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Effect of Integrated Nutrient Management practices on growth, yield and economics of chickpea in maize-chickpea/wheat cropping system

Rajesh Kumar Shivran, Pankaj Kumar, Raj Kumar Jat, Vinay Kumar and Nilmani Prakash

Abstract
A field experiment was conducted at Agricultural Research Station, Ummedganj, Kota (Rajasthan) during the winter season of 2008 and 2009 to evolve an integrated nutrient management strategy for *chickpea*. The experiment was laid out in randomized block design with 12 treatment combinations of FYM (0, 5 t/ha) P $_2O_5$ (0, 40, 60 kg /ha), and sulphur (0, 20 kg/ha) replicated four times. Application of FYM @ 5t/ha, inorganic P $_2O_5$ @ 40 kg/ha and S @ 20 kg/ha resulted significantly higher plant height, Branches/plant, number of pods/plant, number of seeds/pod, number of nodules, dry weight of nodules and hence higher seed, straw yield and protein content during 2008 and 2009.There were no significant difference observed within 40 and 60 kg P_2O_5/ha The gross return, net return and B:C ratio increased with the application of FYM@5t/ha inorganic P_2O_5 @ 40 kg/ha and S @ 20 kg/ha during both the years. But highest B:C ratio was recorded under 60 kg P_2O_5/ha but it was on par with 40kg P_2O_5/ha It was concluded that for higher productivity, profitability and soil health, chickpea should be fertilized with 40 kg P_2O_5/ha in conjunction with 5 t/ha FYM and 20kg S/ha

Keywords: *Chickpea*, FYM, Sulphur, Phosphorus, Soil fertility nodules and economics

1. Introduction
Chickpea is an important pulse crop of rain fed areas in semiarid/arid climate. Average chickpea yield in India is very low compared with developed countries of the world such as China (4135 kg ha^{-1}), Canada (1427 kg ha^{-1}) and USA (1391kg ha^{-1}) (FAO, 2005). This low yield is due to a number of genetic, agronomic and environmental factors and imbalanced fertilizer application is the key among them. To achieve self-sufficiency in this commodity its acreage and productivity must be increased. In the recent years, cultivation of 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 yield is not realized. Phosphorus is one of the nutrients, required in large quantity for optimum growth and yield in pulses. Chickpea is generally considered to be highly efficient in extracting P from low P soils due to the production of acidic root exudates which dissolve insoluble soil P. Phosphorus fertilizer application results in increased occupation of anion adsorption sites by phosphate, which then releases sulphate ions into the soil solution. Thus, it may be subjected to leaching if not taken up by plant roots. The use of sulphur is considered to increase the efficiency of native sulphur as well as applied phosphorus. Both S and P are known to interact with almost all essential macronutrients, secondary nutrients and micronutrients (Abdin *et al.*, 2003) [1]. Application of S containing fertilizer can result in soil acidification and eventually may influence nutrient uptake (Havlin *et al.*, 2007) [3]. Application of farmyard manure (FYM) also improves soil health by improving nutrient availability, soil physical properties and microbial activity. Therefore, integration of P fertilizers with sulphur and organics would not only improve the productivity but also maintain soil health. In India, work done regarding crop response to S application is limited to oilseeds and their oil contents only Research work regarding FYM, P and S and their role in legumes growth and quality is very rare. Therefore, present study was conducted to assess the effect of FYM, sulphur and phosphorus application on yield attributes, dry weight of nodules, yield, protein content and economics of chickpea in south eastern plain zone of Rajasthan.

Materials and Methods
A field experiment was conducted during winter season of 2008 and 2009 at the Agricultural

Research Station, Ummedganj, Kota (Rajasthan).

The soil was clayey in texture, slightly alkaline in reaction (pH 7.5), low in organic carbon (0.56%) and medium in available nitrogen (278 kg/ha), medium in available phosphorus (10.3 kg/ha) and high in available potassium (325 kg/ha). The experiment was laid out in randomized block design with 12 treatment combinations of FYM (0, 5 t/ha) P $_2O_5$ (0, 40, 60 kg /ha), and sulphur (0, 20 kg/ha) replicated four times. FYM was incorporated at the time of field preparation, as per treatment. The compositions 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 2008 and 56, 0.48, 0.103 and 0.432% during 2009, respectively. The source of inorganic P was DAP which was drilled at the time of sowing. The source of sulphur was elemental S which was applied to soil as per treatment. A uniform dose of 23.5 kg N/ha was applied basal through DAP and urea, as per treatment. The variety 'GNG-469' was sown in rows 30 cm apart on 10 November 2008 and 05 November 2009 at the seed rate of 80 kg/ha. 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. 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 surface irrigation of 6 cm depth. During second year, rainfall was received at the time of germination (4.5 mm) and irrigation was given at pod filling stage. 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 analyzed using standard procedures. Results of both the years were analyzed statistically and data which did not show the homogeneity hence were given individual year- wise. Economic analysis was done based on prevailing market prices.

