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Response of Forage Sorghum Hybrids to Nitrogen

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ABSTRACT

A field experiment was conducted with three forage sorghum hybrids (AS-9, GFSH-1 and X-988) and four nitrogen levels (0, 40, 80 and 120 kg N/ha) at Forage Research Farm, Anand (Gujarat). Forage Sorghum hybrids GFSH-1 and AS-9 produced significantly higher green forage yield than pioneer hybrid X-988 during 1988, 1989 as well as on pooled basis. Forage Sorghum hybrids GFSH-1 also gave significantly higher dry matter yield than X-988 during 1988, but they were at par on pooled basis. Increasing N application increased the forage production, but significant response of N was observed upto 40 kg N/ha for green forage and dry matter production. Crude protein yield and crude protein content increased markedly with the successive increase in nitrogen levels. From the economic point of view, maximum net ICBR was also obtained from the application of 40 kg N/ha.

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal fodder crop admirably adapted to varying soil and climatic conditions. Nitrogen fertilizer plays an important role in increasing forage production of sorghum with better nutritive value. The plant height of the hybrid GFSH-1 is ranged between 237 to 263 cm alongwith 10 to 15 number of dark and broad leaves, medium thickness of stem and compact earhead. Maturity period (50% flowering days) of this hybrid is 67-80 and 63-75 days for *kharif* and summer season, respectively. It can also be profitably cultivated in saline sodic soils as it performed well in *Bhal* area. It resists better to the incidence of pest and diseases. It is also suitable for single as well as multicut management. The maximum green forage yield produced by the hybrid GFSH-1 was found 65.95% and 82.07% higher than the pioneer hybrid X-988 in single cut and two cut, respectively. To study the forage production potential of promising hybrid AS-9 alongwith recently released forage sorghum hybrid GFSH-1 by the Gujarat Agricultural University in the year 1992 and Pioneer Hybrid X-988 under N fertilization, this experiment was conducted at Forage Research Farm, Gujarat Agricultural University, Anand.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 1989 and 1990 on alluvial soils, low in available nitrogen (258.7 and

TABLE 1

Forage yields and other ancillary characters of forage sorghum hybrids as affected by nitrogen levels.

Treatment	Yield in q/ha						Morphological characters							
	Green forage			Crude protein			Plant height (cm)		Leaf length (cm)		Leaf width (cm)		Leaf stem ratio	
	1989	1990	Pooled	1989	1990	Mean	1989	1990	1989	1990	1989	1990	1989	1990
Sorghum Hybrids														
AS-9	339 *(71.5)	500 (93.7)	420 (82.6)	5.36 **(7.34)	6.22 (6.56)	5.79 (6.95)	186.6	212.2	68.6	83.4	4.5	5.8	1.04	0.74
GFSH-1	375 (80.6)	488 (87.4)	432 (84.0)	5.26 (6.45)	6.20 (6.93)	5.73 (6.69)	216.1	215.4	71.2	82.1	5.0	6.1	0.75	0.54
Pioneer hyb. X-988	285 (67.5)	407 (92.8)	346 (80.2)	4.66 (7.01)	6.29 (6.70)	5.48 (6.86)	190.3	206.4	67.9	82.5	3.9	5.3	0.92	0.56
S.Em. ±	16 (3.5)	21 (4.2)	13 (5.0)	– (–)	– (–)	– (–)	–	–	–	–	–	–	–	–
C.D. (5 %)	46 (10.4)	60 (NS)	37 (NS)	– (–)	– (–)	– (–)	–	–	–	–	–	–	–	–
Nitrogen (kg/ha)														
0	215 (43.7)	318 (62.4)	266 (53.0)	2.81 (6.72)	3.52 (5.68)	3.17 (6.20)	183.9	190.5	69.2	81.7	4.4	5.3	1.11	1.06
40	330 (77.7)	531 (100.0)	431 (88.9)	4.96 (6.39)	6.71 (6.68)	5.84 (6.54)	199.7	213.0	67.0	80.7	4.5	5.2	0.93	0.65
80	394 (83.4)	494 (101.2)	444 (92.3)	6.07 (7.29)	6.73 (6.65)	6.40 (6.97)	203.1	218.4	68.8	84.0	4.5	6.3	0.88	0.42
120	394 (88.0)	519 (101.6)	456 (94.8)	6.53 (7.34)	7.98 (7.92)	7.26 (7.63)	203.9	224.3	71.9	84.3	4.5	6.2	0.68	0.32
S. Em ±	18 (4.1)	24 (4.8)	15 (3.2)	– (–)	– (–)	– (–)	–	–	–	–	–	–	–	–
C. D. (5 %)	53 (12.0)	70 (14.1)	43 (9.1)	– (–)	– (–)	– (–)	–	–	–	–	–	–	–	–

Figures in parenthesis indicates * dry matter yield and ** Crude protein concentration (%) respectively.

164.6 kg N/ha), and high in available phosphorus (60.9 and 58.6 kg P_2O_5/ha) and medium in potash (230.0 and 250.0 kg K_2O/ha). Twelve treatment combinations comprising of three forage sorghum genotypes (AS-9, GFSH-1 and X-988) and four levels of N (0, 40, 80 and 120 kg N/ha) were tested in factorial randomized block design with three replications. Half of the required N in the form of urea and entire quantity of P_2O_5 (Single superphosphate) @40 kg/ha were applied at the time of sowing, whereas remaining half of the N was top dressed one month after sowing. Other cultural practices were followed as per recommendations. The crop was harvested at 50 per cent flowering stage. Nitrogen content of plant was estimated by modified Kjeldahl's method and crude protein content was worked out on dry weight basis (Jackson, 1973).

RESULTS AND DISCUSSION

Effect of Genotypes

Forage sorghum hybrids GFSH-1 and AS-9 being at par with each other produced significantly higher green forage yield than Pioneer Hybrid X-988 during both the years as well as when results were pooled. Forage Sorghum GFSH-1 also produced significantly higher dry matter yield than X-988 during 1989. GFSH-1 hybrid also produced the highest dry matter yield on pooled basis, though the differences were to be not significant. Genotype AS-9 synthesized the highest crude protein yield on an average of two years. The higher forage production in GFSH-1 and AS-9 might be due to higher plant height, leaf length and leaf width due to their potentiality (Table-1). Patel (1985) and Raj and Patel (1989) reported that hybrid genotypes of forage sorghum gave higher forage yield than Pioneer hybrid X-988.

Effect of Nitrogen

During 1989, application of 80 and 120 kg N/ha produced equally higher green forage yield and found significantly superior than no application of N and 40 kg N/ha. Application of 40 kg N/ha was also found significantly superior than no application of N. The differences in green forage yield were found not significant for 40 kg, 80 kg and 120 kg N/ha and these levels produced significantly higher yield than no application of N during 1990 and on pooled basis. The signifacant response of nitrogen was observed upto 40 kg N/ha for dry matter yield. There were no significant differences among 40 kg, 80 kg and 120 kg N/ha for dry matter yield during both the years as well as on pooled basis and these levels outyielded the control. The higher forage production with nitrogen application might be due to low availability of initial nitrogen in the soil and hence addition of nitrogen increased plant height, leaf length and leaf width as compared to no application of N (Table 1). Patel (1985) and Patel *et al.* (1990) reported that green forage and dry matter yields of forage sorghum increased with nitrogen application probably due to increased vegetative growth of plants. The crude protein yield increased with increasing levels of nitrogen application. Application of 40 kg, 80 kg and 120 kg N/ha increased crude protein yield by 84.2, 101.9 and 129.0 per cent than no application of N on an average of two years. Increased crude protein content of sorghum by increasing N application was also reported by Desai and Deore (1980), Hussein *et al.* (1980) and Patel *et al.* (1990). Considering the economics of nitrogen fertilizer, application of 40 kg N/ha showed the maximum net ICBR of 1:22.13 followed by the application of 80 kg N/ha (1:11.48) (Table 2).

TABLE 2

Economics of forage sorghum hybrids as influenced by nitrogen levels.

Treatment	*Pooled green forage yield q/ha for 1989 & 1990*	*Total return Rs./ha*	*Additional return control Rs./ha*	*Additional cost Rs/ha (N-fertilizer)*	*Gross ICBR*	*Net ICBR*
Nitrogen (kg/ha)						
0	266	7980	—	—	—	—
40	431	12930	4950	214	1:23.13	1:22.13
80	444	13320	5340	428	1:12.48	1:11.48
120	456	13680	5700	642	1:8.89	1:7.89

Cost calculated on the basis of Rs. 30/- per q of green forage,
Rs. 5.35 per kg of nitrogen fertilizer from urea.
ICBR = Incremental Cost Benefit Ratio.

The results suggested that recently released forage sorghum hybrid GFSH-1 found promising than other getotypes and application of 40 kg N/ha was found optimum for getting higher forage production and net returns.

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Growth Response, Content and Uptake of Nutrients by Different Forage Sorghum Varieties (*Sorghum bicolor* (L.) Moench) as Influenced by Nitrogen and Zinc Fertilization

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ABSTRACT

Forage sorghum grown on sandy loam soil responded to nitrogen and zinc application. The response for green forage yield was more to Zn application (8 to 12%) than N (6.8 to 7.0%). However, in case of dry matter yield, the response to Zn application (11 to 13%) was almost equal to N application (9 to 11%). Among different fertilizer combinations, 80 kg N/ha alongwith 2.5 kg Zn/ha produced maximum forage yield. Genotype AS-15 gave significantly higher green forage as well as dry matter yields than M. P. Chari and X-988. It also removed the highest amount of all the nutrients. Application of nitrogen to forage sorghum significantly influenced uptake of N and P as well as content and uptake of Zn and Fe. Zinc application significantly increased the uptake of K and Zn by sorghum but depressed the per cent composition as well as uptake of N and P. It also depressed the content of Fe but increased the uptake of Fe at 2.5 kg Zn/ha application.

(Received on 19th Janu., 1988)

INTRODUCTION

Jower (*Sorghum bicolor* (L.) Moench) is known to respond extremely well to the application of 40 to 120 kg N/ha (Desai and Deore, 1980 and Patel *et al.*, 1990). It has also been reported that dry matter production of forage sorghum varieties increased due to application of zinc sulphate in the soil (Hegde and Relwani, 1974 and Patel and Patel, 1988). Dangarwala *et al.* (1983) reported Zn status of soil of Kheda district (Gujarat) as deficient in 14%, medium in 43% and sufficient in 43% of soils. Zinc deficiency not only adversely affects plant growth but also impairs health of milch animals indirectly. The use of nitrogen fertilizer alongwith Zn may play a significant role in increasing the availability of Zn (applied as well as native) by acidifying effect and thereby forage yield. In this context, a field experiment was conducted on different varieties of forage sorghum at Forage Research Farm, Gujarat Agricultural University, Anand.

MATERIALS AND METHODS

A field experiment with three different forage sorghum genotypes (M. P. Chari, Pioneer Hybrid X-988 and AS-15), three nitrogen levels (60, 80 and 100 kg N/ha as

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MATERIALS AND METHODS

A field experiment with three different forage sorghum genotypes (M. P. Chari, Pioneer Hybrid X-988 and AS-15), three nitrogen levels (60, 80 and 100 kg N/ha as

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urea) and three zinc levels (0, 2.5 and 5.0 kg Zn/ha as $ZnSO_4$) was conducted in a split-split plot design on sandy loam soil (alluvial type) of Forage Research Project Farm, GAU, Anand during *kharif* season. The soil was low in available N (149 kg/ha), sufficient in available phosphorus (60 kg P_2O_5/ha) and medium in potassium (152 kg K_2O/ha). The DTPA extractable Fe, Mn, Cu and Zn were 14.5, 22.3, 1.5 and 0.63 ppm, respectively. A basal dose of 30 kg P_2O_5/ha, 25 kg K_2O/ha, half of the total N and whole amount of zinc as per treatments were applied at the time of sowing and remaining N as top-dressing after one month of sowing.

The crop was harvested at 50% flowering and yield attributing characters and yields were recorded. The soil and plant samples from each plot after harvest were also analysed for their nutrient contents by following the standard procedures (Jackson, 1967).

RESULTS AND DISCUSSION

Green forage and dry matter yield

The results (Table 1) indicated that genotype AS-15 produced significantly higher green forage (31 and 21%) and dry matter (19 and 9%) yields than genotypes M. P. Chari and X-988. Genotypes AS-15 produced higher forage yield due to more plant height and stem

TABLE 1

Effect of nitrogen and zinc on vegetative growth and yield of forage sorghum.

Treatments	*Plant height (cm)*	*Stem thickness (mm)*	*Yield (q/ha)*	
			Green forage	*Dry matter*
Genotype				
M. P. Chari	289.3	6.54	402	128.6
X-988	252.5	7.88	437	79.6
AS-15	367.0	12.05	528	153.2
C. D. at 5%	14.8	0.63	30	12.9
Nitrogen (kg/ha)				
60	292.9	8.36	435	113.2
80	305.2	8.98	466	125.3
100	310.0	9.12	465	122.8
C. D at 5%	12.0	0.45	26	8.0
Zinc (kg/ha)				
0	296.1	8.65	428	111.8
2.5	311.5	9.23	478	123.7
5.0	300.4	8.88	460	125.8
C. D at 5%	9.8	0.45	19	6.8

thickness as compared to that of X-988 and M. P. Chari. The genotype X-988 produced less dry matter yield due to higher moisture percentage (82) as compared to M. P. Chari (68) and AS-16 (71).

Application of 80 and 100 kg N/ha resulted in significantly increased the plant height and thickness of stem and thereby green forage (7 and 6.8%) and dry matter (11 and 9%) yields over 60 kg N/ha (Table 1). This can be ascribed to low availability of N (149 kg/ha) in the soil. The results are in agreement with those reported at Anand Centre (Patel *et al.*, 1990).

Application of 2.5 and 5.0 kg Zn/ha significantly increased the green forage (12 and 8%) and dry matter (11 and 13%) yields over no zinc as the soil contained available zinc just at marginal level (0.63 ppm). The vegetative growth of sorghum plant increased significantly at 2.5 kg Zn/ha level as compared to no zinc and hence resulted in higher yields. However, further increase in zinc application (5.0 kg Zn/ha) slightly reduced the yield, it might be due to imbalance in nutrition. The results are in accordance with those reported by Hegde and Relwani (1974) and Patel and Patel (1988).

Content and uptake of nutrients

Genotype X-988 was found to have significantly higher content of nutrients N, P, K, Zn and Fe than M. P. Chari and AS-15 (Table 2) while genotype AS-15 removed the highest amount of all the nutrients (Table 3). This can be ascribed to highest dry matter yield recorded with genotype AS-15.

TABLE 2

Effect of nitrogen and zinc on nutrients content in forage sorghum.

Treatments	*N (%)*	*P (%)*	*K (%)*	*Fe (ppm)*	*Zn (ppm)*
Genotype					
M. P. Chari	0.66	0.17	1.5	164.19	18.92
X-988	1.05	0.24	2.9	340.35	25.20
AS-15	0.71	0.17	2.0	236.35	22.38
C. D. at 5%	0.09	0.04	0.54	11.39	2.31
Nitrogen (kg/ha)					
60	0.77	0.19	2.15	229.45	19.89
80	0.82	0.19	2.13	247.76	24.96
100	0.82	0.19	2.19	263.69	21.66
C. D. at 5%	NS	NS	NS	17.67	2.41
Zinc (kg/ha)					
0	0.90	0.21	2.15	265.67	21.34
2.5	0.76	0.18	2.16	244.82	23.51
5.0	0.75	0.18	2.16	230.41	21.66
C. D. at 5%	0.06	0.01	NS	13.61	NS

TABLE 3

Effect of nitrogen and zinc on uptake of nutrients by forage sorghum.

Treatments	*Uptake of nutrients*				
	(kg/ha)			*(g/ha)*	
	N	*P*	*K*	*Fe*	*Zn*
Genotype					
M. P. Chari	85.0	21.7	197.7	2103.1	243.2
X-988	83.2	18.7	230.9	2702.4	200.7
AS-15	105.0	25.4	225.5	3616.1	346.8
C. D. at 5%	14.0	5.5	72.4	418.8	13.7
Nitrogen (kg/ha)					
60	83.7	20.4	231.3	2439.6	222.5
80	96.8	22.6	254.1	2958.7	311.7
100	92.5	22.8	251.8	3023.2	256.7
C. D at 5%	7.5	1.8	NS	299.8	28.3
Zinc (kg/ha)					
0	95.7	22.3	229.7	2812.6	233.3
2.5	90.7	21.7	251.6	2865.2	288.0
5.0	86.8	21.7	255.7	2743.7	269.3
C D at 5%	NS	NS	17.7	NS	31.0

The data presented in Table 2 reveal that nitrogen content in sorghum increased with increasing the level of nitrogen. Similar results were also obtained by Patel *et al.* (1990). The differences in P and K contents did not reach to the level of significance due to the application of nitrogen.

There was significant influence of nitrogen application on micronutrient concentration in sorghum (Table 2). The highest content of Fe was recorded at 100 kg N/ha, while Zn content was highest at 80 kg N/ha. This can be ascribed to acidifying effect of nitrogen fertilizer and thereby increase in the availability of soil native iron and zinc as evident by data reported in Table 4 (Giordano *et al.*, 1966; Lncas and Davis, 1961). However, with further increase in nitrogen level i.e. 100 kg N/ha, Zinc content slightly decreased as compared to 80 kg N/ha. It can be attributed to possible retention of Zn in root as Zn-protein complex (Satinder and Shukla, 1980).

Application of 2.5 or 5.0 kg Zn/ha significantly decreased the nitrogen content of sorghum as compared to no zinc. This can be attributed to dillution effect of increased dry

TABLE 4

Effect of nitrogen and zinc application on availability of Zn and Fe (ppm) in post harvest soil.

Available nutrient	Nitrogen level (kg/ha)			Zinc level (kg/ha)			C. D. (5%) N or Zn levels
	60	80	100	0	2.5	5.0	
Zn	0.69	0.75	0.78	0.46	0.82	0.95	0.07
Fe	8.30	8.67	8.93	8.91	8.50	8.50	0.33

matter yield (Rajagopal and Mehta, 1971). The phosphorus content was reduced significantly from 0.21 to 0.18 per cent due to application of zinc. This can be ascribed to antagonism between phosphorus and zinc in plants (Boawn and Brown, 1968). The differences in content of K and Zn did not reach to the level of significance due to the application of zinc. The Fe content of sorghum reduced significantly with the increased rate of zinc. This might be due to antagonism between Zn and Fe. The results are in accordance with those observed by Rajagopal and Mehta (1971) in corn.

The removal of N and P by the crop were 16 and 11 per cent higher with the application of 80 kg N/ha than 60 kg N/ha (Table 3). This can be attributed to higher dry matter production at higher levels of nitrogen. The uptake of K was not altered significantly with applied N. Sorghum crop removed 21 and 24 per cent higher Fe and 40 and 15 per cent higher Zn, respectively at 80 and 100 kg N/ha as compared to 60 kg N/ha. The increase in Fe and Zn uptake were mainly because of additive effects of both increase in dry matter yield and content of Fe and Zn in forage sorghum with the increase in the rate of nitrogen application.

Application of 2.5 and 5.0 kg Zn/ha increase dry matter yield significantly over no zinc. However, the removal of N and P were not influenced significantly due to zinc application as the concentration of both the nutrients were reduced significantly (Table 2). The application of 2.5 or 5.0 kg Zn/ha significantlyincreased the potash uptake over no zinc as dry matter production was increased by zinc application. The increase in Zn uptake by the crop was mainly because of additive effects of both increase in dry matter yield as well as Zn content with the application of zinc (Rajagopal and Mehta, 1971). Uptake of Fe was not altered significantly by the application of zinc as Fe content was reduced significantly by the application of zinc.

The interaction effect of genotype and nitrogen on content and uptake of N and Zn by sorghum was significant (Table 5). Application of 100 kg N/ha to sorghum genotype X-988 showed significantly higher N content than other interactions except X - 988 x 80 kg N/ha.

TABLE 5

Interaction effect of genotype and nitrogen on content and uptake of nitrogen and zinc by forage sorghum.

Nitrogen level (kg/ha)	Nitrogen (%)			Zinc (ppm)		
	M. P. Chari	X-988	AS-15	M. P. Chari	X-988	AS-15
60	0.60 (71.9)	0.95 74.7	0.76 (104.4)	18.4 (220.6)	22.0 (173.1)	19.3 (273.7)
80	0.67 (87.0)	1.08 (88.1)	0.71 (115.6)	18.6 (241.9)	28.0 (228.4)	28.3 (464.6)
100	0.71 (963)	1.10 (86.6)	0.65 (94.7)	19.8 (267.1)	25.6 (200.3)	19.6 (302.4)
C D (5%)		0.11 (13.00)			4.20 (49.20)	

Figures in parentheses indicate uptake of N (kg/ha) and Zn (q/ha).

Application of 80 kg N/ha to sorghum genotype AS-15 removed maximum nitrogen than other interactions. Similarly same genotype recorded the maximum Zn content (28.3 ppm) and Zn uptake (464.6 q/ha) at 80 kg N/ha.

This study indicated that genotype AS-15 with the application of 80 kg N/ha alongwith 2.5 kg Zn/ha increased green forage, dry matter among the three varieties of forage sorghum which ultimately resulted in larger removals of nutrients from the soil.

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A Survey of Capacity, Intensity and Rate of Release Factors of Soil Phosphorus in Different Subgroups of Soils of South Gujarat

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ABSTRACT

The survey of capacity (Olsen's P), intensity (EPP) and rate of release (Organic C/organic P ratio) factors of phosphorus was carried out in different sub groups of soils of South Gujarat. The soils of all the sub groups were found low in intensity factor. The soils of vertic ustochrepts and Lithic ustochrepts were found to be medium in capacity and high in the rate of release characteristics of P. The soils of typic ustochrepts were found to be medium in capacity and rate of release factor while soils of Fluventic ustochrepts were found to be high in capacity and rate of release factor of P.

The values of all the sub group soils of South Gujarat were found to vary for the Olsen's available P from 0.61 to 57.17 ppm, for EPP from 6.40 to 7.80 and organic C/organic P ratio from 12.59 to 426.08 with the mean values of 9.19, 7.16 and 143.38, respectively. Olsen's P and EPP show a negative significant correlation (r = -0.22) in different sub groups soils of South Gujarat. There was no significant correlation between Olsen's P and organic C/organic P ratio in different sub group soils of South Gujarat.

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INTRODUCTION

Phosphorus has long been recognized as an essential constituent of all living cells and organisms. No tangible survey of the factors of phosphate availability has been carried out in different sub group soils of South Gujarat. Determination of capacity (Olsen's P), intensity (EPP) and rate of release parameters of different sub group soils of South Gujarat made it possible to define which of the sub group soils of South Gujarat have better supply of phosphorus.

MATERIALS AND METHODS

Ninety six surface soil samples from cultivators' fields of vertic ustochrepts, Typic ustochrepts, Lithic ustochrepts and Fluventic ustochrepts sub group soils of South Gujarat were collected. The soil sample were grouped in different sub groups as per 7th approximation (Smith, 1970). The collected soil samples were analysed for capacity, (Olsen's P), intensity (EPP) and rate of release (Org. C/Org. P ratio) factors. Olsen's P was determined by using 0.5 m $NaHCO_3$ (pH = 8.5) extractant as suggested by Olsen *et al.* (1954). White and Beckett

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(1964) procedure was followed for the determination of equilibrium phosphate potential (EPP). The organic carbon was determined as per Walkely and Black's Titration method as described by Jackson (1967). The organic phosphorus was determined as suggested by Legg and Black (1955).

RESULTS AND DISCUSSION

The variable trends of capacity, intensity and rate of release factors in various sub groups are well reflected in the present study.

(1) Vertic ustochrepts

A perusal of Table-1 shows that available phosphorus as determined by Olsen's extractant ranged between 0.61 and 57.17 ppm with an average of 9.84 ppm. The values for equilibrium phosphate potential ranged between 6.40 to 7.69 with an average value of 7.11. The minimum and maximum values for organic C/organic P ratio were recorded as 12.59 and 426.08, respectively having an average value of 146.22.

(2) Typic ustochrepts

The results of this sub group soils shows that Olsen's extractant phosphorus varied from 1.23 to 19.05 ppm with an average value of 6.68 ppm. The range of equilibrium phosphate potential was found to range from 6.69 to 7.80 with an average of 7.21. The minimum and maximum values for organic C/organic P ratio of this sub-group soils were 58.08 and 336.00, respectively having an average ratio of 159.12 (Table 1).

(3) Lithic ustochrepts

The results in Table-1 revealed that available phosphorus as determined by Olsen's method ranged between 1.23 to 49.18 ppm with an average value of 6.66 ppm. The lowest and highest values of equiilibrium phosphate potential were observed to be 7.07 to 7.79, respectively with a mean value of 7.34. The values for organic C/organic P ratio ranged from 29.83 to 333.65 witth an average value of 125.80.

(4) Fluventic ustochrepts

The values for Olsen's P varied from 14.75 to 17.82 ppm for equilibrium phosphate potential from 6.63 to 7.45 and of organic C/organic P ratio from 99.60 to 181.33. The mean values for all these characteristics taken in the same order were 16.59, 7.09 and 143.14, respectively (Table 1). The values of all the sub group soils of South Gujarat for the Olsen's available P varied from 0.61 to 57.17 ppm, for EPP from 6.40 to 7.80 and organic C/organic P ratio from 12.59 to 426.08. The mean values for all the characteristics taken in the same order were 9.19, 7.16 and 143.38 (Table 1).

In general, looking to the overall picture for the status of capacity factor, the availability of phosphorus was found to be in the following decreasing order; Fluventic ustochrepts > vertic ustochrepts > Typic ustochrepts > Lithic ustochrepts.

It was further observed that the Typic ustochtepts and Lithic ustochrepts sub-group soils could be rated more or less similar in respect to capacity factor (Table 1).

As far as the status of intensity factor is concerned, the availability of phosphorus was observed in the following decreasing sequence. Fluventic ustochrepts > Vertic ustochrepts > Typic ustochrepts > Lithic ustochrepts.

TABLE 1

Range and average values of Olsen's P equilibrium phosphate potential (EPP) and organic C/organic P ratios of different sub group soils of South Gujarat.

Sr. No.	*Soil sub-groups*	*Olsen's P (ppm)*		*EPP**		*Org. C/erg. P ratio*	
		Range	*Average*	*Range*	*Average*	*Range*	*Average*
1.	Vertic ustochrepts	0.61 — 57.17	9.84	6.40 — 7.69	7.11	12.59 — 426.08	146.22
2.	Typic ustochrepts	1.23 — 19.05	6.68	6.69 — 7.80	7.21	58.08 — 336.00	159.12
3.	Lithic ustochrepts	1.23 — 49.18	6.66	7.07 — 7.79	7.34	29.83 — 335.65	125.80
4	Fluventic ustochrepts	14.75 — 17.82	16.59	6.63 — 7.45	7.09	99.60 — 181.33	143.14
	General	0.61 — 57.17	9.19	6.40 — 7.80	7.16	12.59 — 426.08	143.38

Equilibrium Phosphate Potential

The Vertic ustochrepts and Fluventic ustochrepts sub group soils could be rated more or less similar in respect to intensity factor. The Fluventic ustochrepts and Vertic ustochrepts contained more Olsen's P and EPP as compared to Typic ustochrepts and Lithic ustochrepts because of difference in physiographic situation. The low equilibrium phosphate potential (intensity factor) indicated the higher availability of phosphorus and vice versa.

Considering the status of rate of release factor, the availability of phosphorus was found to be in the following decreasing order; Lithic ustochrepts > Fluventic ustochrepts > Vertic ustochrepts > Typic ustochrepts.

The low rate of release factors indicated high organic P mineralization. Vertic ustochrepts and Fluventic ustochrepts sub group soils could be rated more or less similar with each other in respect of mean value of rate of release factor (Table 1). Neptune *et al.* (1974) observed that with variation in the ratio of C, N, s to p for the Brazilian soil could be due to the presence of variable amounts of inositol phosphorus. The average value (123.8) of organic C/organic P ratio of Lithic ustochrepts sub group soils was the lowest among all the sub groups. This may be due to high organic P mineralization potential. Somani and Saxena (1971) reported that organic C/organic P ratio have been found to be narrow indicating a high organic P miheralization potential in soils of Rajasthan.

TABLE 2

Correlation coefficient values between Olsen's P, EPP and organic C/organic P ratios in different sub group soils of South Gujarat.

	*EPP**	*Organic C/organic P ratio*
Olsen's P	-0.220**	-0.067
EPP*	–	0.060

* Equilibrium phosphate potential.

** Significant at 5 per cent level.

The co-efficient of correlations were worked out for different parameters presented in Table 2 which indicated that Olsen's available phosphorus and equilibrium phosphate potential (EPP) has a negative significant correlation (r = -0.220*). It was further observed that no significant correlation was found between Olsen's P vs. organic C/organic P ratio (r = -0.067) and equilibrium phosphate potenti vs. organic C/organic P ratio (r = 0.060) in d ferent sub group soils of South Gujara Kanzaria (1974) observed significant correl tion between Morgan's P and organic C/organ P ratio, EPP and organic C/organic P ratio deep black soil, but no significant relation w observed between Morgan's P and EPP.

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Yield Stability and Soil Fertility in Sorghum-Wheat Sequence over Years

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ABSTRACT

An experiment conducted on sorghum-wheat sequence for six years showed the stable yield levels for both the crops and the soil fertility was maintained. The economical dose for sorghum and wheat was found to be $N_{80}P_{40}K_0$ and $N_{80}P_{40}K_{40}$ respectively, implying the possibility of reduction in recommended dose in both the crops.

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INTRODUCTION

Large quantities of fertilizers are continuously needed for sustaining higher yields in a crop sequence. Rational use of costly chemical fertilizers is strictly envisaged to fetch maximum crop yields from sequential cropping system without losing soil fertility.

Present investigation was attempted in order to pinpoint an optimum NPK dose for a given crop sequence viz., sorghum-wheat on Vertisol.

MATERIALS AND METHODS

A long term field experiment on sorghum-wheat crop sequence on Vertisol under A.I.C Agronomic Research Project, at Punjabrao Krishi Vidyapeeth, Akola (M.S.) was in progress. The data for a period of six years (1984-85 to 1989-90) is utilized in this paper. The experiment was laid out with 18 combinations consisting of three levels of N (40, 80 and 120 kg ha^{-1}), three levels of P (0, 40 and 80 kg P_2O_5 ha^{-1}) and two levels of K (0 and 40 kg K_2O ha^{-1}) fitted in $3^2 \times 2$ factorial partially confounded design with three blocks in a replication having an absolute control in each block. There were four replications. Selected treatments were picked up for drawing out broad conclusions.

The data for grain yields and fertility status of the soil (organic carbon content, available N, P, K) were recorded.

RESULTS AND DISCUSSION

Grain yield

The data pertaining to grain yield (Table 1) revealed that the mean cumulative yield (1984-85 to 1989-90) of sorghum was lower than the initial year where it was higher in wheat.

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TABLE 1

Mean cumulative yield (q ha^{-1}) and linear regression coefficients in sorghum-wheat crop sequence.

Treatment	*Initial yield level (84-85)*	*Mean cumulative yield (89-90)*	*Linear regression coefficient*	*Initial yield level (84-85)*	*Mean cumulative yield (89-90)*	*Linear regression coefficient*
0-0-0	5.09	4.90	0.0723	2.23	3.70	0.1909
80-0-0	23.23	16.29	-0.6117	03.91	8.06	0.3889
80-40-0	30.23	24.74	0.2566	14.83	15.33	0.1611
80-40-40	33.20	24.13	-0.5377	17.17	17.65	0.8340
120-0-0	15.90	13.68	0.2703	4.67	7.01	0.2324
120-80-0	34.71	27.92	0.0206	15.66	17.52	0.9411
120-80-40	37.49	30.45	-0.3117	18.81	19.17	0.8540
C. D. at 5%	8.77	5.59	0.81	3.57	2.79	0.36

The crop sequence, sorghum-wheat involves both cereal crop which are heavy feeders of nutrients. Further, there was continuous addition of only chemical fertilizers. Hence, the deterioration in subsequent yields might have been caused as organic matter was not applied during the course of investigation. There were seasonal fluctuations in yields.

