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Effect of moisture-conservation practices, phosphorus levels and bacterial inoculation on chickpea (*Cicer arietinum*) under rainfed condition

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ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 1997–98 and 1998–99 at the Indian Agricultural Research Institute, New Delhi, to study the effect of conserved soil moisture, levels of phosphorus and bacterial seed inoculation. *In-situ* moisture conservation through field bunding + farmyard manure (FYM) @ 10 tonnes/ha proved to conserve maximum moisture and improved the yield, nodulation and water-use efficiency (WUE) in chickpea (*Cicer arietinum* L.). The next important practice was found to be field bunding + green-manure (GM) (*dhaincha*). However, both these practices did not exhibit marked differences on the yield during both the years as well as in pooled data. Application of phosphorus @ 60 kg P_2O_5/ha significantly increased yield attributes, yield, number of nodules/plant, dry weight of nodules and consumptive use of water. The increase in above values was progressively related to P doses from 0 to 60 kg P_2O_5/ha. However, grain yield and WUE were maximum (20.02 q/ha and 8.38 kg/ha-mm) up to 30 kg P_2O_5/ha in both the years. Use of phosphate-solubilizing bacteria increased the yield attributes, like pods/plants, seed weight/plant and test weight and consumptive use of water and WUE of the chickpea in comparison to no inoculation.

Key words : Chickpea, Phosphorus, Phosphobacterin, Water-use efficiency, Consumptive use

Chickpea is the most important winter (*rabi*) pulse crop, cultivated in India covering 7.01 million hectares with production of 6.12 million tonnes. It has significant contribution to pulse production, accounting 30.1% of the total area and 38.5% of the production under pulses (Asthana and Mishra, 1999). There has been no substantial rise in its production chiefly on account of soil-moisture deficiency mostly at critical stages. Efforts have been made to augment the soil-moisture conservation techniques by dividing the field into small beds. Putting

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bunds, helps to conserve more rain water in soil by minimizing runoff water from soil surface during rainy season.

Thus, it is helpful for conserving more moisture resulting in good crop production. Besides moisture conservation, other important factor for stepping up the yield of gram or chickpea (*Cicer arietinum*) is phosphorus management. The major problem with this nutrient is low availability due to its fixation in the soil and low solubility (10–25%) of applied phosphate utilized by the crops in *rabi* season (Pandey, 1987). Therefore, there is an urgent need of enhancing the availability of applied as well as native phosphate to crops, by use of phosphate-solubilizing bacteria under *in-situ* moisture conservation.

Therefore, the work was undertaken to observe the response of different moisture-conservation practices, phosphorus levels and bacterial inoculation on productivity of chickpea under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted at New Delhi under rainfed condition during winter seasons of 1997–98 and 1998–99. The soil was sandy loam, slightly alkaline (pH 7.4), medium in organic carbon content (0.37%) and low with available P (7.88 kg/ha) and fairly rich in K (279 kg/ha) content. The soil-moisture content on gravimetric basis at field capacity (1/3 bar) and wilting point (15 bars) was 19.24 and 6.9% (by weight) respectively. The bulk density of the upper profile ranged from 1.45 to 1.46 g/cm^3).

The treatments comprised 4 moisture-conservation practices [(control, field bunding, field bunding + FYM at the rate of 10 tonnes/ha and field bunding + green-manure (GM) (*dhaincha*)] as main plot treatments and combination of 3 levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) and 2 levels (no inoculation and inoculation) of phosphobacterin as sub-plot treatments replicated 4 times in split-plot design. Moisture-conservation practices were adopted in rainy season and phosphorus and phosphobacterin were applied to chickpea crops grown in winter (*rabi*) season.

Chickpea cultivar 'BG 256' obtained from the National Seeds Corporation was sown on 27 and 28 October in 1997–98 and 1998–99 respectively. The seeds of chickpea were treated with phosphate-solubilizing bacteria (*Pseudonomas striata*) followed by drying under shade before sowing. Sowing was done by using bullock-drawn *desi* (country) plough in 30 cm rows spacing with seed rate of 80 kg/ha.

Recommended cultivation practices were followed for the crop. Rainfall received during crop season of 1997–98 and 1998–99 after making bunds was 181.5 and 101.1 mm respectively. The soil-water content in different soil layers from 30 to 120 cm was determined with gravimetric method at monthly intervals and water-use efficiency was calculated on the basis of kg seed yield/mm water used by the chickpea.

Crop was harvested manually and threshed by using a mechanical thresher (Pullman's thresher).

