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Role of benzyladenine and gibberellic acid in alleviating water-stress effect in gram (*Cicer arietinum*)

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ABSTRACT

Two gram (*Cicer aerietinum* L.) genotypes, 'C 235' (susceptible) and 'RSG 143-1' (moderately tolerant to water stress), were grown in earthen pots. One set of plants were subjected to water stress only once (S_1) at 45 days after sowing and another set twice (S_2) at 45 and 80 days after sowing. Both the control (non-stress) and stressed plants were sprayed with benzyladenine and gibberellic acid separately at the time of imposing stress. Water stress increased the proline, amino acids and total soluble sugars but decreased the soluble proteins and starch content in the leaves. Spray of hormones stimulated accumulation of all these metabolites, especially under water stress in both the genotypes. Stress-induced increase in amino acids, particularly of proline and soluble sugars, might be responsible for osmotic adjustment. Spray of benzyladenine and gibberellic acid could alleviate adverse effect of water stress partly in both the genotypes especially in 'RSG 143-1'. Gibberellic acid was more effective in ameliorating water-stress effect than benzyladenine in both the genotypes.

Key words : gram, water stress, benzyladenine, gibberellic acid, osmoticum, *Cicer arietinum*

Water stress leads to accumulation of some organic substances (Joyce *et al.* 1992), including proline and reducing sugars in plants. It also influences functional properties of several enzymes, which are responsible for change in inorganic ions (Reddy and Veeranjaneyulu 1990). Plant growth-regulators possibly act as modulators of plant responses and have potential to increase crop production through redirecting the metabolism and partitioning of assimilates (Nowak and Lowson 1983). Information is lacking on modulation of biochemical processes by cytokinin and gibberellin under water stress of crop plants in contrasting genotypes. The present investigation was therefore undertaken to study the effect of benzyladenine and gibberellic acid on biochemical attributes of drought tolerance in 2 genotypes of gram (*Cicer arietinum* L.).

MATERIALS AND METHODS

Two genotypes, 'C 235' (susceptible to water stress) and 'RSG 143-1' (relatively tolerant to water stress), of gram were sown during winter season (*rabi*; November–March) of 1993–94 in earthen pots containing loamy sand with farmyard manure (5 : 1). The soil in the pots had *p*H 8.2, bulk density 1.48 g/cm^3, field capacity 11.8% and permanent wilting point 2.8%. One set of plants was subjected to water stress once (S_1) at 45 days after sowing and another to 2 cycles of stress (S_2), one at 45 and another at 80 days after sowing. Water stress was created by withholding water supply for 4–5 days before at the 2 stages. The control plants were kept at optimal soil moisture throughout. One-third pots were under the control and one-third under water stress were sprayed with benyzladenine (465 μM). Similarly, other one-third pots were sprayed with gibberellic acid (290 μM). The remaining pots without any hormone spray under non-stress and water stress were used as the control. Hormones were sprayed at the time of imposing water stress.

Plant leaves along with the twigs were collected at 45, 55 and 65 days after sowing from S_1 pots and from 80 days after sowing till 120 days at an interval of 10 days from S_2 pots for estimation of biomolecules. Methods described earlier were followed for estimation of free proline (Bates *et al.* 1973), amino acids (Yemm and Cocking 1955), protein (Lowry *et al.* 1951), total soluble sugars (Dubois *et al.* 1951) and insoluble sugars (Clegg 1956) in leaves. The experiment was conducted in 3 replications. One replication consisted of 2 pots and each pot maintained 2 plants. Data were analysed using complete randomized design.

RESULTS AND DISCUSSION

Water stress led to accumulation of proline in both the genotypes, but it was more in 'RSG 143-1' than in 'C 235' (Fig 1). This increase was further stimulated with

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Table 1 Effect of benzyladenine and gibberellic acid on amino acid content under non-stress and water stress in gram varieties

Variety	Treatment	Amino acid content (mg/g fresh weight) at different days after sowing							
		S_1			S_2				
		45	55	65	80	90	100	110	120
		Effect of benzyladenine							
'C 235'	NS	0.78	1.15	1.04	1.31	1.49	1.36	1.54	1.77
	NS + BA	+7.69	+10.43	+6.73	+9.92	+6.04	+11.03	+8.44	+3.95
	WS	+21.79	+23.48	+18.27	+22.14	+14.76	+13.97	+12.34	+9.04
	WS + BA	+33.33	+39.13	+31.73	+33.59	+20.80	+26.47	+17.53	+12.43
'RSG 143-1'	NS	0.62	0.85	0.79	0.87	1.04	1.19	1.32	1.43
	NS + BA	+4.84	+10.59	+6.33	+9.19	+13.46	+16.81	+11.36	+7.69
	WS	+20.97	+22.35	+18.99	+20.69	+26.92	+21.00	+23.48	+18.18
	WS + BA	+30.64	+38.82	+30.38	+34.48	+33.65	+32.77	+34.85	+23.08
SEm±		0.03	0.02	0.03	0.02	0.04	0.04	0.05	0.03
CD ($P = 0.05$)		0.10	0.07	0.08	0.07	0.12	0.13	0.14	0.10
CD ($P = 0.01$)		0.14	0.09	0.11	0.09	0.17	0.18	0.19	0.13
		Effect of gibberellic acid							
'C 235'	NS	0.78	1.15	1.04	1.31	1.49	1.36	1.54	1.77
	NS + GA	+11.54	+11.30	+3.85	+11.45	+3.35	+9.56	+3.90	+3.39
	WS	+21.80	+23.48	+18.27	+22.14	+14.76	+13.97	+12.34	+9.04
	WS + GA	+37.18	+46.09	+21.15	+29.00	+22.82	+21.32	+14.93	+9.60
'RSG 143-1'	NS	0.62	0.85	0.79	0.87	1.04	1.19	1.32	1.43
	NS + GA	+6.45	+14.12	+3.80	+13.79	+8.65	+8.40	+3.03	+4.19
	WS	+20.97	+22.35	+18.99	+20.69	+26.92	+21.00	+23.48	+17.48
	WS + GA	+33.87	+47.06	+23.32	+31.03	+31.73	+31.09	+37.88	+21.68
SEm±		0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03
CD ($P = 0.05$)		0.11	0.08	0.08	0.11	0.10	0.10	0.12	0.10
CD ($P = 0.01$)		0.15	0.11	0.10	0.15	0.14	0.13	0.17	0.14

S_1, First cycle of stress; S_2, second cycle of stress; NS, non-stress; WS, water stress, GA, gibberellic acid; BA, benzyladenine

The values with (+) or (–) indicate % increase or decrease respectively over the control (non-stressed)

Table 2 Effect of benzyladenine and gibberellic acid on protein content under non-stress and water stress in gram varieties

Variety	Treatment	Protein content (mg/g fresh weight) at different days after sowing							
		S_1			S_2				
		45	55	65	80	90	100	110	120
					Effect of benzyladenine				
'C235'	NS	64.26	65.79	61.59	59.81	61.69	62.28	60.79	54.51
	NS + BA	+3.50	+4.30	+1.93	+4.01	+3.37	+2.46	+2.43	+2.42
	WS	–18.83	–33.86	–33.19	–28.02	–21.15	–20.86	–30.88	–24.14
	WS + BA	–16.45	–29.12	–26.97	–26.10	–18.38	–18.61	–25.28	–19.88
'RSG 143-1'	NS	66.19	69.47	66.93	55.92	66.28	69.41	66.15	60.82
	NS + BA	+4.27	+4.40	+2.27	+5.72	+4.92	+1.66	+3.99	+6.38
	WS	–19.91	–31.02	–27.80	–25.12	–17.65	–32.11	–33.66	–29.63
	WS + BA	–16.66	–25.74	–25.20	–21.98	–16.44	–30.43	–31.20	–15.03
SEm±		0.19	0.23	0.27	0.23	0.22	0.23	0.29	0.36
CD (P = 0.05)		0.56	0.69	0.87	0.70	0.68	0.70	0.89	1.08
CD (P = 0.01)		0.78	0.95	0.14	0.97	0.93	0.97	1.21	1.51
					Effect of gibberellic acid				
'C 235'	NS	64.26	65.79	61.59	59.81	61.69	62.28	60.79	54.51
	NS + GA	+1.58	+3.33	+0.91	+2.89	+2.92	+3.84	+2.02	+1.28
	WS	–18.83	–33.86	–33.19	–28.02	–21.15	–20.85	–30.88	–24.14
	WS + GA	–17.75	–31.86	–28.22	–26.70	–20.49	–17.71	–28.31	–20.89
'RSG 143-1'	NS	66.19	69.47	66.93	55.92	66.28	69.41	66.15	60.82
	NS + GA	+3.16	+3.03	+1.64	+3.43	+2.78	+2.77	+1.89	+12.19
	WS	–19.91	–31.02	–27.80	–25.12	–17.65	–32.11	–33.67	–29.63
	WS + GA	–17.98	–27.72	–25.62	–23.12	–16.88	–28.67	–31.46	–27.51
SEm±		0.12	0.20	0.30	0.22	0.23	0.29	0.30	0.24
CD (P = 0.05)		0.35	0.60	0.91	0.65	0.69	0.88	0.91	0.71
CD (P = 0.01)		0.48	0.84	1.26	0.91	0.97	1.23	1.26	1.01

S_1, First cycle of stress; S_2, second cycle of stress; NS, non-stress; WS, water stress; GA, gibberellic acid; BA, benzyladenine

The values with (+) or (–) indicate % increase or decrease respectively over the control (non-stressed)

benzyladenine and gibberellic acid sprays, and was maximum in S_2 cycle in both the genotypes. The increase in proline was more due to benzyladenine than to gibberellic acid, but this effect was greater in 'C 235' (14%) than in 'RSG 143-1' (8%). The evidence linking changes in benzyladenine and gibberellic acid on accumulation of proline is tenous. Earlier studies have shown increase (Gu *et al.* 1984) as well as decrease (Singh *et al.* 1973) in proline. Benzyladenine and GA_3 increased the total soluble sugars and starch, which might have prevented proline oxidation and stimulated proline synthesis, leading to its accumulation. Such effect of carbohydrates on metabolism of proline was observed in kidney bean (*Phaseolus vulgaris* L.) (Stewart 1972) and barley (*Hordeum vulgare* L.) (Stewart 1978).

Water stress increased the total free amino acid content also in both the genotypes (Table 1); however, this increase was greater in 'RSG 143-1' than in 'C 235'. Both the hormones further stimulated the accumulation of amino acids

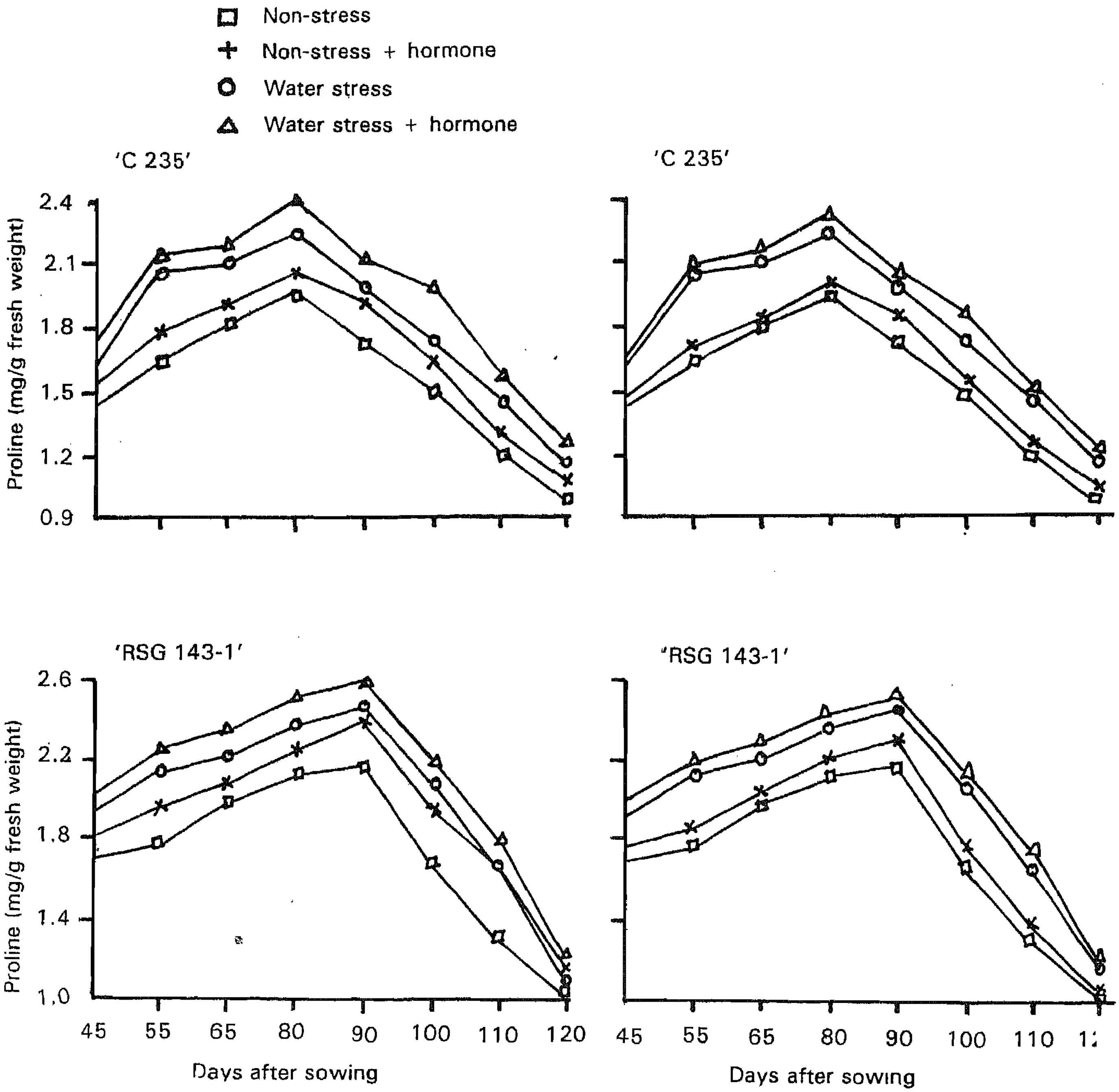

Fig 1 Effect of benzyladenine (BA) and gibberellic acid (GA_3) on proline under non-stress and water stress in gram varieties 'C 235' and 'RSG 143-1'

Table 3 Effect of benzyladenine and gibberellic acid on starch under non-stress and water stress in gram varieties

Variety	Treatment	Starch content (mg/g fresh weight) at different days after sowing							
		S_1			S_2				
		45	55	65	80	90	100	110	120
				Effect of benzyladenine					
'C 235'	NS	15.62	14.25	12.89	11.21	11.79	12.87	14.01	15.23
	NS + BA	+2.11	+4.49	+10.78	+28.72	+28.16	+21.13	+13.06	+5.19
	WS	–16.90	–17.75	–15.98	–7.40	–16.71	–22.13	–25.12	–26.00
	WS + BA	–15.75	–14.74	–8.20	–3.66	–0.25	–3.57	–7.92	–12.54
'RSG 143-1'	NS	16.15	18.14	16.39	16.04	16.48	12.29	17.98	18.72
	NS + BA	+2.23	+3.75	–23.85	+13.84	+12.50	+9.66	+8.95	+7.26
	WS	–12.57	–27.34	–24.00	–23.63	–32.95	–32.73	–33.15	–27.83
	WS + BA	–11.14	–25.52	–19.58	–17.21	–17.05	–17.23	–18.69	–20.14
SEm±		0.28	0.24	0.27	0.24	0.32	0.26	0.15	0.13
CD ($P = 0.05$)		0.84	0.73	0.82	0.74	0.96	0.78	0.46	0.40
CD ($P = 0.01$)		1.16	1.00	1.14	1.02	1.34	1.09	0.65	0.56
				Effect of gibberellic acid					
'C 235'	NS	15.62	14.25	12.89	11.21	11.79	12.87	14.01	15.23
	NS + GA	+4.86	+8.28	+9.00	+32.20	+31.55	+24.40	+16.63	+9.42
	WS	–16.90	–17.75	–15.98	–7.40	–16.71	–21.13	–25.12	–26.24
	WS + GA	–15.56	–14.74	–12.49	+3.66	+1.70	–1.40	–7.07	–10.67
'RSG 143-1'	NS	16.15	18.14	16.39	16.04	16.48	12.29	17.98	18.72
	NS + GA	+3.84	+4.46	+5.92	+13.84	+12.50	+10.58	+9.96	+10.90
	WS	–12.57	–27.34	–24.40	–23.63	–32.95	–32.73	–32.87	–27.83
	WS + GA	–10.28	–23.65	–20.56	–15.27	–14.99	–15.44	–16.07	–17.84
SEm±		0.37	0.31	0.18	0.21	0.30	0.28	0.16	0.13
CD ($P = 0.05$)		1.11	0.93	0.55	0.65	0.90	0.84	0.47	0.40
CD ($P = 0.01$)		1.54	1.30	0.77	0.90	1.25	1.17	0.65	0.55

S_1, First cycle of stress; S_2, second cycle of stress; NS, non-stress; WS, water stress; GA, gibberellic acid; BA, benzyladenine

The values with (+) or (–) indicate % increase or decrease respectively over the control (non-stressed)

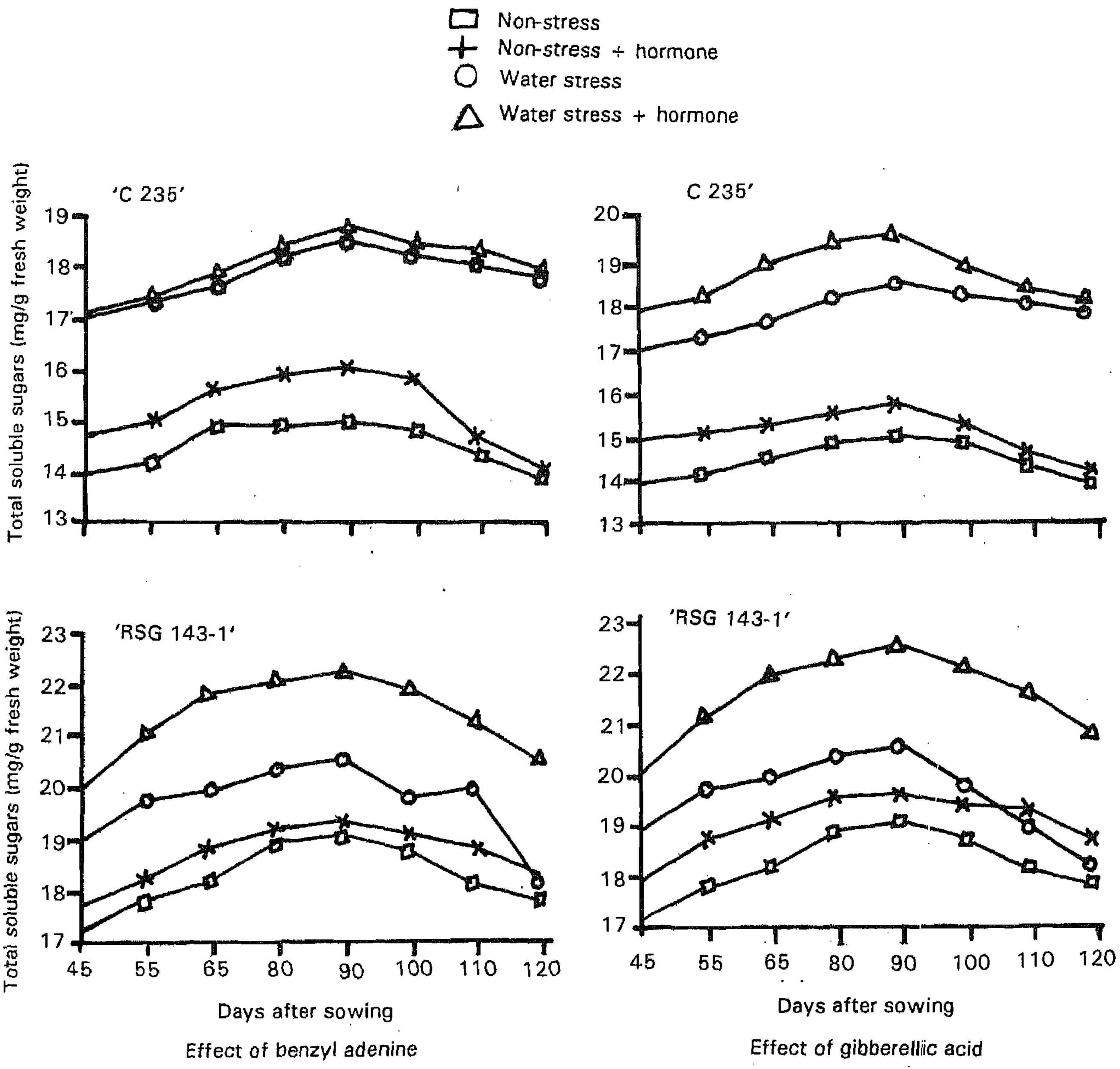

Fig 2 Effect of benzyladenine (BA) and gibberllic acid (GA_3) on total soluble sugars (TSS) under non-stress and water stress in gram varieties 'C 235' and 'RSG 143-1'

under water stress and the increase was more with gibberellic acid than with benzyladenine. The increase due to water stress and the hormone in amino acids was highest in S_1 cycle. Genotype 'C 235' responded equally to both the hormones, whereas 'RSG 143-1 responded more to GA_3 than to benzyladenine. This increase in free amino acids seems mainly due to proline accumulation. Gu *et al.* (1984) reported increase in amino acids on applying cytokinins to wheat (*Tritium aestivum* L. emend. Fiori & Paol.) coleoptile.

Soluble proteins and starch content decreased due to water stress in both the genotypes (Tables 2,3). This decrease was highest in S_1 cycle, ie early growth stages in both the genotypes. Spray of the hormones could reduce the decrease in starch and protein. The increase in protein was more due to the benzyladenine and in genotype 'C 235' than in 'RSG 143-1' in S_1 cycle. But the increase in starch was more due to gibberellic acid, and in genotype 'RSG 143-1' compared with 'C 235' in the S_2 cycle. But increase in starch was more due to gibberellic acid and in genotype 'RSG 143-1' than 'C 235' in S_2 cycle. Khalil and Mandurach (1990) made similiar observation in cowpea [*Vigna unguiculata* (L.) Walp.].

Both the gram genotypes recorded increase in total soluble sugars due to water stress (Fig 2). Singh (1993) made similar observations in gram or chickpea. Spray of benzyladenine and gibberellic acid further stimulated the accumulation of soluble sugars under water stress in both the genotypes. The accumulation was more with gibberellic acid than with benzyladenine, and in 'RSG 143-1' than in 'C 235' in the S_2 cycle. There are reports of increase in soluble sugars in zeatin-treated wheat coleoptile (Rayle *et al.* 1982) and GA_3-treated pea (*Pisum sativum* L. var *arvense* Poir.) (Rao 1973).

Accumulation of total soluble sugar and starch with spray of these hormones indicates increase in the photosynthesis. This is further substantiated by increased water potential and decrease in diffusive resistance (increased stomatal conductance) with spray of these hormones under water stress (unpublished data). The present investigation showed increase in total soluble sugars and decrease in starch content under water stress without hormone spray in both the genotypes. This is possibly due to stress-induced conversion of starch into soluble sugars, which also serve as osmoticum (Gu *et al.* 1984), in addition to free amino acids including proline.

It was concluded that adverse effect of water stress is manifested at early stages in 'C 235' (55 days after sowing) and at later stages (90–110 days after sowing) in 'RSG 143-1'. Both the hormones could decrease or ameliorate the adverse effect of water stress; however, gibberellic acid was more effective than benzyladenine and the genotype 'RSG 143-1' more than 'C 235'.

