leaf area/plant, internodes/plant, length of

internode and stem thickness which ultimately resulted in significantly higher green and dry fodder yield. Variety GFS-4 produced 19.8 and 20.7% higher green and dry fodder yield, respectively over variety Gundari, Vekaria (1989) also made similar observations.

Growth attributes and fodder yield were significantly increased with each increament in level of N, except number of internodes/plant. Application of 60 kg N/ha recorded significantly the highest plant height (at 30 DAS, 45 DAS and harvest), leaf area/plant, length of internode and stem thickness which reflected in significantly higher green and dry fodder yield. N fertilization @ 60 kg/ha registered 100.3, 43.5 and 15.4% higher green fodder yield as well as 101.1, 44.5 and 15.0% higher dry fodder yield over 0, 20 and 40 kg N/ha, respectively. Similar results were also obtained by Vekaria (1989) and Patel (1991).

Different levels of phosphorus exert thier significant influence on growth attributes and fodder yield. Both the higher levels of P i.e. 20 and 40 kg P_2O_5 /ha being on par, significantly improved plant height, leaf area/plant, length of internode and stem thickness and consequently higher green and dry fodder yield to the tune of 29.8 and

TABLE 1
Effect of nitrogen and phosphorus on growth and yield of sorghum varieties.

Treatment	Plant height (cm)			Leaf area/ plant (dm ²)	Number of internodes/ plant	Length of internode (cm)	Stem thickness (mm)	Fodder yld (q/ha)	
	30 DAS	45 DAS	Harvest					Green	Dry
Variety									
GFS-4	55.3	121.7	160.0	14.66	7.1	21.8	3.9	218.0	75.5
Gundari	47.2	108.8	138.9	12.90	6.2	19.8	5.4	182.0	62.6
C. D. at 5%	4.3	7.2	12.8	1.44	0.5	1.8	0.5	28.4	8.4
Nitrogen (kg/ha)									
0	41.3	90.8	110.2	12.29	6.5	15.3	3.6	130.4	44.9
20	49.4	108.6	147.4	13.54	6.6	20.7	4.2	182.0	62.5
40	55.1	121.1	163.1	14.20	6.7	22.8	5.0	226.4	78.5
60	59.4	130.5	177.2	15.09	6.7	24.4	5.6	261.2	90.3
C. D. at 5%	1.8	3.6	6.4	0.60	NS	1.1	0.2	13.6	3.9
Phosphorus (kg/ha)									
0	48.8	110.5	120.8	13.35	6.6	16.8	4.2	166.0	57.4
20	51.2	115.1	162.6	14.07	6.6	22.7	4.7	215.5	74.4
40	53.8	112.7	165.0	13.92	6.7	22.9	4.9	218.5	75.4
C. D. at 5%	1.6	3.2	5.6	0.52	NS	0.9	0.2	11.8	3.4
Interactions									
	NS	Ns	NS	NS	NS	NS	NS	NS	NS

29.6%, respectively over control. The findings are in confirmity with those of Patel (1991).

Interaction effects of variety, nitrogen and phosphorus were found non-significant for all the growth parameters and yield.

Thus, the sorghum variety GFS-4 can be fertilized with 60 kg N + 20 kg P_2O_5 /ha for securing higher fodder yield under south Saurashtra agro-climatic conditions.

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Performance of Safflower (*Carthamus tinctorius*) Varieties Under Different Sowing Dates

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A field experiment was conducted at Agronomy Farm, Gujarat Agricultural University, Junagadh during *rabi* season of 1992-93. The soil was clayey in texture, medium in total nitrogen (0.07%), medium in available phosphorus (34 kg/ha), high in available potassium (303 kg/ha) and slightly alkaline in reaction (7.9 pH) with normal E.C. (0.30 dS/m). The treatments comprising 4 dates of sowing (October 10, 20, 30 and November 9) and 5 varieties (Bhima, Tara, Manjira, A-1 and NRS-209) were tested in a split plot design with 4 replications taking dates as main plot treatment. Half dose of N and full dose of P_2O_5 were applied in forms of urea and single-super phosphate, respectively at the time of sowing and remaining half dose of N was top-dressed at 40 days after sowing. The crop was sown at 45 cm row spacing using 15 kg/ha seed rate.

Dates of sowing significantly influenced growth and yield of safflower. Each delay in sowing after October 10 significantly reduced the growth and yield of the crop. The growth and yield attributes viz., plant height, plant spread, primary and secondary branches/plant, seeds/head, 100-seed weight and seed yield/plant were higher in October 10 sowing. However, October 20 sowing was on a par with October 10 sowing with respects to plant spread, primary and secondary branches/plant and heads/plant. Harvest index remained unaltered under different dates of sowing. The results are in concurrence with those reported by Ghule *et al.* (1987).

Growth parameters viz., plant height and primary and secondary branches/plant as well as yield attributes viz., heads/plant, seeds/head, 100-seed weight and seed yield/plant were significantly higher in variety 'Bhima'. However, there was no significant difference in plant spread and harvest index among the varieties. The variety 'Bhima' recorded significantly highest seed and stover yield, which have evidently resulted from higher growth and yield parameters. The higher genetic yield potentiality and greater adaptability of variety

TABLE 1

Effect of sowing dates on growth and yield of safflower varieties.

Treatment	Plant height (cm)	Plant spread (cm)	Branches/plant		Heads/ plant	Seeds/ head	Seed yld/ plant (g)	100- seed weight (g)	Yield (q/ha)		Harvest index (%)	
			Primary	Secondary					Seed	Stover		
Dates of sowing												
October 10	78.80	38.35	8.3	13.1	18.9	20.9	15.20	3.93	18.40	52.82	25.80	
October 20	71.80	35.95	8.0	12.4	18.6	19.2	12.07	3.80	16.32	47.19	25.67	
October 30	71.15	31.55	6.6	9.3	15.4	16.7	7.86	3.66	13.38	38.59	25.72	
November 9	69.50	30.35	5.7	8.5	13.7	15.6	5.57	3.48	7.99	23.03	25.73	
C. D. at 5%	4.44	2.96	0.7	0.9	1.8	1.0	0.97	0.13	1.24	3.30	NS	
Varieties												
Bhima	76.87	35.50	7.6	11.3	18.3	21.4	13.78	4.62	17.71	51.29	25.63	
Tara	68.87	31.31	7.2	10.1	16.6	17.3	9.91	3.34	13.21	38.04	25.74	
Manjira	73.18	34.43	6.8	11.2	16.6	17.2	8.71	3.11	12.07	34.76	25.75	
A-1	70.75	34.06	6.5	10.3	16.0	16.3	9.93	3.54	12.50	35.95	25.76	
NRS-209	74.37	34.93	7.6	11.2	16.0	18.3	11.57	3.98	14.61	41.99	25.79	
C. D. at 5%	3.16	NS	0.6	0.8	1.6	0.7	0.50	0.09	0.68	2.00	NS	

'Bhima' might be responsible for higher yield. Such kind of varietal difference was

also studied by Bhanvadia (1993).