Results and Discussion

Effect of Farm Yard Manure: Plant under the influence of FYM @5 t/ha significantly attained higher plant height (5.6, 5.4%), number of pods per/plant (14.08, 11.95%), number of seeds per/pod (13.11, 13.11%), number of nodules/plant (10.46, 8.33%) and dry weight of nodules/plant (10.2g, 10.2g) over the control during 2008 and 2009 respectively (Table-1). Incorporation of FYM results in improvement in soil physical properties (water holding capacity, porosity and bulk density) and also increased organic carbon, available P and K status of the soil. Application of FYM @ 5tonnes/ha also registered yield advantage (0.79q and 0.95q/ha), net return (Rs/ha2221 and 2413) and B: C ratio (2.99 and 2.79) compared to control. Significantly improvement in grain yield net return and B: C ratio owing to FYM application could be ascribed to its favorable effect on plant growth, yield attributes and lower cost of cultivation. Protein content in grain significantly increased in both the years due to the application of FYM. The increase in protein content was 10.60 and 9.89% with the application of FYM @ 5t/ha compared with control in 2008 and 2009 respectively (Table-2) similar effect of inorganic P and FYM on residual soil fertility was reported by Lakpale *et al.* (2003) [7]

Effect of Phosphorus

Phosphorus favorably influenced plant height, dry weight of nodules per plant, yield attributes, yield and economics of chickpea in comparison of control. The significantly maximum plant height (7.14, 7.04%) number of pods per plant (25.00, 10.98%), number of seeds per pod (11.0, 7.43%), number of nodules/plant (6.27, 1.98%) and dry weight of nodules/plant (5g, 5g) of chickpea were recorded with the application of 40 kg P2O5/ha in 2008 and 2009 respectively but it was on par with 60 kg P2O5/ha (Table 1). Application of 40 kg P2O5/ha/ha also registered advantage in yield (10.35 and 12.15%), net return (Rs/ha3231 and 3279) and B: C ratio (3.05 and 2.79) respectively over control The improvement of P status of plant with increasing levels of P resulted in greater metabolism and physiological processes in the plant system. Protein content in grain significantly increased in both the years due to the application of phosphorus. The increase in protein content was 7.73 and 11.97% with the application of 40 kg P_2O_5/ha over control in 2008 and 2009 respectively (Table 2). Higher concentration and uptake of nutrients by plants under P application resulted in greater synthesis of protein. The improvement in P status in soil at chickpea harvest might owing to be buildup of phosphorus in soil as result of addition of P. Besides, On addition of P fertilizers to the soil there might be some sort of triggering action of native soil P resulting in increased its availability. Phosphorus plays a very 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 leads to efficient and greater partitioning of metabolites and adequate translocation of photosynthates and nutrients to reproductive structure (Tisdale *et al.* 1995) [10]. It has been well documented that organic matter not only releases the nutrients during its decomposition but also provide substrate for microbial growth. Hence, the effect of Phosphorus and sulphur was enhanced when applied in conjunction with FYM (Nilambari *et al*., 2003; Jat and Ahalawat; 2004) [8, 6].

Table 1: Effect of cropping system and different nutrient levels on growth, yield and economics of Chickpea.

Treatments	**Harvest Index (%)**		**Gross return (Rs/ha)**		**Net return (Rs/ha)**		**B: C ratio**	
Cropping System	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
Soybean-Wheat	24	27	33551	32783	22560	18473	3.05	2.29
Soybean-Chickpea	28	28	37078	37626	26434	26336	3.49	3.33
Soybean-Wheat/**chickpea**	27	27	34747	33829	23583	22539	3.14	2.99
SEm±	1.71	0.59	529	675	411	675	0.02	0.06
CD 5%	NS	NS	1832	2341	1425	2341	0.06	0.2
Nutrient Levels								
Absolute control	26	27	29045	30379	18091	18279	2.65	2.58
Inorganic nutrients (RDF)	27	2627	39800	37935	29209	25471	3.76	3.09

Organic nutrients	28	28	36532	35924	25277	23597	3.27	2.98
SEm±	1.01	0.50	1142	700	1044	700	0.09	0.05
CD 5%	NS	NS	3956	2081	3617	2061	0.32	0.18

Table 2: Effect of cropping system and different nutrient levels on growth, yield and economics of Chickpea.

