ha at 90 days. This may be owing to less number of plant population under the lower seed rate, which resulted in better root development and formation of root nodules. Hand-weeding twice recorded the maximum number of nodules/plant.

The seed yield decreased with an increase in seed rate from 75 to 125 kg/ha (Table 1). The results are in agreement with those of Ahlawat *et al.* (1985). All the weed-control treatments proved superior to the unweeded check treatment. However, hand-weeding at 25 and 45 days was found most promising in increasing the grain yield of chickpea as compared with alone application of fluchloralin @ 1.0 kg/ha and in combination with 1 hand-weeding at 25 days after sowing. Malik *et al.* (1988) also reported similar results. Uncontrolled weeds reduced the crop yield by 47.3 % compared with hand-weedings at 25 and 45 days.

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Effect of soil ameliorants on production potential of gram (*Cicer arietinum*) in salt-affected environment and their residual effect on pearlmillet (*Pennisetum glaucum*)

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Crop growth and yield are adversely affected by saline-alkaline soil and water. A sizeable area in the flood-prone Eastern Plains Zone of Rajasthan faces problems of saline-alkaline soil and irrigation water. Gram (*Cicer arietinum* L.) is a preferred rainy-season pulse crop. Hence an experiment was conducted during 1988–91 to study the effect of easily available soil ameliorants, viz. gypsum and farmyard manure, for increasing the production of gram and their residual effect on succeeding crop of pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] at Navgaon.

In gram ('RSG 2') the treatments were 3 levels of gypsum (0, half and full gypsum requirement in finely ground form) and 3 levels of farmyard manure (0, 10 and 20 tonnes/ha) applied 3 weeks prior to sowing and only once at the start of the experiment. The experiment was conducted in randomized block design with 3 replications. The residual effects of the 2 soil ameliorants were assessed in terms of production poten-

Table 1. Yield attributes and yield of gram and pearlmillet as affected by gypsum and organic manure (average data of 3 years)

Treatment	Gram				Pearlmillet				Grain yield (q/ha)	Straw yield (q/ha)
	Pods/ plant	Grains/ plant	1,000-grain weight (g)	Pooled grain yield (q/ha)	Plant height (cm)	Ear length (cm)	Grains/ ear	1,000-grain weight (g)		
Gypsum (tonnes/ha)										
0	28.2	43.7	138.6	7.91	176.3	18.1	456.7	4.9	13.81	52.82
2	34.3	59.8	141.9	9.46	199.5	22.6	653.4	6.2	15.27	58.44
4	38.9	67.4	143.8	11.14	206.4	25.2	749.3	6.8	17.03	62.19
CD (P = 0.05)	3.1	2.7	1.6	1.35	5.3	1.3	31.2	0.8	0.21	1.24
Farmyard manure (tonnes/ha)										
0	29.6	45.1	138.2	8.58	180.8	17.7	538.5	4.7	14.10	50.42
10	34.8	58.6	142.1	9.63	198.6	23.2	670.8	6.5	14.82	57.35
20	36.9	67.2	144.0	10.29	202.9	25.1	740.2	6.7	16.52	65.00
CD (P = 0.05)	3.1	2.7	1.6	1.35	5.3	1.3	31.2	0.8	0.21	1.24

Table 2. Benefit : cost ratio of crop production (gram–pearlmillet sequence) as affected by gypsum

Treatment	Pearlmillet						Gram			Grand total increase in income (Rs)	Cost of gypsum (Rs)	Benefit : cost ratio
	Grain			Straw			Yield (q/ha)	Increase in yield (q/ha)	Increase in income (Rs)			
	Yield (q/ha)	Increase in yield (q/ha)	Increase in income (Rs)	Yield (q/ha)	Increase in yield (q/ha)	Increase in income (Rs)						
Gypsum (tonnes/ha)												
0	13.18			52.82			7.91					
2	15.27	1.46	438	58.44	5.62	562	9.46	1.55	930	1,930	1,000	1.93
4	17.03	3.22	966	62.19	9.37	937	11.14	3.23	1,938	3,841	2,000	1.92

Sale price (Rs/q): Pearlmillet grain, 300; pearlmillet straw, 100; gram grain, 600
Cost of gypsum (Rs/tonnes); 500.00 (unsubsidized rate)

tial of succeeding crop of 'WCC 75' pearlmillet grown in the same plots. Soil characteristics were estimated along with the benefit : cost ratio.The soil of experimental field was low in available nitrogen and medium in both phosphorus and potash, having electrical conductivity (EC_2), pH_2 and exchangeable sodium percentage 0.6 dS/m, 8.4 and 15.06 respectively. The gypsum requirement of soil was 4.0 tonnes/ha. The irrigation water used had pH 8.4, EC 2.6 dS/m, residual sodium carbonate 4.8 and sodium-absorption ratio 12.9.