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Influence of neem oil-coated urea and maxican lilac (*Gliricidia sepium*) as green-manure on transformation of soil nitrogen in rice (*Oriza sativa*)–wheat (*Triticum aestivum*) system in Typic Hapluestert

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ABSTRACT

A study was carried out to evaluate the influence of neem oil-coated urea and green-manure on N-use efficiency and transformation of organic fractions of soil nitrogen and their residual effect under rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system in Vertisol. Application of neem oil-coated urea and lac-coated urea increased the grain yield of rice respectively by nearly 15 and 16%, with a residual effect of 41 and 48% compared with prilled urea. Incorporation of green-manure through mexican lilac (*Gliricidia sepium* L.) also increased the grain yield of both the crops. The coating of neem oil on urea increased the N-use efficiency by 13.8%. Application of N through neem oil-coated urea and lac-coated urea and the incorporation of green-manure to rice increased the total hydrolyzable N, amino acid N, amino sugar N, hydrolyzable ammonia N, hydrolyzable unidentified N and non-hydrolyzable N. Their application after wheat reduced the amino acid N, amino sugar N and hydrolyzable ammonia N, but their level was more than under prilled urea and the initial level. Incorporation of mexical lilac increased the hydrolyzable unidentified N after rice as well as wheat. Correlation studies between different fractions of organic N and yield and the uptake of rice and wheat indicated that total hydrolyzable N, amino sugar N, hydrolyzable ammonia N and amino acid N are the active components of the available pool of nitrogen in the plant.

Key words : N transformation, neem oil-coated urea, green-manure, rice–wheat system, *Oryza sativa, Triticum aestivum*

The extent of removal of nutrients from the soil is considerably larger than the quantity added through fertilizers, which has resulted in net negative balance not only of nitrogen but of all other plant nutrients. This has led to decline in the productivity levels of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system. The gap between demand and supply of N has widened in the last decade and recycling of organic materials offers an alternative source of N to meet its requirement for crops and to bridge the future nutrient gap. The negative balance of nitrogen is due to addition of fertilizer N in low quantity and poor utilization efficiency of fertilizer N, due to its loss through volatilization, leaching and denitrification. The modification of urea by coating neem oil checks the volatilization loss (Singh *et al.* 1996) and the incorporation of leaf of mexican lilac (*Gliricidia sepium* L.) as green-manure also helps in retention of applied N in addition to its transformation into more resistant material like hydrolyzable unidentified and non-hydrolyzable organic N (Pathak and Sarkar 1995) to supplement nitrogen to the crop as well as to increase the efficiency of applied fertilizer. Therefore a study was conducted to evaluate the influence of coating neem oil on urea on the N-use efficiency and of green-manure on transformation of organic fraction of the soil in rice–wheat system in a Typic Hapluestert.

[1] Senior Scientist, [2] Director

MATERIALS AND METHODS

A pot study was conducted during 1993–94 using surface soil (0–0.15 m) collected from Islamnagar soil series (Typic Hapluestert). The processed soil was passed through 2 mm sieve, and 4.6 kg soil was filled in 7 kg capacity plastic pot. The soil is clayey, with *p*H 8.1 (1 : 2; soil : water), electrical conductivity 1.18 dS/m, organic carbon 4.5 g/kg, available P 7 ppm, $CaCO_3$ 2.12%.

The treatments comprised the control (T_1) and 100 ppm N through prilled urea (T_2), neem oil-coated urea (T_3) and lac-coated urea (T_4); and 4 levels of green-manure through mexican lilac leaves, viz the control (G_1), 5 tonnes (G_2), 10 tonnes (G_3) and 15 tonnes/ha (G_4); superimposed in triplicates in a completely randomized block design. Thus total 48 pots were prepared. The green leaves of *Gliricidia sepium* were chopped to 5–10 cm before incorporating into the soil. All the pots received P, K and Zn basal @ 30, 40 and 5 ppm respectively, through single superphosphate, muriate of potash and zinc sulphate before puddling. Three seedlings of 'Kranti' rice at 21 days were transplanted and were removed after a week. Two plants were grown till maturity. After harvesting rice, wheat were sown and grown up to 60 days. Dry-matter yield of wheat was recorded. Grain and straw samples of rice and plant samples of wheat were analysed for nitrogen and soil samples after rice as well as wheat were fractionated for inorganic (N_1), amino acid (N_2), amino sugar (N_3), hydrolyzable ammoniacal (N_4), hydrolyzable unidentified (N_5), total hydrolyzable (N_6) and total (N_7) nitrogen, using the procedure outlined by Bremner (1965).

RESULTS AND DISCUSSION

Influence of neem oil coating and green-manure

Grain and straw yields of rice and dry matter of wheat: Modification of urea by coating with neem oil and lac increased the grain yield of rice and dry matter of wheat significantly in comparison with urea (Table 1). Coating of neem oil increased the grain yield of rice by 15.46% and dry matter of subsequent wheat from 10.8 to 15.3 g/pot (41.6%), which was statistically at par with lac-coated urea. Similar effect of neem oil coating was also seen on straw yield of rice. Incorporation of green-manure @ 5, 10 and 15 tonnes/ha also increased the grain yield of rice by 25.7, 49.0 and 67.5% and dry-matter yield of wheat by 25.5, 74.0 and 114% respectively in comparison with the control.

N uptake and use efficiency : Coating of neem oil and lac significantly increased the uptake of N by rice 17.1 and 18.85% and by wheat 39.9 and 40% respectively in comparison with prilled urea (Table 2). Coating of neem oil increased the N-use efficiency of prilled urea by 13.8% and residual effect by 46%, which was statistically at par with lac-coated urea. In the subsequent wheat crop 39.8% higher recovery of N was recorded in the treatment receiving neem oil-coated urea and lac-coated urea in comparison with urea.

The increase in grain yield of rice on application of neem oil-coated urea is due to slow release rate of urea from granule. The coating of neem oil acted as physical barrier between urea granule and soil solution, which reduced the solubilization of urea and the plant had longer time to utilize the N, which resulted in higher growth. Neem oil coating reduced the concentration of NH_4^+ in soil water by reducing the release rate, which led to significant reduction of volatilization loss (Singh *et al.* 1996).

NH_4 concentration : Ammonium-ion concentration in flood water increased from 1 mg to 18 mg/litre at 4 days after application, and thereafter declined sharply on sixth day and reached below 2 ppm at ninth day in pot receiving the N through prilled urea; whereas in neem oil-coated urea and lac-coated urea the increase in ammonium ion was also recorded but with a very slow rate (Fig 1). The sudden increase in NH_4 ion in prilled urea treatment was possibly due to rapid hydrolysis of urea, which required 48–72 hr (Patnaik *et al.* 1966), and sharp decline in concentration of

Table 1 Grain and straw yields of rice as affected by green-manure of mexican lilac and modifed urea materials and their residual effect on wheat

Treatment	Green-manure (tonnes/ha)				
	G_1	G_2	G_3	G_4	Mean
			Rice grain (g/pot)		
T_1	6.4	10.8	15.4	20.6	13.3
T_2	16.7	21.4	25.6	27.2	22.7
T_3	20.7	25.6	28.5	30.2	26.2
T_4	21.4	24.5	27.8	31.4	26.3
Mean	16.3	20.5	24.3	27.3	
			Rice straw (g/pot)		
T_1	11.5	19.4	27.7	37.1	23.9
T_2	31.7	40.6	48.6	51.2	43.0
T_3	39.3	48.6	59.2	57.2	49.8
T_4	42.0	49.0	55.6	62.8	52.6
Mean	31.3	39.4	46.5	52.2	
			Wheat (g/pot)		
T_1	5.6	7.2	11.5	13.6	9.2
T_2	6.6	9.8	12.5	15.6	10.8
T_3	10.5	13.5	17.8	20.6	15.3
T_4	11.8	12.5	18.2	22.5	16.0
CD (P=0.05)					
		Materials (M)		*Green-manure (GM)*	*M × GM*
Rice grain		2.8		3.1	1.8
Rice straw		3.9		4.5	2.8
Wheat dry matter		2.2		2.3	1.6

Details of treatments are given under Materials and Methods

Table 2 Influence of application of modified urea and green-manure of *Gliricidia sepium* on N uptake and utilizations efficiency in rice and residual effect on wheat

Factor	Rice		Rice	
	N uptake (mg/pot)	N-use efficiency (%)	N uptake (mg/pot)	Residual effect (%)
Treatment				
T_1	178.6		143	
T_2	374.9	42.8	168	18.3
T_3	439.2	56.6	235	64.3
T_4	445.6	58.0	235	65.5
CD (P=0.05)	21.8	2.1	12	
Urea materials				
G_1	189.9		142.3	
G_2	350.1		168.5	18.3
G_3	409.9		234.0	64.4
G_4	435.3		282.3	98.4
CD (P=0.05)	12.0		14.0	

Details of treatments are given under Materials and Methods.

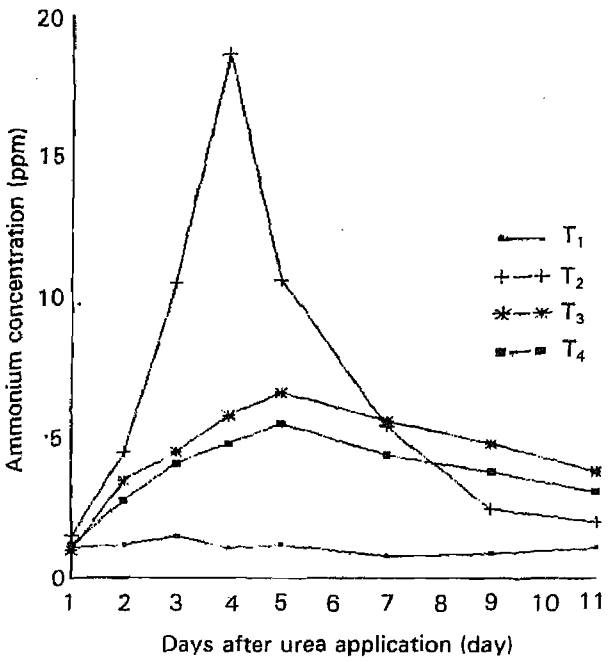

Fig 1 Ammonium-ion concentration (ppm) in flood water as influenced by urea materials

ammonium ion due to loss of ammonia from the system to the atmosphere, as recorded by Fillery *et al.* (1986) and Chauhan and Misra (1989). The slow and steady increase in ammonium ion in the pot receiving N through neem oil-coated urea and lac-coated urea is due to their slow release nature, as both lac and neem oil are immiscible in water and form a layer around the granule and act as physical barrier between urea granule and water, leading to reduction in release of urea-N from granule. Neem oil not only controls the rate of release but also inhibits the nitrification (Vyas *et al.* 1991), which ruled out the possibility of denitrification loss of N from oxidized layer in rice culture. The coating of neem oil on urea does not allow build-up of concentration of ammonium ion in water and reduces the volatilization loss (Singh *et al.* 1996). Coating of neem oil and lac helped maintain ammonium ion in water below a threshold value of volatilization, which reduced the possibility of volatilization; as a result the plants get long period to utilize N from the supplied fertilizer.

Transformation of soil organic N

After harvesting rice, there was increase in all organic fractions of N in the pots receiving fertilizer N irrespective of the source of nitrogen, but the increase was larger in the treatment receiving N through neem oil-coated urea and lac-coated urea compared with prilled urea. The incorporation of green-manure also increased the total N, total hydrolyzable, amino sugar, amino acid and hydrolyzable ammonia N compared with the control (Table 3). Incorporation of green-manure increased the hydrolyzable unidentified N after harvesting rice as well as wheat, indicating that application of green-manure induced transformation of applied nitrogen into resistant material that may be available during the stress condition. After harvesting wheat, 17.37 and 18% reduction was noted in amino sugar, amino acid and hydrolyzable ammoniacal N from their respective status at rice harvest, indicating that wheat received nitrogen from these fractions. An increase in hydrolyzable unidentified N after harvesting rice as well as wheat indicates that it may be due to partial transformation of amino sugar and acid and hydrolyzable ammoniacal N into hydrolyzable unidentified N due to biological decomposition of native and added organic fractions (Table 3). Jain and Sarkar (1984) and Pathak and Sarkar (1995) reported that subsequent wheat derived most of its nitrogen from these organic fractions of nitrogen and incorporation of green-manure increased the non-hydrolyzable fractions of N considerably in rice–wheat system.

The simple linear correlation coefficients (Table 4) of grain yield of rice and dry matter of wheat and their uptake with organic fractions of N, viz total hydrolyzable, amino sugar, amino acid and inorganic nitrogen, were positively correlated. However, a negative correlation of rice grain and dry-matter yield of wheat was found with hydrolyzable unidentified N and non-hydrloyzable N. This finding confirms that of Pathak and Sarkar (1995). It indicates that the coating of neem oil and lac on urea and incorporation of green-manure played an important role in transformation of soil organic fractions. The study also revealed that in rice–wheat system the application of neem oil and lac-coated urea not only increased the utilization of fertilizer N by reducing the volatilization loss but also conserved the soil N in different fractions. Incorporation of *Gliricidia sepium* as green-manure increased the hydrolyzable unidentified fraction of soil nitrogen, which may help in sustaining the health and productivity of the soil.

Table 3 Organic and inorganic fractions of soil N (kg/ha) as affected by application of modified urea and green-manure (*Gliricidia sepium*) after wheat

Treatment	N_1	N_2	N_3	N_4	N_5	N_6	N_7
Initial	25	78	78	154	275	615	902
				After rice			
T_1	12	68	62	135	265	530	872
T_2	21	125	90	175	234	624	930
T_3	27	145	108	185	236	674	960
T_4	28	160	112	178	226	676	960
CD (P=0.05)	5	12	9	16		32	42
G_1	14	55	70	142	341	585	905
G_2	20	145	90	165	329	729	925
G_3	32	168	118	195	304	785	972
G_4	38	188	128	220	329	865	968
CD (P=0.05)	7	14	11	18		41	43
				After wheat			
T_1	10	52	45	125	298	520	860
T_2	15	102	52	125	331	625	907
T_3	25	131	58	145	327	661	928
T_4	26	135	62	151	316	664	920
CD (P=0.05)	4	8	6	9		29	NS
G_1	12	45	48	130	343	566	890
G_2	18	107	57	135	366	665	905
G_3	30	135	68	145	322	726	928
G_4	35	145	85	178	378	745	925
CD (P=0.05)	NS	6	5	14	NS	31	NS

Details of treatments are given under Materials and Methods

Table 4 Relationship of soil-N fractions with grain yield and N uptake of rice and dry-matter yield of wheat

Soil fraction	Grain yield (rice)	Dry matter (wheat)	N uptake	
			Rice	Wheat
Total N	0.94**	0.98**	0.75**	0.76**
Inorganic N	0.88**	0.99**	0.71*	0.74*
Total hydrolyzable N	0.96**	0.96**	0.89**	0.95**
Hydrolyzable NH_4 - N	0.92**	0.97**	0.91**	0.81**
Amino sugar N	0.63*	0.95**	0.53*	0.81**
Amino acid N	0.67*	0.97**	0.61*	0.82**
Hydrolyzable unidentified N	–0.98**	–0.15	0.15	–0.15
Non-hydrolyzable N	–0.28	–0.28	–0.29	–0.34

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Computing fertilizer N dose for rice (*Oryza sativa*) and wheat (*Triticum aestivum*) for high yield and profit

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ABSTRACT

A long-term field experiment was conducted at university farm, Ludhiana, for 4 years (1988–92) with rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) in rotation with 20 fertilizer treatments. These treatments comprised 5 levels of N, 4 levels of P and 3 levels of K with and without addition of farmyard manure (in addition to 4 control plots) in 4 artificially created fertility strips of a uniform field. Both rice and wheat responded significantly to N application. The yield response, value of the additional produce over preceding N level, profit/ha and rate of marginal response declined sharply with increase in fertilizer N level. Similarly, marginal rate of return also declined sharply with increase in fertilizer N dose. Considering the marginal rate of return of Rs 2.50 or more for each rupee spent on fertilizer N as optimum, fertilizer N dose was worked out to be 125 and 100 kg N/ha in rice and 125 kg N/ha in wheat without and with farmyard manure respectively. Addition of farmyard manure raised the production potential of both rice and wheat and saved about 25 kg N/ha in rice.

Key words : farmyard manure, fertilizer N, yield response, economics, rice, *Oryza sativa*, wheat, *Triticum aestivum*

Indian soils are generally deficient in available N (Sekhon and Singh 1987), and thus all cereal crops including rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) show significant response to applied N. Farmers usually add both chemical fertilizers (for N, preferably urea) and organic manures (mainly farmyard manure) to maintain soil productivity. Due to the high costs of chemical fertilizer nitrogen, there may be need to adjust fertilizer N dose taking into consideration the contribution from added farmyard manure. In the present investigation an effort was made to study the response and economics of fertilizer-N use in rice and wheat grown in rotation with and without addition of farmyard manure and fertilizer calibrations made for high yield and profit.

MATERIALS AND METHODS

A long-term field experiment was conducted on the university farm at Ludhiana in a Typic Ustochrept to study the effect of graded levels of fertilizer nitrogen in the presence or absence of farmyard manure on grain yield of rice and wheat grown in rotation for 4 years (1988–92). The surface soil (0–0. 15 m) was sandy loam with *p*H 8.3, electrical conductivity 0.3 dS/m and low in available nutrients ($KMnO_4$-N 100 kg/ha, Olsen's P 10.4 kg/ha and 1N NH_4OAc-K 107 kg/ha).

In a uniform field with same cropping history, 4 adjacent fertility strips were created by applying differential amounts of farmyard manure, N (as urea), P (as single superphosphate) and K (as muriate of potash). In fertility strip I, no organic or inorganic fertilizers were added. In fertility strip II, 10 tonnes/ha farmyard manure, 50 kg N/ha, 52 kg P/ha and 70 kg K/ha were added. Likewise, in fertility strips III and IV, farmyard manure and fertilizer doses applied were 2 and 4 times respectively compared with that in fertility strip II. The field was given 3 wetting and drying cycles by ploughing and irrigation to stabilize the treatment effects. A non-experimental crop of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] for fodder was raised and harvested at 60 days of growth. Thereafter each fertility strip was further subdivided into 24 plots, to receive selected 20 fertilizer treatments, comprising 5 levels of N (0, 50, 100, 150 and 200 kg N/ha), 4 levels of P (0, 22, 44 and 66 kg P/ha) and 3 levels of K (0, 42.5 and 85.0 kg K/ha), keeping 4 plots untreated (the control). Lay-out of the experiment was planned in a partial factorial randomized block design. The yield data of rice and wheat were recorded from plots receiving 5 graded doses of N, viz 0, 50, 100, 150 and 200 kg N/ha as urea, along with a basal dose of 22 kg P/ha and 42.5 kg K/ha without or with farmyard manure applied @ 9.0 tonnes/ha before transplanting rice, and its residual effect was studied in wheat for 4 years. The crops were raised to maturity as per package of practices and grain yield was recorded plot-wise.

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Pre-sowing soil analysis showed that the samples drawn from each plot tested low (< 250 kg $KMnO_4$-N/ha) in available N (Subbiah and Asija 1956) every year, both before transplanting rice in July and seeding wheat in November in manured as well as unmanured plots. Soil-test values for available N were, however, slightly higher in manured plots compared with unmanured plots. Therefore the data on grain yield of wheat and rice for fertility strips were pooled for statistical analysis.

RESULTS AND DISCUSSION

Yield response of rice

Grain yield of rice showed significant response to applied N both in manured and unmanured plots in all the years of experimentation and the nature of response was curvilinear (Fig 1). In unmanured plots, grain yield increased from 3 580 kg/ha in the control to 5 770 kg/ha with an application of 150 kg N/ha in 1988. Similarly, this increase in grain yield was from 4 340 to 6 570 kg/ha in 1989, 5 920 to 9 050 kg/ha in 1990 and from 6 080 to 8 750 kg/ha in 1991 with an application of 100 kg N/ha. In manured plots, grain yield increased from 4 000 kg/ha in the control to 6 280 kg/ha with 200 kg N/ha in 1988. Similarly, this increase in grain yield was from 5 570 to 8 410 kg/ha in 1989, from 6 540 to 9 610 kg/ha in 1990 and from 6 760 to 9 220 kg/ha in 1991 with 150 kg N/ha.

Fitting of these data on grain yield of rice for 4 years into a quadratic equation led to the following relationships:

$$Y_1 = 5051^{**} + 40.70\ FN^{**} - 0.145\ FN^{2**} \quad (R^2 = 0.805^{**}) \qquad ...(1)$$

$$Y_2 = 7468^{**} + 43.36\ FN^{**} - 0.155\ FN^{2**} \quad (R^2 = 0.698^{**}) \qquad ...(2)$$

where Y_1 and Y_2, grain yields (kg/ha) in unmanured and manured plots respectively; and FN, fertilizer N dose (kg/ha).

The rice yield in the control plots increased with the application of farmyard manure from 5 051 to 7 468 kg/ha, indicating beneficial effect of manure on rice-grain yield. Further, fertilizer N dose for obtaining maximum yield in farmyard manure plots was lower (108 kg N/ha) in comparison with that of 140 kg N/ha, where no farmyard manure was applied, leading to economy of fertilizer N use by farmyard manure in rice. Gill and Meelu (1982), Dev *et al.* (1984) and Maskina *et al.* (1988 a, b) also reported similar results.

Using Eq 1, expected grain yield of rice at various fertilizer N levels without farmyard manure addition was 5 051, 5 979, 6 726, 7 291, 7 676, 7 879, 7 741 and 7 740 kg/ha in comparison with fertilizer N application @ 0, 25, 50, 75, 100, 125, 150 and 175 kg N/ha respectively (Table 1). The response yardstick applied to N was 37.1, 29.9, 22.6, 15.4, 18.2 and 0.88 kg rice grain per kg applied N at 25, 50 75, 100, 125 and 150 kg/ha respectively. It indicates that the magnitude of marginal response with successive levels of applied N declined sharply and there was no increase in yield with addition of fertilizer N after 150 kg N/ha. The value of additional produce per hectare over the preceding level declined from Rs 3 340 with 25 kg N/ha to Rs 317 with 150 kg N/ha. Similarly, marginal net return in rupees per rupee spent on fertilizer N also declined sharply from 18.55 to 1.76.

Similarly, using Eq 2, expected grain yield of rice at various levels of applied N in the presence of farmyard manure was 7 468, 8 211, 8 760, 9 115, 9 277, 9 239, 9 020, 8 600 and 7 988 kg/ha with application of fertilizer N @ 0, 25, 50, 75, 100, 125, 150, 175 and 200 kg/ha respectively. The marginal response to applied N (kg per kg applied N) compared with the preceding N level was 29.7, 21.9, 14.2 and 6.5 at 25, 50, 75 and 100 kg N/ha respectively. This result indicated that the magnitude of marginal increase with applied N declined sharply with successive levels of applied N and it was negligible after application of 100 kg N/ha. Similarly, the marginal response to per kg applied N decreased sharply with successive levels of N. The value of additional produce obtained with fertilizer N also declined from Rs 2 675 /ha at 25 kg N/ha to Rs 583 at 100 kg N/ha, and thus the marginal net return in Rs per Re spent on fertilizer N decreased from 14.87 to 3.24. The result showed that N application at relatively lower level gave comparatively high marginal return, and it becomes negligible for N application beyond 100 kg/ha in farmyard manure-treated plots.

Yield response of wheat

Grain yield of wheat showed significant response to applied N in all the years of experimentation and the nature of response was curvilinear (Fig 1). Grain yield increased from 1 390 kg/ha in the control to 5 090 kg/ha in 1988–89, from 1 620 to 5 030 kg/ha in 1989–90 and 1 700 to 4 400 kg/ha in 1990–91 with application of 150 kg/ha in the unmanured plots. However, this increase in grain yield was from 1 930 to 5 330 kg/ha in 1991–92 at 200 kg N/ha. In manured plots the grain yield of wheat increased from 2 680 kg/ha in the control to 5 830 kg/ha in 1988–89, from 2 160 to 5 440 kg/ha in 1989–90, from 2 360 to 4 720 kg/ha in 1990–91 with 150 kg N/ha and from 2 660 to 5 850 kg/ha in 1991–92 with 200 kg N/ha, showing the beneficial effect of farmyard manure application to the preceding rice crop.