Soni *et al.* (1988) observed very little scope of reducing or skipping any amount of nitrogen, phosphorus and potassium either for rice crop or to the wheat crop. Anonymous (1985) also reported decline in yield in sorghum-wheat sequence in three locations. They observed small improvement or stable yields in four locations in similar type of experimentation mentioned in this paper.

The data, further, revealed that 80 kg N ha^{-1} (80-0-0) was more productive than 120 kg N ha^{-1} (120-0-0) for the sequence. Application of NPK was favourable than NP application. Higher doses of NPK had resulted in producing comparatively higher yield in both the crops of the sequence.

Anonymous (1985) also reported that an optimum dose of NPK for all the seven locations was found to be lower than the recommended dose (120:80:40) for each crop in sorghum-wheat sequence.

Monetary returns for the sequence represented in Table 2 revealed that highest returns were received with $N_{120}P_{80}K_{40}$ combination in both the crops. However, highest cost benefit ratios (4.24 and 4.62) were observed with $N_{80}P_{40}K_0$ and $N_{80}P_{40}K_{40}$ combinations in sorghum and wheat respectively.

Cumulative effects

The data represented in Table 1, revealed that the cumulative effects of different treatment combinations were significant for sorghum-wheat sequence.

TABLE 2

Economics of sorghum-wheat crop sequence.

Treatments N- P_2O_5 - K_2O	*Mean cumulative yield*	*Response (q ha^{-1})*	*Value of produce (additional)*	*Cost of fertilizer*	*Net profit (Rs. ha^{-1})*	*C. B. ratio*	*Mean cumulative yield*	*Response (q ha^{-1})*	*Value of produce (additional)*	*Cost of fertilizer*	*Net profit (Rs. ha^{-1})*	*C. B. ratio*
			Sorghum						**Wheat**			
0-0-0	4.90	–	–	–	–	–	3.70	–	–	–	–	–
80-0-0	16.29	11.39	18.11	386	1425	3.69	8.06	4.36	1199	386	813	2.11
80-40-0	24.74	19.84	3155	602	2553	4.24	15.33	11.63	3198	602	2596	4.31
80-40-40	24.13	19.23	3058	683	2375	3.48	17.65	13.95	3836	683	3153	4.62
120-0-0	13.68	8.78	1396	578	818	1.42	7.01	3.31	910	578	332	0.57
120-80-0	27.92	23.02	3660	1010	2650	2.62	17.52	13.82	3801	1010	2791	2.76
120-80-40	30.45	25.55	4062	1091	2791	2.72	19.17	15.47	4254	1091	3163	2.90

Nutrient prices (Rs. kg^{-1})

N = 4.82

P = 5.40

K = 2.03

Crop prices (Rs. kg^{-1})

Sorghum - 1.59

Wheat - 2.75

TABLE 3

Average nutrient/response for six years (1984-85 to 1989-90).

Crops	Yield increase (q ha^{-1}) due to					Response grain (kg^{-1}) nutrient application				
	N		P		K	N		P_2O_5		K
	80	120	40	80	40	80	120	40	80	40
Sorghum	11.39	9.08	3.45	13.94	2.53	14	8	21	17	6
Wheat	4.36	3.31	7.27	10.51	1.65	5	3	18	13	4

Though the combinations $N_{120}P_{80}K_{40}$ resulted in highest grain yield in both the crops, the combination $N_{120}P_{80}K_0$ was comparatively economical as it saved 40 kg K_2O but still remained at par with $N_{120}P_{80}K_{40}$ in yield performance.

While considering the nutrient response over years, it was clear from the data in Table 3 that both the cereal crops gave more response to lower levels of N and P. Both the crops responded to potash application. It was prominently seen that sorghum was more responsive to fertilizers than wheat.

Evaluation for changes in yield

For evaluation of decline or increase in grain yield in sequence over years, linear regression coefficients were calculated. Highest positive and negative linear regression coefficients were recorded at $N_{120}P_0K_0$ and $N_{80}P_0K_0$ treatments respectively for sorghum. Negative coefficients were also observed in $N_{80}P_{40}K_{40}$ and $N_{120}P_{80}K_{40}$ combinations in sorghum. This variation might be due to favourable season for sorghum in 1989-90, where general yield levels were comparatively higher.

The values of linear regression coefficients were positive for wheat crop. The data revealed that the highest value (0.9411) was obtained for $N_{120}P_{80}K_0$ combination which was followed by $N_{120}P_{80}K_{40}$.

Fertility status of the soil

The fertility status of the soil before sowing of sorghum in 1984-85 and after harvest

TABLE 4

Changes in soil fertility.

Treatments N-P_2O_5-K_2O (kg ha^{-1})	*Available** O. C. (%)	*Available** N (kg ha^{-1})	*Available** (P_2O_5 (kg ha^{-1})	*Available** K_2O (kg ha^{-1})
0-0-0	0.35	310	36	316
80-0-0	0.49	351	38	349
80-40-0	0.47	339	37	327
80-40-0	0.49	367	38	330
120-0-0	0.47	307	31	313
120-80-0	0.44	358	41	360
120-80-40	0.45	314	39	349

* After harvest of rabi 1989-90.

Initial fertility status : Organic carbon 0.46%.
Available N P_2O_5 and K_2O (kg ha^{-1})
(125, 15 and 355 respectively)

of wheat in 1989-90 is shown in Table 4. Organic carbon content in the soil was slightly raised in most of the treatments. However, appreciable changes were not observed as organic matter was not incorporated through out the span of investigation. Available N content was found to increase with continuous addition of N to both the crops. There was also increase in control plots which indicated the release of N from parent materials.

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Distribution and Status of DTPA Extractable Micronutrient Cations in Some Soils of North and North West Agroclimatic Zones of Gujarat

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ABSTRACT

A survey work was carried-out by excavating 10 profiles (0-15, 16-30, 31-60, 61-90 and 91-120 cm) from North and North West agroclimatic zones of Gujarat. Similarly, for knowing the status of DTPA extractable micronutrients, 10 surface (0-15 cm) samples were collected from the periphery of 2 km of each profile location. Data revealed that the content of DTPA extractable Fe and Zn was higher in the surface layers as compared to lower layers. However, gradual decrease in Mn content was found along with the depth of soil. The Cu content was maximum in 16-30 cm layer and it was found to decrease with soil depth. Further, the per cent distribution of surface samples based on critical levels was of the order of 47.8, 18.33, 1.00 and 52.56 per cent in deficient range for Fe, Mn, Cu and Zn respectively.

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INTRODUCTION

Use of high analysis fertilizers and adoption of high yielding varieties in present day intensive agriculture has resulted in greater depletion of nutrients, particularly those of micronutrients. This situation become more acute in light textured and alkaline soils of Northern part of Gujarat, which are prone to micronutrients deficiencies. Not much information pertaining to vertical distribution and recent status of DTPA extractable micronutrients is available for this part of Gujarat. In order to generate some information on this aspect present survey was taken-up and the results are reported here in.

MATERIALS AND METHODS

For determining the vertical distribution of micronutrients cations (DTPA extractable) viz. Fe, Mn, Cu and Zn in soil, 10 profiles were exposed at Research Stations of GAU coming under North and North West agroclimatic zones of Gujarat. The locations of profiles were : (1) Sardar Krushinagar, (2) Deesa and (3) Madana of Banaskantha district, (4) Jagudan and (5) Vijapur of Mehsana district, (6) Talod and (7) Khedbrama of Sabarkantha district, (8) Dehgam of Ahmedbad district and (9) Bhachau and (10) Mundra of Kutch district. From each profile, 5 samples were taken at varying depths i.e. 0-15, 16-30, 31-60, 61-90 and 91-120 cm.

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TABLE 1

Content (µg/g) of Fe, Mn, Cu and Zn in soil profiles.

District Location	*Depth (cm)*									
	Fe					*Mn*				
	0-15	*16-30*	*31-60*	*61-90*	*91-120*	*0-15*	*16-30*	*31-60*	*61-90*	*91-120*
Banaskantha										
S. K. Nagar	3.86	4.32	4.10	3.98	3.56	5.32	5.73	4.15	4.61	4.72
Deesa	4.26	4.28	4.12	4.34	5.45	10.91	4.23	4.71	6.36	8.90
Madana	6.06	2.52	2.57	6.22	2.50	9.53	8.20	6.53	8.29	5.25
Mehsana										
Jagudan	3.04	2.84	2.77	3.15	2.94	4.98	6.15	6.49	6.78	5.01
Vijapur	3.77	3.64	4.50	4.96	4.98	7.90	7.38	8.54	9.99	11.51
Saharkantha										
Khedbrama	24.88	15.28	10.41	8.50	6.37	19.92	23.00	15.08	12.95	6.42
Talod	4.36	4.08	4.45	4.63	4.36	9.65	7.93	8.26	9.69	8.70
Ahmedabad										
Dehgam	9.15	12.29	0.10	7.19	5.30	12.96	22.86	27.50	15.86	12.71
Kutch										
Bhachau	6.36	3.10	4.09	4.02	4.20	9.96	3.09	4.15	3.62	2.71
Mundra	6.20	7.32	6.47	7.99	15.56	2.64	2.80	1.97	1.62	2.05
Mean	7.19	5.97	4.36	5.50	5.53	9.38	9.14	8.74	8.00	6.80
	Cu					Zn				
Banaskantha										
S. K. Nagar	0.490	0.528	0.530	0.522	0.470	0.450	0.234	0.156	0.154	0.236
Deesa	0.544	0.550	0.576	0.632	0.822	0.766	0.422	0.186	0.460	0.354
Madana	0.728	0.688	0.598	0.722	0.478	0.564	0.210	0.210	0.328	0.340

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Mehsana										
Jagudan	0.626	1.984	0.786	1.020	0.566	0.250	0.278	0.968	0.314	0.156
Vijapur	1.286	1.602	1.476	1.140	1.032	0.598	0.484	0.220	0.212	0.216
Sabarkantha										
Khedbrama	1.842	1.772	1.210	1.048	0.470	0.930	0.502	0.328	0.258	0.248
Talod	0.764	0.762	0.804	0.826	0.770	0.238	0.167	0.186	0.202	0.392
Ahmedabad										
Dehgam	1.498	1.894	1.950	1.544	1.030	0.554	0.258	0.364	0.232	0.294
Kutch										
Bhachau	0.838	0.526	0.512	0.500	0.364	0.618	0.222	0.462	0.506	0.306
Mundra	0.424	0.386	0.390	0.324	0.762	0.570	0.374	0.522	0.322	0.432
Mean	0.903	1.069	0.883	0.827	0.676	0.533	0.315	0.360	0.299	0.292

Similarly, for knowing the status of available (DTPA extractable) micronutrients cations in surface (0-15 cm) soils of North and North West agroclimatic zones of Gujarat, 10 surface soil samples were collected from 2 km periphery of each profile location except that of Sardar Krushinagar from where only 9 samples were collected.

After proper processing of soil samples, micronutrient cations were extracted using 0.005 M DTPA reagent (pH = 7.3) as described by Lindsay and Norvell (1978). Then estimation of Fe, Mn, Cu and Zn from filtrate was carried-out on Atomic Absorption Spectrophotometer (Model : Shimadzu, AA-646, Japan). The samples were then categorized in to deficient and sufficient groups based on critical values of respective elements.

RESULTS AND DISCUSSION

Vertical distribution of micronutrient cations

Data presented in table 1 and mean values depicted in fig. 1 reveal that Fe content was higher in surface strata and found to decrease up to 60 cm depth and thereafter tended to increase up to 120 cm. With increase in depth, Mn content was decreasing gradually. Similar decrease in Mn content with depth was also reported by Singh *et al.* (1990) for soils of Haryana. Higher content of Zn and Cu was registered at 0-15 and 16-30 cm depth, respectively. Both of these elements were almost uniformly distributed in the lower horizons of the profile. The pattern of Zn and Fe distribution (Fig. 1) in the profile clearly indicates that there is depletion of these two elements in sub-surface soil. The deficient layers of Fe and Zn

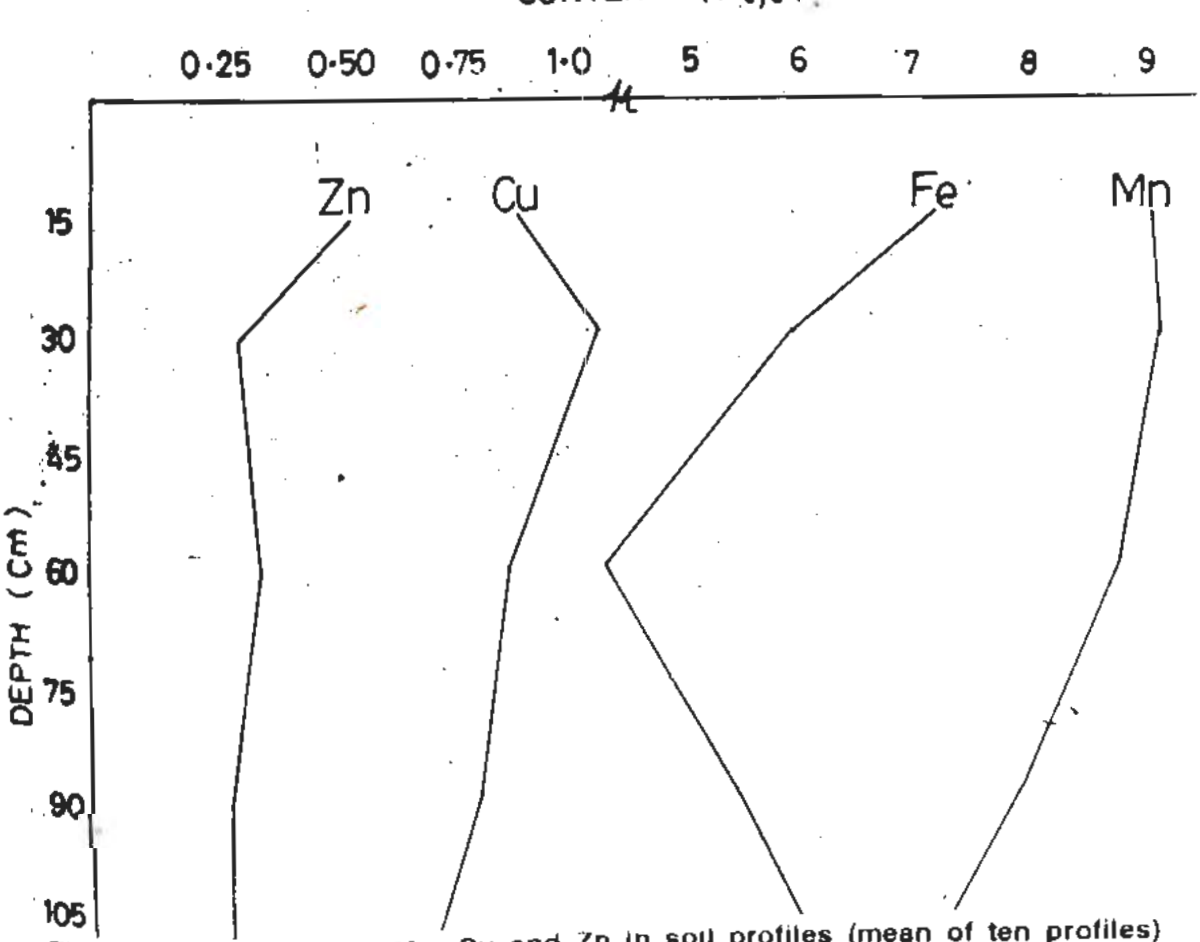

Fig. 1 - Content of Fe, Mn, Cu and Zn in soil profiles (mean of ten profiles)

are coinciding with the effective root zone of crops normally grown in this area. Deficiencies of these two elements are also reported from this area (Dangarwala *et al.* (1983) by earlier workers.

Status of micronutrient cations

Locationwise, mean and range values of DTPA extractable cations viz. Fe, Mn, Cu and Zn are reported in table 2. Relatively higher mean values of 19.02, 21.87 and 1.55 µg/g soil for Fe, Mn and Cu content, respectively, were recorded with Khedbrama area and in the case of Zn (1.395 µg/g soil) it was with Vijapur location. This might be due to hilly area and low cropping intensity in Khedbrama area. The use of $ZnSO_4$ in Vijapur area seems to be probable reason for higher Zn content. On the other hand, lower values of 3.77 for Fe at Deesa, for Mn 2.48 and Zn 0.328 at Mundra and for Cu 0.51 µg/g soil at Sardar Krushinagar were recorded. High cropping intensity in Deesa area

TABLE 2

Mean and range values (µg/g) of DTPA extractable Fe, Mn, Cu & Zn content in the soils.

District *Location*	*Fe*	*Mn*	*Cu*	*Zn*
Banaskantha				
Sardar Krushinagar	4.78 (2.86-10.84)	6.49 (3.86-8.44)	0.51 (0.38-0.84)	0.78 (0.28-1.69)
Deesa	3.77 (2.22-5.56)	5.90 (3.59-8.35)	0.86 (0.59-1.90)	1.04 (0.36-4.70)
Madana	5.40 (3.62-9.56)	10.69 (16.14-13.36)	0.56 (0.36-0.80)	0.38 (0.26-0.53)
Mehsana				
Jagudan	4.52 (3.35-8.26)	6.55 (4.84-8.63)	1.19 (0.48-3.27)	0.85 (0.23-2.92)
Vijapur	4.91 (3.42-8.41)	8.65 (6.73-11.49)	1.16 (0.65-2.10)	1.39 (0.47-3.30)
Sabarkantha				
Khedbrama	19.02 (9.30-29.62)	21.87 (11.28-41.88)	1.55 (1.32-1.90)	0.62 (0.42-0.93)
Talod	6.15 (4.24-9.16)	9.14 (4.56-17.07)	0.60 (0.31-0.77)	0.50 (0.19-0.93)
Ahmedabad				
Dehgam	6.29 (5.37-8.08)	17.36 (5.54-25.43)	1.03 (0.64-1.67)	0.41 (0.29-0.66)
Kutch				
Bhachau	5.64 (4.06-10.64)	8.11 (2.35-11.89)	1.00 (0.19-1.79)	0.62 (0.23-1.41)
Mundra	8.37 (5.63-15.37)	2.48 (1.60-3.76)	0.83 (0.32-1.21)	0.33 (0.17-0.60)
Mean	6.89 (2.22-29.62)	9.72 (1.61-41.88)	0.93 (0.19-3.27)	0.70 (0.17-4.70)

TABLE 3

Per cent distribution of soil samples in sufficient and deficient categories.

Location	Fe		Mn		Cu		Zn	
	S	D	S	D	S	D	S	D
S. K. nagar	22	78	67	33	100	0	44	56
Deesa	10	90	80	20	100	0	60	40
Madana	40	60	100	0	100	0	20	80
Jagudan	20	80	90	10	100	0	40	60
Vijapur	20	80	100	0	100	0	90	10
Khedbrama	100	0	100	0	100	0	70	30
Talod	80	20	90	10	100	0	40	60
Dehgam	100	0	100	0	100	0	30	70
Bhachau	30	70	90	10	90	10	70	30
Mundra	100	0	0	100	100	0	10	90
Mean	52.2	47.8	81.67	18.33	99	1	57.44	52.56

S = Sufficient and D = Deficient.

and proximity of Mundra to sea might have reduced the availability of Fe, Mn and Zn. An overall mean values of 6.89, 9.72, 0.93 and 0.704 µg/g soil, for Fe, Mn, Cu and Zn content, respectively, suggest that Fe and Zn content are nearer to their respective critical values, but Mn and Cu content are on sufficient side.

The soil samples were further categorized in to two groups viz. deficient and sufficient using the critical levels of 5 µg/g for Fe and Mn as suggested by Katyal and Sharma (1979) and 0.2 µg/g for Cu and 0.5 µg/g for Zn by Katyal and Randhawa (1983). Almost similar values were also reported by Dangarwala *et al.* (1983) for soils of Gujarat. The per cent deficient values of Fe range between 0 to 90 and that of Zn from 10 to 90 per cent. Similar extent of Zn deficiency was also reported by Singh and Sekhon (1991) and Dangarwala *et al.* (1983). However, this was not the case with Mn and Cu content excepting Mundra location (Table 3). From the overall mean per cent dificient values (Fig. 2) of 47.8 and 52.56 for fe and Zn,

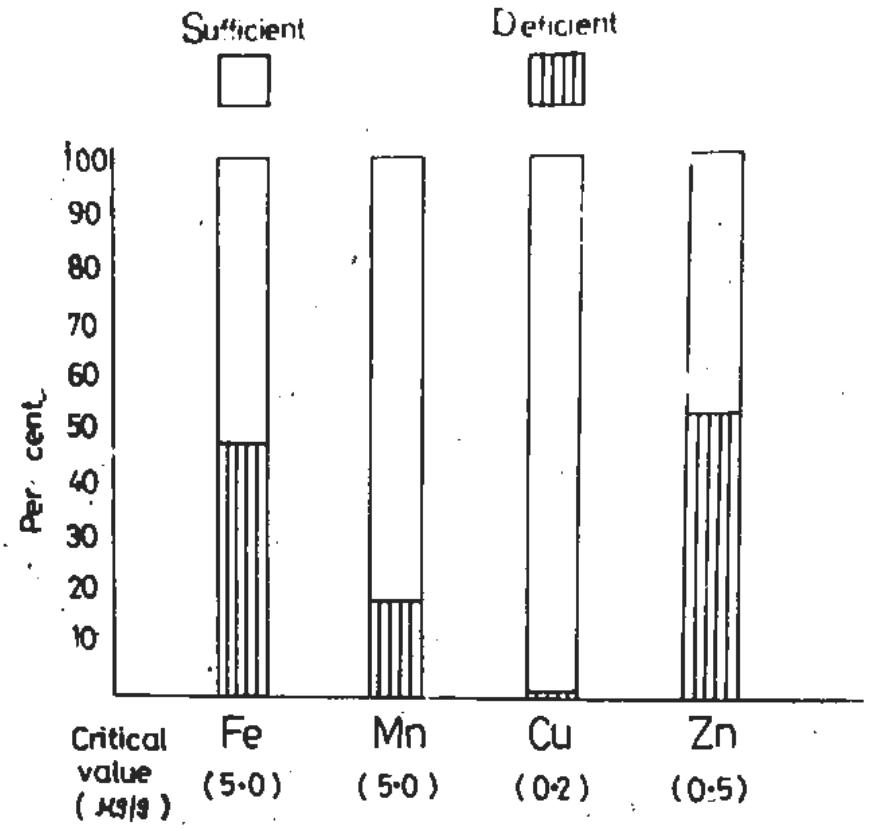

Fig. 2 : Distribution of surface samples into sufficient and deficient categories

respectively, it can be said that an application of Fe and Zn considering the soil type, its analysis and cropping pattern, may prove beneficial in this area. In the case of Mn, the per cent deficient samples (18.33) clearly indicate that some attention should be paid toward this element. So far as, Cu content is concern, there is no need to worry about it at present.

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Evaluation of Economic Insecticidal Control Schedules for the Pod Borer Complex in Pigeonpea*

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ABSTRACT

Investigations were carried out at Junagadh (Gujarat) for the estimation of avoidable losses due to pod borer complex in pigeonpea and for the evaluation of the insecticidal spray schedules for the control of pod borer pests. All the spray schedules were proved significantly superior over control. The over all percentage of pods damaged due to pod borer complex at harvest of the crop was minimum (2.25 per cent) in treatment which sprayed for four times i.e. first spray of fenvalerate 0.01% at bud initiation, second with monocrotophos 0.04% at 50 per cent flowering, third spray with fenvalerate 0.01% at 50 per cent pod setting and followed by monocrotophos 0.04% at 10 day after pod setting. It also gave 50.30 per cent highest yield (1245.83 kg/ha) over isolated control plot (829.17 kg/ha). The percentage of pods damaged was 5.15 per cent in the plot sprayed with endosulfan 0.07% at 50 per cent flowering and followed by monocrotophos 0.04% at 50 per cent pod setting. But, it was the next best in yield (1122 kg/ha) which gave 35.54 per cent higher yield over control. The percentage of avoidable loss in yield was lowest in the plot sprayed with fenvalerate 0.01% at bud initiation, monocrotophos 0.04% at 50 per cent flowering, fenvalerate 0.01% at 50 per cent pod setting and followed by monocrotophos 0.04% at 10 days after pod setting. This treatment was followed by plot sprayed with monocrotophos 0.04% at bud initiation, endosulfan 0.07% at 50 per cent flowering and 50 per cent pod setting and monocrotophos 0.04% at 10 days after pod setting (4.25 per cent) and treatment sprayed for two times i.e. spray with endosulfan 0.07% at 50 per cent flowering and monocrotophos 0.04% at 50 per cent pod setting (9.95 per cent). Whereas in isolated control loss was 33.47 per cent. The highest NICBR (1:4.30) was observed in treatment sprayed at 50 per cent flowering with endosulfan 0.07 per cent and second spray at 50 per cent pod setting with monocrotophos 0.04 per cent. The next highest NICBR (1:3.67) was obtained in treatment sprayed with monocrotophos 0.04 per cent at 50 per cent flowering.

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INTRODUCTION

The efforts for increasing production of pigeonpea are greatly hampered by number of pod borer pests, which severely damaged to flowers and pods of the crop. Amongst the various pod borer pests, gram pod borer, *Heliothis armigera* (HUB), plume moth, *Exelastis atomosa* (Wlam), blue butterfly, *Euchrysops cnejus* (Fab.), and the podfly, *Melanagremyza obtusa* (Malloch) cause extensive damage to the crop year-after-year. Considering the behaviour of pod borer pests in the field, a strategy for effective and

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economical control of pod borer complex was formulated to restrict the insecticidal application in pigeonpea to realise its maximum yield with losses insecticidal input.

MATERIALS AND METHODS

Field experiments were conducted at Junagadh (Gujarat) for two years (1984-85 and 1985-86) on pigeonpea BDN-2. The crop was sown at a distance of 75 x 10 cm in first week of July in both the years. All the recommended agronomical practices were followed for crop maintenance. The experiments were conducted in randomized block design with four replications. The gross and net size of each plot was kept 4.5 x 5.0 m (6 lines/plot) and 3.0 x 4.0 m (4 lines/plot), respectively. The most commonly recommended insecticides monocrotophos 0.04 per cent (500 ml/ha/spray) endosulphan 0.07 per cent (1 lit/ha/spray) and fenvalerate 0.01 per cent (250 ml/ha/spray) were tested. The respective spraying of insecticides for 1st, 2nd, 3rd and 4th was done at bud initiation, 50 per cent flowering, 50 per cent pod setting and 10 days after pod setting stage of the crop, respectively. Observations in pigeonpea pods damaged by the pod borers were recorded from five randomly selected plants from each plot at the time of harvest. Percentage pod damage was worked out and subjected to angular transformation, for statistical pooled analysis. The treatment-wise yield was also recorded separately for two years and pooled analysis was carried out. The losses due to pest in various treatment were calculated by using a formula of Pradhan (1969) and Poul (1976).

$$\% \text{ loss due to pest.} = \frac{\text{Yield in treatment which gave the highest yield} - \text{Yield in any other treatment of no treatment}}{\text{Yield in treatment, which give the highest yield}} \times 100$$

The economics and net incremental cost benefit ratio (NICBR) of insecticidal treatments were also worked-out and conclusion was drawn.

RESULTS AND DISCUSSION

Pod borer incidence

From the results (Table 1) of two years on overall mean per cent pods damaged by pod borer complex, it is evident that all the insecticidal treatments were found significantly superior over control and isolated control. Treatment sprayed at bud initiation with fenvalerate 0.01 per cent, second spray at 50 per cent flowering with monocrotophos 0.04 per cent, third spray at 50 per cent pod setting with fenvalerate 0.01 per cent and fourth spray at 10 days after pod setting with monocrotophos 0.04 per cent and treatment sprayed at bud initiation with monocrotophos 0.04 per cent, second and third sprayed at 50 per cent flowering and 50 per cent pod setting with endosulfan 0.07 per cent and fourth sprayed at 10 days after pod setting with monocrotophos 0.04 per cent were found the best in all insecticidal treatments and they followed by treatment sprayed at 50 per cent flowering with monocrotophos 0.04 per cent and second sprayed at 50 per cent pod

TABLE 1

Effect of insecticidal sprayed schedules on per cent pods damaged, grain yield and avoidable losses due to pod borer complex at harvest.

Treatment No.	Insecticides	Spray at growth stages	Per cent pod damaged due to pod borer (pooled mean)	Grain yield in kg/ha (pooled mean)	Percentage increased in yield over isolated control)	Percentage avoidable loss in grain yield
T1	Monocrotophos	50% flowering	18.91 (10.08)	960.00	15.80	22.85
T2	Endosulphan	50% flowering	13.12	1121.67	35.34	9.95
	Monocrotophos	50% pod setting	(05.15)			
T3	Monocrotophos	bud initiation	19.52	1009.17	21.71	19.02
	Endosulphan	50% flowering	(10.10)			
	Monocrotophos	50% pod initiation				
T4	Monocrotophos	bud initiation	11.33	1192.50	43.90	4.25
	Endosulphan	50% flowering	(03.86)			
	Endosulphan	50% pod setting				
	Monocrotophos	10 day after pod setting				
T5	Fenvalerate	50% flowering	18.54 (10.11)	942.50	13.75	24.31
T6	Fenvalerate	50% flowering	14.45	1054.17	27.14	15.41
	Monocrotophos	50% pod setting	(06.21)			
T7	Monocrotophos	bud initiation	16.75	1067.50	28.82	14.29
	Fenvalerate	50% flowering	(08.29)			
	Monocrotophos	50% pod setting				
T8	Fenvalerate	bud initiation	8.65	1245.83	50.30	00.00
	Monocrotophos	50% flowering	(02.25)			
	Fenvalerate	50% pod setting				
	Monocrotophos	10 days after pod setting				
T9	Control		25.16 (18.06)	836.67	00.70	32.83
T10	Isolated	(pesticide free area)	25.52 (18.55)	829.17	00.00	33.47
	S.Em.		1.05	41.67		
	C.D. at 5%		2.96	116.67		
	C. V. %		17.35	11.33		

Figures in paranthesis are retransformed values.

setting with endosulfan 0.07 per cent, and treatment sprayed with fenvalerate 0.01 per cent at 50 per cent flowering and second sprayed with monocrotophos 0.04 per cent at 50 per cent pod setting. However, treatment sprayed at 50 per cent flowering with monocrotophos 0.04 per cent and second sprayed at 50 per cent pod settihg with endosulfan 0.07 per cent was significantly equally effective with the treatment sprayed for four times i.e., first spray with monocrotophos 0.04%, second with endosulfan 0.07%, third with endosulfan and fourth with monocrotophos 0.04%. The over all per cent damage was 5.12, 3.86 and 2.25 per cent in insecticidal treatments T2 (first sprayed at 50 per cent flowering with endosulfan and second sprayed at 50 per cent pod setting with monocrotophos), T4 (first sprayed with monocrotophos at bud initiation, second and third sprayed with endosulfan at 50 per cent flowering and 50 per cent pod setting, respectively and fourth sprayed with monocrotophos at 10 days after pod setting), and T8 (first spray with fenvalerate, second monocrotophos, third fenvalerate and fourth sprayed with monocrotophos), respectively. While in control and isolated control plots per cent pod damaged were recorded 18.06 and 18.55 per cent, respectively. Results also clearly indicated that one spray of endosulfan or fenvalerate was superior to control plot but it was not equally effective to protect with two spray or more present studies confirm the finding of Srivastava (1980), Deware and Dhanarkar (1981), Talati *et al.* (1983) and Babu *et al.* (1984).

Grain yield

Results also revealed that all the insecticidal treatment were gave significantly better yield than the control. The highest grain yield (1245.830 kg/ha) was obtained in the treatment sprayed for four times i.e., 1. Fenvalerate, 2. Monocrotophos, 3. Fenvalerate, 4. Monocrotophos which was significantly better over all the treatments except treatment sprayed for two times i.e., endosulfan and monocrotophos and treatment sprayed for four times i.e., 1. monocrotophos, 2. endosulfan. 3. endosulfan, and 4. monocrotophos. Treatments T2 and T4 gave 1121.670 and 1192.500 kg/ha yield, respectively. Whereas, the plot gave low yield which have sprayed only T5 one time at 50 per cent flowering.

