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Productivity, nutrient balance and economics of *kabuli* chickpea (*Cicer kabulium*) as influenced by integrated nutrient management

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ABSTRACT

Field experiments were conducted at Kota (Rajasthan) during winter seasons of 2005-06 and 2006-07 to evolve an integrated nutrient management strategy for *kabuli* chickpea. The experiment was laid out in randomized block design with 12-treatment combinations of levels of P (0, 12.9, 25.8 kg /ha), phosphate solubilising bacteria (control, PSB) and FYM (0, 5 tonne/ha) replicated 4 times. Conjunctive use of inorganic P @ 12.9 kg/ha + PSB + FYM had resulted in maximum number of pods/plant (102.6), bolder seeds (31.88 g) and higher seed yield (2.53 and 2.80 tonne/ha). It was in parity with 25.8 kg P/ha + PSB + FYM (2.42 and 2.96 tonne/ha) in 2005-06 and 2006-07, respectively. Harvest index and N uptake followed similar trend. The P uptake increased with the application of P upto 25.8 kg /ha but was on par with 12.9 kg P/ha + PSB + FYM. Integrated use of inorganic P with PSB and FYM also improved N and P status of soil. The maximum net returns were obtained with 12.9 kg P/ha + PSB + FYM (Rs 53,200 /ha) during 2005-06 and with 25.8 kg P/ha + PSB + FYM (Rs 64,870/ha) during 2006-07. But highest B:C ratio was recorded under 12.9 kg P + PSB. Consequently for higher productivity, profitability and soil health *kabuli* chickpea should be fertilized with 12.9 kg P/ha in conjunction with 5 tonne/ha FYM and PSB inoculation.

***Key words**:* Phosphorus solubilizing bacteria (PSB), Chickpea, FYM, Phosphorus, Soil fertility

India is a major consumer of *kabuli* chickpea and a significant amount of it is imported. To achieve self sufficiency in this commodity its productivity and acreage must be increased. In the recent years, cultivation of *kabuli* chickpea has been introduced in the tail end villages of Chambal command areas of Rajasthan where wheat cultivation is affected by limited water availability. However, due to pod borer infestation and sub-optimum or no application of nutrients, potential crop yields are not realized. Phosphorus is one of the nutrients, required in large quantity for optimum growth and yield in pulses. The use of PSB is considered to increase the efficiency of native as well as applied phosphorus with the secretion of organic acids (Gaur, 1990). Application of farmyard manure (FYM) also improve soil health by improving nutrient availability, soil physical properties and microbial activity. Therefore, integration of P fertilizers with PSB and organics would not only improve the productivity but also maintain soil-health. In view of this and the paucity of work done, the present investigation was carried out to evolve an integrated nutrient management strategy for *kabuli* chickpea in South-Eastern Rajasthan.

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MATERIALS AND METHODS

Field experiments were conducted during winter seasons of 2005-06 and 2006-07 at the Agriculture Research Station, Ummedganj, Kota, Rajasthan. The soil was clayey in texture, slightly alkaline in reaction (pH 7.8), low in organic carbon (0.57%) and medium in available nitrogen (278 kg/ha), phosphorus (10.3 kg/ha) and potassium (298 kg/ha). The experiment was laid out in randomized block design with 12 treatment combinations of P (0, 12.9, 25.8 kg /ha), PSB (control, PSB) and FYM (control, 5 tonne/ha) and were replicated 4 times. FYM was incorporated at the time of field preparation, as per treatment. The composition of FYM on oven dry basis *i.e.* dry matter, N, P and K content was 54, 0.45, 0.095 and 0.429% during 2005, and 56, 0.48, 0.103 and 0.432% during 2006, respectively. The source of inorganic P was DAP which was drilled at the sowing. PSB (*Bacillus polymyxa*) was applied as seed treatment. A uniform dose of 23.5 kg N/ha was applied basal through DAP and urea, as per treatment. The variety 'KAK 2' was sown in rows 30 cm apart on 10 November

2005 and 25 October 2006. Two sprays of Endosulfan 35 EC @ 1 l /ha were applied at flower initiation and pod filling stages as prophylactic measure against pod borer.

