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Efficacy of Sprinkler Irrigation in Chickpea

V. K. Chandegara and J. P. Yadavendra

Agricultural Research Station, Gujarat Agricultural University, Derol

ABSTRACT

An experiment on ascertaining the relative efficacy of sprinkler and surface irrigation in chickpea was conducted on sandy loam soil at Agricultural Research Station, Derol (Gujarat). It was evident from this study that there was 43.75 per cent saving in water with an increase in grain yield by 60 per cent. Three sprinkler irrigations of 60 mm each at sowing time, branching time and pod formation stages were found best suited to chickpea crop. Further, higher economic returns were obtained with 62.5 per cent saving in water over surface irrigation, when the crop was given only two sprinkler irrigations at sowing and branching stages.

(Received on 11th Sept., 1997)

INTRODUCTION

Gram (*Cicer arietinum* L.) is an important pulse crop cultivated in Gujarat during winter season. To get higher yield per unit area, farmers are applying irrigation to the crop. For proper use of irrigation water, it becomes imperative to study the new method of sprinkler irrigation in chickpea crop specifically, where the soils are deep sandy loam with a high infiltration rate. With this objective, it was planned to study the efficacy of sprinkler method of irrigation over surface method.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Derol for three years (1994-95 to 1996-97). The soils of the experimental site was sandy loam in texture

and neutral in reaction. The gram variety ICCV-4 was used in the study. The sowing was done on 22-11-94, 14-11-95 and 29-10-96 keeping a seed rate of 60 kg per hectare with a spacing of 30 x 10 cm. The crop was given a basal dose of 20 : 40 kg nitrogen and phosphorous per hectare, respectively. The treatment consisting of four irrigation schedules applied through sprinkler system (T_1 - two irrigations at sowing and branching T_2 - three irrigations at sowing, branching and pod formation, T_3 - three irrigations at sowing, branching and flowering and T_4 - four irrigation at sowing, branching, flowering and pod formation stage) compared with four irrigation given through check basin method of surface irrigation. In sprinkler irrigation, the depth of irrigation was fixed to 60 mm, while in surface irrigation it was kept 80 mm due to water losses. The twin nozzle sprinkler placed at 12

x 12 M were operated to get a water application rate of 1.67 cm/hr with 2.74 kg/cm² pressure for three and half hours duration. The experiment was conducted on a non-replicated large plot size (36 x 36 M) and the treatments were compared individually by 't' test.

RESULTS AND DISCUSSION

The pooled results of three years experimentation have indicated the superiority of sprinkler method of irrigation over surface

irrigation method (Table 1). This was evident from the increased grain yield as well as water saving. The best time of application of sprinkler irrigation was found at sowing, branching and pod formation stages (T_2) indicated by the increased grain yield (62.93%) and water saving (43.75%). Similarly Shinde *et al.* (1985) found that sprinkler irrigation at presowing, branching and pod formation stage resulted in maximum seed yield in chickpea. Maximum water saving was observed, when irrigation through sprinkler

TABLE 1

Yield and water use parameters under different methods of irrigation (three years pooled data).

Sr No.	Particulars	Sprinkler treatments				Surface method (control)
		T_1	T_2	T_3	T_4	
1.	Grain yield (kg/ha)	1417.17	1873.67	1176.00	1577.67	1150.00
	S. Em. = ± 58.43		C. D. = 166.92		C. V. = 13.78%	
2.	Straw yield (kg/ha)	1614.17	2465.83	1826.67	2610.00	2007.50
	S. Em. = ± 132.17		C. D. = 430.95		C. V. = 9.83%	
3.	Total water applied (mm)	120	180	180	240	320
4.	Water use efficiency (kg/ha-mm)	11.81	10.40	6.54	6.57	3.59
5.	Saving in water over control (%)	62.50	43.75	43.75	25.00	—
6.	Change in grain yield over control (%)	23.23	62.93	2.46	37.26	—
7.	Net income Rs. ha.	4855	9136	2156	5887	3210
8.	Additional area can be covered (ha)	0.33	0.78	0.78	1.67	—
9.	Cost benefit ratio	1.52	1.95	1.22	1.60	1.39

Selling Price

Gram - Rs. 10.0/kg grain.

was given at time of sowing and branching stage (T_1) but it reduced the grain yield significantly. It was evident from these findings that the sprinkler irrigation at the time of flowering (T_3) was detrimental as it reduced the grain yield in chickpea Raman *et al.* (1983) also reported that grain yield in chickpea was reduced when irrigation was given at flowering stage.

The cost of cultivation was higher in sprinkler method of irrigation than the traditional surface method. In surface method,

the cultivation cost was Rs. 8290/-. The highest net income over control (Rs. 5926/-) was realised, when sprinkler irrigation was given at the time of sowing, branching and pod formation stage (T_2). In addition to this income, there was a saving of 43.75 per cent in irrigation water. With this saving of water an additional 0.78 hectare land can be brought under irrigation which will result in further additional income. Basu *et al.* (1995) have also observed higher net profit by sprinkler irrigation than surface irrigation in blackgram.

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Response of Soybean (*Glycine max* L.) Genotype to Row Spacings and Fertility Levels under Rainfed Conditions

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ABSTRACT

A field experiment was conducted on soybean during *kharif* season of 1993 and 1994 to study the performance of newly developed soybean (*Glycine max* L.) genotypes in relation to different row spacings and fertility levels. Genotype JS-87-59 gave significantly higher seed yield than JS-87-60. Wide row spacing (45 cm) and high level of fertilizers (30 : 80 : 20 kg NPK/ha) proved superior than close row spacing (30 cm) and low fertilizer dose (20 : 60 : 15 kg NPK/ha).

(Received on 5th Febru., 1998)

INTRODUCTION

Soybean (*Glycine max* L.) is most energy rich commercial crop during *kharif* season in Satpura Plateau zone of M. P. It has wide adoptibility and mainly grown as rainfed crop. Optimum plant population and proper fertilizer application play an important role in increasing yield of soybean particularly under rainfed condition. Fertilizers being a costly inputs, it has become necessary to improve the productivity per unit area by efficient use of fertilizers. Selection of high yielding improve genotypes and adoption of proper row spacing may help to achieve this target (Kacha *et al.*, 1990). In lacking of informations, the present investigation was undertaken to identify the suitable genotype under varying row spacings and fertility levels.

MATERIALS AND METHODS

A field experiment was conducted on soybean in clay loam soil at Zonal Agricultural Research Farm, Chhindwara (M.P.) during *kharif* season 1993 and 1994. The soil was low in available nitrogen (245 kg N/ha), medium in phosphorus (12 kg P/ha) and high in potash (580 kg K/ha) with 7.3 pH. The total rainfall was 863 and 1183 mm in the two consecutive years during crop season. Treatments consisted with 2 genotypes (JS-87-60 and JS-87-59) and 2 row spacings (30 and 45 cm.) as main plot treatments and 2 fertility levels (30 : 80 : 20 and 20 : 60 : 15 kg N, P₂O₅ and K₂O/ha) as subplot treatments were tested in split plot design with 3 replications. Sowing was done on June 26, 1993 and June 28, 1994 in 5.0 m x 4.5 m plots with 100 kg seeds/ha. Before sowing seeds were treated with thiram and with

rhizobium culture respectively. All fertilizers were given as basal as per treatments. Interculture operations like hoeing two times and single hand weeding were done uniformly in all plots. The crop was harvested at maturity genotype wise. Date on growth, yield attributing characters and yield were collected and exposed to statistical analysis.

RESULTS AND DISCUSSION

In general, the yield of soybean was 41.2% higher during 1993 than yield of during 1994 under all treatments. During second year crop suffered due to continuous rains at vegetative and flowering stages which resulted in the poor yield.

Genotypes

Genotype JS-87-59 recorded significantly taller plants, higher number of

branches and pods/plant, longer pods, more number of seeds/pod and bolder seeds as compared to genotype JS-87-60 which attributed to produce significantly higher seed yield (24.3 q/ha) and straw yield (38.2 q/ha).

Row spacings

Wide row spacing (45 cm) resulted in significantly more seed yield than the close spacing of 30 cm in both the years but straw yield did not vary due to row spacings (Table 1). Growth and yield contributing parameters were superior with wide spacing than close spacing mainly due to better utilization of available nutrients, light and soil moisture. These results also confirmed the findings of Deshmukh *et al.* (1977) and Kacha *et al.*, (1990).

TABLE 1

Effect of row spacings and fertility levels on yields of soybean genotypes.

Treatment	Seed yield (q/ha)			Straw yield (q/ha)		
	1993	1994	Mean	1993	1994	Mean
Genotypes						
JS-87-60	26.6	18.5	22.6	40.1	28.6	34.4
JS-87-59	28.2	20.3	24.3	45.9	30.5	38.2
CD (P = 0.05)	0.3	—	0.7	0.7	1.0	—
Row spacings						
30 cm	27.0	18.5	22.8	42.1	30.8	36.5
45 cm	27.8	20.3	24.1	43.9	28.3	36.1
CD (P = 0.05)	0.3	0.5	—	0.7	1.0	—
Fertility levels						
NPK (kg/ha)						
30 : 80 : 20	27.9	20.4	24.2	43.8	31.3	37.6
20 : 60 : 15	26.9	18.3	22.6	42.2	27.8	35.0
CD (P = 0.05)	0.6	0.4	—	1.0	0.9	—

TABLE 2
Growth and yield attributes of soybean as affected by genotypes spacings and fertilizers.

Treatment	Plant height (cm)		Branches/ plant		Pods/ plant		Pod length (cm)		Seeds/ pod		1000 seed weight (g)	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Genotypes												
JS-87-60	76.7	69.1	2.53	3.43	37.6	23.5	3.62	3.23	2.65	2.42	68.4	53.5
JS-87-59	83.9	77.6	2.74	2.07	44.1	31.0	3.81	3.58	2.73	2.93	73.3	59.6
CD (P=0.05)	1.6	1.6	0.09	0.12	1.8	1.7	0.03	0.08	0.09	0.06	1.1	1.1
Row spacings												
30. cm	79.2	72.0	2.46	2.58	39.3	25.4	3.67	3.32	2.60	2.54	69.7	54.4
45 cm	81.4	74.7	2.81	2.92	42.4	29.1	3.76	3.58	2.78	2.78	72.0	58.7
CD (P=0.05)	1.6	1.6	0.09	0.12	1.8	1.7	0.03	0.08	0.09	0.06	1.1	1.1
Fertility levels												
NPK (kg/ha)												
30 : 80 : 20	82.6	76.8	2.89	2.97	44.0	30.8	3.82	3.53	2.78	2.81	72.1	58.2
20 : 60 : 15	78.0	69.8	2.38	2.53	37.7	23.7	3.60	3.28	2.59	2.54	69.6	54.9
CD (P=0.05)	2.2	1.3	0.12	0.16	1.1	0.7	0.09	0.09	0.10	0.09	1.4	0.7

Fertility levels

Application of higher fertilizer dose (30 : 80 : 20 kg NPK/ha), significantly produced the more grain (24.2 q/ha) and straw (37.6 q/ha) yields than lower fertilizer dose (20 : 60 : 15 NPK kg/ha). The beneficial effect of higher fertilizer dose on yields were reflected through plant height, branches and

Pods/plant, seeds/pod, pod length and test weight (Table 1). Application of adequate fertilizers improve these growth and yield parameters because of efficient photosynthesis, metabolic activity and cell division and ultimately gave more yields. Similar results were reported by Kacha *et al.*, 1990, Patel *et al.*, 1992 and Singh *et al.*, 1994.

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Effect of Iron Nutrition on the Yield, Chlorosis, Fruit Quality and Leaf Composition of Acidlime Trees Grown on Loamy Sand Soils*

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ABSTRACT

A field experiment was conducted to find out effectiveness of application of inorganic sources of Fe and S to alleviate iron chlorosis in acidlime of trees, cultivar *Kagzilime* (*Citrus aurantifolia*, Swingle) grown on a loamy sand soil. Iron and S were applied to the soil as sulphates, oxides and elemental form individually in twelve different treatments. The fruit yield and fruit quality were improved in all treatments as compared to the control. Ferrous sulphate (108 g Fe/tree), sulphuric acid (719 and 1439 g S/tree) and elemental sulphur (1800 g S/tree) treatments gave significantly higher fruit yield and improved the quality as compared to the control due to higher recovery of iron chlorosis. These treatments had also significantly increased the Mg, S, total Fe, Mn and Zn content in leaves. With increasing availability of sulphur, there was increased turnover of Fe^{2+} ions for chlorophyll synthesis.

(Received on 13th Sept., 1996)

INTRODUCTION

Acidlime (Cultivar-*Kagzilime*) has attained the commercial status throughout India. The seedlings of *Kagzilime* are successfully grown under loamy sand soils of North Gujarat, but interveinal chlorosis is common occurrence. The soil factors reported to have caused Fe deficiency include high soil pH, high CO_3^{2-} , HCO_3^- in alkaline soils of arid and semiarid regions and high P concentrations (Tisdale *et al.*, 1990). The plant factors include alkaline nature cell sap; low active iron, low concentrations of organic compounds like citrate involved in its translocation, high P concentration, high metallic micronutrient concentration,

imbalances in nutrient rations involving Fe and factors relating to enzymatic activities associated with Fe utilization (Ronald, 1987). The present investigation was undertaken into objecting to assess various sources of Fe for longterm prevention of Fe-chlorosis and effect on the yield and fruit quality of *Kagzilime* grown on loamy sand soil.

MATERIALS AND METHODS

An experiment was conducted in a farmer's orchard located at Deesa (Banaskantha, Gujarat) during 1993-94 to study the effect of sixteen-year-age severely chlorotic *kagzilime* trees (*Citrus aurantifolia*, Swingle) grown on loamy sand soil, through

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

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soil application of FeSO_4 , FeO , elemental sulphur, sulphuric acid and calcium sulphate. All trees involved in this study were nearly uniform in vigour, shape and size of trees. The experimental soil was sandy mixed hyperthermic family of Typic Ustipsamments having organic matter 1.04%, pH 7.8, EC 0.17 dSm^{-1} , available sulphur 8.9 ppm and DTPA extractable Fe 7.36 ppm.

The treatments were — three levels of iron as $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$ (20% Fe) at the rates of 36, 72 and 108 g Fe/tree (IS_{10} , IS_{20} , IS_{30} , respectively), - three levels of iron as FeO (70% Fe) at the rates of 36, 72 and 108 g Fe/tree (IO_{10} , IO_{20} , IO_{30} , respectively), - two levels of sulphur as elemental sulphur (80% S) at the rates of 180 and 1800 g S/tree (ES_{50} , ES_{500} , respectively), - two levels of sulphur as sulphuric acid (30% S) at the rates of 719 and 1439 g S/tree (SS_{200} , SS_{400} , respectively), - two levels of sulphur as CaSO_4

$2 \text{H}_2\text{O}$ (13.6% S) at the rates of 180 and 360 g S/tree (CS_{50} , CS_{100} , respectively), control (untreated trees with Fe or S) but applied recommended 500 g N + 500 g P_2O_5 + 500 g K_2O and 50 kg farmyard manure per tree designated as RFM, - control (untreated trees with Fe or S) but applied 50 kg farmyard manure per tree designated as RM and absolute control (untreated trees) no NPK and FYM or treatment AC. The requisite quantities of fertilizers were applied once in a season (August, 1993). The recommended dose of N, P_2O_5 and K_2O (500 g each) was applied to each tree in 3 equal splits during August, October and February. The experiment was planned in a randomized block design having two replications each of one tree.

Fruit yield was recorded in 7 pickings. Uniform fruits were selected for assessing quality parameters (AOAC, 1975).

TABLE 1

Effect of source and rate of iron and sulphur carriers on yield and per cent decrease in chlorosis of *Kagzilime* trees.

Treatment	Fruit yield kg/tree*	Number of fruit per tree*	Per cent decrease in chlorosis with respect to initial scoring**
IS_{10}	6.934	160.5	27.3
IS_{20}	7.694	168.0	35.3
IS_{30}	9.600	202.5	47.8
IO_{10}	6.374	124.5	20.8
IO_{20}	7.672	193.0	30.6
IO_{30}	7.945	151.0	34.8
ES_{50}	7.380	150.0	21.3
ES_{500}	9.252	120.0	39.7
SS_{200}	9.173	147.0	38.1
SS_{400}	9.299	189.0	53.0
CS_{50}	7.144	121.5	25.0
CS_{100}	7.586	146.5	24.8
RFM	5.850	112.5	12.8
RM	5.338	93.0	10.8
AC	5.203	87.0	4.8
S. Em. $\pm$	00.36	2.94	1.3
C. D. at 5%	1.086	8.93	4.1

* Total of seven pickings.

** Average of 7 periods of observations.

Four shoots of almost same physiological age and vigour on each side of the plant were tagged randomly on each test plant. These shoots were then used exclusively for recording the chlorosis scoring. The chlorosis was visually rated on the basis of yellowing of the top leaves using the scale : 1 = no yellowing, 2 = slight yellowing, 3 = moderate yellowing, 4 = intense yellowing, 5 = severe yellowing with some necrosis. Observations on chlorosis were recorded on 45, 60, 90, 150, 180 and 240 days after soil application of treatments i.e., P_1 , P_2 , P_3 , P_4 , P_5 and P_6 , respectively. The periodical samples were collected for analytical purpose.

The dried samples were subjected to sulphur estimation as per method suggested by Chaudhary and Cornfield (1966). Zinc, iron and manganese were estimated from acid extract on AAS-Simandzu-624 model. Magnesium was estimated by versenate method. Statistical calculations were carried out according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Fruit yield

Data given in (Table 1) indicated that IS_{30} gave significantly higher fruit yield than the untreated acidlime trees with Fe and S (RFM, RM & AC). However, it was at par with the yields of SS_{400} , ES_{500} and SS_{200} . The higher fruit yield obtained by these treatments was due to efficient control of the chlorosis (Table 1). All the Fe and S treatments have significantly higher number of fruits per tree as compared to the AC. The number of fruits per tree gave a highly significant correlation with fruit yield ($r = 0.715^{**}$). Higher level of ferrous sulphate (IS_{30}) had a direct role in increasing the concentration of Fe and S in plants. The

higher efficiency of sulphuric acid (SS_{400}) might be attributed to decreased the chlorosis more effectively due to decrease in soil pH and acidulation of organic matter in soil. Higher level of elemental sulphur (ES_{500}) increased available S in soil and content of the plant. It also increased active iron and total iron concentration in the plant. Increase in S content as a characteristic of the recovery of the chlorosis has been related in the literature to the role of S in promoting utilization of Fe in chlorophyll synthesis. Beneficial effects of increasing yield due to $FeSO_4$ @ 500 g/plant, 30 kg S/ha and sulphuric acid or elemental sulphur @ 900 g S/plant was endorsed (Khera *et al.*, 1985, Malavolta *et al.*, 1987 and Gajipara, 1988).

Fruit quality

The influence of soil treatments on *Kagzilime* fruit quality was presented in Table 2. The juice per cent was not significantly influenced due to Fe and S treatments whereas total soluble solids was affected significantly. The treatments RFM, IS_{10} , IS_{30} , IO_{10} , IO_{20} , IO_{30} , ES_{500} , SS_{200} , SS_{400} and CS_{100} recorded significantly higher total soluble solids than the control AC. These results were in agreement with those of Khera *et al.* (1985) who observed that total soluble solids of the citrus fruits increased due to soil application of $FeSO_4$ as compared to the untreated control AC.

The per cent increase in the ascorbic acid content of fruit in CS_{100} , ES_{500} , CS_{50} , IO_{10} , RFM, SS_{400} , SS_{200} , RM, IS_{30} treatments over the control AC varied from 66.7 to 130.2 per cent (Table 2). The improved growth and development of plants due to restoration of green leaves and consequent improved metabolic activity during fruit formation and maturity might have triggered processes contributing to quality parameters (Sharma and Reddy, 1984).

TABLE 2

Effect of source and rate of Iron and sulphur carriers on fruit quality of *Kagzillime* trees.

Treatment	Juice per cent	Total soluble soils (%)	Assorbic acid content (mg/100 ml juice)
IS ₁₀	34.75	6.6	16.130
IS ₂₀	39.05	6.3	18.955
IS ₃₀	37.05	6.6	22.175
IO ₁₀	45.45	6.6	26.615
IO ₂₀	37.60	6.6	18.145
IO ₃₀	39.35	6.7	20.565
ES ₅₀	39.05	6.1	18.950
ES ₅₀₀	40.90	6.8	27.820
SS ₂₀₀	42.15	6.7	26.205
SS ₄₀₀	36.40	6.8	26.210
CS ₅₀	42.00	6.6	27.420
CS ₁₀₀	42.35	6.9	30.645
RFM	45.80	7.1	26.610
RM	47.15	6.6	25.400
AC	33.05	5.9	13.310
S. Em. ±	2.84	0.18	2.864
C. D. at 5%	NS	0.55	8.688

Leaf analysis

Total iron content of *Kagzillime* leaves was substantially increased over control due to treatments of iron (IO₃₀, IS₃₀, IS₂₀ & IO₂₀) and sulphur (SS₄₀₀, ES₅₀₀, SS₂₀₀ & CS₁₀₀) applied individually during 1993 season. However, the most effective treatments were SS₄₀₀ and ES₅₀₀. Application of sulphuric acid (SS₂₀₀, SS₄₀₀), elemental sulphur (ES₅₀₀) and calcium sulphate (CS₁₀₀) in the soil significantly increased the total iron concentration in the leaf. This might be due to lowering of soil pH because of biological oxidation of these sulphur sources. The efficacy of gypsum was less than that of elemental sulphur and sulphuric acid due to its low solubility and lack of acidulating nature. Moreover gypsum treatment added low amount of sulphur (100 kg S ha⁻¹) to soil as compared to sulphuric acid. As expected, Fe sources also increased the total iron content in leaf.

The critical deficiency concentration (CDC) could be higher in the fast-growing meristematic and expanding tissues, in the

range of 200 ppm total iron (Haussling *et al.*, 1985). Reddy and Sharma (1982) reported that CDC for chlorotic leaves of acidlime varied from 38 to 275 ppm with an average of 141.30 ppm, while the healthy leaves had 90 to 315 ppm with an average of 209.65 ppm. The total Fe concentrations given in Table 3 were of top leaves and based on these references the control values can be rated as CDC and the recovery of the chlorosis can said to be related to increase in total Fe *per se*. The soil was sufficient in available Fe, still these was distictly more total Fe content in the healthy leaves as compared to the chlorosis leaves showed a positive role of total Fe content in the leaves as a cause of the chlorosis.

Elemental sulphur (ES₅₀₀) recorded the maximum value of leaf sulphur and it was at par with the treatments SS₄₀₀ and SS₂₀₀. It was followed by CS₁₀₀. The positive response of sulphur in leaf due to sulphur sources applied in soil might be due to low availability of sulphur in the soil (8.95 ppm of Ca (H₂PO₄)₂ extractable S). The findings were confirmed by UL Haq

TABLE 3

Sulphur and iron concentration of *Kagzillime* leaves as influenced by source and rate of iron and sulphur application in soil.

Treatment	Sulphur content (S %)				Mean
	P ₂	P ₄	P ₅	P ₆	
IS ₁₀	0.081 (159)	0.189 (146)	0.140 (250)	0.102 (261)	0.128 (204)
IS ₂₀	0.090 (102)	0.206 (175)	0.245 (311)	0.097 (314)	0.160 (225)
IS ₃₀	0.116 (171)	0.238 (167)	0.243 (321)	0.108 (315)	0.176 (244)
IO ₁₀	0.107 (127)	0.136 (140)	0.193 (245)	0.077 (260)	0.128 (193)
IO ₂₀	0.122 (209)	0.102 (161)	0.213 (239)	0.096 (264)	0.133 (216)
IO ₃₀	0.110 (144)	0.122 (179)	0.264 (263)	0.099 (423)	0.149 (252)
ES ₅₀	0.196 (151)	0.179 (204)	0.257 (257)	0.092 (281)	0.181 (223)
ES ₅₀₀	0.236 (207)	0.244 (222)	0.335 (296)	0.116 (366)	0.233 (272)
SS ₂₀₀	0.221 (182)	0.215 (187)	0.262 (284)	0.101 (341)	0.200 (249)
SS ₁₀₀	0.252 (202)	0.241 (223)	0.318 (306)	0.112 (364)	0.231 (274)
CS ₅₀	0.140 (184)	0.147 (98)	0.197 (219)	0.096 (325)	0.145 (207)
CS ₁₀₀	0.193 (184)	0.208 (120)	0.257 (307)	0.097 (335)	0.189 (237)
RFM	0.131 (127)	0.109 (90)	0.317 (213)	0.101 (208)	0.165 (160)
RM	0.148 (147)	0.134 (93)	0.307 (231)	0.084 (319)	0.168 (197)
AC	0.088 (135)	0.142 (98)	0.206 (191)	0.071 (232)	0.127 (164)
Mean	0.149 (162)	0.174 (154)	0.250	0.097	
Period (P) Treatment (T) P x T					
S. Em. ±	0.005 (8)	0.012 (19)			0.019 (30)
C. D. at 5%	0.014 (22)	0.036 (56)			0.055 (NS)

Figures in parentheses indicated total iron concentration of *kagzillime* leaves in ppm.

and Carlson (1993) who reported increase in S content in fresh prune leaf when S was applied to soil through different sources of S.