Avoidable losses

It is clear from the results that in all the treatments, yield was increased from 13.75 to 50.30 per cent over isolated control plots. Treatment T2 (first sprayed with endosulfan and second monocrotophos) was the next best with 35.54 per cent higher yield over isolated control polt. Whereas, in treatment sprayed with monocrotophos and treatment sprayed with fenvalerate, the per cent increased in yield over control was only 15.80 and 13.75 per cent, respectively. Thus it is cleared from the results that in all the treatments a loss due to pod borer complex in yield was 4.25 to 33.47 per cent over maximum yield. The percentage of avoidable loss in yield was lowest in treatment T8 (sprayed for four times i.e., fenvalerate, 2. monocrotophos, 3. fenvalerate and monocrotophos 4.25 per cent) followed by T4 (sprayed for four times i.e., first monocrotophos, second and third edosulfan and fourth monocrotophos), 9.95 per cent. Whereas, in control and isolated control plots. the avoidable losses was 32.83 and 33.47 per cent, respectively.

TABLE 2

Economics of insecticidal spray schedules tried for control of pod borer complex in pigeonpea.

Treatment No.	Insecticides	Spray at growth stages	No. of spray	Total cost of treatment application	Gross realisation (Rs/ha)	Net realisation over isolated control (Rs/ha)	Net profit (Rs/ha)	NICBR
T1	Monocrotophos 50%	flowering	1	112.00	3840	524	412.0	1:3.67
T2	Endosulphan 50% Monocrotophos 50%	flowering pod setting	2	221.00	4488	1172	951.0	1:4.30
T3	Monocrotophos Endosulphan 50% Monocrotophos 50%	bud initiation flowering pod initiation	3	333.00	4836	728	387.0	1:1.16
T4	Monocrotophos Endosulphan 50% Endosulphan 50% Monocrotophos 10 day after pod setting	bud initiation flowering pod setting	4	442.00	4772	1456	1014.7	1:2.29
T5	Fenvalerate	50% flowering	1	189.50	3772	456	346.5	1:3.16
T6	Fenvalerate 50% Monocrotophos 50%	flowering pod setting	2	221.50	4216	900	678.5	1:3.06
T7	Monocrotophos Fenvalerate 50% Monocrotophos 50%	bud initiation flowering pod setting	3	333.50	4272	956	622.5	1:1.86
T8	Fenvalerate Monocrotophos 50% Fenvalerate 50% Monocrotophos 10 day after setting	bud initiation flowering pod setting	4	443.00	4984	1668	1225.0	1:2.76
T9	Control	—	—	—	3348	32	—	—
T10	Isolated	(Pesticide free area)	—	—	3316	—	—	—

1) PRICE of seeds = 4 Rs/kg

2) LABOUR charges = 22 Rs/ha/spray

3) PRICE of insecticides = Endosulphan 35 EC = 87 Rs/litre
= Monocrotophos 36 EC = 180 Rs/litre
= Fenvalerate 20 EC = 350 Rs/litre

Economics

Economics of the insecticidal sprayed schedules applied during 1984 and 1985 are presented in Table-2. The data revealed that the net realization was maximum in case of treatment sprayed for four times i.e., 1. fenvalerate, 2. monocrotophos, 3. fevalerate and 4. monocrotophos (1668 Rs/ha). Similarly, treatment sprayed four times with the insecticides namely monocrotophos, endosulfan, endosulfan and monocrotophos was get 1456 Rs/ha net realization 1172 Rs/ha was obtained by treatment sprayed two times namely endosulfan and monocrotophos which was protected only two times. Thus looking to the Net Incremental Benefit Ratio (NICBR) the highest NICBR was recorded in treatment sprayed two times with insecticides namely endosulfan and monocrotophos (1:4.30) followed by treatment sprayed with monocrotophos (1:3.67) and treatment sprayed with fenvalerate (1:3.16). The insecticidal treatment sprayed three times with insecticides namely monocrotophos, endosulfan and monocrotophos gave the lowest NICBR. Therefore, insecticidal spray schedules as per the treatment sprayed three times with monocrotophos, endosulfan and monocrotophos and treatment sprayed three times with fenvalerate, monocrotophos and fenvalerate were not found more economical as they gave minimum economical returns. Thus it can be inferred from these results that the protection of pigeonpea variety BDN-2 at 50 per flowering with endosulfan 0.07 per cent and at 50 per cent pod setting stage with monocrotophos 0.04 per cent are essential to get maximum return with minimum cost.

These results are similar with the findings of Talati *et al.* (1983). They have also revealed that one spraying of endosulfan 0.07 per cent and second with monocrotophos 0.04 per cent gave economical return of the pigeonpea variety T-15-15.

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Effect of Weather Parameters on Brinjal Jassid, *Amrasca biguttula biguttula* Ishida

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ABSTRACT

Jassid, *Amrasca biguttula biguttula* Ishida, an important regularly occurring insect-pest of brinjal in Gujarat is found throughout the year. Among the various weather parameters studied to know their effect on population build up of this pest minimum temperature (r = -0.56), average temperature (r = -0.41) and vapour pressure (r = -0.64) showed significant negative association, whereas sunshine hours (r = 0.45) had positive association. However, only vapour pressure contributed 41 per cent variation in jassid population.

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INTRODUCTION

The life cycle, severity and threshold population of insect depend upon the prevalence of weather conditions. In semi arid tropics, various generations of jassid *Amrasca biguttula biguttula* Ishida overlap each other and all stages of jassid could be seen throughout the year. The information regarding effect of weather parameters on the population build up of insect pest is very useful in predicting the pest outbreak. Varma (1975), Balasubramanian *et al.* (1981) and Dubey and Ballal (1991) have studied such relationship for *Myzus persicae Scirpophaga incertulas* and *Aproaerema modicella*, respectively but no information is available for jassid, *A. biguttula buguttula*. Hence study was carried out on the seasonal incidence of *A. biguttula biguttula* infesting brinjal at the Gujarat Agricultural University, Anand during 1983 to 1985.

MATERIALS AND METHODS

To make the brinjal crop available throughout the year, brinjal 'Doli 5' was raised at 90 cm x 90 cm spacing at every two months interval in 0.04 hectare area. The agronomic practices in vague on the farm were followed. The jassid population was recorded by counting the number of nymphs on five leaves at different height of each of the twenty five plants selected at random at weekly interval after one month of transplanting of each crop to removal of the crop.

The meteorological parameters were monitored daily in the Agrometeorologi-

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cal observatory which was about 100 m away from experimental site. The cause and effect analysis and step wise regression analysis were carried out for determining the contribution of weather parameters having significant effect on build up of jassid population.

RESULTS AND DISCUSSION

The three years study on effect of weather parameters on population buildup of jassid, *A. biguttula biguttula* (Fig. 1) revealed activity of jassid throughout the year. However, the maximum jassid population per leaf was observed in the range of 1.16 to 2.81 during the 10th and 11th standard week (2nd and 3rd week of March), whereas minimum population ranged from 0.02 to 0.05 jassid per leaf during the 24th and 35th standard week (3rd week of June and 1st week of September). Thereafter population steadily increased to 2 or 3 jassids per leaf from the 38th standard week (3rd week of September). This increasing trend of jassid population coincided with the decrease in vapour pressure from 22 mm of Hg to 10 mm of Hg and minimum temperature from 20°C to 8°C. It indicated that these two weather parameters played important role in the building up of the jassid population. The influence of maximum temperature was not found, however increase in sunshine hours increased the jassid population.

TABLE 1

Correlation co-efficient between jassid population and weather parameters.

Year	Temperature °C		Vapour pressure	Sunshine
	Min	Av	mm of Hg	hours
1983	-0.63	-0.50	-0.66	0.43
1984	-0.64	-0.47	-0.75	0.53
1985	-0.61	-0.45	-0.70	0.49
Pooled	-0.56	-0.41	-0.64	0.45

The rainfall occuring during July to September might be responsible for low population build up of jassid during 26th to 35th standard week.

The results of correlations co-efficient between weather parameters and jassid population (Table 1) revealed significant negative association between jassid population and weather variables viz., minimum temperature (r = -0.56), average temperature (r = -0.41) and vapour pressure (r = -0.64) had positive association with sunshine hours (r = 0.45).

To quantify the cause and effect analysis of weather parameters and jassid population, path co-efficient analysis was performed. The results (Table 2) revealed negative significant association of jassid with minimum temperature, which had negative low direct effect and was balanced out by its indirect positive effect through average temperature. The minimum temperature had maximum but negative indirect effect through vapour pressure. The average temperature having negative association with jassid population showed positive direct effect. The direct effect of average temperature was nullified by

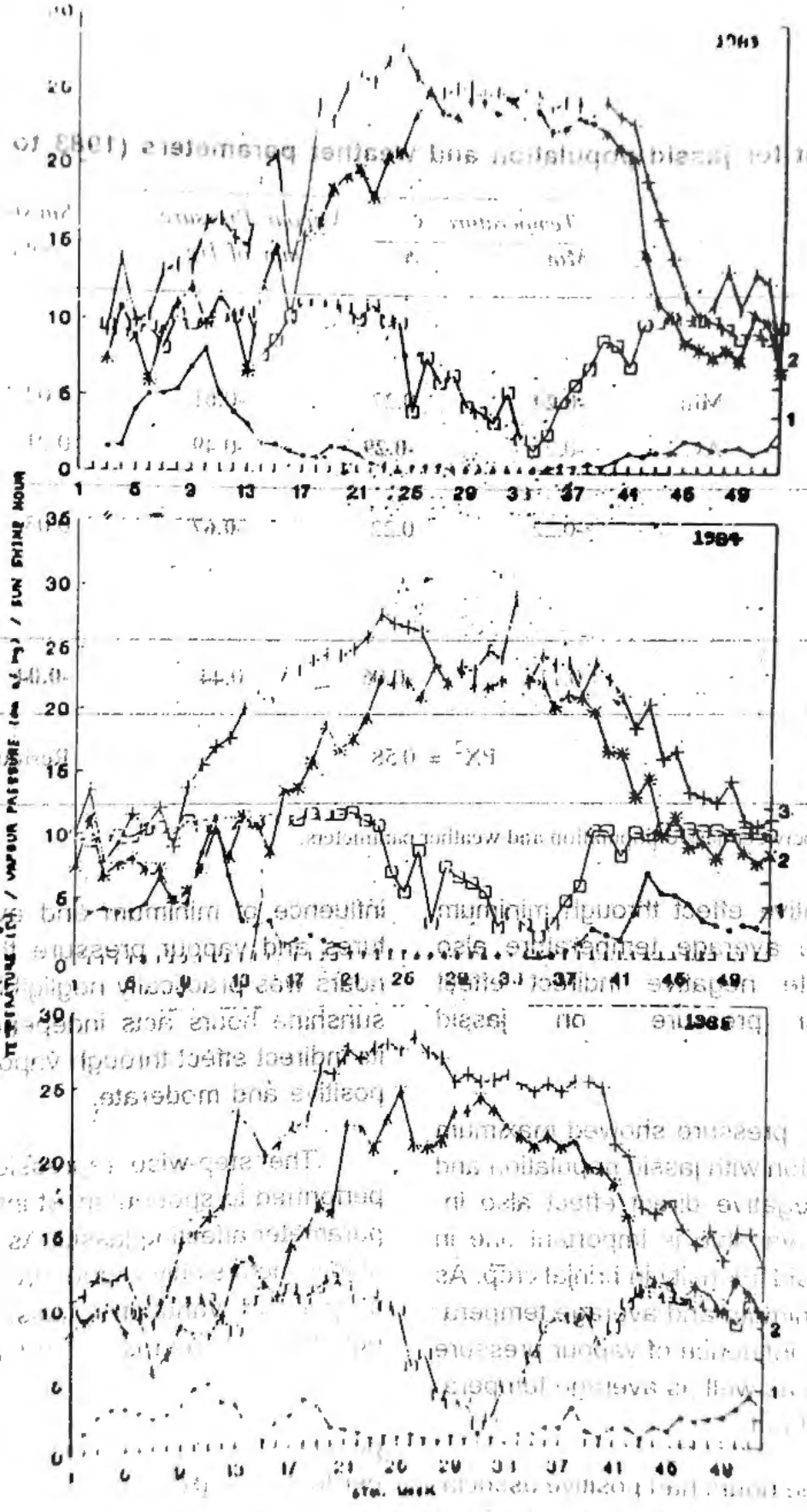

Fig. 1 : effect of weather parameters on jassid population

TABLE 2

Path co-efficient for jassid population and weather parameters (1983 to 1985 pooled).

Weather parameters		*Temperature ℃*		*Vapour Pressure mm of Hg*	*Sunshine hours*	*r**
		Min	*Av*			
Temperature C						
	Min.	**-0.24**	0.27	-0.61	0.02	-0.56
	Av.	-0.22	**-0.29**	-0.49	0.01	-0.41
Vapour pressure mm of Hg		-0.22	0.22	**-0.67**	0.03	-0.64
Sunshine hours		0.11	-0.06	0.44	**-0.04**	0.45
$R^2 = 0.42$			$PX^2 = 0.58$		Residual = 0.76	

* Total correlation between jassid population and weather parameters.

its indirect negative effect through minimum temperature. The average temperature also showed moderate negative indirect effect through vapour pressure on jassid population.

The vapour pressure showed maximum negative association with jassid population and had maximum negative direct effect also indicating that this variable is important one in predicting the jassid intensity in brinjal crop. As observed with minimum and average temperatures, the indirect influence of vapour pressure through minimum as well as average temperatures was evened out.

The sunshine hours had positive association with jassid population, however its direct effect was practically negligible. The indirect influence of minimum and average temperatures and vapour pressure through sunshine hours was practically negligible indicating that sunshine hours acts independently. However its indirect effect through vapour pressure was positive and moderate.

The step-wise regression analysis was performed to spot out most influencial weather parameter affecting jassid. As a result out of all abiotic factors only vapour pressure contributed 41 per cent variation in jassid population, the equation obtained is as under :

Jassid population per leaf = 1.215 - 0.048 (Vapour pressure mm of Hg) (R^2 = 0.41)

This relation is depicted in Fig. 2

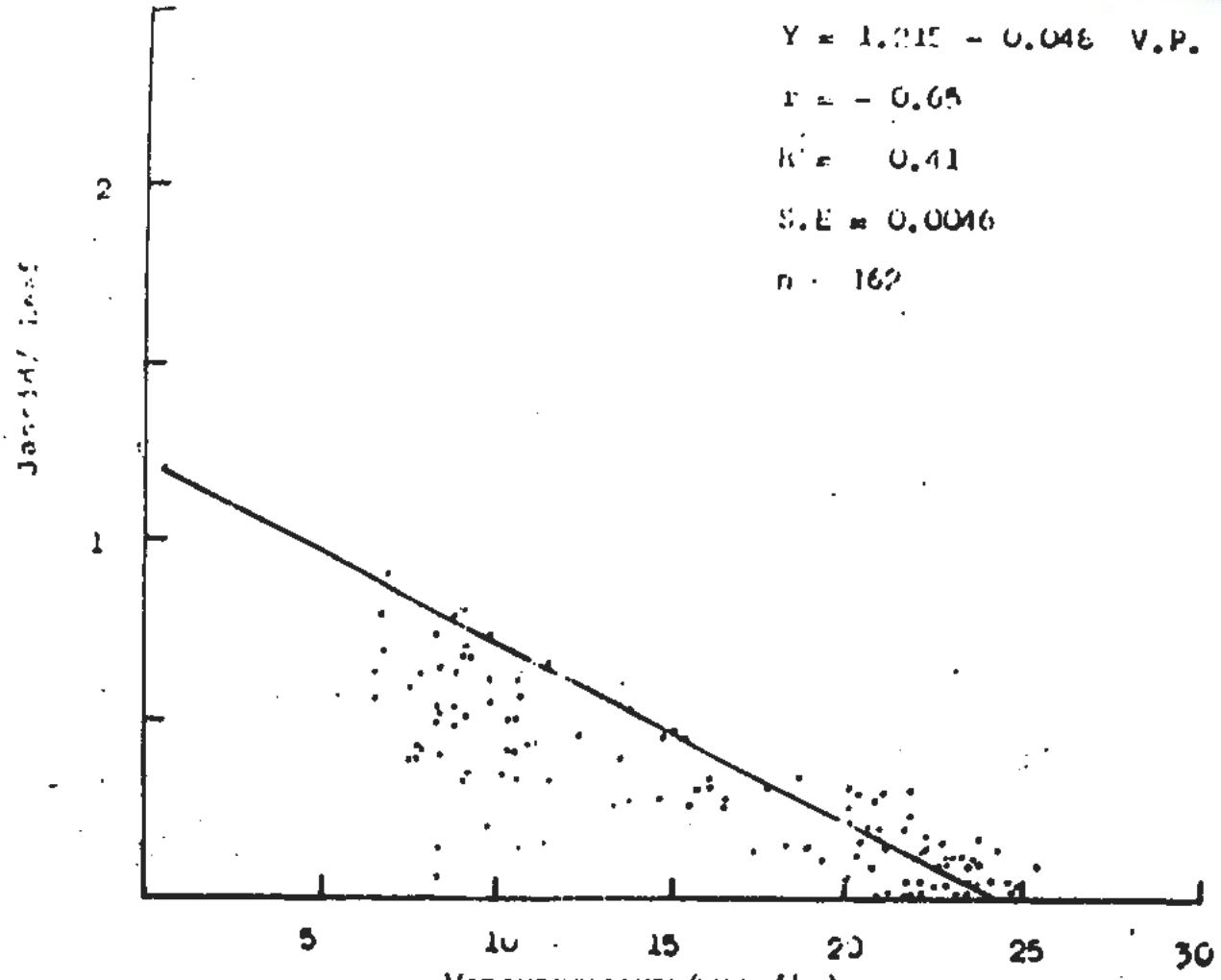

Fig. 2 : Relationship between jassid population and vapour pressure

Whereas, other significant variables viz., minimum temperature and sunshine hour when included in the step-wise regression analysis they did not improve prediction considerably but confined to only 44 per cent. Hence these variables were not considered in developing regression equation.

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Biology of *Anagyrus punctulatus* Agarwal, a Parasitoid of *Saccharicoccus sacchari* (Cockerell) and Residual Toxicity of Certain Insecticides to Adult Parasitoids

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ABSTRACT

Biology of *Anagyrus punctulatus* Agarwal, a parasitoid of sugarcane mealybug was studied. The egg to adult emergence period was 15.2, 29.0 and 12.6 days during December, January and March, respectively. The mean fecundity was 29.7 eggs per female with an oviposition period of 6.3 days. A female parasitized 6.6 hosts during its life span of 10.9 days. The female parasitoids survived longer (28.3 days) in December and shorter (5.5 days) in March. Population of females doubled that of males (2.0-3.6:1) during October-December under field conditions. Parasitism of mealybug ranged from 20.8 to 38.8 per cent during the year. Maximum parasitism was recorded during January and February and the activity ceased during August - September.

Studies on residual toxicity of nine insecticides against *A. punctulatus* adults revealed that fenvalerate, dimethoate, endosulfan and formothion were less toxic on 7th day of application. Fenvalerate had the shortest residual toxicity among all the tested insecticides.

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INTRODUCTION

The sugarcane pink mealybug, *Saccharicoccus sacchari* (Cockerell) (Homoptera : Pseudococcidae) was found associated with eight natural enemies, five parasitoids and three predators, in Saurashtra region of Gujarat State (Patel and Mittal, 1989). Among them, the encyrtid, *Anagyrus punctulatus* Agarwal was found most important in regulating the mealybug population. This parasitoid was recorded for the first time, whereas *Anagyrus saccharicola* Timberlake was reported from Hawaii (Pemberton, 1932), India (Butani, 1972), Thailand (Napompeth, 1990), Bolivia (Pruett and Colque, 1984) and Australia (Inkerman *et al.*, 1986). Patel and Mittal (1989) studied about its development. In the present investigation, studies were carried out on the biology, development and impact of insecticides on *A. punctulatus*.

MATERIALS AND METHODS

The period from egg to adult emergence was determined by releasing *A. punctulatus* adults in glass tubes (16 x 4 cm) which contained mealybugs glued to cardboard strip

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(10 x 3 cm). This cardboard strip was replaced every day. The parasitized mealybugs were kept separately for recording the adult emergence. Ten pairs of parasitoids were confined individually in glass tube containing 10 healthy mealybug glued on small cardboard strip for studying the fecundity. The host was replaced daily till the death of the female parasitoid. The mealybugs parasitized by individual female was kept separately for adult emergence. Fecundity was calculated on the basis of number of adults emerged out from the total exposed mealybugs.

Periodical collections of mealybug from the sugarcane field were made to determine the natural parasitism. The collected mealybugs which glued on the cardboard were kept in the glass tube for the parasitoid emergence. After one month the mealybugs having the parasitiod emergence holes were counted and thus the percentage parasitism was worked out.

In order to find out the residual toxicity of insecticides to *A. punctulatus* adults, one day old adults were exposed to the insecticide treated sugarcane leaf. The sugarcane leaves were sprayed with the insecticide solution at recommended concentration, using stomizer, air dried for 2 hours and then the middle piece of the leaf was held in glass tube (10 x 3.5 cm). Test insects were introduced into tube and exposed for a period of 6 hours and then adult mortality was recorded. Untreated control was maintained using sugarcane leaves sprayed with water. Each treatment was replicated three time with ten adults (females) in each replication. The treated leaves were exposed at 1, 3, 7, 14 and 21 days after treatment. The persistence and relative efficacy of different insecticides was determined as per procedure followed by Pradhan (1967). The product (PT) of average residual toxicity (T) and the period (P) for which the toxicity persisted, was used as an index of persistent toxicity. The value of corrected percentage mortalities at various specified periods were added. This sum was then divided by the number of observations in order to obtain average residual toxicity (T).

RESULTS AND DISCUSSION

Egg to adult emergence period

The adults of this parasitoid started to emerge at 9.00 AM and 82.5 per cent of adults emerged out within 12.00 AM, while the remaining emergence was completed by 15.00 PM. The period for egg to adult emergence averaged 15.2, 29.0 and 12.6 days in December, January and March, respectively (Table 1). Chandler *et al.* (1982) reported the development time of *A. pseudococci* (Girault) to be 15.5 days.

TABLE 1

Egg to adult emergence period of *A. punctulatus.*

Period of study	*No. observed*	*Egg to adult emergence period (days)*		*Temp. (°C)*	*Relative humidity (%)*
		Average	*Range*		
6-12-90 to 24-12-90	111	15.2	13-18	24.3 ± 2.4	58.1 ± 5.0
8-12-90 to 5-1-91	217	27.1	21-28	22.5 ± 2.6	62.3 ± 7.3

1.	2.	3.	4.	5.	6.
28-12-90 to 29-1-91	210	29.0	26-39	20.9 ± 2.5	62.3 ± 8.5
28-1-91 to 20-2-91	200	21.8	21-23	25.2 ± 2.6	59.0 ± 14.9
19-2-91 to 13-3-91	124	18.4	18-19	27.0 ± 2.7	57.7 ± 6.9
13-3-91 to 27-3-91	85	12.6	12-14	29.4 ± 1.8	53.2 ± 11.7

Fecundity

The sexes could be distinguished on the basis of antennal and abdominal structures. The females allowed the males for multiple matings. The females preferred mostly fourth instar mealybugs for oviposition and deposited their eggs within 30-45 seconds.

The pre-oviposition, oviposition and post oviposition periods averaged 1.7, 6.3 and 3.0 days, respectively (Table 2). The fecundity ranged from 11 to 58 with an average of 29.7. A female parasitized 4 to 10 mealybugs during its life span.

Longevity

The longevity varied widely according to changes in the temperature (Table 3). The females survived longer than males. The longevity of females was 12.4, 28.3 and 10.9 days

TABLE 2

Fecundity of *A. punctulatus* at 25.1 ± 2.3°C and 60.0 ± 12.6 % RH.

Particulars	*No. studied*	*Duration in days*	
		Average	*Range*
Pre-oviposition period	10	1.7	1-3
Oviposition period	10	6.3	5-8
Post-oviposition period	10	3.0	2-5
Fecundity	10	29.7	11-58
No. of host killed/female	10	6.6	4-10
Longevity Female	10	10.9	9-12
Male	10	8.0	4-11
Sex ratio (Female : Male)	297	1:1.25	–

on an average during December, January and February, respectively. In March the female parasitoids could not survive for more than 8 days. Chandler *et al.* (1982) reported the life span of *A. pseudococci* adults to be 6.2 to 8.2 days.

TABLE 3

Longevity of *A. punctulatus* during different months.

Period of study	*Longevity in days*				*Temp. °C*	*Relative humidity (%)*
	No. Studied	*Female*	*No. Studied*	*Male*		
5-12-90 to 28-12-90	72	12.4 (7-23)	30	6.5 (3-15)	24.1 ± 2.4	60.0 ± 5.9
13-12-90 to 17-1-91	16	28.3 (21-35)	15	15.0 (4-21)	21.6 ± 2.4	63.3 ± 7.6
17-2-91 to 1-3-91	10	10.9 (9-12)	10	8.0 (4-11)	25.1 ± 2.3	60.0 ± 12.6
6-3-91 to 14-3-91	420	5.5 (5-8)	(both sexes)		29.4 ± 0.9	55.0 ± 10.9

Figures in parentheses indicate the range.

Sex ratio

In field, the females preponderated to males. The female population was more than double to males during the months of October, November and December (2.00 - 3.64:1) and afterwards it declined but remained almost constant (1.12 - 1.28:1). However, in laboratory bred parasitoid progeny the sex ratio was observed to be 1 female : 1.25 males (Table 2).

Extent of parasitism

A. punctulatus, a gregarious parasitoid, parasitized almost late instar mealybugs. As many as 14 adults emerged from a single mealybug mummy. However, the number was dependent upon the host size. Each adult emerged from the host by making an individual hole.

TABLE 4

Parasitism by *A. punctulatus* in different months of the year 1990-91.

Month	*Total mealybugs observed*	*Parasitism (%)*
March	250	20.8
April	400	20.5
May	400	22.5
June	200	26.5
July	250	31.2
August	100	00.0
September	100	00.0
October	300	30.0
November	450	17.8
December	800	17.9
January	450	38.2
February	250	38.8

TABLE 5

Relative toxicity of different insecticides to *A. punctulatus* adults.

Insecticide	*Conc. (%)*	**Corrected per cent mortality at different intervals (days)*								
		1	*3*	*7*	*14*	*21*	*P*	*T*	*PT*	*RE*
Fenvalerate	0.02	46.67	20.00	3.33	00.00	00.00	7	41.67	291.69	1.00
Dimethoate	0.03	93.33	76.67	6.67	00.00	00.00	7	58.89	412.23	1.41
Endosulfan	0.07	73.33	66.67	30.00	00.00	00.00	7	67.50	472.50	1.62
Formothion	0.05	100.00	100.00	6.67	00.00	00.00	7	76.67	536.69	1.84
Monocrotophos	0.04	53.33	50.00	23.33	6.67	00.00	14	44.00	616.00	2.11
Phosphamidon	0.03	100.00	100.00	53.33	33.33	00.00	14	77.33	1082.62	3.71
Chlorpyriphos	0.05	100.00	100.00	50.00	43.33	10.00	21	67.33	1413.93	4.85
Quinalphos	0.05	100.00	100.00	96.67	73.33	20.00	21	81.67	1715.07	5.88
Malathion	0.05	100.00	100.00	100.00	70.00	23.33	21	82.22	1726.62	5.92

* Average of three replications

P = Period

T = Residual toxicity

PT = Production of P X T

RE = Relative efficacy

The data presented in Table 4 revealed that the percentage parasitism by *A. punctulatus* ranged from 20.8 to 38.8 during the months of March 1990 to February 1991. The level of parasitism increased from March (20.8%) to July (31.2%). The activity of the parasitoid ceased in August and September probably due to heavy rainfall. The activity reached the peak (38%) in January and Fubruary. Parasitism of mealybug was observed maximum (35.5%) on the upper portion of the cane as compared to middle (25.5%) and lower (15.3%) portions. Barro (1990) reported that the abundance of *A. saccharicola* appeared to be correlated to rainfall and accounted for 10.1 - 19.8 per cent parasitism in dry season and 0 - 1.3 per cent parasitism in wet season.

Residual toxicity of insecticides

The data (Table 5) indicated that dimethoate, fenvalerate, endosulfan and formothion were less toxic on the 7th day of application. Phosphamidon and monocrotophos were harmless on 14th day of application, while quinalphos, malathion and chlorpyriphos were toxic up to 21st day of application. On the basis of PT values, the highest PT value was recorded in malathion (1726.62), followed by quinalphos (1715.07), chlorpyriphos (1413.93) and phosphamidon (1082.62). The lowest PT value was recorded in fenvalerate (291.69), followed by dimethoate (412.23), endosulfan (472.50), formothion (536.69) and monocrotophos (616.00). These results showed that fenvalerate was the least persistent insecticide against *A. punctulatus* adults as compared to the other tested insecticides.

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Bio-Efficacy of Insecticides Against Mustard Sawfly *Athalia lugens proxima* Klug

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ABSTRACT

Field experiments were conducted with various insecticides *viz.*, monocrotophos 0.036%, acephate 0.075%, methyl-o-demeton 0.025%, quinalphos 0.025%, formothion 0.025%, endosulfan 0.035%, methyl parathion 0.05%, quinalphos 1.5%, dust @ 25 kg/ha and endosulfan 2% dust @ 25 kg/ha for three consecutive rabi seasons i.e. 1987-88, 1988-89 and 1989-90 to control mustard sawfly, *Athalia lugens proxima* Klug. Need based one application of quinalphos 0.025% emulsion spray as ETL two larvae/900 sq.cm area gave quick, effective and economical control of sawfly infesting the mustard crop.

(Received on 2nd Nov. 1993)

INTRODUCTION

Mustard, *Brassica juncea* Coss is an important oil seed crop which is generally found heavily infested with mustard sawfly, *Athalia lugens proxima* during the early stage. Sometimes in severe infestation, farmers have to resow the crop. Several workers have reported the use of insecticides as spray or granule or seed treatment for the control of sawfly (Rai *et al.* 1978, Patel *et al.* 1971 and Pareek and Gupta 1977). However, for effective and economical management of mustard sawfly need based application of insecticide is very important. Since no information on this strategy is available, this study was undertaken to find out the effective and economical insecticide for the control of this pest.

MATERIALS AND METHODS

Field experiments were conducted in randomized block design at Gujarat Agricultural University, Anand Campus, Anand with 4 replications using mustard var. Varuna during rabi seasons of 1987-88 to 1989-90. The plot size was 5.0 x 3.6 m. The row to row 30 cm and plant to plant 15 cm distance was maintained. Nine insecticide formulation were tested (Table 1). All the insecticides were applied on mustard crop only once when sawfly larval population reached to ETL i.e. two larvae/900 sq. cm area. The pre-treatment and post-treatment observations were recorded by observing randomly selected 5 spots each of 900 sq. cm. area in each plot prior and after 24, 48, 72 h and 1 week of application. The data were subjected to analysis of variance and are presented in the Table 1.

RESULTS AND DISCUSSION

The larval populations of mustard sawfly. *A. lugens proxima* (Table 1) reveal the effectiveness of all the insecticides tested as compared to control. However, among the insecticides, application of quinalphos 1.5%

TABLE 1

Bio-efficacy of various insecticides against mustard sawfly *A. lugens proxima* Klug infesting mustard crop (Pooled 1987-88 to 1989-90).