The environmental conditions varied during study period with regards to temperature and precipitation (Fig. 1). In the first year temperature was high during first week of November causing delay in sowing. It was also high at pod filling stage and no precipitation was received at this stage, hence crop was given a irrigation of 6 cm depth. During second year, rainfall was received at the germination (4.5 mm) and again at the pod filling (26.2 mm) hence, no irrigation was required. The temperature and soil moisture availability were conducive at flowering and pod development stage, hence yield levels were high. The N and P content in plant and soil were analysed using standard procedures. Results of both the years were analysed statistically and data which do not follow the homogeneity test were given year wise. Economic analysis was done based on prevailing market prices.

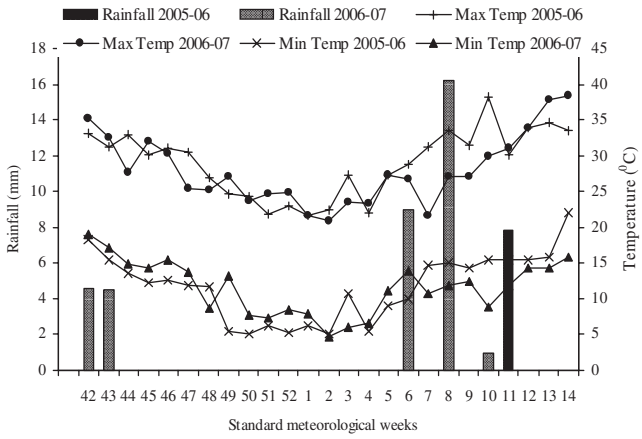

Fig. 1. Weatger parameters recorded during crop growth period

RESULTS AND DISCUSSION

Productivity

Mean data of two crop season revealed that integrated use of inorganic P, FYM and PSB significantly increased the number of pods, 100 seed weight and seed yield. Application of P @ 12.9 kg/ha with PSB and FYM resulted in maximum number of pods/plant (102.6). It resulted in significantly bolder seeds (31.88 g/100 seed) that was at par with 25.8 kg P/ha + PSB + FYM (Table 1). Maximum seed yield was recorded under 12.9 kg P/ha + PSB + FYM (2.53 tonne/ha) during 2005-06, and under 25.8 kg P/ha + FYM + PSB (2.96 tonne/ha) during 2006-07, although both the treatments were in statistical parity with each other during both the years. The magnitude of yield increase with 12.9 kg P/ha + PSB + FYM was 45.4 % and 50% over control and 33.1% and 20.1% over 12.9 kg P/ha alone between 2005-06 and 2006-07, respectively. The response of *kabuli* chickpea to P was quadratic under the influence of FYM and PSB (Fig. 2). Application of PSB considerably reduced the optimum level of applied P. A dose of 19.28 kg P/ha alongwith 5 tonne/ha FYM and PSB was computed economic optimum with the predicted yield of 2.76 tonne/ha. As the treatments did not differ significantly in growth attributes and stover yield, harvest index followed similar trend as that of seed yield. The maximum harvest index was recorded under 12.9 kg P/ha + PSB + FYM.

The enhancement in seed yield occurred owing to significant improvement in yield attributes and their individual contribution were quantified through the multiple regression equation ($R^2 = 0.784^{**}$) i.e.:

Table 1. Effect of integrated nutrient management on yield attributes of *kabuli* chickpea (Pooled data of 2 years)

Treatment	Plant height (cm)	Branches/ plant	Pods/plant	Seeds/pod	100-seed weight(g)
Control	53.9	3.93	62.8	1.55	30.56
PSB	58.0	4.09	68.3	1.46	30.44
FYM (5t/ha)	61.9	3.96	69.4	1.50	30.50
FYM + PSB	57.1	4.18	74.4	1.46	31.56
P 12.9 kg/ha	56.8	4.30	75.4	1.48	31.31
P 12.9 kg/ha + PSB	55.6	4.29	74.0	1.60	31.25
P 12.9 kg/ha + FYM	55.5	4.38	80.2	1.43	31.19
P 12.9 kg/ha + FYM + PSB	57.0	4.14	102.6	1.59	31.88
P 25.8 kg/ha	56.8	3.88	81.8	1.53	30.69
P 25.8 kg/ha + PSB	57.0	4.30	85.0	1.59	31.75
P 25.8 kg/ha + FYM	55.3	4.30	88.9	1.40	31.38
P 25.8 kg/ha + FYM + PSB	57.8	4.36	89.1	1.55	32.31
SEm±	2.5	0.33	2.9	0.05	0.05
CD (P=0.05)	NS	NS	8.2	NS	1.32