The leaf samples of the control treatment contained S in the range of 0.086 to 0.206 per cent in different periods with an average of 0.127 per cent. CDC in acidlime for S was reported by 0.2 per cent (Bennett, 1993). Thus, nutritional status of the control trees can be stated as S deficient. Sulphur

containing treatments SS₄₀₀, IS₃₀, ES₅₀₀ and SS₂₀₀ significantly synthesis, in comparison to control. These treatments had also significantly increased Mg, S, Mn, Zn and total Fe content in leaves. Thus it can be stated that with increased availability of sulphur there was restoration of nutrient balance in leaves, which favoured increased turnover of Fe²⁺ ions for use in chlorophyll synthesis. Sahu and Singh (1987) also reported that sulphur

TABLE 4

Nutrient contents of *Kagzillime* leaves as affected by source and rate of iron and sulphur application in soil.

Treatment	ppm Fe^{2+} *	% Mg	ppm Mn	ppm Zn
IS ₁₀	20.68	0.68	19.15	16.80
IS ₂₀	19.79	0.63	14.68	17.28
IS ₃₀	20.46	0.56	12.40	17.24
IO ₁₀	22.67	0.52	16.49	18.47
IO ₂₀	21.72	0.55	14.10	19.16
IO ₃₀	20.89	0.67	15.95	20.81
ES ₁₀	19.42	0.63	17.26	20.25
ES ₅₀₀	21.82	0.58	19.90	20.34
SS ₂₀₀	21.67	0.59	16.84	17.86
SS ₄₀₀	23.62	0.55	24.56	20.99
CS ₅₀	20.73	0.46	12.65	17.38
CS ₁₀₀	22.46	0.65	14.07	16.64
RFM	15.34	0.53	14.20	16.59
RM	14.49	0.53	16.28	17.04
AC	10.81	0.41	13.09	13.22
S. Em. $\pm$	0.69	0.03	1.39	0.88
C. D at 5%	2.11	0.09	4.21	2.68

* Nutrient content of *Kagzillime* leaves from the average of P₁, P₄, P₅ & P₆ periods.

application created a balanced nutrition environment and thus kept iron physiologically active.

Magnesium content in *Kagzillime* leaves increased significantly in IS₁₀, IO₃₀, IO₂₀, CS₁₀₀, IS₂₀, ES₅₀ and SS₂₀₀ than the untreated control AC. The Mg content was higher in the soil receiving iron and sulphur treatments than the control because of alleviation of chlorosis in treated leaves. These results are in accordance with those obtained by Tropea *et al.* (1984) and Fernandez-Lopez *et al.* (1993)

in citrus who observed that Mg content in healthy leaves was higher than chlorotic leaves.

The Mn contents averaged over the four periods showed that SS₄₀₀ recorded significantly higher value (Table 4). Next to SS₄₀₀, ES₅₀₀, IS₁₀ and ES₅₀ registered higher values of Mn. The effect of SS₄₀₀ and ES₅₀₀ in distinctly increasing the Mn content can be attributed to its lowering of soil pH and increasing Mn concentration in soil. These treatments caused only a marginal increase in

Mn content which coincided with the increase in Fe content in leaf there by maintaining Fe : Mn ratio favourable for alleviation of iron chlorosis.

Leaf contents of Zn increased significantly by all treatments used when compared to the untreated trees (AC). The higher response was obtained by the

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- treatments SS₄₀₀, IO₃₀, ES₅₀₀, ES₅₀, IO₂₀ and IS₁₀. Since there was no Zn deficiency symptoms, the nutritional status of the plants with reference to Zn may be considered as normal. The increase in Zn content in leaf due to S and Fe treatments can be attributed as a consequence of alleviation of the chlorosis and overall improvement in growth of the plants (Dhingra and Kanwar, 1963).
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✓ Effect of Fluchloralin and Farm Yard Manure on Soil Microflora

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ABSTRACT

A field experiment was carried out at Bidi Tobacco Research Station, Anand during 1994-95 to find out the effect of fluchloralin and farm yard manure on the soil microflora. Bacterial and fungal population in the soil was significantly decreased over control due to fluchloralin application at both the recommended (1.5 kg ha^{-1}) and double the recommended dose (3.0 kg ha^{-1}). However, the effect last only upto 10 days after application. Addition of FYM @ 5.0 t ha^{-1} significantly increased bacterial and fungal population. The interaction effect of levels of fluchloralin and farm yard manure on soil microbial population at 3 hr after application was significant.

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INTRODUCTION

Application of herbicides has become inevitable due to paucity of labourers. But their use alters the delicate balance of various types of soil micro-organisms, which are required for efficient use of nitrogen, carbon and other minerals. Sidhu *et al.* (1985) have also reported suppressing effect of fluchloralin application on soil microflora upto 7 days. Soil organic matter has a high cation exchange capacity as well as high specific surface area, hence absorption of herbicides on soil varies with different levels of organic matter. But information on fluchloralin application with and without FYM on microbial population is not available, hence, the present investigation was planned.

MATERIALS AND METHODS

The field experiment was conducted in Randomized Block Design with four replications in a permanent plot of $1.2 \text{ m} \times 1.2 \text{ m}$ size, at Bidi Tobacco Research Station, Gujarat Agricultural University, Anand during *rabi* 1994-95. The soil was loamy in texture, alkaline in reaction (pH 8.14), high in organic carbon (0.86%), optimum in electrical conductivity (0.30 dSm^{-1}) and high in available phosphorus (59.6 kg ha^{-1}) and potassium (420.2 kg ha^{-1}). Fluchloralin (Basalin 45% EC) was applied as pre-plant incorporation treatments @ 0, 1.5 and 3.0 kg ha^{-1} . Farm yard manure was mixed well with soil in the respective treatments and fluchloralin was applied after 10 days of FYM incorporation. Five irrigations were given

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TABLE 1

Effect of fluchloralin and FYM on soil microbial population.

Treatment	Bacteria ($\times 10^5$ /g soil)					Fungi ($\times 10^3$ /g soil)				
	Days after application					Days after application				
	0	10	20	30	60	0	10	20	30	60
Fluchloralin levels										
Control	3.75	5.60	5.63	6.69	7.85	2.31	1.60	1.10	1.14	1.83
1.5 kg ha ⁻¹	3.24	3.8	5.18	5.87	7.45	2.01	0.84	1.03	1.01	1.64
3.0 kg ha ⁻¹	2.90	2.29	5.15	5.81	7.38	1.75	0.73	1.01	1.09	1.60
S. Em. $\pm$	0.064	0.158	0.139	0.272	0.351	0.058	0.064	0.087	0.075	0.081
C. D. 0.05	0.194	0.477	NS	NS	NS	0.174	0.194	NS	NS	NS
Farm Yard Manure										
0 t ha ⁻¹	2.73	3.78	5.18	6.14	7.45	1.61	0.93	0.87	0.93	1.60
5 t ha ⁻¹	3.86	4.67	5.45	6.10	7.65	2.44	1.18	1.20	1.29	1.78
S. Em. $\pm$	0.053	0.129	0.114	0.222	0.287	0.047	0.053	0.071	0.062	0.066
C. D. 0.05	0.158	0.389	NS	NS	NS	0.142	0.158	0.213	0.185	NS
Interaction	Sig.	NS	NS	NS	NS	Sig.	NS	NS	NS	NS
C.V. %	5.5	10.6	7.4	12.6	13.1	8.0	17.3	23.4	19.2	13.6

during the study. Soil samples were collected on 0, 10, 20, 30 and 60 days after application and analysed immediately after sampling.

The samples were analysed for enumeration of total population of bacteria and fungi using Dilution Plate Technique. Ten fold serial dilutions were made in sterile water and suitable dilutions were plated using streptomycin Potato Dextrose Agar (PDA) and nutrient agar media (N-agar) for fungi and bacteria, respectively. The plates were incubated at 27°C for fungi and 30°C for bacterial counts. Counting was done and expressed as colonies forming units per gram of soil.

RESULTS AND DISCUSSION

Effect of fluchloralin on bacterial and fungi population

Application of fluchloralin at both the levels had inhibitory effect on bacterial as well as fungal population and the effect was noticed upto 10 days after application (Table 1) indicating thereby the herbicidal influence upto 10 days.

TABLE 2

Interaction effect of fluchloralin and FYM on soil microbial population (3 hrs after spraying).

Levels of FYM	Levels of fluchloralin (kg ha ⁻¹)		
	0	1.5	3.0
Bacterial counts (x 10⁵/g soil)			
0 t ha ⁻¹	3.35	2.60	2.23
5 t ha ⁻¹	4.15	3.88	3.58
S. Em.	0.091		
C. D.	0.275		
Fungal counts (x 10³/soil)			
0 t ha ⁻¹	1.78	1.58	1.48
5 t ha ⁻¹	2.85	2.45	2.03
S. Em.	0.081		
C. D.	0.246		

Sidhu *et al.* (1985) have also reported suppression of soil microflora up to 7 days due to fluchloralin application. Effect due to fluchloralin was more pronounced on fungi than bacteria. Fungal population started building up after 20 days of its application. Thus, the deleterious effect of the herbicide on soil microbes persisted only upto 10 days after application.

Effect of farm yard manure on bacterial and fungal population

In the present study, addition of FYM @ 5 t ha⁻¹ significantly increased bacterial population over control on the same day and 10th day of application of fluchloralin. While fungal population was significantly higher upto 30 days. Microbial population was higher in FYM treated plots over control at all the intervals. These results are in confirmity with those of Patel (1990).

Interaction effect

The interaccation effect of levels of fluchloralin and FYM was significant in modifying

the bacterial and fungal counts in soil immediately after application of the herbicide (Table 2). However, it was non-significant at the latter stages.

Reduction observed in soil microbial population upto 10 days after fluchloralin

incorporation is unlikely to alter the growth and development of agricultural crops hence, use of fluchloralin for weed management under loamy soil condition of middle Gujarat appears to be safe.

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Genetic Architecture of Yield and its Components in Bread Wheat (*Triticum aestivum* L.)

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ABSTRACT

The genetic components analysis showed that both additive and non-additive type of gene action played an important role in the genetic architecture of almost all the characters with a significant contribution of non-additive gene action. Asymmetrical distribution of positive and negative genes in the parents was observed. Overdominance was observed for all the characters except plant height. The estimates of narrow sense heritability were moderate to high in most of the traits.

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INTRODUCTION

Wheat occupies prime position among the cereals in India, which contributes about 33 per cent to the total food grain production of the country. There is a little scope for further increase in area, however, tremendous scope exists to ameliorate the inherent production potential of cultivars by way of further breeding work. Hence, a good knowledge of gene action involved in the inheritance of quantitative characters of economic importance is required to frame an efficient breeding programme leading to rapid improvement.

MATERIALS AND METHODS

In a diallel cross, eight cultivars of wheat namely, K 65, Pitic 62, Raj 1777, HD 2189, GW 496, GW 173, HI 1077 and Lok 1

were used. The trial was conducted in a randomized block design with three replications at Junagadh under each environment (1st Nov., 15th Nov., 1st Dec.) during *rabi* 1993-94. Each entry was planted in a single row of 2.5 m length keeping an inter and intra row spacing of 22.5 x 5 cm. The observations were recorded on five randomly selected plants for various characters studied. The genetic components of variation for different characters were evaluated over environments using Hayman's (1954 a, b) approach.

RESULTS AND DISCUSSION

Genetic components of variance analysis showed that the dominance component was relatively larger in magnitude than the additive component for all the

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TABLE 1

Genetic components analysis over environments in wheat.

Genetic component	Days to flowering	Days to maturity	Plant height	Productivity tillers/plant	Length of main spike	Number of grain/spike	1000-grain weight	Grain yield/plant
D	92.88** ±3.70	58.00** ±4.02	145.94** ±4.09	0.11 ±0.44	1.74** ±0.16	46.30** ±6.36	30.15** ±1.40	0.44 ±2.97
F	87.06** ±17.46	64.05* ±18.93	25.57 ±19.31	-0.91 ±2.06	-0.76 ±0.75	-57.67 ±30.07	2.53 ±6.59	-5.55 ±14.04
H ₁	155.66** ±33.98	140.69** ±36.93	116.07* ±37.58	29.76** ±4.02	5.12* ±1.45	465.67** ±58.52	72.06** ±12.83	142.55** ±27.32
H ₂	108.68* ±29.56	119.93** ±32.13	106.51* ±32.70	26.35** ±3.49	3.66* ±1.26	354.81** ±50.91	63.29** ±11.16	126.06** ±23.77
h ²	5.13 ±4.96	54.33** ±5.39	8.94 ±5.48	25.51** ±0.59	0.87** ±0.21	303.20** ±8.54	61.88** ±1.87	102.65** ±3.98
E	0.13 ±1.23	0.15 ±1.34	0.35 ±1.36	0.06 ±0.15	0.02 ±0.05	0.54 ±2.12	0.12 ±0.47	0.06 ±0.99
(H ₁ /D) ^{1/2}	1.29	1.56	0.89	16.34	1.71	3.17	1.55	18.05
H ₂ /4H ₁	0.17	0.27	0.23	0.22	0.18	0.19	0.22	0.22
KD/KR	2.13	2.10	1.22	0.60	0.77	0.67	1.06	0.48
k=h ² /H ₂	0.05	0.45	0.08	0.97	0.24	0.85	0.98	0.81
H ₁ -H ₂	46.98	20.76	9.56	3.41	1.46	110.86	8.77	16.49
r(Wr+Vr) YR	0.59	-0.85	0.47	-0.21	0.76	-0.59	-0.91	0.51
%Heritability (n.s.)	49.16	19.62	70.66	24.99	68.04	54.61	53.29	26.2
t ²	3.47	0.22	0.68	11.26*	0.09	0.37	0.37	58.25**
t for b-0	7.30**	2.15	4.38**	1.39	1.65	3.49*	3.72**	-0.12
t for b-1	1.24	1.61	0.12	-6.34**	-2.34	-1.09	-1.39	-15.77**

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

characters except plant height for which significant additive effect (D) was recorded (Table 1). The values of H_1 and H_2 for all the characters except for plant height, were higher than those of D and were significant and positive, which indicate the preponderance of non-additive genetic variance to control most of the characters under study. Similar results have also been reported earlier by Sharma and Singh (1976), Sharma and Ahmad (1980), Sharma and Gupta (1980) and Sharma *et al.* (1986). In majority of the cases F values mostly negative and non-significant except for days to flowering and maturity, indicating that recessive alleles were more frequent than dominant ones. This was also corroborated by the lower values of KD/KR for productive tillers/plant, length of main spike, number of grains/spike and grain yield/plant. The values of net dominance variance effect (h^2) was significant for days to maturity productive tillers/plant, length of main spike, number of grains/spike, 1000-grain weight and grain yield/plant.

The t^2 estimates to test the uniformity of the W_r , V_r values were non-significant for days to flowering, days to maturity, plant height, length of main spike, number of grains/spike and 1000-grain weight indicating the fulfilment of diallel assumptions for these traits. For remaining traits the t^2 values were highly significant indicating the failure of one or a few assumptions for diallel mating design. Non-significant regression coefficients deviating from unity for most of the characters

under study revealed absence of linkage and epistasis except for productive tillers/plant and grain yield/plant.

The values of $(H_1/D)^{1/2}$ ratio were more than unity for all the characters except plant height indicating the operation of overdominance as reported earlier by Rao (1977), Gill *et al.* (1979) and Mitkees and Rassas (1986). However, for plant height, partial dominance was observed. The H_2 component was smaller than the H_1 , indicating the unequal proportion of positive and negative alleles in the loci governing the characters. The asymmetrical distribution of positive and negative genes in the parents was evidenced by the value of $H_2/4H_1$, which was less than 0.25 in most of the cases. The ratio h^2/H_2 was nearer to unity indicating that one gene or gene group operated in the inheritance of these traits under investigation. The moderate to high estimates of narrow sense heritability were obtained for most of the characters suggesting that the phenotypic variability for different traits was attributed due to genetic part rather than environmental influence. Moderate to high heritability for various characters have been reported by Gill *et al.* (1979), Mitkess and Rassas (1986) and Nayeem (1994).

As both additive and non-additive genetic components were important in the inheritance of yield and its components, biparental mating in early generation among the selected lines is suggested for the improvement of the characters studied.

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Adaptability Under Predictable Environments in Grain Amaranthus [*Amaranthus hypochondriacus* (L.)]

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ABSTRACT

Nine genotypes of *Amaranthus* were evaluated for their adaptability in respect of grain yield and other yield components by growing over four predictable environments. Significant differences among genotypes and environments suggested the presence of diversity in genotypes and environment. Based upon stability parameters, the genotypes IC-35642, IC-42256 and AG-114 exhibited wider adaptation and stability for grain yield, Annapurana (ch), IC-35711, IC-32186 and genotypes IC-95342, IC-41997 and IC-42256 exhibited wider adaptability for late and early flowering, respectively. Genotype, 41997 exhibited stability for plant height, genotypes, IC-35642, IC-42256 and AG-114 for number of spikeletes/plant; IC-42256, AG-114 and IC-32186 for length of inflorescence, IC-42256, AG-114 and IC-32186 for girth of inflorescence and IC-95342, IC-32186 and GA-1 wider adaptability for grain protein content. Sowing in 1st week of Oct., with 80 : 40 : 20 : kg NPK/ha provided most suitable environment for yield and its components.

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INTRODUCTION

Amaranthus (*Amaranthus hypochondriacus* L.) plant has multipurpose uses Medicinal, Nutritional, Dye, Ornamental, Vegetable, and Food grains to human-beings. Also, used to feed Pig and Poultry birds and dried stalks can be used for roof construction (Gopalan *et al.* 1971). *Amaranthus* is grown widely in India, along Himalayas from Kashmir to Bhutan, and South Indian hills, Tamil Nadu etc. (Harbhajan Singh, 1961 and Sauer 1967).

The relative performance of different genotypes varies both environment and there exists a genotype x environment

interaction. The occurrence of genotype x environment interaction has long provided a major challenge to obtaining fuller understanding of the genetic control of variability. The study of genotype x environment interaction is thus important not only from the genetical and evolutionary point of view, but also is very relevant to production problems of agriculture in general and to Plant Breeding in particular (Breese, 1969).

The present study was conducted with a view to assess the elite genotypes of *Amaranthus* for their wider/general adaptability by growing in different environments.

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TABLE 1

Analysis of variance for stability for different characters in Amaranthus.

Sr. Source No.	d.f.	Days to 50% flowering	Plant height	No. of branches/plant	No. of spikelets/plants	Length of inflorescences (cm)	Girth of inflorescences (cm)	Leaf area/flowering/plant (cm ²)	Days to maturity	Grain yield/plant (g)	Grain protein content (%)
1. Genotypes	8	28.61††	81.89††	26.36††	119.21††	174.38††	20.87††	261831.54††	30.58††	103.03††	7.9††
2. ENV.	3	0.292	338.75**	1.341**	1370.37**	277.03**	101.832**	385410.98**	0.436	151.749**	298.9**
3. G X E	24	0.226**	3.402**	0.068	0.894**	1.125**	2.254**	118.51**	0.260	1.556**	0.163**
4. E + (G x E)	27	0.233	40.66	0.210	153.06	31.78	13.32	42928.78	0.280	18.245	3.466
5. ENV (L)	1	0.8734	1016.28††	4.025††	4111.10††	831.09††	35.5††	1156227.7††	1.294†	455.248††	89.672††
6. G x E (L)	8	0.108	3.310	0.151††	2.003††	0.816	0.331	151.507	0.124	3.918††	0.364††
7. Pooled deviation	18	00.254**	3.066**	0.024	0.302	1.136**	2.858**	90.964**	0.293	0.334**	0.056
8. Pooled Error	64	0.104	0.225	0.160	0.306	0.303	0.147	1.007	0.255	0.133	0.022

** indicates 1 per cent level of significance when tested against G x E.

†, †† indicates 5 per cent level of significance when tested against pooled deviation.

++ indicates 1 per cent level of significance when tested against pooled error.

TABLE 2

Estimation of stability parameters for different characters of Amaranthus by (Eberhart and Russell, 1966 Model).

Sr. Genotype No.	Days to 50% flowering			Plant height at flowering			No. of spikelets per plant			Length of inflorescence		
	Mean	bi	δdi	Mean	bi	δdi	Mean	bi	δdi	Mean	bi	δdi
1. IC-95342	41.50	0.5724	-0.0640	113.012	0.8279	10.4537**	58.25	0.9592	-0.1745	55.30	1.0311	0.8630
2. IC-41997	45.33	0.00	-0.1038	121.86	1.1661	0.2429	61.75	0.9324	0.1632	61.55	0.8896	2.1947**
3. IC-35711	48.42	-3498	-0.0677	118.93	1.0000	-0.1496	57.08	0.9049	0.5097	53.77	0.9125	1.8340**
4. IC-35642	46.25	1.7491	0.1223	122.96	1.2201	7.0612**	70.25	1.0013	-0.2767	69.35	1.1153	1.3596*
5. IC-42256	44.83	1.8445	0.0094	116.08	1.0886	1.0738*	65.83	1.005	-0.3038	64.33	0.9677	-0.2307
6. AG-114	42.92	2.3851	0.9952**	114.49	0.770	1.3622**	68.00	1.0046	-0.17	67.47	1.0078	0.6143
7. IC-32186	47.17	2.0990	0.1824	127.41	1.1862	2.4176**	73.67	1.1286*	0.7546	73.33	1.0247	-0.1581
8. Annapurna (check)	49.75	0.9222	-0.1031	119.02	0.8645	00.3295	64.00	0.9908	-0.2994	62.73	0.8961	0.7413
9. GA-1	48.08	-0.2226	0.3801*	121.57	0.8771	2.7818**	62.17	1.0322	-0.239	57.20	1.1552	0.2764
$\bar{X}$	46.03			119.48			64.54			62.78		
S. Em. $\pm$	0.291			1.022			0.3171			0.6153		

Sr. Genotype No.	Girth of inflorescence			Leaf area at flowering			Grain yield per plant			Protein content		
	Mean	bi	δdi	Mean	bi	δdi	Mean	bi	δdi	Mean	bi	δdi
1. IC-95342	17.57	0.9606	0.8161**	914.19	1.00	77.54**	12.568	0.8106	-0.0783	17.72	1.08	0.04
2. IC-41997	18.86	1.0592	-0.0694	1010.96	1.00	1.56	15.127	0.7315	-0.1069	16.77	0.98	0.09
3. IC-35711	18.04	0.7773	10.2943**	811.08	1.01	2.30	11.504	0.7810	0.0775	14.31	1.11	-0.02
4. IC-35642	21.72	1.1004	12.8225**	1457.06	1.01	5.14**	22.368	1.1903	0.1871	18.76	0.57*	0.01
5. IC-42256	20.93	1.0782	0.3461	1292.00	1.06	337.66**	18.700	1.0968	0.0462	15.29	1.14	-0.02
6. AG-114	22.23	1.0454	0.1111	1390.71	0.99	43.30**	20.558	1.1386	0.1475	16.17	1.17	0.00
7. IC-32186	24.47	0.9443	0.1689	1501.41	0.92	305.61**	27.068	1.5823*	1.3746**	17.00	1.14	-0.02
8. Annapurna (check)	19.95	1.0442	-0.1255	1155.10	1.00	41.91**	16.38	0.8850	0.1408	17.08	0.91	0.24**
9. GA-1	18.43	0.9904	0.0388	950.24	1.01	0.63	13.90	0.7839	0.0237	18.28	0.88	-0.01
X	20.24			1164.75			17.54			16.82		
S. Em. $\pm$	0.976			5.507			0.334			0.137		

bi = regression co-efficient., δdi = deviation from regression. *, ** = Significant at 5% and 1% level.

MATERIALS AND METHODS

The field experiment comprising of nine genotypes of grain *Amaranthus* (*Amaranthus hypochondriacus* L.) was sown in R.B.D. with three replications during rabi 1993 in four predictable environments as under :

E_1 — Sowing 1st October, with 20 + 40 + 20 kg NPK/ha.

E_2 — Sowing 1st October, with 80 + 40 + 20 kg NPK/ha.

E_3 — Sowing 1st November, with 20 + 40 + 20 kg NPK/ha.

E_4 — Sowing 1st November, with 80 + 40 + 20 kg NPK/ha.

Observations were recorded on ten characters viz., days for 50% flowering, plant height at flowering (cm), number of branches/plant, number of spikelets/plant, length of inflorescence (cm), girth of inflorescence (cm), leaf-area/plant at flowering (cm²), days to maturity, grain yield/plant (g) and grain protein content (%). Pooled analysis of variance over four environments and stability parameters [mean (μ), regression co-efficient (b_i) and deviation from regression ($\delta^2 di$)] and environmental indices (I_j) were estimated as per the model suggested by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Pooled analysis of variance over four environments showed that genotypic and environmental differences when tested against $G \times E$, were significant for all the characters under study (Table 1) indicating the presence of genetic variability among the genotypes and environments. Genotype $\times$ environment interaction was significant when tested against pooled error for all characters except number of branches/plant and days to maturity. Indicating that major portion of interaction was linear in nature and prediction over

environments was possible. Significant pooled deviation was observed for most of the characters including grain yield per plant which suggested that the genotypes differed considerably for various economic characters and grain yield.

According to Eberhart and Russell (1966) the ideal genotype would be the one which has high mean, regression coefficient equal to unity ($b_i = 1$) and low deviation mean square $\delta^2 di = 0$. In the present study linear regression (b_i) is treated as measure of response of a particular genotype whereas deviation from the regression line ($\delta^2 di$) is considered as a measure of stability. Therefore, genotype with lowest or non significant deviation being most stable and vice versa. The estimates of stability parameters i.e. mean (m), regression coefficient (b_i) and deviation from regression ($\delta^2 di$) for different characters are presented in Table 2. From the table it is obvious that the three genotypes IC-35642, IC-42456 and AG-114 exhibited wider adaptability for grain yield as they have mean greater than average. Regression co-efficient ($b_i > 1$) and deviation from regression ($\delta^2 di$) was also low indicating that these genotypes respond to changing environments and give high yield in favourable environments. The genotypes, Annapurana (ch), IC-35711, IC-32186 and genotypes IC-95342, IC-41997 and IC-42256 exhibited wider adaptability for late and early flowering respectively, IC-41997 exhibited stability for plant height, IC-42256 and AG-114 for number of spikelets/plant, IC-42256, AG-114 and IC-32186 for length and girth of inflorescence, IC-95342, IC-32186 and GA-1 exhibited wider adaptability for grain protein content, while the IC-35186 and IC-35642 were having specific adaptability for number of spikelets/plant and grain protein content respectively.