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Status of Micronutrient Cations in Soils of Gujarat

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In order to delineate micronutrient deficient areas, in all 29,532 surface soil (0-15 cm) samples were collected from different regions of Gujarat in three phases during 1967 to 1992. These soils were analysed for their important physico chemical properties and contents of available micronutrient cations by standard methods (Jackson, 1967; Lindsay & Norvell, 1978). On the basis of established critical limits, deficiency percentage for the soils were worked out (Table 1). Besides, the occurrence of Zn deficiency, its associations with important soil properties were also worked out.

The results revealed that deficiency of Mn and Cu was quite meagre, where as that of Fe and Zn was to the tune of 8 and 24 per cent, respectively. Further, the results indicated that, the least percentage deficiency for Zn-13 and Fe-3 per cent was in South and Middle Gujarat regions, respectively as against the corresponding maximum percentage of 31 and 13 in North

Gujarat, Saurashtra and Kutch regions, respectively.

From the reassessment point of view the results revealed that over the years, the soil status improved and the deficiency decreased in the case of all the micronutrients barring Zn, which showed a reverse trend in Middle and North Gujarat and Saurashtra regions (Table 1). The low percentage of Zn deficiency in South Gujarat may be due to higher availability on account of higher organic carbon content in those soils. The higher percentage of deficiency of the nutrients in the initial years could be attributed to the adaptation of intensive cropping and use of high analysis fertilizers resulting in their higher exhaustion. The subsequent improvement in the soil status could be mainly due to the awareness among farmers about the use of micronutrients in improving the crop yields and sustaining the soil fertility. However, Zn deficiency still prevails in light textured and calcareous soils.

Relationship of Zn status with physico-chemical properties indicated that with the rise in pH of soils, the percentage of Zn deficient soils increased from 20 to 30 i.e. alkaline soils were more prone to Zn deficiency. Negative and significant coefficients of correlation obtained between the available zinc and soil pH have been

TABLE 1
Available micronutrient cations (ppm) in different regions of the Gujarat State.

Type of soil	Order	Sub-order	Period	No. of samples	Fe		Mn		Zn		Cu	
					Range (Mean)	PSD*	Range (Mean)	PSD	Range (Mean)	PSD	Range (Mean)	PSD
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
South Gujarat												
Clayey and deep black with few patches of coastal alluvial and lateritic medium black Soils.	Inceptisols Vertisols Entisols	Ochrepts	1967-76	385	0.3-47 (5.0)	17.8	0.2-43 (6.4)	13.4	0.17-28 (1.18)	17.4	0.04-0.5 (0.12)	10.2
		Orthents										
		Usterts										
		Psamments Fluents	1976-83	3877	0.4-165 (17.3)	2.5	2.9-490 (36.1)	1.9	0.14-18 (1.19)	12.9	0.08-15 (3.5)	0.0
			1991-92	81	4.2-54 (22.8)	1.0	8.0-96 (39.5)	0.0	0.68-5.4 (2.0)	1.0	1.7-6.5 (4.0)	0.0
			Overall	4343	0.3-165 (16.0)	4.0	0.2-490 (33.5)	6.0	0.10-28 (1.2)	13.0	0.04-16 (3.3)	2.0
Middle Gujarat												
Deep black, medium black to Loamy sand (goradu) soils	Inceptisols Entisols	Ochrepts	1967-76	410	0.4-100 (6.8)	14.4	0.3-29 (5.0)	8.5	0.15-26 (1.4)	8.1	0.02-1.2 (0.13)	9.20
		Usterts										0.92
		Orthents										
		Psamments Fluents	1976-83	5124	0.6-95 (13.8)	2.0	2.7-359 (26.3)	0.9	0.05-25 (1.2)	16.7	0.08-14 (1.8)	0.00
			1984-92	1078	2.4-48 (14.8)	3.0	3.2-104 (26.5)	1.0	0.17-8 (1.2)	12.0	0.3- 9.6 (2.6)	
			Overall	6612	0.4-100 (13.5)	3.0	0.3-359 (25.0)	2.0	0.05-26 (1.2)	16.0	0.02-14 (2.0)	2.00
North Gujarat												
Sandy loam to sandy soils	Inceptisols Entisols Aridisols	Ochrepts	1967-76	359	0.4-83 (3.7)	24.3	0.8-20 (5.0)	12.0	0.11-4.9 (0.78)	29.6	0.03-0.8 (0.10)	13.4
		Orthids										
		Orthents										
		Psamments Fluents	1976-83	4817	0.2-72 (8.4)	11.1	2.2-202 (19.9)	2.6	0.04-72 (0.98)	35.3	0.01-9.0 (1.19)	8.1
			1984-92	2305	1.8-46 (11.1)	5.3	2.8-99 (22.7)	0.5	0.70-6.6 (1.23)	13.7	0.2- 21 (1.58)	2.2
			Overall	7481	0.2-83 (9.0)	10.0	0.8-202 (20.0)	3.0	0.04-72 (1.0)	31.0	0.01-21 (1.3)	7.0

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Saurashtra and Katch medium												
Shallow black, calcareous sandy and saline soils	Inceptisols Entisols Aridisols	Ochrepts	1967-76	837	0.8-16 (3.0)	10.9	0.3-44 (4.2)	8.9	0.10-19 (1.12)	16.9	0.02-1.2 (0.14)	10.1
		Aquepts	1876-83	6820	0.1-49 (6.9)	18.3	0.8-318 (23.0)	2.4	0.11-20 (0.86)	31.0	0.03-10.8 (1.87)	2.6
		Orthents	1986-92	3439	3.0-47 (9.6)	1.3	2.7-107 (22.5)	1.3	0.10-8 (1.00)	28.6	0.3-11.9 (2.30)	0.0
		Psamments			Fluvents	Orthids						
Overall			11096	0.1-49 (7.5)	13.0	0.3-318 (21.5)	5.0	0.10-20 (0.9)	30.0	0.02-12 (2.0)	4.0	
Gujarat												
			1967-76	1991	0.3-100 (4.3)	15.4	0.2-44 (4.9)	10.3	0.10-28 (1.13)	17.5	0.02-1.2 (0.13)	10.5
			1976-83	20638	0.1-165 (10.9)	9.6	0.8-490 (25.6)	2.0	0.04-72 (1.02)	25.1	0.01-1 (2.00)	3.0
			1984-92	6903	1.8-54 (11.2)	2.9	2.8-107 (23.3)	1.0	0.11-8.0 (1.12)	20.7	0.20-21 (2.14)	0.7
Gujarat			29532	0.1-165 (10.2)	8.0	0.2-490 (23.6)	4.00	0.04-72 (1.1)	24.0	0.01-21 (1.9)	4.0	

*PSD = Per cent Soil Deficient.