RESULTS AND DISCUSSION

Yield and yield attributes

Yield attributes of chickpea, viz. number of pods/plant, seed weight/plant, test weight and seed yield, increased significantly with moisture-conservation practices (Table 1). Thus, minimum number of yield attributes resulted in lowest seed yield of chickpea in the control plot, probably owing to poor growth low availability of soil moisture. Among the moisture-conservation practices, the field bunding + farmyard manure at the rate of 10 tonnes/ha recorded the highest number of pods/plant, seeds weight/plant and test weight compared to other moisture-conservation practices. Seed yield in field bunding + farmyard manure at the rate of tonnes/ha and field bunding + green-manure (*dhaincha*) was at par in both the years in average data, but both these practices were significantly superior to the former practices (no bunding and bunding). This might be due to increase in the availability of soil moisture in field, as bunds in field during rainy season act as a barrier against the runoff of excess water and therefore the maximum water was absorbed in the soil. Besides, incorporation of farmyard manure or green-manure (*dhaincha*) in bunded field further helped to absorb and retain more water (11.07% at flowering and 7.01% at grain filling) as compared with the control (8.96% at flowering and 5.15% at grain filling). Similar observations were also made by Patel and Patel (1991) and it seems that use of either farmyard manure or green-manure in bunded field had pronounced effect and finally reflected in more seed yield of chickpea.

The application of phosphorus at the rate of 60 kg P_2O_5/ha to chickpea significantly increased pods/plant, seed weight/plant, 100-seed weight (Table 1). However, seed yield was observed to be at par with 30 kg P_2O_5/ha during both the years as well as in pooled data. But yield increase at both these levels was statistically superior to the control.

The increase in yield-attributing characters with phosphorus application might be owing to low initial phosphorus status of the soil (7.88 kg available P/ha). Application of P led to increase in vigour and growth of plant and resulted in better development of yield attributes. The yield attributes and yield of chickpea were also observed significantly higher with seed inoculation with phosphobacterin (PSB) than no inoculation (Table 1). The increase in seed yield was 15.93 and 14.95% in seed inoculation with phosphobacterin as compared with no inoculation in 1997–98 and 1998–99 respectively. These results are in close conformity with the findings of Namdeo *et al.* (1989) and Chandra and Kumar (1995).

Nodulation

Number of nodules and their dry weight/ plant at 90 days after sowing significantly higher in field bunding + farmyard manure at the rate of 10 tonnes/ha and field bunding + green-manure (*dhaincha*) in comparison to the control and only field bunding during both the years. Parihar and Tripathi (1989) also reported increase in the number and dry weight of active nodules on root increased with the availability of soil moisture. Application of phosphorus up to the highest level tried, i.e. 60 kg P_2O_5/ha, recorded more number of nodules/plant and their dry weight in both the years (Table 2).

Table 1. Effect of moisture conservation practices, phosphorus levels and bacterial inoculation on yield attributes and seed yield of chickpea

Treatment	Pods/plant		Weight of seed/plant (g)		100-seed weight (g)		Seed yield (q/ha)		
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Pooled
Moisture conservation									
Control	42.96	47.45	9.51	9.55	17.54	17.64	14.20	17.38	15.79
Field bunding	47.44	52.03	9.98	12.00	19.73	19.81	17.45	19.20	19.85
Field bunding + FYM@10 tonnes/ha	55.86	60.65	10.65	12.86	20.48	20.84	18.70	21.01	18.37
Field bunding + GM (*dhaincha*)	54.16	58.83	10.16	12.42	20.14	20.29	18.50	19.93	19.21
CD (P=0.05)	1.44	1.39	0.34	0.41	0.30	0.49	1.08	1.37	0.94
Phosphorus (kg P_2O_5/ha)									
0	42.09	47.03	8.47	8.74	17.23	17.39	13.43	15.55	14.49
30	51.02	55.38	10.17	11.74	19.43	19.54	18.89	21.15	20.02
60	57.05	61.81	11.58	14.79	21.96	21.99	19.32	21.51	20.41
CD (P=0.05)	1.25	1.20	0.30	0.35	0.26	0.43	0.93	1.84	0.81
Bacterial inoculaltion									
No phosphobactein	48.47	52.40	9.74	10.64	19.04	19.08	15.94	18.05	16.99
Phosphobacterin	51.64	57.08	10.64	12.20	20.11	20.13	18.48	20.75	19.61
CD (P=0.05)	2.36	2.26	12.20	0.55	0.17	0.81	0.63	0.76	0.47

Y_1, 1997–98; Y_2, 1998–99
FYM, Farmyard manure; GM, green-manure

Table 2. Effect of moisture-conservation practices, phosphorus levels and bacterial inoculation on nodulation and water-use efficiency of chickpea