Estimation of environmental indices (I_j) suggested E_2 environment (sowing on 1st October with 80 + 40 + 20 kg NPK/ha) was most favourable for the characters early

TABLE 3

Estimates of environmental indices (Ij) for different characters in Amaranthus.

ENV. No.	Days to 50% flowering	Plant height at flowering	No. of branches/ plant	No. of spikelets per plant	Length of inflorescence per plant	Girth of inflorescence per plant	Leaf area at flowering plant	Days to maturity	Grain yield per plant (g)	Protein content (%)
E ₁	-0.10133	-4.95	-0.29	-4.45	-5.32	-1.21	-49.22	-0.08	-3.03	-1.7
E ₂	-0.10244	4.91	0.34	14.44	0.14	3.6	248.23	-0.12	4.57	1.36
E ₃	-0.06467	-5.65	0.37	-14.45	-2.26	-4.05	-248.88	-0.16	-3.87	-2.6
E ₄	+0.2680	+5.69	0.34	+4.44	-7.4	+1.66	+49.87	+0.33	+2.34	+2.94

flowering, number of spikelets/plant, girth of inflorescence, leaf area at flowering, days to maturity and grain yield. The environment E₁ (Sowing on 1st November, with 80 + 40 + 20 kg NPK/ha) was most favourable for plant height, length of inflorescence, grain protein content and number of branches/plant.

Estimates of environmental indices (I_j) are presented in Table 3.

The genotypes IC-32642, IC-42256 and AG-114 were high yielders with wider adaptability. They can be used as parents in breeding programmes. This is first report on stability analysis in Amaranthus.

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Genetic Architecture of Yield and its Components in Cowpea (*Vigna unguiculata* (L.) Walp)

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ABSTRACT

A nine parent partial diallel analysis was done in F_1 and F_2 generation of cowpea (*Vigna unguiculata* (L.) Walp). The combining ability studies revealed that both additive as well as non-additive gene effects were involved in the inheritance for all the characters with pre-dominant role of non-additive gene action. The parent GC-940 was good general combiner for grain yield, plant height, branches per plant and pods per plant, the parent GC-3 was good combiner for grain yield, pods per plant, pod length and seeds per pod and Pusa Phalguni and RC-8 for early flowering, maturity and plant height. The crosses V 240 x GC-9017, Pusa Phalguni x RC-8 and V 269 x GC 9017 were found to be good combiners for the yield and its components. These parents and crosses can be exploited to develop high yielding elite lines of cowpea. Biparental mating followed by recurrent selection in segregating generations is suggested for the improvement of these characters.

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INTRODUCTION

A knowledge of combining ability provides information on the performance of genotypes in hybrid combinations and also on the nature and magnitude of gene actions involved in controlling such metric traits, which would be helpful in planning the suitable breeding programme for improving the crop. Diallel analysis provides such information. The present study was therefore carried out to study genetic architecture and combining ability of parental material for formulating an efficient breeding methodology in cowpea.

MATERIALS AND METHODS

Nine diverse cultivars of cowpea viz., Pusa Phalguni (PP), GC 2, GC 3, V 240,

V 269, RC 8, GC 9017, GC 9024 and GC 9040 were crossed in all possible combinations excluding reciprocals. F_2 progenies were produced by selfing F_1 hybrids. The experimental material consisting of 36 each of F_1 and F_2 progenies alongwith nine parents were sown during kharif 1991-92 in a randomized block design with three replications. Each plot consisted of a single row for each parent and F_1 and five rows of each F_2 keeping row length of 1.5 m a spacing of 45 x 15 cm. Data were recorded from 5 (parents and F_1) and 10 (F_2) randomly selected plants. Observations were recorded on days to flowering, days to maturity, plant height (cm), branches per plant, pods per plant, pod length (cm), seeds per pod, 100 seed weight (g) and grain yield per plant (g).

TABLE 1

Analysis of variance for combining ability.

		Day to flowering	Dys to maturity	Plant height	Branches per plant	Pods per plant	Pod length	Seeds per pod	100 seed weight	Yield per plant
GCA	F ₁ 8	13.35**	24.80**	146.05**	18.25**	94.34**	6.92**	3.05**	12.87**	63.97**
	F ₂ 8	12.46**	22.11**	167.21**	16.88**	119.03**	5.44**	4.15**	12.77**	83.48**
SCA	F ₁ 36	3.19**	3.35**	33.02**	12.97**	36.73**	1.06**	1.69**	1.40**	30.06**
	F ₂ 36	2.31**	2.49**	20.29**	11.80**	31.72**	0.86**	1.10**	0.66**	24.72**
Error	F ₁ 88	0.20	0.25	0.58	0.19	0.74	0.12	0.07	0.04	0.90
	F ₂ 88	0.24	0.21	0.51	0.20	0.65	0.10	0.07	0.04	0.91
σ^2 GCA	F ₁ —	0.92	1.95	10.28	0.48	5.24	0.53	0.12	1.04	3.08
	F ₂ —	0.92	1.78	13.36	0.46	7.94	0.42	0.28	1.10	5.34
σ^2 SCA	F ₁ —	2.99	3.10	32.44	12.78	35.99	0.94	1.62	1.36	29.16
	F ₂ —	2.07	2.28	19.78	11.60	31.07	0.76	1.03	0.62	23.81
Predictability ratio	F ₁ —	0.38	0.56	0.39	0.07	0.23	0.53	0.12	0.60	0.17
	F ₂ —	0.24	0.61	0.57	0.07	0.34	0.53	0.35	0.78	0.31

** Significant at 1 per cent level.

Plot means were used for statistical analysis. Combining ability analysis was performed according to the method 2 and model 1 of Griffing (1956). General predictability ratio was estimated after Baker (1978).

RESULTS AND DISCUSSION

Variances due to genotypes were highly significant for all the characters. Differences among parents, F_1 's and F_2 's were also highly significant in respect of all these characters. This indicated the presence of greater diversity among the parents selected for the study. The comparison of parents Vs crossess ($F_1 + F_2$) was significant for all the characters, except days to maturity. Similarly, differences between F_1 and F_2 population were found significant for all characters except for pod length. Thus, the presence of general heterosis was evident for majority of the characters. Combining ability analysis (Table 1) indicated that the variances due to general and specific combining ability were highly significant for all characters in both the generations. The results indicated that additive as well as non-additive variances were important in the expression of all the characters. Predictability ratio was less than 0.50 in both generations for the traits except for days to maturity, pod length and 100 seed weight. This indicated preponderance of non-additive gene effects for these traits. For the remaining three characters both types of gene effects were equally important. The non-additive gene action has also been reported for days to flowering, days to maturity, pods per plant, pod length and test weight by Patil and Bhapkar (1986), Patil and Shete (1986), Zaveri *et al.* (1983) and Patel (1988) while for plant height, branches per plant, seeds per pod and grain yield by Godhani (1986) and Thiyagarajan *et al.* (1990).

In general sca variances of F_1 's were higher than their sca variances for F_2 . Similarly the predictability ratio of F_2 's were

generally higher than respective F_1 's ratio. This indicated presence of higher non-additive effect in F_1 's than in F_2 's. Under such situation methods like diallel selective mating (Jensen, 1970) and biparental mating followed by recurrent selection in segregating generations will be helpful to break the undesirable linkage and to provide better opportunity for selection, recombination and accumulation of desirable genes.

Estimates of gca effects of parents are presented in Table-2. None of the parents exhibited high general combining ability for all the characters. The parent GC 9040 and GC 3 displayed high general combiners for grain yield and one more yield components. The use of these two parents in future breeding programmes would be useful to improve yield in this crop. The parent Pusa Phalguni, GC 2, RC 8 and GC 9024 showed high and negative gca effects for earliness. Thus, these parents may be exploited to develop early varieties of cowpea. High and negative gca effects for plant height were expressed by Pusa Phalguni, RC 8 and GC 9024. Use of these parents would be helpful for developing dwarf variety. Parents V 240 and V 269 were good general cominers for pod length, seed per pod and branches per plant. The use of these parents would be helpful to improve such yield components of high yielding but small podded lines.

Two best specific cross combinations for seed yield and yield component (Table-3) indicated that for days to flowering V 240 x V 269 showed high sca effect in F_1 followed by V 240 x GC 9024. The later hybrid also expressed high sca effects for early maturity. The cross combinations V 269 x GC 9040 exhibited high sca effect in F_2 for days to flowering followed by V 240 x GC 9017. The later hybrid expressed high sca for early maturity in F_1 and plant height in F_1 and F_2 . The hybrid GC 2 x GC 3 expressed high sca for days to maturity and seeds per pod in F_2 while second best hybrid for early maturity in

TABLE 2

Estimates of general combining ability effects.

	Day to flowering		Dys to maturity		Plant height		Branches per plant		Pods per plant		Pod length		Seeds per pod		100-seed weight		Yield per plant	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Pusa	-1.07**	-0.88**	-1.19**	-1.36**	-6.60**	-6.01**	-2.03**	-2.00**	-2.07**	-1.22**	-0.54**	-0.41**	-0.35**	-0.49**	-0.88**	-1.25**	-1.22**	00.02
Phalguni																		
GC2	-0.56**	-0.55**	-0.80**	-0.93**	0.83**	0.41*	-0.52**	-0.42**	-0.81**	-0.19	-0.79**	-0.96**	-0.46**	-0.61**	-0.16**	-1.19**	0.09	-0.40
GC3	1.38**	1.03**	1.33**	1.10**	0.73**	-0.83**	-0.11	0.30*	3.90**	3.51**	0.53**	0.75**	0.59**	0.76**	0.07	0.09	3.81**	3.14**
V240	0.66**	1.82**	1.30**	1.80**	4.73**	6.09**	0.70**	0.30**	-2.30**	-2.33**	0.61**	0.79**	0.44**	0.69**	0.26**	0.75**	-2.41**	-1.02**
V269	1.35**	-1.03**	1.60**	1.95**	4.90**	5.10**	0.51**	0.21	-3.95**	-4.20**	1.42**	0.83**	0.90**	0.83**	0.80**	0.51**	-3.08**	4.12**
RC8	-1.47**	-1.13**	-2.31**	-1.08**	-3.79**	-4.26**	-0.95**	-1.03**	-1.10**	-3.43**	-0.89**	-0.84**	-0.65**	-0.71**	-1.87**	-1.64**	-1.49**	-3.66**
GC9017	0.38	0.15	0.99**	0.34*	-0.17	0.81**	-0.43**	0.65**	0.94**	1.82**	0.26**	0.01	-0.07	-0.29**	1.12**	1.21**	1.23**	1.51**
GC9024	-1.22**	-1.06**	-1.73**	-1.96**	0.19	0.29	0.20	-0.12	0.36	0.16	-0.75**	-0.47**	-0.32**	-0.24**	0.38**	0.45**	-0.30	0.42
GC9040	0.54**	-0.40**	0.81**	0.16	-0.81**	-1.61**	2.65**	2.53**	5.04**	5.88**	0.14	0.29**	-0.08	0.05	1.29**	1.07**	3.72**	4.11**
SE (GG)	0.19	0.21	21	0.20	0.32	0.30	0.19	0.10	0.37	0.34	0.15	0.13	0.12	0.11	0.8	0.08	0.41	0.41

* Significant at 5 per cent.

** Significant at 1 per cent.

TABLE 3

Estimates of sca effects of two best crosses each per character (Parenthesis showed sca value).

Characters	Best two cross	
	F_1	F_2
Days to flowering	V240 x V269 (-3.59**) V240 x GC9024 (-2.68**)	V269 x GC9040 (-2.73**) V240 x GC9017 (-2.07**)
Days to maturity	V240 x GC9024 (-3.50**) V240 x GC9017 (-3.23**)	GC2 x GC3 (-2.96**) Pusa Phalguni x V240 (-2.23**)
Plant height	V240 x GC90017 (-14.04**) Pusa Phalguni x V269 (-10.20**)	V240 x GC9017 (-12.73**) PP x V269 (-7.94**)
Branches per plant	RC8 x GC9040 (5.69**) GC2 x V269 (5.41**)	RC8 x GC9040 (7.96**) GC2 x V240 (6.90**)
Pods per plant	GC9017 x GC9024 (9.84**) PP x RC8 (8.15**)	V269 x GC9017 (10.80**) RC8 x GC9040 (9.83**)
Pod length	V269 x GC9017 (2.10**) PP x RC8 (1.44**)	GC3 x GC9017 (1.42**) GC3 x V240 (1.38**)
Seeds per pod	V269 x GC9017 (2.23**) GC2 x V269 (2.01**)	PP x GC2 (1.72**) GC2 x GC3 (1.66**)
100-seed weight	V269 x GC9017 (3.69**) V240 x GC9040 (1.97**)	PP x GC2 (1.85**) GC3 x GC9040 (1.35**)
Yield per plant	PP x RC8 (9.45**) GC9017 x GC9024 (8.57**) GC3 x GC9040 (6.43**) GC3 x GC9017 (5.27**) V269 x GC9017 (4.48**)	GC3 x GC9017 (8.38**) GC2 x V240 (8.27**) GC3 x GC9040 (5.67**) V269 x GC9017 (3.12) PP x RC8 (-1.97**)

F_2 was Pusa Phalguni x V 240. For plant height second best hybrid was Pusa Phalguni x V 269. The cross combination RC 8 x GC 9040 expressed sca effect for branches per plant in both generation and for pods per plant in F_2 . The cross GC 2 x V 269 was second best combiners for branches per plant and seeds per pod in F_1 , whereas GC 2 x V 240 for branches per plant and grain yield in F_2 . The cross GC 9017 x GC 9024 was best combiners for pods per plant and yield in F_1 , Pusa Phalguni x RC 8 for pods per plant, pod length and yield per plant

in F_1 . The hybrid V 269 x GC 9017 expressed significantly sca effect for pods per plant in F_2 and for pod length, seeds per pod and test weight in F_1 . The cross combination GC 3 x GC 9017 exhibited highest sca effect for pod length and grain yield in F_2 whereas, GC 3 x V 240 for pod length in F_2 only. The cross Pusa Phalguni x GC 2 expressed highest sca effect for seeds per pod and test weight in F_2 . The cross combination V 240 x GC 9040 in F_1 and GC 3 x GC 9040 in F_2 exhibited sca effect for test weight.

The specific combining ability effects for grain yield some crosses [Pusa Phalguni x RC 8 and V 269 x GC 9017] were higher in F_1 and low in F_2 . They also involved both or atleast one poor combining parent. This suggested the presence of mainly dominance and dominance x dominance or dominance x additive type of gene actions. To exploit prevailing variability of such crosses methods like biparental mating in

early segregating generations would be more useful than pedigree method. In crosses like GC 3 x GC 9017 and GC 3 x GC 9040 which showed high sca effect in both the generation for grain yield involved both the good combining parents. It could be due to the presence of additive x additive type of epistasis. Such hybrid can be handled by simple pedigree method to isolate elite and high yielding lines.

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Evaluation of Some Rice Cultures for its Reaction to Pests and Yield Performance

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ABSTRACT

Rice cultures evaluated for its resistance to insect pests and yield performance at Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat) since 1993-94, through 1995-96, revealed that the cultures Mo-1, Co-29 and IET-10750 with stand against incidence of major insect pests (white backed plant hopper, leaf folder and stem borer) of rice and designated as multiple resistant cultures. These cultures yielded 17.54 to 17.94% higher grain yields over presently recommended high yielding varieties like Masuri and Narmada. Breeders can utilize these promising cultures as donor for developing high yielding and pest resistant variety of rice.

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INTRODUCTION

Rice (*Oryza sativa* L.), is an important food grain crop of Gujarat, attacked by various insect pests during its different growth period resulting into greater yield losses. Use of resistant/tolerant variety is prima facie to minimize the yield losses by pests. Use of resistant cultivars virtually does not involve any skill or cash investment in pest control. It can be considered as a principal component of pest management besides cultural, biological and chemical means. For development of resistant variety, use of appropriate donor parents is of almost importance. There is no single variety in the state recognised as totally resistant to all the insect pests of rice. Hence, there was an urgent need to identify cultures resistance to

major insect pests of rice alongwith its yield performance to use in breeding programme for development of variety resistant/tolerant to insect pests. In this context some of the promising cultures/entries selected from various screening trials were evaluated alongwith recommended varieties. The results obtained are summarized here under :

MATERIALS AND METHODS

The field experiment was carried out for three successive kharif seasons from 1993-94, through 1995-96, at Main Rice Research Station, Gujarat Agricultural University, Nawagam (Gujarat). The experiment was laid out in Randomized Block Design with fourteen cultures replicated twice. The gross and net plot size was 6.9 x 3.0 m²

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TABLE 1

Incidence of insect pests in some of the promising cultures/varieties of rice under study.

Sr. No.	Culture/ Variety	Av. No. WBPH/hill			% leaves damaged by LF			% tillers damaged by SB			
		1993-94	1994-95	Pooled	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	Pooled
(1)	HBC-19	5.45	10.20	7.83 ab	6.53	11.41	3.05	7.00 bcd	4.75* (12.57)	25.09 (30.02)	14.92 (21.30) def
(2)	IET-10750	5.00	18.05	11.53 cde	4.13	11.53	3.97	6.54 abc	9.95 (18.37)	14.86 (22.62)	12.41 (20.49) de
(3)	Mo-1	3.60	8.15	5.88 a	4.44	7.54	3.13	5.04 a	5.59 (13.65)	33.39 (35.29)	19.49 (24.47) fgh
(4)	Co-29	9.65	9.90	9.78 bc	5.89	9.76	6.61	7.42 bcdef	4.77 (12.59)	32.52 (34.77)	18.65 (23.68) efg
(5)	Narmada	7.05	11.75	9.40 bc	4.60	11.70	4.53	6.94 bcd	0.84 (5.26)	8.46 (16.88)	4.65 (11.08) b
(6)	Masuri	7.80	10.90	9.35 abc	4.52	8.83	5.01	6.12 ab	0.84 (5.24)	2.43 (8.87)	1.64 (7.06) a
(7)	IR-66	13.95	14.25	14.10 de	8.56	11.71	5.25	8.51 defg	4.04 (11.42)	27.48 (31.56)	15.76 (21.50) def
(8)	P-203-2	11.35	15.25	13.30 de	6.35	16.67	4.04	9.02 fg	5.15 (12.91)	65.27 (53.90)	35.21 (33.41) i
(9)	P-203-3	13.55	18.25	15.90 efg	8.76	14.72	4.22	8.93 efg	8.52 (16.78)	63.01 (52.59)	35.77 (34.69) i
(10)	GR-11 x Te-tap/ 1-6-8	15.65	20.40	18.03 g	7.12	14.82	5.83	9.25 g	4.54 (12.29)	44.66 (41.93)	24.60 (27.11) h
(11)	GR-101	11.90	16.45	14.18 def	5.18	11.29	7.21	7.89 cdefg	4.24 (11.80)	11.69 (19.98)	7.97 (15.89) c
(12)	GR-12	14.95	14.10	14.53 def	7.38	9.44	5.03	7.29 bcde	2.73 (9.51)	28.91 (32.49)	15.82 (21.00) de
(13)	GR-11 (check)	17.95	18.60	18.28 g	6.99	13.23	6.55	8.92 efg	5.07 (13.01)	39.92 (39.15)	22.50 (26.08)gh
(14)	Vikas (check)	19.55	15.70	17.63 fg	9.44	13.49	10.54	11.16 h	3.70 (11.09)	23.47 (28.97)	13.59 (20.03) d
S. Em. ±		1.64	1.36	1.14	—	1.28	0.68	0.55	1.24	1.85	1.10
C. D. at 5%		5.02	4.17	3.48	NS	3.90	2.08	1.69	3.85	5.72	3.41
C. V. (%)		20.67	13.38	12.57	—	15.21	18.04	9.94	14.78	8.14	7.08

* Arcsin transformed values.

TABLE 2

Grain and fodder yield performance of some of the promising cultures/varieties of rice under study.

Sr. Culture/ No. Variety	Grain (kg/ha)				Fodder (kg/ha)			
	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled
(1) HBC-19	2052	1852	1097	1667 cde	3759	4630	3421	3937 a
(2) IET-10750	3133	1340	1579	2018 efg	4543	6092	3597	4744 bc
(3) Mo-1	2538	1657	2018	2071 fg	4386	6336	5264	5329 cd
(4) Co-29	1880	2193	2281	2118 g	2851	7067	4474	4797 bc
(5) Narmada	2600	1413	1119	1711 cdef	4856	7067	6667	6197 ef
(6) Masuri	2444	1560	1404	1802 defg	4543	8285	7939	6921 g
(7) IR-66	1567	1803	1075	1481 bcd	3384	4398	3421	3852 a
(8) P-203-2	1974	415	1097	1162 ab	3634	3948	5351	4311 ab
(9) P-203-3	1833	488	1294	1205 ab	3759	4630	6974	5121 bc
(10) GR-11 x Te-tap/1-6-8	1598	415	830	948 a	3916	3655	4474	4015 a
(11) GR-101	2444	731	1031	1402 bc	4543	6579	6536	5886 de
(12) GR-102	2632	951	943	1509 bcd	5076	7310	7237	6541 fg
(13) GR-11 (Check)	1645	1048	1075	1256 ab	3290	5848	4079	4406 ab
(14) Vikas (Check)	1488	804	592	962 a	3697	5605	3728	4343 ab
S. Em. ±	185.78	181.06	142.06	123.03	279.79	274.37	399.0	213.28
C. D. at 5%	575.37	560.75	439.99	381.04	866.54	849.75	1235.73	660.56
C. V. (%)	12.33	21.51	16.14	11.43	9.85	6.67	10.80	6.00

and 5.7 x 2.0 m², respectively. The seedling of 25-30 days age of all the cultures were transplanted at a distance of 20 x 15 cm during all the years on 4-9-93, 26-8-94 and 12-8-95. The crop was fertilized with 100 kg N and 30 kg P₂O₅ per hectare. All other recommended agronomic practices, except plant protections were followed for raising the healthy crop.

Incidence of white backed plant hopper (WBPH), *Sogatella furcifera* (Horv) leaf folder (LF), *Cnaphalocrocis medinalis* Guen. and stem borer (SB), *Scirpophaga incertulas* (Walker) was recorded when the activity of the pests was at peak level. For the purpose, 10 hills selected at random from each net plot area were observed for pest incidence. Number of WBPH present on 1 hills were recorded. Similarly, total number of leaves and tillers and leaves damaged by LF and tillers damaged by SB were recorded to assess the damage caused by LF and SB, respectively, incidence of WBPH and SB was not to a desired level in experimental area during third year (1995-96) of experimentation. Pest incidence data recorded were thus subjected to statistical analysis and presented in Table 1.

The crop was harvested during second fortnight of November to first fortnight of December. Grain and fodder yields were recorded separately from each net plot. Data obtained were statistically analysed and presented in Table 2.

RESULTS AND DISCUSSION

Analysis of results (Table 1) revealed that amongst 14 cultivars, the population of WBPH was significantly low (5.88 to 11.53 WBPH/hill) in Mo-1, HBC-19, Co-29 and IET-10750 and were at par with the resistant cultivars like Masuri and Narmada, than rest

of the cultures. These three cultures performed equally resistance to WBPH like Masuri and Narmada. Reports of Anonymous (1991, 1992, 1994 and 1996 a) showed moderate to high level of resistance in culture Mo-1, against WBPH supports the present findings. Similarly, Anonymous (1996b) is isolated IET-10750 as WBPH resistant culture and released as 'Gurjari' for cultivation in Gujarat State. The above listed promising cultures have also registered low (5 to 7%) incidence of LF and the damage level was more or less same as found in case of resistant varieties (Masuri, Narmada and GR-102). HBC-19 (Karnal local) found tolerant to LF and WBPH as reported by Anonymous (1992). The cross GR-11 x Te-tap/1-6-8 was found susceptible to WBPH and LF incidence. Though the cultures HBC-19 and IET-10750 found promising against WBPH and LF, it recorded significantly high 12.41 to 14.92% incidence of SB than the recorded significantly high 12.41 to 14.92% incidence of SB than the recommended cultivars (Masuri, Narmada and GR-101). However, these promising cultivars exhibited significantly low incidence of the pest than the susceptible check (GR-11).

So far grain yield is concerned, the cultures Co-29, Mo-1 and IET-10750 differed significantly from rest of the cultures evaluated, except Masuri and Narmada. These, three promising entries yielded 17.54 to 17.94% higher (2018 to 2118 kg/ha) grain yield over the presently available high yielding cultivars like Masuri and Narmada. Further, these promising cultures yielded 4744 to 5329 kg/ha of fodder yield and hence were intermediate.

Based on the above discussion it can be concluded that the cultures Mo-1, Co-29

and IET-10750 withstand against incidence of major insect pests of rice and yielded higher grain yields, hence designated as multiple

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resistant strains. These cultures could be useful to breeders for developing high yielding and pest resistant variety.