These data on yield of wheat for 4 years fitted into a quadratic equation gave the relationships :

$$Y_1 = 1\ 844^{**} + 33.2\ FN^{**} - 0.103\ FN^{2**} \quad (R^2 = 0.801^{**}) \qquad ...(3)$$

$$Y_2 = 2\ 424^{**} + 38.6\ FN^{**} - 0.190\ FN^{2**} \quad (R^2 = 0.747^{**}) \qquad ...(4)$$

where Y_1 and Y_2, grain yields (kg/ha) in unmanured and manured plots respectively; and FN, fertilizer N dose (kg/ha).

The wheat-grain yield in control plots increased with residual effect of farmyard manure applied to the previous

Table 1 Profitability of fertilizer N use in rice

Treatment	Expected yield	Marginal increase over preceding N level			Marginal rate of return***
		Yield response (kg/ha)	Marginal rate of response*	Value of additional produce** (Rs/ha)	
			Without farmyard manure		
N (kg/ha)					
0	5 051				
25	5 979	928	37.1	3 340	18.55
50	6 726	747	29.9	2 689	14.94
75	7 291	565	26.6	2 034	11.30
100	7 676	385	15.4	1 386	7.70
125	7 879	203	8.1	731	4.06
150	7 901	22	0.88	317	1.76
175	7 741				
			With farmyard manure		
0	7 468				
25	8 211	743	29.7	2 675	14.87
50	8 760	549	21.9	1 976	10.98
75	9 115	355	14.2	1 278	7.10
100	9 277	162	6.5	583	3.24
125	9 239				

* kg grain/kg applied N; ** price urea N Rs 7.20/kg, rice grain Rs 3.60/kg; ***Rs/Re spent on fertilizer N

Table 2 Profitability of fertilizer N use in wheat

Treatment	Expected yield	Marginal increase over preceding N level			Marginal rate of return***
		Yield response (kg/ha)	Marginal rate of response*	Value of additional produce** (Rs/ha)	
			Without farmyard manure		
N (kg/ha)					
0	1 844				
25	2 611	767	30.7	2 765	15.36
50	3 260	638	29.9	2 300	12.78
75	3 758	509	20.4	1 835	10.19
100	4 142	384	15.4	1 384	7.69
125	4 388	246	9.8	887	4.93
150	4 510	121	4.8	436	2.42
175	4 502				
			With farmyard manure		
0	2 424				
25	3 246	822	32.9	2 963	16.46
50	3 919	673	26.9	2 426	13.48
75	4 443	524	20.9	1 889	10.49
100	4 819	376	15.0	1 355	7.53
125	5 046	227	9.1	818	4.55
150	5 104	58	2.3	209	1.16
175	5 052				

* kg grain/kg applied N; ** price urea N Rs 7.20/kg, rice grain Rs 3.60/kg; ***Rs/Re spent on fertilizer N

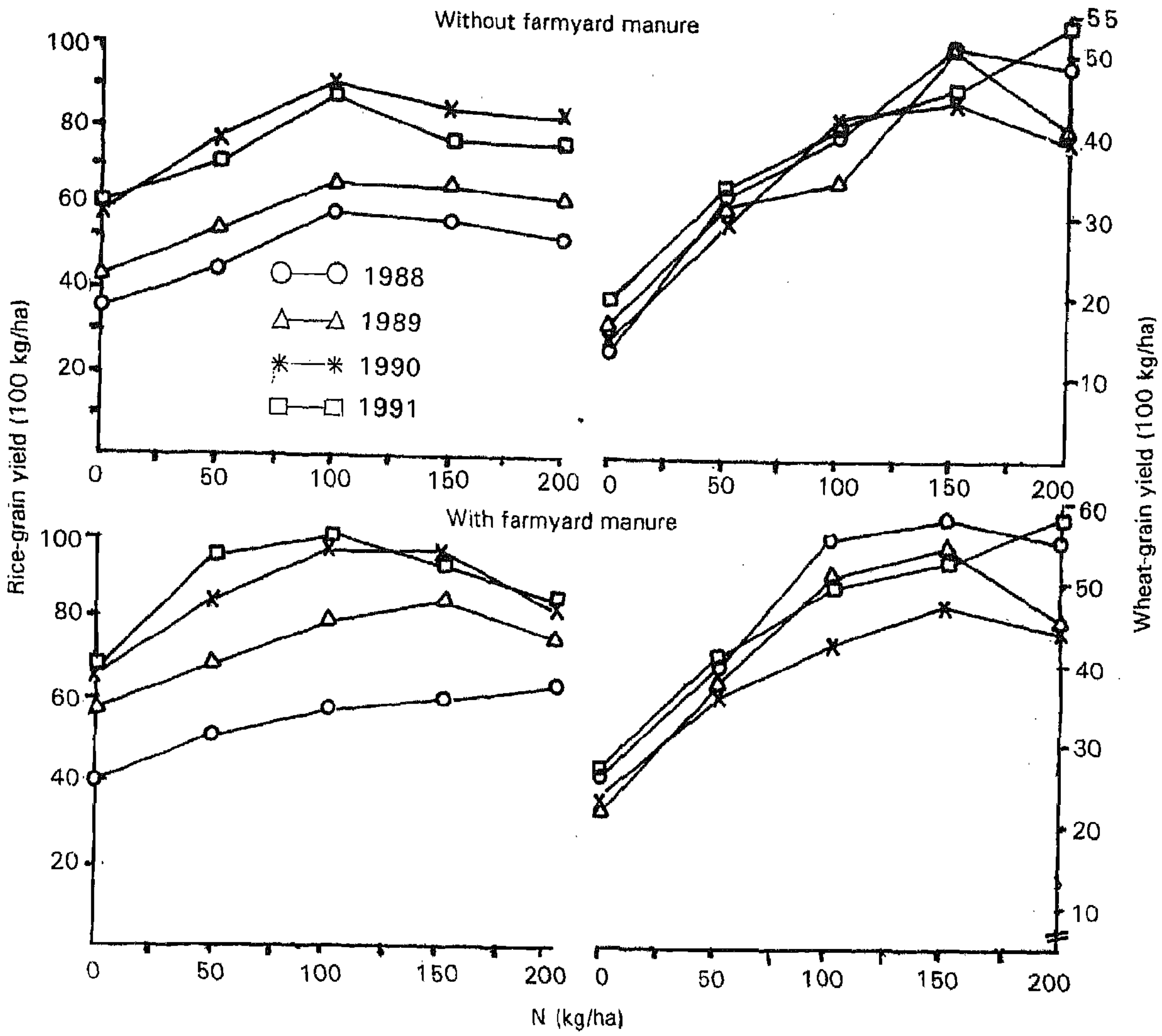

Fig 1 Response of rice and wheat to N application in different years

rice crop from 1 844 to 2 424 kg/ha, indicating beneficial effect of farmyard manure. Further, fertilizer dose for obtaining maximum yield in farmyard manure-treated plots was lower (150 kg/ha) in comparison with that of 160 kg/ha where no farmyard manure was applied. The result showed the economy of N use by wheat where farmyard manure was applied to the previous rice crop. Gill and Meelu (1982) and Maskina *et al.* (1988 a, b) also reported similar results.

Using Eq (3), expected grain yield of wheat at various fertilizer N levels in unmanured plots was 1 844, 2 611, 3 250, 3 758, 4 142, 4 388, 4 510, 4 502 and 4 364 kg/ha with N application @ 0, 25, 50, 75, 100, 125, 150, 175 and 200 kg/ha respectively. The marginal response yardstick due to applied N (kg grain per kg N) was 30.7, 25.5, 20.4, 15.4, 9.8 and 4.8 kg of wheat grain per kg applied N at 25, 50, 75, 100, 125 and 150 kg/ha respectively. Thus the magnitude of marginal response with successive N levels declined sharply with no increase in yield with addition of N beyond 150 kg/ha. The value of additional produce per hectare over previous level also declined from Rs 2 765 with application of 25 kg N/ha to Rs 436 with 150 kg N/ha. Similarly, marginal rate of return in Rs per Re spent on N also declined from 15.36 to 2.42.

Similarly, using Eq (4) the expected grain yield of wheat at various levels of applied N in farmyard-manured plots was 2 424, 3 246, 3 919, 4 443, 4 819, 5 046, 5 104, 5 052 and 4 832 kg/ha with application of fertilizer N @ 0, 25, 50, 75, 100, 125 150, 175 and 200 kg/ha respectively. The marginal response to applied N over preceding level was 32.9, 26.9, 20.9, 15.4, 9.1 and 2.3 kg grain per kg N at 25, 50, 75, 100, 125 and 150 kg/ha respectively. Thus the marginal increase with applied N declined sharply with successive levels of applied N and there was no response beyond the application of 150 kg N/ha. Similarly, the magnitude of response (kg grain per kg applied N) decreased sharply with successive N levels. The value of additional produce obtained with N also declined from Rs 2 963 with 25 kg N/ha to Rs 209 with 150 kg N/ha. Similarly, the marginal rate of return in rupees per rupee spent on N declined from 16.46 to 1.16. Thus N application at lower levels gave higher marginal returns, but not beyond 125 kg/ha.

To get at least Rs 2.50 for each Re spent on fertilizer N, N application in rice @ 125 kg N/ha is necessary where farmyard manure is not applied, but with the addition of farmyard manure this dose can be reduced to 100 kg N/ha, with a saving of 25 kg N/ha. Similarly, optimum N dose in wheat was worked out to be 125 kg N/ha both without and with farmyard manure addition. Moreover, farmyard manure addition raised the total production potential, magnitude of yield response, profit/ha, marginal rate of response and marginal returns of N application of both rice and wheat crops in a fixed rotation, showing an overall improvement in fertilizer N-use efficiency.

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Fertilizer requirement of babycorn (*Zea mays*) in wet and winter seasons

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ABSTRACT

A field experiment was carried out during winter 1995–96 (December–February) and wet (July–August) season 1996 at Jashipur in Orissa to work out the fertilizer requirement of babycorn (*Zea mays* L.) for increasing its productivity. Treatments consisted of application of 7 levels of N, P, K, viz $N_0P_0K_0$, $N_{20}P_{4.4}K_{8.3}$, $N_{40}P_{8.7}K_{16.7}$, $N_{60}P_{13.1}K_{25}$, $N_{80}P_{17.5}K_{33.3}$, $N_{100}P_{21.8}K_{41.7}$ and $N_{120}P_{26.2}K_{50}$ kg/ha. Application of $N_{120}P_{26.2}K_{50}$ brought about a significantly higher yield compared with other fertilizer levels, giving 1 634 and 1 491 kg/ha in winter and wet seasons, with a corresponding net profit of Rs 10 300 and Rs 7 700 /ha respectively.

Key words : babycorn, fertilizer requirement, *Zea mays*

Babycorn (*Zea mays* L.) is the dehusked young cob harvested just after the emergence of white silk. Although it is getting popular due to its varied uses, not much is known regarding its production technology in general and fertilizer management in particular. Hence a study was undertaken to work out the fertilizer requirement of babycorn for optimizing its productivity.

MATERIALS AND METHODS

A field experiment was carried out in the North Central Plateau agro-climatic zone of Orissa at the research farm of the substation at Jashipur during winter season of 1995–96 and wet season of 1996 to work out the fertilizer requirement of babycorn. The field had a red sandy-loam soil, acidic in reaction. The treatments consisted of application of 7 levels of N, P and K, viz $N_0P_0K_0$, (N, P and K @ 0, 0 and 0 kg/ha respectively), $N_{20}P_{4.4}K_{8.3}$, $N_{40}P_{8.7}K_{16.7}$, $N_{60}P_{13.1}K_{25}$, $N_{80}P_{17.5}K_{33.3}$, $N_{100}P_{21.8}K_{41.7}$ and $N_{120}P_{26.2}K_{50}$. Seeds of a composite 'Kiran' were sown on 2 December 1995 for winter crop and 11 July 1996 for wet-season crops. The seed was sown at a depth of 3 cm from soil surface with a spacing of 40 cm from row to row and 20 cm from plant to plant. Nitrogen, phosphorus and potassium were applied through urea, single superphosphate and muriate of potash respectively. All the P and K and half the N as per treatment were applied in lines before sowing the seed. The remaining half nitrogen was top-dressed 25 days after sowing. The experiment was laid out in randomized block design replicated thrice, with a plot size of 20 m^2.

The winter crop was irrigated at fortnightly intervals. The wet-season crop was provided with proper drainage to avoid water stagnation. The tassels were pulled out after emergence of male inflorescence. Babycorn was harvested just after emergence of white silk. Biometric observations such as plant height and population were recorded before that.

After harvest the babycorn was dehusked and observations on its length, girth and weight were taken. The fresh yields of babycorn and green fodder were also recorded.

The fertilizer-use efficiency (FUE) was calculated as :

$$\text{FUE (kg fresh ear/kg nutrient applied)} = \frac{\text{Yield in treatment (kg)} - \text{yield in control (kg)}}{\text{Nutrient applied (kg)}}$$

RESULTS AND DISCUSSION

The babycorn yield increased progressively with increase in the rates of application of fertilizers (Table 1). The green-fodder production also followed a similar trend. The highest yield of 1 634 kg/ha in winter and 1 491 kg/ha in wet season were realized with application of $N_{120}P_{26.2}K_{50}$. Thakur (1995) reported optimum yield with application of $N_{150}P_{26.2}K_{33.3}$. This indicates its high fertilizer requirement. Single ear of babycorn on treatment with $N_{120}P_{26.2}K_{50}$ weighed 8.9 g during winter and 6.6 g during wet season, being 53% heavier in winter and 65% in wet season compared with the respective control. The individual cob weight, however, remained comparable at higher levels of fertilizer application, ie at $N_{100}P_{21.8}K_{41.7}$ or above. The number of ears of babycorn/plant, however, was more with $N_{120}P_{26.2}K_{50}$ in winter, but in wet season the fertilizer rates more than $N_{80}P_{17.5}K_{33.3}$ did not differ among themselves.

The plant stand at harvest was not influenced by the

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Table 1 Effect of fertilizer on yield and net profit of babycorn in different seasons

Fertilizer (kg/ha)	Babycorn yield (kg/ha)		Fodder yield (tonnes/ha)		Ears/plant		Weight of ear (g)		Net profit ('000 Rs/ha)		Fertilizer-use efficiency (kg ear/kg nutrient)	
	Winter	Wet	Winter	Wet	Winter	Wet	Winter	Wet	Winter	Wet	Winter	Wet
$N_{120}P_{26.2}K_{50}$	1 634	1 491	29.1	27.1	2.1	2.6	8.9	6.6	10.3	7.7	2.8	3.6
$N_{100}P_{21.8}K_{41.7}$	1 597	1 279	28.0	25.5	1.8	2.5	8.2	5.9	7.6	6.0	3.2	3.3
$N_{80}P_{17.5}K_{33.3}$	1 385	1 140	26.6	24.6	1.8	2.1	7.3	4.8	8.6	4.6	2.7	3.2
$N_{60}P_{13.1}K_{25}$	1 324	1 058	25.8	22.0	1.7	2.1	6.8	4.7	8.4	4.0	3.1	3.6
$N_{40}P_{8.7}K_{16.7}$	1 318	909	24.4	21.3	1.5	2.1	7.3	4.3	8.5	2.6	4.5	3.5
$N_{20}P_{4.4}K_{8.5}$	1 272	779	22.0	20.2	1.7	1.8	6.1	4.4	6.7	1.7	7.9	3.8
$N_0P_0K_0$	957	628	19.1	17.9	1.3	1.4	5.8	4.0	5.8	0.7		
CD (P=0.05)	12	114	5.4	1.7	0.3	0.6	0.9	1.1				

Table 2 Effect of fertilizer on crop growth and size of babycorn in different seasons

Fertilizer (kg/ha)	Plant stand ('000/ha)		Plant height (cm)		Days to harvest		Length of ear (cm)	
	Winter	Wet	Winter	Wet	Winter	Wet	Winter	Wet
$N_{120}P_{26.2}K_{50}$	122	119	159	125	62	42	8.1	7.7
$N_{100}P_{21.8}K_{41.7}$	121	119	163	125	62	42	8.1	6.9
$N_{80}P_{17.5}K_{33.3}$	120	119	159	116	63	42	7.6	7.0
$N_{60}P_{13.1}K_{25}$	121	117	147	96	64	44	7.3	6.9
$N_{40}P_{8.7}K_{16.7}$	118	117	147	96	64	45	7.6	6.6
$N_{20}P_{4.4}K_{8.3}$	119	116	108	77	65	46	7.1	6.6
$N_0P_0K_0$	115	115	93	50	67	48	6.5	5.4
CD (P=0.05)	NS	1.2	17	23	1.2	1.2	0.7	0.9

application of different doses of fertilizer during winter season, whereas the plant population was significantly higher with application of rates higher than $N_{80}P_{17.5}K_{33.3}$ during wet season (Table 2). The increase in babycorn yield with application of higher doses of nutrients was due to more number of ears/plant and relatively more ear weight of babycorn. During wet season, however, relatively more plant population added to babycorn yield further at higher rates of fertlizer application.

Application of $N_{120}P_{26.2}K_{50}$ produced 29.1 and 27.1 tonnes/ha of green fodder during winter and wet season respectively. During wet season the fodder yield at a fertilizer dose of $N_{100}P_{21.8}K_{41.7}$ and above remained at par, whereas in winter comparable fodder yields were obtained with application of $N_{40}P_{8.7}K_{16.7}$ and above. Plant height at harvest (Table 2) also followed a similar trend.

The duration for production of babycorn decreased at higher rates of plant nutrients (Table 2). During winter and wet seasons the babycorn was harvested at about 62 and 42 days, which were early by 5 and 6 days respectively compared with the control.

Application of different rates of nutrients did not have any significant influence on the ear girth. The length of ear, however, tended to increase with increase in the rate of fertilizer application. The longest ear of babycorn (8.1 cm in winter and 7.7 cm in wet season) was obtained with $N_{120}P_{26.2}K_{50}$.

The fertilizer-use efficiency (Table 1) was 3.2–3.8 during wet season and 2.7–7.9 during winter season. In general it was higher at lower levels of fertilizer application in winter season, whereas no definite trend could be observed during the wet season. Fertilizer-use efficiency was more in wet season compared with winter at levels beyond $N_{60}P_{13.1}K_{25}$.

Thus the winter crop proved superior to wet-season crop for yields of babycorn and green fodder, weight of ear and crop density. The winter crop produced 30% more ears, 10% more green fodder, 11% longer and 45% heavier ears with 103% higher net profit than wet-season crop. The duration of the crop, however, was extended by 45% in winter compared with the wet season. Hence babycorn needs high rates of fertilizer application, ie $N_{120}P_{26.2}K_{50}$ or above. The optimum dose, however, needs to be determined through further experimentation. Winter crop though takes little more time is more profitable.

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Weed-control efficiency of different herbicides in rainfed groundnut (*Arachis hypogaea*)

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ABSTRACT

A field experiment was conducted during the rainy season of 1994 and 1995 at Raigarh to study the efficiency of different herbicides in rainfed groundnut (*Arachis hypogaea* L.). The herbicides were applied as pre-planting incorporation, pre-emergance and post-emergence to control annual weeds especially coxcomb (*Celosia argentea* L.). The major weed species observed in the field were coxcomb, barnyard grass [*Echinochloa crus-galli* (L.) Beauv.], jungle rice [*Echinochloa colona* (L.) Link], bermuda grass [*Cynodon dactylon* (L.) Pers.] and purple nutsedge (*Cyperus rotundus* L.), in decreasing order. Oxyfluorfen @ 0.4 kg ai/ha as pre-emergence showed maximum weed-control efficiency, particularly for coxcomb and minimum weed index (92.3 and 13.2% respectively) but lagged behind the control (weed-free plot) in pod yield. The pod yield under the control and oxyfluorfen was 1 561 and 1 361 kg/ha respectively. Lactofen @ 0.15 kg ai/ha applied as post-emergence recorded weed-control efficiency of 53.2, but was inferior in pod yield to pendimethalin @ 1.5 kg ai/ha as pre-emergence and fluchloralin @ 1.0 kg ai/ha as pre-planting incorporation, which recorded 1 182, 1 327 and 1 314 kg/ha pod yield respectively.

Key words : herbicides, weed-control efficiency, weed index, rainfed groundnut, *Arachis hypogaea*

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop grown in trans-Mahanadi belt of Chhattisgarh region of eastern Madhya Pradesh, under rainfed condition during rainy season. Rainy-season groundnut is heavily infested with several annual weeds, particularly with coxcomb (*Celosia argentea* L.). The crop-weed competition in groundnut crop is maximum during early stage of the crop (first 45 days after sowing) because of its slow initial growth habit. Competitional stress of weeds leads to 17–84% reduction in pod yield (Guggari *et al.* 1995). The occurrence of intermittent rains, prohibitive cost and scarcity of labour during crop-growing season makes manual weeding less effective and uneconomical. Thus the use of herbicides has immense scope in groundnut cultivation. Therefore the present investigation was undertaken to evaluate the efficiency of diffrerent herbicides including oxyfluorfen and lactofen for controlling annual weeds, particularly coxcomb in comparison with weed-free treatment in rainfed groundnut.

MATERIALS AND METHODS

A field experiment was conducted for 2 years during the rainy season of 1994 and 1995 at Raigarh. The soil was sandy, low in available N (171.3 kg/ha) and P (3.6 kg/ha) and medium in K (306 kg/ha), having *p*H 6.2. The experiment was laid out in randomized block design with 3 replications. The treatments consisted of pre-planting incorporation (before sowing) of fluchloralin @ 1.0 kg ai/ha; pre-emergence application (24 hr after sowing) of pendimethalin @ 1.5 kg, alachlor @ 2.0 kg, metalachlor @ 1.0 kg, clomazone @ 1.0 kg and oxyfluorfen @ 0.4 kg ai/ha; and post-emergence application (20 days after sowing) of sethoxydim @ 1.0 kg, fluazifop butyl @ 0.5 kg and lactofen @ 0.15 kg ai/ha along with a weed-free control and a weedy control. The herbicides were sprayed as per schedule using 500 litres water/ha. 'ICGS 11' groundnut was sown at 30 cm × 10 cm spacing using 120 kg/ha seed rate. Before sowing the seeds were treated with ceresan @ 3 g and *Rhizobium* culture @ 5 g/kg seed. The crop was fertilized with N, P and K @ 30, 60 and 30 kg/ha through urea, single superphosphate and muriate of potash respectively as basal. Weeds were counted by using least-count quadrat method. Weed-control efficiency (WCE) and weed index (%) were calculated as suggested by Somani (1992).

RESULTS AND DISCUSSION

The predominant weed species observed in the experimental field were: coxcomb (*Celosia argentea* L.), spider flower (*Cleome viscosa* L.) and dayflower (*Commelina*

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Table 1 Pod yield, weed-control efficiency and weed index as influenced by different herbicides in groundnut

Treatment (kg ai/ha)	Weed-control efficiency (%)			Weed index (%)			Pod yield (kg/ha)		
	1994	1995	Mean	1994	1995	Mean	1994	1995	Mean
Fluchloralin @ 1.0 kg	34.1	45.0	39.6	13.88	17.23	15.56	1 129	1 499	1 314
Pendimethalin @ 1.5 kg	52.3	44.3	48.3	3.05	23.63	13.34	1 271	1 383	1 327
Alachlor @ 2.0 kg	46.8	35.3	41.1	10.68	28.27	19.48	1 171	1 299	1 235
Metalachlor @ 1.0 kg	30.5	24.9	27.7	9.61	25.79	17.70	1 185	1 344	1 265
Clomazone @ 1.0 kg	41.5	21.9	31.7	16.71	40.53	28.35	1 099	1 077	1 088
Oxyfluorfen @ 0.4 kg	92.5	92.1	92.3	15.33	11.04	13.19	1 110	1 611	1 361
Sethoxydim @ 1.0 kg	20.2	28.0	24.1	9.08	27.00	18.04	1 192	1 322	1 257
Fluazifop butyl @ 0.5 kg	10.2	39.8	25.0	8.70	31.31	20.01	1 197	1 244	1 221
Lactofen @ 0.15 kg	76.2	30.2	53.2	13.81	31.92	22.87	1 130	1 233	1 182
Weed-free control							1 311	1 811	1 561
Weedy control				25.25	50.30	37.78	980	900	940
SEm±	6.03	7.37					86	100	74
CD (P=0.05)	17.91	22.09					252	295	217

PPI, Preplanting incorporation; PE, pre-emergence; PO, post-emergence at 20–21 days after sowing

benghalensis L.) among dicotyledons; jungle rice [*Echinochloa colonum* (L.) Link], barnyard grass [*Echinochloa crus-galli* (L.) Beauv.], crabgrass [*Digitaria ciliaris* (Retz.) Koelar], crow footgrass [*Dactyloctenium aegypticum* (L.) P. Beauv.] and bermuda grass [*Cynodon dactylon* (L.) Pers.] among grasses; and purple nutsedge (*Cyperus rotundus* L.) and yellow nutsedge (*Cyperus esculentus* L.) among sedges.