A significant increase in the yield attributes of gram and pearlmillet was recorded with every increase in level of gypsum and farmyard manure; however, 1,000-grain weight of pearlmillet did not show significant improvement with gypsum applied beyond 0.5 gypsum requirement and with farmyard manure beyond 10 tonnes/ha.

Pooled data indicated that each successive higher level of gypsum resulted in significant yield increase in gram. Application of gypsum at full gypsum requirement (4 tonnes/ha) increased the gram yield by 40.8 and 17.8% over the control and half gypsum requirement (2 tonnes/ha) respectively, whereas half gypsum requirement increased the yield by 19.6% over the control. No significant increase in yield of gram over the control was recorded with half the gypsum requirement in the beginning, i.e. first year. The significant enhancement in yield in subsequent year was due to gradual improvement of soil characteristics. Thus gypsum level at half the gypsum requirement was found adequate for significant contribution to gram yield that had been cost effective too as revealed by benefit : cost ratio (Table 2). Low solubility of gypsum (Yadav and Gupta, 1984) could lead to an increase in net salt load in condition of relatively drier climate, as in our study where soil EC_2 of field at the end of experimentation was 0.71 dS/m which was 0.60 dS/m before the start of study.

Increased application of farmyard manure along with gypsum increased the grain yield of gram. Pooled analysis of yield data showed that farmyard manure @ 20 tonnes/ha significantly increased the grain yield over the control only. The farmyard manure @ 10 tonnes/ha did not prove significantly better than the control in terms of gram yield.

Gypsum and farmyard manure applied earlier to gram crop had significant effect on succeeding crop of pearlmillet as well (Table 2). Pooled analysis for 3-year data revealed that each successive higher dose of gypsum as well as of farmyard manure significantly increased the grain and straw yields of pearlmillet, whereas gypsum at half and full gypsum requirements increased the grain yield by 10.6 and 24.0% respectively over the control. Farmyard manure @ 10 and 20 tonnes/ha increased the same by 5.1 and 17.2% respectively over the control. Similar trend was observed for straw yield of pearlmillet. Khurana *et al.* (1991) reported similar residual effect of gypsum on pearlmillet grown after either wheat or Indian mustard.

It was concluded that application of gypsum at half the gypsum requirement or that of farmyard manure @ 20 tonnes/ha may give higher yield of gram in saline-alkaline soil and water environment. The gypsum and farmyard manure also showed their beneficial residual effects on succeeding crop of pearlmillet.

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Effect of nitrogen, phosphorus and *Rhizobium* inoculation on yield and quality, N and P uptake and economics of blackgram (*Phaseolus mungo*)

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A field experiment was conducted during the rainy season of 1990 at Junagadh. The soil was clayey in texture, medium in total nitrogen (0.072%), low in available phosphorus (18.7 kg/ha), medium in available potassium (261.8 kg/ha) and slightly alkaline in reaction (7.9 pH), with normal electrical conductivity (0.31 dS/m). Treatments consisting of 3 levels of N (10, 20 and 30 kg/ha) and P (20, 40 and 60 kg/ha) and 2 levels of *Rhizobium* inoculation (with and without inoculation) were laid out in factorial randomized block design, replicated 4 times. Full dose of N and P_2O_5 was applied as urea and single superphosphate respectively at sowing as per treatments. The seed was sown on 30 June 1990 with inter-row spacing of 45 cm, using 25 kg/ha seed rate.

Nitrogen @ 20 kg/ha yielded as high as that of 30 kg/ha, and gave significantly higher yield than 10 kg/ha (Table 1). Similar trend was also observed for straw yield. This was owing to the beneficial effect of this level on all the yield parameters. The results are in accordance with those of Vidhate *et al.* (1986). Protein content of seeds remarkably increased with each increment in N level from 10 kg N/ha to 30 kg N/ha. Nitrogen is the major constituent of protein, its application also enhanced the N uptake which might have increased the protein content of seeds. The result confirms the finding of Vidhate *et al.* (1986). Application of 30 kg N/ha gave the maximum net return; however, the highest incremental cost : benefit ratio was obtained was recorded with 20 kg N/ha.

Significantly higher grain yield was recorded at 40 and 60 kg P_2O_5/ha compared with 20 kg P_2O_5/ha. Likewise, the application of 40 and 60 kg P_2O_5/ha were found equally effective and significantly superior to 20 kg P_2O_5/ha for straw yield. The findings are in agreement with those of