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Life Table and Innate Capacity of Increase of *Helicoverpa armigera* (Hubner) Hardwick on Sunflower

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ABSTRACT

The gram podborer, *Helicoverpa armigera* (Hubner) Hardwick is a pest feeds on many cultivated and non-cultivated host plants. Studies were carried out to determine the multiplication rate of its population on sunflower at $26 \pm 1^\circ\text{C}$. The maximum duration of egg, larva and pupa was 3.18 and 15 days, respectively. The net reproductive rate (R_0) representing the total female births was 489.23. The population increased with an infinitesimal rate (rm) of 0.1396 and finite rate (λ) of 1.150 females per female per day on this host. The mean generation time (T_c) was 44.66 days. On reaching the stable age distribution, the eggs, larvae, pupae and adults contributed to the tune of 45.78, 50.05, 3.70 and 0.41 per cent, respectively. The expectation of further life at the age of 30 to 35 days was reduced to 7.80 days from 17.05 days in the beginning.

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INTRODUCTION

The gram podborer, *Helicoverpa armigera* (Hubner) Hardwick is one of the most destructive and polyphagous pests having worldwide distribution. Life tables are the most useful tool to make quantitative and qualitative evaluation of different host plants. The statistic is used to determine which stage contributes the most in the life cycle of a pest. The life tables developed by Birch (1948) can be successfully used to determine the growth statistics and further applied to estimate the potential increase of insect reared on different hosts. The information on

sunflower for *H. armigera* is very scanty. Therefore, an attempt was made to construct the life table on this crop.

MATERIALS AND METHODS

In order to construct the life-fecundity tables, 100 eggs were kept in BOD incubator at a constant temperature of $26 \pm 1^\circ\text{C}$ in 10 batches in plastic boxes (5.0 x 5.5 cm). The eggs were glued with the help of a soft wet camel hair brush on the white paper in one row to facilitate observations on hatching. After hatching, all the larvae were reared individually on sunflower heads. Fresh food was supplied daily. Observations on hatching,

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age-specific mortality of eggs, larvae, pupae and adults were recorded daily. For determining the age-specific fecundity, the total number of adults emerged on a particular day were transferred to a separate cage for egg laying. The eggs laid by the females on subsequent days were noted daily till all the females died. The number of eggs laid per female was divided by two (sex ratio 1:1) to get the number of female births (mx). A life table was constructed according to the method of Birch (1948), Howe (1953) and Atwal and Bains (1974). The innate capacity for increase in numbers (rm) was calculated from the data in the life-table. The values of x (pivotal age in days), lx (survival of female at different age interval) and mx (number of female progeny per female) were worked out.

The stable age-distribution (distribution percentage of various age-groups) was also worked out by observing the population schedule of birth rate and death rate (mx and lx).

RESULTS AND DISCUSSION

The data on survival of different stages of *H. armigera* during developmental period on sunflower are presented in Table 1. It has been observed that there was 11 per cent mortality in egg stage. The maximum duration of egg, larva and pupa were 3.18 and 15 days, respectively. The number that survived from egg to adult emergence was 80 individuals. The data regarding the life fecundity and age-specific fecundity for this pest are presented in Table 2 and Fig. 1. It is evident from the data that immature stages lasted for 36 days. The pre oviposition period ranged from 37th to 40th day of pivotal age. The first female mortality within the cohort occurred on tenth ($1x = .76$) day after the emergence of adults and mortality increased thereafter. The females contributed the highest egg production ($mx = 115.13$) in the life cycle on 44th day and the lowest ($mx = 2036$) on 50th day of pivotal age. The reproduction ceased by tenth day after starting

TABLE 1

Survival of different stages of *H. armigera* during development on sunflower.

No. of eggs	Egg stage (0 to 3 days)	Numbers survival	
		Larval stage (4 to 21 days)	Pupal stage (22 to 36 days)
10	9	7	6
10	9	9	8
10	9	9	9
10	9	9	9
10	9	8	8
10	9	7	6
10	9	9	8
10	10	10	10
10	8	8	8
10	8	8	8
100	89	84	8

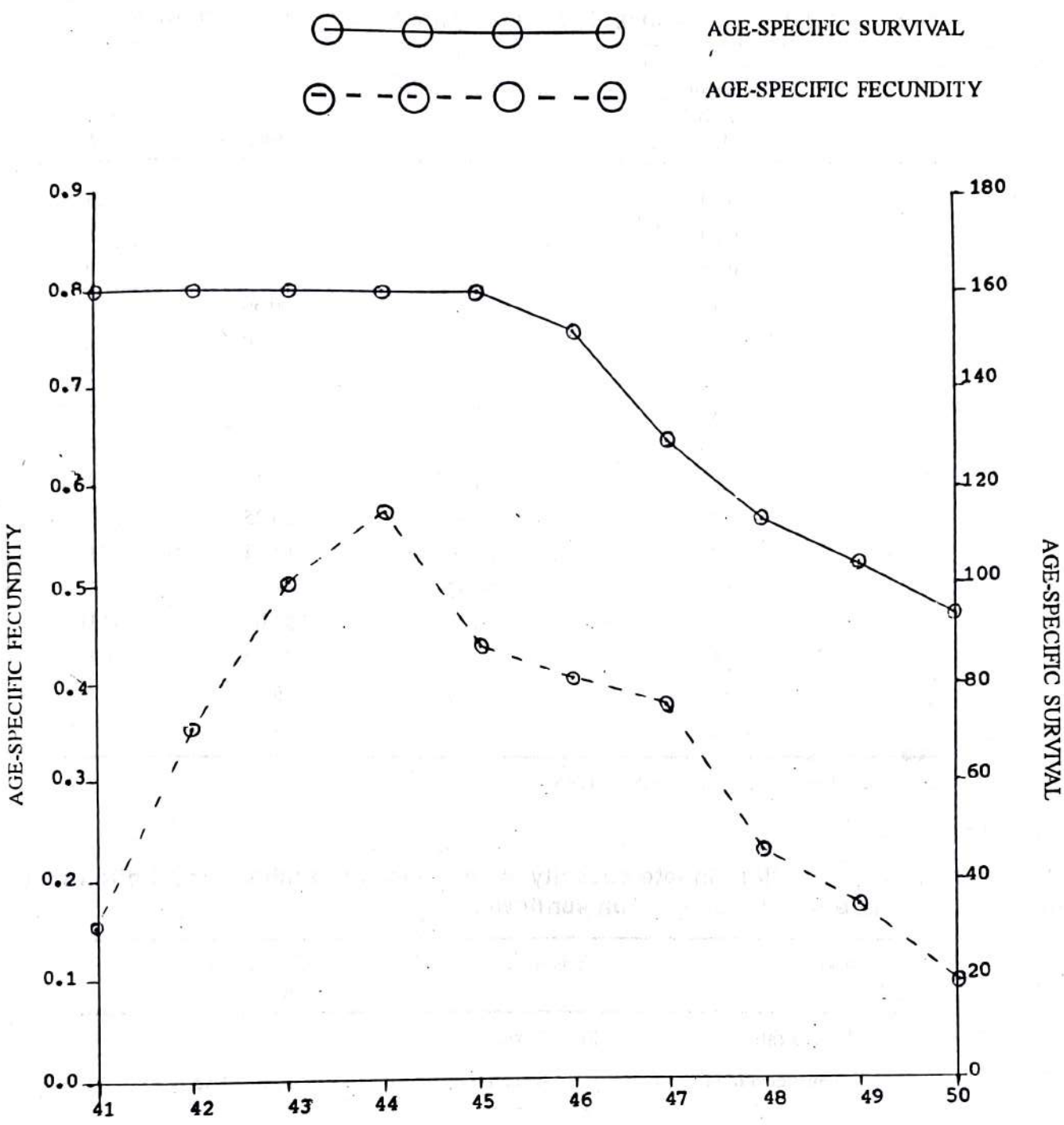


Fig. 1 : Age-specific survival and fecundity of *H. armigera* on sunflower.

TABLE 2

Life table (for females) and age-specific fecundity for *H. armigera* on sunflower.

Pivotal age in days x	Survival of female at different age interval l_x	Age schedule for female birth m_x	$l_x m_x$	$x/l_x m_x$
0 - 36	0.80	—	—	Immature
37	0.80	—	0.80	29.60
38	0.80	—	0.80	30.40
39	0.80	—	0.80	31.20
40	0.80	—	0.80	32.00
41	0.80	25.20	20.16	826.56
42	0.80	71.39	57.11	2398.70
43	0.80	101.36	81.09	3486.78
44	0.80	115.13	92.10	4052.58
45	0.80	87.81	70.25	3161.16
46	0.76	81.10	61.64	2835.26
47	0.65	76.32	49.61	2331.58
48	0.57	45.76	26.08	1251.99
49	0.52	35.42	18.42	902.50
50	0.47	20.36	9.57	478.46
51	0.40	—	—	—

 $\Sigma l_x m_x = 489.23$ $\Sigma x/l_x m_x = 21848.77$

TABLE 3

Mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers of *H. armigera* on sunflower.

Sr. No.	Population growth statistics	Formula	Calculated values
1.	Net reproductive rate	$R_0 = \Sigma l_x m_x$	489.23
2.	Mean length of generation	$T_c = \frac{\Sigma x/l_x m_x}{R_0}$	44.66 Days
3.	Innate capacity for increase in numbers	$r_m = \frac{\log_e R_0}{T_c}$	0.1387 Females/ female/ day
4.	Arbitrary 'rm' (re)	0.13 and 0.14	
5.	Corrected 'rm'	$\Sigma e^{-r_m x} l_x m_x$	0.1396 Females/ female/ day

1.	2.	3.	4.
6.	Corrected generation time	$T = \frac{\log_e R_0}{rm}$	44.36 Days
7.	Finite rate of increase in number	= antilog e^{rm}	1.150 Females/ female/ day
8.	Weekly multiplication of population	$(\lambda)^7$	2.660 Times
9.	Hypothetical F_2 females.	$(R_0)^2$	239345.99

TABLE 4

 Age-specific distribution of *H. armigera* on sunflower ($rm = 0.1396$).

Pivotal age (days)	Lx	$e^{-rm}(x+1)$	$Lx \cdot e^{-rm}(x+1)$	Per cent contribution
1.	2.	3.	4.	5.
0.	1.00	0.8697	0.8697	14.1100
1.	1.00	0.7564	0.7564	12.2719
2.	1.00	0.6578	0.6578	10.6722
3.	0.94	0.5721	0.5378	8.7253
				45.7794
4.	0.89	0.4976	0.4428	7.1840
5.	0.89	0.4327	0.3851	6.2479
6.	0.89	0.3764	0.3350	5.4350
7.	0.88	0.3273	0.2880	4.6725
8.	0.88	0.2847	0.2505	4.0641
9.	0.88	0.2476	0.2179	3.5352
10.	0.88	0.2153	0.1895	3.0745
11.	0.88	0.1873	0.1648	2.6737
12.	0.88	0.1629	0.1433	2.3249
13.	0.88	0.1416	0.1246	2.0215
14.	0.88	0.1232	0.1084	1.7003
15.	0.88	0.1071	0.0943	1.5299
16.	0.87	0.0932	0.0811	1.3158
17.	0.85	0.0810	0.0689	1.1178
18.	0.84	0.0704	0.0592	0.9605
19.	0.84	0.0613	0.0515	0.8355
20.	0.84	0.0533	0.0448	0.7268
21.	0.84	0.0464	0.0389	0.6311
				50.0510

1.	2.	3.	4.	5.
22.	0.84	0.0403	0.0339	0.5500
23.	0.84	0.0351	0.0295	0.4786
24.	0.84	0.0305	0.0256	0.4153
25.	0.84	0.0265	0.0223	0.3618
26.	0.84	0.0231	0.0194	0.3147
27.	0.84	0.0201	0.0169	0.2742
28.	0.84	0.0174	0.0147	0.2385
29.	0.84	0.0152	0.0127	0.2060
30.	0.84	0.0132	0.0111	0.1801
31.	0.84	0.0115	0.0096	0.1557
32.	0.84	0.0100	0.0084	0.1363
33.	0.84	0.0089	0.0073	0.1184
34.	0.84	0.0076	0.0063	0.1022
35.	0.84	0.0066	0.0055	0.0892
36.	0.84	0.0057	0.0048	0.0779
				3.6989
37.	0.82	0.0050	0.0041	0.0665
38.	0.80	0.0043	0.0035	0.0568
39.	0.80	0.0038	0.0030	0.0487
40.	0.80	0.0033	0.0026	0.0422
41.	0.80	0.0028	0.0023	0.0373
42.	0.80	0.0025	0.0020	0.0324
43.	0.80	0.0021	0.0017	0.0276
44.	0.80	0.0019	0.0015	0.0243
45.	0.80	0.0016	0.0013	0.0211
46.	0.76	0.0014	0.0011	0.0178
47.	0.65	0.0012	0.0008	0.0130
48.	0.57	0.0011	0.0006	0.0097
49.	0.52	0.0009	0.0005	0.0081
50.	0.47	0.0008	0.0004	0.0065
				0.4120

TABLE 5

Life table for computing life expectancy of *H. armigera* reared on sunflower.

Pivotal age (days)	Numbers surviving to the beginning of age interval	Numbers dying during x	Mortality rate per hundred alive at beginning of age interval $\frac{lx}{(dx \cdot 100)}$	Alive between age x and x + 1 $(1x + (1x + 1))$	Numbers of the individual's life days beyond x (Tx)	Expectation of further life $Tx - x$
(x)	(lx)	(dx)	lx (100 qx)	(Lx)	(Tx)	(ex)
0 — 5	100	11	11.00	94.50	852.50	17.05
5 — 10	89	1	1.12	88.50	758.00	17.03
10 — 15	88	0	0.00	88.00	669.50	15.22
15 — 20	88	4	4.55	86.00	581.50	13.22
20 — 25	84	0	00.0	84.00	495.50	11.80
25 — 30	84	0	0.00	84.00	411.50	9.80
30 — 35	84	0	0.00	84.00	327.50	7.80
35 — 40	84	4	4.76	80.00	243.50	5.80
40 — 45	80	0	0.00	80.00	163.50	4.09
45 — 50	80	33	41.25	63.50	83.50	2.09
50 — 55	47	7	14.89	20.00	20.00	0.85

fecundity and of egg laying. The net reproductive rate (R_0) representing the total female births was 489.23 indicating that the population would multiply 489.23 times at the end of every generation.

The data on intrinsic rate of *H. armigera* (Table 3), indicated that the innate capacity for increase in number (r_m) was 0.1396 females per female per day with a daily finite rate of increase (λ) 1.150 females per female per day. Thus, the population would be able to multiply 2.660 times per week. The mean length of generation (T) was

worked out 44.36 days for the cohort.

On reaching the stable age distribution (Table 4) the eggs, larvae, pupae and adults contributed to the tune of 45.78, 50.05, 3.7 and 0.41 per cent, respectively to the population. The life expectancy tables were constructed and the results are presented in Table 5. The life expectancy (ex) of newly deposited eggs was only 17.05 days. The mortality rate was very high up to the pivotal age of 5 days. Almost similar observations on sunflower for different parameters of life table were also reported by Bilapate *et al.*, 1980. Thus, the present findings are in close conformity of the earlier reports.

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Population Build up of Leafminer, *Aproaerema modicella* Deventer (Gelechiidae : Lepidoptera) in Popular Varieties of Groundnut

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ABSTRACT

Incidence of leafminer, *Aproaerema modicella* Deventer was studied on 15 popular varieties (grown in different parts of the country) in the agroclimatic condition of Junagadh in 1995 and 1996. Results indicated that spreading variety GG 13 registered significantly lowest leafminer larvae per plant, whereas Girnar 1 showed maximum larvae per plant. In general, all spreading and semi-spreading varieties showed lower incidence of leafminer as compared to erect varieties.

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INTRODUCTION

Groundnut is the important cash crop of Saurashtra region of Gujarat State. Many insect pests cause damage to groundnut, of which leafminer, *Aproaerema modicella* Deventer is one of the most serious pest in Saurashtra. It infests the crop from germination to harvest. The avoidable crop loss due to this pest was estimated to the tune of 51.06 per cent in *kharif* season on bunch groundnut in Gujarat (Vyas, 1989). The resistant or less susceptible variety plays an important role in formulating pest management programme. With this objective, present studies were conducted to identify least susceptible variety against leafminer by recording population building up of leafminer on different popular varieties of groundnut.

MATERIALS AND METHODS

In two years field experiments, conducted in *kharif* 1995 and 1996 at Oilseed

Research Station, Gujarat Agricultural University, Junagadh. Fifteen popular varieties (different habit group grown in different parts of the country) were sown for the study of incidence of leafminer in the agro-climatic condition prevailing at Junagadh. Each variety was grown in a plot size of 4.0 x 6. m². The details regarding varieties and their habit group are as follows :

Sr. No.	Variety	Habit group	Botanical group
1.	GG 2	Erect (bunch)	Spanish
2.	GG 3	" "	"
3.	GG 4	" "	"
4.	JL 24	" "	"
5.	J 11	" "	"
6.	TG 26	" "	"
7.	ICGS 37	" "	"

1.	2.	3.	4.
8.	Girnar 1	Erect (bunch)	Spanish
9.	GG 20	Semi-spreading	Virginia
10.	TMV 10	" "	"
11.	Kadiri 3	" "	"
12.	GG 11	Spreading (runner)	"
13.	GG 12	" "	"
14.	GG 13	" "	"
15.	Somnath	" "	"

All the recommended agronomic practices were adopted. The plot was kept unsprayed throughout the season. Each plot was divided into four quadrates. Ten plants from each quadrates were selected for observing leafminer population. The leafminer larvae per plant was recorded at

weekly interval till harvest. Mean pes incidence was worked out and the data thus obtained were subjected to statistical analysis for assessing the relative incidence in groundnut varieties.

RESULTS AND DISCUSSION

The results (Table 1) revealed that leafminer population was higher during the year 1995 as compared to 1996 in different varieties tested. Pooled results of two *kharif* seasons indicated that the spreading variety GG 13 registered significantly lowest leafminer larvae per plant (3.50) and was at par with GG 20 (3.60). The variety Girnar 1 was found to be the most susceptible as it carried 5.29 larvae per plant and was at par with ICGS 37 (5.24), TG 26 (5.20) and JL 24

TABLE 1

Mean number of *A. modicella* larvae per plant in different groundnut varieties.

Sr. No.	Variety	1995		1996		Pooled Mean	
1.	GG 2	2.34*	(5.48)	1.95	(3.80)	2.14	(4.58)
2.	GG 3	2.29	(5.24)	1.86	(3.46)	2.08	(4.33)
3.	GG 4	2.39	(5.71)	1.99	(3.96)	2.19	(4.80)
4.	JL 24	2.46	(6.05)	2.06	(4.24)	2.26	(5.11)
5.	J 11	2.29	(5.24)	1.87	(3.50)	2.08	(4.33)
6.	TG 26	2.47	(6.10)	2.10	(4.41)	2.28	(5.20)
7.	ICGS 37	2.47	(6.10)	2.11	(4.45)	2.29	(5.24)
8.	Girnar 1	2.48	(6.15)	2.12	(4.49)	2.30	(5.29)
9.	GG 20	2.11	(4.45)	1.68	(2.82)	1.90	(3.60)
10.	TMV 10	2.21	(4.88)	1.76	(3.10)	1.98	(3.92)
11.	Kadiri 3	2.22	(4.93)	1.77	(3.13)	1.99	(3.96)
12.	GG 11	2.20	(4.84)	1.74	(3.03)	1.97	(3.88)
13.	GG 12	2.20	(4.84)	1.75	(3.06)	1.98	(3.92)
14.	GG 13	2.10	(4.41)	1.64	(2.69)	1.87	(3.50)
15.	Somnath	2.23	(4.97)	1.78	(3.17)	2.00	(4.00)
	S. Em.	0.01		0.01		0.02	
	C. D. at 5%	0.02		0.03		0.05	
	C. V. %	2.62		3.22		1.92	

* $\sqrt{\quad}$ Transformed values.

Figures in the parenthesis are retransformed values.

(5.11). The varieties viz., GG 11, GG 12, TMV 10, Kadiri 3, Somnath, GG 3, J 11, GG 2 and GG 4 were found moderately susceptible as they showed larvae population of 3.88 to 4.80 per plant.

All spreading and semi-spreading varieties showed lower incidence of leafminer as compared to erect (bunch) varieties. Similar observations were also reported by Motka *et al.* (1985), Ghule *et al.* (1988) and Mahadevan *et al.* (1988).

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A Study on Profile of Dairy Entrepreneur Women and their Problems and Suggestions Regarding Dairy Farming

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ABSTRACT

This study was conducted during *rabi* 1994-95. The ex-post facto research design was selected. The sample size decided for the study was 225 respondents on the basis of variability in population existing. One dependents i.e. entrepreneurial behaviour and twelve independent variables were selected for the study. The results observed that the majority of the respondents have medium level of entrepreneurial behaviour, out of 12 independent variables, 10 variables were found to be positively and highly significantly related with entrepreneurial behaviour of dairy women. Those, were education, type of family, size of family, land holding, dairy farming experience, herd size, dairy income, social participation, milk yield infrastructural experience.

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INTRODUCTION

India is predominantly an agricultural country, where keeping milch animals has been never a separate occupation from agriculture. The production and consumption of milk and milk product per capita in India is very low as compared to some developed countries. India occupies second place in total milk production in the world, whereas, in Gujarat, 62.40 lakh cattle and 45.02 lakh buffaloes produce about 3.68 million tonnes of total milk production (Anonymous, 1994).

In Indian rural families, dairy women possess good knowledge on dairy farming management activities since these are highly traditional and women oriented. The knowledge on these aspects are passed on from generation to generation and they are

within the domain of women. When a woman controls the household income, the family benefits. The dairy women also come across many problems in performing their responsibilities in management of dairy farming.

Dairy women who are progressive, can not be identified as dairy farming entrepreneurial but those who are having entrepreneurship are essentially progressive dairy women. The term 'entrepreneur' can be defined as 'creative' and 'innovative' response to the environment. The entrepreneur is an economic woman who strives to maximise her profits by adopting innovation. Essentially, an entrepreneur one who creates something new, undertakes risks, organises production and handles the economic uncertainty.

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The role of profile is very crucial in understanding the human action. Entrepreneurial behaviour takes place in situation and it has therefore, profound influence on the individual action. The social system of which individual is member has dominant effect on the entrepreneurial behaviour.

Various dairy farming management technologies are accepted and utilised by the dairy women for their betterment. The acceptance and utilisation of these technologies are the resultant of human action. These human actions are in the form of entrepreneurial behavioural changes for the betterment in every walk of life. Hence, the acceptance and utilisation of technologies is kind of decision making and has been conceptualised as involvement of the dairy women in dairy farming management.

Therefore, the decision of dairy women in dairy farming is influenced by many factors like personal, social, economical and situational. The entrepreneur is a crucial factor in the socio-economic and situational change who envisages new opportunities, new techniques, new lines of production and also co-ordinates with various other activities. She is a woman with a will to act, and to bring about changes through organisation of human efforts, with the following objectives :

- (1) To study the profile of dairy women.
- (2) To determine the relationship between the characteristics of dairy women influencing their entrepreneurial behaviour.
- (3) To understand and sort out the problems and suggestions of dairy women to improve the dairy farming.

MATERIALS AND METHODS

The study was conducted in Mehsana district of Gujarat during the *rabi* 1994-95 out of eleven talukas of Mehsana district, three talukas namely, Mehsana, Vijapur and Kalol were selected purposely by applying scale

developed for measuring the entrepreneurial behaviour of dairy women. From the each talukas, five villages were purposively selected based on the multistage random sampling technique. The ex-post facto research design was selected, the sample size decided for the study was 225 dairy women on the basis of variability in population existing. The research procedure consisted of dependent (entrepreneurial behaviour) and independent variables namely; age, education, type of family, size of family, landholding, herd size, fodder crops area, social participation, dairy income, dairy experience. The selected dairy women were personally interviewed with the help of interview schedule. The statistical procedure like frequencies, percentage, arithmetic mean and correlation were used to analyse the data for simple comparisons and classification of the respondents into different categories. The correlation to measure the degree of association between the dependent and independent variables.

RESULTS AND DISCUSSION

Profile of the dairy women

The profile of the dairy women in which independent characteristics are presented in Table 1. It is clear from Table 1, that about half of the respondents (48.89 per cent) were found in young age group had middle education (30.67 per cent), joint family (51.56 per cent), size of family observed in middle size (64.89 per cent), marginal farmers (37.33 per cent) and had upto 0.20 ha low cultivation area of fodder crops (40.89 per cent). Further, they had upto 10 years dairy farming experience (53.78 per cent), medium herd size (63.56 per cent), majority in medium group of dairy farming income (72.44 per cent) and were members of one organisation (42.67 per cent). Most of the (11.56 per cent) respondents were in medium group of milk yield and further, most of the respondents were (70.66 per cent) in medium infrastructural experience group of the dairy women.

TABLE 1

Distribution of respondents according to their profile.