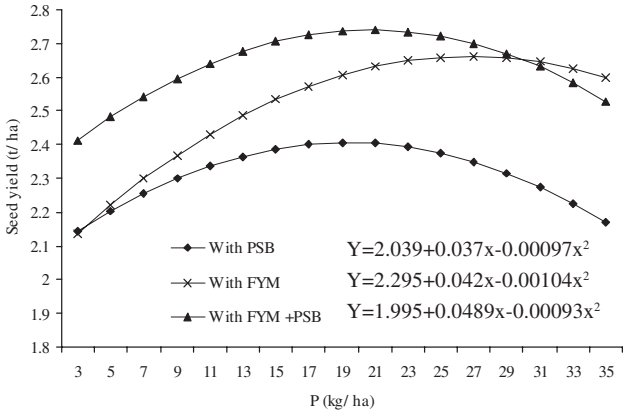

Fig 2. Response of *kabuli* chickpea to applied P under the influence of PSB and FYM

$$Y = - 30.47 + 0.175 X_1 + 1.272 X_2$$

where, X_1 and X_2 stands for number of pods/plant and 100 seed weight, respectively.

Phosphorus plays an important role in nitrogen-fixation in legumes, where it acts as a source of energy. It plays a pivotal role in early formation of roots, their proliferation, increased microbial activity in nodules and symbiotic biological N-fixation process. This also led to efficient and greater partitioning of metabolites and adequate translocation of photosynthates and nutrients to develop reproductive structure (Tisdale *et al.,* 1995). The organic matter not only releases the nutrients during its decomposition but also provide substrate for microbial growth (Hannapel *et al.*, 1964). Hence, the effect of PSB was enhanced when applied in conjunction with FYM. In the present study a reduction in P dose by half was recorded with the application of FYM and PSB. Similar curtail in P dose with the application of organics and biofertilizers was reported by Jat and Ahalawat (2004).

Nutrient uptake and balance

Significant improvement in N uptake was observed when FYM was added in conjunction with inorganic P with or without PSB (Table 3). The maximum uptake of N was recorded under 12.9 kg P/ha + PSB + FYM during 2005-06, and 25.8 kg P/ha + PSB + FYM during 2006-07 and were on par with each other. However, the treatments FYM and PSB alone, FYM + PSB and 12.9 kg P/ha alone could not significantly improve N uptake by the crop over control. The increased uptake was due to higher N content in seed and stover and increased biological yield. It was observed that raising of *kabuli* chickpea had either maintained or enhanced the available soil N status except under the control treatment during 2005-06. The application of FYM with inorganic P significantly improved final N status of soil. A net gain of 32.6 and 21 kg/ha was recorded under 12.9 kg P/ha + PSB + FYM, and 27.5 and 31 kg/ha under 12.9 kg P/ha + PSB + FYM during 2005-06 and 2006-07, respectively. The computed N balance (column f) was negative under all the treatments. The maximum negative balance was recorded under 12.9 kg P/ha + PSB + FYM during 2005-06 and 25.9 kg P/ha + PSB + FYM during 2006-07. This unaccountable N might have come through symbiotic nitrogen-fixation. Increased nutrient uptake with inorganic P application and PSB inoculation was also reported by Nilambari Kaprekar *et al*. (2003)

The P uptake by crop increased significantly upto the highest level of P application (Table 4). Maximum P uptake was observed under 25.8 P/ha + PSB + FYM which

Table 2. Effect of integrated nutrient management on yield (tonne/ha), harvest index and economics (x 10^3 Rs/ha) of *kabuli* chickpea