Treatments	No. of seeds/pod		Seed Index		Soybean seed yield		Chickpea equivalent yield		Biological yield (kg/ha)	
Cropping System	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Soybean-Wheat	1.15	1.19	21	21	1225	1207	1459	1558	6184	5796
Soybean-Chickpea	1.16	1.21	22	22	1370	1331	1612	1612	5810	5843
Soybean-Wheat/chickpea	1.20	1.20	22	21	1243	1228	1511	1493	5666	5497
SEm±	0.04	0.04	0.33	0.31	26	19.93	23	34	380	230
CD 5%	0.13	0.13	NS		90	69.03	80	120	1316	797
Nutrient Levels										
Absolute control	1.20	1.17	21	21	1003	1011	1263	1326	5081	4863
Inorganic nutrients (RDF)	1.14	1.23	22	22	1483	1416	1730	1689	6389	6405
Organic nutrients	1.17	1.20	22	22	1353	1339	1588	1648	6190	5868
SEm±	0.02	0.02	0.35	0.34	25	27.48	50	43	247	229
CD 5%	0.08	0.07	NS	NS	88	81.59	172	139	856	680

Table 3: Effect of nutrient management on yield and economics of chickpea in maize-chickpea/wheat cropping system (Pooledof 2 years)

Treatments	Yield (kg/ha)						
	Soybean		Wheat/Chickpea		Chickpea equivalent		Pooled
	2008	2009	2008-09	2009-10	2008-09	2009-10	
Cropping System							
Soybean-Wheat	1225	1196	3050	2979	2576	2515	2526
Soybean-Chickpea	1300	1372	1612	1636	2559	2889	2724
Soybean-Wheat/chickpea	1243	1228	3059	1471	2597	2592	2595
CD at 5%	-	-	-	-	NS	108.9	99.6
Nutrient Levels							
Absolute control	1003	1060	1263	1321	2141	2304	2223
Inorganic nutrients (RDF)	1483	1406	1730	1649	2904	2922	2913
Organic nutrients	1353	1330	1588	1562	2686	2770	2728
CD at 5%	-	-	-	-	167.7	139.4	139

Table 4: Effect of phosphorus and sulphur management on productivity of soybean-chickpea cropping system

S Treatments	Soybean yield (kg/ha)		Chickpea yield (kg/ha)		Chickpea equivalent yield (kg/ha)		Pooled
	2008	2009	2008-09	2009-10	2008-09	2009-10	
Phosphorus (kg P_2O_5/ha)							
0 DAS	1242	1262	1448	1361	2420	2349	2385
30 DAS	1406	1428	1597	1527	2698	2644	2671
60 DAS	1432	1457	1648	1545	2769	2685	2727
CD (P=0.05)	92.16	91.00	88.53	108.58	81.01	89.9	77.0
Sulphur (kg/ha)							
0DAS	1309	1330	1500	1426	2525	2467	2796
20 DAS	1410	1435	1629	1538	2733	2661	2677
CD (P=0.05)	75.25	74.30	72.28	88.65	66.14	73.4	62.7

Effect of Sulphur fertilizer application

The observed data, reveals that plant growth, yield attributes, pods per plant, number of seeds per pod, number of nodules per plant, dry weight of root nodules per plant, seed yield, protein content, net returns and B : C ratio increased significantly with sulphur application upto 20 kg/ha. The application of 20 kg S /ha were increase in plant height(5.60,6.94%) pods per plant(12.67,8.69%) number of seeds per pod (6.34,8.87%) number of nodules per plant(4.36,1.29%), dry weight of root nodules per plant (5. 5,5.2g)seed yield (8.66,6.67%), protein content(13.2,12.65%) net returns(Rs/ha2684,2881) and B : C ratio (3.07,2.81 in 2008 and 2009 respectively over control. (Table 3 and 4). Increasing levels of sulphur significantly increase seed yield and sulphur uptake by seed and straw upto 20 kg S/ha the similar finding were also reported by Islam *et al*., (2009) [5]. The improvement in crop growth, nodulation and yield attributes with the application of S could be ascribed to its pivotal role in regulating the metabolism and enzymatic processes including photosynthesis, respiration and legume rhizobium symbiotic nitrogen fixation which reflected in increased yield (Rao *et al*., 2001) [9]. Sulphur application increases chlorophyll formation thereby enhances nitrogen use efficiency (|NUE). Nutrient combinations of FYM @5t/ha, 40 kg P_2O_5 /ha^1 and 20 kg S /ha^{-1} resulted in maximum yield, net return and B: C ratio of crop. This will not only result in increased fertilizer use efficiency and saving of precious and costly inputs but will also minimize the threats of soil and water pollution (Table 5). Phosphorus and sulphur management in maize- chickpea cropping system.

Phosphorus and sulphur management in soybean-chickpea cropping system. Application of 30 kg P_2O_5 gave significantly higher chickpea equivalent yield (2671 kg/ha) over control but remained on par with 60 kg P2O5/ha. Maximum and significantly higher chickpea equivalent yield (2697 kg/ha) was recorded in 20 kg S/ha over no sulphur application.

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