Sr. No.	Characters	Number	Per cent
(1)	Age		
	Young (upto 35 years)	110	48.89
	Middle (Between 36-50 years)	99	44.00
	Old (above 50 years)	16	7.11
(2)	Education		
	Illiterate (No education)	44	19.56
	Primary education (Upto IV standard)	40	17.78
	Middle education (V to VII standard)	69	30.67
	Secondary education (VIII to Xth standard)	63	28.00
	Higher secondary education (XI to XIIth standard)	6	2.66
	College level education (above XIIth standard)	3	1.33
(3)	Family Type		
	Nuclear family	109	48.44
	Joint family	116	51.56
(4)	Family Size		
	Small size (Upto 4 members)	44	19.56
	Middle size (5 to 9 members)	146	64.89
	Large size (above 9 members)	35	15.55
(5)	Farm Size		
	Marginal farmers (Upto 1.00 ha)	84	37.33
	Small farmers (1.1 to 2.00 ha)	65	28.89
	Medium farmers (2.1 to 5.00 ha)	57	25.33
	Big farmers (above 5.00 ha)	19	8.45
(6)	Fodder Crops Area		
	No cultivation	1	00.44
	Low cultivation (upto 0.20 ha)	92	40.89
	Medium cultivation (0.21 to 0.40 ha)	55	24.45
	High cultivation (above 0.40 ha)	77	34.22
(7)	Dairy Farming Experience		
	Low (Upto 10 years)	121	53.78
	Medium (11 to 20 years)	91	40.44
	High (above 20 years)	13	5.78
(8)	Herd Size		
	Small size (1 to 3 animals)	16	7.11
	Medium size (4 to 10 animals)	143	63.56
	Large size (above 10 animals)	66	29.33

1.	2.	3.	4.
(9)	Income from Dairy Farming		
	Low (Upto Rs. 37 thousands)	37	16.44
	Medium (37.1 to 112 thousand)	163	72.44
	High (above Rs. 112 thousand)	25	11.12
(10)	Social Participation		
	No participation	113	50.22
	Low participation (Member of 1 organization)	96	42.67
	Medium participation (Member of more than one organization)	15	6.67
	High participation	1	0.44
(11)	Milk Yield		
	Low (Upto 303 index)	39	17.33
	Medium (304 — 930 index)	161	71.56
	High (above 930 index)	25	11.11
(12)	Infrastructural Experience		
	Low (upto 45 score)	33	14.67
	Medium (46 to 60 score)	159	70.66
	High (above 60 score)	33	14.67

TABLE 2

Distribution of respondents by their entrepreneurial behaviour.

Category E. B. score	Frequency	Percentage
Low (Upto 53)	23	12.89
Medium (53.1 — 68)	162	72.00
High (above 68)	34	15.11
Total :	225	100.00

$\bar{X}$ = 60.72 S. D. = 7.68 C. V. % = 6.09

Where as dependent character; entrepreneurial behaviour score is presented in Table 2 revealed that majority (72 per cent) of the dairy women exhibited medium level of entrepreneurial behaviour. The almost nearly equal no. of the dairy women were low (12.29 per cent) and high (15.11 per cent) level of entrepreneurial behaviour group.

TABLE 3

Correlation coefficient between personal, socio-economic and situational characteristics of dairy women and their entrepreneurial behaviour.

N = 225

Sr. No.	Variable	Correlation (<i>r'</i> value)
1.	Age	-0.0248 N.S.
2.	Education	0.3442 **
3.	Type of family	0.2716 **
4.	Family size	0.2870 **
5.	Land holding	0.3581 **
6.	Fodder crops area	0.0362 N.S.
	Herd size	0.2342 **
8.	Social participation	0.1913 **
	Infrastructural experience	0.3025 **
10.	Dairy farming experience	0.9175 **
11.	Income from dairy farming	0.9360 **
12.	Milk yield	0.9152 **

N. S. = Non significant

** = Significant at 1 per cent level of probability.

It can be concluded that the majority (72 per cent) of the respondents have medium level of entrepreneurial behaviour. This might be due to the similar pattern of working situations like; with cross bred cow, availability of green fodder and market in which they were working.

It is cleared from Table 3 that, out of 12 independent variables, 10 variables were found to be positively and significantly related with entrepreneurial behaviour of dairy women. Those, were education, type of family, size of family, landholding, dairy farming experience, herd size, dairy income, social participation, milk yield and infrastructural experience. The calculated correlation coefficient of these attributes was found statistically highly significant at 1 per cent level of probability.

This might be due to the fact that these 10 characters were dependent upon each other and the absence of any one of them affects the whole system of dairy

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farming business. Dairy farming totally depends on these characters.

This finding is in line with the finding of Chari (1985).

Problems and Suggestion by the Dairy Women

Problems faced by the dairy women :
As stated in Table 4, the dairy women have reported various problems in dairy farming. Among these, the important ones were low milk price, costly management, high cost of milch animals, unsuitable climate for cross bred cow, improper oestros cycle, lack of technical know-how about breeding, feeding, management and health care of milch animals and loan procedure is too much tedious, which were rank first, second, third, fourth, fifth, sixth and seventh respectively. It is surprising to note that none of the respondents had faced the problems like; far away artificial insemination centre and non-availability of veterinary service. This clearly reveals that artificial insemination and health care services provided by the Dudhsagar dairy and I.C.D.P. were quite satisfactorily.

TABLE 4

Problems faced by the dairy women.

N = 225

Sr. No.	Problems	Number	Per cent	Rank
1.	Low milk price	220	97.78	II
2.	High cost of milch animal	170	75.56	III
3.	Costly management	215	95.56	I
4.	Unsuitable climate for cross bred cow	165	73.33	IV
5.	Improper oestrus cycle	150	66.67	V
6.	Lack of technical know how about breeding, feeding, management and health care on milch animals.	120	53.33	VI
7.	Low procedure is too much tedious	115	51.11	VII
8.	Artificial insemination centre being far away.	—	—	—
9.	Non availability of veterinary services.	—	—	—

TABLE 5

Suggestions from dairy women to overcome the problems experienced by them in dairy farming.

N = 225

<i>Sr. No.</i>	<i>Suggestions</i>	<i>Number</i>	<i>Per cent</i>	<i>Rank</i>
1.	Loan should be provided to purchase milch animals.	205	91.11	III
2.	Milk price should be increased.	220	97.78	I
3.	Improved seeds of fodder crops should be provided	195	86.67	IV
4.	Cattle feed should be provided at reasonable price	210	93.33	II
5.	Extension needs to be strengthened for animal production activities.	150	66.67	VI
6.	Training should be given to dairy women.	175	77.78	V
7.	Technologies which are to be evolved by animal scientists should be simple, practicable, economical and based on local resources.	140	62.22	VII

Suggestion from the dairy women : As evident from the data presented in Table 5 that, milk price should be increased was the most important suggestion expressed by 97.78 per cent of the respondents and it occupied first rank. Secondly, majority of the respondents (93.33 per cent) suggested that cattle feed should be provided at reasonable price. It secured second rank. About 91.11 per cent of the respondents endorsed that loan should be provided to purchase milch animals and this suggestion occupied third rank. The

suggestions such as providing improved seeds of fodder crops was reported by about 86.67 per cent of the respondents and occupied fourth rank.

From the above discussion, it can be concluded that important suggestions point out by the dairy women were milk price should be increased. Cattle feed should be available at reasonable price. Loan should be provided for the purchase of milch animals and seeds of improved varieties of fodder crops must be provided.

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A Test to Measure the Knowledge Level of Mango Orchard Growers About Drip Irrigation System

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ABSTRACT

Adoption of drip irrigation system is the only alternate to use irrigation water in agriculture economically. However, knowledge about drip irrigation system plays a crucial role for better understanding and efficient utilization of the system. Hence, there is a great need to measure the knowledge level about drip irrigation system. But, the measurement of knowledge would be impossible without a standard test. Keeping this in view, an effort was made to develop the test. The test developed could be used to measure the knowledge level of mango orchard growers about drip irrigation system as well as at other places with partial modifications.

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INTRODUCTION

It is necessary to economize the use of water for agriculture to bring more area under irrigation. This could be achieved by introducing the advanced method of drip irrigation. The Saurashtra region is considered as a dry farming area, where the availability of water for irrigation in wells is extremely scarce and irregular. Therefore, the farmers of this region have been attracted towards the modern method of irrigation and they have introduced drip irrigation system in their mango orchards.

It is fact that the knowledge plays a vital role in understanding and utilizing the technology more efficiently. Keeping this in view, a test to measure the knowledge level of

mango orchard growers about drip irrigation system was constructed and standardized.

MATERIALS AND METHODS

(a) Item collection

The content of knowledge test composed questions called items. Items were collected by referring to the relevant literature by consulting the scientists working in agronomy, horticulture and farm engineering department of College of Agriculture, Irrigation Department of College of Agricultural Engineering and Technology, Water Management Project and from discussion with the extension experts. The 47 items covering all aspects of drip irrigation system were collected to form an initial test battery to carry out item analysis.

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(b) Item analysis

The method of item analysis used by Jha and Singh (1970) was followed so as to yield three kinds of indices viz., index of item difficulty, index of item discrimination and index of item validity.

The items collected were numbered from 1 to 47 and administered to the 42 mango orchard growers selected randomly from the study area, resembling the sample farmers which were not included for the final study. Each respondent was given the score 1 or 0 for the dichotomised response of correct or incorrect and for yes or no answers, respectively. Thus, the total score obtained by an individual respondent on 47 items for correct or yes answers was the knowledge score. The scores obtained by 42 respondents were arranged separately from highest to lowest in magnitude.

These 42 respondents were divided into six equal groups, each of seven and were

arranged in descending order of the total scores obtained by them. Each group was named as G1, G2, G3, G4, G5 and G6, respectively. The range of scores obtained by the respondents of six groups is as under :

Group	Score out of 47	Respondents
G1	42 to 35	7
G2	35 to 33	7
G3	33 to 31	7
G4	30 to 28	7
G5	27 to 26	7
G6	26 to 23	7

For the purpose of item analysis, the middle two groups (G3 and G4) were eliminated keeping four extreme groups with high and low scores. The data pertaining to the correct responses for all the items in respect of these four groups (G1, G2, G5 and G6) were tabulated for calculating the difficulty and discrimination indices. An example of the calculation of the difficulty and discrimination indices is presented below :

Difficulty (P) and discrimination (E 1/3) indices of the knowledge test items.

Item no. in the initial list	Frequencies of correct answer				Total frequencies of correct answers (S ₁ +S ₂ +S ₃ + S ₄ +S ₅ +S ₆)	Percentage of respondents giving correct answers (P)	E 1/3
	S ₁	S ₂	S ₃	S ₄			
3	6	7	2	2	28	66.66	0.642
19	7	7	3	1	25	59.52	0.714
40	5	4	1	0	16	38.09	0.571

Where,

- P = Item difficulty index
- E 1/3 = Item discrimination index
- E 1/3 =
$$\frac{(S_1 = S_2) - (S_5 = S_6)}{N/3}$$

Where,

S1, S2, S5 and S6 are the frequencies of correct answer in the group of G1, G2, G5 and G6, respectively.

N = total number of respondents in the item analysis sample = 42.

Substituting the values for item number 3 of the above table, value arrived at

E 1/3 for item No. 3 =
$$\frac{(6 + 7) - (2 + 2)}{42/3} = 0.642$$

Selection of items for the final format of the knowledge test based on the following criteria :

1. Item difficulty index

The index of difficulty was worked out as the percentage of the respondents answering an item correctly. The usual assumption in this item index of difficulty was that the difficulty was linearly related to the level of respondent's knowledge about DIS. The item with 'P' values ranging from 17 to 90 were considered for final selection of the knowledge test battery.

2. Discrimination index

The second criteria for item selection was the discrimination index indicated by E 1/3 values items. In the present study, the items with E 1/3 values ranging from 0.21 to 0.79 were considered for final selection.

3. Biserial correlation

It is used for the test of item validation when the criterion of validity is ranged as

internal consistency, that is, the relationship of total score to a dichotomised response to any given item. Keeping this in view, the Biserial correlation for each of the items was calculated with the help of formula suggested by Guilford (1965). The significance of the Biserial correlation for each of the items was calculated and tested by using the formula given by Guilford (1965). The items having significant Biserial correlation at 0.05 level of probability were retained in the final format of the knowledge test.

Representativeness of the test

Though the aforesaid criteria were the main considerations for the final selection of the knowledge items, yet care was taken not to eliminate the important aspects if any.

Thus, in light of the four criteria described above, 18 items were finally selected, which formed the actual (final) format of the knowledge test and it has been appended in Appendix-I.

Appendix - I

Final format for measuring knowledge level of mango orchard growers about drip irrigation system :

1. Does the drip system keep soil moisture within the desired range for optimum plant growth ?
2. Which type of soil is more suitable for drip irrigation ?
3. Why above mentioned type of soil is more suitable ?
4. Is the drip system useful for more saline water ?
5. Can plant nutrients be supplied along with irrigation water in DIS ?
6. Does DIS offer considerable flexibility in fertigation ?
7. Is application of soluble fertilizers easy in drip system ?
8. Which device is useful in fertilizers application through DIS ?
9. Name the fertilizers which can be applied through DIS.
10. Does the fertilizers application through DIS seem beneficial over the traditional method ?
11. What could be the reason behind the failure of entire system ?
12. Is there any mechanical damage to drip system caused by rodents ?
13. Which care is required to prevent the damage caused by rodents to DIS ?
14. Is there any chemical treatment required for clogging of emitters ?
15. When DIS does not start, which steps do you follow ?
16. Do you know insecticides/pesticides/fungicides/nematicides and weedicides may also be applied through DIS ?
17. Do you know general repairing of the DIS ?
18. Name the chemicals commonly used for acid and chlorine treatment.

(c) Reliability and validity of the knowledge test :

To know the reliability of the knowledge test developed, the 'split-half method' was employed. In this method, the 18 items were divided into two equal halves, with 9 odd numbered statements in one half and 9 even numbered statements in the other. These were administered to 20 respondents separately who were neither previously interviewed nor had a chance to come in the final sample of the study. Thus, two sets of knowledge scores were obtained for each of the 20 respondents. The co-efficient of reliability between two sets of knowledge scores was calculated by the Rulon's formula (Guilford, 1954), which was found to be highly significant ($r = 0.863$). Therefore, the knowledge test under study has been found to be highly stable and dependable.

The Biserial correlation (r_{bis}) was considered as a measure of test item validity. Highly significant Biserial correlation co-efficient (r_{bis}) proved the construct validity of the items included in the knowledge test battery.

RESULTS AND DISCUSSION

The test consisted of 18 items concerning drip irrigation system, the respondents would ask to answer in dichotomised categories, that is, correct or incorrect, yes or no or they would ask to answer some direct questions specifically. The correct answers would be tick-marked. The total number of tick-marked items would take as the knowledge score obtained by an individual respondent. The knowledge score would be calculated as sum of the scores of correct responses.

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Genotype x Environment Interaction and Stability Analysis in Pearl Millet (*Pennisetum americanum* L.)

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ABSTRACT

The genotype x environment interaction and stability parameters were studied for 9 genotypes of pearl millet screened under four weed management treatments (created environments) during the *kharif* seasons of the years 1991, 1992 and 1993 at GAU, Anand and significant G x E interaction for yield and its attributes were revealed. Differential response of genotype to environment was observed in individual year as well as in pooled analysis for yield and its attributes. The mean grain yield and two stability parameters viz., regression coefficient (bi) and deviation from regression (S^2d) were obtained to access the superior genotype. An ideal genotype is one that combines high yield, unit regression and least deviation from regression. Genotype GHB 229 was noticed high yielding and stable in 'no weeding' and 'hand weeding' environments whereas MH 179 appeared high yielding and stable under herbicide applications.

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INTRODUCTION

The genotype x environment interaction is of great importance to plant breeder when he is testing genotypes over a series of environments (viz., seasons, years, locations and artificially created environments) for developing improved varieties/hybrids. The presence of such G x E interactions causing problem in ordering and relative ranking of the genotypes when tested under varying environments. An ideal genotype is one that combines high yield and stability in performance (Eberhart and Russel, 1966). The literature on stability analysis for comparing genotypes of various crops tested over space and time is available in plenty. But such information is not available very specifically for

genotypes of any crop tested under varying weed management aspects. The present study, therefore, was undertaken to ascertain whether the different genotypes of pearl millet differ in their response to environments created artificially through weed management treatments.

MATERIALS AND METHODS

An experiment was conducted on pearl millet (*Pennisetum americanum* L.) at Weed Control Research Project, GAU, Anand during *kharif* season of the years 1991, 1992 and 1993. The trial was laid out in split plot design with four replications. Four weed management treatments viz., unweeded (E1), hand weeding (E2), atrazine @ 0.75 kg. a.i./ha. (E3) and

atrazine 1.25 kg. a.i. kg/ha (E4) were relegated to main plot which were considered as four created environments and nine pearl millet hybrids/varieties (hereafter referred to as genotypes) viz., GHB 227 (G1), GHB 30 (G2), GHB 32 (G3), GHB 181 (G4), GHB 183 (G5), GHB 184 (G6), GHB 229 (G7), MH 179 (G8) and B.K. 560 (G9) to sub plot. The genotypes were sown in the first week of July every year, the seed rate being 4.00 kg/ha. Atrazine herbicide was applied as pre-emergence treatment next day after seeding.

The net plot size comprised three rows each of 5 m. length, the intra and inter row spacings were 10 cm and 45 cm respectively. All recommended agronomic practices in

vogue were followed throughout the crop season. Every year observations were recorded on plant stand, plant height (cm), earhead length (cm), weed counts, grain yield (kg/plot) and straw yield (kg/plot). The statistical model proposed by Prabhakaran and Jain (1984) was employed for genotype x environment interaction analysis. The stability parameters were obtained as outlined by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The data generated through this investigation for all the characters were analysed for individual year as well as pooled over years and are presented in Table 1 and Table 2 respectively.

TABLE 1

Year-wise test of significance for genotype (G), environments (E) and G x E interaction effects.

Characters	1990			1991			1992		
	G	E	G x E	G	E	G x E	G	E	G x E
Plant stand	**	NS	NS	**	*	*	**	NS	NS
Plant height	**	NS	*	**	**	*	**	NS	*
Earhead length	**	NS	*	**	NS	*	**	NS	*
Grain yield	**	**	*	**	**	**	**	**	**
Dry fodder yield	**	**	*	**	**	**	**	**	**
Weed counts	NS	**	NS	NS	**	NS	NS	**	NS

Legend : * = Significant at 0.05 probability level.

** = Significant at 0.01 probability level.

NS = Not Significant.

TABLE 2

Test of significance based on pooled analysis for different characters.

Characters	Y	E	Y x E	G	Y x G	G x E	Y x G x E
Plant stand	**	NS	NS	NS	**	NS	NS
Plant height	**	*	NS	**	**	**	NS
Earhead length	**	*	NS	**	**	**	NS
Grain yield	**	**	NS	**	**	**	NS
Dry fodder yield	**	**	NS	**	**	**	NS
Weed counts	**	*	NS	*	NS	*	NS

Legend : * = Significant at 0.05 probability level.

** = Significant at 0.01 probability level.

NS = Not Significant.

The results (Table 1) revealed that the differences in performances due to genotypes were significant for all the characters except weed counts in all the years. The variation due to environments (weed management treatments) was significant for grain yield, straw yield and weed counts in all the years. However, G x E interaction significantly influenced with all the characters except weed counts.

Pooled analysis (Table 2) showed that genotype, environment and G x E interaction significantly influenced that genotypes and environments were not independent in causing variation for all the attributes. Thus the presence of G x E interaction signified for the present study. The existence of G x E interaction (under artificial created environments) was reported in pearl millet by Singh and Murty (1974); Machanda and Mehta (1980); Pethani and Kapoor (1985) and Das *et al.* (1985). The presence of such interaction creating difficulties in demonstrating significant superiority of any genotype. Hence

stability was carried out using yield data only.

The mean grain yield and two stability parameters regression coefficient (b_i) and deviation from regression (S^2d) of nine genotypes tested under four environments (weed management treatments) pooled over three years are given in Table 3. The results (Table 3) showed that mean of genotypes ranged from 1.86 kg (G3) to 3.03 kg (G7) with grand mean 2.38 kg for E1; the difference being significant. For E2 it varied from 2.42 kg (G3) to 3.54 kg (G7) with ground mean 2.94 kg, the difference being significant. In case of G3 it varied from 2.01 kg (G1 to 3.10 kg (G8) with overall mean 2.56 kg with significant difference and 1.27 kg (G1) to 2.79 kg (G8) with general mean 2.03 kg under E4 and the difference was significant. The pooled mean over four environments ranged from 2.4 kg (G3) to 3.15 kg (G7) with grand mean 2.48 kg, the mean difference being significant. The regression coefficient (b_i) varied from 0.62 (G3) to 1.24 (G1) while mean square deviation (S^2d) varied from -0.23 (G8) to 0.28 (G1). The stable

TABLE 3

Average grain yield and stability parameters for nine genotypes tested under four environments.

Genotypes	Environments				Average	b_i	S^2d
	E1	E2	E3	E4			
G1	2.18	2.80	2.01	1.27	2.07	1.24*	0.28*
G2	2.21	2.93	2.42	2.09	2.41	1.15	0.22*
G3	1.86	2.42	2.02	1.85	2.04	0.62*	0.02
G4	2.63	3.49	2.87	2.44	2.85	1.04	0.02
G5	2.47	2.81	2.64	1.92	2.46	1.34*	0.04
G6	2.50	2.97	2.80	2.40	2.67	0.52	-0.06
G7	3.03	3.54	2.59	1.88	2.76	1.01	0.02
G8	2.53	3.04	3.10	2.79	2.86	1.10	-0.23
G9	1.96	2.47	2.55	1.63	2.15	1.04	0.20*
Average	2.37	2.94	2.56	2.03	2.48	—	—
C. D. 0.05	0.66	0.41	0.56	0.68	0.46	—	—

Legend : * Significant at 0.05 probability level.

TABLE 4

Environment-wise mean grain yield and stability parameters for nine genotypes.

Genotype	E1			E2		
	$\bar{Y}_i$	bi	S^2d	$\bar{Y}_i$	bi	S^2d
G1	2.18	1.43	0.15**	2.80	1.04**	0.90**
G2	2.21	1.64*	-0.03	2.93	0.78**	0.09*
G3	1.86	0.54*	-0.05	2.42	0.31*	0.09*
G4	2.63	1.02	-0.03	3.49	1.00	0.01
G5	2.47	0.91	0.38**	2.81	0.58	-0.02
G6	2.50	-0.23	0.03	2.97	0.84	-0.04
G7	3.03	0.91	-0.02	3.54	0.94	-0.11
G8	2.53	1.31*	0.62**	3.04	1.16**	-0.41*
G9	1.96	1.07	0.49**	2.47	2.35**	-0.05
Mean	2.37			2.94		
C. D. 0.05	0.66			0.41		

Genotype	E3			E4		
	$\bar{Y}_i$	bi	S^2d	$\bar{Y}_i$	bi	S^2d
G1	2.01	1.19*	0.05**	1.27	0.78	0.62**
G2	2.42	1.80*	-0.01	2.09	1.69*	0.07*
G3	2.02	0.16	-0.03	1.85	0.82	0.20**
G4	2.87	1.09	-0.08	2.44	1.02	-0.04
G5	2.64	1.26*	0.20**	1.92	1.02	-0.03
G6	2.80	0.91	-0.03	2.40	0.54*	0.32**
G7	2.59	0.57*	-0.01	1.88	0.71	0.07
G8	3.10	1.06	-0.01	2.79	1.04	-0.04
G9	2.55	0.76	-0.03	1.63	0.96	-0.05
Mean	2.56			2.03		
C. D. 0.05	0.56			0.68		

Legend : * Significant at 0.05 probability level.

** Significant at 0.01 probability level.

genotype is one that combines high yield and stability in performance. For this investigation genotypes G4 (GHB 181), G7 (GHB 229) and G8 (MH 179) showed high grain yield, regression coefficient near unity and lower deviation from regression. Hence were considered as stable genotypes. Among which G4 and G8 were suited to better environments

($bi > 1$) while G7 exhibited suitability under poor environments.

Environment-wise stability analysis was carried out to screen environment specific genotype using grain yield data pooled over three years showed significant differences among genotypes (Table 4). The mean grain

yield and two stability parameters (bi and Sd) obtained for four environments (weed management treatments) revealed that genotype G7 (GHB 229) was found stable under E1 (no weeding) and E2 (hand weeding) while genotype G8 (MH 179) exhibited superiority in E3 and E4 (herbicide application) environments.

Use of herbicide for controlling weed is a labour saving practice. However, its application requires great care and finance. Herbicide causes pollution problems also. Due to industrialization in the country, farmers are facing acute shortage of labour for agriculture.

This problem could be solved partly if genotype tolerance to weedy conditions are developed.

Thus results leads to the conclusion that 'like no tillage' (cost saving agronomic practice) 'no weeding and no herbicide application' in pearl millet could be advocated as cost saving practice without affecting yield potential, if genotypes like GHB 229 are developed and made available to the farmers. This practice takes care of pollution problem due to herbicide use also.

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Plot Technique in Potato (*Solanum tuberosum* L.)

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ABSTRACT

An uniformity trial on Lowker variety of potato was conducted at the College Agronomy Farm, B. A. College of Agriculture, Gujarat Agricultural University, Anand, to work out optimum size and shape of the plot and block using maximum curvature method and Fairfield Smith's variance method. The variability as judged by coefficient of variation per unit area (C.V.) decreased with the increase in plot size. The optimum plot (net) size obtained was 7.2 sq. m. covering 16 rows (45 cm. apart) each of one meter length for field experiments on potato but, for conveniency of agronomical operations, 8 rows each of two meter length (7.2 sq. m.) could be taken as net plot.

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INTRODUCTION

For efficient planning of field experiment, choice of suitable size and shape of plot is one of the important factors. The optimum plot size depends on the nature of experimental material, soil variability, kind of crop, number of treatments per block and the cost of various operations. The knowledge of soil variability which could be evaluated through uniformity trial, helps in determining the optimum size and shape of plot.

However, such information is not available for potato crop grown on sandy loam soils of Middle Gujarat. Therefore, the uniformity trial on potato (variety Lowker) was conducted at the College Agronomy Farm, B. A. College of Agriculture, Gujarat Agricultural University, Anand during winter season of the year 1992 with a view to determine optimum size and shape of the plot and block for field experimentation on potato.