Effect on crop yield

The pod yield of groundnut differed significantly due to different weed-control treatments during 1994 and 1995 (Table 1). Maximum dry-pod yield was obtained with weed-free treatment, which was similar to all the herbicide treatments during 1994, but significantly superior to other treatments during 1995 except pre-emergence application of oxyfluorfen @ 0.4 kg ai/ha. However, on mean basis higher pod yield (1 561 kg/ha) was obtained with weed-free treatment (Table 1). Among the pre-emergence herbicides, highest pod yield (1 361 kg/ha) was obtained with the application of oxyfluorfen @ 0.4 kg ai/ha, though initially it showed temporary phytotoxic effect on germinating seedlings of groundnut, followed by pendimethalin @ 1.5 kg ai/ha (1 327 kg/ha) and fluchloralin @ 1.0 kg ai/ha (1 314 kg/ha). Guggari *et al.* (1995) also obtained higher pod yield of groundnut with the pre-emergence application of pendimethalin, whereas Murthy *et al.* (1992) found higher pod yield under pre-sowing incorporation of fluchloralin @ 1.0 kg ai/ha. Herbicides applied at post-emergence stageof groundnut were found inferior in recording yield comparable to pre-emergence herbicides.

Weed-control efficiency and weed index

The highest weed-control efficiency of 92.3% including for coxcomb was registered with the application of oxyfluorfen @ 0.4 kg ai/ha with lowest weed-index value of 13.19% among the pre-emergence and post-emergence herbicides. Pendimethalin @ 1.5 kg ai/ha, alachlor 2.0 kg ai/ha and fluchloralin @ 1.0 kg ai/ha proved equally good but lagged behind oxyfluorfen, giving 48.3, 41.1 and 39.6% weed-control efficiency with weed-index values of 13.34, 19.48 and 15.56% respectively. Kondap *et al.* (1989) also reported similar results. Among the post-emergence herbicides, lactofen @ 0.15 kg ai/ha proved the best, giving 53.2% weed-control efficiency and 22.87% weed index compared with sethoxydim and fluazifop butyl, which gave 24.1 and 25.0% weed-control efficiency and 18.04 and 20.01% weed index respectively. Girijesh and Patil (1991) also registered 32.60 and 24.86% weed-control efficiency and weed index respectively with the application of fluazifop butyl @ 0.25 kg ai/ha.

It was concluded that pre-emergence application of oxyfluorfen is beneficial for effective control of annual weeds along with coxcomb, though it showed initial splash injury. Further post-emergence application of lactofen provides another opportunity to manage weed infestation in groundnut under rainfed condition.

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Irrigation and nutrient requirement of garlic (*Allium sativum*) under south Saurashtra region of Gujarat

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ABSTRACT

A field experiment was conducted during winter season (*rabi* of 1991–92 and 1992–93) on clayey soil of Junagadh to study the effect of irrigation (1.0, 1.2 and 1.4 IW : CPE ratio), nitrogen (25, 50 and 75 kg N/ha) and phosphorus (11, 22 and 33 kg P/ha) on garlic (*Allium sativum* L.). The crop irrigated at 1.4 irrigation water : cummulative pan evaporation (IW : CPE) ratio produced significantly higher bulb yield but remained at par with 1.2 IW : CPE. Maximum net return was secured with irrigation at 1.4 IW : CPE, whereas maximum water-use efficiency at 1.2 IW : CPE. Different levels of N did not exert significant influence on bulb yield; however, application of 50 kg N/ha recorded maximum net return and water-use efficiency. Application of 11 kg P/ha recorded significantly equivalent bulb yield to that of 33 kg P/ha and realized maximum net return.

Key words : irrigation, nitrogen, phosphorus, garlic, *Allium sativum*

Garlic (*Allium sativum* L.) has aroused interest among farmers of Gujarat state because of its high market demand along with remunerative prices. The success of its cultivation depends mainly on proper irrigation schedule and nutrient management to ensure sustainable production, especially under semi-arid tropics. Since the information on these aspects is very meagre, the study aimed to determine proper irrgiation schedule and optimum nutrient requirement for maximizing garlic productivity and water-use efficiency was undertaken under south Saurashtra agro-climatic conditions, where irrgiation water is the main limiting factor in crop production.

MATERIALS AND METHODS

The field experiment was conducted during the winter season (*rabi*) of 1991–92 and 1992–93 at the instructional farm of the college at Junagadh on clayey soil, having *p*H 8.2, electrical conductivity 0.30 dS/m with 0.42% organic carbon, 9.6 kg/ha available P and 225 kg/ha available K. The field had saturation point of 60.55% and bulk density of 1.42 g/cm^3. The treatments comprising 3 levels each of irrigation [1.0, 1.2 and 1.4 irrigation water : cumulative pan evaporation (IW : CPE) ratio], nitrogen (25, 50 and 75 kg N/ha) and phosphorus (11, 22 and 33 kg P/ha) were tried in split-plot design replicated 4 times. Irrigation levels were assigned to main plots and combinations of nitrogen and phosphorus levels were assigned to subplots. Treatment-wise half the N and full amount of P were applied at sowing and the remaining half N was top-dressed 30 days after sowing. Urea and single superphosphate fertilizers were the sources of N and P respectively. 'G 1' garlic was sown at 15 cm x 10 cm using 450 kg cloves/ha. A measured quantity of water (50 mm) was applied at each irrigation to the desired treatments. Initial 3 common irrigations were given to all plots to achieve better germination and establishment of crop. Then 10, 12 and 14 irrigations were given during 1991–92 and 8, 10 and 12 irrigations during 1992–93, as per 1.0, 1.2 and 1.4 IW : CPE ratio respectively. The total quantity of water applied at 1.0, 1.2 and 1.4 IW : CPE was 650, 750 and 850 mm during 1991–92 and 550, 650 and 750 mm during 1992–93 respectively.

RESULTS AND DISSCUSSION

Effect of irrigation

Irrigation at 1.4 IW : CPE ratio recorded the highest bulb yield during all the years of study, but the increase in garlic productivity due to this schedule compared with irrigation applied at 1.2 IW : CPE was significant during 1991–92 only. Maksound *et al.* (1986) and Panchal *et al.* (1992) also reported similar results. Better moisture availability under 1.2 and 1.4 IW : CPE schedules compared with 1.0 IW : CPE might increased the nutrient availability and growth, which ultimately reflected in higher yield. Maximum net return of Rs 11 401/ha was realized with

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Table 1 Effect of irrigation, nitrogen and phosphorus on bulb yield of garlic, net return and water-use efficiency

Treatment	Bulb yield (kg/ha)			Net return (Rs/ha)			Water-use efficiency (kg/ha-cm)		
	1991–92	1992–93	Pooled	1991–92	1992–93	Mean	1991–92	1992–93	Mean
Irrigation (IW : CPE)									
1.0	3 289	4 433	3 861	1 210	7 502	4 356	50.6	80.6	65.6
1.2	4 366	5 385	4 875	6 653	12 258	9 456	58.2	82.8	70.5
1.4	5 039	5 594	5 316	9 875	12 927	11 401	59.3	74.6	67.0
S Em ±	131	212	189						
CD (P=0.05)	514	834	583						
N (kg/ha)									
25	4 132	5 076	4 604	5 719	10 911	8 315	55.1	78.1	66.6
50	4 272	5 298	4 785	6 361	12 004	9 183	57.0	81.5	69.3
75	4 290	5 039	4 664	6 333	10 452	8 393	57.2	77.5	67.4
S Em ±	69	106	73						
CD (P=0.05)	NS	NS	NS						
P (kg/ha)									
11	4 109	5 289	4 699	5 313	11 803	8 558	54.8	81.4	68.1
22	4 224	4 921	4 572	5 540	9 373	7 457	56.3	75.7	66.0
33	4 361	5 203	4 782	5 887	10 518	8 203	58.1	80.0	69.1
S Em ±	69	106	73						
CD (P=0.05)	197	302	203						

irrigation at 1.4 IW : CPE ratio. In general, scheduling irrigation at 1.2 IW : CPE ratio recorded the highest water-use efficiency, except during 1991–92. On an average, the maximum water-use efficiency of 70.5 kg/ha-cm was recorded with irrigation at IW : CPE 1.2.

Effect of N

Different levels of N did not differ significantly in influencing the bulb yield during both the years and in pooled results. The result confirms the finding of Panchal *et al.* (1992). It clearly showed that N requirement of the crop might have been fulfilled with the lowest level of 25 kg N/ha. The maximum Rs 9 183/ha was obtained with 50 kg N/ha. Application of 50 kg N/ha recorded the highest water-use efficiency during 1992–93, with the highest 69.3 kg/ha-cm in average of 2 seasons.

Effect of P

Very inconsistent results were obtained due to the effect of P level on bulb yield. Application of 33 kg P/ha recorded significantly highest yield during 1991–92 and in pooled results, whereas 11 kg P/ha recorded significantly highest yield during 1992–93; but both these levles were at par during both the years and in pooled results. The result confirms that of Das *et al.* (1985). Since the crop did not respond to the higher levels of P fertilization, application of the lowest dose of 11 kg P/ha was the optimum level of P for garlic by securing the maximum mean net return of Rs 8 558/ha. The maximum water-use efficiency was recorded by 33 kg P/ha during 1991–92 whereas by 11 kg P/ha during 1992–93. Application of 33 kg P/ha recorded the highest mean water-use efficiency of 69.1 kg/ha-cm.

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Growth, flowering, corm yield and corm-rot incidence as affected by level and frequency of potassium application in gladiolus (*Gladiolus grandiflorus*)

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ABSTRACT

Significantly higher corm weight and less incidence of corm rot were noticed when potassium was applied @ 100 kg/ha to 'Pink Friendship' gladiolus (*Gladiolus grandiflorus* L.). But significantly higher number and weight of cormels/ plant were obtained when K was applied @ 200 kg/ha. Other parameters like vegetative growth and floral characters were not significantly influenced by graded levels and their methods of potassium application. The interactions between graded levels and methods of potassium application were non-significant for all the parameters studied.

Key words : potassium, gladiolus, *Gladiolus grandiflorus*

Gladiolus (*Gladiolus grandiflorus* L.) is an important bulbous flower crop, being grown mainly for use as cut-flower and beautification of surroundings. The significance of potassium application in gladiolus has been reported by several researchers. Wilfret (1980) stated that deficiency of potassium in gladiolus reduces the number of florets in the spike, shortens the spike length, delays flowering, and leads to yellowing of older leaves and interveinal yellowing of younger leaves. Ansetta (1958) reported that potassium should be applied 1 month before flowering, for obtaining quality flowers in gladiolus. The reports on the effect of potassium in gladiolus under Indian conditions are contradictory (Motial *et al.* 1979, Bose 1984, Potti and Arora 1986). The present study was therefore taken up to determine the influence of graded levels and methods of potassium application on vegetative growth, floral parameters, corm and cormel production and the incidence of corm-rot disease in gladiolus cultivar 'Pink Friendship'.

MATERIALS AND METHODS

A field trial was conducted at Hessaraghatta Farm, Bangalore, during 1992–93 and 1994–95. The soil belongs to Alfisol, being sandy loam, having a *p*H 6.74, electrical conductivity 0.089 mm, organic carbon 0.45%, nitrogen 73 ppm, phosphorus 21.9 ppm, potassium 162 ppm (low), calcium 537 ppm, magnesium 52 ppm, sulphur 25 ppm, ferrous 3 ppm, molybdenum 7 ppm, zinc 1.1 ppm and copper 1 ppm. The treatments consisted of 4 levels of potassium, viz the control (K_0), K_{100}, K_{200} and K_{300}, and their 3 frequencies of application, viz full dose at planting time (M_1), full dose at 30 days after planting (M_2) and half the dose at 30 days and the remaining half at 60 days after planting (M_3). There were 12 treatments, replicated 3 times in factorial randomized block design. The graded levels of potassium were supplied through muriate of potash (60% K). Full dose of phosphorus (100 kg P/ha) was supplied through single superphosphate (16%P) at planting time, whereas nitrogen (400 kg N/ha) was supplied through urea (46% N) in 2 equal split doses, ie at the stage of 3 and 6 leaves. Healthy and uniform-size corms (4.0–4.5 cm diameter) were selected and planted 30 cm x 20 cm apart at 5 cm depth in 1 m x 1 m size plots. Observations on various growth and floral parameters were recorded during flowering stages, whereas those pertaining to corm and cormel production and the incidence of corm-rot disease were recorded a few days after lifting the crops (75 days after flowering). Data of 2 seasons were pooled and analysed statistically.

RESULTS AND DISCUSSION

The pooled data of 2 seasons (Table 2) revealed that potassium @ 100 kg/ha gave significantly higher weight of corm (64.57g), though the treatments of K_{200} and K_{300} were statistically at par with that of K_{100}. Higher number (46.41) and weight (18.55 g) of cormels / plant were obtained with 200 kg K/ha, but K_{200} and K_{300} treatments gave statistically equal results for number of cormels/plant. Bhattacharjee (1981) obtained significantly higher average weight of corm and number of cormels/plant in gladiolus when potassium

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Table 1 Influence of level and frequency of potassium application on vegetative growth and floral parameters in gladiolus (pooled data of 2 season)

Treatment	Days for 100% corm sprouting	Plant height (cm)	Leaves / plant	Leaf breadth (cm)	Days for spike emergence	Days for flowering (no.)	Floret diameter (cm)	Flowering duration (day)	Florets / spike (no.)	Spike length (cm)	Rachis length (cm)
					K (kg/ha)						
K_0 (control)	27.00	85.00	8.74	4.37	66.90	75.37	12.76	9.21	15.98	69.54	38.44
K_{100}	26.64	85.34	8.68	4.31	67.76	75.57	13.19	9.09	15.90	69.27	39.12
K_{200}	26.80	85.86	8.76	4.42	68.21	76.48	13.02	8.91	15.64	69.82	38.30
K_{300}	26.30	84.63	8.71	4.41	67.10	75.69	12.83	8.98	15.84	69.34	38.29
S Em ±	0.37	0.76	0.04	0.06	0.60	0.61	0.10	0.13	0.19	1.09	0.75
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
					Frequency of K application						
M_1	26.47	85.47	8.70	4.39	67.54	75.24	12.96	8.85	15.83	69.46	39.04
M_2	26.63	85.19	8.76	4.31	67.69	76.79	12.92	9.18	15.73	69.88	38.08
M_3	26.97	85.36	8.68	4.43	67.84	76.09	13.16	8.94	15.83	69.17	38.56
S Em ±	0.32	0.66	0.04	0.05	0.52	0.52	0.09	0.11	0.16	0.94	0.78
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Details of treatments are given under Materials and Methods
The interaction between levels and frequencies was found non-significant in all parameters

Table 2 Influence of level and frquency of potassium application on corm and cormel development and corm-rot in gladiolus (pooled data of 2 seasons)

Treatment	Corm diameter (cm)	Corm weight (g)	Corms/plant (no.)	Cormels/plant (no.)	Weight of cormels/plant (g)	Corms infected/ plot (%)
			K (kg/ha)			
K_0 (control)	6.04	50.22	1.05	34.36	12.73	28.00
K_{100}	6.30	64.57	1.17	34.73	11.70	18.55
K_{200}	6.26	59.37	1.09	46.41	18.55	19.53
K_{300}	6.37	58.89	1.15	43.39	14.81	41.78
S Em ±	0.12	2.17	0.02	1.75	0.76	1.61
CD (P=0.05)	NS	6.36	NS	5.14	2.23	4.73
			Frequency of K application			
M_1	6.20	55.16	1.12	37.55	12.89	23.10
M_2	6.22	56.67	1.17	39.68	13.87	22.43
M_3	6.23	55.65	1.11	35.27	12.47	23.78
S Em ±	0.10	1.88	0.02	1.51	0.66	1.39
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Details of treatments are given under Materials and Methods

was applied @ 150 kg/ha compared with the control. Potti and Arora (1986) reported that application of potassium @ 200 kg/ha produced significantly higher weight of cormels of gladiolus compared with the control. Our result also supports this finding.

Compared with the control (K_0), where infected corms per plot (28%) were the highest, the disease incidence was significantly lower at all the levels of potassium tried. Though the lowest incidence of corm rot was obtained by application of potassium at 100 kg/ha, different frequencies of potassium application did not show significant differences in corm-rot incidence (Table 2). All the growth and floral parameters and also size of corm and number of corms/plant were not significantly influenced by graded levels of potassium application (Tables 1,2). Motial *et al.* (1979) observed that application of potassium fertilizer had non-significant effect on floral parameters of gladiolus.

The present investigation revealed that frequencies (methods) of potassium application and also their interactions with graded levels did not have significant influence on any of the various parameters pertaining to plant growth, floral parameters, corm and cormel development and the incidence of corm-rot disease.

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Effect of row skipping in tree cotton (*Gossypium arboreum*) on efficacy of chemical control of spotted bollworms (*Earias vittella* and *E. insulana*) and pink bollworm (*Pectinophora gossypiella*)

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ABSTRACT

The effect of skipping a row at sowing to provide a path for spray operation was studied on the efficacy of chemical control of bollworms on 'LD 327' tree cotton (*Gossypium arboreum* L.) during 1992 and 1993. Skipping the fourth, fifth, sixth and seventh rows was compared with no skipping at 3 locations during 1992. However, skipping of fourth row was omitted in subsequent trials in 1993. Average data of locations and years showed that skipping every fifth row at sowing proved significantly better than no skipping as well as skipping of sixth and seventh rows in lowering the incidence of spotted bollworms (*Earias vittella* Fabr. and *E. insulana* Boisd.) and pink bollworm (*Pectinophora gossypiella* Saund.) as well as stained seed-cotton. Besides compensating for the missing row, this treatment also increased the seed-cotton yield by 15.2 and 20.1% during 1992 and 1993 respectively.

Key words : row skipping, tree cotton, bollworms, chemical control, *Gossypium arboreum*

Cotton (*Gossypium* spp) crop suffers from severe insect-pest damage, particularly from bollworms, the spotted bollworms (*Earias vittella* Fabr. and *E. insulana* Boisd.) and pink bollworm (*Pectinophara gossypiella* Saund.). Often it becomes difficult to raise a good crop without their control. In India about 45% of the pesticide is used on cotton alone (Narayanan 1991), though it occupies only 5% of the total cropped area. According to Ramachandran *et al.* (1980) and Narayanan and Jayaswal (1984), insecticides account for 30-40% of the cost of cultivation in irrigated cotton and 10-25% in rainfed cotton.

In Punjab the cotton crop when raised under high-fertility conditions in years of heavy rainfall attains luxuriant growth and it becomes difficult to enter into the field for spray to control bollworms with manually operated knapsack sprayer even by making pathways through pressing branches. The spray material is therefore not properly dispersed in the central rows. The improperly covered plants bear a few pickable bolls and contribute less towards yield, but greatly help the pest by acting as reservoirs. Keeping this problem in view, an experiment was planned during 1992 and 1993 to study the effect of skipping a row after some rows at sowing to provide a path for spray operations of insecticides and on the efficacy of chemical control of bollworms in tree cotton (*Gossypium arboreum* L.).

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MATERIALS AND METHODS

The skip-row experiment was conducted on *Gossypiella* 'LD 327' tree cotton (*Gossypium arboreum* L.) during 1992 at Ludhiana and at its 2 research stations Kheri and Jalandhar in Punjab.

The treatments involving skipping of every fourth, fifth, sixth and seventh rows and no skipping were replicated 4 times at all the locations. In the subsequent trials conducted at Kheri and Jalandhar during 1993, skipping of fourth row was omitted in the light of results of 1992, and the treatments were replicated 6 times. All the treatments received 5 sprays for controlling bollworms at Kheri and 6 each at Ludhiana and Jalandhar. The recommended package of practices was followed for successful cultivation of the crop (PAU, Ludhiana 1992).

To judge the efficacy of chemical control in various treatments, 10 plants were tagged at random from each plot, leaving aside the border row and plants. At maturity all the opened bolls of these plants were removed and examined for bollworm infestation on boll as well as locule basis, stained seed-cotton and diapausing population of pink bollworm. The yield of seed-cotton per plot was also recorded. After the final pick, left-over bolls or burs on the tagged plants were plucked and examined to record larval population of pink bollworm. Pooled data on all the parameters were analysed after appropriate transformation.

Table 1 Effect of row skipping on bollworm infestation, stained seed-cotton, diapausing pink bollworm population and yield during 1992 (pooled data of 3 locations)

Row skipped at sowing	Bollworm infestation (%)		Stained seed-cotton (%)	Population of pink bollworm larvae/10 plants in		Seed-cotton yield (kg/ha)	Increase in yield over no skipping (%)
	Boll basis	Locule basis		Seed cotton	Left-over bolls or burs		
4	8.12 (16.46)	4.60 (12.32)	2.89 (9.74)	1.25	1.50	1 461	–1.2
5	8.71 (17.27)	4.99 (12.88)	3.13 (10.12)	1.67	1.58	1 703	15.2
6	10.11 (18.47)	5.37 (13.81)	3.79 (11.18)	1.58	1.67	1 648	11.5
7	11.28 (19.55)	6.53 (14.77)	4.43 (12.11)	2.00	2.08	1 624	9.9
None (control)	13.77 (21.63)	8.21 (16.58)	5.70 (13.73)	2.75	2.92	1 478	
CD (P=0.05)	(1.46)	(1.05)	(0.85)	NS	NS	111	

Figures in parentheses indicate angular tranformation

Table 2 Effect of row skipping on bollworm infestation, stained seed-cotton, diapausing pink bollworm population and yield during 1993 (pooled data of 2 locations)

Row skipped at sowing	Bollworm infestation (%)		Stained seed-cotton (%)	Population of pink bollworm larvae/10 plants in		Seed-cotton yield (kg/ha)	Increase in yield over no skipping (%)
	Boll basis	Locule basis		Seed cotton	Left-over bolls or burs		
5	8.72 (17.06)	5.68 (13.70)	4.00 (11.42)	2.66	2.16	1 716	20.1
6	10.08 (18.40)	6.44 (14.62)	4.54 (12.18)	2.92	2.33	1 577	10.4
7	11.72 (19.89)	7.46 (15.80)	5.54 (13.50)	3.25	2.50	1 482	3.7
None (control)	17.29 (24.46)	10.54 (18.85)	7.62 (15.80)	4.25	3.42	1 429	
CD (P=0.05)	(1.94)	(1.32)	(1.22)	NS	NS	91	

Figures in parentheses indicate angular tranformation

RESULTS AND DISCUSSION

The pooled effect of various skipping treatments showed significant differences for bollworm infestation, stained seed-cotton and yield, but for diapausing population of pink bollworm differences were not significant during 1992 and 1993 also (Table 1). Skipping of fourth and fifth rows recorded significantly lower bollworm infestation on boll (8.12–8.71%) as well as locule basis (4.60–4.99%). The latter treatment was, however, at par with the sixth row skipping, which in turn was at par with skipping of seventh row, and all were better than no skipping. The treatments involving skipping of fourth and fifth rows had lower stained seed-cotton (2.89–3.13%). Skipping of sixth and seventh rows, though less effective, was better than no skipping. All the skipping treatments had less population of pink bollworm in seed-cotton (1.25–2/10 plant) as well as in the left-over bolls or burs (1.50–2.08/10 plants) than no skipping (2.75 and 2.92/10 plants) but the differences were not significant. The highest seed-cotton yield of 1 703 kg/ha (15.2% increase over no skippping) was recorded in skipping of fifth row, but it was at par with skipping of sixth and seventh rows (increases being 11.5 and 9.4% respectively). Skipping of fourth row was least effective, resulting in 1.2% reduction in yield than no skipping. This treatment though highly effective for bollworm control, was omitted in the subsequent trials due to poor yield.