Insecticide	Average number of larvae/900 sq. cm. area					Total quantity of insecticide (g a.i./ha)	Cost of insecticide used (Rs/ha)	Total cost of plant protection (Rs/ha)
	Before Spray	spray 24 h	After 48 h	72 h	1 week			
1. Monocrotophos** 0.036%	2.14* (4.13)	0.72* (0.03)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	108	60	93
2. Acephate 0.075%	2.10 (3.97)	0.82 (0.18)	0.74 (0.05)	0.71 (0.00)	0.71 (0.00)	225	135	168
3. Methyl-o-demeton 0.025%	2.03 (3.72)	0.92 (0.37)	0.72 (0.02)	0.71 (0.00)	0.71 (0.00)	75	50	83
4. Quinalphos 0.025%	2.09 (3.90)	0.75 (0.07)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	75	48	81
5. Formothion 0.025%	1.99 (3.50)	1.09 (0.75)	0.97 (0.50)	0.96 (0.47)	0.72 (0.03)	150	47	80
6. Endosulfan 0.035%	2.04 (3.73)	1.14 (0.92)	1.08 (0.75)	1.06 (0.72)	0.84 (0.23)	105	36	69
7. Methyl parathion 0.05%	2.00 (3.52)	0.06 (0.28)	0.81 (0.17)	0.71 (0.00)	0.71 (0.00)	150	50	83
8. Quinalphos 1.5% dust @ 25 kg/ha	2.00 (3.52)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	375	260	293
9. Endosulfan 2% dust @ 25 kg/ha	1.97 (3.41)	0.76 (0.08)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	500	200	233
10. Control	2.14 (4.13)	2.24 (4.60)	2.11 (4.02)	2.28 (4.77)	1.63 (2.20)			
S. Em. ±	0.05	0.08	0.08	0.07	0.06			
C. D. at 5%	NS	0.25	0.24	0.22	0.20			
C. V. %	8.79	15.38	10.62	11.75	7.23			

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

** One spray dust was applied

labour charge Rs. 33/ha/treatment

Figures in parentheses are original values.

dust @ 25 kg/ha at ETL two larvae/900 sq. cm. area gave cent per cent mortality of mustard sawfly larvae within 24 h of application and showed significant superiority to formothion 0.025% and endosulfan 0.035% whereas, after 48 h endosulfan 2% dust, quinalphos 0.025% and monocrotophos 0.036% sprays gave cent per cent larval mortality and showed superiority to formothion and endosulfan. The mustard crop sprayed with methyl parathion 0.05%, acephate 0.075% and methyl-o-demeton 0.025% had cent per cent larval control after 72 h of application and they showed their significant superiority to formothion and endosulfan. Formothion and endosulfan could not give cent per cent larval control even after one week of their application. However, they were at par to rest of the insecticides tested and showed significant superiority to control after one week of application.

Looking to the cost and effectiveness of insecticides spray of quinalphos 0.025% emulsion should be made on mustard crop infested with sawfly at ETL two larvae/900 sq. cm. area.

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Some Physiological Studies on Trichoderma Harzianum Rifai

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ABSTRACT

Among eight liquid media Brown's medium and Elliott's medium supported maximum mycelial growth of *T. harzianum*. A pH range of 4.0 to 6.0 was found most suitable for the growth. Maximum germination of spores occurred at 35°C exposure for 5 min while it failed to germinate after exposure at 55°C for 5 min.

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INTRODUCTION

Trichoderma harzianum Rifai, a common soil inhabitant, is well recognized for its antagonistic activity against important soil-borne plant pathogens. Information on the growth and sporulation of *T. harzianum* and factors affecting it *in vitro* can be useful in developing the technology for large scale production of the bio-agent. Although some *in vitro* studies have been taken up on this antagonist, more information is required. Therefore, studies were undertaken on the effect of liquid media and H-ion concentration on the mycelial growth and viability of spores of *T. harzianum* at different temperature.

MATERIALS AND METHODS

Liquid media : Eight liquid viz. Richard's solution, Czapek's, Elliott's, Asthana and Hawker's, Brown's medium, sucrose nitrate, potato dextrose broth and glucose broth were tried. The pH of each medium was adjusted to 6.0 before autoclaving. Twenty ml of each liquid medium was taken separately in 100 ml Erlenmeyer flasks, sterilized at 15 lbs p.s.i. for 20 min and inoculated with mycelial disk (5 mm) from 7 day old culture of *T. harzianum* (Anand isolate) grown on potato dextrose agar (PDA). After 15 days of incubation at 28°C, mycelial mat was collected on Whatman filter paper (No. 44), dried at 60°C and weighed.

H-ion concentration : Since Brown's medium was found best it was used at different pH levels viz. 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5 and 8.0. Flasks containing 20 ml of sterilized Brown's medium at respective pH values were inoculated and incubated as in liquid media studies.

Exposure of conidia to different temperature : Five ml spore suspension of *T. harzianum* was taken in sterile test tubes

and kept in thermostatically controlled water bath cum shaker at different temperature of 35, 40, 45, 50 and 55°C for 5, 15, 30, 45 and 60 min. After exposure to various temperatures and time, one ml of spore suspension was poured onto 2% agar medium (4 petri plates in each treatment). The petri plates were examined under microscope for germination of the spores after 36 hrs of incubation at 28°C. At least 400 spores were counted in each replication.

RESULTS AND DISCUSSION

Effect of liquid media on the growth of *T. harzianum*

Significant differences in dry mycelial weight of *T. harzianum* was observed in each liquid medium (Table-1). Maximum (183.75 mg) mycelial weight was recorded in case of Brown's medium which did not differ with Alliott's medium (170.00 mg). Sucrose nitrate medium was next best but did not differ significantly from Asthana and Hawker's medium and potato dextrose broth. Richard's solution, glucose broth and Czapek's solution were found poor for the growth of *T. harzianum*. The differences in dry mycelial weight in various liquid media may be due to differences in the composition of the medium. Brown's and Elliott's medium contain L-asparagina and magnesium sulphate which might be responsible for supporting better growth of *T. harzianum*. These results are similar to those of Shukla and Mishra (1970) who reported that growth of *T. viride* was significantly increased when magnesium sulphate was added to the medium. Sesan (1981) observed that *T. viride* grew best on media containing peptone, mine acids, DL-asparagine and ammonium salts.

TABLE 1

Effect of liquid media on the mycelial growth of *T. harzianum*.

Liquid medium	*Dry mycelial weight in mg**
Richard's solution	115.00
Czapek's solution	126.25
Sucrose nitrate medium	158.75
Elliott's medium	170.00
Asthana and Hawker's medium	153.75
Brown's medium	183.75
Potato dextrose broth	141.25
Glucose broth	118.75
S.Em.	6.89
C.D. (0.05)	20.11
C.V. (%)	9.44

* Average of four replications.

Effect of H-ion concentration on the growth of *T. harzianum* :

Dry mycelial weight of *T. harzianum* was maximum at pH 4.5 with no significant difference at pH 4.0. However, with increasing H-ion concentrations, there was gradual decline in dry mycelial weight except at pH 5.5 and 6.0 which supported equal growth (190 mg). Brian and Homming (1950) reported that pH 4.0 to 6.0 was the best for the spore production of *T. viride*. Chet and Baker (1980) concluded that acidic condition enhanced the growth of *T. harzianum*.

TABLE 2

Effect of H-ion concentrations on the mycelial growth of *T. harzianum*.

pH	*Dry mycelial weight in mg**
4.0	220
4.5	245
5.0	210
5.5	190
6.0	190
6.5	170
7.0	155
7.5	130
8.0	105
S.E.m.	8.69
C.D. (0.05)	25.21
C.V. (%)	9.68

*Average of four replications.

Effect of different temperature on the viability of spores of *T. harzianum* :

Maximum spore germination was observed at an exposure for 5 min. at 55°C. More than 60% spores germinated upto 45° at 30 min. exposure and thereafter there was decline in germination at subsequently higher temperature and time of exposure. Spores failed to germinate when exposed to 55°C for even 5 min. Hence it can be concluded that *T. harzianum* spores can not survive exposure to higher tempertures. Danielson and Davey (1973) found that maximum temperature favourable for the growth and sporulation of this bioagent was in the range of 30-38°C.

TABLE 3

Effect of temperature and time of exposure on the viability of *T. harzianum* spores.

Time (minute).	*Spore germination (%)* Temp. °C*				
	35°	*40°*	*45°*	*50°*	*55°*
5	87.1	70.5	66.5	31.8	0.0
15	86.0	66.6	62.5	28.6	0.0
30	82.4	62.6	60.3	22.3	0.0
45	71.7	44.0	40.8	12.0	0.0
60	58.5	32.2	22.7	9.7	0.0

	S. Em.	C. D.	(0.06)	C. V. (%)
Temp. (T)	3.0		8.58	22.82
Time (H)	3.35		9.59	
T X H	6.70		NS	

*Average of 4 replications.

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Selection Criteria for Improving Yield Potential in Okra

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ABSTRACT

An experiment comprising seven genotypes of okra and 21 diallel crosses was conducted in randomized block design with three replications at the Plant Breeding Research Farm, GAU, Anand to study the significance of agromorphological traits in selection programme for improving yield potential of okra. Pod yield was positively associated with all the attributes barring days to first flower. The yield was influenced directly and/or indirectly through pod weight, pod length, pod girth and number of pods per plant suggesting that prime emphasis should be given on these traits for evolving high yielding genotypes.

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INTRODUCTION

The primary objective of a plant breeding programme is to improve yield and quality of crop by evolving superior varieties. The yield of green pod of okra (*Abelmoschus esculentus* L. Moench) being consumed as vegetable, is an economically important quantitative character. Effective improvement in yield could be achieved through improving yield components which show associations among themselves and with yield. The knowledge about associations between characters may also help to identify characters that have little or no importance in the selection programme. Very limited information on this aspect is available for okra under Gujarat conditions (Patel, 1982). The present investigation was undertaken at the Plant Breeding Research Farm, Gujarat Agricultural University, Anand with a view to find out significance of agro-morphological characters of okra in breeding programme through correlation and path analysis (Wright, 1934).

MATERIALS AND METHODS

The experimental material consisted of seven parents (genotypes) and 21 diallel crosses. The parents were selected at random from the germplasm maintained by the farm. The material was grown at 45 cm x 30 cm spacing in randomized block design with three replications during *kharif* season of 1982. Each plot had two rows of ten plants each. End borer rows were provided in each replication. Cultural practices in vogue on the farm were followed.

Three plants were tagged at random per plot for recording days to first flower(days from seeding to the opening of first flower), plant height in cm (from ground level to the tip of the main stem after last picking) and number of branches per plant. The same tagged plants were inspected daily in the morning hours. The flowers which were found open on tagged plants were labelled with date. The six days old green pods developed from labelled flowers were harvested separately for recording pod weight (g), pod length (cm) and pod girth (cm). The number of pods as well as pod yield per plant were derived after last picking. The average values were used in estimation of correlation coefficients (genotypic and phenotypic) between pairs of attributes and path coefficients based on genotypic and phenotypic correlations.

RESULTS AND DISCUSSION

The results (Table 1) revealed that out of 28 intercharacter associations, 14 genotypic and 11 phenotypic correlation coefficients were significant. In general, the estimates of genotypic correlations were higher in magnitude than phenotypic correlations. The pod yield per plant (pod yield) was significantly influenced by all the attributes studied barring days to first flower. The latter had positive significant genotypic association with plant height as well as number of pods per plant and negative association with pod girth suggesting that selection in favour of late flowering type will induce tall stature and also increase number of pods per plant but at the same time it will reduce pod girth which is not desirable from yield view point. The plant height had significant positive genotypic as well as phenotypic associations with number of pods per plant which showed significant correlations with number of branches per plant. The pod weight, pod length and pod girth showed positive high associations among themselves. These results suggested that the selection in favour of longer pods will help in increasing pod weight as well as pod girth and thereby pod yield. These results are akin to those reported by Singh and Singh (1978), Mahajan and Sharma (1979) and Murty and Bavaji (1980).

The results (Table 2) revealed that days to first flower, plant height and number of branches per plant had very low direct contribution to pod yield. These attributes had low positive indirect effect on pod yield through number of pods per plant. The pod weight had maximum direct positive influence on pod yield. The number of pods per plant had moderate positive effect on pod yield. The pod length had moderate negative genotypic direct effect on pod yield. It had very high positive (genotypic) contribution through pod weight to pod yield. The pod girth had low negative direct effect on pod yield and very high positive indirect effect (genotypic) on pod yield through pod length.

The results thus indicated that pod weight and number of pods per plant were the main attributes in increasing pod yield of okra. From indirect effect view point also these traits were of prime importance for the improvement of pod yield. It is interesting to note that though the association (r_g) of pod length as well as pod girth with pod yield was significant and positive they had indirect contribution through pod weight. The results thus suggest that the breeder should give prime emphasis on selecting plants having more number of long heavy thick pods for evolving high yielding okra cultivars. These results are in conformity with those reported by Majumdar *et al.* (1974) and Murty and Bavaji (1980).

TABLE 1

The estimates of genotypic (r_g) and phenotypic (r_p) correlation coefficients between all pairs of eight characters.

Character		Plant height	No. of branches per plant	No. of pods per plant	Pod weight	Pod length	Pod girth	Pod yield per plant
Days to first flower	r_g	0.55*	0.36	0.41*	-0.36	-0.37	-0.64**	0.11
	r_p	0.19	-0.02	0.22	-0.18	-0.23	-0.29	0.05
Plant height	r_g	–	0.21	0.68**	-0.17	-0.18	-0.26	0.57*
	r_p		0.24	0.63**	-0.12	-0.16	-0.19	0.44*
No. of branches per plant	r_g	–	–	0.66**	0.04	0.08	0.04	0.61**
	r_p			0.38	0.06	0.05	0.03	0.39*
No. of pods per plant	r_g	–	–	–	-0.20	-0.21	-0.18	0.69**
	r_p				-0.16	-0.18	-0.14	0.68**
Pod weight	r_g	–	–	–	–	0.97**	0.83**	0.68**
	r_p					0.96**	0.88**	0.49**
Pod length	r_g	–	–	–	–	–	0.75**	0.63**
	r_p						0.80**	0.47*
Pod girth	r_g	–	–	–	–	–	–	0.54**
	r_p							0.40*

Legend : * and ** indicate significant at 5 and 1 per cent levels of significance respectively.

TABLE 2

Direct (underlined) and indirect effects of various characters on pod yield per plant.

Character	*	Days to first flower	Plant height	No. of branches per plant	No. of pods per plant	Pod weight	Pod length	Pod girth	Correlation with pod yield per plant
Days to first flower	G	**-0.179**	0.091	0.081	0.262	-0.658	0.302	0.213	0.11
	P	**-0.007**	0.007	-0.001	0.162	-0.083	-0.051	0.023	0.05
Plant height	G	-0.099	**0.166**	0.047	0.433	-0.311	0.147	0.086	0.47*
	P	-0.001	**0.038**	0.015	0.464	-0.056	-0.035	0.015	0.44*
No. of branches per plant	G	-0.065	0.035	**0.224**	0.421	0.073	-0.065	-0.013	0.61**
	P	0.001	0.009	**0.064**	0.280	0.028	0.011	-0.024	0.39*
No. of pods per plant	G	-0.073	0.113	0.148	**0.637**	-0.366	0.171	0.060	0.69**
	P	-0.001	0.024	0.024	**0.736**	-0.075	-0.040	0.011	0.68**
Pod weight	G	0.065	-0.028	0.009	-0.127	**1.829**	-0.791	-0.276	0.68**
	P	0.001	-0.005	0.004	-0.118	**0.467**	0.211	-0.071	0.49**
Pod length	G	0.066	-0.030	0.018	-0.134	1.774	**-0.815**	-0.249	0.63**
	P	0.002	-0.006	0.003	-0.132	0.448	**0.220**	-0.064	0.47*
Pod girth	G	0.115	-0.043	0.009	-0.115	1.518	-0.611	**-0.332**	0.54**
	P	0.002	-0.007	0.002	-0.103	0.411	0.176	**-0.080**	0.40*

* G = Genotypic; P = Phenotypic

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Genetic Architecture of Lint Component Characters in Interspecific Hybrids of Cotton

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ABSTRACT

In interspecific crosses between varieties of Asiatic (*Gossypium hirsutum* L.) and Egyptian (*G. barbadense* L.) cotton all three kinds of gene effects (Additive, Dominance and Epistatic) were involved in the inheritance of lint yield per plant, seed index and lint index. Additive and epistatic gene effects were important for inheritance of ginning percentage and number of motes per boll.

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INTRODUCTION

Major break through in quality cotton production came with the release of an inter-specific hybrids of upland cotton and Egyptian cotton. Long staple cotton is produced from a *hirsutum* type. Superior long staple cottons are produced from *hirsutum barbadense* and their intra and interspecific hybrids. Lint quality is important factor for long and superior long staple cotton. Hence, this study was taken to know the genetic architecture of lint components characters in interspecific hybrid with its various generations. The information on gene effects may help in planning effective breeding programme.

MATERIALS AND METHODS

The material of the present investigation consisted of two interspecific cotton crosses (*G. hirsutum* L. x *G. barbadense* L.) (H 51-3 x Suvin and H 51-3 x SILS-9). Six generations i.e. P_1, P_2, F_1 (P_1 x P_2), F_2, BC_1 (F_1 x P_1) and BC_2 (F_1 x P_2) of each of two crosses were produced and evaluated in compact Family Block Design with four replications during the year 1984-85 at Plant Breeding Farm, GAU, Anand. Each parental and F_1 generation was represented by two rows, BC generation by four rows and F_2 by six rows of 6 m row length with 120 x 60 inter and intra row spacing. Data were recorded on five competitive plants in each row for five lint component characters (Table 1). The data were subjected to statistical analysis for six-parameter model (6, 7) to obtain estimates of m, (d), (h), (i), (j) and (l).

RESULTS AND DISCUSSION

The estimates of different parameters are presented in Table 1. The mean value was significant for all the characters studied in both the crosses.

TABLE 1

Gene action for the lint component characters in hybrid H 51-3 x Suvin (H_1) and H 51-3 x SILS-9 (H_2).

Characters	*M*		*d*		*h*		*i*		*j*		*l*	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Lint-yield per plant	36.40**	50.03**	-19.61**	10.41	242.58**	55.86	130.78**	37.39	-41.69**	-23.74**	-59.84**	58.59
Ginning percentage	29.17**	29.30**	0.38	1.31*	1.26	-1.68	2.12	-1.26	1.18*	2.99**	-6.88**	0.50
Number of motes per boll	1.42**	1.39**	0.11*	-0.02	-0.44	-0.56	-0.59*	-0.56**	0.06	0.03	1.03*	0.39
Seed index	10.05**	10.59**	-0.71*	0.87**	6.50**	2.38**	5.18**	0.98	-1.05**	0.22	-2.79	1.52
Lint index	4.17**	4.39**	-0.18	0.57**	2.76**	0.94	2.46**	0.46	-0.13	0.53**	-2.56**	0.01

* Significant at 5% level; ** Significant at 1% level

M = mean value d = additive h = dominance i = epistasis (a x a)

j = epistasis (a x d) l = epistasis (d x d)

For lint yield per plant mean value was higher with cross H 51-3 x SILS-9. All the three types of gene effects viz., additive, dominance and epistasis (additive x additive, additive x dominance and dominance x dominance) were involved for this trait in cross H 51-3 x Suvin 9, whereas for cross H 51-3 x SILS-9 only additive x dominance gene interaction was significant.

Mean value of ginning percentage was more or less equal for both the crosses. The important role of both additive x dominance and dominance x dominance digenic interaction were observed in cross H 51-3 x Suvin whereas for cross H 51-3 x SILS-9 additive as well as additive x dominance gene effects were important.

For number of motes per boll mean value was more or less equal. In cross H 51-3 x Suvin, additive and epistasis viz., additive x addtive and dominance x dominance gene action were significant, whereas in cross H 51-3 x SILS-9 only duplicate epistatic gene action was significant for expression of this trait.

Mean value of seed index was more or less equal. Except dominance x dominance gene effect, all the other gene effects were imporant in cross H 51-3 x Suvin, whereas in cross H 51-3 x SILS-9 only main gene effect (additive and dominance) showed importance in inheritance of this character.

For lint index mean value was more or less equal with both the crosses. In cross H 51-3 x Suvin, dominance, additive x additive and dominance x dominance gene effects were involed, whereas in cross H 51-3 x SILS-9 additive as well as additive x dominance gene components were found to be important in expression of lint index.

The findings are in agreement with for lint yield per plant (1), for ginning percentage (3,5,8,10) for number of motes per boll (2), for seed index (1,8,9) and for lint index(4,8).

In inheritance of above various characters magnitude of non-fixable gene effects (dominance and epistasis) were high, hence *inter se* crossing as well as reciprocal recurrent selection is suggested for improvement of above studied traits in desired direction.

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Genetic Divergence in Pigeonpea*

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ABSTRACT

The genetic divergence was assessed using Mahalanobis D^2 statistic where in 70 genotypes of pigeonpea were grouped in as many as 14 clusters. The clustering pattern of the genotypes was independent of their geographical origin. The characters grain yield per plant, number of pods per plant, plant height and number of primary branches per plant showed high genetic divergence. Based on the inter cluster distance, cluster XIV showed high genetic divergence with XIII, XII and X. It was therefore concluded that the genotypes belonging to these clusters be included/utilised for improving seed yield in pigeonpea.

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INTRODUCTION

Now a days pigeonpea is getting popularity in rainfed areas. Therefore it is essential to develop the genotypes having high productivity under such condition. For developing such genotypes, diversity among characters contributing towards the yield is a must. The present study was undertaken to identify diversed genotypes for effective breeding programme.

MATERIALS AND METHODS

Seventy geographically diversed genotypes were planted in *kharif* 1990 on Instructional Farm of Agriculture College, Navsari. The material was sown in single row plots of 5 m length at a distance of 90 x 20 cm in randomised block design with 3 replications. Five competitive plants selected at random were used for recording observations on 10 characters (Table 1). From estimates of variances and covariances, V statistic, which utilises Wilk's 'A' criterion, a simultaneous test of difference between mean values of a number of correlated variables was done. Genetic diversity was calculated using Mahalanobis D^2 statistic as suggested by Rao(1952). On the basis of magnitude of D^2 values, varieties were grouped in to a number of clusters by Tocher method(Rao 1952). The mutual relatioship was also determined by using the principal component analysis.

RESULTS AND DISCUSSION

A high significant difference among genotypes revealed the existance of sufficient

*Part of M. Sc. (Agril) thesis submitted by senior author to Gujarat Agricultural University.

TABLE 1

ANOVA and coefficient of variability fcr 70 genotypes of pigeonpea.

Character	Mean sum of square			Coefficient of variability (%)
	Replication (2 df)	Genotypes (69 df)	Error (138 df)	
Grain yield per plant (g)	29.37	1162.17**	39.54	8.83
Number of pods per plant	344.87	2931.58**	226.45	10.65
Number of seeds per pod	0.11	0.35**	0.04	5.58
100 seed weight (g)	0.04	3.24**	0.10	2.90
Height of plant (cm)	5.75	1575.16**	127.66	7.64
Number of primary branches per plant	0.97	2.65**	0.25	7.22
Length of secondary branch (cm)	24.69	267.72**	43.51	8.68
Pod length (cm)	0.02	0.50**	0.05	4.21
Days to flower	44.75	222.16**	17.88	4.44
Days to maturity	785.50	438.43**	37.33	3.73

** Significant at 1% probability.

TABLE 2

Cluster composition of seventy genotypes of pigeonpea.

Cluster	Number of genotypes	Genotypes and origin
I	25	BP 434, BP 84-46, BP 449, BP 84-72, BP 433-BP 84-76, BP 84-42, BP 84-202, BP 84-91, BP 84-83, BP 1107, BP 463, BP 2060, BP 471, BP 84-41, T-15-15, GAUT 85-18 (Gujarat), ICPL 7203, ICPL 86026, ICP-81 (ICRISAT), Pusa -1 (IARI), TT 6 (Trombay) BDN 1, BDN 7 (Maharashtra), BAU 1 (Bihar).
II	14	BP 86-109, BP 444, BP 1103, BP 84-48, GAUT 85-21 (Gujarat), T 21. (U.P.), ICPL 315 (ICRISAT), MKU 66, BDN 2 (Maharashtra), C 21, Pusa 33 (IARI), AL 56 (Punjab), CORG 3 (Tamilnadu), VR 3 (A.P.).
III	10	PPE 45-2, ICPL 186 (ICRISAT), BP 450, BP 1148, GAUT 87- 10(Gujarat), UR 10 (Orissa), MTH 9, MTH 20, BDNA 5 (Maharashtra), BKW 23 (Bihar).
IV	3	GAUT 85-22, BP 1809 (Gujarat), BSMR 198 (Bihar).

1.	2.	3.
V	2	BP 86-126, BP 84-51 (Gujarat).
VI	3	TAT 10 (Trombay), ICP 909 (ICRISAT), Pusa Ageti (IARI)
VII	3	BP 476, GAUT 8299 (Gujarat), BSMR 736 (Bihar)
VIII	2	SPMA 8(Karnataka), ICP 84060 (ICRISAT).
IX	3	GAUT 82-92 (Gujarat), ICPL 87, ICPL 83024 (ICRISAT)
X	1	UPAS 120 (U.P.)
XI	1	Nylon (Israel)
XII	1	CO 5(Tamilnadu)
XIII	1	Bhadbhoot (Gujarat)
XIV	1	ICPL 89044 (ICRISAT)

amount of variability in the material studied(Table 1). On the basis of magnitude of D^2 values, all the seventy genotypes were grouped in 14 clusters (Table 2). The cluster I was the largest which consisted 25 genotypes from Trombay, ICRISAT, IARI, Bihar, Maharashtra and Gujarat. Cluster II which was the second largest, accommodated 14 genotypes from IARI, Punjab, ICRISAT, Gujarat, Maharashtra, Andhra Pradesh, Tamilnadu and Uttar Pradesh. Cluster III had 10 genotypes whereas clusters IV, VI, VII and IX possessed 3 genotypes from Gujarat, Trombay, ICRISAT, IARI and Bihar. Cluster V and VIII contained 2 genotypes from Gujarat, ICRISAT and Karnataka. The clusters from X to XIV were single variety cluster which included varieties from Uttar Pradesh, Israel, Tamilnadu, Gujarat and ICRISAT respectively. Thus the clustering pattern of genotypes was not as per their geographical origin as the varieties of same geographical area were grouped in different clusters and of different areas in the same cluster which is in accordance to Singh *et al.* (1988) and Murty and Dorairaj (1990). Such clustering pattern may be because of genetic drift and selection in different environments resulting in considerable diversity than the geographical isolation (Murty and Arunachalam,1966). The free exchange of seed material among different regions may consequently also cause character constillations because of human interferance and material may loose its individuality.

The inter cluster distance (Table 3) was maximum (D^2 = 1749.66) between clusters XIII and XIV followed by clusters XII and XIV (D^2=1513.44) and it was minimum (52.46) between I and IX (Fig. 1) indicating relative closeness of genotypes of these clusters. The intra-cluster distance ranged from 0.0 to 55.65

TABLE 3

Inter and intra cluster average values of D^2 in pigeonpea.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
I	43.08 (6.56)	73.52 (8.57)	68.87 (8.29)	79.91 (8.93)	69.87 (8.35)	98.41 (9.92)	93.48 (9.66)	125.29 (11.19)	52.46 (7.24)	253.35 (15.91)	142.50 (11.93)	333.69 (18.26)	364.86 (19.10)	644.22 (25.38)
II		44.52 (6.67)	81.67 (9.03)	252.58 (15.89)	137.10 (11.70)	73.37 (8.56)	95.52 (9.77)	64.08 (8.00)	138.02 (11.74)	151.52 (12.30)	272.46 (16.50)	224.66 (14.98)	252.95 (15.90)	1033.31 (32.14)
III			38.87 (6.23)	140.08 (11.83)	79.09 (8.89)	63.18 (7.94)	132.22 (11.49)	95.23 (9.75)	98.56 (9.92)	167.93 (12.95)	208.86 (14.45)	254.04 (15.93)	394.59 (19.83)	739.65 (27.19)
IV				37.80 (6.14)	136.14 (11.65)	228.92 (15.13)	186.18 (13.64)	252.03 (15.87)	139.53 (11.81)	477.70 (21.85)	106.17 (10.30)	565.22 (23.77)	540.87 (23.25)	400.41 (20.01)
V					51.57 (7.31)	124.95 (11.17)	134.61 (11.60)	98.97 (9.94)	149.45 (12.22)	297.55 (17.24)	121.18 (11.00)	399.84 (19.99)	355.87 (18.86)	743.80 (27.27)
VI						55.65 (7.45)	157.14 (12.53)	123.45 (11.11)	96.00 (9.78)	111.82 (10.57)	166.13 (12.88)	354.44 (18.82)	404.01 (20.10)	915.27 (30.25)
VII							43.60 (6.60)	117.02 (10.81)	161.99 (12.72)	319.71 (17.88)	250.43 (15.82)	155.18 (12.45)	193.92 (13.92)	919.49 (30.32)
VIII								29.68 (5.44)	223.87 (14.94)	199.43 (14.12)	103.33 (10.16)	285.02 (16.88)	222.62 (14.92)	1054.79 (32.47)
IX									47.26 (6.87)	199.58 (14.12)	265.76 (16.30)	368.42 (19.19)	498.42 (22.32)	721.23 (26.86)
X										– –	518.25 (22.76)	485.41 (20.86)	483.67 (21.99)	1308.02 (36.18)
XI											– –	631.55 (25.13)	479.96 (21.90)	897.56 (29.95)
XII												– –	208.41 (14.43)	1513.44 (38.90)
XIII													– –	1749.66 (41.82)
XIV														– –

Fig. 1 : Inter cluster distance between different clusters (D values)

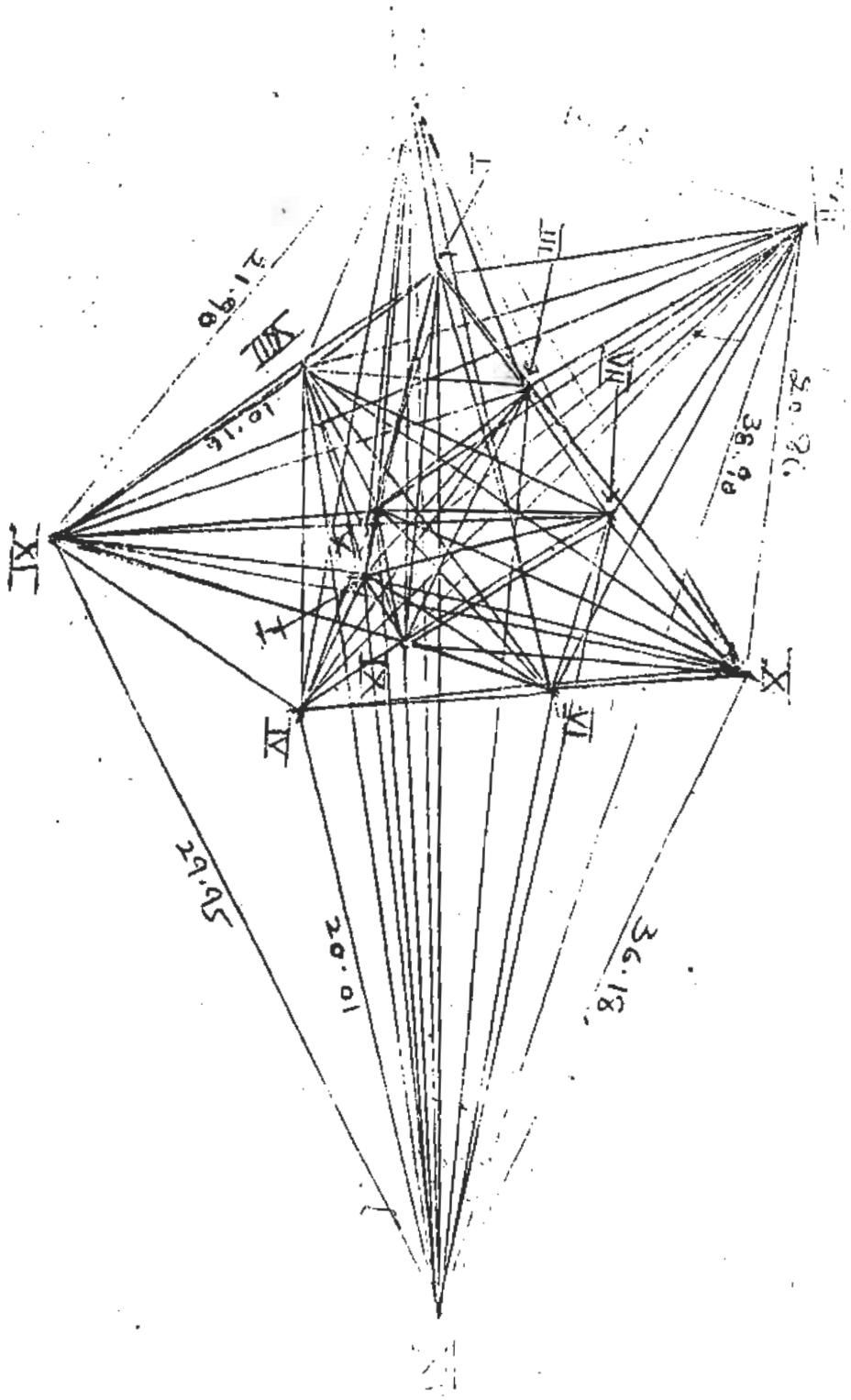

TABLE 4

Cluster mean for different characters in pigeonpea.