MATERIALS AND METHODS

The potato (*Solanum tuberosum* L.) is the most popular vegetable crop grown throughout the world. In Gujarat. Kheda district ranks the first in terms of area and production. In India Sardana *et al.* (1967), Bist *et al.* (1975) and Sharma (1991) conducted uniformity trials on potato.

An uniformity trial was conducted on potato, with inter and intra-row spacings of 45 and 15 cm. respectively. The net experimental area had a dimension of 43.2 m x 24 m (i.e. 96 rows each having 24 m length). The other crop cultivation practices in vogue on the

farm were followed. The potato tuber yield data recorded for 1152 basic units each having a dimension of 0.9 m x 1.0 m (i.e. 2 rows each of 1 m length). Two methods viz., maximum curvature method (Federer, 1955) and Fairfield Smith's method (Smith, 1938) were employed to determine optimum plot size for field experimentation on potato.

RESULTS AND DISCUSSION

The results presented in Table 1 revealed that maximum coefficient of variation

(33.86 %) was observed in the smallest sized plot i.e. one unit (0.90 sq. m.), and it decreased with the increase in plot size upto 64 units size (12.84%). Sardana *et al.* (1967), Bist *et al.* (1975), Jaggard (1975) and Sethi *et al.* (1989) also reported similar trend. The decrease in C.V. was not proportional to the increase in plot size beyond 6 units plot (Fig.1). Therefore, 6 units size could be taken as point of maximum curvature and 8 units size plot i.e. just adjacent to 6 units size, appeared to be optimum plot (net) size for field experiments on potato crop.

TABLE 1

Coefficient of variation per unit size in per cent for potato tuber yield.

Plot and U*	Size shape W	L	Coefficient of variation (%)	Average for plot size	Difference in C. V. #	Per unit decrease in C. V.
1	1	1	33.86	33.86	—	—
2	2	2	27.93	27.77	6.09	6.09
2	1	2	27.61			
3	3	1	25.14	25.26	2.51	2.51
3	1	3	25.39			
4	4	1	23.36	23.64	1.62	1.62
4	2	2	23.49			
4	1	4	24.08			
6	6	1	21.72	21.93	1.71	0.86
6	3	2	21.89			
6	2	3	21.68			
6	1	6	22.45			
8	8	1	19.40	20.48	1.45	0.72
8	4	2	20.73			
8	2	4	20.85			
8	1	8	20.92			
12	12	1	19.08	19.60	0.88	0.22
12	6	2	19.69			
12	4	3	19.30			
12	3	4	19.74			
12	2	6	19.80			
12	1	12	20.01			
16	16	1	13.71	17.11	2.49	0.62
16	8	2	17.61			
16	4	4	18.80			
16	2	8	18.32			

1.	2.	3.	4.	5.	6.	7.
18	6	3	18.49	18.68	-1.57	-0.79
18	3	6	18.86			
24	24	1	16.41	17.39	1.29	0.22
24	12	2	17.55			
24	8	3	16.48			
24	6	4	18.06			
24	4	6	18.03			
24	3	8	17.52			
24	2	12	17.97			
24	1	24	17.11			
32	16	2	12.25	15.05	2.34	0.29
32	8	4	16.18			
32	4	8	16.72			
36	12	3	16.81	17.19	-2.14	-0.54
36	6	6	17.39			
36	3	12	17.34			
48	48	1	4.95	13.99	3.20	0.27
48	24	2	15.43			
48	16	3	11.23			
48	12	4	16.43			
48	8	6	15.64			
48	6	8	16.15			
48	4	12	16.82			
48	2	24	15.28			
64	16	4	11.07	12.84	1.15	0.07
64	8	8	14.60			
72	24	3	14.89	15.42	-2.58	-0.32
72	12	6	16.14			
72	6	12	16.27			
72	3	24	14.40			

* U = Basic units; W = Width and L = Length # of consicutive values given in Col. 5.

The trend in C.V. expressed in equation form using original data as well as log transformed data was as under :

$$\begin{array}{llllll}
 \text{C. V.} & = & 23.72 & - & 0.25 x + 0.0012 x^2 & \dots \dots (R^2 = 0.83) \\
 \text{C. V.} & = & 29.05 & - & 3.74 \ln x & \dots \dots (R^2 = 0.96) \\
 \ln \text{C. V.} & = & 3.095 & - & 0.0067 x & \dots \dots (R^2 = 0.82)
 \end{array}$$

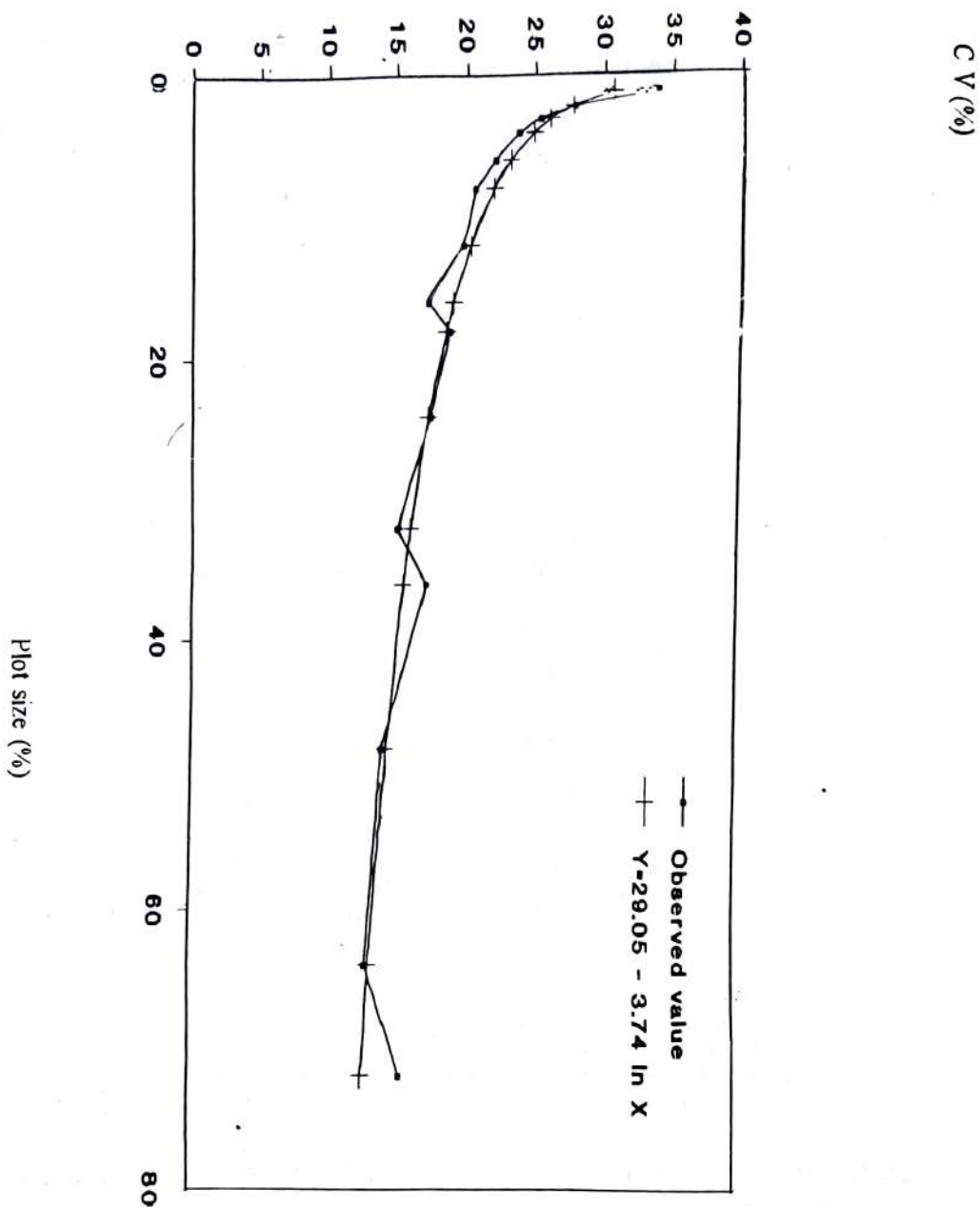


Fig. 1 : Coefficient of variation for different sized plots.

The regression of coefficient of variation on the plot size (x) indicated that the efficiency of prediction of C. V. was high when the variable x was transformed to log scale ($R^2 = 0.96$). The quadratic prediction equation based on original data accounted for 83 per cent of variation.

The rate of reduction in C. V. was more with the increase in width of the plot (i.e. number of rows) than that with the increase in length of the plot (Table 1). In fact such plots are long and narrow plots. The results thus revealed that long and narrow plots covering more number of rows (rather than length of rows) should be preferred for field experiments on potato. The per unit decrease in C. V. for different plot sizes estimated from the differences between C. V. of the consecutive points indicated that the effective decrease in C. V. due to increase in plot size was upto 8 units sized plot. The graphical presentation of C. V. (Figure 1) also revealed similar trend. Therefore, 8 units size i.e. 7.20 sq. m. size was considered as an optimum plot size. Sardana *et al.* (1967) obtained a corresponding area of 8.40 sq. m. for potato in plains while Bist *et al.* (1975) obtained 5.58 sq. m. for potato in hills.

Among all combinations of 8 units plot, (8 x 1), a plot of 7.2 m x 1 m had minimum coefficient of variation per unit area (19.4%). Therefore, it was concluded that a plot of 7.20 m x 1 m (a plot of 16 rows each of one meter length) was optimum. These findings are in agreement with those reported by Sardana *et al.* (1967) and Bist *et al.* (1975). Keeping in view the above results as well as practical difficulties for carrying out the agricultural operations, the plot having dimensions 2 m x 3.6 m i.e. 8 rows each of two meter length could be used instead of the plot having dimension of 1 m x 7.20 m. This shape had little higher C.V. (20.73%) than that for 1 m x 7.20 m shape (19.4%).

In the varying cost ratio K_1/K_2 i.e. the ratio of cost proportional to the number of plots required per treatment to the cost proportional to the total area per treatment, and soil heterogeneity index, 'b', were considered for estimating optimum plot size (Table 2).

TABLE 2

Optimum plot size in units under varying cost considerations.

b'	K_2		
	30%	40%	50%
0.30	1.00	0.64	0.43
0.40	1.56	1.00	0.67
0.41	1.60	1.03	0.68
0.50	2.33	1.50	1.00
0.60	3.50	2.25	1.50

The results (Table 2) revealed that the plot size increased with the increase in the cost ratio i.e. K_1/K_2 . For $b' = 0.41$ the plot size varied from 0.68 to 1.60 units for the K_2 ranging from 50 to 30 per cent. Generally K_2 varies between 30 to 50 per cent. For a given cost K_2 , plot size increased with the increase in soil heterogeneity. These results are akin to those reported by Sardana *et al.* (1967), Bist *et al.* (1975) and Sharma (1991).

The optimum plot size obtained by the Smith's variance method is very small and inconvenient for laying out the field trials. Thus the plot of size 7.20 sq. m. as obtained from the Maximum Curvature method, covering 16 rows (45 cm. apart) each of one meter length should be considered as a optimum (net) plot size for field experimentation on potato. [For conveniency of agronomical operations, 8 rows each of two meter length (7.20 sq. m.) can be taken as net plot].

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Trends of Groundnut Productivity in Long Term Experiment

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ABSTRACT

With a view to study the trend of groundnut productivity due to various fertilizer treatments under intensive cropping system, the yield data were collected from a long term experiment conducted at Gujarat Agricultural University, Junagadh Campus, Junagadh. The use of moving average values reduced the seasonal/irregular fluctuations in the data effectively and gave better fit as compared to that of original set of data. For groundnut crop, third degree polynomial equation ($X^{0.5}$ as base) expressed the trend for all the treatments. The initial decline, followed by a rapid increase upto the point of maxima was the characteristic of the best fitted equation. Comparative picture which emerged from the trend in productivity of groundnut crop showed that for majority of the treatments, the productivity declined after 6 point of time. The average rate of change from the point of minima to maxima and maxima to the end point was the highest in the case of direct effect of FYM (FYM1) treatment.

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INTRODUCTION

Long term field experiments help in studying the changes in the productivity of the soil over the time along with direct, residual and cumulative effects of fertilizer application. In all the long term experiments, time is a quantitative factor, hence a common practice is to partition time into components associated with orthogonal polynomials (Gomez and Gomez, 1984). In most of the cases, a simple linear trend either positive or negative may be sufficient to describe a long term trend. However, in the case where, the yield fluctuates substantially over the time, the trend may not be easily described. The method of adjustment of such fluctuations in statistical analysis can be studied using time series

analysis. Keeping this in view, an attempt has been made in the present study to examine the trend in yield due to various fertilizer treatments in groundnut crop under intensive cropping system of groundnut-wheat-sorghum (fodder) in medium black soil of Junagadh (Gujarat).

MATERIALS AND METHODS

The data for the present study were collected from a long term experiment conducted by the Department of Agricultural Chemistry in collaboration with the Department of Agronomy, Gujarat Agricultural University, at Junagadh for the period 1979 to 1992. The treatments tried on the crop were :

- (1) Control : No nutrient (organic or inorganic) application.
- (2) FYM1 : Application of FYM @ 25 t/ha every third year starting from first year of experimentation to the *kharif* crops only.
- (3) FYM2 : Application of FYM @ 25 t/ha to the *kharif* crops every third year, starting from second year of experiments.
- (4) FYM3 : Application of FYM @ 25 t/ha to *kharif* crops every third year starting from third year of experimentation.
- (5) N50 : Half dose of nitrogen as recommended for the crop under irrigated conditions.
- (6) NP50 : Half dose of N and P as recommended for the crop under irrigated conditions.
- (7) NPK50 : Half dose of N and P as recommended for the crop under irrigated condition with K application.
- (8) N100 : Full dose of N as recommended for the crop under irrigated conditions.
- (9) NP100 : Full dose of N and P as recommended for the crop under irrigated conditions.
- (10) NPK100 : Full dose of N and P as recommended for the crop under irrigated conditions with K application.
- (11) NsPs : Application of N and P as per the initial soil test values.
- (12) NsPsKs : Application of N, P and K as per initial soil test value.

Methods of Analysis

In order to explore the possibility of identifying the trend equations for various treatments over the period of time, 24 different equations (Table 1) were tried using curve

fitting approach i.e. by fitting different equations (i) using original treatment mean and (ii) using three years moving average so as to partly take care of the inter year fluctuation due to climatic differences.

TABLE 1

List of equations.

Eq. No.	Form of equation	Equation name
1	$Y=A+B \cdot X$	Straight line
2	$Y=B \cdot X$	Line through origin
3	$Y=A+B \cdot X^{.5}+C \cdot X$	2nd deg. poly. with $x^{.5}$ as base
4	$Y=A+B/X^{.5}+C/X$	2nd deg. poly. with $1/X^{.5}$ as base
5	$Y=A-B \cdot X+C/X$	Linear and reciprocal
6	$Y=A+B/X$	Hyperbola
7	$Y=X/(A \cdot X+B)$	Reciprocal hyperbola
8	$Y=A+B \cdot X^{.5}+CX+D \cdot X^{1.5}$	3rd deg. poly. with $x^{.5}$ as base
9	$Y=A+B/X+C/X^2$	2nd order hyperbola
10	$Y=A+B \cdot X+C \cdot X^2$	Parabola

1.	2.	3.
11	$Y=A+B*X+C/X^2$	Mod. parabola
12	$Y=A+B*X+C*X^2+D*X^3$	3rd deg. polynomial
13	$Y=A+B/X+C/X^2 + D/X^3$	Reciprocal 3rd deg. polynomial
14	$Y=A+B/X^{.5}+C/X+D/X^{1.5}$	3rd deg. poly. with $1/X^{.5}$ as base
15	$Y=A*X^B$	Power function
16	$Y=A*B^X$	Mod. power function
17	$Y=B^{(1/X)}$	Root function
18	$Y=A*X^{(B*X)}$	Super geometric
19	$Y=A*X^{(B/X)}$	Mod. geometric
20	$Y=A*e^{(B*X)}$	Exponential
21	$Y=A*e^{(B/X)}$	Mod. exponential
22	$Y=A+B*\ln(X)$	Logarithmic
23	$Y=1/[A+B*\ln(X)]$	Reciprocal logarithmic
24	$Y=A*B^X*X^C$	Hoerl function

Using original treatment means the respective equations for each of the treatment for various crops were fitted and the best fitted equation was identified as the one having the highest adjusted coefficient of determination ($\bar{R}^2$). The adjusted R^2 was calculated as

$$\bar{R}^2 = 1 - \frac{n-1}{n-p} (1 - R^2)$$

n = number of years

p = number of regressors

R^2 = unadjusted coefficient of determination.

In the second approach, taking first year of the experiment as the base year, three years moving average values of the original treatment means were obtained and using these values the best fitted equation was identified from the equations tried for each treatment of the crops under study. The regression coefficients for the fitted equations were tested for their significance using 't' test.

After identifying the best approach for fitting the trend equation, the best fitted equations were used to study the trends in

yield due to various treatments over the of time. The points of maxima and minima and minima were estimated as given by Arya and Lardner, (1979).

Let $Y = f(x)$ then,

for the point of maxima :

$$\frac{dy}{dx} = 0; \quad \frac{d^2y}{dx} < 0$$

for the point of minima :

$$\frac{dy}{dx} = 0; \quad \frac{d^2y}{dx} > 0$$

The average rate of change between the two points (initial to minima/maxima, minima to maxima, maxima to last points) was calculated as :

$$\text{Average rate of change} = \frac{\bar{Y}_m - \bar{Y}_n}{m - n}$$

Where,

$\bar{Y}_m$ = expected productivity at time point m

$\bar{Y}_n$ = expected productivity at time point n

$(m - n)$ = difference between two time points.

TABLE 2

Comparison of trend equations fitted through original data and moving average values in various treatments.

Treatments																								
Control		FYM1		FYM2		FYM3		N50		NP50		NPK50		N100		NP100		NPK100		N _P ₅		N _S P ₅ K ₅		
Eq.	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²	R _i ²
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	-10	-15	-12	-16	-12	-16	-12	-16	-10	-13	-11	-16	-10	-16	-10	-14	-11	-14	-10	-16	-10	-16	-10	-16
2	.01	-15	-05	-13	.04	-12	-01	-15	-00	-16	.07	-12	-01	-10	.00	-16	.10	-14	-00	-12	.14	-09	-06	-13
3	-13	.19	.03	.48	-01	.45	-05	.41	-17	.07	-16	.10	-04	.22	-15	.12	-20	.02	-07	.23	-18	.00	-04	.31
4	-21	-09	-17	-06	-21	-07	-22	-09	-22	-12	-24	-18	-19	-13	-22	-11	-23	-18	-21	-14	-24	-23	-19	-08
5	-20	.07	-09	.16	-14	.11	-17	.10	-23	.01	-23	.06	-15	.10	-22	.01	-24	.03	-17	.15	-23	-02	-15	.17
6	-08	.00	-06	-01	-08	-02	-08	-00	-09	.04	-10	-01	-06	-03	-09	.01	-11	.02	-07	-03	-11	-04	-06	-03
7	-08	-09	-12	-11	-10	-13	-11	-10	-07	-03	-03	-14	-10	-14	-07	-08	-02	-12	-09	-12	-01	-16	-11	-11
8	-03	.78	-05	.81	-16	.81	-19	.80	-04	.78	-04	.73	.04	.78	-04	.78	-03	.77	.02	.77	-09	.73	.02	.79
9	-19	-17	-21	-17	-23	-17	-24	-17	-20	-14	-23	-20	-20	-21	-20	-17	-21	-16	-20	-19	-24	-24	-18	-17
10	-03	.65	.17	.72	.05	.57	.04	.67	-08	.59	-07	.63	.06	.68	-06	.59	-12	.61	.03	.69	-10	.56	.06	.70
11	-22	-13	-15	.01	-19	-00	-21	-03	-24	-18	-24	-21	-19	-13	-23	-15	-24	-23	-20	-14	-24	-26	-19	-08
12	-09	.76	.03	.72	-09	.76	-10	.73	-10	.78	-10	.73	.00	.76	-09	.78	-09	.77	-03	.69	-13	.69	-02	.72
13	-31	-04	-16	.48	-28	.34	-24	.36	-33	-10	-34	-10	-31	-01	-33	-10	-34	-13	-31	.00	-39	-22	-27	.06
14	-22	.21	-02	.70	-17	.60	-13	.60	-25	.12	-25	.16	-19	.24	-25	.12	-26	.12	-19	.30	-31	.04	-15	.34
15	-11	-11	-12	-13	-11	-14	-12	-12	-10	-05	-08	-13	-11	-15	-10	-09	-05	-11	-11	-14	-04	-15	-10	-14
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21	-11	-02	-10	-05	-12	-07	-12	-04	-10	.02	-09	-07	-10	-09	-11	-01	-06	-03	-10	-07	-07	-11	-09	-06
22	-08	-07	-10	-10	-10	-11	-10	-08	-09	-02	-10	-09	-08	-11	-09	-05	-11	-05	-09	-12	-11	-10	-07	-12
23	-05	-15	-10	-14	-04	-16	-07	-15	-04	-11	.01	-16	-06	-16	-04	-14	.03	-16	-06	-16	-06	-16	-09	-16
24	-15	.33	.02	.43	-01	.29	-07	.36	-20	.27	-14	.31	-05	.36	-18	.25	-12	.27	-10	.42	-08	.20	-08	.44

R_i² = Adjusted R square of the equation using original data.R_i² = Adjusted R square of the equation using moving average.

TABLE 3

Best fitted equations for different treatments in groundnut.

Treatment	Equation	Coefficients				
		A	B	C	D	R ²
Control	$Y=A+BX^{0.5} + CX + DX^{1.5}$	4475.61	-7922.07*	4694.33*	-840.15*	86
FYM 1	$Y=A+BX^{0.5} + CX + DX^{1.5}$	6365.85	-12419.26	8374.84	-1674.99*	89
FYM 2	$Y=A+BX^{0.5} + CX + DX^{1.5}$	4649.92	-8840.38	5851.73*	-1156.97*	90
FYM 3	$Y=A+BX^{0.5} + CX + DX^{1.5}$	3905.76	-7696.00	4846.88*	-950.57*	89
N50	$Y=A+BX^{0.5} + CX + DX^{1.5}$	5468.39	-9545.95*	5509.63*	-967.44*	87
NP50	$Y=A+BX^{0.5} + CX + DX^{1.5}$	5151.43	-9006.60*	5259.41*	-934.46*	84
NPK50	$Y=A+BX^{0.5} + CX + DX^{1.5}$	7525.71	-13379.10*	8004.30*	-1445.53*	86
N100	$Y=A+BX^{0.5} + CX + DX^{1.5}$	4837.20	-8484.09*	4953.78*	-877.07*	83
NP100	$Y=A+BX^{0.5} + CX + DX^{1.5}$	5813.78	-10152.68*	5825.57*	-1020.85*	84
NPK100	$Y=A+BX^{0.5} + CX + DX^{1.5}$	7942.03	-14258.77*	8564.34*	-1551.72*	85
NsPs	$Y=A+BX^{0.5} + CX + DX^{1.5}$	5514.57	-9523.48*	5495.68*	-963.15*	81
NsPsKs	$Y=A+BX^{0.5} + CX + DX^{1.5}$	6759.14	-12210.38*	7483.47*	-1372.09*	85

* Significant at 5 % level.

Expected response at different points of time was calculated using the best fitted equation for different treatments for the period under study. Using these expected values the productivity trend over the period of time under various treatments was also examined using graphical approach.

RESULTS AND DISCUSSION

The trend equations fitted through both the methods are presented in Table 2. The results indicated that the use of moving average values reduced the irregular fluctuations in the data remarkably and gave better fit (adjusted R^2) as compared to original treatment mean equations.

Trend in yield corresponding to various treatments

For all the treatments in case of groundnut, the trend in yield due to various treatments was measured by third degree polynomial equation with $x^{0.5}$ as base.

Control

The results presented in Table 4 and depicted in Figure 1 indicated an increase in productivity at the average rate of 147.03 kg preceded by a decline in the productivity in the early stage of experimentation. Diminishing productivity was observed after reaching the maxima at 5.92 point of time.

FYM1

The results (Table 4 and Figure 2) indicated that, average decline of 371.07 kg in the productivity during early stage was followed by increasing productivity at the average rate of 300.19 kg up to the point of maxima (5.81).

FYM2

A perusal of Table 4 and Figure 2 indicated declining trend in the productivity (at the average rate of 273.16 kg) in the early stage. There was an increasing trend at the rate of 194.40 kg up to 5.84 point of time (maxima), followed by continuous decline in the productivity at the average rate of 274.87 kg during the period under study.

Average productivity of groundnut for different treatments and rate of change under different segments of fitted equations.

Treatment	Average production (kg/ha)	Moving initial product.	Average final product.	Expected initial product.	Average final product.	Av. rate of change			Point of Minima Maxima
						A	B	C	
Control	553	379	267	408	274	-213.87	147.03	-199.67	1.67 5.92
FYM 1	1027	680	437	646	337	-159.10	307.87	-606.45	1.24 4.93
FYM 2	740	511	317	504	280	-136.46	202.61	-409.37	1.31 4.97
FYM 3	597	412	276	404	247	-122.23	165.42	-327.26	1.34 5.03
N50	551	394	264	430	288	-241.62	149.16	-199.63	1.73 6.00
NP50	563	443	225	470	236	-249.92	171.98	-204.89	1.68 6.13
NPK50	935	662	410	705	398	-349.99	251.92	-358.80	1.64 5.82
N100	569	428	275	465	296	-281.99	160.38	-213.04	1.79 6.05
NP100	537	433	191	466	223	-305.75	162.74	-225.26	1.83 6.02
NPK100	958	667	423	696	348	-367.33	274.36	-390.51	1.62 5.79
NsPs	545	467	191	503	215	-281.30	162.85	-208.72	1.78 6.10
NsPsKs	979	634	481	660	433	-286.99	255.72	-357.61	1.53 5.76

A = Average rate of change in the productivity from initial point of time to the point of minima.