During 1993, skipping of fifth row with 8.72% boll infestation, 5.68% locule infestation and 4% stained seed-cotton proved the best, though it was at par with sixth row skipping (Table 2). Skipping of seventh row recorded bollworm incidence at par with that of sixth row, but had higher stained seed-cotton though significantly lower than in no skipping. Skipping of fifth row also gave the highest yield of seed cotton (1 766 kg/ha), reflecting an increase of 20.1% compared with no skipping. It was followed by sixth row skipping with 10.4% increase, and skipping of seventh row with only 3.7% increase being the least effective.

It was concluded that skipping of every fifth row was the best for low bollworm infestation as well as stained seed-cotton and higher seed-cotton yield. This treatment not only compensated for the missing row but also gave 10 and 15.2–20.1% more seed-cotton yield. The effect of skipping may be attributed to better penetration into the crop, resulting in uniform and efficient dispersal of pesticides.

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Establishment of rhizotron for *in-situ* monitoring of root growth

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ABSTRACT

To study the root-growth behaviour of crops for devising environmentally sound strategies for efficient input-use and high yields, a rhizotron facility was established at Ludhiana for *in-situ* monitoring of root-growth dynamics. It consists of 16 rhizotron chambers and was developed by using indigenous design and materials, and is the first of its kind in India. Each rhizotron cell has 1.2 m wide and 2.4 m deep viewing-window, specifically designed to study root growth, nutrient and water dynamics in field crops raised on deep alluvial soils. Besides root-growth monitoring, it has a provision of metered water supply, soil-water measurement and manually operated mobile rain shelter and hence can be used as lysimeter.

Key words : rhizotron, root growth, lysimeter

Information on root-growth dynamics can be exploited to devise practices for managing soil, water and nutrients to increase crop yield, ensure efficient input-use and safeguard the environment (Gajri and Prihar 1985, Gajri *et al.* 1989, Arora *et al.* 1991). Owing to difficulty involved in studying below-ground plant growth and absence of suitable method for its quantification, there is general lack of such an information (Hamblin 1985). Since the sixties, various kinds of sophisticated underground chambers, rhizotrons, have been developed that permit plant roots to be studied under replicated conditions, whereas shoots are exposed to the field environment (Huck and Taylor 1982).

Basically a rhizotron is a root-observation facility, consisting of series of soil compartments fitted with transparent windows along with an access tunnel. These are valuable tools for studying root–shoot physiological relations, root-system responses to the physical, chemical and biological environments of the soil, varietal comparisons and mass-balance studies of cropped soils (Klepper and Kaspar 1994). Many such facilities exist in the developed countries (Soileau *et al.* 1974, Huck and Taylor 1982, Klepper and Kaspar 1994), but these are almost non-existent in most of the developing countries due to high financial investment and technological or material limitations. As no such pre-farbicated facility exists any where in India, rhizotrons were established during 1992–93 after experimenting with various prototypes using different designs and materials for 2 years. The experimentation with prototypes included standardization of design for size of viewing-window, screening of glass panels for visibility of roots, thickness and strength *vis-a-vis* enormous soil load and entrapped air pressure, tunnel roof and rain-shelter design, phytotoxicity of sealants, and the procedure for reconstitution of soil profiles. Within the financial and technological limitations, attempt was made to incorporate the best features of the existing facilities (Huck and Taylor 1982). The main objectives for creating this facility are : (*i*) to study root-growth behavior in relation to soil physical, chemical and biological environments; and (*ii*) to quantify the effect of different management practices on root growth and nutrient–water balance in different crops.

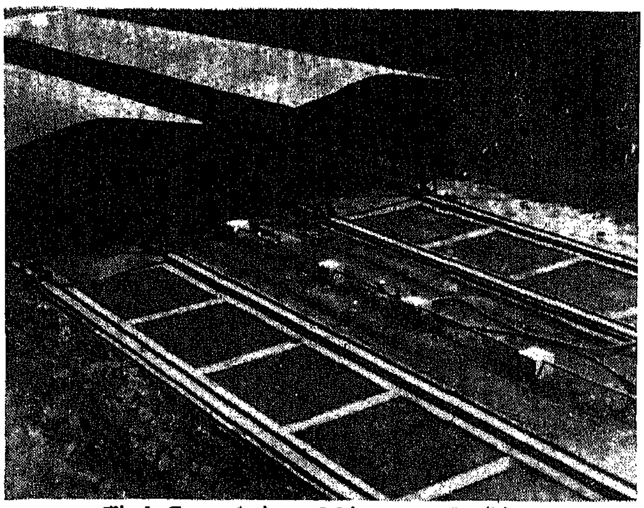

Fig 1 General view of rhizotron at Ludhiana

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[3] Former Professor, 136-D Kitchloo Nagar, Ludhiana 141 004

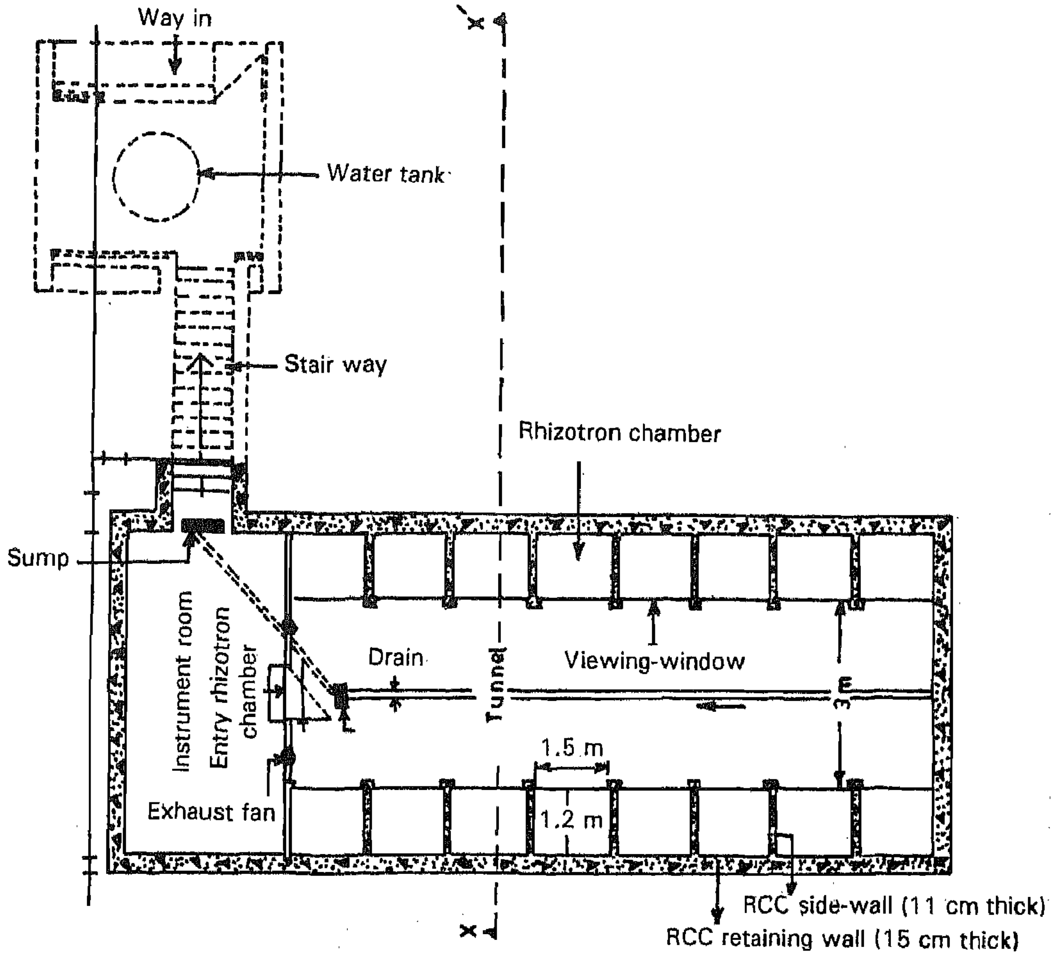

Fig 2 General plan of rhizotron, at Ludhiana

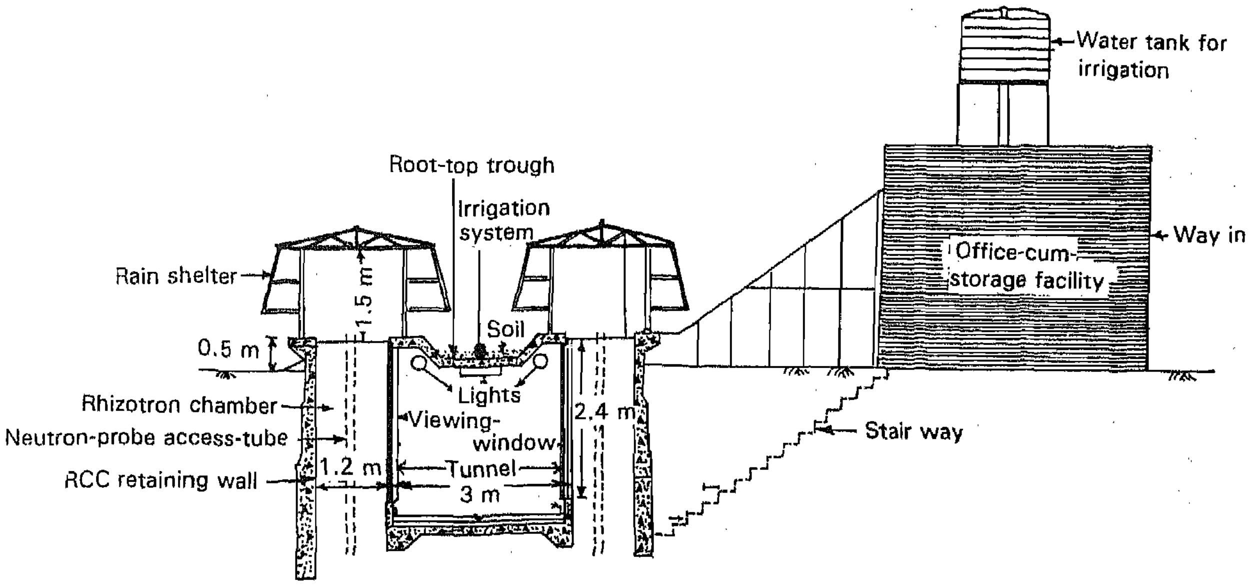

Fig 3 Cross-section view of rhizotron structure

DESCRIPTION

This facility consists of 16 rhizotron chambers, 8 each on either side of a 3 m wide tunnel (Figs 1, 2) designed for studying root growth, nutrient and water dynamics in field crops raised on deep alluvial soils. Besides root-growth monitoring, it has a provision of metered water supply, soil-water measurement and manually operated mobile rain shelter. The facility costs about Rs 0.5 million at 1992–93 prices.

Rhizotron chamber

Each rhizotron chamber is 2.4 m deep, 1.2 m thick and has a 1.5 m wide viewing-window. The underground structure is surrounded by 0.15 m thick retaining wall of reinforced concrete which acts as back wall for rhizotron chambers and separates the structure from the adjoining soil. The rhizotron chambers are separated from each other by 0.11 m thick reinforced concrete side-walls. The front portion of each chamber is provided with a 0.006 m thick glass-fitted viewing- window, held in place by a 0.10 m x 0.10 m x 0.006 m mild steel-angle frame. The 0.15 m thick roof of the tunnel is designed in the shape of a 0.30 m deep trough (Figs 2, 3), which is filled with soil for growing crop to reduce advection to the crop growing in the chambers. The design and thickness of the roof does not prevent the visibility of the growing root system. The soil profiles in the chambers were reconstituted by filling the lower part with subsoil and the upper part with top soil in the sequence as existed in the field. The soil in the chambers was stabilized with wetting and drying cycles.

Viewing-window

The viewing-window is 1.5 m wide and is divided into 5 segments, each having 0.25 m viewing width (Fig 4). Four segments are fitted with 0.006 m thick clear transparent glass-sheet, and the fifth with 0.006 m thick transparent acrylic sheet. The acrylic sheet facilitates drilling of holes for installation of instruments and obtaining root, soil and solute samples. The viewing-glass and acrylic sheets are properly fixed to the window frame with glazer's *putty* (clay + synthetic adhesive) and are kept in place by pressure of the soil. The end-to-end viewing panels have been sealed with thin coat of synthetic adhesive. Both the materials were tested to be non-phytotoxic.

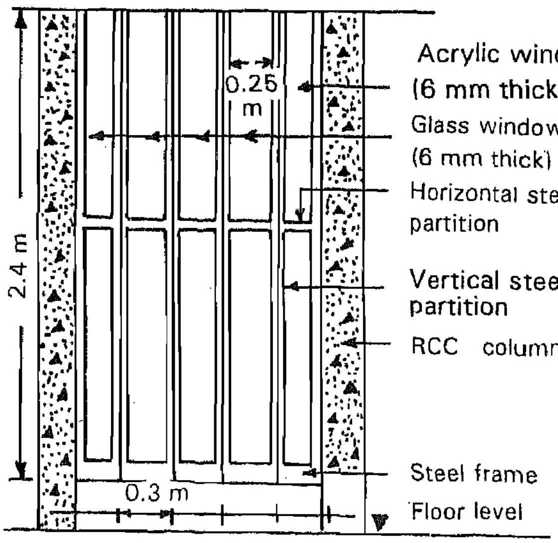

Fig 4 Plan of viewing-window of rhizotron chamber

Lighting

There is a provision of proper lights in the tunnel in the walk-way and at the head of each rhizotron chamber for recording root-growth observations (Fig 2). Individual rhizotron chamber can be illuminated while the other lights are switched off. There is also a provision of power supply for hand-held lights. A black opaque cover is attached to the viewing-window to act as a barrier for light, which is removed at the time of recording the observations.

Water-control system

Addition of water to the rhizotron chambers can be controlled and monitored, as there is provision of metered supply and rain shelters (Fig 2). Controlled irrigation facility has been installed through a water-storage tank on the roof of the stairway. The water-supply pipeline having water-meters and control valves is installed in the centre of tunnel roof. Each row of rhizotron chambers is provided with specially designed manually operated rain shelters made from steel and acrylic sheets. These shelters can accommodate a maximum crop height of 1.5 m. To monitor soil-water content, neutron-probe access-tubes have been installed in the centre of each rhizotron chamber. There is a provision for installation of tensiometers for monitoring water fluxes across a given plane. These provisions for water control and monitoring features of rhizotron chambers permit their use as lysimeter.

Drainage or seepage

The facility is constructed in the middle of a 4 000 m^2 field. The soil dug out of the ground for construction is piled along the rhizotrons flush, with its top with a gentle outwardly slope on both sides. To avoid advection effect in the crop growing in the rhizotron chambers, the same crop is planted in the surrounding structure. The structure stands 0.5 m above the ground level (Fig 2) to provide gravity drainage to the roof top to prevent flooding due to heavy monsoon rains. The prevent lateral seepage between rhizotron chambers as well as to and from the adjoining field, all concrete surfaces are plastered with water-proof cement and treated with 2 coats of bitumen. The bottom of each rhizotron chamber is flush with subsoil to provide for natural drainage. The floor of the tunnel is provided with a drainage channel, with arrangement of pumping out water from the structure.

Air exhaust

Exhaust fans are installed at the entry of the tunnel to remove any toxic gases before entering the underground structure.

Instrument and sample storage rooms

There is a instrumentation room having facility of weighing and drying of samples. It also includes root scanner, neutron probe and leaf-area meter.

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Field evaluation of power tiller rotavator with seating attachment

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ABSTRACT

A 7.5 kW rotary-type power tiller fitted with seating attachment was field evaluated for rotapuddling and rotatilling operations under soil conditions of Bhopal region and its performance was compared with that of power tiller without seating attachment. For rotapuddling operation, effective field capacity and fuel consumption of power tiller with seating attachment were 0.098 ha/hr and 1.350 litres/hr respectively compared with the respective values for power tiller without seating attachment 0.099 ha/hr and 1.300 litres/hr. For dry rotatilling the effective field capacities of power tiller with and without seating attachment were 0.097 and 0.099 ha/hr when operated in the plots of more than 0.3 ha size. However, on per-day basis the toal area covered by power tiller with seating attachment was more, because the operator required less frequent rests of shorter duration (2 rest periods aggregating to 0.78 hr in a working day of 6.65 hr) compared with that without seating attachment (4 rest periods aggregating to 1.95 hr in a working day of 7.33 hr). Depth of operation was more uniform when power tiller was fitted with seating attachment, as the rotavator was restrained from coming out from the soil even at hard soil spots. Fuel consumption of power tiller with seating attachment during dry rotatilling was slightly more (1.280 litres/hr) than that of power tiller without seating attachment (1.200 litres/hr).

Key words : power tiller, seating attachment, field capacity, field efficiency, fuel consumption

The drudgery involved in the operation of power tillers and fatigue produced during the operation are major problems for power tiller operators, which ultimately reduce the productive capacity of man–machine system. While operating the power tiller with a 600 mm size rotavator at a field efficiency of more than 70–80%, an operator has to walk behind the tiller a distance of 20–25 km to cover 1 ha. This creates a lot of fatigue to the operator, and the operators often show reluctance in operating power tillers. Keeping these problems in view and to make power tiller an attractive power source, a seating attachment matching the rotary-type power tillers was designed and developed by Tiwari *et al.* (1995). The design of seating attachment is mainly based on the anthropometric data of Indian farm workers as reported by Gupta *et al.* (1983) and Gite and Yadav (1989), and general requirements of seat design as recommended by Murrel (1965) and Grandjean (1988). Power tiller equipped with seating attachment was field evaluated for land preparation under wetland and dryland conditions and its performance was compared with that of power tiller without seating attachment under similar soil conditions.

MATERIALS AND METHODS

The seating attachment to power tiller mainly consists of a trough-type metallic seat, a scooter wheel mounted on a vertical telescopic shaft for depth control, a hand-wheel mounted over the telescopic shaft to assist in controlled steering of power tiller on road as well as in the field and 2 foot-rests having provision for adjustment of popliteal height (Fig 1). The complete assembly is mounted over the upper longitudinal beam of power tiller rotavator with the help of 2 angle-iron braces and nut-bolts for easy attachment and detachment. The telescopic shaft, which is made of standard screw shaft, can be fixed at 3 vertical positions, one each for rotavating, for moving on farm road as well as on undulating ground surface. Further vertical adjustment of about 20 cm can be made at these positions by moving the shaft assembly as a whole and locking it at the desired height with the help of a latch.

The seating attachment was fitted to a 7.5 kW rotary-type power tiller. The power tiller was field evaluated in 1995–96 for the performance of rotavator and its performance was compared with that of power tiller without seating attachment for rotapuddling and rotatilling operations. The soil was black cotton with 55% clay, 30% silt and 15% sand. For rotapuddling operation the field was submerged with an average water depth of 10.00 cm. The average moisture content and bulk density of soil in the plots of dry rotatilling were 18.80% and 1.54 g/cc respectively. Average weed intensity on wet-weight basis was 873 g/m^2 in the plots where

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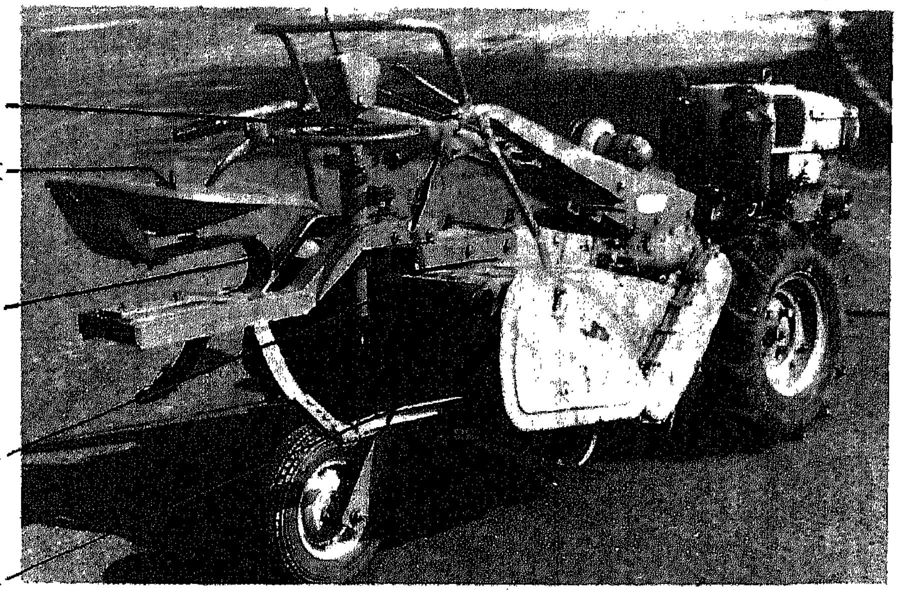

Fig 1 Power tiller with operator's seat

rotapuddling operations were conducted, compared with 65 g/m^2 in the plots of dry rotatilling operations.

The power tiller equipped with seating attachment was operated in the plots for rotapuddling as well as for dry rotatilling. The seat was then removed and the same power tiller without seating attachment was operated in other plots having similar soil conditions. Lugged iron wheels were used during rotapuddling operation, whereas pneumatic wheels were used during rotatilling operation. As per prevailing practice of operation, power tiller without seating attachment was operated adjacent to the previous pass by turning the power tiller by 180° at the ends, as the rear portion of power tiller could be lifted at turns. With seating attachment however, since lifting of rear portion was not convenient, the method of operation was followed similar to the operation by tractors in small blocks. The lever position of engine throttle was set to obtain three-fourths of rated engine speed (2 000 rpm). Tests were conducted in second low gear of power tiller with rotavator in low speed gear. Various performance parameters as specified by the Bureau of Indian Standards, New Delhi (BIS, New Delhi 1988) were recorded.

Power tiller rotavator with and without seating attachment was also evaluated in large-size (0.6 ha) plots for dry rotatilling to find out the area covered on per-day basis, when appropriate rest pauses were given to the operator to avoid any undue fatigue. The rest pauses to operator were given on the basis of subjective assessment. Under these tests the operator was asked to perform the rotatilling operation continuously as long as he could operate the power tiller with and without seating attachment. When the operator felt tired he was advised to

Table 1 Performance of power tiller rotavator with and without seating attachment during rotapuddling and rotatilling operations

Parameter	Rotapuddling		Rotatilling			
	With seating attachment	Without seating attachment	With seating attachment		Without seating attachment	
			First rotatilling	Second rotatilling	First rotatilling	Second rotatilling
Average weed intensity (wb) (g/m^2)	795	952	68		62	
Plot size (m^2)	989	751	1 050	1 050	1 050	1 050
Forward speed (m/sec)	0.55	0.53	0.53	0.52	0.55	0.54
Width of operation (cm)	60.00	60.00	67.75	67.5	67.25	67.50
Depth of operation (cm)	10.44	10.23	10.36	10.40	10.00	10.00
Duration of test (hr)	1.01	0.76	1.20	1.22	1.05	1.08
Effective field capacity (ha/hr)	0.098	0.099	0.088	0.086	0.100	0.097
Field efficiency (%)	82.90	85.94	68.23	67.88	75.10	74.07
Fuel consumed (litres/hr)	1.350	1.300	1.280	1.260	1.200	1.160

The depth of ponded water was 9.80 cm on rotapuddling with seating attachment and 9.85 cm without seating attachment; a low gear (II) was selected for operation take rest for a duration until he again felt fresh and was willing to operate the tiller. The process was continued for the whole day. Depth of operation was maintained similar in both the cases, ie power tiller with and without seating attachment. Total area covered during the whole day was measured. Time for work and rest periods was noted.