TABLE 2

Relationship of DTPA - extractable Zn with Important soil properties.

Characteristic	% of total samples	Per cent*	
		Deficient < 0.50 ppm Zn	Sufficient > 0.50 ppm Zn
Soil pH			
< 8.0	47	20	80
8.0 — 8.5	44	30	70
> 8.5	09	30	70
EC (mmhos/cm)			
< 1.0	93	26	74
1.0 — 2.0	05	18	82
> 2.0	02	19	81
Org. C. (%)			
< 0.5	31	32	68
0.5 — 0.75	32	23	77
> 0.75	36	22	78
Av. P₂O₅ (kg/ha)			
< 25	36	35	65
25 — 50	28	25	75
> 50	36	15	85
Av. K₂O (kg/ha)			
< 250	13	38	62
350 — 500	43	25	75
> 500	44	20	80
Overall		25	75

*Per cent in respective category.

reported (Katyal and Agrawal, 1982). In case of electrical conductivity, such relationship was not very clear as more than 93 per cent of the soils were in low category. Unlike pH, a reverse trend was noticed in case of organic C content, available phosphorus and potassium contents as the percentage of Zn deficiency decreased from 32 to 22, 35 to 15 and 38 to 20, with increase in status of these nutrients, respectively.

The available nutrient status is largely influenced by the presence of soil organic

matter and as such a positive relationship of organic matter with available Zn has been reported by different workers (Mehra and Basar, 1991; Gupta, 1995). The enhancement in the Zn availability in the soil is attributed to the complexing agents produced by organic matter which bind Zn in plant available form. Hence, in general, the soils poor in fertility status with alkaline reaction in nature are relatively more prone to Zn deficiency (Table 2).

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Biology of *Spodoptera litura* (Fabricius) As a Pest of Castor in Gujarat*

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Spodoptera litura (Fabricius) is a polyphagous pest and its outbreak was reported earlier on tobacco, cauliflower and maize in India and in recent years on castor in South Saurashtra (Gujarat). Its comparative development of different host plants was

studied by Rattan Lal and Nayak (1963), Thomas *et al.* (1969), Singh and Byas (1975) and Bhalani and Talati (1984), and they have reported the castor as the most preferable host. However, little information on its biology particularly on castor is available from Gujarat. Hence, a laboratory study on its biology on castor was done during September-October, 1993 when maximum and minimum temperatures ranged from 32.9 to 35.5 and 22.4 to 23.7°C. respectively and relative humidity from 38 to 94 per cent.

Spodoptera larvae were collected from castor field and reared on castor leaves in

TABLE 1

Biology of *Spodoptera litura* when reared on castor.

Stage	No. Studied	Duration in days	
		Range	Average
Egg	303	2-3	2.99
Larva	25	8-11	9.04
First instar	25	3-4	3.12
Second instar	25	1-2	1.56
Third instar	25	2-3	2.20
Fourth instar	25	1-2	1.08
Fifth instar	25	1-2	1.00
Sixth instar	25	1-2	1.33

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1.	2.	3.	4.
Pre-pupa	25	1-3	1.76
Pupa	25	6-8	6.68
Pre-oviposition	10	1-4	2.67
Oviposition	10	1-4	2.16
Post-oviposition	10	1-2	1.17
Fecundity	10	415-2294	1205.90
Adult			
Female	10	3-6	4.22
Male	10	3-5	3.75
Sex ratio	28	1.55:1 (Field)	
(Female : Male)	25	1.01 : 1 (Laboratory)	

glass jars (15 x 20 cm) till the pupation and adult emergence. Newly emerged moths were paired and confined in glass jars (15 x 20 cm) containing castor leaves for oviposition and five per cent honey solution as food for them. Castor leaves were replaced daily by fresh ones and number of eggs laid by a female was recorded. Newly hatched larvae were reared individually in petridishes (9.5 x 1.5 cm). Larval instar was determined by presence of exuviae casted off or head capsules. The observation on different development stages are summarised in Table 1.

Incubation period averaged 2.99 days and egg viability was 92.08 per cent. Narayanan (1959) reported the egg period of 3-5 days. The larva passed through six instars and duration of each instar was 3.12, 1.56, 2.20, 10.8, 1.00 and 1.33 days.

Total larval period lasted for 8 to 11 days. Larval period was reported to be 18 days (Rattan Lal and Nayak, 1963, Singh and Byas, 1975) and 12.05 days (Bhalani and Talati, 1984). Pre-pupal and pupal period lasted for 1 to 3 and 6 to 8 days, respectively. Narayanan (1959), Thomas *et al.* (1969) and Bhalani and Talati (1984) reported pupal stage to be 7-14, 9-11 and 6.06 days, respectively.

Females laid eggs in 2-9 egg masses. Pre-oviposition, oviposition and post-oviposition periods averaged 2.67, 2.16 and 1.17 days, respectively. A female laid an average of 1205.90 eggs with a range of 415 to 2294 eggs. Rattan Lal and Nayak (1963) and Thomas *et al.* (1969) reported the fecundity to be 580 and 808.50 eggs per female, respectively.

Female and male moths survived for 4.22 and 3.75 days, respectively. Female to male

ratio was 1.55 : 1 in field collected samples and 1.01 : 1 in laboratory reared pest.

The study concluded that *Spodoptera litura* completed its life cycle on castor within

24.70 days, accounting high fecundity (mean 1206) in 1-4 days of oviposition period.

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Biology of Sesamum Leaf Roller and Capsule Borer *Antigastra catalaunalis* (Duponchel) in Gujarat

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The leaf and capsule caterpillar, *Antigastra catalaunalis* (Duponchel) (Pyralidae : Lepidoptera) is an important pest of sesamum. Its biology has been reported from Uttar Pradesh (Menon *et al.* 1960, Teotia and Hussain, 1965) and Punjab (Cheema and Singh, 1987). A perusal of the published literature has shown that its biology in detail has not been reported from Gujarat except a report on preliminary observation made by Desai and Patel (1965). Hence the present study was made during November – December 1993, prevailing $26.7 \pm 8.15^{\circ}\text{C}$ and $41.75 \pm 12.25\%$ relative humidity.

Initial culture was raised by collecting the larvae of the pest from the sesamum field and reared in laboratory till the emergence of adults. The freshly emerged adults were paired (female and male) and confined in a plastic jar (16 x 7 cm) containing tender leaves for oviposition and 5% sugar solution in cotton swab as food for them. Fourteen pairs

were studied for egg laying capacity and longevity. The larvae were reared individually on tender leaves in the plastic box (7.5 x 3.5 cm) until pupation and adult emergence. The instar was determined by presence of the caste off head capsule. The observations on different developmental stages are summarised in Table 1.