Treatment	Seed yield		Stover yield		Harvest index(%)		Cost of cultivation		Net returns		Benefit : cost ratio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Control	1.74	1.86	6.36	6.91	21.80	21.48	11.14	10.85	34.98	38.39	3.14	3.54
PSB	1.87	2.20	5.90	7.33	24.08	23.49	11.24	10.95	38.43	47.42	3.42	4.33
FYM (5t/ha)	1.79	2.21	6.04	7.49	22.80	22.83	13.14	12.85	34.16	45.60	2.60	3.55
FYM + PSB	2.05	2.54	6.85	8.46	23.20	23.05	13.24	12.95	41.16	54.26	3.11	4.19
P 12.9 kg/ha	1.90	2.33	6.67	8.08	22.30	22.38	11.65	11.36	38.81	50.32	3.33	4.43
P 12.9 kg/ha + PSB	2.22	2.49	7.04	8.09	24.27	23.59	11.75	11.46	46.99	54.46	4.00	4.75
P 12.9 kg/ha + FYM	2.37	2.57	6.75	7.51	26.01	25.66	13.65	13.36	49.14	54.84	3.60	4.11
P 12.9 kg/ha + FYM + PSB	2.53	2.80	7.05	7.90	26.86	26.21	13.75	13.46	53.20	60.78	3.87	4.52
P 25.8 kg/ha	2.24	2.47	7.02	7.95	24.16	23.69	12.15	11.86	47.11	53.56	3.88	4.52
P 25.8 kg/ha + PSB	2.24	2.45	6.59	7.46	25.49	24.71	12.25	11.96	47.01	52.87	3.84	4.42
P 25.8 kg/ha + FYM	2.32	2.95	6.61	8.59	26.09	25.40	14.15	13.86	47.30	64.43	3.34	4.65
P 25.8 kg/ha + FYM + PSB	2.42	2.96	6.94	8.47	26.08	25.89	14.25	13.96	49.84	64.41	3.50	4.61
SEm±	0.10	0.15	0.49	0.54	1.04	0.83			2.55	3.87	0.20	0.30
CD (P=0.05)	0.28	0.42	NS	NS	2.98	2.39			7.34	11.13	0.57	0.86

Price of *kabuli* chickpea during both the years: Rs. 26.50/kg

was on par with 25.8 kg P /ha alone or with FYM, PSB or both as well as 12.9 kg P + FYM or PSB during first year. However, it was on par with 25.8 P/ha + FYM and 12.9 P/ha + PSB + FYM only during second year. The increased level of P application increased the availability of P and its better absorption by the plant due to more root proliferation. There might be some release of P in the labile pool of soil from the FYM. Besides, better physical conditions in the rhizosphere might have helped in more absorption of nutrients by the crop. The P status of soil after harvest was observed higher over the initial status except under control. It had increased with the increasing P levels. Maximum gain was recorded under 25.8 kg P/ha + FYM + PSB. The beneficial effect of PSB could be ascribed due to solubilization of native P through excretion of glutamic, succinic, lactic, oxalic, fumaric acids etc. (Subba Rao, 1986). However, a negative P balance was computed under all the treatment which indicated P mining. The negative balance computed was less under higher P levels and FYM application. Similar effect of inorganic P and FYM on residual soil fertility was recorded by Lakpale *et al.* (2003).

Table 3. Balance sheet of N (kg/ha) as influenced by integrated nutrient management in *kabuli* chickpea

Treatments	Initial soil N status (a)		N added (b)		N uptake by crop (c)		Soil N status after harvest (d)		Actual gain/ lossover initial statuse = (a - d)		N Balance (a + b) - (c + d)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Control	269.0	287.0	23.5	23.5	103.9	111.5	265.5	294.5	-3.5	7.5	-76.9	-95.5
PSB	269.0	287.0	23.5	23.5	107.7	128.6	271.3	290.5	-2.3	3.5	-86.5	-108.6
FYM (5t/ha)	269.0	287.0	35.8	36.9	111.2	136.2	278.3	303.0	-9.3	16.0	-84.6	-115.3
FYM + PSB	269.0	287.0	35.8	36.9	128.8	155.3	285.6	305.8	-16.6	18.8	-109.6	-137.2
P 12.9 kg/ha	269.0	287.0	23.5	23.5	115.0	137.9	278.5	289.2	-9.5	2.2	-101.0	-116.7
P 12.9 kg/ha + PSB	269.0	287.0	23.5	23.5	133.1	149.8	277.6	295.5	-8.6	8.5	-118.1	-134.8
P 12.9 kg/ha + FYM	269.0	287.0	35.8	36.9	141.9	157.9	301.6	308.0	-32.6	21.0	-138.7	-142.0
P 12.9 kg/ha + FYM + PSB	269.0	287.0	35.8	36.9	153.2	169.8	300.9	307.8	-31.9	20.8	-149.3	-153.7
P 25.8 kg/ha	269.0	287.0	23.5	23.5	131.4	145.5	279.0	295.0	-10.0	8.0	-117.9	-130.0
P 25.8 kg/ha + PSB	269.0	287.0	23.5	23.5	133.0	146.4	282.3	299.9	-13.3	12.9	-122.8	-135.7
P 25.8 kg/ha + FYM	269.0	287.0	35.8	36.9	142.6	181.8	296.0	314.0	-27.0	27.0	-133.8	-171.9
P 25.8 kg/ha + FYM + PSB	269.0	287.0	35.8	36.9	151.4	184.6	296.5	318.0	-27.5	31.0	-143.1	-178.7
SEm ±					6.7	9.3	4.5	3.6	3.6			
CD (P=0.05)					19.2	26.9	13.0	10.3	10.3			