RESULTS AND DISCUSSION

Performance during rotapuddling

Performance results indicated that field capacities of power tiller rotavator with and without seating attachment during rotapuddling operation under submerged soil conditions were 0.098 and 0.099 ha/hr respectively (Table 1). The corresponding forward speeds were 1.97 and 1.92 km/hr. Field efficiency of power tiller with seating attachment was lower (82.90%) than that without seating attachment (85.94%). The major reason for low field efficiency with seating attachment was greater turning time than that without seating attachment. Fuel consumption of power tiller with seating attachment was slightly higher (1.350 litres/hr) than that without seating attachment (1.300 litres/hr). The result indicates that power tiller rotavator may be successfully operated with seating attachment without much effect on field capacity and fuel consumption with added advantage of operator's comfort. As per operator's opinion the seating attachment is better in terms of less spillage of wet soil over the operator and less tiredness. At spots of low water depth, however, little difficulty in turning the power tiller rotavator with seating attachment was observed. Power tiller with seating attachment should be operated under the conditions of sufficient water depth (>5 cm). At spots of low water depth the operator has to get down from seat to avoid bogging of power tiller.

Performance during dry rotatilling

The field performance of power tiller rotavator with and without seating attachment during dry rotatilling indicated lower effictive field capacity with seating attachment (0.088 and 0.086 ha/hr during first and second rotatilling respectively) than without seating attachment (0.100 and 0.097 ha/hr during first and second rotatilling respectively) when operated in plots of 0.1 ha with length and width ratio 1 : 1 (Table 1). The lower field capacity of power tiller rotavator with seating attachment was mainly because of more time lost during turning compared with power tiller without seating attachment.

Fuel consumption of power tiller rotavator with seating attachment was slightly more (1.280 litres/hr) in comparison with power tiller without seating attachment (1.200 litres/hr). The higher consumption of the former was due to more loading of power tiller engine, owing to maintenance of uniform depth of operation even at the spots of hard soil, more weeds and root stumps due to inability of power tiller rotavator to move out because of the weight of seat and operator. Another reason may be the pulling force required for pulling the operator's weight. Without seating attachment the general tendency of rotavator is to vary the operating depth with the variation in upward force due to different soil strengths. Under the very hard soil conditions when the upward force exceeds the weight applied by the operator on the handle, the power tiller without seating attachment completely moves out of the soil and runs forward at a speed much higher than the normal. Sometimes it even tilts forward, which may result in fatal accidents if the operator is not very much alert.

Table 2 Performance of power tiller rotavator for dry rotatilling with and without operator's seat during long-duration testing

Parameter	With seating attachment	Without seating attachment
Engine speed (rpm)	2 010	2 010
Forward speed (m/sec)	0.540	0.545
Width of operation (cm)	67.50	67.75
Depth of operation (cm)	12.0	11.0
Area covered (ha)	0.5722	0.5326
Total time required (hr)	6.65	7.33
No. of rest periods	2	4
Total duration of rest periods (hr)	0.78	1.95
Net duration of work (hr)	5.87	5.38
Ratio of work and rest periods	7.53	2.76
Field capacity [ha/day (8 hr)]	0.6848	0.5811
Fuel consumption (litres/hr)	1.500	1.450

Long-duration testing for dry rotatilling

Long-duration testing was conducted to find out the work output of man–machine system of power tiller rotavator with and without seating attachment for dry rotatilling. The work output of man–machine system on per-day basis was more with the seating attachment than without seating attachment (Table 2). Its reason is the higher ratio of work and rest periods compared with that without seating attachment. The operator was able to operate the power tiller rotavator with seating attachment with shorter and less frequent rests compared with that without seating attachment. In a day of 7.33 hr the operator required 4 rest periods aggregating to 1.95 hr and gave an output of 0.53 ha when operating the power tiller rotavator without seating attachment compared with an output of 0.57 ha in a working day of 6.65 hr with total rest period of 0.78 hr with seating attachment. In spite of longer and frequent rests during rotatilling without seating attachment the operator felt more pain in pelvis, shoulder, knee, thigh and whole vertebral column compared with rotatilling by power tiller with seating attachment. Higher fuel consuption during long-duration testing was owing to the pressure of stumps of indian mustard crop [*Brassica juncea* (L.) Czernj. & Cosson] in the test field and relatively less soil moisture content than that during field-performance tests.

Precautions

Since power tiller is basically a walking-type machine, precautions are essential while operating the machine with seating attachment. As the constant depth of operation is to be maintained even at the hard soil spots, depth of operation should be selected considering the limitations of power for maintaining the operating depth at these spots. Though the provision of seating attachment improves the longitudinal stability of power tiller, its lateral stability is reduced especially when the seat is at its highest position, road is uneven and taking turn at high forward speeds. Such situations must be taken care of and the wheel tread should be kept at its maximum to increase the lateral stability of the power tiller.

Conclusions

The field capacity of power tiller rotavator with seating attachment will remain unaffected if operated in plots of bigger size (> 0.30 ha size); however, in smaller plots the field capacity will be lower with seating attachment than without seating attachment. For rotapuddling operation effective field capacity and fuel consumption of power tiller with seating attachment were 0.098 ha/hr and 1.350 litres/hr respectively, and for power tiller without seating attachment 0.099 ha/hr and 1.300 litres/hr. For dry rotatilling the effective field capacities of power tiller with and without seating attachment were 0.097 and 0.099 ha/hr when operated in the plots of more than 0.3 ha size. Depth of operation was more uniform when power tiller was fitted with seating attachment. Fuel consumption of power tiller with seating attachment during dry rotatilling was slightly more (1.280 litre/ha) than that of power tiller without seating attachment (1.200 litres/hr).

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Genetic parameters of radiation-induced variability and appropriate mutagenic generation of effective selection for seed yield, harvest index and seeds per pod in kidney bean (*Phaseolus vulgaris*)*

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Key words : induced mutation, radiation, gamma-rays, kidney bean, *Phaseolus vulgaris*

Mutation breeding is a valuable supplementary approach in kidney bean or *rajmash* (*Phaseolus vulgaris* L.), where interspecific and inter-varietal incompatibility pose problem in getting desired recombinants (Singh 1991). Biotechnologically also kidney bean is a problematic crop for its improvement. In such a situation induced mutation can prove fruitful for improving 1 or a few traits of the existing and adaped varieties. Among various mutagens, radiation has been used commonly for the induction of variations and resulted in the development of new varieties (Micke *et al.* 1990). Hence the gamma-rays were used in the present investigation to know the nature of induced variability and the appropriate stage of effective selection in kidney bean.

The experiment was conducted with 2 adapted varieities, 'Jawala' and 'HPR 35', of kidney bean. For each variety 200 dry seeds under each dose were irradiated with 5, 10 and 15 kR doses of gamma-rays at the Indian Agricultural Research Institute, New Delhi. The irradiated seeds were sown to raise M_1 generation. The surviving M_1 plants were harvested separately and sown in single-plant completely randomized design to raise M_2 generation at the experimental farm of the department of Plant Breeding and Genetics at Palampur during summer 1991. The single plants of M_2 generation were harvested separately and sown in completely randomized block design to raise M_3 generation at Research Substation, Katrain, during summer 1992. Data in M_2 were recorded on single-plant basis, whereas in M_3 on the available or 5 randomly selected plants for seed yield/plant (g), harvest index (%) and seeds/pod. Dose-wise analysis based on individual plant in each generation was carried out. The data were analysed statistically as per Johanson *et al.* (1955) and Yonezawa (1979). Yonezawa (1979) advocated the use of M_3 generation for estimation of parameters of induced variability for better reliability, and the same approach was followed in the present study, though the use of M_2 generation was also made wherever required. The parameters of variability were not computed where mean sum was non-significant.

Analysis of variance indicated the induction of sufficient genetic variability for seed yield/plant, harvest index and seeds/pod. The results obtained on the parameters of induced variability in M_3 of 'Jawala' and 'HPR 35' varieties under different radiation doses (Table 1) showed increased variation for seed yield and related traits. In the present investigation phenotypic coefficient of variation (pcv) and genotypic coefficient of variation (gcv) were higher within the lines than between lines under different radiation doses for both the varieties (Table 1). High magnitudes (>20%) of pcv and gcv were observed in almost all the cases. In general, pcv and gcv estimates were high under 10 kR dose for 'Jawala', whereas no particular trend was evident for 'HPR 35' variety.

Another parameter of variability that needs consideration for the induced polygenic variation is the heritability, ie the magnitude of genetic variance generated or induced. In the present study heritability estimates were low to high and these were higher within lines than between lines (Table 1). This indicates that selection would be more effective within lines in this generation.

Johanson *et al.* (1955) indicated that for estimating the real effect of selection, heritability along with genetic advance is more useful. The estimates of genetic advance expressed as percentage of parental mean were very high for the most traits between and within lines in both the varieties (Table 1). However, these estimates were low in between lines for seed yield under 10 kR for 'Jawala' and seed yield and harvest index under 5 kR for 'HPR 35'. High genetic advance along with high heritability were observed in some. More than 100% genetic advance over the parent was noticed within lines for seed/pod under 5 kR in 'HPR 35'. Several earlier workers also observed an increase in genetic parameters in mutagenized populations of grain-legume crops, viz Williams and Hanway (1961) in soybean [*Glycine max* (L.) Merr.], Malik (1988) in greengram (*Phaseolus radiatus* L.), Kalia and Gupta (1989) in lentil

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Table 1 Estimates of parameters of variability under different doses of gamma-rays in M_3 generation of kidney bean varieties 'Jawala' and 'HPR 35'

Treatment	Shift in mean		pcv (%)	gcv (%)	Heritability (%)	GA (%) based on parental mean
			Seed yield / plant			
'Jawala'						
5 kR	–4.18*	A				
		B	44.20	37.12	70.58	28.39
10 kR	–4.01*	A	27.73	15.76	32.33	8.58
		B	48.08	42.33	77.50	35.67
15 kR	–4.34*	A				
		B	51.87	45.34	76.40	34.34
'HPR 35'						
5 kR	–0.78	A	30.40	15.12	24.74	13.32
		B				
10 kR	0.42	A				
		B				
15 kR	–1.37*	A				
		B				
			Harvest index			
'Jawala'						
5 kR	–1.34*	A				
		B	29.84	25.11	72.52	43.01
10 kR	–1.97*	A				
		B	29.48	24.82	70.88	40.94
15 kR	0.92	A				
		B	37.36	34.01	82.86	62.24
'HPR 35'						
5 kR	–10.49*	A	16.89	8.37	24.55	6.83
		B				
10 kR	–4.47*	A				
		B				
15 kR	–8.61*	A				
		B	27.90	24.11	74.67	35.83
			Seeds/pod			
'Jawala'						
5 kR	–0.47*	A				
		B	35.84	35.51	82.28	51.22
10 kR	–0.26	A				
		B	28.50	25.20	76.87	41.67
15 kR	–0.51*	A				
		B	29.55	21.48	73.00	36.80
'HPR 35'						
5 kR	–0.07	A				
		B	91.31	90.14	97.44	178.73
10 kR	0.06	A				
		B				
15 kR	0.01	A				
		B	26.08	21.88	70.37	37.91

A, Between lines; B, within lines; pcv, phenotypic coefficient of variation; gcv, genotypic coefficient of variation $P \leq 0.05$

(*Lens culinaris* Medikus), Gupta *et al.* (1996) in horsegram (*Macrotyloma uniflorum* L.)

Different doses of gamma-rays showed relationship with shift in mean of irradiated population from its parental mean. The shift of mean in M_3 of 'Jawala' (Table 1) under different doses was negative for most of the traits, as also reported by Crocomo *et al.* (1978) in kidney bean. In 'HPR 35' under all the doses the shift in mean in M_3 was either neutral or toward negative direction. As per Brock (1965), the theoretical expectation of inducing random micromutations

Table 2 Frequency (%) of lines showing significant within-line variance and significant shift in mean in kidney bean varieties 'Jawala' and 'HPR 35'

Dose		Seed yield/plant		Harvest index		Seeds/pod	
		M_2	M_3	M_2	M_3	M_2	M_3
'Jawala'							
5 kR	A	75.00	33.33		33.33	50.00	33.33
	B	12.50$^{\vee}$	10.00$^{@}$	2.50$^{\vee}$	33.33$^{@}$	7.50$^{\vee}$	50.00$^{@}$
		30.00$^{@}$				7.50$^{@}$	
10 kR	A	64.29	75.00		50.00	50.00	50.00
	B	57.14$^{@}$	75.00$^{@}$	7.14$^{\vee}$	14.29$^{@}$	50.00$^{\vee}$	24.00$^{@}$
				7.14$^{@}$		50.00$^{@}$	
15 kR	A	60.00	31.25		50.00	20.00	50.00
	B	20.00$^{\vee}$	87.50$^{@}$	20.00$^{\vee}$	37.50$^{@}$	20.00$^{\vee}$	62.50$^{@}$
		60.00$^{@}$				40.00$^{@}$	
'HPR 35'							
5 kR	A	53.13	21.43		35.71		35.71
	B	25.00$^{\vee}$	28.57$^{\vee}$		7.14$^{\vee}$		35.71$^{@}$
		43.75$^{@}$	7.14$^{@}$		50.00$^{@}$		
10 kR	A	48.13	25.00		12.50		
	B	30.00$^{\vee}$	62.50$^{\vee}$		12.50$^{@}$		12.50$^{@}$
		20.00$^{@}$					
15 kR	A	20.00	22.22		37.04		33.33
	B	60.00$^{@}$	11.11$^{\vee}$		37.04$^{@}$		22.22$^{@}$
			18.52$^{@}$				

A, Frequency (%) of lines with significant within-line variance; B, frequency (%) of lines with significant shift in mean; $^{\vee}$ significant positive shift in mean; $^{@}$ significant negative shift in mean

in self-fertilizing species with large number of genes, each having small individual positive or negative effect for a particular trait, will depend on the total number of genes involved or the realtive proportion of genes with positive or negative effect and on the degree to which the genes of the parental genome operate in balanced set. In such cases random mutation may increase the variation and shift the mean away from the direction of previous selection history. Higher the selected or adapted traits, greater will be the shift in mean and also asymmetry of distribution of variances. In the present study, Brock's hypothesis fitted well in M_3 generation under different doses for almost all the 3 traits in 'Jawala' and for harvest index in 'HPR 35' (Table 1). Shift in the mean further indicated differential radio-sensitivity of the 2 varieties studied.

In M_2 generation of 'Jawala', 75% lines under 5 kR, 64.29% lines under 10 kR and 60% lines under 15 kR dose showed significant variance within line for seed yield (Table 2). None of the lines under any level showed significant variance within line for harvest index in M_2 of 'Jawala'. Under 5, 10 and 15 kR doses 33.33, 75, 31.25% lines respectively showed the induction of significant variation within line for seed yield in M_3 of 'Jawala'. In M_2 of 'HPR 35', 53.13% lines under 5 kR, 48.33% lines under 10 kR and 20% lines under 15 kR showed significant variation within line for seed yield (Table 2), whereas the rest of the traits did not show significant variation within line under any dose. Further, 21.43% lines under 5 kR, 25% lines under 10 kR and 22.22% lines under 15 kR dose showed significant variation within line for seed yield in M_3 of 'HPR 35'. However, significant variation within line was not observed for any line under 10 kR for seeds/pod in M_3 generation of 'HPR 35'.

In 'Jawala' seed yield and seeds/pod in M_2 and M_3 and harvest index in M_3 followed Brock's hypothesis under almost all the doses and in 'HPR 35' it was operational for seed yield in M_2 and M_3 under all the doses (Table 2).

Estimates of heritability within the line were very high for most of the traits, including seed yield in M_2 generation of both the varieties at all doses. However, these estimates were moderate to very high under different doses in M_3 generation in both the varieties. The estimates of genetic advance of parental mean (%) were moderate to very high for different lines under different doses in M_2 and M_3 of both the varieties. These estimates were very high (>50%) for seed yield under all the doses in M_2 for 'Jawala' and high (>30%) for all the lines under all the doses in M_3. The estimates of genetic advance for 'HPR 35' were also high for all the lines for seed yield under all the doses in M_2. A majority of the lines showed more than 100% genetic advance. In M_3 of 'HPR 35', very high genetic advance was observed for all the lines for seed yield under all the doses.

Therefore it was concluded that selection within line would be more effective than between lines, and such a selection should be practised in generations from M_3 onward as also reported by Yonezawa (1979).

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Cauliflower (*Brassica oleracea* var *botrytis*) genotypes for May–June maturity under north Indian plains*

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Cauliflower [*Brassica oleracea* L. convar *botrytis* (L.) Aleb. var *botrytis* L.] is highly thermo-sensitive for curd initiation and development. Depending on the seasonal temperature, cauliflower is sown during May–November, which starts forming marketable curds from September–November to March at a temperature of 10–27°C under north Indian conditions (Chatterjee and Swarup 1983, Gill 1989, Lal 1993). The present study was taken up to breed a cauliflower variety suitable for May–June maturity when mean temperature is 30–35°C.

Available germplasm of early cauliflower comprising 63 genotypes was used, viz 'Early Kuwari', 'First Crop Ageti', 'Pusa Early Synthetic', 'Pusa Katki', 'Sel 23-7', 'Sel 41-5', 'Sel 98-4', 'Pusa Deepali', 'Sel 97-4', 'Sel 41', 'Sel 98-1', 'Jawahar Moti', 'Sel 100', 'Sel 110', 'Sel 99', 'Sel 96-4', 'JM 92', 'Sel 819', 'Sel 824', 'Sel 9', 'Sel 98-10', 'Sel 5', 'Sel 820', 'Sel 98-7', 'Sel 10', 'Katiki Manoj', 'KW 1', 'KW 2', 'Katiki Span', 'xx', 'vv', 'aa', 'Sel 351', 'Sel 113', 'Sel 114', 'Sel 328', 'CC 12', 'CC 13', 'CC 14', 'CC 15', 'Hissar 1', 'Sel 327-14-8-3-1', 'Sel 327-14-8-3-2', '395 EE-1', '395 EE-2', '754', '327-14-4-17', '327-14-4-17-2', 'Puakea', 'Katiki Jamun White', 'Sel 33-8', 'Kuwari Raj Beej', 'Kanchan Kuwari', 'Sel 1', 'Early Verma', 'Summer Sweet Heart', 'Phaguni Swarn', '395-2', 'Early Market', 'Summer Deep', 'KD 1', 'KD 2' and 'KD 7. It was sown at weekly intervals starting from the first to fourth week of February during 1991 and 1992. Seedlings of each sowing at 5 weeks were transplanted in observational rows to work out the optimum sowing period and simultaneously identify promising genotypes. On the basis of better performance during 1991 and 1992, 15 genotypes including 'Pusa Early Synthetic' as the control were evaluated in a replicated trial during 1993 and 1994. The crop was sown on 16 February 1993 and 25 February 1994 and transplanted on 30 March 1993 and 2 April 1994 respectively at a spacing of 30 cm × 45 cm. During both the years the experiment was laid out in randomized block design with 3 replications. Observations were recorded on curd weight, yield/plot, ricey curds, harvest index, number of non-curding plants, buttons and leaves/plant. Colour and compactness of the curds were also studied.

Twenty-six genotypes failed to produce marketable curds in any of the sowings in 1991 and 1992. This can be attributed to the lower temperature requirement of these genotypes for curd initiation and development, which was absent during this period. Buttoning was observed in the remaining 37 genotypes either before or after transplanting in the first or second sowing in 1991, as also in 1992. The crop sown during third and fourth weeks of February and transplanted by the end of March or begining or April, when the average temperature was 16 and 21°C respectively, gave better performance. The curds were ready for harvesting either from the end of May or begining of June and continued till the end of June when the temperature was 30–35°C; hence this may be the optimum sowing and transplanting time under north Indian plains. Sowing and transplanting after this period resulted in poor curd quality, having bracts and late maturity; these curds were also prone to rotting caused by monsoon rains during July. Development of bracteate curds can be attributed to the available higher temperature after the curd initiation suitable for vegetative growth (Nieuwhof 1969, Wiebe 1984, Chatterjee 1986).

All the enteries were superior to the control 'Pusa Early Synthetic' for most of the characters (Table 1). 'Sel 23-7' was on top for yield (868 kg/ha) and low buttons (6.24%) but had cream-coloured curd, followed by 'Sel 98-4' and 'Sel 41-5' with white curds. The former was also superiormost for curd weight (276 g). All the 3 lines were at par for curd compactness, harvest index, ricey and non-curding plants. All the lines showed variation in maturity period; except 'Sel 23-7', other genotypes showed a lot of variation in all the studied characters due to interaction of years. 'Sel 98-4' and 'Sel 41-5' also gave better performance for September maturity in the last 3 years.

To minimize disorders like riceyness, buttoning, bracting and non-curding plants, *in-vitro* clonal propagation (Kumar *et al.* 1994) of the selected plants in promising lines may be followed, since normal bolting, flowering and seed setting are not possible under prevailing high temperature and rainfall

* Short note

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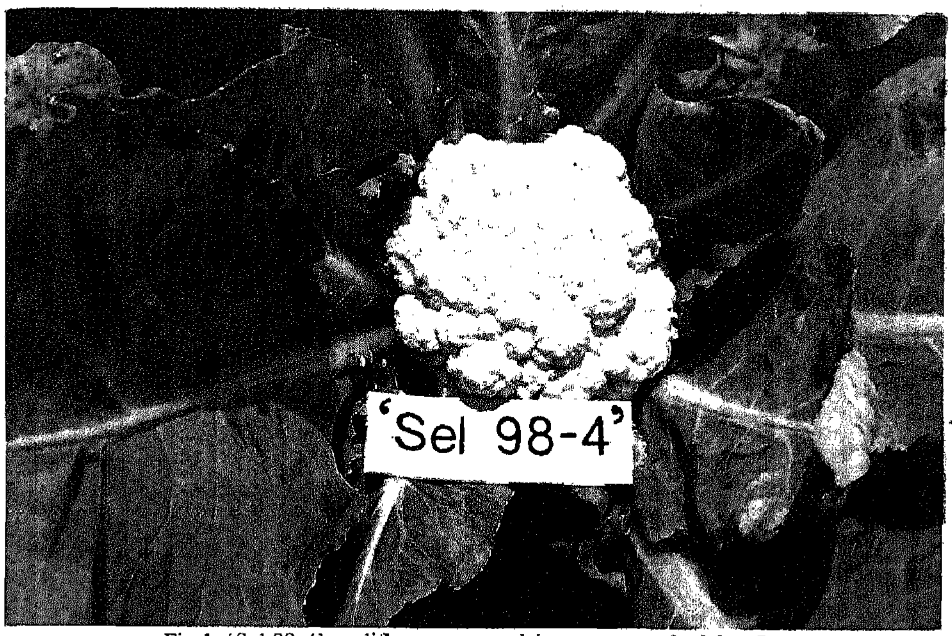

Fig 1 'Sel 98-4' cauliflower, a promising genotype for May–June

Table 1 Mean performance of cauliflower genotypes maturing in May–June (1993 and 1994)

Genotype	Yield (kg/plant)	Calculated yield (kg/ha)	Curd weight (g)	Harvest index	Non-curding plant (%)	Buttons (%)	Ricey curds (%)	Leaves/ plants	Curd colour	Curd compactness
'Sel 23-7'	8.68	8 680	261.67	25.01	10.84	6.24	5.17	17.00	Creamish	Compact
'Sel 41-5'	6.50	6 500	220.00	25.08	10.40	13.07	4.33	18.67	White	Compact
'Sel 98-4'	6.97	6 970	276.67	27.82	14.39	16.31	9.83	20.33	White	Compact
'Sel 33-8'	3.94	3 940	267.50	24.41	27.67	20.32	38.50	19.33	Creamish	Compact
'Sel 10'	3.52	3 520	260.00	22.25	33.50	18.12	30.50	21.67	Creamish	Compact
'Sel 820-13'	2.43	2 430	165.00	22.48	28.66	27.95	16.67	20.67	Creamish	Compact
'Sel 113'	2.17	2 170	140.00	20.61	19.72	26.52	30.17	18.33	Yellow	Less compact
'Sel 98-7'	4.99	4 990	221.67	22.56	19.80	19.17	8.33	17.17	White	Compact
'Sel 754'	2.49	2 490	221.67	27.09	37.83	15.52	31.33	18.17	Creamish	Less compact
'Sel 98-1'	6.73	6 730	238.33	22.09	3.54	16.17	8.17	18.67	White	Compact
'Sel 41'	5.59	5 590	196.67	25.35	12.47	11.99	6.67	19.17	Creamy white	Compact
'Sel 92'	3.63	3 630	226.67	23.39	23.50	23.77	22.50	17.17	Yellow	Loose
'Sel 98-10'	5.71	5 710	213.33	27.17	14.85	15.00	11.67	18.33	White	Compact
'Sel 110'	2.29	2 290	193.33	21.33	32.51	22.50	36.33	19.33	Yellow	Loose
'Pusa Early Synthetic'	1.50	1 500	175.00	18.13	32.27	30.73	46.83	23.33	Yellow	Loose
C D (P=0.05)	1.00	1 000	27.70	3.83	11.48	6.77	5.81	2.41		

in this season. Hybrids or newer varieties can be bred involving these lines to achieve higher yields, uniform maturity and plant type. The available superior genotypes can only be fitted from August–December to March when the mean temperature is less than 27°C (Gill 1989, Lal 1993, Singh *et al.* 1994). Till better hybrids are evolved, 'Sel 23-7', 'Sel 98-4' and 'Sel 41-5' may be considered for May–June maturity period (when average temperature is 30–34°C), as there is no genotype available for this temperature range and season.