Biology

Female laid eggs singly on the tender leaves. Egg was whitish, 0.53 mm long and 0.31 mm broad. The incubation period averaged 3.05 days. Egg viability was 96.41 per cent. Newly hatched larva was whitish, black headed, 2.63 mm long and 0.46 mm broad. The larva passed through five instars and duration of each instar was 4.64, 2.52, 1.93, 1.20 and 1.40 days. Total larval period lasted for 10-13 days. Fifth instar larva measured 15.16 mm long and 3.69 mm broad. The pre-pupal stage lasted for 1 to 2 days. It was covered by whitish silken threads. It pupated inside the webbed leaves or between the two capsules. The pupal period averaged 6.03 days. The egg period was reported to be 5.9 days (Cheema and Singh, 1987) and 4-5 days (Desai and Patel, 1965). Teotia and Hussain (1965) reported the larval period to be 18-19 days and 10-15 days (Desai and Patel, 1965). The pupal period lasted for 3-9 days (Teotia and Hussain, 1965) and 4-5 days (Desai and Patel, 1965).

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TABLE 1

Biology of *Antigastra catalaunalis* reared on sesamum ($26.7 \pm 8.15^{\circ}\text{C}$, $41.75 \pm 12.25\%$ RH).

Stage	No. studied	Duration in days	
		Range	Average
Egg	108	2-6	3.05
Larva	30	10-13	11.03
First instar	32	4-5	4.65
Second instar	32	2-4	2.52
Third instar	30	1-2	1.93
Fourth instar	30	1-2	1.20
Fifth instar	30	1-2	1.40
Pre-pupa	30	1-2	1.16
Pupa	30	5-7	6.03
Pre-oviposition	14	1-2	2.07
Oviposition	14	2-5	3.97
Post-oviposition	14	1-2	1.83
Fecundity (Eggs/Female)	14	28-173	86.94
Adult			
Male	14	3-6	4.00
Female	14	5-7	6.00
Sex ratio (Female : Male)	58	1.66 : 1.00	

The pre-oviposition, oviposition and post-oviposition periods averaged 2.07, 3.97 and 1.83 days, respectively. Females laid a mean of 86.94 eggs with an average of 28 to 173 eggs. Females survived longer (6.00 days) than males (4.00 days). The female to male ratio was 1.66 : 1 in the field collected samples. The present results of oviposition period and fecundity agree with the report of Cheema and Singh (1987). Menon *et al.* (1960) recorded 14-95 eggs per female.

Parasitism

An ichneumonid, *Eriborus trochanteratus* Morely was found parasiting the larvae of the pest. It was a solitary endoparasitoid, causing 24.00 per cent parasitism. An unidentified *Chrysopa* sp. was also observed predating upon the immature stages of the pest.

The study concluded that *A. catalaunalis* completed its life-cycle within 27.27 days during November-December under Gujarat conditions. Cheema and Singh (1987) reported the life-cycle of 51 days in winter.

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or

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Effect of Insecticides on Natural Enemies of Major Insect Pests of Paddy

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Sufficient information on the effectiveness of insecticides against insect pests of paddy is generated through experimental results. Large number of insecticides belonging to various chemical groups and its different formulations are evaluated against paddy pests. With the increasing awareness regarding environment, the insecticides whose adverse effect on environment and on beneficial fauna is minimum should be encouraged in integrated pest management programme. Safety to natural enemies of insect pests is therefore one of the most important attributes of such insecticides. The knowledge about the adverse effect of insecticides on natural enemies of paddy pests is meagre. Therefore, this trial has been formulated to assess the effect of recommended insecticides on some of the common natural enemies of paddy pests prevailing in middle Gujarat area.

The trial was carried out during five successive *kharif* seasons of 1989-90 to 1993-94, at the Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat). The experiment was laid-out in Randomised Block Design with four replications. There were eight treatments including check (Control). Three granular formulations viz., carbofuran, phorate and quinalphos and four sprayable formulations viz., monocrotophos, chlorpyrifos, quinalphos and acephate were tested at the recommended doses (Table 1). The gross and net plot size were 10.50 m x 5.8 m and 9.30 m x 4.6 m respectively. Individual plots were separated by bunds and channels to regulate waterflow and prevent water movement from one plot to other. The seedlings of susceptible variety (GR-11) of paddy were transplanted at 20 cm x 15 cm spacing on 11-8-89, 6-8-90, 8-8-91, 3-8-92 and 20-8-93, in 1989, 1990, 1991, 1992 and 1993, respectively. All the recommended agronomic practices except plant protection were followed for raising healthy crop. Insecticidal applications were given at 10, 30 and 50 days after transplanting (DAT) in each treatment.

Observations on natural enemies were recorded at 10 days after each application. For the purpose, number of spiders present or

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TABLE 1

Effect of insecticides on spiders in paddy crop.