Cluster No.	Number of population	X_1 Grain yield plant (g)	X_2 Number of pods/ plant	X_3 Number of seeds/ pod	X_4 100 seed weight (g)	X_5 Plant height (cm)	X_6 No. of primary brancnes /plant	X_7 Length (cm) of secondary branch	X_8 Pod length (cm)	X_9 Days to flowering	X_{10} Days to maturity
I	25	71.34	143.53	3.717	11.42	154.452	7.036	78.508	5.141	95.919	175.022
II	14	76.195	150.059	3.595	10.315	148.375	6.953	75.123	5.255	93.142	169.645
III	10	54.500	110.126	3.438	10.173	131.630	6.520	71.366	4.672	94.460	166.810
IV	3	67.555	136.400	3.444	12.530	149.150	7.144	78.355	4.858	101.444	184.978
V	2	71.000	137.600	3.608	10.322	175.917	7.408	78.130	5.490	109.833	181.733
VI	3	59.444	104.623	3.516	9.768	129.222	5.544	62.955	5.022	79.888	163.666
VII	3	99.444	194.289	3.427	12.340	161.570	7.888	79.800	5.180	98.222	163.000
VIII	2	87.700	171.200	3.441	10.242	156.866	7.467	80.150	4.639	123.833	191.100
IX	3	48.444	105.755	4.266	11.180	108.577	6.138	60.95	5.295	86.666	164.289
X	1	38.000	79.067	4.217	8.737	80.467	3.967	60.600	4.200	82.000	164.067
XI	1	84.667	180.400	3.783	12.200	190.800	5.667	91.400	5.440	115.333	222.800
XII	1	155.000	254.500	4.433	12.657	187.800	9.807	95.400	5.560	89.667	166.330
XIII	1	152.000	174.800	3.583	12.913	198.133	7.800	103.200	5.583	110.000	184.367
XIV	1	105.000	191.000	3.617	12.637	135.333	8.000	83.100	4.117	106.000	174.800
Mean		82.16	152.38	3.720	11.245	150.607	6.957	78.502	5.044	101.172	175.829
S. Em. ±		8.576	12.290	0.090	0.354	8.740	0.371	3.332	0.125	4.9499	4.543
C. V. %		39.055	30.223	9.057	1.389	21.644	19.973	15.879	9.459	18.306	9.668

which was the highest in clusters VI and the lowest in cluster VIII (D^2=29.68). Clusters X to XIV had no intra-clusters values and such clusters are supposed to have maximum diversity with the other varieties.

The cluster means of various clusters presented in table 4 denoted high coefficient of variations for the traits like seed yield, pods per plant and plant height and low for test weight and number of seeds per pod. Cluster XII had the high mean values for grain yield,number of pods per plant;number of seeds per pod, test weight and number of primary branches whereas,cluster XIII was good for test weight, plant heigth length of secondary branch and pod lenght. For earliness cluster VI had the lowest values for days to flowering and maturity. Therefore it is concluded to have inter crossing of genotypes involving these clusters for creating wide spectrum variabliity and improving seed yield in rainfed pigeonpea.

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Combining Ability Analysis in Brinjal (*Solanum melongena* L.)

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ABSTRACT

A set of 7 x 7 diallel crosses excluding reciprocals was studied for combining ability in brinjal. The analysis showed that general combining ability variances were significant for all the characters. The ratio of additive to nonadditive genetic variance indicated prepondarance of non additive type of gene action for all the characters. General combining ability of the parents revealed that the parents K-314, P.B.R.-5 and Pusa Purple Long were good general combiners for fruit yield per plant and some of the yield contributing characters. Hybrids K-316 x N.D.B.-25, K-316 x Pusa Purple Long, P.B.R.-5 x K-314 and Junagadh Selection-1 x Pusa Purple Long were good specific combinations for fruit yield per plant and most of its yield contributing characters.

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INTRODUCTION

Brinjal (*Solanum melongena* L.) also known as eggplant, is one of the important vegetable crops. It is cultivated throughout the tropics and also as a summer annual in warm subtropics. Brinjal having 2n=24 chromosomes belong to the family solanaceae and is classified as a self-pollinated crop. However, natural out crossing has also been reported which is known to vary with the variety and environment, the average being about 6 to 7 per cent (Choudhary, 1976). According to Vavilov (1928), brinjal had originated in India.

The average yield of existing varieties of brinjal has remained low, despite the fact that considerable scope exists for its improvement by adopting appropriate breeding programmes. In crop improvement programme, the breeder is often confronted with the difficulty of choosing the parental lines which when crossed, will result in a higher proportion of desirable segregants. Therefore, in order to develop high yielding varieties, firstly, it would be most appropriate to identify better combiners for different traits. The evaluation of potential parental lines for combining ability is not only helpful in selecting the parents for hybridization, but also for developing superior hybrids.

Amongst different approaches available for studying combining ability, Griffing's (1956) method of working out combining ability from the diallel crosses is one of the most widely used methods because of its precision and

versatility. The same has been followed in present investigation. The method in short provides a systematic approach for identification of superior parents and crosses, which is the basic requirement for successful breeding programme.

MATERIALS AND METHODS

The seven diverse genotypes used in generating the experimental material were, Junagadh Selection-1, K-316, Kat-4, Pusa Purple Long, N.D.B.-25, P.B.R.-5 and K-314. These were crossed during kharif 1988-89, in diallel fashion making all possible combinations, excluding reciprocals, to obtain seeds of 21 F_1 'S. The 28 entries comprising of seven parents and their 21 hybrids were transplanted in a randomized block design with three replications at Vegetable Research Farm, College of Agriculture, Sardar Krushinagar during *kharif*-1989. Each entry was grown in one row plot of six meters length keeping inter and intra row distance of 90 and 60 cm, respectively. Data were recorded on five randomly selected plants from each entry in each replication for various characters. Then the mean values were calculated and used for statistical analysis. The observations were recorded for eight characters viz., days to flowering, plant height, number of primary branches per plant, number of fruits per plant, average fruit weight, fruit length, fruit girth and fruit yield per plant.

Mean values of 28 entries comprising of seven parents and 21 hybrids were arranged in a diallel tabie for combining ability analysis according to the procedure described by Griffing (1956) for model-I (fixed model) and method-2 in which parents and one set of F_1S were included without reciprocals. Model-I assumes that the variety and block effects are constant (fixed) but environmental effect is variable.

TABLE 1

Analysis of variance for combining ability, estimation of components of genetic variance and their ratios for different characters.

Characters	*Mean squares*			*Genetic variance*		$\frac{1}{\text{d.f. g.c.a}} \Sigma g_i^2 \Big/ \frac{1}{\text{d.f. s.c.a.}} \Sigma\Sigma s_{ij}^2$
	g.c.a	*s.c.a.*	*Error*	Σg_i^2	$\Sigma\Sigma s_{ij}^2$	
Days to flowering	98.498**	13.819**	1.021	64.985	268.758	0.846
Plant height	180.264**	65.319**	7.539	115.150	1213.80	0.332
Number of primary branches per plant	0.412*	0.947**	0.156	0.171	16.611	0.036
Number of fruits per plant	50.088**	18.957**	3.008	31.387	334.929	0.328
Average fruit weight	224.194**	92.011**	2.961	147.489	1870.05	0.276
Fruit length	7.768**	3.320**	0.221	5.031	65.079	0.271
Fruit girth	4.778**	1.430**	0.091	3.131	28.119	0.389
Fruit yield per plant	213149.600**	189927.600**	14614.120	132356.986	3681583.08	0.126

*, ** = Significant at 5% and 1% level of significance, respectively.

RESULTS AND DISCUSSION

In a systamatic breeding programme, selection of parents with desirable characteristics, having good general combining ability effects for yield as well as its component characters and cross combinations having high estimates of specific combining ability effects are obviously the essential features.

In present study, the analysis of combining ability variance (Table-1) indicates that general combining ability and specific combining ability variances are significant for all the characters. This suggests that both additive and non additive gene effects are involved in the expression of fruit yield per plant and its components, but later is predominant. The ratio of additive to non additive genetic variance also shows that non additive genes are predominantly involved in the expression of fruit yield per plant and its components. The results are in general agreement with the findings of Gotoh (1954), Rajendran (1972), Lal *et al.* (1973), Peter and Singh (1973), Singh *et al.* (1974, 1981) and Parmar (1988). The results of present study suggest that, for exploitation of both additive and nonadditive genetic variances, population breeding approach in the form of biparental crosses followed by modified reccurent selection may result in greater genetic improvement in the early segregating generations. The similar view was held by Dixit *et al.*, 1984.

General combining ability effects of parents (Table-2) reveals that none of the parents has proved to be good combiner for all the characters. Parent K-314 was found to be good general combiner for days to flowering, plant height, number of fruits per plant, average fruit weight, fruit length and fruit yield per plant. The high yielding parent PBR-5 was found to be good general combiner for days to flowering, number of primary branches per plant, average fruit weight, fruit girth and fruit yield per plant. The dwarf parent Pusa Purple Long proved to be good general combiner for days to flowering, number of fruits per plant, fruit length and fruit yield per plant. Parent Junagadh Selection-1 was observed to be good general combiner for plant height, average fruit weight, fruit length and fruit girth. The late flowering parent N.D.B.-25 was found to be good general combiner for fruit girth.

As far as specifc combining ability effects are concerned, no cross-combination was consistently good for all the characters (Table-3). The third high yielding hybrid K-316 x N.D.B.-25 (average x poor) recorded highest significant positive SCA effects for fruit yield per plant. This hybrid also recorded significant SCA effects in desired direction for remaining all the characters except fruit length. The highest yielding hybrid PBR-5 x K-314 (good x good) manifested significant SCA effects in desired direction for fruit yield per plant, days to flowering, plant height, number of fruits per plant and average fruit weight. Second high yielding hybrid K-316 x Pusa Purple Long (average x good) had significant SCA effects in desired direction for all the characters except plant height. The fourth high yielding hybrid Junagadh Selection-1 x Pusa Purple Long (poor x good) exhibited significant SCA effects in desired direction for number of primary branches per plant, average fruit weight and fruit yield per plant. Certain hybrids showed SCA effects in negative direction as well. The crosses displaying high positive or negative SCA effects contained good x good, good x average, good x poor, average x average, average x poor and poor x poor combiners. The

TABLE 2

Estimates of general combining ability (gca) effects of parents for various characters.

Parents	*Days to flowering*	*Plant height*	*Number of primary branches per plant*	*Number of fruits per plant*	*Average fruit weight*	*Fruit length*	*Fruit girth*	*Fruit yield per plant*
J.S.-1	2.18**	4.41**	0.15	-3.14**	4.04**	0.93**	0.76**	-108.45**
K-316	1.59**	5.84**	0.02	-0.99	3.28**	-0.77**	0.20**	30.43
Kat-4	3.96**	-3.44**	0.07	-0.38	-9.54**	-0.95**	-1.37**	-257.58**
P.P.L.	-2.86**	-5.88**	-0.12	4.40**	-3.13**	1.12**	-0.47**	187.42**
N.DB.-25	2.59**	-3.87**	-0.41**	-1.13*	-0.59	-1.09**	0.34**	66.87
P.B.R.-5	-3.93**	0.81	0.25*	-0.05	4.30**	0.18	0.59**	95.79*
K-314	-3.52**	2.13*	0.05	1.30*	1.63**	0.59**	-0.04	119.35**
S.E. (g.) ±	0.31	0.85	0.12	0.53	0.53	0.14	0.09	37.31
S.E.(g_j-g_i) ±	0.48	1.29	0.19	0.82	0.81	0.22	0.14	56.99

*, ** = Significant at 5% and 1% level of significance, respectively.

J.S.-1 = Junagadh Selection-1 and P.P.L. = Pusa Purple Long.

TABLE 3

Estimates of specific combining ability (sca) effects of hybrids for various characters.

Hybrids	Days to flowering	Plant height	Number of primary branches per plant	Number of fruits/ plant	Average fruit weight	Fruit length	Fruit girth	Fruit yield/ plant
J.S.-1 x K-316	0.93	2.11	-0.36	-2.16	7.15**	-0.53	-0.60*	-48.04
J.S.-1 x Kat-4	0.23	2.79	0.32	1.39	7.98**	2.30**	0.68*	281.85*
J.S.-1 x P.P.L.	5.05**	4.77	0.97**	2.52	5.202**	0.01	0.31	351.89**
J.S.-1 x N.D.B.-25	-6.73**	10.28**	-1.13**	-0.19	-3.19*	-2.22**	1.59**	-115.81
J.S.-1 x P.B.R.-5	3.79**	2.80	0.21	-0.94	11.71**	1.91**	0.007	151.50
J.S.-1 x K-314	-3.29**	-1.91	1.14**	4.13**	-3.18*	2.98**	-0.54*	184.73
K-316 x Kat-4	1.16	-4.24	-0.55	-3.50*	9.70**	3.22**	0.28	-13.75
K-316 x P.P.L.	-5.69**	-11.20**	0.77*	5.04**	11.61**	2.66**	1.13**	666.11**
K-316 x N.D.B.-25	-2.47**	9.45**	0.80**	9.16**	9.19**	-0.08	2.66**	809.97**
K-316 x P.B.R.-5	1.38	5.30*	0.20	-2.00	-4.40**	-1.02*	0.11	-251.59*
K-316 x K-314	-3.03**	6.72**	1.34**	0.06	0.35	-0.50	0.13	-18.28
Kat-4 x P.P.L.	-1.06	6.22**	0.78*	3.93*	3.76**	0.41	-0.07	270.08*
Kat-4 x N.D.B.-25	-1.51	-1.26	-0.39	-1.36	-9.40**	-1.14**	-1.76**	-278.41*
Kat-4 x P.B.R.-5	1.68	10.12**	0.75*	1.72	-2.92	-1.37**	0.78**	29.12
Kat-4 x K-314	1.93*	1.48	-0.25	1.62	-5.31**	-0.56	0.07	-101.87
P.P.L. x N.D.B.-25	2.64**	8.17**	-0.07	4.77*	-1.23	-0.91*	-1.20**	198.26
P.P.L. x P.B.R.-5	4.82**	-4.71	0.01	-0.40	-0.31	-0.50	0.64*	-25.87
P.P.L x K-314	-3.25	8.91**	0.14	0.25	1.95	0.79	1.37**	67.11
N.D.B.-25 x P.B.R.-5	-4.95	1.14	1.83**	0.81	11.10**	1.76**	0.95**	286.63**
N.D.B.-25 x K-314	1.97*	-9.70**	0.63	0.87	7.15**	1.38**	0.37	205.89
P.B.R.-5 x K-314	-2.51**	6.13*	-0.42	4.70**	12.00**	0.28	0.16	673.66**
S.E. (S_{ij}) ±	0.89	2.42	0.35	1.53	1.52	0.41	0.27	106.61
S.E. (S_{ij} - S_{kl}) ±	1.26	3.42	0.49	2.16	2.15	0.59	0.38	150.77

*, ** = Significant at 5% and 1% level of significance, respectively.
J.S.-1 = Junagadh Selection-1 and P.P.L. = Pusa Purple Long.

marked undesirable SCA effects in hybrids between good x good combiners can be attributed to the lack of coadoptation between favourable alleles of the parents involved.

On the basis of combining ability analysis, the most promising parents were K-314, PBR-5 and Pusa Purple Long. The most promising hybrids were, K-316 x N.D.B.-25, K-316 x Pusa Purple Long, PBR-5 x K-314 and Junagadh Selection-1 x Pusa Purple Long. These parents and hybrids offer the best possibility of their future exploitation for developing high yielding varieties.

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Combining Ability Analysis for Polygenic Traits in Greengram

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ABSTRACT

In a 6 x 6 diallel cross of greengram, general and specific combining ability variences were found significant for all the characters except GCA for plant height and SCA for number of grains per pod. The GCA : SCA variences ratio signified the predominant role of additive verience for days to 50 per cent flowering, days to maturity, pod length, number of grains per pod amd test weight. The parent ML-69 and hybrid ML-69 x Gujarat-1 were found to be promising for further exploitation.

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INTRODUCTION

Greengram is an important food grain legume in India, however, very little work has been done to understand the nature of gene action of yield and its components. Consequently, the progress in the development of new high yielding varieties has been quite slow as compared to other crops. The present study was, therefore, undertaken to study the gene action involved in the inheritance of yield and its components.

MATERIALS AND METHODS

Experimental material for the present study consisted of six varieties viz., ML-69, MJC 72, MJC 35, Gujarat 1, Gujarat 2 and Culture 1 and their all possible 15 F_1S (excluding reciprocals). The experimental was evaluated of Pulse Research Station, Junagadh in randomized block design with three replications in 4 m long single row plot spaced 45 cm between rows and 10 cm within a row. Ten plants excluding border ones were randomly selected in each entry in each replication for plant height, days to 50 per cent flowering, number of effective branches per plant, number of cluster per plant, number of pods per plant, days to maturity, pod length, number of grains per pod, 100 seed weight and yield per plant. Data were analysed according to the procedure described by Griffing (1956) using model-1 and method-2.

RESULTS AND DISCUSSION

Combining ability analysis furnishes information about fixable and nonfixable genetic variences. In the present study, general and specific combining ability varience were found to be significant for all the traits except GCA for plant height and SCA for number of grains per

TABLE 1

Analysis of variance for various quantitative trials in diallel analysis in greengram.

Source	df	Plant height (cm)	Days to 50% flowering	No. of effective branches/ plant	No. of clusters/ plant	No. of pods/ plant	Days to maturity	Pod length (cm)	No. of grains/ pod	Test weight (g)	Grain yield/ plant (g)
GCA	5	0.409	0.912**	0.151*	2.208*	35.834**	2.395**	0.899**	1.167**	0.418**	1.391**
SCA	15	9.643**	0.873**	0.277**	2.674**	35.899**	1.610**	0.326**	0.335	0.153**	3.932**
ERROR	40	0.784	0.221	0.053	0.424	0.063	0.183	0.059	0.234	0.020	0.269
GCA / SCA		0.042	1.046	0.545	0.863	0.998	1.487	2.759	3.487	2.728	0.354

* Significant at 5% level of probability.

** Significant at 1% level of probability.

TABLE 2

General combining ability effects for various quantitative traits.

Parents	Plant height (cm)	Days to 50% flowering	No. of effective branches/ plant	No. of clusters/ plant	No. of pods/ plant	Days to maturity	Pod length (cm)	No. of grains/ pod	Test weight (g)	Grain yield/ plant (g)
ML-69	0.300	0.311**	0.078	0.855**	3.969**	0.306**	-0.399**	-0.294	-0.351**	0.507*
MJC-72	0.461	-0.566**	-0.272**	-0.663**	-1.460**	-0.819**	-0.119	-0.503**	0.367**	-0.295
MJC-35	-0.083	0.381*	0.053	0.296	2.234	-0.361**	0.371**	0.478**	0.046	-0.453**
Gujarat-1	0.385	-0.025	0.036	-0.292	0.515	0.721	-0.249**	-0.138	-0.028	0.148
Gujarat-2	0.229	-0.023	0.099	-0.292	-0.230**	-0.111*	0.434**	0.369*	0.154**	-0.325
Culture-1	-0.682*	-0.079	0.007	0.099	0.270	0.264**	0.039	0.088	-0.129**	0.438*
S.E. ± (g_i)	0.286	0.152	0.064	0.210	0.651	0.019	0.078	0.167	0.046	0.168
S.E. ± (g_i-g_j)	0.043	0.235	0.100	0.230	1.008	0.046	0.121	0.242	0.071	0.259

* Significant at 5% level of probability.

** Significant at 1% level of probability.

TABLE 3

Specific combining ability effects for ten quantitative traits.

Crosses	*Plant hight (cm)*	*Days to 50% flower-ing*	*No. of effective branches/ plant*	*No. of cluster/ plant*	*No. of pods/ plant*	*Days to maturity*	*Pod length (cm)*	*Grain/ pod*	*Test weight (g)*	*Grain yield plant (g)*	
ML-69 x MJC-72	0.736	0.008	1.159**	4.130**	12.873**	1.200**	1.130	0.555	-0.182	2.311**	(12.29)
ML-69 x MJC-35	-0.780	0.140	0.134	0.728	6.206**	0.402**	-0.200	0.045	-0.081	2.528**	(12.35)
ML-69 x Gujarat-1	-0.948	-0.123**	0.485**	0.715	4.628**	-0.010	0.020	-0.410	0.043	2.267**	(12.69)
ML-69 x Gujarat-2	-0.728	0.874*	-0.278	1.425	4.903*	0.492**	-0.502	-0.716	0.002	-0.289	(9.66)
ML-69 x Culture-1	-0.051	-0.399	0.447	-1.206*	4.096	0.447**	0.105	0.435	0.004	0.927	(11.64)
MJC-72 x MJC-35	1.619*	-0.322	-0.082	-0.551	0.775	-1.867*	-0.950**	0.054	-0.759**	-0.709	(8.31)
MJC-72 x Gujarat-1	0.221	-0.246	0.032	0.276	0.484	-1.555**	-0.230	0.329	-0.305*	-0.141	(9.48)
MJC-72 x Gujarat-2	0.316	-1.248	0.038	-0.864	-0.709	-1.723	-0.542	0.238	-0.647	-0.117	(9.03)
MJC-72 x Culture-1	-1.643*	0.478	0.030	1.655**	-2.029	0.902*	0.370	-0.226	0.096	1.870**	(11.78)
MJC-35 x Gujarat-1	1.665*	0.477	0.376*	0.947	1.830	0.987**	0.820**	0.989**	10.186	1.967**	(11.43)
MJC-35 x Gujarat-2	-0.700	0.474	0.047	0.044	-0.315	-1.180	0.008	0.082	0.004	-0.459	(8.53)
MJC-35 x Culture-1	-1.669*	1.090**	0.739	0.653	1.615	-1.215**	0.720**	0.824	0.387**	0.343	(9.41)
Gujarat-1 x Gujarat-2	1.293	1.210**	-0.003	0.361	3.026	1.467*	0.552*	-0.373	0.128	0.340	(9.93)
Gujarat-1 x Culture-1	0.434	0.597	-0.144	0.670	2.056	1.362**	0.020	-0.061	0.089	0.104	(10.25)
Gujarat-2 x Culture-1	0.029	0.934*	0.193	-0.040	0.341	0.865**	0.418	-0.198	-0.040	1.859**	(11.74)
S. E.± (S_{ij})	0.785	0.417	0.176	0.577	1.676	0.145	0.215	0.429	0.125	0.460	
S. E. ± (S_{ij}-Sik)	1.171	0.622	0.263	0.861	2.667	0.323	0.321	0.640	0.187	0.417	
S. E. ± (S_{ij}-Sik)	1.084	0.576	0.244	0.797	2.469	0.277	0.297	0.593	0.173	0.636	

* Significant at 5% level of probability

** Significant at 1% level of probability

Mean grain yield data are given in the perantheses.

pod (Table 1) this suggested the importance of both additive and nonadditive genetic. components. However, higher relative magnitude of GCA varience over SCA varience for days to flowering, days to maturity, pod length, grain per pod and test weight (Table-1) indicated that additive type of gene action was primarily involved in the expression of these characters. Reddy and Shreekumar (1982) had shown the predominance of additive gene action in the expression of most of the traits.

General combining ability effects of the parent (Table 2) revealed that considering all the characters, parent ML 69 appeared to be good general combiner contributed maximum favourable genes for grain yield, pods per palnt and clusters per plant. Parent MJC-72 was found to be good general combiner for days to 50 per cent flowering and test weight. Thimmappa *et al.* (1989), and Saxena and Sharma (1989) also reported the similar results. Parent MJC 35 and Gujarat 2 were good general combiner for days to maturity, pod length and grains per pod. Culture 1 was good combiner for grain yield. Bold seeded varieties MJC 72 and Gujarat 2 exhibited good general combining ability for test weight. Jatasra (1980) had reported in cowpea that bold seeded varieties were good combiners for higher grain weight. It would not be out place to mention here that the commercial variety may not always turn out to be best combiner. In this investigation too. Gujarat 2 a commercial cultivar did not perform well.

The estimation of specific combining ability effects (Table 3) indicated that the top yielding hybrid ML-79 x Gujarat 1 was a good specific combination for grain yield per plant, number of pods per plant, number of effective branches per plant and days to 50 per. cent flowering. These results were as that of Natarajan *et al.* (1989). Thus there is every likelihood of improvement, both by selection and hybridization, for most of the characters.

All the hybrids gave high grain yield their best parent. Significant SCA effect for grain yield per plant was found for hybrid ML 69 x Gujarat 1 which gave highest grain yield (Table-3). The parents involved in this cross were good x average combiner for grain yield and number of pods per plant, average x average for number of effective branches per plant and poor x average combiner for number of days to 50 per cent flowering.

The genetic information obtained from the present study revealed that Parent ML 69 and Hybrid ML 69 x Gujarat 1 were found to be promising for further exploitation.

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Annual and Seasonal Effects of Meteorological and Associated Parameters on Pan Evaporation

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ABSTRACT

This paper deals with an approach to establish a quantitative relationship between the pan evaporation and 8 different meteorological parameters using stepwise multiple regression analysis. The variables viz. evaporating power of the air (Ea) and solar radiation (Rs) were found to be the significant factors influencing pan evaporation for annual and seasonal basis while the weather parameters like air temperature, relative humidity and wind velocity showed a signigicant effect during summer season. The prediction equations fitted for different seasons and annual basis explained more than 91% variation in pan evaporation. With the help of the regression equations developed in this study it may be possible to estimate pan evaporation in South Saurashtra agroclimatic zone.

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INTRODUCTION

Evaporation from a free water surface is a good indication of the climatic condition of a region for crop production. It reflects the influence of several meteorological parameters like air temperature, sunshine hours, wind velocity, relative humidity, solar radiation, evaporating power of the air and vapour pressure deficit of a locality. It may be pointed out that pan evaporation data are mainly used for predicting evapotranspiration and water requirement of crops. Since actual measured pan evaporation data are not readily available in most of the locations, it becomes assertive to use formulae which can estimate pan evaporation from available climatic data. A number of empirical methods have therefore been proposed by several investigators (Penman, 1948; Fitzpatrick, 1963; Christiansen, 1968; Linacre, 1977; Singh *et al.* 1981; Senapati *et al.* 1985; Swan and Volum, 1986; and Cahoon *et al.* 1991) in different countries and India. The major limitation to the use of these formulae is that they can be used in the climates, seasons or environments from where they were evolved. Therefore, the present study is an attempt to investigate the influence of some meteorological and associated parameters on evaporation as measured in a class a type pan evaporimeter at Junagadh under South Saurashtra agroclimatic zone on annual as well as seasonal basis.

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MATERIALS AND METHODS

Daily meteorological data for 27 years (1965-91) was collected from the agro-meteorological observatory at Junagadh campus (21°30' N lat., 70°30' E long., 61 m msl). The location represents subtropical semi-arid type of climate with an annual average rainfall of 916.7 mm. The associated parameters such as (1) Evaporating power of the air (Ea), (2) Solar radiation (Rs), (3) vapour pressure deficit (VPD) were computed using standard meteorological formulae as described in FAO (1983) from the routinely recorded meteorological parameters viz., maximum and minimum temperature, morning and afternoon relative humidity, wind velocity in km/hr and bright sunshine hours. Mean air temperature (T) and temperature range (TR) were calculated using maximum and minimum temperature, and mean relative humidity (RH) by averaging morning and afternoon r.h. values. Weekly values of all the above variables were compiled and computed to a single estimate for 52 weeks of the years and used for further analysis.

The analysis of data was carried out in two steps. In the first step, the mean, coefficient of variation and correlation coefficients for all the variables were estimated and tested for significance to 5% level. In the second step, stepwise multiple regression analysis was undertaken to assess quantitatively the relative importance/influence of each variable on evaporation for each season separately. A software package MICROSTAT was used for the above purpose.

Considering uniformity in weather conditions the whole year was divided into four seasons (1) monsoon (June to September), (2) post monsoon (October-November), (3) winter (December-February) and (4) summer (March-May) to study the effect of weather variables on evaporation during each season.

RESULTS AND DISCUSSION

Mean and variability of weather variables

The mean, coefficient of variation (CV%) and correlation coefficients (r) between pan evaporation and weather variables are given in Table 1 indicating the effect of variables during different seasons and on annual basis. The daily mean evaporation rate is 7.1 mm with 29 per cent variability during the whole year. The rate of evaporation during monsoon, winter and summer seasons were 6.0 mm, 6.3 mm and 10.1 mm respectively with the highest variability of 29% during monsoon season. This may be attributed to the influence of other variables which show very high variability (Table 1). The high variability of weather variables indicates their responsibility to influence pan evaporation during different seasons (Fatzpatrick, 1963).

Correlation studies

From the correlation analysis it was observed that most of the correlation coefficients were highly significant at 1% level except for the 2 month period of post monsoon season. The relative humidity had negative correlation during all the seasons except summer season. All the weather variables except evaporating power of the air (Ea) and vapour pressure deficit (vpd) were found to be associated with evaporation significantly during summer season.

In view of various effects of meteorological parameters with evaporation, stepwise multiple regression analysis was carried out to

TABLE 1

Mean, coefficient of variation (CV) and correlation coefficient (r) of weather variable for different seasons at Junagadh.

Variables	Annual			Monsoon			Post monsoon			Winter			Summer		
	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r
EO mm/day	7.1	29	_	6.0	29	_	6.0	8	_	6.3	15	_	10.1	7	_
Ea mm/day	5.6	36	0.868**	3.7	49	0.947**	5.5	16	0.366	5.6	15	0.920**	8.1	6	-0.198
Rs mm/day	8.6	14	0.849**	8.1	9	0.551*	7.8	8	0.600	7.4	10	0.965**	9.8	5	0.862**
Td°C	15.6	30	0.193	9.6	19	0.048	17.4	9	0.470	20.5	3	-0.551*	17.4	13	-0.75**
T°C	26.6	14	0.513**	28.5	6	0.939**	26.8	7	0.415	21.3	6	0.649*	29.3	7	0.880**
RH %	59	25	-0.374**	78	8	-0.667**	55	12	-0.016	46	9	-0.834**	51	15	0.781**
W, km/hr	7.7	34	0.501**	9.4	32	0.833**	5.0	16	0.190	6.4	10	0.625*	8.8	16	0.803**
BSS hr/day	7.9	33	0.460**	4.7	48	0.221	8.9	5	0.697*	9.5	5	0.834**	9.8	4	0.647*
VPD mm Hg/day	10.5	34	0.777**	6.6	38	0.784**	11.8	10	0.518	10.3	14	0.912**	14.8	8	-0.164

* Significant at 5% and ** at 1% levels

find out the most influensive parameters for different seasons and on annual basis at Junagadh.

Multiple regression analysis

In the multiple regression analysis six variables out of eight were found to influence the pan evaporation significantly in different seasons and annual basis. The linear models derived for different seasons are given below :

(1) Annual (52 weeks)

$$E_0 = -3.7629 + 0.5983\ Ea + 0.7218\ Rs + 0.1949\ W$$

(14.95) (9.36) (7.22)

$$r^2 = -0.9561$$

(2) Monsoon (June-September) 17 weeks

$$E_0 = -8.0459 + 1.2750\ Ea + 0.1203\ RH$$

(13.1) (4.55)

$$r^2 = 0.9585$$

(3) Post monsoon (October-November) 9 weeks

$$E_0 = -0.7654 + 0.6207\ Ea + 1.0909\ Rs + 0.1178\ TD - 0.8056\ BSS$$

(4.12) (5.98)

$$r^2 = 0.9484$$

(4) Winter (December - February) 13 weeks

$$E_0 = -3.2445 + 0.6740\ Ea + 1.5569\ Rs - 0.5683\ VPD$$

(3.38) (6.00) (3.16)

$$r^2 = 0.9722$$

(5) Summer season (March - May) 13 weeks

$$E_0 = 2.5079 - 0.4892\ Ea + 0.5190\ T - 0.1816\ RH + 0.6348\ W$$

(4.32) (3.04) (3.30)

$$r^2 = 0.9077$$

Numbers written in the brackets are 't' values of corresponding parameters indicating their significant contribution in the equations. Evaporating power of the air (Ea) was found to be the most common factor influencing pan evaporation in association with either relative humidity in monsoon season, or solar radiation and vapour pressure deficit in winter season or with wind velocity on annual basis at Junagadh station. The linear models derived in this study

showed more than 96 per cent predictability with nearly 98% of total variation in evaporation on annual basis.

