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Effect of phosphorus levels with PSB on yield, nutrient use efficiency and uptake of nutrients by chickpea

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Abstract
The field experiment was conducted during 2015-16 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) to study on "Effect of phosphorus levels with PSB on uptake of nutrients, quality and yield of chickpea". The experiment was laid out in Randomized Block Design with seven treatments randomized in three replications. The treatments comprised of unfertilized control, chemical fertilizer alone and their combinations with PSB. The soil of experimental site was medium black belongs to Vertisols particularly Vertic Haplustepts. The soil and plant samples were collected and analyzed for their different properties.

Grain yield of chickpea, total uptake of nitrogen, phosphorus and potassium as well as available NPK after harvest of chickpea were significantly increased due to application of 75% RDP + PSB. It was further increasing with every successive increase in doses of phosphorus from 75% RDP to 125% RDP. The increasing levels of RDF along with PSB inoculation increased the uptake of nutrients and yield contributing characters over no inoculation. Use efficiency of N and K were found maximum with application of 125% RDP + PSB but use efficiency of phosphorus was recorded maximum with application of 75% RDP + PSB. Recovery of N & K were found maximum with the application of 125% RDP + PSB but phosphorus recovery was recorded higher with application of 100% RDP + PSB.

Keywords: PSB, chickpea, Vertisols

Introduction

Chickpea (*Cicer arientinum*) or Gram is most important and premier pulse crop of India. Chickpea has been well recognized as a valuable source of protein particularly in developing countries, where majority of population depends on the low priced food for meeting its dietary requirements. The main problem of phosphorus fertilizer is its low availability.

Phosphorus is one of the major plant nutrients. It is an indispensable element plays a unique role in several plant metabolic and energy transformation process. The major importance of phosphorus is usually a constituent of phospholipids, nucleic acids, protein, co-enzymes, NAD, NADP and ATP. It is essential for growth and development of root nodules and multiplication and effectiveness of root nodules bacteria. It is also necessary for cell division, a constituent of chromosomes stimulates root development, meristematic growth, seed, fruit development and stimulates flowering. Phosphorus application increases the protein content in chickpea seed. The main problem of phosphorus fertilizer is its low availability. Phosphorus is quite immobile and reversion making it unavailable to plant. Consequently only 10-25% of applied phosphorous is utilized by the crops.

The PSB have capacity to dissolve insoluble form of inorganic phosphate and make, it available to crops. These results are in conformity with finding reported by Kamparia (1995). Soil phosphate are rendered available either by plant roots or soil microorganism, through secretion of organic acid, such as formic acid, acetic acid, propionic, lactic, glycolic acids etc. PSB may also release soluble phosphate into the soil through decomposition of phosphate from organic compounds.

Material and Methods

A field experiment was conducted with seven treatments and three replications laid out in Randomized Block Design (RBD) at the experimental field of Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during rabi 2015-16. The treatment offered were T_1: Control, T_2: 75% RDP, T_3: 100% RDP, T_4: 125% RDP, T_5: 75% RDP + PSB, T_6: 100% RDP + PSB and T_7: 125% RDP + PSB (Full dose of N & K was applied to all the treatments, except T_1 and seed treatment with PSB @ 20 g kg^{-1} of seed). The representative plants were carefully uprooted retaining most of the roots intact at

harvest of chickpea crop. Plant material expects roots was chopped into small pieces and air dried under the shade and then in oven at 65ºC for uptake of nutrients. The soil samples from the experimental site (0-20 cm) were collected randomly from four spots and composite sample was prepared for the determining the chemical properties of soil before sowing, After harvest of chickpea crop surface soil sample (at 20 cm death) were collected from each plot and analyzed for Avail. N, P and K (Subbaih and Asija, 1952), (Watanabe and Olson, 1685) [17] and (Hanway and Heidel, 1952).

Results and Discussion

Grain and straw of chickpea

Grain and straw yield of chickpea was recorded low in control (Table1). It was further increasing with every successive increase in doses of phosphorus from 75% RDP to 125% RDP. A significant increase in grain yield (15.10 q ha^{-1}) and straw yield (26.78 q ha^{-1}) was obtained with the application of 125% RDP + PSB (T_7) but statistically at par with all treatments except T_2 & T_1.

Jackson and Miller (2006) reported that, the effect of phosphorus with and without PSB on grain and straw yield of chickpea was found to be significant over control. In case of phosphorus with PSB, grain and straw yield of chickpea was recorded significantly higher over without PSB. Sardana *et al*. (2006) [13] also found that, every increased dose of phosphorus produced significantly higher seed yield over its lower dose. PSB produces growth substances like IAA & GA and also helps for formation of growth hormones which promotes seed maturation. This could be reason for increased grain and straw yield of chickpea (Bhattacharyya and Jain, 2000). Similar report reported that combined application of phosphorus and PSB caused significant inclined in the grain and straw yield of chickpea (Dinesh Kumar *et al*. 2014) [3].

Table 1: Yield of chickpea as influenced by various treatments.