Sr. no.	Treatments	Dose (kg a.i. / ha)	Average number of spiders/5 hills															Pooled
			1989-90			1990-91		1991-92			1992-93			1993-94				
			40	60	80	60	80	40	60	80	40	60	80	40	60	80		
			DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT		
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	
1.	Carbofuran 3 G	0.75	4.25 *(2.23)	3.75 (2.16)	1.25 (1.41)	3.00 (1.97)	5.75 (2.58)	2.75 (1.97)	2.25 (1.78)	0.75 (1.29)	4.50 (2.34)	2.75 (1.93)	7.25 (2.87)	2.25 (1.80)	1.75 (1.64)	0.50 (1.29)	3.07 (2.02)b	
2.	Phorate 10 G	1.00	2.00 (1.72)	4.00 (2.16)	6.00 (2.64)	1.75 (1.64)	2.50 (1.87)	0.75 (1.29)	4.25 (2.29)	0.25 (1.10)	4.50 (2.32)	3.25 (2.05)	4.00 (2.23)	1.00 (1.39)	2.00 (1.72)	0.50 (1.21)	2.62 (1.90)c	
3.	Quinalphos 5 G	1.00	4.50 (2.30)	2.00 (1.62)	3.75 (2.17)	3.50 (2.11)	2.00 (1.72)	2.25 (1.78)	5.00 (2.44)	2.75 (1.93)	0.00 (1.00)	2.25 (1.78)	5.75 (2.59)	2.25 (1.79)	1.75 (1.64)	2.25 (1.76)	2.86 (1.96)bc	
4.	Monocrotophos 36 w/w	0.50	2.50 (1.85)	3.00 (1.99)	3.75 (2.14)	0.00 (1.00)	2.00 (1.70)	0.75 (1.29)	1.75 (2.10)	1.25 (1.49)	0.00 (1.00)	0.00 (1.00)	4.75 (2.36)	2.00 (1.72)	0.75 (1.29)	0.75 (1.29)	1.66 (1.63)ef	
5.	Chlorpyriphos 20 EC	0.50	2.25 (1.77)	0.00 (1.00)	2.50 (1.85)	0.00 (1.00)	1.00 (1.39)	1.50 (1.54)	1.75 (1.65)	2.00 (1.72)	3.75 (2.17)	3.25 (2.05)	4.00 (2.18)	2.00 (1.72)	1.00 (1.39)	1.00 (1.35)	1.37 (1.53)f	
6.	Quinalphos 25 EC	0.50	5.00 (2.41)	3.00 (1.98)	0.00 (1.00)	1.25 (1.47)	1.50 (1.55)	2.25 (1.74)	1.50 (1.57)	2.00 (1.68)	3.25 (2.06)	3.00 (1.99)	6.25 (2.67)	1.00 (1.39)	0.50 (1.21)	0.25 (1.10)	2.20 (1.78)d	
7.	Acephate 75 wp.	0.50	2.25 (1.77)	3.25 (2.05)	1.00 (1.35)	0.50 (1.21)	1.25 (1.49)	1.00 (1.39)	3.50 (2.11)	0.50 (1.21)	4.25 (2.28)	2.25 (1.80)	5.25 (2.48)	1.75 (1.64)	0.25 (1.10)	0.00 (1.00)	1.93 (1.71)de	
8.	Control	—	9.50 (3.23)	5.75 (2.60)	9.50 (3.22)	6.50 (2.71)	5.50 (2.55)	6.25 (2.67)	8.50 (3.07)	6.00 (2.64)	5.50 (2.55)	2.50 (1.86)	10.00 (3.30)	2.75 (1.93)	3.25 (2.05)	2.75 (1.93)	6.02 (2.64)a	
	S. Em.		0.217	0.216	0.295	—	0.120	0.210	0.267	0.149	0.125	0.102	0.185	—	0.138	0.181	0.038	
	C. D. at 5%		0.648	0.636	0.866	NS	0.354	0.619	0.784	0.438	0.369	0.299	0.545	NS	0.406	0.534	0.111	
	C. V. (%)		20.18	22.24	29.93	—	12.99	24.66	25.08	18.24	12.77	11.25	14.33	—	18.39	26.68	3.98	

* $\sqrt{x + 1}$ transformed values.

DAT = Days After Transplanting.

randomly selected 5 hills in net plot area were counted. The data obtained were analysed after $\sqrt{x + 1}$ transformation and presented in Table 1. The egg-masses of yellow stem borer, *Scirpophaga incertulas* (Walker) and eggs of leaf folder, *Cnaphalocrosis medinalis* Guen. available from net plot area were collected from respective treatment at 7-10 days interval. The eggs collected were kept in separate test tube and observed for the emergence of parasitoids and larvae from the eggs. Similarly, the larvae and pupae of leaf defoliators (leaf folder and rice skipper) were collected from net plot area of each treatment at weekly interval and observed for their parasitism. The parasitoids which emerged out were identified on the basis of earlier records. Per cent parasitism in eggs, larvae and pupae was worked out for the entire season and depicted in Table 2.

Data presented in Table 1, revealed that the spider population significantly differed in all the observations recorded during entire study period, except on 60 DAT during 1990 and 1993. Pooled analysis showed significantly highest (6.02, spiders/5 hills) population of spiders was found in untreated control. Significantly higher number (2.62 to 3.07) spiders/5 hills) of spiders were recorded in the plots treated with granular formulations than those of sprayable formulations. Carbofuran was relatively safe to spiders by registering 3.07 spiders/5 hills followed by quinalphos (2.86) and phorate (2.62), whereas in case of sprayable formulations, quinalphos was safe as compared to other formulations tested. These findings are fully supported by DRR (1990, 1991, 1992) reports, wherein it is very clearly showed that granular formulations relatively safer to spiders than spray formulations.

Data recorded on egg, larval and pupal parasitism (Table 2) in paddy pests during present study indicated that all the treatments exhibited zero per cent egg-parasitism in yellow stem borer (by *Telenomus* sp.) and leaf folder (by *Trichogramma chilonis*), except acephate and control. Experimental plots without any insecticidal application recorded highest egg-parasitism in yellow stem borer (67.67%) and leaf folder (33.33%) during 1989-90 and 1991-92, respectively. The larvae of leaf folder were parasited by *Apanteles* sp. and *Brachymeria lasus* (Walker). The extent of parasitism by *Apanteles* sp. was 4.65 and 10.00 per cent in quinalphos 25 EC (1990-91) and carbofuran 3 G (1989-90) treated plots, respectively. The parasitism value by this parasite in control was found to be 16.67 and 31.43 per cent during 1989-90 and 1990-91, respectively. Similarly *B. lasus* parasited 41.18 per cent larvae in untreated plots during 1989-90. The larvae of rice skipper were attacked by *Apanteles baoris* Wilk and *Charops biocolor* Szepliget. The parasitism value for the former species was 25.00 (carbofuran 3 G) and 8.33 (phorate 10 G) per cent during 1989-90 and 1990-91, respectively, whereas in case of later it was 10.00 (acephate) to 11.11 (quinalphos 25 EC) per cent in sprayable formulations and 28.57 per cent in granular formulation (quinalphos 5 G) during 1989-90. The *C. bicolor* attacked 50 and 10.41 per cent larvae of rice skipper in control plots during 1989-90 and 1990-91, respectively.

Pupal parasitism in leaf folder by *Xanthopimpla flavolineata* Cameron was found as 11.76, 10.53 and 8.33 per cent in control plots during 1989-90, 1990-91 and 1991-92, respectively. *B. lasus* was also recorded as pupal parasite of leaf folder and rice

TABLE 2

Effect of insecticides on natural enemies of insect pests of paddy.

Sr. No.	Treatments	% Egg parasitism in		% Larval parasitism in								% Pupal parasitism in					
				LF				RS				LF RS					
		YSB 89-90 SP 1	LF 91-92 SP 2	89-90		90-91 SP 3	89-90		90-91		89-90 SP 7	90-91		91-92 SP 7	89-90 SP 4	90-91 SP 8	
				SP 3	SP 4		SP 5	SP 6	SP 5	SP 6		SP 7	SP 4				
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	
1.	Carbofuran 3 G 0.75 kg a.i./ha	0.00	0.00	10.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2.	Phorate 10 G kg a.i./ha.	0.00	0.00	0.00	0.00	8.33	0.00	0.00	8.33	0.00	0.00	8.57	4.28	0.00	0.00	0.00	
3.	Quinalphos 5 G 1.0 kg a.i./ha	0.00	0.00	0.00	0.00	0.00	0.00	28.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4.	Monocrotophos 36 w/w 0.5 kg a.i./ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5.	Chlorpyrifos 20 EC 0.5 kg a.i./ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6.	Quinalphos 25 EC 0.5 kg a.i./ha	0.00	0.00	0.00	0.00	4.65	0.00	11.11	0.00	0.00	0.00	4.87	2.43	0.00	0.00	0.00	
7.	Acephate 75 wp 0.5 kg a.i./ha	33.33	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8.	Control (check)	67.67	33.33	16.67	41.18	31.43	0.00	50.00	22.91	10.41	11.76	10.53	15.78	8.33	5.55	4.16	

YSB = Yellow Stem Borer

LF = Leaf Folder

RS = Rice Skipper.

