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Effect of phosphorus levels through Integrated Nutrient Management (INM) packages on different parameters of groundnut crop

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ABSTRACT
The field experiment was conducted at University of Agricultural and Horticultural Sciences (UAHS), College of Agriculture, Shivamogga and ZAHRS, Shivamogga. The results on the different growth viz., plant height, number of branches and nodules per plant, leaf area and root length, yield parameters viz.,test weight, shelling percentages, pod yield, haulm yield and quality parameters viz.,oil content revealed that the higher the height of the groundnut was recorded in treatment T_6 with application 75 % of 30 kg P_2O_5 ha $^{-1}$ through CF + 25 % through FYM along with PSB whereas, lowest plant height was recorded in treatment (T_1) application with 20 kg P_2O_5 ha^{-1}. The branches of groundnut at 30 DAS found to be statistically non significant. Quality parameters viz., oil content, oil yield (kg ha^{-1}) and protein content was recorded higher value in in treatment T_6 with application 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM along with PSB whereas lowest value was recorded in lower dose application of phosphorus without PSB. The significantly highest yield was recorded in highest dose phosphorus application (T_6) whereas; lowest yield was recorded in treatment (T_1). The higher B: C ratio was recorded as 2.82 in treatment (T_6).
Key Words: *Phosphorus, INM, Groundnut*

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INTRODUCTION

In soils, applied phosphate fertilizer enter into complex reactions with the various constituents of soils such as Fe, Al, Ca, Mg and get quickly converted to less soluble or insoluble forms as a result 20-25 per cent of applied phosphatic fertilizer is utilized by the crop in a season indicating low phosphorus use efficiency and build up of P in soil is very common in the soils. The fixation of P is a pH dependent chemical reaction that makes it unavailable to crops. Phosphorus availability in acid soils is low because of its fixation by iron and aluminium oxides which often limit the plant growth. Further, phosphorus occurs in soils in both inorganic and organic forms. The inorganic phosphorus forms are largely associated with aluminium, iron and calcium compounds which act as major forms phosphorus in soils. On the contrary, the occluded and reductant soluble forms of phosphorus are interrelated and contribute to the pool of plant available phosphorus in soils.

Integrated use of phosphorus fertilizers with FYM and bio-fertilizers like P solubilising bacteria for instance *Pseudomonas striatus*, enhancing the more P solubility and availability in soils. The INM practices increases available nutrients, facilitates slow release of nutrients and thus reduces nutrient losses. As such, P status is not poor in soils but its availability to plants from soil is meager as it is present mostly in unavailable or fixed forms. Therefore, efforts need to be made to solubilize unavailable P forms to plant available forms.

Keeping these views and facts in mind, a field experiment was conducted at College of Agriculture, Navile, Shivamogga during 2015-2016 on sandy loam soil to study the effect of phosphorus levels through integrated nutrient management (INM) packages on status of phosphorus in soil under groundnut crop.

MATERIALS AND METHODS

A field experiment was conducted to investigate the effect of phosphorus levels through integrated nutrient management (INM) packages on status of phosphorus in soil under groundnut crop during the *kharif* 2015-16 under rainfed condition at College of Agriculture, Shivamogga, comes under University of Agricultural and Horticultural Sciences, Shivamogga and belongs to Southern Transition Agro-climatic Zone of Karnataka (Zone No. 7). The experimental site is situated at 14°0' to 14°1' North latitude and 75° 40' to 75° 42' East longitude with an altitude of 650 meters above the mean sea level. Groundnut crop variety (G2-52) was selected as a test crop. The experiment comprised nine treatment combinations with three phosphorus levels *viz.,* 20, 30 and 50 kg P_2O_5 ha^{-1} applied through inorganic P fertilizer (75 %) and FYM (25 %) along with PSB bio fertilizer which are laid out in Randomized Completely Block Design (RCBD) with three replications. The treatment details are given below.

Treatment details

T_1: RDNK + 20 kg P_2O_5 ha^{-1}, **T_2:** RDNK + 75 % of 20 kg P_2O_5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM, **T_3:** T_2 + PSB, T_4: RDNK + 30 kg P_2O_5 ha^{-1}, **T_5:** RDNK + 75 % of 30 kg P_2O_5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM, **T_6:** T_5 + PSB, T_7: RDNK + 50 kg P_2O_5 ha^{-1}, **T_8:** RDNK + 75 % of 50 kg P_2O_5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM and **T_9:** T_8 + PSB

The initial properties of experimental site were determined by following standard procedures. The experimental site was Sandy loam (72.54 % sand, 10.25% silt, 17.21% clay). The soil was acidic in reaction pH : 5.47, EC: 0.078 dS m^{-1}, OC : 4.82 g kg-1, CEC: 9.3c mol (p+) kg^{-1} and the status of available N, P and K were 207.43, 142.48 and 191.06 kg ha^{-1}, respectively. Exchangeable Ca and Mg were2.70 and 1.50, respectively and available sulphur were 8.40 mg kg^{-1}. Oil content in groundnut kernels was determined by NMR (Nuclear Magnetic Resonance) using appropriate standards as outlined by (Granhund and Zimmerman, 1975). The oil content in kernels expressed as percentage. The analysis of variance to factorial randomized block design to test difference among treatments was carried out as per the procedure described by Panse and Sukhatme (1985).