The analysis reveals that the meteorological parameters have selective and significant influence on pan evaporation seasonally and annually under South Saurashtra agroclimatic conditions prevailing at Junagadh. The estimation equations developed in this paper can successfully be used to predict evaporation in this zone. However, it is necessary to make similar studies at other stations located in different agroclimatic zones.

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Use of Information Sources at Different Stages of its Adoption by the Cumin Growers

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ABSTRACT

The present study highlights the various sources of information used by cumin growers for its adoption. The study reveals that 'VLW', 'Farmers discussion group' and 'family members' are major sources of information used by the cumin growers.

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INTRODUCTION

Information sources are pre-requisite for the awareness and adoption of innovation. It provides link between the diffusion of innovation and its final adoption. The sources or channels of supply of information on new idea greatly influence the adoption process.

Supe (1971) stated that the farmers gave high credibility to the informal sources like personal experience, friends, relatives and neighbours. Shukla (1972) found that the extension workers was the first source. Most of the adopters had consulted extension workers at the decision stage. Jadon (1973) concluded that 73 per cent of the respondents had received information from progressive farmers about improved practices of potato cultivation and 65 per cent adopters had also received the same from VLW. Panchal (1975) found that radio, progressive farmers and VLW were the important sources of information at various stages of adoption process for improved seeds and plant protection measures for hybrid-4 cotton. While in case of chemical fertilizers, printed literature and personal experience were also important sources besides VLWs and progressive farmers. Patel (1977) concluded that source of family members was the most important source of information at initial as well as decision stages.

The difference in utilization of information sources was studied at initial, detailed information seeking and decision taking stages of adoption by cumin growers.

MATERIALS AND METHODS

The study was conducted in five talukas of Bhavnagar district having maximum area under cumin crop. The data were collected by arranging personal interview with the 205 cumin growers.

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The sources of information utilised by the respondents at various stages of adoption process were worked out. Three important stages, according to Prasad and Sinha (1971) were used in this study. They were (a) first information (b) most information and (c) decision. These stages were renamed as initial, detailed information seeking and decision taking stage respectively.

Every respondent was asked to indicate the source/sources from which they got the first idea of introducing cumin crop. Such sources were considered as sources at initial stage. For detailed information seeking and decision stages, an open-ended question was asked to every respondent. They were asked to indicate the sources from which they sought detailed information regarding the complete cultivation practices of the cumin crop. These sources were considered as sources utilised a detailed information seeking stage. They were further asked to indicate the name of the agencies who were consulted at the time of considering advantages and disadvantages of cumin cultivation and feasibility of introducing crops other than cumin. These were considered as sources utilized at decision taking stage. Their frequencies were counted and percentages were worked out.

RESULTS AND DISCUSSION

Farmers utilize various sources of information at different stages of adoption. In this study three stages namely (1) Initial/getting idea (2) Detailed information seeking and (3) Decision taking, were considered. The data collected on source utilization at these three stages have been presented in Table 1.

TABLE 1

Distribution of cumin growers according to source of information used by them at three stages of adoption.

(N = 205)

Information sources used	*Stages*					
	Initial/getting idea		*Detialed information seeking*		*Decision taking*	
	No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
Family members	7	3.41	14	6.83	36	17.56
Relatives	57	27.80	35	17.07	8	3.90
Friends	9	4.39	9	4.39	17	8.29
Neighbours	8	3.90	10	4.88	5	2.44
Other cumin growers	85	41.46	130	63.41	54	26.34
Village level workers (VLW)	13	6.34	98	47.80	11	5.00
Agril. Extension Officer (AEO)	0	0	17	8.29	2	0.98

1.	2.	3.	4.	5.	6.	7.
Cooperative Society	0	0	8	3.90	0	0
Radio	0	0	25	12.20	0	0
Printed literature	0	0	23	11.22	0	0
Farmer discussion group	0	0	8	3.90	56	27.32
Pesticides store	0	0	29	13.17	0	0
Cumin merchants	11	5.37	0	0	0	0
Others (self experience)	13	6.34	17	8.29	59	28.79

'F' value

(1) Sources 3.35 highly significant at 13 d.f.

(2) Stages 2.02 non significant at 2 d.f.

(1) Initial Stage

Data presented in Table 1 indicate that 41.46 per cent of the respondents had got the idea of introducing cumin cultivation from other cumin growers (experienced farmers) followed by relatives (27.80%) and VLW (6.34%). While top merchants dealing with sales and purchase of cumin, friends, neighbours and family members were sources for getting the idea of cumin cultivation initially for 5.37 per cent, 4.39 per cent, 3.90 per cent and 3.41 per cent respectively.

In case of 6.34 per cent respondents, the idea of cumin cultivation was self-motivated. While AEO, radio, farmer discussion group, co-operative society, printed literature and pesticides store were not the sources of information at the initial stage as indicated by the cumin growers. On the basis of the above discussion, it can be concluded that other cumin growers (experienced farmers) were the most important sources at the initial stage. The second best source was relatives. The mass madia like radio and printed literature were not used as sources of information at the first stage of adoption.

(2) Detailed Information Seeking Stage

It can be visualised from the Table-1 that at the detailed information seeking stage, the respondents had sought detailed information from more than one source, other cumin growers (experienced farmers) were at the top as a source of information at this stage and it was utilised by 63.41 per cent of the respondents. Next to other cumin growers, VLW (47.80%), relatives (17.07%), pesticides store (14.05%), radio (12.20%) and printed literature (11.22%) were the other sources in the sequence. AEO, family members,neighbours and friends were utilised by 8.29 per cent, 6.83 per cent, 4.88 per cent and 4.39 per cent of the respondents respectively. While a few i. e. 3.90 per cent of the respondents had collected detailed information on cumin cultivation from coooperative society and farmers discussion group. Self experience was expressed as a source of information by 8.29 per cent of the cumin growers. It is clear from the above dis-

cussion that other cumin growers (experienced farmers), VLW and relatives were the most utilised sources of information by the respondents for collecting detailed information regarding cumin cultivation.

(3) Decision taking stage

The data presented in Table-1 related to source utilization at the decision stage revealed that out of total respondents, more than one-fourth (27.32% and 26.34%) of the respondents were helped by farmer discussion group and other cumin growers (experienced farmers) respectively in taking decision for starting cultivation of cumin crop. About 28 per cent of the respondents had took decision of adoption of cumin cultivation themselves without taking help from any person. Other sources like family members, friends and VLW were utilised by farmers at the final stage of adoption. A few respondents had sought help at decision taking stage from neighbours and AEO.

The experienced farmers were found to be the most utilised source at all three stage because the information based on their experience is generally considered more dependable.

On the whole, it can be concluded that other cumin growers (experienced farmers) was the most important source of information at initial as well as decision taking stage. While the other cumin growers, VLW and relatives were the most utilised sources of information at the detailed information seeking stage.

The calculated 'F' value (3.35) for sources was more than the table value at 1 per cent level of significance. It indicates that the difference in the utilization of various sources is highly significant. Thus, it can be inferred that the utilization of various sources by the cumin growers did differ among themselves. In other words, all sources were not equally utilised.

The calculated 'F' value (2.02) for stages was found to be non-significant showing that the variation in the sources utilization at three stages was not significant. It means sources utilized at various stages did not differ. In other words, the source utilization patern at three stages were more or less silimar.

Implication

1. Cumin growers relied on informal personal sources for information about cumin cultivation. Information of such persons may be incomplete and incorrect. Therefore, farmers should be motivated and trained to use formal sources of information to supplement and verify the information obtained from the informal sources.

2. Even when the cumin growers had a good educational background, the utilization of mass media like radio, printed literature etc. was negligible. Hence, the extension service should create favourable attitude towards the mass media among the farmers by intensifying the dissemination of knowledge regularly through publications like leaflets, pemphlets, circular letters, radio talks and news paper release etc.

3. The most identified information sources at initial stage were other cumin growers (experienced farmers) and relatives. Thus, while planning to communicate the farmers for new changes, the counselling agencies should consider these sources through proper training.

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Optimum Plot Size for Summer Paddy in the Navsari Zone of Gujarat

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ABSTRACT

Optimum plot size and shape of plot has been worked out from uniformity trial on summer paddy crop. Maximum curvature method, Fair-field Smith's verlance law and the comparable variance method were used for the purpose. A plot of 12 units i.e. 10 rows each of 6.3 meter length (i.e. 2 m. x 6.3 m. was found optimum for paddy variety I.R.8 grown at Navsari zone of Gujarat State.

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INTRODUCTION

One of the important factors which has direct impact on the efficiency of the field experimentation in the size and shape of experimental plot, which varies with the crops. The other factors affecting the precision of the experimental result are experimental material, cost of various operations and material involved in conducting the experiment. Several workers have worked with the methodology for determining optimum plot size from uniformity trial data (Smith, 1938; Keller, 1949; Koch and Rigney, 1951; Federer, 1955; Hatheway and Williams, 1958 and Patel and Patel 1968). While Abraham and Vachhani (1964) and Agrawal and Deshpande (1967) reported optimum plot size for paddy crop. However, there is no report on optimum plot size for paddy for South Gujarat, being predominantly paddy growing area. This paper reports the results of uniformity trial on paddy conducted at the Agronomy Farm, N. M. College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari during the summer season of the year 1982.

MATERIALS AND METHODS

The popular variety I.R. 8 was planted in a field of 26 m x 23 m size. Three seedling per hill was transplanted. The spacing was 20 cm between rows and 15 cm between two dibbles within row. All the recommended practices in vogue were followed. The crop was harvested in small units each of 35 hills (5 row each having 7 hills), the size of the basic unit being 1 m x 1.05 m. Border area of one meter width all around was excluded from the trial. Thus total area harvested was 24 m x 21 m making 480 basic units under study. Grain yield of paddy was recorded seperately for each basic unit. The different sized plots of sizes 1, 2, 4, 5, 6, 8, 10, 12, 16, 20, 24 and 30 units were

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formed by combining the adjacent units both length wise as well as width wise.

Statistical analysis

Maximum curvature method (Federer, 1955). Smith's variance law (Smith, 1938) and comparable variance method (Keller, 1949) were employed to investigate the optimum plot size and shape for summer paddy (Cv. IR 8).

Maximum curvature method involves plotting a curve of the C. V. per cent per unit area against plot size. Therefore C. V. per cent per unit area was estimated for various sized plots. These C. V. per cent are termed as unadjusted C. V. per cent.

Soil heterogeneity index 'b' was also estimated for determining optimum plot size with the help of an emperical relation between plot variance and size, developed by Smith (1938) as under :

$$Vx = V_1 / X^b$$

The estimated 'b' indicates the degree of correlation among the adjacent units. It was therefore, thought worthwhile to work out C. V. per cent after adjusting variance per unit area for degree of correlation 'b' among adjacent units to help workout optimum plot size based on uncorrelated estimates. These C. V. per cent are termed as adjusted C. V. per cent.

RESULTS AND DISCUSSION

The C. V. per cent was worked out and comparison were made among different sizes and shapes of plots using adjusted and unadjusted C. V. per cent.

TABLE 1

Average C. V. per cent per unit size for grain yield of paddy.

Size of plot	*C. V. per cent (unadjusted)*	*Difference in C. V. per cent (unadjusted)*	*Per unit decrease in CV % (unadjusted)*	*C.V. per cent (adjusted)*
1	20.69	–	–	20.69
2	17.71	2.98	2.98	18.23
4	15.40	2.31	1.16	16.10
5	14.34	1.06	1.06	15.65
6	14.30	0.04	0.04	15.42
8	13.84	0.86	0.43	14.90
10	13.31	0.53	0.27	14.24
12	12.59	0.72	0.36	13.95
16	12.51	0.08	0.02	13.69
20	12.50	0.01	0.003	13.76
24	11.53	0.97	0.24	12.25
30	11.04	0.49	0.15	12.38

The average C. V. per cent (unadjusted) varied from 20.69 for one unit plot size to 11.04 for thirty unit plot size (Table 1), while C. V. per cent (adjusted) varied from 20.69 to 12.38 for the same range of plot size (Table 1). The C. V. per cent gradually decreased with the increase in plot size. Decrease in C. V. per cent with increase in plot size in case of paddy crop was also reported by Abraham and Vachhani (1964) and Agrawal and Deshpande (1967).

A further look into C. V. per cent (unadjusted) revealed that the reduction was more in beginning and then decrease become marginal. The average C. V. per cent (unadujsted), beyond 12 units plot size was not proportional to the area added in forming large sized plot. The results are in agreement with the results reported by Abraham and Vachhani (1964) and Agrawal and Deshpande (1967).

The difference between C. V. per cent of the consecutive points (plot size) may help to estimate per unit decrease in C. V. per cent and thereby the point of maximum curvature. The per unit decrease in C. V. per cent (unadjusted) decreased with the increase in the plot size upto 10 units (Table 1). Beyond 10 units plot size, the decrease in C. V. per cent was not proportional to the amount of land used in forming large sized plots. The optimum plot size is just beyond the point of maximum curvature (Figure 1). Therefore, 12 units plot size was considered as an optimum plot size for paddy.

The correlation among adjacent units ('b' = 0.4052) when used in adjustment, increased the variance per unit (Vx). The relation derived by Smith (1938) to estimate Vx is $Vx = V_1 / X^b$ where 'b' varies from 0 to 1. The C. V per cent adjusted were high as compared to C. V. per cent unadjusted (Table 1). The optimum plot

TABLE 2

Comparable variance and relative information for different plot size of summer paddy.

Size of plot (X)	*Observed variance (Vx)*	*Comparable variance (V)*	*Relative information (%)*
1	3651	3651	100
2	5355	2677	68
4	7895	1974	64
5	8775	1755	42
6	13070	1728	28
8	13066	1633	28
10	15104	1510	24
12	16179	1348	23
20	26769	1338	14
24	27229	1135	13
30	34664	1155	11

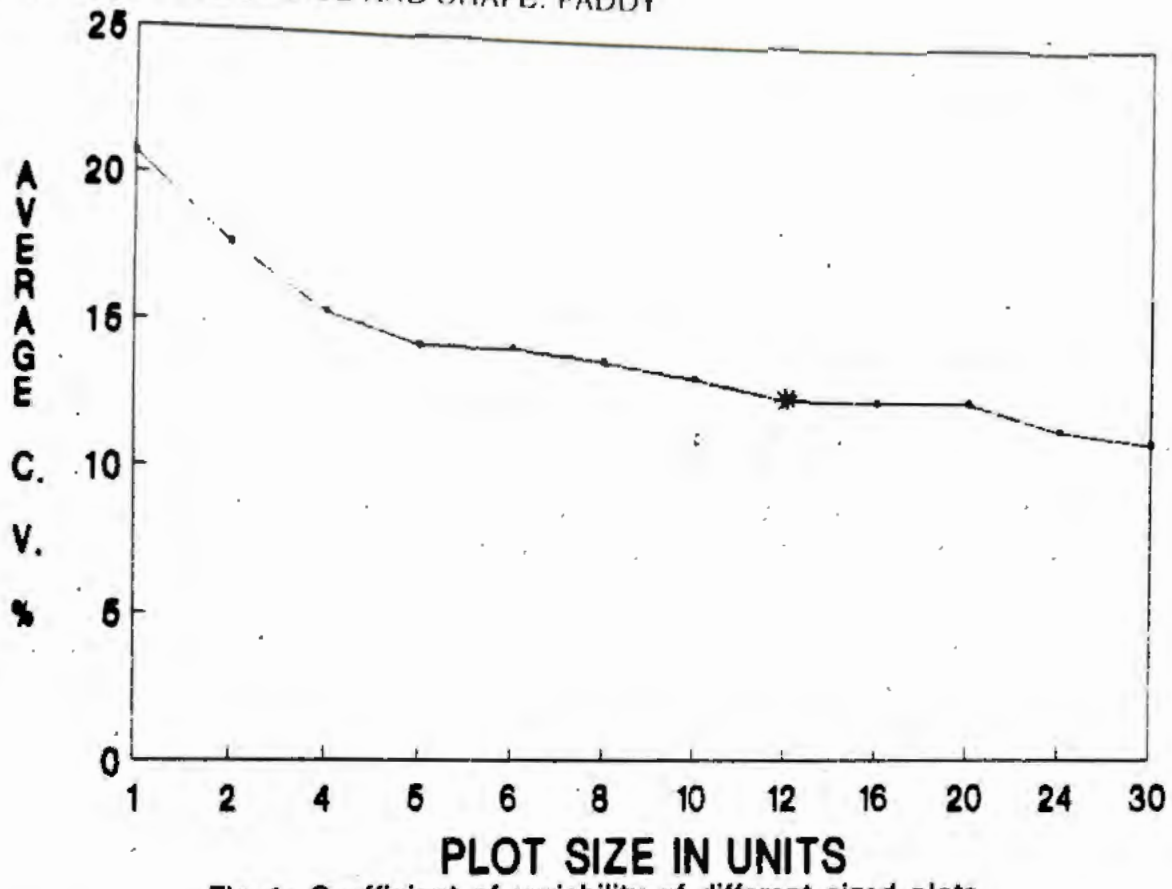

Fig. 1: Coefficient of variability of different sized plots

size worked out on the basis of Smith's formula depends on K2 (the cost proportional to total area per treatment) which varies with the nature of the experiment. It is rather difficult to arrive at exact value of K2 for each and every experiments. Therefore, K2 imposes limitations in defining the exact value of the optimum plot size. The Smith's variance law, thus provides only guideline in determining the optimum plot size. Pearce (1976) also showed that Smith's law lacks theoretical basis.

The comparable variance (V) and relative information (RI) were calculated for different sized plot (Table 2). If the occurrence of plots were completely at random (completely heterogeneity) then b=1 and from the equation by Smith (1938), we have $XVx = V_1 = V$.

Thus under the assumption of randomness, the comparable variance is constant and any plot size will give 100 per cent relative information. However, such a situation is hardly possible due to the correlation among adjacent plots. Hence increase in plot size should results in decrease in variance (Vx) and relative information.

The results (Table 2) revealed that the variance (Vx) and relative information decreased as the plot size increased. The variance (Vx) of basic unit was assumed to contribute 100 per cent relative information which is the greatest relative information (Keller, 1949). The decrease in Vx and relative information was rapid in the beginning upto 6 units size plot (3651 to 1728 and 100 to 28 per cent in Vx and relative information respectively) and thenafter decrease becomes gradual. In general Vx and relative information decreased as plot size increased (Keller, 1949). Since the decrease in Vx and relative information beyond 12 units plot size, was not proportional to the area added, a 12 unit plot size could be considered as an optimum plot size.

In order to estimate the optimum plot size due to plot shape, comparable variance (V) and relative information (RI) were calculated for two sets of plot size viz., X1 > X2 and X1 < X2 where X1 is length of plot along the row and X2 the width across the row (Table 3). An examination of data (Table 3) reveales that V increased and RI decreased as plot size increased. The same result was observed by Keller (1949) who developed this method. In general, the variance per unit area in both the cases remained more or less stabilized after 12 basic units and hence optimum plot size can be safely fixed at 12 times basic units. Another interesting information is that the variance is minimum when length of row is increased

TABLE 3

Average variance per basic unit, comparable variance and relative information for different shapes of plot (X1 > X2 and X1 < X2) of summer paddy.

Size of plot (X) (X1 > X2)	*Observed variance (Vx)*	*Comparable variance (V)*	*Relative information (RI %)*	*Regression coefficient (b)*
2 (2 x 1)	5413	2707	67	0.4316
4 (4 x 1)	7741	1935	47	0.4579
5 (5 x 1)	8775	1755	42	0.4551
6 (6 x 1)	9760	1627	37	0.4510
8 (8 x 1)	12743	1593	29	0.3988
10 (5 x 2)	15104	1510	24	0.3834
12 (6 x 2)	15974	1331	23	0.4060
12 (4 x 3)	16203	1350	23	0.4004
20 (5 x 4)	26769	1338	14	0.3350
(X1 < X2)				
1 (1 x 1)	3651	3651	100	–
2 (1 x 2)	5296	2648	69	0.4635
4 (1 x 4)	8049	2012	45	0.4298
6 (1 x 6)	10400	1733	35	0.4158
6 (2 x 3)	10951	1825	33	0.3869
8 (1 x 8)	12937	1617	28	0.3917
8 (2 x 4)	13517	1690	27	0.3704
12 (3 x 4)	17000	1417	21	0.3808
12 (2 x 6)	17572	1464	21	0.3678
24 (4 x 6)	27229	1135	13	0.3676

rather than taking more number of rows i.e. rectangular plot.

Among all combinations of 12 units plot, a plot of 10 rows each of 6.3 m length (6 x 2) had minimum observed variance (Table 3) and there by minimum unadjusted C. V. per cent. The results therefore, leads to the conclusion that 12 units plot (2 m x 6.3 m) is an optimum plot size for summer paddy (Cv. IR 8) in Navsari zone of Gujarat State.

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Comparison of Sampling Methods for Estimating Lucern Yield

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ABSTRACT

The efficiency of three sampling methods, viz., stratified random sampling, double sampling and component sampling over simple random sampling was compared for estimating total green forage yield of lucern (Cv. Anand 2). The uniformity trial data of the years 1988-89 and 1989-90 were used for the purpose. In all six cuts were obtained in each year. The results revealed that the stratified random sampling and component sampling were more efficient than the SRS. The double sampling could not prove effective for this purpose.

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INTRODUCTION

Several sampling methods have been developed for crop survey to estimate total production with a view to get maximum information at a minimum cost. Generally simple random sampling (SRS), stratified random sampling etc are employed depending upon the situation. It become easy to collect data of crops having single cut. But for crops like lucern having multi-cut harvest, it becomes difficult to collect the data because of transport and supervision difficulties. Such surveys are time consuming and costlier. Goel *et al.* (1978) and Kaistha and Goel (1981) showed that it is feasible to utilize partial harvest data collected through double sampling and component sampling to estimate total production of crops having multi-harvest nature. However such information is lacking for lucern crop. The results presented herein relate to the relative efficiency of stratified random sampling, double sampling and component sampling in comparison to SRS for estimating total green fodder yield of lucern variety Anand 2, being the most popular variety among farmers.

MATERIALS AND METHODS

The data generated through uniformity trial conducted at the Forage Research Farm, GAU, Anand during the crop seasons of the years 1988-89 and 1989-90 were utilized for the purpose. The analysis of yield data of 1200 and 400 basic units each of one sq. m. revealed that a sampling plot of 10 sq. m. area (1 m length x 10 m width) was the optimum size for recording green fodder yield. The adjacent basic units were combined to form plots each of 10 sq. m. area, making 120 and 40 plots in

first and second year respectively. Cut-wise green fodder yield data for these plots were generated and used in comparing efficiency of various sampling methods. In all six cuts were obtained in both the years.

Sampling plans

In *stratified* random sampling, the data of six cuts were grouped into three strata on the basis of mean yield. The first two cuts formed stratum 1; the third and fourth cut formed stratum 2 and last two cuts formed stratum 3. Thus each stratum size was of 240 plots (observations) in the first year and of 80 plots in the second year. A random samples of size equivalent to 10 and 20 per cent of the total plots were selected from each stratum to workout average total yield and variance of mean (Cochran, 1972) and relative efficiency (RE).

RE = S^2/Sw^2 where S^2 is the overall (total) mean square and Sw^2 is the within strata mean square in analysis of variance.

In *double* sampling a small number of plots were selected for recording yield data for all the cuts (n") whereas large number of plots were selected for only one cut (n') which was highly correlated with the total yield. The datails about samples selected for analysis were as under :

Year	No. of plots per unit	n'	n"	
			10%	20%
1988-89	120	75	12	24
1989-90	40	25	4	8

The average total yield based on all cuts, variance of mean and efficiency of double sampling compared to SRS were estimated following methods given by Satyapal and Srivastava (1983).

The relative efficiency (RE) of double sampling estimate $\bar{Y}_{ds}$ as compared to SRS estimate $\bar{Y}_{SRS}$ is estimated by

$$R.E. = \left[\frac{1}{\sqrt{1-r^2} + \frac{2}{\sqrt{(K^{-1}}}} \right]^2$$

Where r is the correlation coefficient between j th cut yield and total yield for n" fields (j th cut yield has maximum correlation with total yield).

k is the number of cuts (k = 6).

The procedure for (*component* sampling consists of selecting independent random samples of size n1, n2,.... nk plots (but not fixed plots) and recording yield data of each cut 1, 2, ..., k. Here also 10 and 20 per cent plots were sampled from each cut for recording yield data for analysis. An estimate of average yield for each cut was obtained first ($\bar{Y}_j$) and then an estimate of average total yield over all cuts was obtained by adding the estimates of average yields in individual cuts. $\bar{Y}_c = \Sigma \bar{Y}_j$ (j = 1, 2, ..., k) (Satyapal and Srivastava, 1983). The relative efficiency of this plan in relation to SRS was estimated by

$$R.E. = \frac{K S_y^2}{\left(\sum_{J=1}^{k} S_j^2 \right)}$$

Where S_y^2 is the variance of Y_{SRS} in SRS
S_j is the standard deviation of the j th cut
(j = 1, 2, . . . , 6)

RESULTS AND DISCUSSION

The estimates are presented in Table 1.

TABLE 1

The estimate of total average yield (kg/10 sq. m) and relative efficiency of different sampling methods %.

Year	Sampling methods	Av. total yield		Relative efficiency	
		Size 10 %	Size 20 %	Size 10 %	Size 20 %
1988-89	1. Stratified random sampling	51.91	52.23	191	178
	2. Double sampling				
	— Third cut	55.92	52.29	67 *	
	— Fourth cut	53.61	53.02	118 *	
	3. Component sampling	56.01	52.50	128	167
	Population	52.93			
1989-90	1. Stratified random sampling	64.43	64.16	223	168
	2. Double Sampling				
	— Third cut	64.17	64.41	74 *	
	— Fourth cut	64.40	65.47	75 *	
	3. Component sampling	64.35	64.48	192	113
	Population	64.29			

* The reduction in cost was not estimated

The results revealed that the stratified random sampling and component sampling were more efficient than the SRS for estimating total yield of lucern. The relative efficiency of stratified random sampling over SRS was 191 and 178 per cent during first yeat and 223 and 168 per cent during second year. The component sampling was 128 and 167 per cent more efficient than SRS during first year, while these estimates were 192 and 113 per cent during second year. It is worth noting that during second year the efficiency of these two sampling methods was higher when sample size taken was 10 per cent of the total plots than that when sample size taken was 20 per cent of the total plots (for this deviation reason could not be resolved). Of these two methods, stratified random sampling appeared better

than component sampling for estimating total yield of lucern. The latter is better for partial harvest data.

The double sampling had lower efficiency than the SRS. The efficiency of former depends on the correlation between yield of individual cut and total yield. The yield of a cut having high correlation with the total yield is given more weightage in double sampling. This might be the reason for low efficiency of double sampling. The results indicated that the double sampling should not be followed for estimating total green fodder yield of lucern crop.

For the estimation of total green fodder yield of lucern (Cv. Anand 2), stratified random sampling and component sampling proved efficient in both the years of study. For partial harvest data, component sampling proved better, while double sampling could not. These results are indicative in nature and actural field survey needs to be undertaken for indepth study.

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Returns to Investment in Agricultural Research in Gujarat A Preliminary Investigation

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ABSTRACT

Research expenditure is public expenditure therefore, it is important for planners and policy makers to look for the estimates of returns from such investment. The analysis showed that the investment in agricultural research in the State has grown at an annual rate of 11.96 per cent and gave a maximum return after a time lag of four years. The average returns to one rupee investment were over Rs. 38.

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INTRODUCTION

Agricultutal sector constitutes the most strategic component of the economy. The agricultural research plays an essential role in improving production of crops and livestock. As the agricultural research system has expanded, research productivity and research resource allocation have become issues of prime importance (Bal and Kahlon, 1977). In Gujarat State the expenditure on agricultural research has increased over time but not much is known about the contribution of research to agriculture and the State economy. In this light, therefore, an attempt has beeen made here to analyse the role of agricultural research in the State. Specifically, following are the objectives of the study :

1. to estimate the time lag between a particular investment in agricultural research and its returns in Gujarat.
2. to estimate the rate of growth of returns and investment in agricultural research in the State and,
3. to estimate the returns to the investment in agricultural research in Gujarat.

MATERIALS AND METHODS

For the purpose of this investigation time series data from 1972-73 to 1987-88 have been used. To measure the returns to investment in agricultural research, the gross domestic product of Gujarat State from agriculture only (GDP(agri.)) was taken as a proxy to returns.

the output variable (Y_t). Thus GDP (agri) is the difference between the GDP (primary sector) and the GDP from forestry, logging, mines, fishing, etc. The expenditure made on agricultural research by Gujarat Agricultural University (GAU) under the plan schemes, non-plan schemes and the schemes financed by ICAR and other agencies was taken as input variable (I_t). These input and output data were then deflated by the wholesale price index (1970=100) to eliminate the effect of price changes.

Any investment in research does not yield its returns in the same year in which it is made. Therefore, the time lag between an investment on research and its returns was estimated. For working out the time lag the correlation coefficients between Y_t and I_{t-k} for different values of k (k = 0, 1, 2,....., 16 years) were computed. The correlation coefficients for different values of k were then adjusted for the degrees of freedom.

Adjustment for past investment

There is need to adjust the Y_t for the past investment i.e., I_{t-k}. For this purpose data on Y_t prior to the formation of GAU i.e., 1972-73-k were also taken and the growth rate of Y_t was computed for this peroid using exponential function of the type $Y = ab^x$, were Y = GDP, X = time period. Thus, growth rate in past returns i.e., 1972-73=Y_0 served as the base for the study period 1973-74 onwards. Similarly the rate of growth in returns from 1973-74 onwards was also worked out i.e., returns in 1973-74-Y_1. The adjustment factor "P" for the past investment was worked out as under —

$$P = \frac{Y_1 - Y_0}{Y_1}$$

This constant multiplier (P) of the returns gives the GDP value adjusted for the effect of past investment ($y'_t = P\ Y_t$).

Basic model for allocating returns to investment

If k denotes the time lag between an investment and its returns then the functional relationship of adjusted output (y'_t) with the previous investment can be written as $Y'_t = f(I_{t-k}, Y'_{t-1}, T)$.

Where, I_{t-k} = investment in agricultural research for the year t-k,

Y'_{t-1} = lagged adjusted returns,

T = time trend.

Linear, log-linear and quadratic equations were fitted to estimate the parameters.

RESULTS AND DISCUSSION

As explained earlier in this study the GDP from agriculture was estimated and considered as returns or output (Y_t). In Table 1, the state GDP from primary sector, GDP (agric.) both at current and constant prices and the investment in agricultural research are given. While analysing the data it was observed that the begining year and the last three years of the series, i.e., 1972-73 and 1985-86 through 1987-88 respectively were unusual years. Hence, these years were dropped from the further analysis. Thus, the time series from 1973-74 to 1984-85 only was considered for analysis and interpretation of results.

TABLE 1

GDP and investment on agricultural research-Gujarat State.

(Rs. crore)

Years	GDP primary sector at current price	GDP-only agriculture		Investment Constant price (1970=100)
		Current price	Constant price (1970=100)	
1972-73	775	730.83	628.94	0.4596
1973-74	1473	1418.34	1015.27	1.0193
1974-75	1014	929.49	531.44	0.9330
1975-76	1518	1413.14	816.84	1.0145
1976-77	1771	1658.49	939.12	1.2421
1977-78	1886	1777.91	956.89	1.5834
1978-79	1897	1747.81	940.69	1.7920
1979-80	2178	2038.62	936.86	2.0026
1980-81	2496	2354.75	915.18	2.0127
1981-82	3305	2981.95	1060.06	1.8818
1982-83	3071	2673.33	925.99	2.6648
1983-84	3768	3308.62	1047.03	2.8873
1984-85	3990	3508.84	1036.89	3.1735

Compound growth rates

Compound growth rates (r) of Y_t and I_t were worked out to know the behaviour of each variable individually. These are presented in Table 2. The table reveals that during 1973-74 to 1984-85 the Y_t increased at a rate of 2.72

TABLE 2

Compound growth rates (r) of Y_t, I_t. equation : $Y = ab^X$.