SP 1 = *Telenomus* Sp.

SP 3 = *Apanteles* sp.

SP 5 = *A. baoris*

SP 7 = *X. flavolineata*

SP 2 = *T. chilonis*

SP 4 = *B. lasus*

SP 6 = *C. bicolor*

SP 8 = *Bracon* sp.

skipper causing 2.43 (quinalphos 25 EC) to 4.28 (phorate 10 G) per cent parasitism in leaf folder in insecticidal treated plots and 15.78 per cent in check. The pupae of rice skipper parasited by *Bracon* sp. attacking 4.16 per cent pupae in control plots. Overall results indicated that the percentage parasitism was relatively high in granular formulations of insecticides as compared to sprayable formulations. Maximum parasitism was noticed in plots without any insecticidal treatments.

The present study very clearly indicated that the granules of carbofuran, phorate and quinalphos were safer to larval and pupal parasitoids of leaf defoliators and predators of leaf and plant hoppers than spray

formulations of monocrotophos chlorpyrifos and quinalphos. This is in accordance to the earlier findings (DRR, 1992).

In general, granular insecticides exhibited better degree of safety to spiders, egg, larval and pupal parasites of paddy pests than other insecticides.

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Impact of Natural Biological Control in Rice Pest Management

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Several workers have studied the natural enemies of important insect pests and generated information on identification and tested the possibility of controlling rice pests. In recent times, there is a growing feeling that natural biological *in situ* itself, if effectively managed, can help in dispensing with the insecticidal application. The knowledge about the effect of natural biocontrol agents in managing rice pests is meagre. Hence, the present study was undertaken to demonstrate and quantify the impact of natural biological control in rice ecosystem.

A field trial was conducted during *kharif* 1994, at the Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat). The trial consisted of two treatments, (i) natural biocontrol plot (NBC) without any insecticide application throughout the crop season and (ii) need based protection (NBP) with insecticides based on periodical pest surveillance considering economic threshold level. The

seeds of susceptible variety GR-11 were sown on 29-7-94 and the seedlings were transplanted at 20 cm x 15 cm spacing on 28-8-94. The crop was fertilized with 100 kg N and 50 kg P_2O_5 per hectare.

The plot with a size of 2500 sq. metre under each treatment was divided into five equal sub-plots. Among the two plots (treatments), one plot (NBP) was treated with recommended insecticides, while the other plot (NBC) was kept untreated (check). The granular insecticides, carbofuran (Furadan) 3 G and phorate (Thimet) 10 G were used @ 25 and 10 kg/ha on 40 and 60 days after transplanting (DAT), respectively. A maxiture of phosphamidon (Dimecron) 85 SL and dichlorvos (Nuvan) 76 EC was sprayed each @0.5 kg a.i./ha on 75 DAT.

Based on the status of pest prevalence, attention was focussed mainly upon two major pests of this locality, i.e. white backed plant hopper (WBPH), *Sogatella furcifera* (Horv.) and leaf folder (LF), *Cnaphalocrocis medinalis* Guen. Pest population and damage level were monitored from the four predetermined fixed quadrates of 1 sq. metre in each sub-plot. Fifth sub-plot was kept for sampling purpose. Pest incidence was recorded three times in a season when activity of the

pests was at peak level i.e. in the months of October and November. For the purpose, number of WBPH present on 5 randomly selected hills from each quadrat was recorded. Similarly, leaf folder damage was assessed by counting total number of leaves and LF damaged leaves.

Population of natural biocontrol agents was estimated two times during the crop period. i.e. 85 and 90 DAT. For the purpose, 5 sampling points were randomly selected from each sampling plot. Thereafter, 5 hills were covered quickly at each sampling point with a large polythene bag avoiding escape of any flying insects. Then the hills were cut carefully under water level and lifted the plants covered with polythene

bag without any disturbance. A cotton squab soaked in dichlorvos was introduced into the bag to kill all the captured arthropods. The collected fauna were listed and identified based on earlier identified specimens.

The crop was harvested during second week of December. Grain yield was recorded from all the sub-plots per treatment except the plots kept for sampling purpose by excluding two border rows.

The data obtained were subjected to 'T' test analysis.

Data (Table 1) indicated that the number of WBPH ranged from 2.80 to 17.60 with an average of 7.02 hoppers/hill in NBP, the

TABLE 1

Incidence of WBPH and leaf folder in natural biological control trial.

Observation period	Sub plot No.	Av. number of WBPH/hill		% leaves damaged by LF.	
		Treated	Check	Treated	Check
1.	2.	3.	4.	5.	6.
October '94 I week	1	3.40	5.00	2.58	3.08
	2	4.80	4.60	3.68	4.76
	3	2.80	4.60	4.57	2.27
	4	4.00	4.00	6.11	2.07
October '94 IV week	1	9.60	16.60	11.11	11.39
	2	14.20	16.80	7.67	10.15
	3	13.80	15.60	11.52	11.21
	4	17.60	15.80	13.95	13.02
November '94 IV week	1	3.80	9.60	1.64	13.38
	2	2.80	8.80	3.40	11.38
	3	4.00	11.80	4.86	9.30
	4	3.40	9.00	2.55	9.52
Seasonal mean	—	7.02	10.22	6.14	8.46
'T' test		NS		NS	

NS = Not Significant.

corresponding figures in NBC were 4.40 to 16.80 and 10.22, respectively. Similarly, rice leaves damaged by LF were 6.14 and 8.46 per cent in treated and check plots, respectively. Though, the pest incidence was comparatively low in former treatment than the later, the differences were not enough to prove significant impact of need based chemical means. Anonymous (1994) from Jagdalpur, noted that the difference in LF damage was marginal between that of natural biocontrol plot and need based protection with insecticide treated plots. This is in close agreement with the present finding.

The coccinellids (mainly *Menochilus secmaculatus* Fab. *Coccinella septempunctata*

Lin. and *Coccinella arcuata* Fab) and staphylinids (*Paederus fuscipes* Curtis) were found active predators of hoppers in rice field. The population of coccinellids/lady bird beetles (LB) and staphylinids (ST) was significantly low in insecticidal treated plots in comparison to untreated plots (Table 2). This explains that toxic chemicals applied against crop pests had adverse effect on beneficial fauna. Suvaparp (1992) also opined that insecticides when applied are detrimental to both pest species and natural enemies.