B = Average rate of change in the productivity from the point of maxima to minima or minima to maxima.

C = Average rate of change in the productivity from the point of maxima to last point of time.

Trends of crop productivity in different treatments

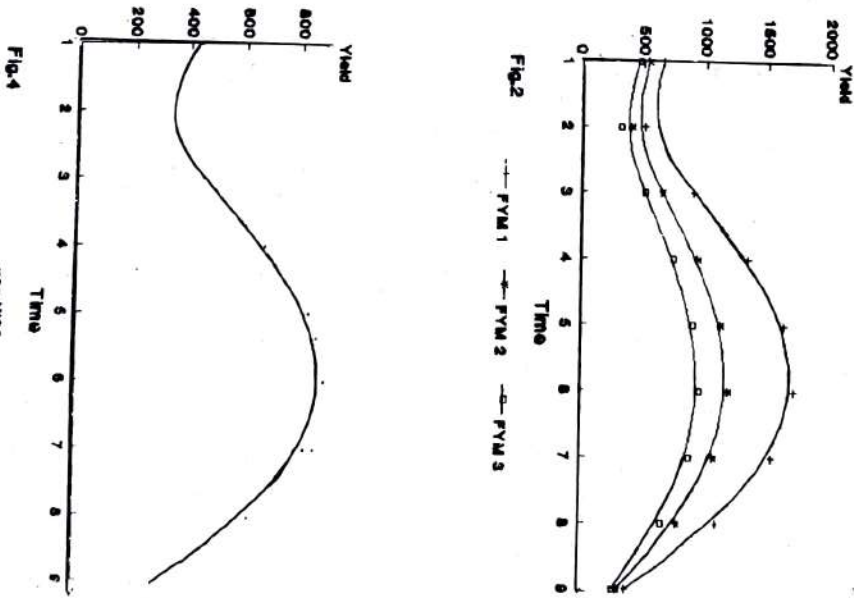
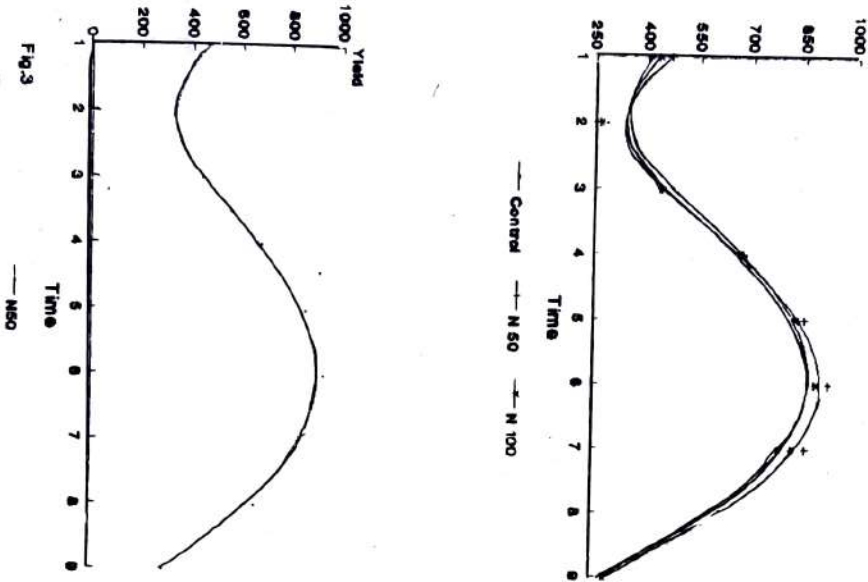
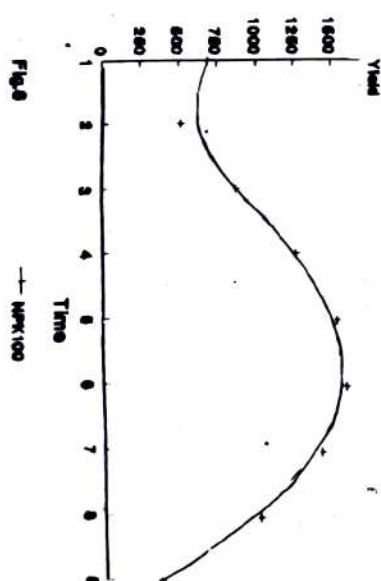
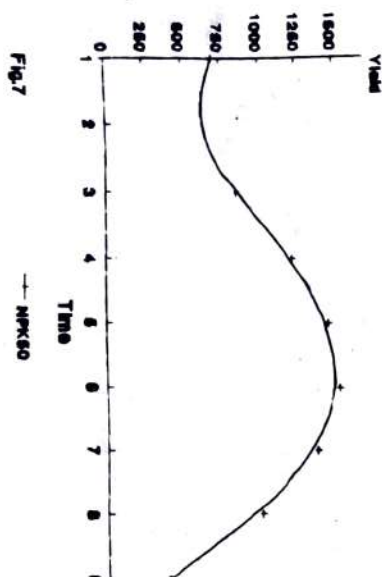
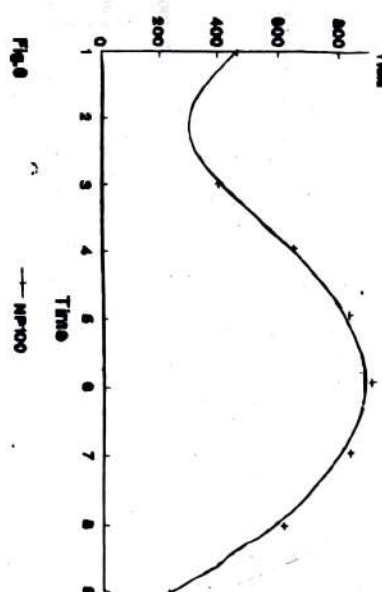
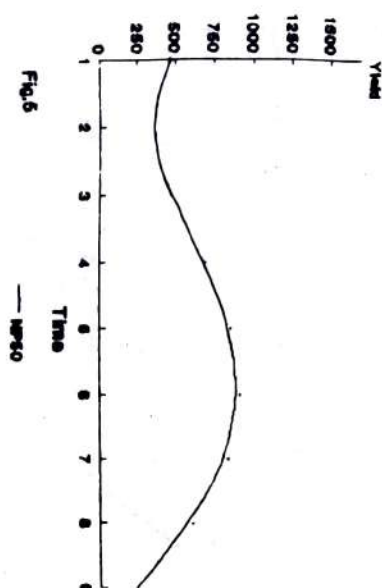


Fig.3

Fig.2

Fig.4

Trends of crop productivity in different treatments



FYM3

Table 4 indicated a decrease in the productivity in early phase of experimentation (average rate of 235.23 kg), followed by increasing productivity at the average rate of 155.60 kg. However, after attaining the point of maxima at 5.90, a continuous decline in the productivity at the average rate of 217.17 kg was observed.

Nitrogen (N 50 and N 100)

The results (Table 4 and Figure 3 and 4) revealed that there was an initial decline at the average rate of 281.99 and 241.62 kg for the lower and higher level of nitrogen, respectively. This decline was followed by increase in the productivity at the average rate of 160.38 and 149.16 kg, respectively.

Phosphorus in presence of Nitrogen (NP 50, NP 100 and NsPs)

The results furnished in Table 4 and depicted in Figures 5, 6 and 7 indicated an

initial decline in the productivity in case of all the three treatments of N and P combinations. These initial declines were followed by the increase at the average rate of 171.98 kg (NP50), 162.74 kg (NP100) and 162.85 kg (NsPs) up to the point of maxima.

Potash in presence of Nitrogen and Phosphorus (NPK50, NPK 100 and NsPsKs)

The results presented in Table 4 and Figures 8, 9 and 10 indicated that for various levels of NPK, the declining trend in the productivity at different rates was observed during the initial period of experimentation. The maximum average rate of increase in the productivity up to the point of maxima was observed in case of NPK100 (274.36 kg), followed by NsPsKs (255.72 kg) and NPK50 (251.92 kg).

Trends of crop productivity in different treatments

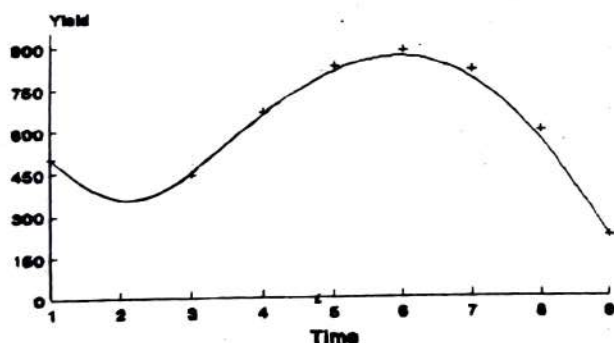


Fig.9

—+— NsPs

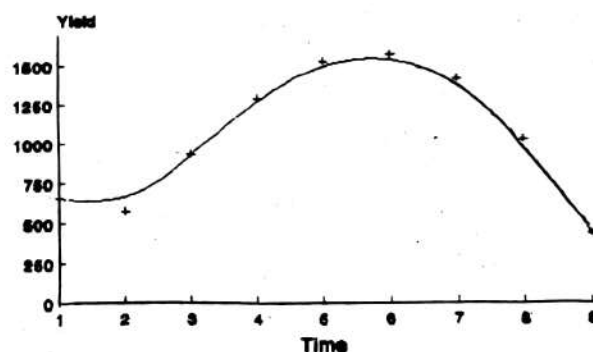


Fig.10

—+— NsPsKs

Thus, the results of the present study revealed that for groundnut crop, use of moving average reduced the irregular fluctuations in the data effectively and gave better fit as compared to that of original set of data.

Further, for the groundnut crop which requires quite low level of nutrients, a single form of the equation expressed the trend for all the treatments. However, regression coefficients (linear, quadratic and cubic) i.e.

rate of change, showed variation. The initial decline, followed by a rapid increase was the characteristic of this fitted equation. The decline in the productivity of the crop was noticed for most of the treatments after 5 to 6 points of time. The average rate of change from the point of minima to maxima and maxima to minima to the end point was the highest in case of direct effect of FYM application for the period under study.

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Short Communications

Response of Summer Groundnut (*Arachis hypogaea* L.) Var GG-2 to Soil Amendments, Biological and Chemical Source of Nitrogen and Phosphorus Under South Gujarat Condition

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A field experiment was conducted during summer season of 1993 at College Farm, Gujarat Agricultural University, Navsari Campus with twenty seven treatment combinations consisting of three levels each of soil amendments (0, FYM @ 10 t/ha, Gypsum @ 1 t/ha), biological and chemical source of nitrogen (0, rhizobium inoculation only and N @ 25 kg/ha) and phosphorus (0, phosphobacteria inoculation and P_2O_5 @ 50 kg/ha) accommodated in a 3^3 factorial partial confounding in Randomized Complete Block Design with two replications. A bunch groundnut GG-2 was sown on February, 5 and harvested on June, 22. The soil of the experimental plot was clayey in texture having higher water holding capacity, deficient in nitrogen (0.050 per cent), medium in available phosphorus (30 kg/ha) and sufficient in available potash (372 kg/ha) with pH 7.7.

The growth of crop measured in terms of plant height, number of primary branches/plant and dry matter production was affected

by soil amendments (Table 1). All these growth attributes ultimately reflected in increased yield of haulm by the gypsum @ 1 t/ha followed by FYM @ 10 t/ha. The number of pods/plant was also significantly affected by the soil amendments. Comparatively higher number of pods/plant were recorded with gypsum followed by FYM over control. The maximum pod yield of 22.25 q/ha was recorded with gypsum (@ 1 t/ha) followed by FYM (@ 10 t/ha) over control. These findings are in accordance with those recorded by Sridhar *et al.*, (1985) and Mehta (1993).

Most of the growth characters like plant height (cm.), number of primary branches/plant and dry matter production were significantly increased by N (25 kg/ha) application over control. These resulted into the highest haulm yield of 49.91 q/ha with 25 kg N/ha. In case of rhizobium inoculation, growth characters and haulm yield increased but remained statistically at par with control, various yield attributes like number of pods/plant and total number of pods/plant were significantly affected by nitrogen (@ 25 kg/ha) application followed by rhizobium inoculation. Consequently maximum pod yield (22.65 q/ha) was recorded with 25 kg N/ha followed by rhizobium inoculation (21.20 q/ha) over control (20.40 q/ha). These findings are in conformation with those reported by Patel and Patel (1987) and Patel *et al.*, (1994).

Growth characters like plant height and dry matter production/plant were increased

TABLE 1

Growth and yield of summer groundnut as influenced by soil amendments biological and chemical source of nitrogen and phosphorus.

Treatments	Plant height at harvest (cm)	Primary branches/plant at harvest	Dry matter production/plant at harvest (g)	Developed pods/plant	Undeveloped pods/plant	Total pods/plant	Pod yield (q/ha)	Haulm yield (q/ha)
Soil amendments								
A ₀ (Control)	39.19	6.10	31.96	13.70	4.70	18.40	20.00	39.00
A ₁ (FYM @ 10 t/ha)	40.29	6.20	35.87	15.82	4.57	20.39	21.99	46.33
A ₂ (Gypsum @ 1 t/ha)	40.49	6.23	36.25	16.51	4.55	21.06	22.25	46.75
S. Em. ±	1.52	0.20	0.92	0.22	0.15	0.29	0.27	1.06
C. D. at 5%	NS	NS	2.81	0.65	NS	0.85	0.77	3.11
Bio and chemical								
Source of nitrogen								
N ₀ (Control)	36.89	5.92	32.05	14.52	4.66	19.18	20.40	39.70
N ₁ (Rhizo. Inoc.)	40.52	6.00	34.44	15.47	4.63	20.10	21.20	42.47
N ₂ (N @ 25 kg/ha)	42.56	6.61	37.59	16.04	4.54	20.58	22.65	49.91
S. Em. ±	1.52	0.20	0.92	0.22	0.15	0.29	0.27	1.06
C. D. at 5%	4.47	0.57	2.81	0.65	NS	0.85	0.77	3.11
Bio and chemical source of phosphorus								
P ₀ (Control)	38.38	5.98	32.67	14.50	4.71	19.21	20.37	40.30
P ₁ (Phosphobacteria Inoc.)	39.12	6.07	34.08	15.30	4.61	19.91	21.19	42.78
P ₂ (P ₂ O ₅ @ 50 kg/ha)	42.47	6.48	37.33	16.23	4.51	20.74	22.68	48.99
S. Em. ±	1.52	0.20	0.92	0.22	0.15	0.29	0.27	1.06
C. D. at 5%	NS	NS	2.81	0.65	NS	0.85	0.77	3.11
C. V. %	16.17	13.53	11.74	6.22	13.90	6.18	4.25	7.03

significantly with phosphorus application. As a result, the highest haulm yield of 48.99 q/ha was recorded with 50 kg P_2O_5 /ha. In case of phosphobacteria inoculation, there were improvement in growth characters and ultimately haulm yield but did not reach up to the level of significance. Various yield attributes such as developed pods and total number of pods/plant were significantly

influenced due to application of phosphorus followed by phosphobacteria inoculation. Consequently maximum pod yield of 22.68 q/ha was recorded by phosphorus application followed by phosphobacteria inoculation (21.19 q/ha). These results are in akin with those reported by Mehta (1993) and Patel *et al.*, (1994).

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Effect of Drip Irrigation on Yield and Water Expense Efficiency of Castor (*Ricinus communis* L.)

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Proper management of critical inputs like water can overcome the productivity constraints to a great extent if high frequency irrigation systems are used. An attempt has, therefore been made to study the effect of drip irrigation on the yield and water expense efficiency in castor.

The experiment was conducted at Narmada Irrigation Research Project, Khandha, Gujarat during 1992-93 to 1995-96 except 1994-95 on castor GCH-4 in Typic chromustert soil. The treatments were flood irrigation of 80 mm depth and fractions of pan evaporation i.e. 0.2, 0.4, 0.6 and 0.8 through drip on alternate day. Basal dose of 40-40-0 kg/ha N, P_2O_5 and K_2O were applied as per recommendation. Nitrogen was applied in two splits. The crop was sown during second to third week of August and harvested in last week of January every year. The water expense efficiency was computed as yield divided by total water (mm) applied include effective rainfall received during crop season. The soil characteristics were pH 7.1,

$EC_{2.5}^{-1.01} \text{ dsm}^{-1}$, total N 0.033%, Olsen's P_2O_5 19.4 kg/ha and available K_2O 1206 kg/ha. During cropping season of 1992-93, 1993-94 and 1995-96, the total rainfall was 737, 978 and 696 mm, while effective rainfall was only 525, 600, 475 respectively. In case of rainfall during the weeks of cropping season, the amount of rainfall was subtracted from the cumulative pan evaporation of the preceding week and rest of the amount was used to calculate the amount of water to be applied. If rainfall during any week exceeded pan evaporation, the irrigation was skipped during that week.

Irrigation scheduled at different fractions of pan evaporation (FPE) i.e., 0.2, 0.4, 0.6 and 0.8 gave significantly higher yield over surface irrigation of 80 mm depth (Table 1). All FPE were at par statistically. The higher yield obtained under different FPE was mainly due to better soil water regime. The results corroborate the findings of Goldberg *et al.* (1976).

The results further indicate that there is saving of water from 31 to 73 per cent under different fractions and highest was with 0.2 fPE. The water expense efficiency (WEE) was higher (3.0 kg/ha-mm) with 0.2 FPE and decreases with increase in the fraction of pan evaporation. This may be due to better utilization of irrigation water at lower fraction where as in higher fraction the rate of water loss as evaporation may be high and relative

TABLE 1

Seed yield, total water applied, per cent water saving, water expense efficiency (WEE) and economics under different treatments.

Treatment	Seed yield kg/ha	Total water applied (WRR=IR+ER) mm	WEE kg/ha-mm	% saving of water over control	Gross income Rs/ha	Total cost Rs/ha	Total net income Rs/ha	Net income over control Rs/ha	Net return per mm water applied Rs/ha
Drip (FPE)									
0.2	2122	706	3.0	73	20159	15640	16720	9674	97
0.4	2315	797	2.9	59	21993	15895	14635	7589	55
0.6	2309	885	2.6	45	21898	16158	16332	3286	29
0.8	2222	977	2.3	31	21109	16455	6981	-	16
Surface irrigation	1728	1178	1.5	-	16416	9370	7046	-	11
S. Em. ±	92.5	-	-	-	-	-	-	-	-
C. D. 0.05%	261.7	-	-	-	-	-	-	-	-

Average effective rainfall is 533 mm.

increase in yield was not proportional to the increase in consumptive use of water. These results are in close association with the findings of Fox *et al.* (1986) and Malik *et al.* (1994) in pulse and vegetable crops.

The economical analysis showed that the gross income was maximum in all the drip treatments as compared to surface irrigation. Considering the additional area that can be cultivated through drip due to saving of water, the total net income is higher than surface method of irrigation for the same quantity of water. The net income (Rs. 9674=00) was higher in 0.2 FPE. The net return per mm of water applied was also higher i.e. Rs. 97/mm of water with 0.2 FPE which is 782 per cent more than the surface.

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The results suggest that the irrigation of castor at 0.2 fraction of pan evaporation through drip after cessation of monsoon i.e. October to January was better to harvest full potential of castor crop and higher net return.

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Influence of Irrigation and Phosphorus on Yield and Economics of Pigeonpea

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Pigeonpea [*Cajanus cajan* (L.) Mills] is generally grown under rainfed condition and without much fertilizer application. Poor yield of pigeonpea was observed due to moisture stress at reproductive stage and also low status of available phosphorus in soils of Region I of Narmada Command. Therefore, post monsoon irrigation and application of phosphorus in Region I of Narmada command assumes paramount importance. A field experiment was undertaken to study the effect of irrigation and phosphorus on yield of pigeonpea.

A field experiment was conducted in randomized block design with three replications during rainy season of 1991-92 to 1995-96 except 1992-93 and 1994-95 at Narmada Irrigation Research Farm, Khandha, Gujarat with pigeonpea variety BDN-2. The rainfall received during crop season was 1022, 978 and 687 mm in 1991-92, 1993-94 and 1995-96, respectively. The soil is clayey in texture with pH 7.2, low in total N (0.029 per cent), Olsen's P_2O_5 (11 kg/ha) and high in available K_2O (1179 kg/ha). The crop was

sown from end of July to first week of August in the intra and inter row spacing of 90 and 30 cm, respectively. Sixteen treatments comprising of four levels of irrigation viz., no irrigation 0.5, 0.7 and 0.9 IW : CPE ratio and four levels of P_2O_5 i.e. 0, 25, 50 and 75 kg/ha were used. A uniform dose of 20 kg N/ha was applied as basal to all the plots. Irrigation each of 80 mm was imposed in respective IW : CPE ratios after the cessation of rains.

The effects of irrigation levels and phosphorus application on yield of pigeonpea are presented in Table 1. The application of irrigation either at 0.5, 0.7 or 0.9 IW : CPE ratio gave significantly higher yield over no irrigation in all the years as well as in pooled analysis. The effect of different IW : CPE ratio on yield was at par statistically. Hence, pigeonpea require to be irrigated at 0.5 IW : CPE ratio i.e. 3 irrigations after cessation of monsoon. The results are in agreement with the findings of Patel and Patel (1994).

The application of phosphorus gave significantly higher yield over no phosphorus but different levels of P_2O_5 were at par statistically during all the years and in pooled analysis (Table 1). The results corroborate the findings of Sarvaiya *et al.* (1993).

The Economic analysis of treatments are presented in Table 2. It revealed that the application of irrigation at 0.7 IW : CPE ratio

TABLE 1

Effect of Irrigation and phosphorus levels on seed yield of pigeonpea.

Treatments	Yield, q/ha				No. of irrigation	Qty. of water applied mm
	1991-92	1993-94	1994-95	Pooled		
IW : CPE ratio						
No irrigation (control)	15.24	11.34	13.50	13.36	—	—
0.5	19.73	12.95	16.58	16.42	3	240
0.7	18.90	14.49	19.57	17.66	4	320
0.9	19.16	13.13	19.96	17.42	5	400
S. Em. ±	0.44	0.31	0.10	0.73		
C. D. at 5%	1.27	0.90	0.30	2.52		
P₂O₅ levels (kg/ha)						
0	16.52	11.83	16.68	15.01	1766 252 1514	
25	18.22	13.25	17.10	16.19		
50	19.62	13.33	17.74	16.90		
75	18.66	13.49	17.91	16.69		
S. Em. ±	0.44	0.31	0.10	0.30		
C. D. at 5%	1.27	0.90	0.30	1.03		
C. V. %	8.3	8.3	6.1	6.8		

TABLE 2

Economics as influenced by different treatment of Irrigation and phosphorus over control.

Treatment	Mean yield Q/ha	No. of irrigation	Addl. yield over control (Q/ha)	Addl. income (Rs/ha)	Addl. cost (Rs/ha)	Net income (Rs/ha)	CBR	NCBR
Irrigation levels								
No irrigation control	13.36	—	—	—	—	—	—	—
0.5 IW/CPE	16.42	3	3.06	5355	1080	4275	1 : 4.96	1 : 3.96
0.7 IW/CPE	17.65	4	4.29	7508	1440	6068	1 : 5.21	1 : 4.21
0.9 IW/CPE	17.42	5	4.06	7105	1800	5305	1 : 3.94	1 : 2.94

1.	2.	3.	4.	5.	6.	7.	8.	9.
P₂O₅ levels (kg/ha)								
0	15.01	-	-	-	-	-	-	-
25	16.19	-	1.18	2065	431	1634	1:4.79	1:3.79
50	16.90	-	1.89	3308	862	2446	1:3.84	1:2.84
75	16.69	-	1.68	2940	1293	1647	1:2.27	1:1.27

Selling price of pigeonpea Rs. 1750/Q

Price of P₂O₅ per kg Rs. 17.25

Labour cost for irrigation application Rs. 60/irrigation

Cost of irrigation water Rs. 300/irrigation.

CBR = Cost Benefit Ratio

NCBR = Net Cost Benefit Ratio

gave higher net return of Rs. 6068/ha. In case of phosphorus application, 25 kg P₂O₅/ha gave higher net cost benefit ratio i.e., 1 : 3.79. The results confirm the findings of Bhan and Khan (1979).

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**Analysis of Variability and
Heritability in Amaranthus**
[*Amaranthus hypochondrioides* (L.)]

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Success of any crop improvement programme depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. The estimates of variability in respect of yield, and its heritable components in the material with which the breeder is working, are therefore, prerequisite for any breeding programme. Hence, it becomes necessary to split the phenotypic variability in to heritable and non heritable components such as genotypic and phenotypic coefficients (GCV and PCV), heritability and genetic advance.

Heritable improvement in the yield is an ultimate aim of the plant breeder which calls for selection on the basis of yield components which are heritable. There is hardly any report on this aspects in *Amaranthus*. The present investigation in *Amaranthus* [*Amaranthus hypochondrioides* (L.)] were therefore, carried out on fifty genotypes having wide genetic diversity studied by Pawar, 1995. The above material was raised in a randomised block

design, with three replications during *rabi* 1993 at instructional farm of Dept. of Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri. Each genotype was sown with a spacing of 50 cm between the rows and 15 cm within the plants. Each genotype was evaluated in two rows of three meter length in each replication. The observations were recorded on five randomly selected plants in each replication for ten characters.