Variable	Coefficient		R^2	(r)
	a	b		
Y_t (1969-70 to 1972-73)	102332.9	0.923359+	0.2193	-7.664
Y_t (1973-74 to 1984-85)	76769.86	1.027219**	0.2721	2.7219
I_t (1973-74 to 1984-85)	82.06478	1.119675**	0.9457	11.9675

** = Significant at 10% level of probability.
+ = Significant at 20% level of probability.
r = Compound growth rate (% per annum).

per cent per annum. As against this the investment in agricultural research grew at an annual rate of 11.96 per cent. The growth of GDP (agri.) for the period 1969-70 to 1972-73 showed a negative trend and the rate of decline was 7.66 per cent per year.

TABLE 3

Correlation coefficients between Y_t and I_{t-k}.

Variables	*Correlation coefficients*	*Corr coeffi adjusted to degree of freedom*	
Y_t, I_t	0..5433**	0.4740	
Y_t, I_{t-1}	0.6444*	0.5418	
Y_t, I_{t-2}	0.6222**	0.5573	
Y_t, I_{t-3}	0.5321	0.4250	
Y_t, I_{t-4}	0.64996**	0.57117	Selected
Y_t, I_{t-5}	0.6014	0.4837	
Y_t, I_{t-6}	0.5467	0.3516	
Y_t, I_{t-7}	0.3839	0.3698	

* Significant at 5% level of significance.
** Significant at 10% level of significance.

Interrelationship and computation of time lag

Correlation coefficients between return and investment, which have been depicted in Table 3 tell the degree of association between two variables. Direct correlation between Y_t and I_t at 0.5433 was positive and significant. To know the full realisation of returns of an investment in research the lagged correlation coefficients were worked out for different time lag i.e., t-1, t- 2, ... t-7. As seen from the table 1st, 2nd and 4th lags were statistically significant. These lagged correlation coefficients were then adjusted for the degree of freedom. The highest adjusted correlation coefficient (0.5711) was observed for fourth year and same was selected for the analysis. It implied that in the State any investment made in agricultural research gave maximum returns after a time lag of four years. The impact of investment was visible in 5th, 6th and 7th years too but was insignificant.

Adjustment of returns for past investment

In order to estimate the returns to I_{t-4}, the Y_t was adjusted for the effects of past investment and for general trend in the use of factors of production. For this purpose the proportion (P) of Y_t which accounts for I_{t-4} over the period of study was studied.

The growth rate of Y_t was worked out for periods (1) 1969-70 to 1972-73 and (2) 1973-74 to 1984-85. The estimated returns for the year 1972-73 i.e., Y_o served as the base for the study. Similarly, from the growth rate of returns for the second period the returns for 1973-74 were estimated and denoted as Y_1. Using the procedure explained in methodology the proportion (P=0.05671) was worked out. Assuming that a constant proportion of Y_t is due to I_{t-4} the values of returns adjusted to past investment (Y'_t) were derived (Table 4).

Relationship between returns and investment in research

The GDP (agric) of the State which has been adjusted for past investment (Y'_t) still includes the effects of general trend in the use of factors of production on returns. That means the return will change even if there is no investment in research. Therefore, past returns (Y_{t-1}) and time trend (T) together with lagged investment (I_{t-4}) were taken as explanatory variables

TABLE 4

GDP (agri) adjusted for past investment.

(Rs. lakhs)

Sr. No.	Year	GDP (agri) (Y_t) at constant price (1970=100)	GDP (agri) adjusted to past investment (Y'_t)
1.	1973-74	101527.56	5757.63
2.	1974-75	53144.08	3013.80
3.	1975-76	81684.39	4632.32
4.	1976-77	93912.23	5325.76
5.	1977-78	95689.45	5426.55
6.	1978-79	94069.43	5334.68
7.	1979-80	93686.58	5312.97
8.	1980-81	91517.68	5189.97
9.	1981-82	106006.04	6011.60
10.	1982-83	92598.89	5251.28
11.	1983-84	104703.16	5937.72
12.	1984-85	103689.13	5880.21

to estimate the effect on Y'_t. For the regression analysis linear, log linear and quadratic equations were fitted with different combinations of explanatory varibles. However, the linear equation with Y'_{t-1} and I_{t-4} was selected as it gave the best fit in terms of R^2 and the number of significant coefficients. The estimated parameters of the chosen equation are as follows :

$$Y'_t = 7845.2853 - 0.6010^{**} \quad Y'_{t-1} + 6.8101^{*} \; I_{t-4}$$

$$R^2 = 0.6695$$

Note : *Significant at 5% level of probability
** Significant at 20% level of probability

The estimated returns to investment in agricultural research are displayed in Table 5. Average returns of Rs. 38.23 to one rupee investment were encouraging. It was also observed that the returns per rupee of investment have shown a declining trend over the period of study.

TABLE 5

Returns to investment on agricultural research.

(Rs. lakhs)

Year	GDP (agri) adj. to past investment (Y'_t)	Estimated returns (Y'_t)	Investment on research for time lag (I_{t-4})	Returns per rupee of investment
1977-78	5426.55	5249.67	101.93	51.50
1978-79	5334.68	5190.91	93.30	55.63
1979-80	5312.97	5246.41	101.45	51.71
1980-81	5189.97	5401.41	124.21	43.48
1981-82	6011.60	5633.83	158.34	35.58
1982-83	5251.28	5775.89	179.20	32.23
1983-84	5937.72	5919.31	200.26	29.44
1984-85	5880.21	5926.19	201.27	29.44
Average	5543.12	5542.95	144.99	38.23

From the results it is clear that the agricultural research has played crucial role in agricultural production and at the overall level it yielded over 38 times more returns than the investment made in it. Further the trend analysis of the productivity of bajra, cotton and groundnut, three most important crops of the State, revealed that the regression coefficients of time variable at 49.25, 7.60 and 0.404 respectively were positive and significant. As per the growth rate analysis the productivity of these crops in the State has been increasing at a simple rate of growth of 6.87, 4.25 and 3.30 per cent respectively. The higher average return due to investment in research also indicate that there has been underinvestment in research in the State, more so during the earlier years. However, it is advised that the results of this analysis must be cautiously observed as there is scope for further improvement in form of quality of data on research expenditure, specification of the form of variables and relationship. While, collecting data on research expenditure, many inconsistencies and inadequacies were observed. The present system of classification of expenditure in budget is irrelevant from the view point of such an investigation. In the allocation of fund for research there should be more meaningful classification of expenditure.

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Response of Soybean to Dates of Sowing and Seed Rates on Yield and Quality

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Sowing date and seed rate play an important role in quantitative and qualitative production of field crops. In view of this an experiment on soybean was laid out in *kharif* season of 1989-90 at the college farm of N. M. College of Agriculture, Gujarat Agricultural University, Navsari.

The soil of experimental plot was clay in texture, low in total nitrogen (0.049 per cent), medium in available phosphorus (28.10 kg/ha) and high in available potassium (320 kg/ha). Treatments involved were four sowing dates and four seed rates (Tabel-1). Crop was sown at spacing of 45 cm between two rows.

A split plot design was adopted with four replications. The seed was sown by applying *Rhizobium* bacterial *(Rhizobium japonicum)* treatment and was fertilized with 30 kg N and 60 kg P_2O_5/ha. The data on yield, yield attributing and quality characters are given in Table-1.

TABLE 1

Effect of various treatments on yield, yield attributing characters and quality of soybean (1989-90).

Treatment	*Number of pods/plant*	*100-Seed weight (g)*	*Seed yield (q/ha)*	*Protein*		*Oil*	
				per cent	*yield (kg/ha)*	*per cent*	*yield (kg/ha)*
Date of Sowing							
D_1 = June, 23	39.88	10.48	39.54	41.63	799.43	19.53	376.16
D_2 = July, 8	38.40	10.42	37.00	40.43	757.72	19.48	366.29
D_3 = July, 23	33.29	9.48	29.75	38.54	569.39	18.00	267.15
D_4 = August, 7	23.46	8.52	23.02	37.25	439.25	17.61	207.96
S. Em. ±	1.12	0.23	1.21	0.41	23.50	0.18	12.65
C. D. at 5%	3.60	0.74	3.86	1.32	75.17	0.56	40.47

1.	2.	3.	4	5.	6.	7.	8.
Seed rate (kg/ha)							
S_1 = 40	37.59	10.17	27.40	40.16	540.67	18.61	253.84
S_2 = 50	34.37	9.94	31.73	39.85	632.05	18.66	296.09
S_3 = 60	32.13	9.57	33.85	39.18	696.36	18.71	332.93
S_4 = 70	30.96	9.23	36.33	38.66	691.10	18.65	334.70
S. Em. ±	1.08	0.17	1.05	0.10	20.86	0.04	10.33
C. D. at 5%	3.09	N.S.	3.00	0.29	59.87	N.S.	29.65

The data presented showed that the number of pods per plant and test weight decreased remarkably as sowing was delayed. Higher values of yield attributes were noticed under earlier sowings. Whereas, only test weight and oil per cent were not affected significantly due to various seeding rates. The results corroborate with those of Subbaiah *et al.* (1977).

The seed yield of soybean was significanlty influenced by sowing dates and seed rates. The yield of seeds was maximum at earlier sowing with higher seed rates, i.e. 39.54 and 36.33 q/ha, respectively. Thus increase in yield was mainly due to higher number of pods/plant and seed weight registered under these treatments. It was mainly due to more favourable growth conditions received during earlier planting. Number of pods/plant and 100 seed weight were also positively associated with grain yield. Deshmukh *et al.* (1977) and Ramani (1988) also reported similar results.

In respect of protein content and its output, the values were higher under earlier sowing (23rd June), thenafter it was decreased significantly. Higher protein content recorded in earlier planting may be due to more translocation of nitrogen towards grains. In case of seed rates, the maximum (40.16 per cent) protein content was observed under the lowest seed rate but yield was statistically higher at higher seed rates (60 and 70 kg/ha). These findings are in agreement with those reported by Deshmukh *et al.* (1977) and Ramani (1988).

Significant reduction was noticed in oil content and its yield as the sowing was delayed from 23rd June. It may be due to poor utilization of resources under unfavourable environmental situations. Whereas it was not affected significantly due to various seed rates but significanlty higher oil yield was noticed under higher seed rates (60 and 70 kg/ha).

Thus, from the view point of yields of soybean seed, protein and oil sowing on 23rd June with 60 kg seed rates/ha, was found to be the optimum.

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Correlation and Regression Studies in Soybean Yield Characteristics

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Knowledge of the interrelationship among yield determining characters and their association with seed yield is of paramount importance in crop improvement programme. In this study the experiment was laidout during *kharif* 1989 with four sowing dates (23rd June, 8th July, 23rd July and 7th August) and four seeding rates (40, 50, 60 and 70 kg/ha) in split plot design. Randomly selected 5 plants from each treatment were used for recording the observations on plant height, number of branches, leaves, nodules, pods and grains as well as 100 seed weight. Simple correlation coefficients was worked out by computer by adopting the formula described by Snedecor and Cochran (1967).

It is evident from Table-1 that the grain yield of soybean was highly significantly and positively associated with plant height and oil content. Whereas, number of nodules/plant,

TABLE 1

Association and simple regression equation of grain yield of soybean with growth, yield attributing and quality characters.

	Character	*Regression equation*	*'r'*
1.	Plant height (cm) at harvest	$\hat{Y} = 8.163 + 0.104^{**} x$	0.925**
2.	Number of branches/plant at harvest	$\hat{Y} = 13.760 + 0.630 x$	0.289
3.	Number of leaves/plant at harvest	$\hat{Y} = 10.369 + 0.407 x$	0.404
4.	Number of nodules/plant at harvest	$\hat{Y} = 4.392 + 0.468^{*} x$	0.588*
5.	Number of pods/plant	$\hat{Y} = 16.778 - 0.024 x$	0.609*
6.	Number of grains/pod	$\hat{Y} = 2.822 + 6.934 x$	0.102
7.	100 seed weight (g)	$\hat{Y} = -6.415 + 2.321^{*} x$	0.579*
8.	Oil content (per cent)	$\hat{Y} = -49.760 + 3.534^{*} x$	0.869**
9.	Protein content (per cent)	$\hat{Y} = -34.752 + 1.290^{*} x$	0.657*

** Significant at 1 per cent level of probability.

* Significant at 5 per cent level of probability.

number of pods/plant, 100 seed weight and protein content were positively and significantly correlated with final production. The association between plant height and grain yield was the highest (0.925) closely followed by oil content (0.869). This result clearly indicated that above parameters exhibited direct influence on final yield of soybean. Therefore, these attributes should be considered at the time of selecting the variety. Almost similar results were also reported by Chaudhari and Singh (1974).

The simple regression co-efficients were computed between yield of seed (y) and important growth, yield and quality attributes (x), which were taken for simple correlation studies. The simple linear regression equation obtained (Table-1) was of the type $\hat{y} = a + b x$, where,

$\hat{y}$ = predicted yield of seed; a = constant,

b = regression co-efficient.

x = growth, yield and quality attributes.

In these equations, plant height, number of nodules/plant, 100 seed weight, oil and protein content exhibited significant influence on seed yield. While rest of the parameters showed negligible impact on the final production of soybean.

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Influence of Irrigation and NP Fertilization on Yield, Consumptive Use of Water, Wate Use Efficiency and Nutrient Uptake by Summer Pearl Millet in South Saurashtra Region

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A field experiment was conducted during summer 1988-89 at Instructional Farm, Gujarat Agricultural University, Junagadh to workout the irrigation, nitrogen and phosphorus requirement of pearl millet in a split plot design with three replications. Irrigation was scheduled at IW/CPE ratios, 0.6, 0.8 and 1.0 with irrigation depth of 50 mm in main plot and NP levels (N_0P_0, $N_{40}P_{20}$, $N_{80}P_{40}$ and $N_{120}P_{60}$) in sub plots. The soil of experimental plot was medium black having pH 8.2, EC 0.27 dsm^{-1} at 25°C, field capacity on w/w basis 26.8% (0-15 cm), permanent wilting point on w/w basis 14.0% (0-15 cm), bulk density 1.419 g/cμ cm (0-15 cm), total N 0.08%, available P_2O_5 21.23 kg/ha and available K_2O 268 kg/ha. The crop was sown on 9th Feb., 1989 and harvested on 16th May, 1989. The gross and net plot size kept were 6.0 x 4.5 m and 4.0 x 2.7 m, respectively.

The consumptive use of water was calculated as per the procedure suggested by Dastane (1972). Total number of irrigation applied as per treatments during crop season were 7, 9 and 11 for IW/CPE ratios 0.6, 0.8 and 1.9, respectively.

Consumptive use of water by pearl millet increased substantially with each increase in IW/CPE ratio from 0.6 to 1.0 (Table 1). The maximum water use of 437.92 mm was recorded under IW/CPE ratio of 1.0. The reason for higher water use under higher ratio of 1.0 is attributed to the fact that this ratio received maximum water (550 mm).

Similar to consumptive use of water, high IW/CPE ratio of 1.0 recorded significanlty higher water use efficiency of 11.37 kg ha^{-1} mm as compared to lower IW/CPE ratio of 0.6. Remarkably higher frequency of irrigation coupled with higher yield under this ratio may be responsible for higher water use efficiency.

Fertilizing the pearl millet with $N_{120}P_{60}$ stood first by recording significantly the highest consumptive use and water use efficiency of 391.11 mm and 12.26 kg ha^{-1} mm, respectively over rest of the lower levels. The higher water use efficiency under this level is attributed to higher grain yield (Table 1).

TABLE 1

Consumptive use of water, water use efficiency, protein nutrient uptake, yield and net return of pearl millet as affected by irrigation and NP fertilizer.

Treatment	Yield ($q\ ha^{-1}$)		Consumptive use (mm)	Water use efficiency (kg grain/ ha mm)	Protein content (%)	Total nutrient uptake ($kg\ ha^{-1}$)		Net return Rs/ha
	Grain	Straw				Nitrogen	Phosphorus	
IW/CPE ratio								
0.6	29.48	102.12	321.33	9.15	9.15	91.72	12.35	5286
0.8	38.86	112.31	377.33	10.06	10.22	116.97	15.19	72.51
1.0	49.87	123.15	437.92	11.37	10.68	151.74	19.37	9599
C.D. at 5%	5.46	8.89	9.97	1.54	0.37	11.00	1.29	
Fertilizer (NP)								
N_0P_0	31.30	100.83	370.78	8.44	9.83	91.43	12.44	7062
$N_{40}P_{20}$	35.74	108.24	373.44	9.46	10.17	109.05	14.28	7925
$N_{80}P_{40}$	41.57	115.83	380.11	10.61	10.39	126.76	16.60	9106
$N_{120}P_{60}$	48.89	125.28	391.11	12.26	10.88	153.33	19.14	10665
C.D. at 5%	4.35	7.03	7.39	1.35	0.31	9.61	1.12	

TABLE 2

Interaction effect of I x NP on nitrogen uptake (kg/ha) by pearl millet.

Irrigation (IW/CPE ratio)	*NP levels*			
	N_0P_0	$N_{40}P_{20}$	$N_{80}P_{40}$	$N_{120}P_{60}$
0.6 (I_1)	71.38	85.19	92.67	117.64
0.8 (I_2)	90.59	107.18	124.05	146.07
1.0 (I_3)	112.32	134.79	163.57	196.30
C.D. at 5%	13.71			

Scheduling irrigation at IW/CPE ratio of 1.0 removed significantly higher nitrogen and phosphorus by 151.74 and 19.33 kg ha^{-1}, respectively over rest of lower ratios. The reason for higher nutrient removal with higher IW/CPE ratio of 1.0 which received 11 irrigations is owing to reduction in soil temperature by frequent irrigation. The decline in the temperature tended to increase specific heat and thermal conductivity of the soil with wetness and greater evaporative cooling. This favourable condition increased the rate of nitrification and resulted in higher nutrient uptake. Similar observations have also been noticed by Lakkad and Patel (1978) and Malik and Sharma (1984).

Nutrient uptake increased substantially with each increase in fertilizer level from N_0P_0 to $N_{120}P_{60}$. Nitrogen and phosphorus removed at $N_{120}P_{60}$ were 153.33 and 19.14 kg ha^{-1}, respectively, which was significantly higher over rest of the lower levels of fertilizer.

Significantly the highest protein content of 10.68 and 10.88 per cent were recorded with high IW/CPE ratio of 1.0 and $N_{120}P_{60}$ fertilizer level, respectively. The high protein content under higher frequency of irrigation may be due to luxurious growth and bumper production of the crop received under this treatment. Likewise higher amount of NP level had a promoting effect on protein content in pearl millet grain.

Scheduling of irrigation at IW/CPE ratio of 1.0 outdid the rest by recording remarkably higher grain yield over rest of lower ratios. A marked increase in total uptake of nitrogen and phosphorus by crop under this ratio might have contributed towards higher grain yield. Maximum net return of Rs. 9599/ha was received under IW/CPE ratio of 1.0. The increase in net return with IW/CPE ratio of 1.0 was 81.58 per cent over IW/CPE ratio of 0.6.

Fertilizing the crop with $N_{120}P_{60}$ recorded significantly higher grain and straw yield over rest of the levels. This level also gave maximum net return of Rs. 10665/ha which was 51.02 per cent higher over control.

Interaction Effect

Interaction effect of I x NP in respect of nitrogen uptake was found significant (Table 2). Results indicate that irrespective of NP levels,

TABLE 3

Interaction effect of I x NP on phosphorus uptake (kg/ha) by pearl millet

Irrigation (IW/CPE ratio)	*NP levels*			
	N_0P_0	$N_{40}P_{20}$	$N_{80}P_{40}$	$N_{120}P_{60}$
0.6 (I_1)	10.39	11.50	12.86	14.65
0.8 (I_2)	12.44	14.01	15.85	18.47
1.0 (I_3)	14.51	17.32	21.35	24.31
C.D. at 5%	1.60			

nitrogen uptake increased substantially with increase in IW/CPE ratio from 0.6 to 1.0. Significantly higher nitrogen was removed at $N_{120}P_{60}$ over rest of the lower levels under all the levels of irrigation. Treatment combination comprised of irrigation schedule based on IW/CPE ratio 1.0 and fertilizing the crop with $N_{120}P_{60}$ removed significantly the highest nitrogen by 196.30 kg/ha over rest of the combinations.

Interaction I x NP in case of phosphorus removed by pearl millet was found significant. Data (Table 3) showed that irrespective of IW/CPE ratio, phosphorus removal increased substantially with each increment in fertilizer level from N_0P_0 to $N_{120}P_{60}$ and significanlty the highest phosphorus uptake was noticed with $N_{120}P_{60}$ over rest of the lower levels. Under same level of fertilizer doses, phosphorus removal increased significantly with increase in IW/CPE ratio from 0.6 to 1.0. The best treatment combination involving scheduling irrigation at IW/CPE ratio of 1.0 and fertilizing the crop with $N_{120}P_{60}$ removed significanlty the highest phosphorus by 24.31 kg ha^{-1} over rest of combinations.

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Salt Tolerance of Gram (*Cicer arietinum*) Genotypes at Germination and Seedling Stage

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The early stages of plant growth are most critical as later development and crop production depend of germination and seedling emergence. Soluble salts beyond a certain limit affect growth adversely depending upon the stage of growth, plant species and variety (Maliwal and Paliwal, 1982, Hassonporath *et al.* 1982, Sheoran, 1980). Recently significant information on the germination capacity of seed in graded salinity has been reviewed for many varieties of field and vegetable crops (Maliwal and Paliwal, 1969 and Gupta, 1979). Results of experiment conducted to find out the most salt tolerant genotypes of gram are presented herein.

Germination study on 32 genotypes of gram was conducted at four salinity (EC 3, 6, 9 and 12 dsm^{-1}) levels alongwith control in three replications at room temperature. The solutions were prepared in 1/5 Hoagland nutrient solution of the following composition in milliequivalents (me) per litre. $Ca(NO_3)_2$, 5; KNO_3, 2.5; $MgSO_4$, 2; KH_2PO_4, 1.5; and 1 me/l of iron as ferric citrate, copper as $CuSO_4$, zinc as $ZnSO_4$, manganese as $MnSO_4$ and boron as H_3BO_3. In all these solutions chloride salts of sodium, calcium and magnesium in the ratio of 65:15:25 were taken and desired conductivity was adjusted on solu bridge. The experiment was conducted in using blotting paper in petredishes. The germination percentage was recorded after every 24-hours till the 10th day of the sowing. Height of seedling from each replicate was recorded on the last day of germination count. Salt tolerance limit of each variety was worked out on the basis of critical difference over control. Arc sine values were used for statistical analysis of data.

The observation on the germination count made after every 24 hours of sowing revealed that the germination was initiated in the control and lower salinity levels within 48 hours. In the higher salinity levels, the initiation of germination begin on the 3rd day. The maximum germination was observed within four days in control and in lower salinity levels while in higher salinity levels, the period for the maximum germination was extended and in some varieties it prolonged till the last day of the observations. In general, the process of germination was delayed linearly with the increase of salt concentration (Table 1) with slight differences amongst the varieties (Yadav *et al.* 1989). The adverse effect of salinity on plant growth may be due to (a) the osmotic effect of

TABLE 1

Effect of salinity levels on the germination (%) of gram genotypes.

Sr. No.	*Genotype*	*EC ds m^{-1}*					*Mean*
		Control	*3*	*6*	*9*	*12*	
1.	JCP-2	99	99	99	99	98	99
2.	JCP-6	99	98	99	99	99	99
3.	JCP-11	99	99	99	99	99	99
4.	JCP-13	99	99	99	99	99	99
5.	JCP-21	99	99	99	99	99	99
6.	JCP-22	99	94	98	92	90	95
7.	JCP-23	99	99	98	99	99	99
8.	JCP-27	99	98	96	96	96	97
9.	JCP-28	90	82	88	86	58	82
10.	JCP-29	96	94	90	82	52	87
11.	JCP-30	90	92	91	70	23	76
12.	JCP-31	96	94	80	38	2	64
13.	JCP-32	85	91	70	20	10	56
14.	JCP-33	77	98	52	40	12	58
15.	JCP-34	92	84	85	56	4	64
16.	JCP-35	96	90	82	58	33	75
17.	JCP-36	92	86	72	36	24	64
18.	JCP-37	95	92	84	77	55	82
19.	JCP-38	85	88	76	61	32	70
20.	JCP-39	91	61	44	40	12	50
21.	JCP-40	78	76	86	38	12	58
22.	JCP-41	83	92	85	58	16	69

1.	2.	3.	4.	5.	6.	7.	8.
23.	JCP-42	88	68	66	58	22	61
24.	JCP-43	76	86	72	64	39	68
25.	JCP-44	99	99	99	99	98	99
26.	JCP-45	90	87	86	86	76	85
27.	JCP-46	96	94	94	87	88	92
28.	JCP-47	82	76	70	46	52	66
29.	JCP-49	99	98	99	94	92	97
30.	JCP-50	98	99	99	99	96	98
31.	JCP-52	96	92	92	92	90	93
32.	JCP-57	98	92	98	92	99	96
	Mean	94	93	89	79	63	

	S. Em ±	C. D. at 5%	C.V. %
Genotype (G)	2.113	5.856	
Solution (S)	0.835	2.315	
G X S	4.724	13.095	9.95

rooting medium (b) the accumulation of toxic ions ($C1^-$ and Na+) in plant issues (Hayward and Wadleigh, 1958, Bernstein, 1962 and Allison, 1964).

The germination percentage decreased with the increase in salt concentration in all the genotypes except JCP-2, 6, 11, 13, 21, 23, 44 and 57. The genotypes JCP 2, 6, 11, 13, 21, to 23, 27, 44 to 46, 49, 50, 52 & 57 tolerate highest salt concentration of 12 dsm^{-1} EC in irrigation water while JCP 29, 30, 34, 37, 38, 40, 41, 43 & 47 tolerate up to EC of 6 dsm^{-1}. JCP 28 and 45 tolerate EC of 9 dsm^{-1}. JCP 39 and 42 tolerate less than 3 dsm^{-1} while others are tolerate to EC of 3 dsm^{-1}.

The height of the seedlings of each genotype decreased with the increase in salt concentration (Table 2). In general more tolerant genotypes showed more height of seedlings and the relative decrease was also less with the increase in salt concentration while reverse was the case for less salt tolerant

TABLE 2

Effect of salinity levels on the height (cm) of seedlings of gram genotypes.

Sr. No.	Genotype/ Solution	EC, ds m^{-1}					Mean
		Control	3	6	9	12	
1.	JCP-2	5.5	4.3	3.1	1.9	0.4	3.0
2.	JCP-6	11.1	8.8	8.1	6.3	1.1	7.1
3.	JCP-11	11.5	5.6	3.7	1.4	0.3	4.6
4.	JCP-13	6.4	6.1	3.3	2.3	1.1	3.8
5.	JCP-21	5.5	4.5	2.9	2.2	0.7	3.2
6.	JCP-22	6.2	1.8	1.8	1.0	0.2	2.2
7.	JCP-23	7.8	4.9	2.7	2.6	0.6	3.7
8.	JCP-27	3.5	2.5	2.1	1.8	0.4	2.1
9.	JCP-28	10.3	5.9	5.7	0.4	0.2	4.5
10.	JCP-29	12.5	12.2	7.3	0.4	0.2	6.5
11.	JCP-30	7.7	9.3	4.3	0.2	0.0	4.3
12.	JCP-31	6.2	9.7	1.5	0.2	0.0	3.5
13.	JCP-32	2.5	2.4	0.0	0.0	0.0	1.0
14.	JCP-33	2.1	1.9	0.2	0.0	0.0	0.9
15.	JCP-34	5.0	3.2	0.2	0.0	0.0	1.7
16.	JCP-35	4.3	1.5	0.7	0.0	0.0	1.3
17.	JCP-36	8.0	4.6	3.7	0.0	0.0	3.3
18.	JCP-37	5.7	2.9	0.4	0.0	0.0	1.8
19.	JCP-38	6.1	1.1	0.4	0.0	0.0	1.5
20.	JCP-39	6.4	1.0	0.0	0.0	0.0	1.5

1.	2.	3.	4.	5.	6.	7.	8.
21.	JCP-40	1.6	1.4	0.2	0.0	0.0	0.6
22.	JCP-41	2.2	1.1	1.1	0.0	0.0	0.9
23.	JCP-42	2.5	1.9	1.0	0.0	0.0	1.1
24.	JCP-43	3.2	3.4	0.5	0.2	0.0	1.5
25.	JCP-44	3.1	4.9	2.9	1.4	1.0	2.6
26.	JCP-45	2.9	3.0	2.6	1.3	1.1	2.2
27.	JCP-46	2.7	3.2	2.6	1.5	0.9	2.2
28.	JCP-47	2.3	1.7	1.3	1.0	0.8	1.4
29.	JCP-49	3.8	3.6	2.6	1.6	1.1	2.6
30.	JCP-50	3.6	3.3	2.3	2.0	1.9	2.6
31.	JCP-52	5.4	4.2	3.0	2.1	1.2	3.2
32.	JCP-57	3.5	4.2	2.1	1.8	1.2	2.6
	Mean	5.3	4.1	2.3	1.1	0.50	

	S. Em. ±	C.D at 5%	C.V.%
Genotype (G)	0.320	0.887	
Solution (S)	0.127	0.351	
G X S	0.716	1.984	38.33

genotypes. In some cases, the height of seedlings seemed to be influenced by the growth rate of the genotype and salt, concentration.

Results obtained clearly show that germinating capacity of the seeds in adversely affected with the increase in salinity in all the genotypes of gram. Besides this, increased osmotic pressure near the root zone seem to adversely affect growth rate and ultimately the height of the seedlings. Genotypes show significant difference both in relation to their duration of germination, germinating capacity and the height of the seedlings. The varietal differences have been observed for gram varieties by Maliwal and Paliwal (1982). The salt tolerant genotypes can be used for breeding programme in salt affected soils.

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A Technique for Mass Collection of Cotton Whitefly Parasitoids

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Two aphelinids, *Encarcia transvena* (Timberlake) and *Eretmocerus mundus* Mercet are important parasitoids of cotton whitefly, *Bemisia tabaci* (Gennadius) (Kapadia and Puri, 1989). They can be reared only on *B. tabaci* nymphs under greenhouse conditions (Butler, 1986). As they are tiny, it is difficulty to get the sufficient amount of these parasitoids required at a time for their biological and toxicological studies. To overcome this problem, a study was, therefore, made to investigate the technique for their mass collection.

For this purpose, the cotton leaves infested heavily with *B. tabaci* nymphs were picked up from the cotton field. Other insects like aphids and predator immatures on these leaves were removed using brush. These leaves were allowed to dry under fan for 24 hours at laboratory conditions of 24.3 ± 2.4°C and 58.1 ± 5.0 % RH so that almost of the turgidity reduced, that helped in avoiding the leaf decaying when to be kept in the jar. Near 50 dried such leaves containing whitefly nymphs were kept loosely in the glass jar (19 x 15 cm) which was enveloped inside with blotting paper. The mouth of the jar was affixed with the plastic funnel (20 cm in diameter) in opposite position so that the outlet of the funnel remained upperside. The funnel was tighted with the jar using cellophane adhesive tape strips at four regular places. The outlet (inner orifice) was attached with a wire or plastic guage (529 holes in 1 sq. cm.) which resisted the adults of whitefly and allow only parasitoid adults to go in the tube. A glass tube (19 x 3.50 cm) was fixed with the funnel in way that the outlet of the funnel remained inner side of the glass tube. The juncture of the tube and funnel was sealed with cellophane adhesive tape.

The parasitoid adults emerged out in the jar gathered in the glass tube because they are having a habit of upward movement. The parasitoids generally start emerged out in between 10 to 11 hours but maximum parasitoid emergence was recorded in between 12.00 to 13.00 hours. The tube collected parasitoids could be replaced by another tube for the purpose of their study. From each set about 300-500 parasitoid adults per day can be collected. However, these number depend upon the intensity of parasitism in the field. During the night time, most of the parasitoid adults hindered in the cotton leaves, and again they came out in the tube on next day after 10

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hours. Mating process in the collection was also seen. The adult emergence continued up to 10-15 days. If it is needed to have the pure culture of a parasitoid species, the whitefly nymphs parasitized by two aphilinids can be distinguished easily by the colouration of nymphs due to parasitization. The host parasitized by *Encarsia transvena* became black in colour, and chocolate colour due to *Eretmocerus mundus*.