About 6 species of predatory spiders (PS) were observed preying on *S. furcifera*. The species, *Tetragnatha fletcheri* Gravaly,

TABLE 2

Number of biocontrol agents in insecticide treated (T) and untreated (UT) plots.

Observation period	Sub plot No.	LB		ST		PS		PB	
		T	UT	T	UT	T	UT	T	UT
1.	2.	3.	4.	5	6.	7.	8.	9.	10.
85 DAT	1	6	18	0	9	6	8	0	4
	2	11	37	6	5	7	12	0	0
	3	32	31	6	6	9	6	0	2
	4	22	33	11	14	7	7	0	0
	5	17	8	9	2	16	5	0	1
90 DAT	1	14	39	11	9	10	12	6	10
	2	13	33	16	24	9	13	0	9
	3	12	48	16	13	10	16	9	0
	4	9	28	15	9	10	13	0	16
	5	9	20	12	16	9	7	0	20
Mean		15.0	29.5	10.2	10.7	9.4	9.9	1.5	6.2
Calculated Value	t'	4.522**		2.805*		NS		NS	

*Significant at 5%. NS = Not Significant

** Significant at 1%

Phiddipus sp., *Lycosa poonaensis* Tikader, *Thomisus projectus* Tikader, *Oxyopes ratanae* Tikader and *Argiope anasula* Thorell were most common in rice field. The population of predatory spiders was more or less the same in both the treatments. Anonymous (1994) found that the population of predatory spiders in rice var. 'Kranti' was abundant in both (insecticide treated and untreated) the plots and had no discernible impact on pest damage, support the above results, however, population of predatory ground beetles was high in NBC compared to that of NBP.

Presence of the same level of PS population in both the treatments under study may be due to less side effect of granular insecticides. According to Kiritani *et al.* (1972), spiders were less affected by applications of granular formulations than by the conventional treatments. Kim *et al.* (1984) recorded more than double population of spiders preying on plant

hoppers even with the use of 2 applications of carbofuran compared with the usual insecticide treatments. These reports are in conformity with the above finding.

The activity of pentatomid predatory bug (PB), *Andrellus spinidens* Fab. was most abundant in NBC plot than the NBP, but without statistical difference. The counts of larval and pupal parasites (those emerged out from sampling) of rice pests i.e. *Apanteles* sp., *Brachymeria lasus* (Walker), *Charops* sp., *Xanthopimpla* sp. and *Goniozus* sp.) were very few in thier numbers in both the treatments and hence not presented in table.

Need-based insecticide treated plots yielded 99.6 kg (25.94 q/ha) grain and 129.6 kg (33.75 q/ha) fodder yield per plot as against 51.5 kg grain and 87.25 kg fodder yield in natural biocontrol plot (Table 3). Despite increase in grain (93.4%) and fodder (48.6%) yield in case of NBP over NBC, the yield values in both the

TABLE 3
Grain and fodder yield (kg) recorded in insecticide treated and untreated plots (384 m²).

Sub-plot No.	Grain		Fodder	
	T	UT	T	UT
1	109.0	45.0	136.0	77.0
2	103.0	52.0	130.5	88.0
3	104.0	48.0	120.0	81.0
4	82.5	61.0	132.0	103.0
Mean	99.63	51.50	129.63	87.25
T' test	NS		NS	

NS = Not Significant

treatments were at par. Feijen (1977), based on the ecological studies of natural enemies of rice borers, concluded that there was no significant difference in yield between sprayed and unsprayed fields. This is in accordance with the present investigation.

From the above it can be concluded that satisfactory control of pests requires a combination of the use of natural enemies supplemented by the judicious use of insecticides. A rationalized application of insecticide fitting into the scheme of an IPM programme should be selected. This approach

needs a greater knowledge of the ecology of existing natural enemies in target areas and hence conservation of natural biocontrol agents in rice ecosystem is essential for minimising pest infestation and reducing the cost of insecticides.

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A New Record of Arthropod Predators in Groundnut at Anand (India)

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Groundnut is grown in large area during summer in Gujarat. It suffers from American bollworm, *Helicoverpa (Heliothis) armigera* Hubner, jassid, *Empoasca kerri* Pruthi, thrip, *Caliothrips indicus*, tobacco caterpillar, *Spodoptera litura* Fab., during April to May. While surveying the natural enemies of the above pests, the authors came across two species of Lygaeid predators, *Geocoris ochropterus* Fieber *G. jucundus* Fabr. hitherto not recorded from Gujarat. *G. ochropterus* abundantly seen than *G. jucundus* with population of the former about 25 adults/25 plants and of the latter 6 adults/25 plants. Both the predators were seen feeding on the nymphs and adults of Groundnut aphid, *Aphis craccivora* Koch., nymphs of *E. kerri* and on

the eggs of *H. armigera* and *S. exigua*. Presence of eggs, nymphs and adults in the crop indicated that their occurrence was not incidental. The predatory bugs were also found associated with crops like cotton, maize and mungbean during the same period. *G. ochropterus* and *G. jucundus* were earlier reported as predators of cotton jassids from Delhi (Subba Rao *et. al.*, 1965). Abundance of *G. ochropterus* was reported on groundnut and on an annual weed *Achyranthes aspera* from Madras where it was found to feed on *Caliothrips indicus*, *Ayyaria chaetophora*, and *Scirtothrips dorsalis*. (Kumar and Ananthakrishnan, 1985). Detailed studies on *G. ochropterus* are under way.

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Occurrence of a New Leaf Spot of Groundnut in Gujarat

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A severe leaf spot of groundnut (*Arachis hypogaea* L.) was observed at Umralla village of Junagadh taluka during survey of different diseases of crop in *kharif*, 1995. Whitish grey spots with brittle papery centre were observed on leaf lamina, petiole and stem of groundnut var. GAUG-10. Initially, the spots were small,

circular light brown in colour and measured 1-2 mm. These spots enlarged upto 8 mm and central portion was shredded giving shot hole appearance (Fig. 1). Several spots were coalesced and finally leaves were defoliated. Whitish mycelial strands and very small whitish sclerotial bodies were observed in necrotic area of the spots. These whitish sclerotia finally turned dark brown in colour.