A wide range of variability was observed in respect of all the characters studied (Table 1). This indicated an ample scope of exploitation of the above traits. Hauptli (1984), Hauptli and Jain (1984) and Rangaswamy *et al.*, (1980) also reported ample variability for various components in *Amaranthus*. The characters like girth of inflorescence and protein content however exhibited comparatively less variability.

In the present investigation, higher estimates of genotypic and phenotypic coefficients of variation were observed for number of branches per plant, grain yield per plant, leaf area per plant, plant height at flowering and number of spikelets per plant indicating more variability and scope for selection in improving these traits. Other characters viz., length of inflorescence, protein content, girth of inflorescence and days to maturity indicated low to medium genotypic and phenotypic coefficients of variation respectively indicating limited scope for

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TABLE 1

Estimation of range, genotypic variance ($\delta^2 g$), phenotypic variance ($\delta^2 p$), environmental variance ($\delta^2 e$) genotypic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), heritability and genetic advance (GA) for various characters.

Sr No.	Character	Range	$\delta^2 g$	$\delta^2 p$	$\delta^2 e$	GCV	PCV	Heritability (%)	GA	GA as per cent of mean
1.	Days to 50% flowering.	48-78	71.57	72.57	1.00	12.95	13.04	98.60	17.30	26.49
2.	Plant height at flowering (cm).	40.73-124	448.23	562.81	114.58	24.11	27.02	79.60	38.90	44.30
3.	No. of branches/plant.	0-12	8.6	9.03	0.97	52.38	55.65	89.30	5.53	101.84
4.	No. of spikelets/plant.	22.2-79.8	155.04	188.89	33.85	24.01	26.50	82.10	23.24	44.82
5.	Length of inflorescence (cm).	34.07-67.07	36.55	53.94	17.39	12.23	14.86	67.80	10.36	20.95
6.	Girth of inflorescence (cm).	19.27-29.47	2.42	13.09	10.67	6.44	14.98	18.50	1.74	7.21
7.	Leaf area per plant (cm).	626.59-2129.08	104481.1	121205.7	16724.60	25.28	27.23	86.20	618.21	48.36
8.	Days to maturity	89-113.67	31.07	32.93	1.86	5.40	5.56	94.40	11.16	10.80
9.	Protein content (%)	8.75-15.17	2.67	2.88	0.21	14.17	14.71	92.90	3.25	28.14
10.	Grain yield per plant (g).	10.12-50.89	43.71	62.17	18.46	28.62	34.13	70.30	11.42	49.43

selection in these traits. Estimates of genotypic and phenotypic coefficients of variation were nearly equal in the case of days to 50% flowering, days to maturity and protein content indicating that the variability existing in these characters was due to genetic factors and there is less influence of environmental factors in the expression of these characters.

The heritability of the characters indicated that almost all characters under study had high heritability, except girth of inflorescence in which moderate heritability was observed. High estimates of heritability in broad sense accompanied with high genetic advance in percentage of mean (Table 1) was observed in characters like number of branches per plant, leaf area per plant, number of spikelets per plant, plant height at

flowering, grain yield per plant indicating that these traits are governed by additive gene action and selection for these traits in the genetically diversified material would be more effective for desired genetic improvement. Rangaswamy *et al.* (1980) also reported similar results.

In the present study considering the estimate of genetic parameters like genotypic coefficient of variation, heritability and genetic advance together, it is evident that number of branches per plant, leaf area per plant, grain yield per plant, plant height at flowering and number of spikelets per plant are the most important characters. Selection for these traits in the segregating generations could be more effective for improving grain yield in Amaranthus.

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Genetic Variability for Yield and Some Yield Attributing Traits in Greengram

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Greengram [*Vigna radiata* (L.) Wilczek] is one of the important grain legume crops in India. Breeding high yielding varieties of crop require information on the nature and magnitude of variability in the available material. Heritability estimates facilitate evaluation of hereditary and environmental effects in the total phenotypic variation. It is also useful in prediction of genetic advance under selection. Therefore, the present study was conducted to assess the extent of variability, heritability and genetic advance for seed yield and its components in greengram.

The materials for the present investigation consisted of 57 genotypes of greengram chosen out of a large collection of greengram germplasm maintained at Pulses Research Station, GAU, Junagadh (Gujarat). The trial was conducted in a randomized block design with 3 replications during summer 1995. Each entry was grown in a single-row plot of ten plants, spaced at 30 x 10 cm. Five competitive plants from each plot were

selected and observations were recorded on seed yield per plant (g), days to flowering, days to maturity, number of pods per plant, pod length (cm), number of seeds per pod, number of clusters per plant, number of branches per plant, plant height (cm) and 100-seed weight (g). Mean values were statistically analyzed for all the characters. Genetic coefficient of variation was calculated according to Burton (1951), heritability in broad sense (H) and genetic advance were computed according to the formula suggested by Allard (1960).

The analysis of variance highly significant differences among the genotypes for all the characters studied. It was observed that wide range of variability existed for various characters studied as evidenced by range (Table 1). The highest genotypic coefficient of variability (GCV) was observed for number of pods per plant (23.46%) followed by seed yield per plant (22.62%), number of branches per plant (21.91%), number of clusters per plant (21.38%) and plant height (16.54%). These characters also revealed high phenotypic coefficient of variation, heritability and high genetic advance expressed as percentage of mean (Table 1). High heritability coupled with high genetic advance as percentage of mean shows the most effective condition for selection and was observed for number of pods per plant, seed yield per plant, number of clusters per plant, number of branches per plant and plant

TABLE 1

Mean, range, coefficient of genotypic (GCV%) and phenotypic variation (PCV%) heritability (h^2_{BS}) and genetic advance as per cent of mean (GA).

Character	General mean	Range	GCV %	PCV %	h^2	GA
Seed yield per plant	5.68 $\pm$ 0.18	3.3 - 7.9	22.62	22.97	97.2	45.91
Days to 50 per cent flowering	42.50 $\pm$ 0.69	38.3 - 46.7	4.34	4.78	82.5	8.13
Days to maturity	67.97 $\pm$ 0.78	62.0 - 75.7	4.11	4.34	89.4	8.00
Numbers of pods per plant	15.57 $\pm$ 0.43	10.1 - 22.7	23.46	23.70	98.0	47.84
Pod length	6.52 $\pm$ 0.21	5.5 - 7.5	7.35	8.37	78.2	13.35
Number of seeds per pod	8.63 $\pm$ 0.41	6.8 - 9.5	6.20	8.46	53.6	9.38
Number of clusters per plant	4.18 $\pm$ 0.21	2.3 - 5.9	21.38	22.27	92.2	42.37
Number of branches per plant	2.46 $\pm$ 0.18	1.3 - 3.6	21.91	23.76	85.0	41.48
Plant height	37.83 $\pm$ 1.04	24.8 - 58.7	16.54	16.89	96.0	33.38
100-Seed weight	4.30 $\pm$ 0.18	3.5 - 5.1	10.15	11.39	79.4	18.58

height. This condition is due to additive nature of gene action. Paramasivam and Rajasekaran (1980) also reported high heritability with high genetic advance for number of pods per plant, seed yield per plant, number of clusters per plant, number of branches per plant and plant height. There are also few characters like days to flowering and days to maturity which showed high heritability but low genetic advance which is due to non-additive gene action (Liang and Walker, 1968). The lower

value of these parameter were reported by Patil *et al.* (1987) and Veerabadhiran and Jehangir (1995) for days to flowering, days to maturity, seeds per pod, pod length and 100-seed weight.

The study indicated that phenotypic selection for pods per plant, seed yield per plant, number of clusters per plant, number of branches per plant and plant height would be most effective.

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Response of Sissoo (*Dalbergia sissoo* Roxb.) Stem Cuttings to Prolonged Dip Method of Auxin Treatments

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Dalbergia sissoo Roxb., of Papilionaceae family is a deciduous tree with a light crown and somewhat crooked bole. It is extensively cultivated in Punjab, U. P., Bengal and Assam. It is planted and often self-sown throughout India. It is also planted on roadsides and as shadetree in tea plantations (Anon. 1952). Singh (1978) reported that sissoo is important species for irrigated plantations. Wild population and seed-raised trees are genetically heterozygous. This necessitates the development of suitable methodology for mass multiplication of the clonal material. Auxins are known to induce rooting in the cutting and promote root and shoot growth and survival percentage (Nanda *et al.* 1968). With a view to study the influence of different auxins on rooting of sissoo stem cuttings and subsequent growth, present investigation was carried out with different levels of IBA, IAA and NAA.

Studies were carried out at the Instructional Farm of Aspee College of Horticulture and Forestry, Gujarat Agricultural

University, Navsari during August to November of 1994. Stem cuttings were taken from 8-10 years old mother trees grown at the farm. Cuttings of uniform size (25 cm long and 3-4 cm girth) were collected from the outer portion of the crown of the mother tree. The basal ends of the prepared cuttings were kept in standing position in auxin solutions to a depth of 3.0 – 4.0 cm for a period of 24 hours under prolonged dip method. Three concentrations (100, 200 and 500 ppm) of Indol Butyric Acid (IBA). Indol Acetic Acid (IAA) and Napthalene Acetic Acid (NAA) were made along with control (Distilled water) for treatment. Ten cuttings of each treatment were planted in raised bed containing 2 : 1 : 1 soil, sand and well – rotted farm yard manure. Weeding was done regularly and watering was done when there was no rain.

Total treatments for each species were ten and were replicated three times in randomized block design. Observations were recorded on rooting percentage, number of roots per rooted cutting, length of the longest root, dry and fresh weight of roots per rooted cutting after 90 days of planting. Fifty per cent of the rooted cuttings were transplanted into a field and survival percentage was recorded after 28 days.

Perusal of the data (Table 1) indicated that among the three auxins tested, IBA at all the concentration levels was found superior as compared to NAA, IAA and control with regard

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TABLE 1

Effect of IBA, IAA and NAA on rooting behaviour root biomass and survival per cent of *Dalbergia sissoo* Roxb. stem cuttings.

Treatment details (ppm)	Rooting per cent	Length of longest root/ rooted cutting (cm)	Number of roots/rooted cuttings	Fresh weight of roots/ rooted cuttings (g)	Dry weight of roots/ rooted cuttings (g)	Survival per cent
IBA 100	86.66	33.41	20.97	1.22	0.43	65.55
200	70.00	25.05	18.55	0.75	0.27	58.33
500	46.66	14.48	15.90	0.36	0.15	44.44
IAA 100	80.00	20.75	24.36	0.91	0.32	53.33
200	60.00	18.70	19.24	0.45	0.17	49.99
500	46.66	13.21	16.36	0.33	0.14	33.33
NAA 100	73.33	19.61	16.52	0.69	0.25	50.00
200	50.00	17.41	12.55	0.42	0.16	47.22
500	40.00	11.80	12.16	0.22	0.09	33.33
Control	30.00	9.00	9.16	0.19	0.08	38.88
S. Em. $\pm$	7.74	3.14	1.65	0.04	0.018	4.03
C. D. at 5%	16.27	6.60	3.48	0.09	0.039	8.48

to rooting characters and survival percentage. The maximum 86.66 per cent rooting was recorded in IBA 100 ppm treatment. However, it was at par with IAA 100 ppm (80 per cent) and NAA 100 ppm (73.33 per cent) while only 30 per cent rooting was recorded in control.

Maximum length of longest root was recorded in IBA at 100 ppm (33.41 cm) followed by IBA at 200 ppm (25.05 cm). The effectiveness of IBA over other auxins for such character has been reported by Bala *et al.* (1969) in *Dalbergia sissoo* Negi and Tiwari (1984) in *Pongamia pinnata* and Nautiyal *et al.* (1992) in *Tectona grandis*. However, contradictory results were noted by Chauhan *et al.* (1993) in *Boerhavia platuphylla*. They observed that length of the longest root was maximum in control as compared to auxin treatments. But IBA, IAA and NAA were superior to control in respect of root length because auxins have tendency to increase cell elongation (Weaver, 1972) which is ultimately related to the number of roots per rooted cutting, length, fresh and dry matter content in the cuttings. The maximum number of roots (24.36 per rooted cutting) was recorded in IAA 100 ppm treatment followed by 20.97 in IBA 100 ppm over control (9.16). Similar trend was also reported by Shamet and Dhiman (1991) in *Grewia optiva*. It is now well established

fact that rooting of cuttings is controlled by exogenous auxins. It was also noted that auxins improve the quality of root systems. Root characters of cuttings were also evaluated in terms of their fresh and dry weight. The results revealed that IBA 100 ppm was superior in its effect on these characters as compared to other treatments.

In clonal propagation through stem cuttings the most pertinent aspect is the survival of rooted plants. There are many factors associated with survival of rooted plants viz., media in which rooted plants are planted, quality and quantity of roots. Shrinkage, growth, physiological status of the plant, climatic condition like humidity, temperature, rainfall, season etc. Among these the quality and quantity of roots on cuttings are the most important reasons for survival success of rooted plants. It is observed from the data presented in Table 1 that among the different concentrations of different auxins used in treating the cuttings with IBA 100 ppm gave maximum 65.55 per cent survival followed by 58.33 per cent in IBA 200 ppm treatment. These results are in conformity with the findings of Pal *et al.* (1993) in *Tylophora indica* and Ravichandran *et al.* (1994) in *Casuarina junghuhiana*.

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**Bioefficacy of Different Insecticides
Against Fruitfly *Carpomyia vesuviana*
Costa (*Tephritidae* : *Diptera*)**

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Ber (*Zizyphus mauritiana* Lamark) is one of the most ancient and common fruits of India, occupying an area of about 22,000 hectares. About 8 insect pests are listed on ber in India (Butani, 1979). Of these, fruitfly *Carpomyia vesuviana* Costa is of much significance, inflicting direct damage to fruits. In India, damage due to fruitfly has been reported as 16.6 per cent (Cv. Gola) in Rajasthan (Sachan, 1984), 80 per cent in Punjab (Batra, 1953) and 100 per cent in South India (Cherian and Sundaram, 1941). Pruthi and Batra (1960) also found fruitfly to be the most serious pest of ber in North-West India. Considering the importance of the pest in the region, a field trial was undertaken to find out effective and economical insecticide against the pest.

The experiment was laid out in Randomised Block Design with seven treatments and four replications at Central Cattle Breeding Farm, N. H. No. 8, Dhamrod, Dist. Surat from the year 1993-94 to 1995-96. Four ber trees (Cv. Gola, spacing : 6 x 6 m)

were allotted to each treatment considering one tree as one replication. In all, two sprays of different treatments was given i.e., first coinciding with peanut stage of the fruits when fruitfly infestation normally begins during December-January and second spray 15 days after first spray. For sampling, four branches were tagged one each from each direction per tree and fruits on them were observed for the incidence of fruitfly before and 7, 14, 21 and 28 days after spraying.

The fruits were categorized as damaged by the presence of either oviposition puncture specially during peanut stage or exit holes, maggot inside fruits mainly at fruit maturity. Hence, depending on size and stage of the fruits, all of the above parameters were considered for fruit infestation. As regard the yield, at each picking total fruits were harvested from each four tagged trees. Infested and healthy fruits were separated and weighed treatment-wise and finally yield of healthy fruits were determined on hectare basis. The data obtained on incidence of fruitfly and yield were subjected to statistical analysis. The economics of the treatments were also calculated.

Anova of pooled analysis of the data taken for three consecutive years (Table 1) indicated that all the insecticidal treatments were significantly superior over untreated control in reducing incidence of fruitfly. The per cent infestation of fruitfly was significantly lowest in the treatment of fenthion 0.1%

TABLE 1

Effectiveness and economics of different insecticides against ber fruitfly*.

Treatment and Concentration	Per cent fruits infested	Fruit yield (kg/ha)	Economics of the treatments						Realization over control	CBR
			Quantity of pesticide used for two sprays	Cost of insecticide	Total cost of plant protection	Gross realization	Net realization	Rs/ha		
			lit./ha	Rs/ha	Rs/ha	Rs/ha	Rs/ha	Rs/ha		
Neemark 0.1%	26.829 ^d (20.37)	1336.343 ^c	1.389	292.61	792.61	13363.43	12570.82	3952.76	1 : 4.99	
Malathion 0.07%	23.263 ^c (15.60)	1628.935 ^b	1.944	531.37	1031.37	16289.35	15257.98	6639.92	1 : 6.44	
Ethofenprox 0.015%	23.359 ^c (15.72)	1318.750 ^c	2.083	4277.11	4777.11	13187.50	8410.39	-207.67	1 : -0.04	
Quinalphos 0.5%	22.079 ^b (14.13)	1135.417 ^d	3.472	2002.16	2502.16	11354.17	8852.01	233.95	1 : 0.09	
Endosulfan 0.07%	21.982 ^b (14.01)	1257.176 ^c	2.778	863.01	1363.01	12571.76	11208.75	2590.69	1 : 1.90	
Fenthion 0.1%	19.480 ^a (11.12)	1797.917 ^a	1.389	1314.91	1814.91	17979.17	16164.26	7546.20	1 : 4.16	
Control (Water spray)	38.303 ^c (38.42)	911.806 ^c	—	—	500.00	9118.06	8618.06	—	—	
Mean	25.042 (17.92)	1340.906								

* Data based on three years study.

Note : 1. Figures in the parentheses are retransformed mean those outside are the $\text{Sin}^{-1} \sqrt{x}$ transformed mean.

2. Figures with same letter (s) are statistically at par in respective columns.

3. Quantity of spray fluid used : 5 lit. tree.

4. Price of marketable fruits (pooled) : Rs. 10/kg.

5. No. of labour employed per spray : 10.

6. Labour charge Rs. 2.5 per day (pooled).

(11.12). It was followed by endosulfan 0.07% and quinalphos 0.05%, which were comparable and significantly superior than remaining treatments. As regard the yield, the treatment of fenthion recorded highest healthy fruit yield (1797.917 kg/ha) among all. It was followed by malathion, neemark, ethofenprox, endosulfan and quinalphos. Considering economics of the treatment, malathion 0.07% ranked first (CBR 1 : 6.44) followed by neemark 0.1% (1 : 4.99), fenthion 0.1% (1 : 4.16) and endosulfan 0.07% (1 : 1.90).

Thus, based on the effectiveness and economics of application of insecticides two

sprays of any of the above treatments in order of preference can be taken advantage for the control of ber fruitfly. The performance of fenthion in present investigation is in confirmity with those of Patel *et al.*, (1990). Malathion is also reported effected against this pest (Singh *et al.*, 1973 Saxena, 1968, Lakra and Singh, 1981).

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Host Range of *Alternaria alternata* (Fr.) Keissler Causing Leaf Spot of Papaya

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Twelve different plant species belonging to various families commonly found in South Gujarat area (Table 1) were tested for their suitability as host of *A. alternata* during 1991.

The healthy respective test plants were raised under glass house conditions in pots

filled with autoclaved field soil. Plants were inoculated after 30 days of seedling by spraying the spore suspension of the fungus (125-150 conidia/100 x micro field). Inoculated plants were covered with polythene bags for 48 hrs. in order to create congenial conditions for infection. One set of each test plant was kept uninoculated as check. Final observations regarding symptom development were recorded 15 days after inoculation.

The results revealed that out of 12 plant species belonging to family Areceae, Cruciferae, Malvaceae, Solanaceae, Cucurbitaceae, Papilionaceae and Musaceae, *A. alternata* infected only 3 plant species viz.,

TABLE 1

Infection test of *Alternaria alternata* on different plants.

Sr. No.	Plant species	Family	<i>A. alternata</i>		Per cent infected
			No. of plant inoculated	No. of plant infected	
1.	Okra (<i>Hibiscus esculentus</i> L.)	Malvaceae	2	0	0
2.	Cabbage (<i>Brassica oleracea</i> Var. <i>capitata</i>)	Cruciferae	2	0	0
3.	Cauliflower (<i>Brassica oleracea</i> var. <i>cauliflora</i> L.)	Cruciferae	2	0	0
4.	Bottle gourd (<i>Lagenaria siseraria</i> (Mol.) <i>standi</i>)	Cucurbitaceae	2	2	100
5.	Cotton (<i>Gossypium herbaceum</i> L.)	Malvaceae	2	2	100
6.	Brinjal (<i>Solanum melongena</i> L.)	Solanaceae	2	2	100

1.	2.	3.	4.	5.	6.
7.	Tomato (<i>Lycopersicon esalantum</i> L. (Karst.))	Solanaceae	2	0	0
8.	Cluster bean or Guar (<i>Cyamopsis tetragonoloba</i> L.)	Papilionaceae	2	0	0
9.	Potato (<i>Solanum tuberosom</i> L.)	Solanaceae	2	0	0
10.	Pegion pea (<i>Cajanus cajan</i> L.)	Papilionaceae	2	0	0
11.	Banana (<i>Musa cavendishi</i> L.)	Musaceae	2	0	0
12.	Elephant's foot (<i>Amorphophalus campanulatus</i> Blume)	Araceae	2	0	0

bottle gourd, cotton and brinjal (Table 1). Fungus produced characteristic leaf spot symptoms similar to the spots observed on papaya after 15 days of inoculations. No symptoms were developed on rest of the plant species tested. Kapoor and Hingorani (1958) reported *A. tenuis* causing leaf spot and blight of brinjal. Madan and Chand (1986) reported bottle gourd as a host *A. alternata* while

cotton is also a known host of this fungus (Faulwetter, 1918; Presley, 1954; Patel *et al.* 1983 and Singh *et al.*, 1984). Thus, *A. alternata* can survive on cotton, brinjal and bottle gourd besides papaya. Brinjal and bottle gourd are grown round the year. Cotton is a long-season crop. Therefore, they harbour the pathogen as well as provide primary source of inoculam for other susceptible field crops.

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Biological Control of Stem Rot (*Sclerotium rolfsii*) of Groundnut*

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Stem, peg and pod rot of groundnut (*Arachis hypogaea* L.) caused by *Sclerotium rolfsii* is the major problem for groundnut production. Around five lakh hectare of land growing groundnut are infested with *S. rolfsii* Mehan (*et al.*, 1995). Mayee and Datar (1988) reported 25 per cent yield losses in groundnut pod due to this pathogen. In Gujarat, around 40,000 ha of area is estimated to be infested by *S. rolfsii* and account for economical losses of Rs. 20 crores.

The disease occurs regularly due to its seed and soil borne nature. It causes damage to the crop up to harvesting. Chemical control of this disease is not feasible. It is necessary to protect the plants during season using effective antagonistic micro organism. The attempt has been made to find out practical and feasible method of management of disease using biocontrol agent *Trichoderma harzianum* under field condition. *T. harzianum* was isolated from native soil and found effective against *S. rolfsii* under *in vitro*.

A field trial was conducted during kharif, from 1993-94 and 1994-95 at Agriculture College Farm, Junagadh. The cultivar GG-2 was used. The trial was laid out in RBD and each treatment replicated four times. The plot size was kept as 5.0 x 2.7 m and spacing 45 x 10 cm. The crop was grown adopting all recommended improved agricultural practices. Every year plots were inoculated with *S. rolfsii* multiplied on wheat grain (500 seeds/meter row). The 200 ml spore suspension of *T. harzianum* (1.38 CFU/ml) was incorporated in 500 g of different carrier viz., wheat husk, wheat coarse meal, Jowar coarse meal and maize coarse meal. These were applied in furrows separately before sowing the seeds. The proper check without application of *T. harzianum* was also maintained. The observations on stem rot incidence were recorded starting right from germination and continued up to harvesting. The data were statistically analysed using arcsine transformation.

The analysis of two year pooled data presented in Table 1 revealed that the suspension of *T. harzianum* (1.38 CFU/ml) with different carrier was found effective for the control of stem rot disease of groundnut. *T. harzianum* mixed with wheat husk (200 ml spore suspension in 500 g of carrier/13.5 sq.m.) and added in furrow before sowing consistently reduced the disease i.e. 28.48%

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TABLE 1

Effect of *T. harzianum* on stem rot and pod yield of groundnut.

Treatment	Disease incidence (%)		Pooled mean	Disease control (%)	Pod yield kg/ha		Pooled yield kg/ha	Yield increase (%)
	1993-94	1994-95			1993-94	1994-95		
Wheat husk 500 g + <i>T. harzianum</i> (1.38 x 10 CFU/ml) 200 ml/plot	19.70 (26.36)	16.40 (23.89)	18.05 (25.13)	24.98	1574	1417	1495	39.79
Wheat coarse meal 500 g + <i>T. harzianum</i>	20.19 (26.70)	21.41 (27.57)	20.80 (27.13)	22.79	1370	1296	1333	32.48
Maize coarse meal 50 g + <i>T. harzianum</i>	25.41 (30.38)	26.00 (30.66)	25.78 (30.52)	13.14	1111	1190	1150	21.73
Jowar coarse meal 500 g + <i>T. harzianum</i>	28.50 (32.27)	25.85 (30.56)	27.17 (31.42)	10.58	907	1204	1055	14.69
Check only <i>S. rolfii</i>	34.30 (35.85)	31.92 (34.41)	33.12 (35.14)	—	796	1005	900	—
C. D. at 5%	(2.10)	(1.46)	(1.66)	—	210	231	209	—

(Figures given in parenthesis are angular transformed value).

followed by wheat coarse meal i.e. 22.79% as compared to check. The yield of pod was also higher in treatment of wheat husk (1495 kg/ha) followed by wheat coarse meal (1333 kg/ha). Maiti and Sen (1985) have reported good

control of stem blight of groundnut with *T. harzianum* in wheat bran. The 30 to 75% control of stem rot and 17 to 47% more yield of groundnut was reported with *T. harzianum* by Asghari and Mayee (1991).

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