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Response of maize (*Zea mays*) hybrid and composite to different levels of nitrogen

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Key words : maize, nitrogen, genotypes, *Zea mays*

A field experiment was conducted at Rajendranagar, Hyderabad, in rainy season (*kharif*) 1993 to study the performance of newly released hybrid 'DHM 107' of maize (*Zea mays* L.) in comparison with the control composite 'Varun' at different levels of nitrogen. The experimental soil was sandy loam, with *p*H 7.6, electrical conductivity 0.28 dS/m, low in available N (271 kg/ha), low in phosphorus (8 kg/ha) and high in potassium (258 kg/ha). There were 10 treatment combinations involving 5 levels of nitrogen (0, 40, 80, 120 and 160 kg/ha) and 2 genotypes (hybrid 'DHM 107' and composite 'Varun'). The experiment was tested in split-plot design with N levels in main plots and genotypes in subplots, with 4 replications. The crop was sown on 6 July 1993 adopting a inter-row spacing 60 cm and intra-row spacing 25 cm. The plot size was 6 m × 4 m. All the experimental units received a uniform dose of 26.2 kg P/ha and 33.3 kg K/ha basal. N was applied as per treatment in 3 equal splits, ie basal, at knee-high stage (24 days after sowing) and at pre-tasselling (44 days after sowing). The crop was harvested on 8 October 1993.

Other recommended plant-production (weed-control) and plant-protection (pest-and- disease control) measures were adhered to. The total rainfall received during the experimental period was 388.7 mm in 26 rainy days.

Application of 160 kg N/ha gave the highest grain yield but it was statistically at par with 120 kg N/ha and significantly superior to other N levels (Table 1). This trend could be traced to similar variation in growth and yield attributes under these treatments. Adequate supply of N might have helped the maize plants to increase their growth, which in turn put forth more photosynthetic surface and leaf-area index (LAI), thus contributing more dry matter. Parthasarathy *et al.* (1984) reported that the LAI was the growth characteristic that limited the rate of dry-matter accumulation of maize under inadequate N supply. Improved vegetative structures (plant height, LAI and dry matter) favoured the early formation of reproductive structures, as evident from the advancement of silking under 120 and 160

* Short note

Based on complete M Sc thesis of the first author submitted to Andhra Pradesh Agricultural University, Hyderabad, in 1994 (unpublished).

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Table 1 Growth, yield attributes and yield of maize as influenced by nitrogen and genotypes

Treatment	Plant height (cm)	LAI	Dry matter (g/plant)	Days to 50% silking	Cobs/ plant	Cob length (cm)	Grain rows/ cob	Grain weight/ cob (g)	Cob weight (g)	Shelling (%)	Grain yield (kg/ha)	Harvest index (%)	Protein content (%)
N (kg/ha)													
0	124.5	1.16	85.1	63.65	0.90	9.5	10.90	34.5	70.7	48.8	1 675	19.6	9.65
40	152.4	1.61	92.0	60.75	1.06	11.7	12.31	41.2	78.3	52.6	2 095	22.7	10.53
80	167.0	1.67	106.4	58.25	1.11	13.8	13.52	53.4	89.2	59.8	3 208	34.2	11.22
120	179.3	1.70	119.4	55.75	1.13	15.7	14.75	68.8	97.5	70.5	4 240	35.5	11.72
160	179.6	1.72	122.9	55.25	1.13	15.8	15.80	68.8	97.6	70.5	4 357	35.5	11.78
S Em±	1.8	0.013	1.25	0.64	0.03	0.15	0.15	0.7	1.0	0.7	59	0.37	0.12
CD(*P*=0.05)	5.4	0.040	3.76	1.97	0.08	0.46	0.45	2.2	3.0	2.2	180	1.15	0.38
Genotype													
'DHM 107'	156.2	1.67	115.7	57.91	1.10	13.4	14.01	56.3	88.2	62.6	3 452	29.1	11.24
'Varun'	164.9	1.48	94.6	59.52	1.05	13.2	12.43	50.3	85.0	58.2	2 778	28.3	10.73
S Em±	1.11	0.01	0.7	0.35	0.02	0.11	0.10	0.42	0.65	0.44	36	0.21	0.08
CD(*P*=0.05)	3.35	0.04	2.2	1.06	NS	NS	0.32	1.26	1.96	1.34	110	0.62	0.23

LAI, Leaf-area index

kg N/ha by 7.9 and 8.4 days respectively in comparison with the crop in no-N treatment (the control). Paradkar and Sharma (1993) reported similar finding. The early set sink in conjunction with accumulated photosynthates might have been responsible for cobs with greater size. Likewise the grain number was significantly high under 120 and 160 kg N/ha treatments. Therefore the higher grain number could be accounted for increased cob size. The higher test weight was associated with the crop under 120 and 160 kg N/ha in comparison with other levels.

The result emphasizes the importance of adequate N supply for the crop for obtaining large-size cobs having more grains, with heavier and bold seeds that contribute to higher harvest indices and in turn higher grain yield.

The cumulative effect of all these growth and yield components were reflected in maize yield, and the effect of adequate N supply was well marked. Application of adequate N not only increased the yield but also improved the quality of grain, as evident from the higher protein content in grain under 120 and 160 kg N/ha treatments. This is logical since N forms the principal constituent of protein molecule (Swamy *et al.* 1989).

Significant differences in grain yield between 'DHM 107' and 'Varun' were noticed in the present study. The former gave significantly more yield than the latter, perhaps due to its higher genetic production potential.

The shelling (%) and harvest index was also more in 'DHM 107' when compared with 'Varun'. The superiority of former to the latter could also be due to its inherent efficient sink mechanism. The interaction between nitrogen × genotypes was found non-significant.

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Critical level of deficiency for predicting response to manganese application of *egyptian clover* (*Trifolium alexandrinum*) on Typic Ustochrepts*

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Key words : critical deficiency level, manganese, egyptian clover, *Trifolium alexandrinum*

Manganese has attained significance next to N, P and Zn in coarse-textured alkaline soils of Punjab, and its deficiency was observed in egyptian clover or *berseem* (*Trifolium alexandrinum* Juslen.) grown on such soils cropped with rice (*Oryza sativa* L.) for more than 5 years (Takkar and Nayyar 1981). The deficiency has resulted from leaching losses of Mn and on account of solubility during soil submergence for rice. Egyptian clover is a medium sensitive crop to Mn deficiency and is an important fodder crop of this region during winter season (*rabi*), giving highly nutritious and palatable fodder for animals. Although the response of barley (*Hordeum vulgare* L.) and cereal crops to Mn fertilization in such soils has been reported (Nayyar *et al.* 1985, Bansal *et al.* 1987), no information is available on the Mn requirement of *berseem* grown in coarse-textured alkaline soils and its critical level; hence a study was conducted.

Forty bulk soil samples, belonging to great group Typic Ustochrepts (0–15 cm), representing a range in DTPA-extractable Mn, were collected from Ludhiana. Each soil was air-dried and ground to pass through a 2 mm sieve. A greenhouse pot-culture experiment was conducted with 'BL 1' *berseem*, as a test crop during winter season of 1993. In polyethylene-lined pot, 4 kg of each soil sample was filled. Each soil was treated uniformly with a solution supplying 25, 32 and 5 mg/kg soil of elemental N, P and Zn respectively. All the soils were adequate in Cu, Fe and B. Manganese in each soil was added @ 0, 20 and 40 mg/kg soil as $MnSO_4.H_2O$ solution. There were 3 replicates. Twenty seeds were sown in each pot and were thinned to 10 after emergence. The soil was initially adjusted to approximately 60% of the saturation percentage moisture content and the pots were subsequently watered as and when required.

The plants were harvested at 50 days by cutting at the soil surface. These were washed successively with 0.1 N HCl solution, rinsed with deionized water, dried at 70°C, and their weight was recorded. The samples were ground in a Wiley mill fitted with stainless steel blades to pass through a 20-mesh sieve. The plant samples were wet washed with a triple acid mixture containing HNO_3, $HClO_4$ and H_2SO_4 in the ratio 9 : 3 : 1 as per procedure described by Piper (1966). Manganese in the soil filtrates and plant extracts was measured by atomic-absorption spectrophotometery.

Bray's yield (%) as well as Mn uptake were chosen to evaluate the parameter of Mn availability in the soil, calculated as:

$$\frac{\text{Yield or Mn uptake without Mn}}{\text{Yield of Mn uptake with optimum Mn}} \times 100$$

The critical deficiency level of Mn in soil and plant was determined by the procedures of Cate and Nelson (1965, 1971).

The soils were coarse in texture, ls–sl; neutral to alkaline; *p*H 8.2–8.7; low to medium in organic carbon, 0.12–0.52%; non-calcareous; $CaCO_3$, 0.3–1.0%; low to medium in available P, 2.2–8.2 mg/kg; and adequate in potassium, 62–240 mg/kg. The soil-available Mn in the untreated soils was 0.96–7.10 mg/kg soil. Consequently the dry-matter yield and Mn concentration in different soils varied greatly (Table 1). In the soils containing 0.96, 1.14, 1.78, 1.86 and 2.58 mg Mn/kg soil, the plants in the control pots showed visible symptoms of Mn deficiency at 20 days of growth. The mid-stem leaves showed grey to yellow mottling, leaving a small region around the margins and one-third area from the base that remained green. Later these spots spread on the entire leaf and developed pinkish brown buff colour, which coalesced to form necrotic lesions.

The DTPA-extractable soil Mn was significantly correlated with Bray's dry-matter yield (%) (r = 0.80**), Bray's Mn uptake (%) (r = 0.90**) and dry-matter yield (r = 78**) as well as Mn content of plants (r = 0.88**) grown in the control treatments, indicating that the DTPA extractant was a good indicator of soil-Mn status. The critical deficiency level of DTPA-extractable Mn, calculated by the relationship between Bray's yield (%) and DTPA-Mn by the graphical method of Cate and Nelson (1965), was 2.94 mg DTPA-Mn/kg soil (Fig 1 *left*). Using the statistical model of Cate and Nelson (1971) the same critical value was found. Considering that a soil giving 85% maximum yield or more than that without Mn application is non-responsive to applied Mn, 82% soils containing 2.94 mg Mn/kg soil or less

*Short note

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Table 1 Effect of manganese application on yield and concentration of Mn by berseem

DTPA-extractable Mn (mg/kg soil)	Dry-matter yield (g/pot) at			Bray's yield (%)	Mn concentration (μg/g) at		
	0 mg Mn/pot	20 mg Mn/pot	40 mg Mn/pot		0 mg Mn/pot	20 mg Mn/pot	40 mg Mn/pot
0.96	3.2	5.2	6.4	50	13.1	28.1	33.0
1.10	4.3	7.8	7.3	55	15.3	24.7	26.7
1.14	2.5	5.2	7.6	33	12.4	20.7	33.0
1.36	4.3	5.0	6.5	66	9.3	15.2	20.9
1.46	5.0	5.1	5.5	91	12.0	26.7	44.0
1.60	5.0	6.6	6.4	76	14.0	32.0	37.3
1.66	5.6	6.3	7.2	78	18.0	33.3	40.7
1.78	3.7	6.5	7.0	53	10.3	16.3	27.3
1.86	4.0	5.1	5.6	71	14.3	18.0	28.0
1.90	5.6	7.0	6.8	80	22.0	27.0	37.0
1.98	6.8	7.5	8.1	84	16.3	25.0	33.4
2.04	5.1	6.2	6.3	81	13.0	23.0	29.0
2.18	4.2	6.0	5.5	76	17.4	21.7	28.0
2.20	4.5	5.0	5.2	86	15.3	24.0	33.3
2.28	5.3	5.8	7.2	74	13.8	20.7	25.0
2.38	4.5	4.9	5.0	90	21.7	28.0	34.0
2.54	5.1	6.7	7.2	71	18.0	26.7	36.7
2.58	3.8	4.7	4.9	77	16.0	23.0	29.0
2.60	4.5	5.0	6.1	74	17.7	31.0	37.0
2.64	6.1	6.5	7.4	82	14.0	25.0	32.0
2.84	5.4	6.1	6.2	87	20.7	24.0	31.0
2.88	5.5	6.4	7.0	79	14.7	16.2	20.3
3.00	5.4	5.5	6.2	87	22.6	27.0	36.0
3.10	5.5	5.7	5.9	93	28.0	34.0	38.0
3.26	7.6	7.9	7.1	96	25.0	27.3	36.0
3.34	5.3	6.0	7.3	73	23.8	38.0	41.0
3.36	4.7	5.6	5.5	84	25.7	33.0	37.0
3.62	5.7	5.8	6.6	86	25.7	33.0	40.0
4.02	7.1	7.8	7.7	91	37.3	51.7	53.2
4.24	6.0	6.5	6.9	87	20.3	29.3	36.0
4.34	7.9	8.1	8.4	94	26.3	32.0	34.0
4.86	5.6	5.8	5.8	96	24.3	32.0	35.0
5.04	6.6	6.9	7.7	80	31.0	30.3	31.7
5.20	6.7	6.8	7.0	96	26.0	28.0	30.0
5.48	6.3	6.6	6.9	91	33.4	48.2	50.3
5.52	8.0	8.4	8.2	95	25.3	28.0	29.0
5.92	7.1	6.6	6.8	107	36.0	50.0	48.2
6.18	6.0	6.2	5.8	104	35.3	36.3	37.0
6.48	7.8	7.0	7.7	111	36.0	40.3	45.0
7.10	11.2	11.1	9.5	118	42.0	44.3	46.0
Means	5.6	6.4	6.7		21.7	28.2	33.8

LSD (0.05) : Dry-matter yield, for Mn level = 0.5; manganese conc. for Mn level = 4.0

responded to Mn application. The response to Mn application was observed in only 11% soils containing more than 2.94 mg Mn/kg soil, thus indicating a 85% predictive value of the critical level established by DTPA method. Several workers have reported different critical values of Mn in the soils and crops. Bansal *et al.* (1987) reported 2.05 mg/kg DTPA-extractable Mn for Ustipsamments and Ustifluvents soils for barley (*Hordeum vulgure* L.), whereas Gajendragadkar and Rathore (1988) reported 5.3 mg/kg DTPA-Mn for Entisol in predicting the response of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) to Mn.

Berseem responded significantly to the application of 20 mg Mn/kg soil, testing 2.94 mg/kg DTPA-Mn. Above this level the responses were non-significant (Table 1). The increase in the dry-matter yield over the control with Mn fertilization in deficient soils varied from 0.5 to 3.2 g/pot with a mean value of 1.8 g/pot, whereas in Mn-sufficient soils the increase in dry-matter yield ranged from 0 to 2.0 g/pot with a

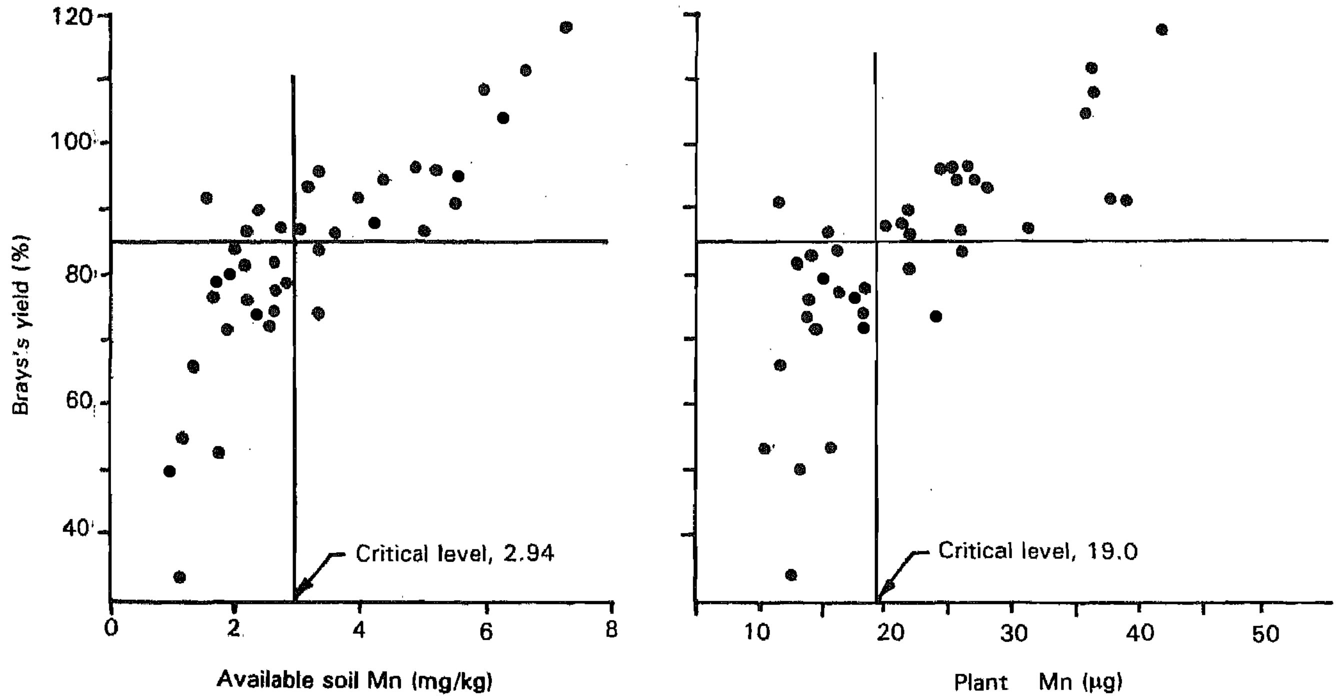

Fig 1 Critical level of Mn in soil and plants of berseem

mean value of 0.5 g/pot. This indicates that in deficient soils the increase in yield was 3.4-fold more than in sufficient soils. Eighteen of the 22 deficient soils responded to Mn fertilization, and out of these soils sufficient in Mn only 2 responded to Mn. In the Mn-deficient soils the mean dry-matter yield in the control treatment was 4.7 g/pot, whereas in sufficient soils it was 6.7 g/pot. This low dry-matter yield in the former might have resulted from the impaired photosynthesis, as Mn is involved in the Hill reaction activity (Bottrill *et al.* 1979, Ohki 1982).

Mn application sharply increased the Mn concentration of the plant in Mn-deficient soils, 2-fold on an average, at the highest rate of Mn application. The range of Mn concentration in plants grown on deficient soils was 10.3–21.7 µg/g, which increased to 15.3–40.7 µg/g in Mn-treated pots. The increase in the Mn concentration of the plant from its application was more marked in the soils low in native Mn.

According to the graphical (Fig 1 *right*) and statistical methods of Cate and Nelson (1965, 1971), the critical deficiency level of Mn in the plants at 50 days, below which the response to Mn fertilization could be expected, was 19.0 µg/g dry matter. This critical level gave a predictive value of 90%. The Mn content in the plants grown in the control treatments was also significantly correlated to both Bray's yield (%) ($r = 0.75^{**}$) and Mn uptake (%) ($r = 0.86^{**}$). Nable *et al.* (1984) determined a critical concentration of 20 µg/g dry matter in young leaf blade of subterranean clover (*Trifolium subterraneum* L.) from a close correlation with evolution of photosynthetic oxygen.

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Indian Journal of Agricultural Sciences 67 (9) : 429–30, September 1997

Response of winter-season groundunt (*Arachis hypogaea*) to calcium, sulphur and zinc

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Key words : winter groundnut, micronutrients, *Arachis hypogaea*

In addition to nitrogen, phosphorus and potassium, calcium, sulphur and zinc play significant role in nutrition of groundnut (*Arachis hypogaea* L.). Allison (1985) reported beneficial effect of calcium application to the pegging zone at the first stage of flowering. Sridhar *et al.* (1985) reported that top-dressing of gypsum @ 500 kg/ha synchronizing with the first flowering is advantageous. The crop grown in red sandy loam soils also responds to zinc application. Application of zinc increases the nodulation, chlorophyll content and pod yield. In groundnut-growing soils, 30–35% area is deficient in secondary and micronutrients like S and Zn. The present study was undertaken to find out the response of groundnut to calcium, sulphur and zinc in maximizing the yield.

The field experiment was conducted at Jagtial during winter season of 1992–93 and 1993–94. The trial was laid out in randomized block design with 3 replications on red sandy loam soils. The soil had *p*H 7.7, electrical conductivity 0.17 dS/m, organic carbon 0.41%, and organic matter 0.71%. The available N, P_2O_5 and K_2O were 180, 7.92 and 105 kg/ha, respectively. The exchangeable calcium, available sulphur and extractable zinc were 3.25 C mole (p+) kg, 15 ppm and 0.6 ppm respectively. There were 8 treatment combinations, viz T_1, soil application of $ZnSO_4$ @ 25 kg/ha; T_2, T_1 + foliar application of $ZnSO_4$ (0.2%); T_3, foliar application of $ZnSO_4$ (0.2%) 45 days after sowing; T_4, elemental sulphur 12.5 kg/ha at sowing + 12.5 kg/ha; T_5, gypsum @ 500 kg/ha at sowing, band placement; T_6, gypsum @ 500 kg/ha at 35 days after sowing in pegging zone; T_7, gypsum @ 250 kg/ha, band placement at sowing + 250 kg/ha at 35 days after sowing; and T_8, only recommended dose (N_{30} P_{60} K_{40} the control).

Nitrogen, phosphorus and potassium @ 30, 60 and 40 kg/ha were applied through diammonium phosphate, urea and muriate of potash respectively. 'JL 24' groundnut was sown on 19 October 1993 and 23 October 1994. The crop received 7 irrigations during both the years. All the recommended agronomic practices and plant-protection measures were followed. The calcium content in the soil was determined by Versanate (EDTA) titration method by using neutral normal ammonium acetate extractant (Jackson 1958). The available sulphur was extracted with 0.15% $CaCl_2$ and estimated by turbidimetric method (Massoumi and Conmfield 1963). Standard methods were used for other determinations.

The result pertaining to pooled mean of pod yield, haulm yield, number of matured pods/plant, shelling and oil (%) (Table 1) showed that the mean pod and haulm yields (of 2 years) differed significantly. Application of gypsum @ 500

*Short note

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Table 1 Effect of calcium, sulphur and zinc sulphate on pod yield, haulm yield and other yield-contributing characters in groundnut (pooled mean data of 2 years)

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	No. of matured pods/plant	Shelling (%)	Oil (%)
T_1	1 900	2 172	9.2	66.7	46.8
T_2	2 089	2 334	9.5	68.4	47.1
T_3	1 839	2 138	9.4	66.2	46.3
T_4	1 807	2 155	9.1	65.0	47.8
T_5	1 926	2 194	9.2	66.1	47.1
T_6	2 178	2 550	9.7	70.2	48.5
T_7	2 085	2 482	9.5	67.0	48.1
T_8	1 705	2 070	8.4	61.5	45.7
SEm±	89	128	0.12	1.2	0.7
CD (*P*=0.05)	246	353	0.35	3.4	2.1

Details of treatments are given in text

kg/ha at 35 days after sowing at pegging zone (T_6) recorded significantly higher pod (2 178 kg/ha) and haulm yields (2 550 kg/ha), followed by soil application of zinc sulphate @ 25 kg/ha +foliar application of 0.2% zinc sulphate at 45 days after sowing, giving 2 089 kg/ha pod yield and 2 334 kg/ha haulm yield. There was 28% increase in pod yield with T_6 compared with the control. Agasimani and Hosmani (1990) reported similar result. The increase in yield due to application of gypsum at pegging zone might be due to increase in availability of calcuim in the root zone for better development of pegs. Allison (1985) also reported beneficial effect of the application of calcium to the pegging zone at first stage of flowering.