Number of collection set can be increased or decreased as per the requirement of parasitoid adults. This technique can be utilized in mass collection of the parasitoids for their laboratorical studies.

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Relative Toxicity of Some Newer Insecticides to the Adults of *Caliothrips indicus* Bagnall on Groundnut*

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The thrip, *Caliothrips indicus* Bagnall, is one of the important pests of *kharif* groundnut crop. It appears in a serious form under drought which greats hot and dry weather conditions (Amin, 1984). It appears in moderate to severe form in Andhra Pradesh, Tamil Nadu, Bihar, Maharashtra and Kerala (Vavai, 1969). The pest causes damage by bleaching off the chlorophyl of the leaves which resembles stipling. There was frequently discolouration of leaves which may be tinged with red or even black colour. The infested leaf surface can be marked with numerous dark spots of excreta. In severe infestation, the plant growth is stunted with stipled leaves which ultimately dry up and results in heavy yield loss. Upadhyay and Vyas (1983) reported losses of 21.97 and 22.54 per cent during *kharif* and summer seasons, respectively systemic insecticides such as dimethoate 0.03 per cent, monocrotophos 0.05 per cent and phosphamidon 0.03 per cent were recommended for effective control of this pest (Amin, 1984 and Anonymous 1986), but information on relative toxicity of different insecticides is very scanty. Therefore, an attempt is made to determine the toxicity of some selected insecticides against this pest.

Relative toxicity of six insecticides (Table 1) was determined against the adults of this pest. Six graded concentrations of each insecticide (0.02, 0.01, 0.005, 0.0025, 0.00125 and 0.0006 per cent for dimethoate and phosphamidon; 0.04, 0.02, 0.01, 0.005, 0.0025 and 0.00125 per cent for monocrotophos, endosulfan and quinalphos and 0.01, 0.005, 0.0025, 0.00125, 0.0006 and 0.0003 per cent for fenvalerate) were prepared in distilled water from the commercial formulations. Individual concentration was applied @ 4 ml per 20 days old potted groundnut plant with the help of Potter's spraying tower. A constant pressure of 1 kg/cm^2 was maintained during spraying. After treatment, potted plants were kept under an electric fan for about 15 minutes to dry the film of insecticides. The plants were then covered with glass *Chimaney*. Ten laboratory reared adults of 24 hours old were transferred on the plant with the help of a glass aspirator and the pots were kept at a constant temperature (25 ± 1°C). There were three replications for each concentration along with a control (no treatment).

* A part of the thesis submitted by the senior author to Gujarat Agricultural University, Sardar Krushinagar.

TABLE 1

Relative toxicity of different insecticides against adult of *C. indicus*.

Sr. No.	*Insecticides*	*Heterogeneity*	*Regression equation*	*LC_{50} values*	*Fiducial limits*	*Relative toxicity*
1.	Dimethoate	*X^2 (4) = 1.0949	Y = 1.4510 + 2.4980X	0.002691	+ 0.0123 − 0.0038	0.9887
2.	Endosulfan	X^2 (4) = 0.4526	Y = 1.5740 + 1.8620X	0.007762	+ 0.0416 − 0.0001	0.3427
3.	Fenvalerate	X^2 (4) = 0.3087	Y = 2.3000 + 2.0272X	0.002344	+ 0.0101 − 0.0044	1.1351
4.	Monocrotophos	X^2 (4) = 0.5433	Y = 0.9532 + 2.2145X	0.005880	+ 0.0046 − 0.0014	0.4581
5.	Phosphamidon	X^2 (4) = 0.8858	Y = 2.3629 + 1.8828X	0.002661	+ 0.0085 − 0.0008	1.0000
6.	Quinalphos	X^2 (4) = 4.2409	Y = 2.6571 + 1.7028X	0.002600	+ 0.0033 − 0.0014	1.0233

* In none of the cases the data were found to be heterogeneous at p = 0.05

Y = Probit kill X = Log (concentration X 10^4)

LC_{50} = Concentration calculated to give 50 per cent mortality.

For the assessment of toxic effect of the inseticides, mortality counts were taken 48 hours after the treatment. The per cent mortality was corrected by Abbott's formula (Abbott, 1925) and then subjected to probit analysis (Finney, 1978). The values of relative toxicity of different insecticides have been calculated by taking the LC_{50} value of phosphamidon as unity and given in Table 1.

It is evident from (Table 1) that fenvalerate, a synthetic pyrethroid proved to be the most toxic and effective insecticide (LC_{50} = 0.002344) and was 1.135 times as toxic as phosphamidon. On the other hand endosulfan found to be the least toxic (LC_{50} = 0.007762). On the basis of LC_{50} values, the order of toxicity of these insecticides against the adults of *C. indicus* was : fenvalerate > monocrotphos > endosulfan. Among the six insecticides fenvalerate and quinalphos were found to be more toxic than phosphamidon, being about 1.135 and 1.023 times as toxic as phosphamidon, respectively, whereas dimethoate, monocrotophos and endosulfan proved less toxic and were respectively about 0.983, 0.452 and 0.343 times as toxic as phosphamidon. Gargav and Vaishampayan (1981) tested certain organophosphate and chlorinated hydrocarbon insecticides against this pest and compared their toxicity with DDT. They reported that dimethoate was slightly more toxic than DDT, but information on relative toxicity of newer insecticide and against this pest on groundnut is scanty.

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Record of Three False Wireworms Infesting Groundnut in Gujarat

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The false wireworms from family Tenebrionidae viz., *Gonocephalum* sp. in Africa and *Agriotes gurgistanus* in Soviet Union have previously been reported damaging groundnut pods (Feakin, 1973; Fenili *et al.*. 1983; Tarimo and Karel 1987). Three false wireworms, *Penthicoides seriatoporus* Fair-maire, *Gonocephalum* sp. and *Opatroides frater* (Fairmaire) (Tenebrionidae : Coleoptera) were found damaging the groundnut pods (variety JL-24) at Main Dry Farming Research Station, Gujarat Agricultural University, Targhadia (Gujarat) during the monsoon season, 1991. Their incidence as pests of groundnut in India was not reported earlier. The incidence was observed more in mid-September 1991, damaging the pods in 25 per cent of groundnut plants. The larvae damaged the immature pods by piercing the shell and feeding on the seed. Their biology was studied in the laboratory during October - December, 1991.

Among these wireworms, *P. seriatoporus* was found important. The larvae were very active, smooth with a yellow brown to dark brown integument. The full grown larva measured 30 mm in length and 2.5 mm in breadth. The pupation took place in the soil. The pupa was pale yellowish. The pupal stage lasted for 2 to 6 days with an average of 3.80 days. The freshly emerged beetle was brown in colour, about 15 mm long and 6 mm wide. The beetles survived for 20 to 39 days with an average of 32 days.

The larvae of *Gonocephalum* were yellow in colour, measured 22 mm in length and 2 mm in breadth. The larval period was 58 days. They pupated in the soil. The pupal period was 9 days. The beetles were grey in colour found emitting offensive smell on disturbance. The adults were 12 mm long and 5 mm wide. Reddy and Puttaswamy (1985) reported this pest damaging Chilli in Karnataka. The beetles of *O. frater* were observed active in the soil near the groundnut plants. The larvae damaged immature pods. The beetles were black in colour, measured 7 mm in length and 2.5 mm in breadth. This wireworm was reported damaging tobacco seedlings in Andhra Pradesh (Joshi and Rao, 1968) and Chilli in Karnataka (Reddy and Puttaswamy 1985).

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During summer season, the adults of these wireworms were observed active in the decayed organic materials on the farm bunds. The population proportion of *Gonocephalum* adults was, however, found higher (97%) than other two wireworms (3%) in May, 1992.

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Extent of Seed Transmission of Urdbean Leaf Crinkle Virus in Gujarat

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Urdbean leaf crinkle virus (ULCV) disease of urdbean (*Vigna mungo* (L.) Hepper) is characterised by an increase in the size and a light green colour of leaves followed by the typical crinkling symptoms. Considerable malformation of the inflorescence in infected plants is also observed. Yield loss of 62 to 100% (Nene, 1973; Kolte and Nene, 1979) under field condition and 71 to 84% in glass-house studies have been observed (Beniwal and Chaubey, 1979). ULCV is reported to be seed, sap and vector transmissible virus in urdbean (Kolte and Nene, 1972, Narayanaswamy and Jaganathan, 1973, 1975, Dhingra, 1975, and Beniwal and Bharathan, 1980). The primary source of infection under field condition is always from the seed. Kolte and Nene (1972) observed that 18.39 per cent of urdbean seeds carried the virus (glass-house study).

The disease has been observed in recent years in Baroda, Kheda, Mehsana, Panchmahal and Sabarkantha districts of Gujarat (Anonymous, 1990, 1991). Therefore, to determine the effect of disease on some yield contributing characters and rate of seed transmission under Gujarat conditions a preliminary study was made. The infected plants in the field were tagged in *kharif* season of 1989 and pods were harvested. The pod size, no. of seeds/pod and test weight (1000-grain weight) from infected as well as healthy plants of urdbean cv. T-9 were determined. The seeds were sown in plastic pots (10 cm) containing autoclaved soil. Two plants were maintained in each pots covered with insect proof cages. The typical crinkled symptoms were observed on some plants and the infectious nature of the disease was confirmed by mechanical transmission on to healthy plants. Seeds from healthy plants served as control.

In the second experiment seeds collected from 3 locations viz. Talod, Vijapur and Anand from diseased and healthy urdbean plants cv. T-9 were sown in field. The seeds were sown in 3 rows of 5 meter each, 45 cm apart. The plant to plant distance was adjusted to 20 cm after emergence. Typical diseased plants were counted weekly.

The data (Table 1) revealed that pod size, no. of seed/pod and test weight were reduced due to ULCV. Similar reduction in yield contributing characters in urdbean due to ULCV

TABLE 1

Effect of urdbean leaf crinkle on pod characters and rate of seed-transmission in urdbean cv. T-9.*

Source of seed	*Pod size (cm)*	*No. of seeds/pod*	*Test weight (gm)*	*Rate of seed transmission of ULCV*
Diseased	3.8	4.7	21.4	8.0
Healthy	4.4	6.0	38.0	0.0

*Average of 50 pods.

have been observed by Beniwal and Chaubey (1979). However, they did not observe reduction in test weight. In the pot experiment 8.00 per cent of plants raised from the seeds of diseased plants showed typical leaf crinkle symptoms which was later transmitted to healthy plants after sap inoculation. Seeds from healthy plants did not show any symptoms.

TABLE 2

Rate of seed-transmission of ULCV in urdbean cv. T-9 under field condition in Gujarat.

Location of seed plot		*Healthy source (ULCV%)*	*Diseased source (ULCV%)*
Talod	(Sabarkantha)	2.2.	31.2
Vijapur	(Mehsana)	3.4	4.4
Anand	(Kaira)	2.1	2.0

In the field experiment (Table 2) differences were found in the rate of seed transmission from location to location. Seeds collected from diseased plants at Talod showed 31.25 per cent ULCV infected plants followed by Vijapur (4.40%) and Anand (2.0%). Seeds collected from healthy plants showed some incidence of ULCV which might have resulted from mechanical/vector transmission as in the initial counts there were no diseased plants in the plots raised with healthy seeds. These results confirm the seed-borne nature of the disease Kolte and Nene (1972) and constitutes, the first record of the disease from Gujarat.

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Correlation and Path Analysis in Pigeonpea Production Traits

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For designing any sound breeding programme, the critical assessment of nature and magnitude of genetic variability is one of the pre-requisite for any plant breeder. Yield, which is a complex character can be improved if its association and magnitude with yield contributing characters are known. The present study was therefore conducted to know such association in pigeonpea.

Seventy pigeonpea genotypes collected from different pigeonpea growing areas of the country were planted on Instruction farm of Agriculture College Navsari in *kharif*, 1990. The sowing was done in single row plot of 5 m length having a spacing of 90 x 20 cm following randomised block design with 3 replications. Observations on 5 randomly selected plants were recorded for 10 characters and their means were used for computing correlations (Al Jibouri *et al.* 1958). Path analysis was done as per method described by Dewey and Lu (1959).

Correlation coefficients presented in table 1 were highly significant in most of the cases and in general genotypic correlations were higher than their corresponding phenotypic correlations. Grain yield was significantly and positively associated with number of pods per plant, number of primary branches, plant height, length of secondary branch, 100 seed weight, days to flower and pod length. The trait number of pods per plant was significantly and positively correlated with all the traits except pod length and number of seeds per pod at genotypic and phenotypic levels. Similar was the trend between 100 seed weight and other characters. Plant height was having positive and significant association with number of primary branches, length of secondary branch pod length, days to maturity and days to flowering. The correlation between days to flower and maturity was substantial and positive. Thus most of the characters were noted to have influence on one another and yield, which is in accordance of Bainiwal and Jatasra (1983) Bhongle and Raut (1987) and Patil *et al.* (1989).

Path analysis (Table 2) revealed positive direct effects of all the traits which had significant association with seed yield except of days to flower and pod length, whose direct effects were negative. The highest direct and indirect positive effect was of pods per plant, where as plant height, number of primary

TABLE 1

Genotypic (G) and phenotypic (P) correlations among ten characters of pigeonpea.

Characters		*Number of pods plant*	*Number of seeds pod*	*100 seed weight (g)*	*Plant height (cm)*	*Number of primary branches plant*	*Length of secondary branches plant (cm)*	*Pod length (cm)*	*Days to flower*	*Days to maturity*
Grain yield plant (g)	G	0.819**	0.013	0.571**	0.702**	0.736**	0.698**	0.245*	0.472**	0.185
	P	0.748**	0.044	0.572**	0.682**	0.679**	0.614**	0.229	0.401**	0.137
Number of pods per plant	G		-0.045	0.577**	0.659**	0.658**	0.611**	0.180	0.515**	0.318**
	P		-0.025	0.519**	0.593**	0.531**	0.484**	0.114	0.435**	0.244**
Number of seeds pod	G			0.170	-0.140	0.109	-0.061	0.280*	-0.090	0.102
	P			0.157	-0.055	0.118	-0.004	0.255*	-0.025	0.092
100 seed weight	G				0.380**	0.513**	0.468**	0.194	0.416**	0.259*
	P				0.367**	0.447**	0.400**	0.171	0.351**	0.210
Plant height	G					0.682**	0.844**	0.425**	0.623**	0.450**
	P					0.598**	0.723**	0.382**	0.510**	0.330**
Number of primary branches/ plant	G						0.621**	0.254*	0.505**	0.077
	P						0.540**	0.232	0.408**	0.049
Length of secondary branches/ plant	G							0.275*	0.649**	0.277*
	P							0.244*	0.466**	0.213
Pod length	G								0.124	0.088
	P								0.077	0.066
Days to flower	G									0.494**
	P									0.421**

* Significant at P = 0.05

** Significant at P = 0.01

TABLE 2

Direct and indirect effects of nine causal variables on seed yield of pigeonpea.

Characters	Direct effect	INDIRECT EFFECTS									Correlation with yield
		Number of pods/ plant	Number of seeds/ pod	100 seed weight (g)	Plant height (cm)	Number of primary branches/ plant	Length of secondary branch (cm)	Pod length (cm)	Days to flower	Days to maturity	
Number of pods/plant	0.5021	—	-0.0026	0.0613	0.1455	0.1028	0.0071	-0.0078	-0.0414	-0.0384	0.8186**
Number of seeds/pod	0.0584	-0.0227	—	0.0181	-0.0309	0.0170	-0.0097	-0.0117	-0.0071	-0.0123	0.0133
100 seed weight	0.1062	0.2898	0.0098	—	0.0839	0.0800	0.0744	-0.0081	-0.0334	-0.0312	0.5714**
Plant heigth	0.2209	0.3307	-0.0082	0.0404	—	0.1064	0.1304	-0.0178	-0.0501	-0.0543	0.7020**
Number of primary branches/plant	0.1561	0.3306	0.0064	0.0544	0.1504	—	0.0987	-0.0106	-0.0406	-0.0093	0.7361**
Length of secondary branch	0.1589	0.3069	-0.0036	0.0497	0.1862	0.0970	—	-0.0115	-0.0522	-0.0334	0.6980**
Pod length	-0.0419	0.0932	0.0163	0.0206	0.0938	0.0396	0.0438	—	-0.0100	-0.0106	0.2448*
Days to flowering	-0.0804	0.2584	-0.0053	0.0441	0.1376	0.0789	0.1032	-0.0053	—	-0.0593	0.4716**
Days to maturity	-0.1206	0.1598	0.0059	0.0276	0.0995	0.0120	0.0440	-0.0037	-0.0398	—	0.1847

Residual effect + 0.4669

*Significant at 5%

** Significant at 1%

branches, length of secondary branch and test weight had the indirect effects through number of pods per plant which was much higher than their individual direct effects. Pod length, days to flower and maturity which had negative direct impact on yield, influenced it considerably positively through pods per plant and plant height. The greater importance of pods per plant along with plant height, test weight and number of branches have also been reported by Sidhu *et al.* (1985), Patel *et al.* (1988) and Patil *et al.* (1989). These characters had strong association with yield and have contributed considerably towards it directly and indirectly. Selection for improving yield through these traits in positive direction and through days to flower and maturity in negative direction will be fruitful in pigeonpea.

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Desirability of Using Powerloom Cloth Bag for Selfing Isabgul (*Plantago ovata* Forsk)

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Isabgul (*Plantago ovata* Forsk) a dicotyledonous annual herbcultivated in North Gujarat and Rajasthan is one of the crops having high export potential. Isabgul has few tillers. Each tiller inturn has many spikes. Bagging of individual spike is time consuming, laborious and costly. It was an usual practice of selfing isabgul plants over the last several years to self the whole plant with selfing bag made of powerloom cloth. It was suspected that the mesh number (approximately) (5/mm^2) in such cloth bag would be sufficiently less, providing reasonably large pores through which the pollen of isabgul (0.00026 mm diameter) can pass through without hindrance. By this study an attempt was made to know whether the usuage of this kind of cloth is appropriate for selfing.

Two types of powerloom cloth bags, namely starched and unstarched were used to cover male sterile plants of variety Gujarat Isabgul 1. For each treatment and a control (i.e. open pollinated) 20 plants were used. Male sterile plants were identified immediately after anthesis in the first spike. These plants were recognised by the presence of small shrivelled anthers and male sterility of these plants was further confirmed by micro-scopic examination of their anthers; which showed no pollen grains.

The powerloom cloth bags used were of 45 cm length with 30 cm breadth. The specifications of fabric used were : threads per inch-warp 68, weft 48; count warp 30 and weft 34. Twenty starch free cloth bags were starched by soaking them for 20-30 minutes in starch solution prepared by boiling 150 g starch powder in 1.5 litres of water for 10 minutes.

Two or three spikes of each selected male sterile plants were covered with tissue paper bag either inside the powerloom cloth bag or in open, before the stigma in the lower most floret became receptive to confirm the male sterility of the selected plants. From every plant, spikes which showed one or more mature receptive stigma were cut off and then the whole plant was bagged and held in place by specially constructed iron frames. All plants were tagged for identification. The data on seed set were collected by observing individual florets of each spike of all the plants. Seed set on the spikes which were bagged with tissue paper bag inside the powerloom cloth bag were also studied.

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Two spikes, bagged with tissue paper bag inside the cloth bag did not set seed in any of the 60 plants studied, confirming that the plants selected for this study were male sterile. Per cent seed set in male sterile plants of isabgul covered with either starched or unstarched powerloom cloth bags revealed that out of 20 male sterile plants covered with starched powerloom cloth bag, 11 plants showed no seed set (Table 1) indicating effective barrier of

TABLE 1

Per cent seed set in male sterile Isabgul plants covered with either starched or unstarched powerloom cloth bags.

Plant No.	*Powerloom cloth bag*		*Control open-pollinated*
	Starched	*Unstarched*	
1.	3.33	10.49	99.15
2.	2.68	15.41	99.00
3.	0.00	22.41	98.85
4.	0.00	20.00	98.00
5.	0.00	11.89	97.45
6.	0.00	12.32	98.12
7.	3.24	13.33	98.25
8.	9.87	13.99	98.30
9.	0.00	11.14	97.30
10.	4.24	10.06	98.18
11.	0.00	15.30	98.45
12.	0.00	37.80	98.36
13.	9.95	23.39	97.50
14.	2.36	10.54	98.19
15.	0.00	9.39	99.10
16.	0.00	7.21	97.43
17.	0.83	30.22	98.40
18.	0.00	8.93	99.00
19.	9.46	14.37	98.65
20.	0.00	6.67	97.90
Total	45.96	302.86	1966.07
Average %	2.30	15.14	98.04
Range	0 to 9.87	6.67 to 37.80	97.42 to 99.15

the cloth for the pollen. While in the remaining 9 plants seed set varied from 0.83 to 9.87%. All the 20 male sterile plants covered with unstarched powerloom cloth bags set seed. Average per cent seed set was 15.14 indicating that pollen did pass through the bag and that powerloom cloth bag was not reliable for selfing isabgul plants. Krishnaswamy (1962) also reported unreliability of muslin cloth bag for selfing pearlmillet indicating that cotton fabrics did not fully prevent the passage of pollen grains.

From the study it can be concluded that the use of unstarched powerloom cloth bag for selfing is not reliable for isabgul as pollen can pass through the cloth. However, evenly starched powerloom cloth bag prepared by using cloth with considerable higher mesh number than the one used in this study can be used for selfing.

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Genotype x Environment Interaction in the Performance Traits of Holstein Friesian x Sahiwal Crossbreds*

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Scientific information on the existence of genotype x environment (G x E) interaction would be of great importance especially for selecting the crossbreds. The present attempt was, therefore, made to know the relative importance of various G x E interactions in Holstein-Friesian (HF) x Sahiwal crossbreds.

Data on 1711, 1352 and 726 HF x Sahiwal crossbreds of three military dairy farms (Bangalore, Pimpri and Secunderabad), born during 1975 to 1983 pertain to economic traits viz. birth weight (BW), age and body weight at first calving (AFC, BFC), first and second lactation traits viz. length (FLL. SLL), yield (FLY, SLY), peak yield (FLPY, SLPY), dry period (FDP, SDP) and calving interval (FCI, SCI), respectively. Assuming multifactor linear model, analysis of variance was done to detect the significance of G x E interactions. The relative contribution of each interaction was to the total variation in the performance traits was calculated as R^2 per cent (Table 1). The genetic variant was breed of sire (B), while environmental variants were farm, period, season, age and body weight at calving.

Perusal of the contributions of various nongenetic effects to the total variation in all performance traints revealed the farm as major effect (R^2% =0.02 to 19.83), followed by body weight (R^2% = 0.02 to 19.83), calving (R^2% = 0.15 to 3.47) and season (R^2% = 0.01) to with period (R^2% = 0.15 to 3.47) and season (R^2% = 0.01 to 5.59) were comparatively less important, in most of the traits. Similar results were obtained for same traits of these crossbreds even when some more data were added to the present and analysed separately for each breed of sire (Tajane *et al.*, 1988, Tajane and Rai, 1989a and 1989b).

Among the various G x E interactions, B x F was found to be the most important contributing around 1.80 to 6.10 per cent ($P < 0.01$) to the total variability in lactation yields (FLY, FLPY, SLY and SLPY). It also significantly influenced the variability in AFC, SIL and SDP (Table 1), while it was almost absent in remaining traits. Ganpule *et al.* (1984) also reported significant sire x location interaction for AFC, ELY and body weights at different ages. However, the contribution of this interaction reported by them (0.00 to 3.00%) was comparatively less.

* Based on the data from Ph. D. thesis of the author.

TABLE 1

Relative contributions (R^2) of various nongenetic effects and their interactions with breed of sire (B) to the total variation in performance traits of HF x Sahiwal crossbreds.

Sources	d.f	BW	AFC	BFC	FLL	FLY	FLPY	FDP	FCI	SLL	SLY	SLPY	SDP	SCI
B	1	0.01	0.32**	0.07	6.49**	3.11**	6.22**	1.56**	1.09**	0.01	1.00**	0.03	1.06**	0.33*
Farm F	2	0.02	3.29**	0.37**	1.35**	15.76**	9.08**	19.83**	0.69**	0.21	13.47**	8.99**	1.65**	1.81**
Period P	1	0.15	3.47**	0.59**	0.42**	0.86**	1.14**	0.06	1.77**	1.04**	0.56**	0.15	0.30	0.82*
Season S	2	0.02	1.31**	0.01	0.74**	0.20**	0.16	0.87**	0.80**	0.20	5.59**	0.48**	0.71	0.82*
Age A	5	—	—	—	0.52**	0.19	0.48*	0.47	0.46	1.36**	1.97**	1.08**	0.59	0.24**
Body wt. Bw	4	—	—	—	0.43*	7.39**	11.50**	1.37	1.54**	0.25	4.99**	8.34**	0.34	0.22
B x F	2	0.05	1.05**	0.23	0.00	1.80**	3.63**	0.00	0.20	0.48**	2.75**	6.10**	1.15**	0.47
B x P	1	0.13	0.00	0.40	0.23	2.24**	2.93**	1.82**	1.20**	0.03	3.69**	6.14**	1.00**	0.62*
B x S	2	0.02	0.00	0.00	0.00	0.00	0.20*	0.12	0.33	0.00	0.00	1.16**	0.00	0.00
B x A	5	—	—	—	0.00	0.31	0.00	0.16	0.24	0.00	0.00	0.00	1.23**	0.00
B x Bw	4	—	—	—	0.07	6.41**	4.08**	0.00	0.00	0.38	4.85**	6.71**	0.29	0.19
Error	—	99.60	90.56	98.33	89.75	61.73	60.58	73.74	91.68	96.04	61.13	60.82	91.68	93.48
Error d.f		1757	1757	1757	1320	1320	1320	913	913	695	695	695	566	566

* ($P < 0.05$), ** ($P < 0.01$). Negative contributions were assumed zero.

The another important interaction was found to be B x BW (R^2% = 4.08 to 6.71) for lactation yields (FLY, FLPY, SLY and SLPY). Contrarily it was (R^2% = 0.00 to 0.38) for negligible for lactation length (FLL, SLL) and reproduction traits. The interaction between B x A (R^2% = 0.00 to 0.31) was also for little importance for almost all traits except for SDP (R^2% = 1.23).

Similarly, B x S interaction was also non significant for most of the traits (R^2% = 0.00 to 0.33) except for FLPY and SLPY (R^2% = 0.20 and 1.16, respectively). Thus, these findings were in close accordance with those reported by Mao and Burnside 1969) for FLY. In contrast to their findings of nonsignificant sire x Y-S interaction, the present study revealed a significant B x P interaction for yield and reproduction traits during first and second lactations (Table 1). Around 0.62 to 6.14 per cent variation in these traits was attributable to B x P interaction. However, it was nonsignificant for BW, AFC, BFC, FLL and SLL (R^2% = 0.00 to 0.40).

In general, B x F, B x Bw and B x P interactions appeared to be of more importance for affecting significantly the variation in yield and reproduction traits of first and second lactation traits. Hence, the selection programme in crossbred population must consider the existence of interactions. The other interactions (B x S and B x A) could be ignored for dairy traits in HF x Sahiwal crossbreds.

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Abstracts of Ph. D. Thesis

Response of GR. 11 Rice (*Oryze sativa* L.) to Potash Under Low Medium and High NP Levels and its Residual Effect on Mustard

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A field experiment was conducted on sandy clay loam soil on the farm of main Rice Research Station, Gujarat Agricultural Univerity, Nawagam to study the response of GR. 11 rice to potash under low, medium and high NP levels and their residual effect on mustard through *kharif* and *rabi* season of 1983 and 1984. Twenty treatments comprising combinations of four levels of NP namely $N_0P_0(F_1)$, $N_{50}P_{25}$ (F_2), $N_{100}P_{50}$ (F_3), $N_{150}P_{75}$ (F_4) and five levels of potash comprising of 0 (K_0), 25 (K_1), 50 (K_2), 75 (K_3) and 100 (K_4) kg/ha were employed in Factorial Randomised Block Design with four replications. Mustard crop was grown in *rabi* season after *kharif* rice on the same site without application of any fertilizer to study the residual effect of NP and K.

The results revealed that potential production and profit from *kharif* rice can be screened by fertilizing the crop with 100 kg N + 50 kg P_2O_5/ha (F_3). $N_{100}P_{50}$ produced 51.71 and 86.76 q/ha grain and straw respectively comparable with that of 53.51 and 89.94 q/ha under $N_{150}P_{75}$ (F_4).

Application of any levels of potash was not found to be beneficial to lowland rice.

Crop fertilized with $N_{150}P_{75}$ resulted in significantly higher protein content in rice grain during individual years. Whereas potash did not made any significant influence on protein content of rice grain. Rice crop fertilized with higher levels of NP removed significantly higher quantity of N, P and K whereas potash did not influence on removal of N and P. Higher K removal was observed with higher K_2O level.

Different levels of NP fertilizers applied to *kharif* rice did not found beneficial effect on yield of succeeding *rabi* mustard crop. Whereas 50 and 100 kg K_2O/ha showed significant residual effect on yield of mustard crop.

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Studies on Wilt of Mustard (*Brassica juncea* (L) Czern and Coss) Caused by *Fusarium oxysporum* F. sp. *conglutinans* (Wr.) Snyder and Hansen

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Wilt disease of mustard incited by *F. oxysporum* F. sp. *conglutinans* (Wr.) Snyder and Hansen was observed in severe form near to maturity stage. The pathogen produced wilting in cruciferous hosts viz. *Brassica campestris* var. *toria*, *B. carinata*, *B. oleracea* var. *botrytis*, *Eruca sativa*. While, *B. napus* and *Ricinus communis* were immune. It also produced 96.67 per cent mortality on inoculation to mustard plants.

Richard's medium supported maximum growth and abundant sporulation. Low C:N ratio (15:1) in media allowed profuse micro-conidial formation. Higher temperature (35°C) favoured exclusive development of chlamydospore. The pH 4.0 was optimum for growth and sporulation. Culture filtrates of the pathogen was inhibitory to germination of seeds and caused severe wilting of seedlings of 'Varuna' mustard. Mustard cultivar 'Varuna' was more susceptible at 105 days old plants while, inoculation in early stage had no wilt.

The fungicides Carbendazim, Thiophenatemethyl and Mancozab completely inhibited the growth. 'Krishna' mustard was found immune while, 'RSK-7' and 'CSR-721' were tolerant to wilt. The population of pathogen decreased gradually 2.5 times in unsterilized soil in absence of host tissues, while increased 1.2 times in sterilized soil in the presence of host tissues and able to survive up to another season.

None of the rhizosphere fungi or bacteria and *Trichoderma harzianum* strains was antagonistic to the pathogen. For thermal death of conidia and chlamydospores of the pathogen, respective peak temperatures were 57°C and 70°C. At 45°C temperature 83 per cent chlamydospores were germinated. Spore germination of the pathogen was inhibited by culture filtrates of *Emericella nidulans*, *E. rugulosa* and *E. quadrilineata*.

Crop Weather Relationship in Summer Pearl Millet (*Pennisetum americanum* (L) Leeke) and Testing of CERES Millet Model for the Middle Gujarat Agroclimatic Zone

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Field experiment were conducted in pearl millet (Cv. GHB. 30) during summer season of 1991 and 1992. Treatments comprising of 3 sowing dates (Feb. 5, 15, 25) and for irrigation levels (Tc-Ta = 1 to 0°C, 0 to - 1°C, Iw/CPE = 1.0 and farmer's method i.e. 8 days interval) were laid out in splitplot design with sowing dates as main treatment and replicated thrice. The result of pooled data reveals that grain yield was significantly higher in I_3 i.e. Iw/CPE = 1.0 whereas dates of sowing did not show any significant effect on grain yield in both year; however there was significant difference in pooled data with highest yield of 43.43 q/ha in Feb. 5 sowing.

Path analysis of grain yield and weather observed revealed that high relative humidity during flag leaf to dough stage and high thermal interception rate (TIR) during the period from anthesis to dough stage are found favourable for higher grain yields.

CERES millet model corrected for genetic co-efficients was found to be good for Middle Gujarat. CERES millet model predict the anthisis date and maturing date with minimum error. However grain yield and total biomass prediction by CERES millet model showed larger per cent of error compared to that grain yield predicted by model developed with help of stepwise regression technique in this study.

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