The fungus was isolated on PDA medium and pathogenicity was proved. On the basis of morphological characters, the fungus was identified as *Sclerotium rolfsii* Sacc. Usually

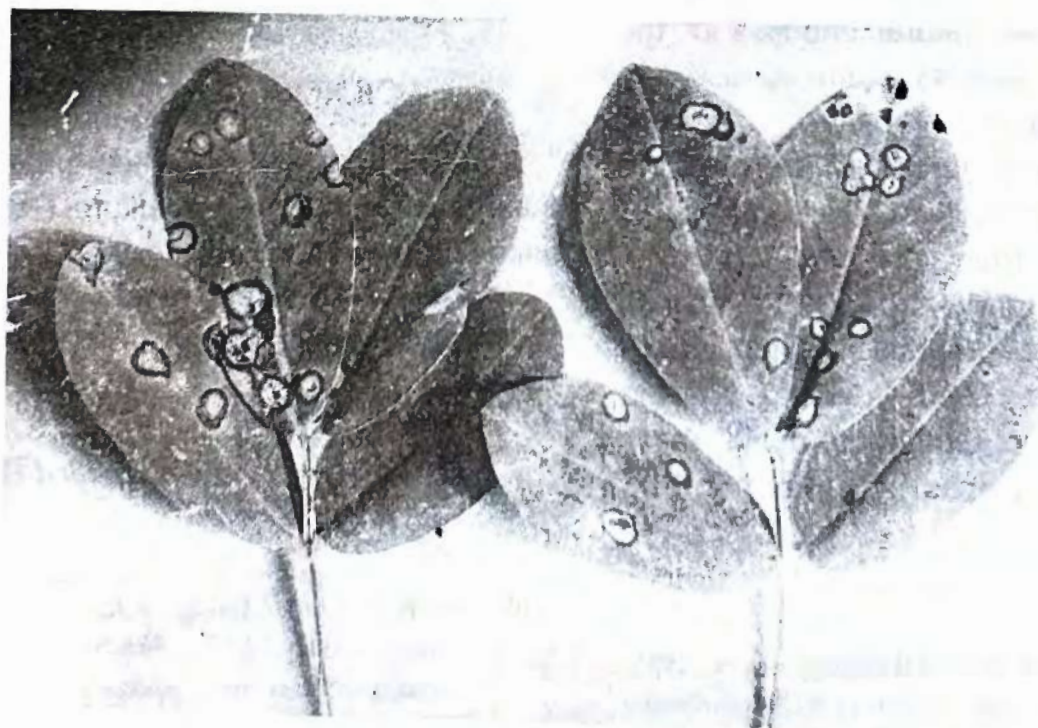


Fig. 1 : Leaf spot caused by *Sclerotium rolfsii* Sacc.

this pathogen attacks on stem and collar region of plant but probably the leaf spots occurred due to the infection resulted from sclerotia dispersed from soil by splashing rain.

The leaf spot of groundnut caused by *S. rolfsii* was reported earlier from Uttar Pradesh

and Madhya Pradesh (Chauhan and Singh, 1988 and Agrawal, 1991).

This is a first report of leaf spots of groundnut in Gujarat.

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First Record of Cytoplasmic-Genic Male Sterility System in Pigeonpea (*Cajanus cajan* (L.) Millsp.) Through Wide Hybridization

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Pigeonpea (*Cajanus Cajan* (L.) Millsp.) is an important pulse crop of Indian sub-continent. Genetic improvement of this crop upto eighties was largely confined to pure line selection from land races/germplasm and subsequently through hybridization followed by pedigree selection from inter-varietal crosses. Discovery of genetic male sterility (Reddy *et al.* 1997; Reddy *et al.* 1978; Wallis *et al.* 1981; Dundas *et al.* 1981; Dundas *et al.* 1982; Saxena *et al.* 1983 a, b) coupled with high degree of outcrossing (Howard *et al.* 1919; Williams 1977; Onim 1981; Bhatia *et al.* 1983; Brar *et al.* 1992) and availability of high degree of heterosis for seed yield (Soloman *et al.* 1957; Patel *et al.* 1991; Patel *et al.* 1992; Malik *et al.* 1995) opened vistas for exploiting heterosis through developing hybrids. In the recent years a number of pigeonpea hybrids (ICPH-8, PPH-4, COH-1, COH-5) have been released in India. However, commercialization of these hybrids is

constraint because of labour intensiveness of seed production and seed purity concerns arising from incomplete roguing of fertile plants from the population which are used as female parent. Pure breeding cytoplasmic-genic male sterile lines would effectively circumvent these constraints and revolutionize hybrid seed production.

This paper reports the development of first stable cytoplasmic genetic sterility system in pigeonpea through wide hybridization.

The work was initiated in 1993 by crossing pigeonpea with its wild relatives (*Cajanus scarabaeoides*) as female parent. The F_1 plant was partially fertile, erect, dwarf, small podded with 2-3 small seeds per pod. The F_2 population raised in isolation (monsoon 1994) arising from this cross comprised 95 plants. Fourteen plants in F_2 were found to be completely sterile. The F_2^s were further advanced in the following manner.

1. Completely male sterile F_2 plants were crossed to four pigeonpea genotypes viz., QMS-2 (Fertile), MS 288 (Fertile), ICPL-87 and GT-100.
2. The sterile plants were also sibmated to phenotypically similar F_2 fertile/partially fertile plants.

3. Selected fertile F_2 plants were advanced to F_3 generation by selfing.
4. Selected sterile F_2 plants were allowed to open pollinate and advanced to F_3 generation.

In all the crosses plant to plant mating was followed with the fertile counterparts maintained by selfing. Fortytwo BC_1F_2 progenies arising from 12 F_2^S and four pollinators raised during monsoon 1995 were examined for the extent of pollen sterility and other quantitative characters. All the 299 plants in 12 BC_1F_2 progenies, resulting from MS 288 (fertile) were found to be 100% sterile, while out of 11 BC_1F_2 progenies, arising from QMS-2 (fertile), four progenies comprising 30 plants were completely sterile. This ruled out the possibility of MS_1 and MS_2 genes to be responsible for the pollen sterility in the present material. Similarly, in ICPL-87 out of nine progenies, three were found to possess completely sterile plants, while in GT-100 out of ten progenies, four possessed completely sterile plants.

In BC_2F_2 (Summer 1996), 17 progenies of 288 at Sardar Krushinagar and 16 progenies at Navsari comprising 401 plants showed complete pollen sterility. In BC_3F_2 (Monsoon 1996) in 207 progenies comprising 2033 plants raised in isolation at Sardar Krushinagar alongwith ICPL-288 as pollinator,

all the plants showed complete pollen sterility. The crosses attempted in BC_1F_2 with F_3 (fully fertile) plants from the derived lines confirmed the restoration of fertility.

Earlier attempts at ICRISAT, Hyderabad (Reddy and Paris, 1981) using *Cajanus cajan* x *Atylosia* spp. (now merged with *Cajanus*) resulted in male sterility associated with varying degree of female sterility. Recently Ariyanayagam et al. (1993) and Ariyanayagam et al. (1995) reported high degree of male sterility at genome transfer stage IV in interspecific crosses of *Cajanus sericeus* x *Cajanus cajan*.

The results of the present study confirmed the existence of a stable cytoplasmic-genic male sterility system in pigeonpea with S-rr as A-line (GT-288A) and its maintainer with F-rr as B-line (GT-288B) alongwith restoration mechanism available in stable fertile lines derived from interspecific hybridization (*Cajanus scarabaeoides* x *Cajanus cajan*).

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