Table 4. Balance sheet of P (kg/ha) as influenced by integrated nutrient management in *kabuli* chickpea

Treatment	Initial soil P status (a)		P added (b)		N uptake by crop (c)		Soil P status after harvest (d)		Actual gain/ lossover initial status P = (a - d)		P Balance (a + b) - (c + d)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Control	10.4	10.6	0.0	0.0	21.5	22.3	10.0	10.2	-0.4	-0.4	-21.1	-21.9
PSB	10.4	10.6	0.0	0.0	21.7	26.2	10.7	10.4	0.3	-0.2	-22.0	-26.1
FYM (5t/ha)	10.4	10.6	2.6	2.6	21.0	26.4	11.0	11.4	-0.6	0.8	-19.0	-24.5
FYM + PSB	10.4	10.6	2.6	2.6	24.1	31.7	11.7	11.6	-1.3	1.0	-22.8	-30.1
P 12.9 kg/ha	10.4	10.6	12.9	12.9	26.3	28.3	11.4	10.3	-1.0	-0.3	-14.4	-15.2
P 12.9 kg/ha + PSB	10.4	10.6	12.9	12.9	27.5	31.2	11.5	11.5	-1.1	0.9	-15.7	-19.1
P 12.9 kg/ha + FYM	10.4	10.6	15.5	15.5	27.9	30.6	12.0	11.9	-1.6	1.3	-14.0	-16.5
P 12.9 kg/ha + FYM + PSB	10.4	10.6	15.5	15.5	31.0	33.6	12.7	12.3	-2.3	1.7	-17.8	-19.8
P 25.8 kg/ha	10.4	10.6	25.8	25.8	27.7	30.6	12.2	11.4	-1.8	0.8	-3.7	-5.6
P 25.8 kg/ha + PSB	10.4	10.6	25.8	25.8	28.6	31.2	12.7	12.3	-2.3	1.7	-5.1	-7.1
P 25.8 kg/ha + FYM	10.4	10.6	28.4	28.4	28.3	36.5	12.9	12.9	-2.5	2.3	-2.4	-10.4
P 25.8 kg/ha + FYM + PSB	10.4	10.6	28.4	28.4	30.5	37.7	13.3	13.3	-2.9	2.7	-5.0	-12.0
SEm±					1.7	1.9	0.2	0.2	0.2			
CD (P=0.05)					4.9	5.6	0.5	0.5	0.5			

Economics

Integrated use of 12.9 kg P/ha + PSB + FYM during 2005-06 (Rs 53,200/ha) and 25.8 kg P /ha + FYM with or without PSB (Rs.64,430 and 64,410 /ha) during 2006-07 produced maximum net returns. During both the years these treatments were on par with each other. But highest B: C ratio was recorded under the treatment 12.9 kg P /ha + PSB due to the nominal cost of biofertilizers. Minimum B: C ratio was observed under FYM during 2005-06 and nominally higher over control during 2006-07 due to higher cost of FYM.

Consequently for higher productivity, profitability and soil health, *kabuli* chickpea should be fertilized with 12.9 kg P/ha in conjunction with 5 tonne/ha FYM and PSB inoculation.

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