Treatment	Nodules/plant at 90 DAS		Weight of nodules/plant (g) at		Consumptive use of water (mm)			Water-use efficiency (kg/ha) (mm)		
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Mean	Y_1	Y_2	Mean
Moisture conservation										
Control	33.64	33.80	108.37	114.67	222.17	225.95	221.06	6.39	7.60	6.99
Field bunding	35.51	36.87	115.76	121.83	228.00	232.91	230.45	7.65	8.28	7.96
Field bunding + FYM@10 tonnes/ha	36.91	39.17	123.33	129.09	258.17	262.96	260.56	7.24	8.00	7.62
Field bunding + GM (*dhaincha*)	36.43	39.08	120.45	127.06	235.21	239.41	237.31	7.86	8.32	8.09
CD (P=0.05)	0.86	1.08	2.96	3.03						
Phosphorus (kg P_2O_5/ha)										
0	26.59	26.70	99.77	104.19	225.09	228.80	226.94	5.97	6.79	6.38
30	37.70	39.91	123.63	130.39	237.63	240.03	238.83	7.95	8.81	8.38
60	42.59	46.15	126.28	133.41	246.69	252.08	249.38	7.83	8.53	8.18
CD (P=0.05)	0.75	0.94	2.57	2.63						
Bacterial inoculation										
No phosphobacterin	32.65	34.29	109.21	116.60	233.29	236.70	234.99	6.83	7.62	7.22
Phosphobacterin	38.60	40.88	123.24	128.73	238.44	243.91	241.17	7.75	8.51	8.13
CD (P=0.05)	1.38	1.75	5.17	5.25						

Y_1, 1997–98; Y_2, 1998–99

FYM, Farmyard manure; GM, green-manure; DAS, days after sowing

The positive effect of higher level of P on root growth promoted activity of rhizobia on plant roots and induced nodulation as reported by Choudhary *et al.* (1973) and Shinde and Saraf (1994). Further, phosphobacterin inoculation increased significantly the number of nodules (6.54 and 8.93/plant) and their dry weight (14.03 and 12.13 mg/plant) at 90 days in both the years. The more number of nodules and their dry weight in chickpea might have been due to solubilization of phosphorus by phosphobacterin (*Pseudomonas striata*). These results are in confirmity with the findings of Namdeo *et al.* (1989).

Comsumptive use of water

The seasonal consumptive use of water differed considerably in both the years of experimentation. The greater use of water was in field bunding + farmyard manure at the rate of 10 tonnes/ha, followed by field bunding + GM (*dhaincha*), field bunding and the control, respectively. When plants are good in vigour in field bunding + farmyard manure and field bunding + GM (*dhaincha*), root may also be higher in terms of mass and length. Therefore, they might penetrate into deeper soil layers and could utilize more water from deeper soil layers, resulting more consumptive use of water. Similar result were also reported by Varshney *et al.* (1998). The highest consumptive use of water was obtained when phosphorus was applied @ 60 kg P_2O_5/ha (246.69 and 252.08 mm), followed by the application of 30 kg P_2O_5/ha during both the yeas. Similar results were also observed by Nimje (1991). During both the years, higher consumptive water use (238.44 mm and 243.91 mm) was observed due to seed inoculation with phosphobacterin. The results are in close agreement with findings of Das (1985).

Water-use efficiency (WUE)

Moisture-conservation practices increased the water-use efficiency over the control by 19.7, 13.3 and 23.0% in first year; and 7.67, 4.03 and 8.19% in second year in field bunding, field bunding + farmyard manure @ 10 tonnes/ha and field bunding green manure (*dhaincha*). Gautam and Kumar (1992) also reported similar results. Maximum water-use efficiency was recorded under application of 30 kg P_2O_5/ha (7.95 and 8.81 kg/mm). Thereafter, a declining trend was observed with further increase in P level (60 kg P_2O_5/ha). However, both the levels of phosphorus (30 kg and 60 kg P_2O_5/ha) had pronounced effect of water-use efficiency than the control in both the years. Seed inoculation with phosphobacterin resulted in higher water-use efficiency than no inoculation. This might be due to increased the grain yield considerably, which is in conformity with Nayar and Singh (1983).

Interaction

Data (Table 3) indicated that the highest seed yield of chickpea was recorded at the application 30 kg P_2O_5/ha along with bacterial inoculation, which was significantly superior to any of the interaction of P levels and bacterial inoculation except application of 60 kg P_2O_5/ha along with bacterial inoculation. This indicated a saving of 30 kg P_2O_5/ha. Similar results were recorded by Tiwari *et al.* (1994) and

Table 3. Interaction effect of bacterial inoculation and phosphorus levels on seed yield of chickpea

Bacterial inoculation	Phosphorus levels		
	P_0	P_{30}	P_{60}
B_0	13.01	16.83	17.98
B_1	13.84	20.94	20.66
CD (P=0.05)			
B at same level of P		0.88	
B at same level of B		0.87	

Raut and Kohire (1991).

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