Treatments	Yield of chickpea (q ha^{-1})	
	Grain	Straw
T_1–Control	08.30	14.76
T_2– 75% RDP	12.13	22.47
T_3- 100% RDP	13.68	24.85
T_4- 125% RDP	14.75	26.06
T_5– 75% RDP + PSB	13.45	24.40
T_6– 100% RDP + PSB	14.58	25.44
T_7 – 125% RDP + PSB	15.10	26.78
SE (m±)	0.55	0.80
CD at 5%	1.68	2.41

Total uptake of nutrients by chickpea

Uptake of nitrogen

The uptake of nitrogen by chickpea was significantly influenced with the increasing levels of phosphorus along with PSB over control (Table 2). The highest uptake of nitrogen in grain (41.67 kg ha^{-1}) and straw (34.27 kg ha^{-1}) was recorded with application of 125% RDP + PSB (T_7) over other treatments but statistically at par with all treatments except T_1, T_2, T_3 and T_5. The highest total nitrogen (76.24 kg ha^{-1}) was recorded in the same treatment which was at par with all the treatments except T_1 & T_2.

Uptake of nitrogen by chickpea was increased with application of phosphorus with PSB could be attributed to synergistic effect between P and PSB. This might be partially attributed to the favourable effect of PSB application to form vegetative plant material which in turns increases in N uptake by chickpea. It is also inferred that plant are not able to survive without adequate or sufficient phosphorus and PSB application because it is essential for synthesis of DNA and RNA and to mobilizing carbohydrates, lipids and protein production. They attributed an increase in weight of air born organ to increase in N uptake was reported by Gupta and Gangwar (2012) [6].

Table 2: Uptake of nitrogen by chickpea as influenced by the various treatments

Treatments	Uptake of Nitrogen (kg ha^{-1})		
	Grain	Straw	Total
T1 – Control	22.07	18.58	40.65
T2 – 75% RDP	32.50	28.31	60.81
T3 – 100% RDP	36.79	31.55	68.34
T4 – 125% RDP	40.56	33.09	73.65
T5 – 75% RDP + PSB	36.39	30.74	67.13
T6 – 100% RDP + PSB	39.94	32.30	72.24
T7 – 125% RDP + PSB	41.67	34.27	76.24
SE (m±)	0.86	0.89	3.05
CD at 5%	2.57	2.66	9.14

Uptake of phosphorus

The uptake of phosphorus by chickpea was significantly influenced with the application of various levels of phosphorus along with PSB over control (Table 3). The highest uptake of phosphorus in grain (11.47 kg ha^{-1}) and straw (5.89 kg ha^{-1}) was recorded with application of 125% RDP + PSB (T_7) over other treatments, but statistically at par with treatment T_6. The same treatment had noted highest total phosphorus uptake (17.36 kg ha^{-}1) but it was at par with treatment T3, T_4 & T_5. The lowest phosphorus uptake (7.02 kg ha^{-1}) was recorded in control (T1).

The increase in concentration of P in grain with the increasing levels of phosphorus application alone or in combination with PSB could be attributed to synergistic effect between P and PSB. Erkovan *et al.,* (2010) [11]. Uptake of phosphorus in grain was significantly affected and was higher in PSB inoculated treatment (17.36 kg ha^{-1}) over no inoculation (7.02kg ha^{-1}).

PSB inoculation had resulted in increased phosphorus uptake in grain and straw. The increased phosphorus uptake due to PSB culture inoculation was due to higher biomass production as well as due to more plant accessible by PSB, from native and applied phosphorus. This type of results was also reported by Paratey and Wani (2005) [10]. The culture can hence prove broad spectrum biofertilizers which may increase yield of crops. Use of PSB culture increases nodulation, crop growth, nutrient uptake and crop yield Gupta (2006).

Table 3: Uptake of phosphorus by chickpea as influenced by the various treatments

Treatments	Uptake of Phosphorus (kg ha^{-1})		
	Grain	Straw	Total
T1 – Control	4.81	2.21	7.02
T2 – 75% RDP	7.40	3.60	11.00
T3 – 100% RDP	9.30	4.72	14.02
T4 – 125% RDP	10.32	5.21	15.53
T5 – 75% RDP + PSB	9.14	4.39	13.02
T6 – 100% RDP + PSB	10.78	5.34	16.12
T7 – 125% RDP + PSB	11.47	5.89	17.36
SE (m±)	0.28	0.22	***I.***45
CD at 5%	0.82	0.60	4.37

Uptake of potassium

The uptake of potassium by chickpea was significantly influenced with the increasing levels of phosphorus along

with PSB over control (Table 4). The highest uptake of potassium in grain (17.21 kg ha^{-1}), straw (49.81 kg ha^{-1}) as well as total (67.02 kg ha^{-1}) were recorded with application of 125% RDP +PSB over remaining treatments. Treatment T_7 was superior over all treatments except treatment T_6 & T_4 in respect of grain uptake while it was superior over all treatments in respect of potassium uptake by straw and was at par with treatment T_4, T_5 & T_6 in respect of total potassium uptake. Similar result stated with Erkosan *et al.*, (2010) reported that the application of 16 kg P_2O_5 ha^{-1} with PSB significantly increased uptake of N, P, K and micronutrients by chickpea over control.