As the experimental site is deficient in zinc status, the zinc application might have increased the pod yield under T_2. The increase in pod yield may primarily be attributed to increase in shelling (%) and number of pods/plant. The result confirms that of Radder and Biradar (1973).

Mean number of pods/plant were significantly higher under T_6 (9.7/plant), followed by T_7 (9.5/plant) and T_2 (9.5/plant). The added advantage of top-dressing of gypsum might be due to the increased availability of calcium and sulphur in the fruiting zone, when it is most needed for proper pod filling (Sridhar *et al.* 1985).

Significant higher shelling (%) was realized with T_6 (70.2%), followed by T_2 (68.4%) and T_7 (67.0%).

Treatment T_6 recorded significantly higher oil content (48.5%) than the control. All the treatments produced significantly higher oil (%) compared with the control, except T_3. Oil content in the kernels increased with S application (through elemental S, $ZnSO_4$ and gypsum), due to higher conversion of carbohydrates to oil under the influence of increasing level of S (Misra and Singh 1987).

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Integrated nutrient management in relation to soil fertility and yield sustainability under dryland farming*

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Key words : integrated nutrient management, yield sustainability, dry farming

Application of organic materials to the soil will improve the hydro-physical environment and fertility level of the soil and sustain crop productivity level (Wani *et al.* 1994). However, due to paucity of organic sources to meet the total nutrient requirement of the crops, their integrated use with inorganic sources is desirable. In the subhumid zone of India, information on improvement of soil-fertility status and yield sustainability through integrated nutrient management is inadequately documented. Keeping these points in view a field experment was conducted to evaluate the change in soil-fertility status and sustainable-yield index of rice (*Oryza sativa* L.)–Lentil (*Lens culinaris* Medikus) cropping sequence through sole and conjunctive use of organic and inorganic nutrient sources under dryland condition.

A field experment was conducted during 1986–87 to 1993–94 at the research farm of the university at Varanasi. The soil was fine loamy mixed hyperthermic Udic-ustochrept. The surface (0–15 cm) soil had sand 15.21%, silt 22.37%, clay 62.42%, bulk density 1.42 Mg/m^3, *p*H 7.7, electrical conductivity 0.11 dS/m, organic carbon 2.77 g/kg soil, and total N, P and K respectively 1.31, 0.25 and 4.16 g kg/soil. Plant nutrients were applied through inorganic, organic and conjunctive use of inorganic and organic sources. The treatments were: T_1, the control, ie no application of nutrient source; T_2, application of recommended inorganic fertilizer @ 80 kg N/ha, 40 kg P/ha and 30 kg K/ha ($N_{80}P_{40}K_{30}$); T_3, 50% of T_2 ($N_{40}P_{20}K_{15}$); T_4, sole application of wheat straw @ 5 Mg/ha; T_5, sole application of farmyard manure @ 5 Mg/ha; T_6, $T_3 + T_4$; T_7, $T_3 + T_5$; T_8, only 20 kg N/ha (farmer's practice). These 8 treatments were laid out in randomized block design with 3 replications each. The treatments were applied only during the rainy season before sowing rice. The organic materials were incorporated 15 days earlier than the date of sowing the rice seed. Rice ('Akashi') and lentil ('PL 72') were taken as the test crops. Soil *p*H, electrical conductivity, organic carbon and the total nitrogen, phosphorus and potassium contents were estimated after completion of 1993–94 crop year, by following the standard methods (Page *et al.* 1982). Grain yield was recorded at the end of each cropping in rainy and winter seasons (*kharif* and *rabi*) each year. Sustainable yield indexes as (SYI) of individual crop as well as of the total sequence were analysed by following the equation proposed by Singh *et al.* (1990) as:

$$SYI = \bar{Y} - \sigma / Y_{max} \qquad ...(1)$$

where $\bar{Y}$, the estimated average yield during 1986–87 to 1993–94; σ, its estimated standard deviation; and Y_{max}, observed maximum grain yield.

During the course of the experimentation sole application of wheat straw and farmyard manure (T_4 and T_5) decreased the soil *p*H respectively to 6.5 and 6.6 compared with the initial status (6.7) of the soil (Table 1). The release of organic acids by these sources could be responsible for the decrease in soil *p*H value. Conjunctive use of inorganic fertilizer along with the organic one led to an increase (6.6–6.8) in soil *p*H value compared with the application of the nutrients either through the sole application of organic or inorganic source. Conjunctive use of both organic and inorganic sources decreased the concentration of released organic acids as well as hydrogen-ion concentration in the soil solution and thus was resoponsible for higher *p*H value under T_6 and T_7 treatments compared with T_2, T_4 or T_5. Electrical conductivity depends on the concentration of different bases in the soil solution. Incorporation of organic sources helps addition of cations like K^+, Na^+, Ca^{2+} and Mg^{2+} (Sarkar *et al.* 1989). Therefore electrical conductivity values under sole and conjunctive use of organic sources (T_4, T_5, T_6 and T_7) were notably higher compared with the initial status of the soil. Conjunctive or sole application of organic materials as nutrient sources increased the level of organic carbon in the soil by 6.8 under T_4 to 14.4% under T_5 than the inital status. Continuous application of inorganic fertilizer decreased the soil C : N ratio and also improved the activity of the micro-organisms responsible for nitrogen mineralization (Sarkar and Rathore 1992). As a result there was a decrease in organic carbon status by 19.4 and 11.9% respectively under T_3 and T_2 treatments compared with the initial status. Application of

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Table 1 Change in soil-fertility status in relation to integrated nutrient management

Treatment	*p*H	Electrical conductivity (ds/m^3)	Total nutrient (g/kg)			
			Organic C	N	P	K
T_1	6.1	0.09	2.77	1.26	0.17	3.87
T_2	6.0	0.065	2.73	1.30	0.23	4.06
T_3	6.2	0.055	2.46	1.29	0.21	4.23
T_4	6.5	0.1	3.06	1.71	0.34	6.94
T_5	6.6	0.145	3.17	1.58	0.29	5.88
T_6	6.6	0.105	2.96	1.65	0.3	6.14
T_7	6.8	0.14	3.02	1.54	0.26	5.56
T_8	6.9	0.09	2.68	1.28	0.19	4.12
LSD (P=0.01)	0.2	0.009	0.13	0.05	0.03	0.16
CV (%)	3.39	8.53	4.00	3.68	10.30	2.77

Details of treatments are given in text

organic material helped in addition of organic forms of nitrogen, phosphorus and potassium to the soil. The organic form of N is available to the plant only through mineralization. Under dryland condition the rate of mineralization is also slow. Therefore the total N status increased in the soil. Similarly, total P content of the soil also increased under T_4, T_5, T_6 and T_7. Field crops mostly consumed more K from the soil. Besides, this addition of organic materials increased the value of cation exchange capacity of the loamy soil. These 2 factors independently (as with T_5 and T_7) or collectively (as with T_4 and T_6) are responsible for higher K concentration in the soil under these 4 treatments compared with the initial status. Addition of inorganic fertilizer for 7 years did not have any effect on total soil-nitrogen status but improved the total P status marginally and decreased the total K status of the experimental soil. Cultivation of rice and lentil in a sequence without the application of nutrients made no significant change in the chemical properties of the soil.

The mean grain yield of rice (Table 2) was the highest under T_2, where the nutrient source was recommended fertilizer dose ($N_{80}P_{40}K_{30}$). This was closely followed (3.2% less) by T_7, where farmyard manure along with 50% of the recommended inorganic fertilizers were applied to the soil. In the first year (1986–87) the gap in yield of rice between T_2 and T_7 was wider (9.1%), which subsequently narrowed down with the continuation of the experimental trial. In the seventh year (1993–94), however, T_7 gave 2.8% more grain yield of rice than T_2. Grain yield of rice was at a moderate level with application of nutrients either through organic source, ie farmyard manure (T_5) or half the recommended ($N_{40}P_{20}K_{15}$) fertilizer dose (T_3, Table 2). Sole application of undecomposed organic materials like wheat straw (T_4) increased the period of immobilization, particularly under dryland condition, decreasing the mean yield of rice (0.872 Mg/ha). Addition of $N_{40}P_{20}K_{15}$ as inorganic fertilizer (T_6) increased the rice-grain yield to 1.164 Mg/ha, which was 33.5% higher than that of T_4. A slow and steady nutrient-release pattern under T_7, was responsible for higher residual nutrient status of the soil after harvesting rice. As a result, the

Table 2 Mean grain yield in rice–lentil cropping sequence as influenced by integrated nutrient management

Treatment	Mean grain yield (mg/ha)		
	Rice	Lentil	Total
T_1	0.761	0.656	1.417
T_2	1.488	0.912	2.4
T_3	1.126	0.804	1.93
T_4	0.872	0.718	1.59
T_5	1.17	0.968	2.138
T_6	1.164	0.826	1.99
T_7	1.439	1.141	2.58
T_8	1.017	0.673	1.69
LSD (P=0.01)	0.103	0.097	0.184
CV (%)	6.71	7.52	8.38

Details of treatments are given in text

magnitude of lentil-grain yield was highest under T_7 in all the years. T_5 gave the second highest yield, and it was 5.8% more than that of $N_{80}P_{40}K_{30}$. The grain yield of lentil under the sole application of wheat straw (T_4) was even better than that of the control, when compared with that of rice. The total grain yield was highest under T_7 in the rice–lentil cropping sequence under dryland farming (Table 2). Sole application of farmyard manure was also useful as per the total yield of the component crops. Application of wheat straw along with $N_{40}P_{20}K_{15}$ gave moderate yield of the cropping system.

The highest result in terms of sustainable yield index (Fig 1) in the rice–lentil cropping sequence was attained by the sole application of decomposed organic material, ie farmyard manure (T_5) as the nutrient source in the fine loamy mixed hyperthermic Udicustochrept of the subhumid zone of eastern Uttar Pradesh. This was closely followed by T_7 (Fig 1). The recommended (T_2) as well as lower dose of inorganic fertlizer (T_3) and sources (T_8) resulted in moderate degree of sustainable yield index. The magnitude of sustainable yield index was lowest when undecomposed organic materials (T_4) were solely applied to the soil, whereas addition of $N_{40}P_{20}K_{15}$ as the inorganic fertilizer along with it increased the sustainable yield index by 11.5% (Fig 1).

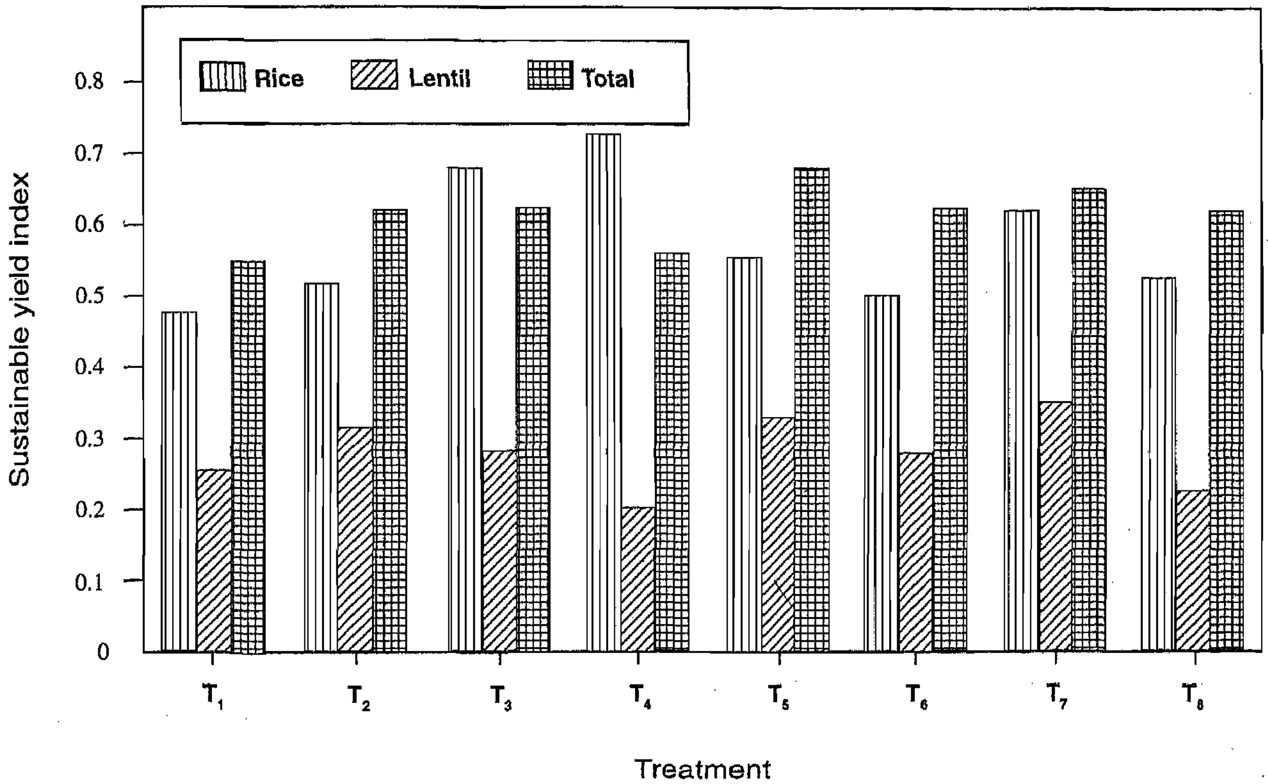

Fig 1 Effect of integrated nutrient management on sustainable yield index in rice–lentil sequence

It can be concluded that application of farmyard manure with or without the inorganic fertilizer helps improve the soil-fertility status and gives higher yield potential and better yield sustainability in the rice–lentil cropping system under dryland farming in the subhumid zone of eastern Uttar Pradesh.

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Soil Organisms and Litter Decomposition in the Tropics. 1996. Reddy M V. Oxford & IBH Publishing Co Pvt. Ltd, 66 Janpath, New Delhi 110 001. i–xi + 274 pp. 23.6 cm x 15.3 cm. Rs 750. ISBN 81-204-0999-X.

Two major concerns recorded at the International Crop Science Congress, Iowa, the USA, on the future of global agriculture, especially of developing countries, are the decreasing soil fertility and diminishing natural resource base (soil, water and biodiversity). As this is largely due to greed-based and energy-intensive agriculture, the US Food Security Act of 1984 initiated alternative agriculture with reduction in the use of chemicals for agriculture, with a fresh look towards biology and ecology of the soil as primary and soil chemistry as secondary factor. This is gaining momentum all over the world despite ways and policies adopted to promote fertilizer and pesticide use beyond imperative and economic levels. It is in this context that the book under review offers a timely and effective combination of eco-biology of the soil and its agronomic field management.

The text of 12 chapters covers the different areas of research of each component of soil life from bacteria to Mollusca , with its functional role of litter decomposition and nutrient dynamics related to soil fertility. Each chapter is a contribution of a specialist on the subject, and the editor's job was executed with care and devotion.

The introductory chapter elucidates the role of soil organisms on physical properties of the soil, and biological activity with special reference to complex and integrated system of nutrient dynamics. The review on the role of bacteria and actinomycetes by Dr Martin Wood and of fungi by Dr Sharma and others. in litter decomposition merits attention. This life component is the most prolific in number and the biochemical versatility as influenced by seasonal changes and management practices is decribed in detail. Special reference to calculation of nitrogen budget where a large amount of nitrogen is mineralized by bacteria (p 26) seems appropriate. Six chapters (in 8 pp) devoted to the role of different invertebrate groups from Protozoa to Mollusca in litter decomposition is the precious part of the text, as this is always the most neglected aspect of decomposition. The work of nematodes in close association with other organisms, dead and alive, is so great that only a few can realize that if they all disappear the life on earth would be disastrous (p 74).

The role of tropical earthworms in litter decomposition is widely recognized recently as more important in the final stages of decomposition process (mixture of soil with humus fraction) than in the litter system. The role of arthropods presented by the editor on the structure, influence of moistrue and rainfall, temperature and *p*H on their bioactivity provides detailed information, with emphasis on energy relationship and role in mineralization. The research needs in this area are identified for furture work. This chapter is noteworthy, as on it rests heavily the furture of management of soil biology and related fertility.

On the role of Mollusca the review clarifies the indirect effect of this group on the associated microflora on nutrient mineralization.

The concluding chapters on the management of tropical ecosystems and the future studies on soil fertility with results of case study at the International Institute of Tropical Agriculture abundantly support the recent rewarding trends toward the inevitable concern for disposal of urban and rural solid waste.

The text is heavily packed with data and information for guidance to scientists, to orient their research programme to achieve the object of sustaining soil productivity. The vicissitude of the balance in soil-organic matter under tropics is well presented by Hans Jenny (the USA). Hence the use of organic manures along with inorganics is necessary under the accelerated demographic pressure and economic activities. The book is well produced and is a valuable addition to agricultural scientists as well as biologists in promotion of sustainable agriculture.

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Global Silk Scenario – 2001: Proceedings of the International Conference on Sericulture-94. 1996. Brought out by Central Silk Board and Swiss Development Corporation, and published by Oxford & IBH Publishing Co. Pvt. Ltd, 66 Janpath, New Delhi 110 001. xvi + 522 pp. 24.50 cm x 16.25 cm. Rs 250. ISBN 81-204-1052-1.

The International Conference on Global Silk Scenario–2001, conducted at Mysore during 25–29 October 1994, is no doubt a noble attempt to make an assessment of silk situation at present and in the future. The conference was well attended with participation by 27 foreign delegates and 184 Indian experts including some administrators. In all, 61 papers were contributed including many original contributions.

The conference was organized under 5 major sections, viz (*i*) changing pattern in international demand for silk and silk goods, (*ii*) production strategies in the changing environment, (*iii*) strategies for technology upgradation, (*iv*) role of non-government sectors in sericulture development, and (*v*) international co-operation among silk producing processing and consuming countries.

The present book is the proceeding of the conference, which, though may not directly benefit the sericulture farming community, will be a useful acquistion for libraries and academic insititutes and especially those interested in silk development, the students and extension workers as a reference book.

In this proceeding many useful general recommendations were made, with emphasis on need to improve the quality of Indian silk, and expectations from the corporate sector to step up the production of quality bivoltine silk. Currently 14 000 million tonnes raw silk is being produced in India, and nearly 50% of this quantity is being imported as bivoltine silk. Switching over to bivoltine silk production would involve improvement in both quality and productivity.

The corporate sector, however, has some limitations. Even at a higher productivity of 100–120 kg/ha bivoltine silk, 8–10 ha of irrigated land is required to produce 1 tonne bivoltine raw silk with all the necessary inputs required for rearing the worms to produce high-quality bivoltine cocoons. If the country is short by 6 000–7 000 tonnes high-quality bivoltine silk today, the corporate sector should immediately develop 60 000 ha of mulberry-sericulture under irrigation, which is not an easy task in view of its current slow progress. Currently 400–500 tonnes bivoltine silk and more than 2 500 tonnes bivoltine cocoons (pure cocoons and not hybrids) are being produced for preparing multi x bivoltine cross-bred layings.

Therefore the correct strategy would be to encourage the sericulture farmers to give up the rearing of multivoltine cross-bred layings and take to bivoltine hybrid layings through proper input servicing and effective extension methodology.

The conference however did not spell out specific strategies to achieve the objectives in near future.

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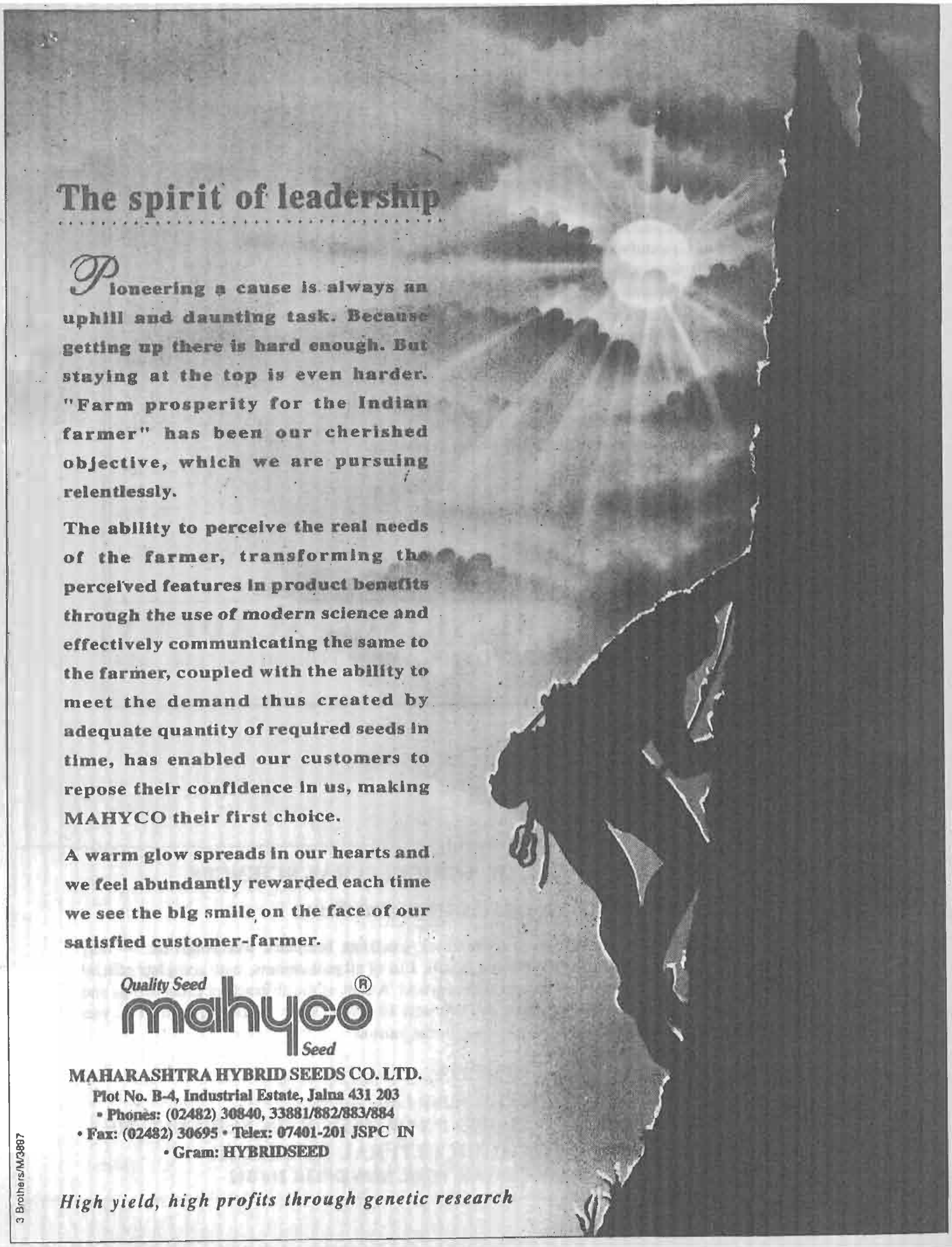
ANNOUNCEMENT

A National Symposium on Microbes in Plant Improvement and Environmental Protection is being planned to be held during 23–24 December 1997. For further information, please contact Dr Ved Pal Singh, Organising Secretary, Department of Botany, University of Delhi, Delhi 110 007.

CORRIGENDUM

The pagination of August 1997 issue (vol 67, no. 8) of *The Indian Journal of Agricultural Sciences* may be read pp 331-80, in place of pp 287–336.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