Table 4: Uptake of potassium by chickpea as influenced by the various treatments

Treatments	Uptake of Potassium (kg ha^{-1})		
	Grain	Straw	Total
T1 – Control	8.88	26.13	35.01
T2 – 75% RDP	13.22	40.00	53.22
T3 – 100% RDP	15.32	45.22	60.54
T4 – 125% RDP	16.66	47.95	64.61
T5 – 75% RDP + PSB	15.04	46.04	61.08
T6 – 100% RDP + PSB	16.47	46.30	62.77
T7 – 125% RDP + PSB	17.21	49.81	67.02
SE (m±)	0.26	0.40	***1.***15
CD at 5%	0.75	1.18	5.97

4.5 Soil chemical properties

Available nitrogen

Available nitrogen in soil after harvest of chickpea was found significantly higher with the various levels of phosphorus along with PSB over control (Table 5). Available nitrogen increases in soil after harvest of chickpea with increasing levels of phosphorus over control. The significantly higher available nitrogen (218.2 kg ha^{-1}) in soil after harvest of chickpea was recorded in treatment 125% RDP + PSB (T_7) over remaining treatments but it was statistically at par with T_4. This may be due to the beneficial effect of phosphorus with PSB in improving soil properties and enhancing the availability of nitrogen in soil has been reported by Subba Rao (1986) [9].

Table 5: Available nutrients in soil after harvest of chickpea

Treatments	Available nutrient (kg ha^{-1})		
	N	P	K
T1 – Control	204.8	13.74	337.6
T2 – 75% RDP	210.4	15.82	366.4
T3 – 100% RDP	213.3	16.77	374.6
T4 – 125% RDP	216.6	17.24	378***3.***
T5 – 75% RDP + PSB	212.2	16.64	370***0.***
T6 – 100% RDP + PSB	***215.3***	18.52	376.5
T7 – 125% RDP + PSB	218.2	19.10	381.7
SE (m±)	0.56	0.62	1.03
CD at 5%	1.72	1.88	3.06

Available phosphorus

Available phosphorus in soil after harvest of chickpea was significantly increases with the application of various levels of phosphorus alone or in combinations with PSB over control (Table 5). The highest available phosphorus (19.10 kg ha^{-1}) was recorded in the treatment 125% RDP + PSB (T_7) over remaining treatments but found statistically at par with T_4 & T_6.

These results were more or less similar to those quoted by (Chandel *et al*, 1989) [2]. They reported that use of bio-fertilizers along with phosphatic fertilizer have greater impact in increasing fertilizer use efficiency by fixing atmospheric nitrogen and solubilising active phosphorus consequently increase the economics of crop.

Available potassium

Available potassium in soil after harvest of chickpea was found to be significant with varying levels of phosphorus along with PSB (Table 5). Available potassium increased in soil with increasing phosphorus level with PSB. The highest available potassium (381.7 kg ha^{-1}) was recorded with the application of 125% RDP + PSB (T_7) over remaining treatments which was superior over all other treatments. Level of N, P and K application may also have an effect on overall crop growth along with bio-fertilizers (Hedge and Murty, 2005).

Nutrient use efficiency and nutrient recovery by chickpea

The maximum nutrient use efficiency and nutrient recovery of nitrogen & potassium by chickpea were recorded with the application of 125% RDP + PSB (T_7) but maximum phosphorus use efficiency was recorded with the application of 75% RDP + PSB (T_5) and maximum phosphorus recovery was recorded with the application of 100% RDP + PSB (T_6).

The nutrient use efficiency and nutrient recovery of N, P and K by chickpea were recorded higher by application of phosphorus with PSB was quoted by Ahmad and Rashid, 2006. The nutrient use efficiency was higher due to combined application of Phosphorus and PSB as compared to their sole P application. These results corroborate with the findings of Kumar *et al*. (2011), who also observed reduction in agronomic efficiency of nutrients with increase in their application rate. Level of N, P and K application may also have an effect of recovery of added bio-fertilizers, as these have influence on overall crop growth, (Khalid, 2007) [8].

Table 6: Nutrient use efficiency and Nutrient recovery of chickpea as influenced by various treatments

Treatments	Nutrient use efficiency (kg kg^{-1} ha^{-1})			Nutrient recovery (%)		
	N	P	K	N	P	K
T_1– Control	---	---	----	----	----	----
T_2 – 75% RDP	15.32	10.21	12.76	41.72	6.90	14.46
T_3 – 100% RDP	21.52	10.76	17.93	58.88	8.98	21.46
T_4 – 125% RDP	25.80	10.32	21.50	73.96	8.81	25.93
T_5 – 75% RDP + PSB	20.60	13.73	18.16	57.28	11.54	20.53
T_6 – 100% RDP + PSB	25.12	12.56	20.93	71.48	11.94	25.30
T_7 – 125% RDP + PSB	27.20	10.80	22.66	78.40	10.65	27.76

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