Table 1: Effect of phosphorus levels through integrated nutrient management packages on plant height

Treatments	Plant height (cm)				Number of braches per plant			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1: 20 kg P_2O_5 ha^{-1}	7.36	15.35	22.78	24.25	5.90	5.99	6.14	6.18
T_2: 75 % of 20 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	7.79	16.22	24.91	26.15	5.91	6.17	6.30	6.35
T_3: T_2 + PSB	8.14	18.49	26.20	28.60	5.92	6.25	6.34	6.41
T_4: 30 kg P_2O_5 ha^{-1}	8.58	19.96	28.04	30.33	5.92	6.28	6.49	6.54
T_5: 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	9.17	21.00	31.57	33.74	5.93	6.33	6.69	6.74
T_6: T_5 + PSB	10.04	24.54	34.89	37.42	5.94	6.39	6.81	6.92
T_7: 50 kg P_2O_5 ha^{-1}	9.30	21.93	31.88	35.22	5.93	6.34	6.71	6.76
T_8: 75 % of 50 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	9.58	22.71	32.90	36.16	5.92	6.36	6.73	6.80
T_9: T_8 + PSB	9.75	23.08	33.03	36.85	5.93	6.38	6.75	6.83
S Em ±	0.24	0.92	0.91	0.98	**NS**	0.05	0.05	0.03
CD (P=0.05)	0.73	2.77	2.74	2.95	**NS**	0.16	0.16	0.11

CF: Chemical Fertilizers, **FYM:** Farmyard Manure, **PSB:** Phosphorus Solubilising Bacteria.
RDNK and FYM @ 10 t ha^{-1} common to all treatments

RESULTS AND DISCUSSION

Effect of phosphorus levels through INM packages on growth parameters of groundnut

The effect of phosphorus levels through integrated nutrient management (INM) packages on growth parameters of groundnut like plant height and number branches per plant data are presented in Table 1

Data recorded on plant height at different growth stages (Table 1) reveals that plant height was significantly increased as the days of crop maturity (from 30, 60, 90 DAS and harvest) and increasing phosphorus levels due to influence of different levels of P application through INM packages.

Among the imposed treatments, the treatment T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB recorded significantly higher plant height at 30, 60, 90 DAS and harvest stage (10.04, 24.54, 34.89 and 37.42 cm, respectively) followed by treatment T_9 (75 % of 50 kg P_2O_5 ha^{-1}

through CF + 25 % through FYM + PSB). This might be due to the combined use of FYM and PSB solubilised the applied and native build P in to an easily soluble and available form and their subsequent uptake by the crop. Akbari *et al.* (2002) reported that application of FYM increased the availability of P to crop. Further, phosphorus plays an important key role in photosynthetic reactions in plant which resulted in increased growth and development of groundnut. Moreover, P is involved in cell division, elongation, multiplication and development. Barik *et al.* (1994) was reported that plant height increased linearly by the application of P @ 80 kg P_2O_5 ha^{-1}. This finding corroborates with the results of Maurya and Rathi (2000), Subrahmaniyan *et al.* (2000), Mishra (1994), Geethalakshmi *et al.,* (1993), Singh *et al.* (2011) and Munda *et al.* (2004). Significantly lower value of plant height (7.36, 15.35, 22.78 and 24.25 cm at 30, 60, 90 DAS and at harvest, respectively) was noticed due to treatment T_1 supplied with low dose of P @ 20 kg P_2O_5 ha^{-1} indicating lesser availability of P in soil and crops.

Table 2: Effect of phosphorus levels through integrated nutrient management packages on growth, yield and quality parameters

Treatments	Leaf area (cm ^{2}plant^{-1})			No. of nodules plant^{-1}	Root length (cm)	Number of pods plant^{-1}	Test weight (g)	Shelling percentage	Pod yield (q ha^{-1})	Haulm yield (q ha^{-1})	Oil content (%)
	30 DAS	60 DAS	90 DAS								
T_1: 20 kg P_2O_5 ha^{-1}	127.04	281.25	504.67			11.14	33.70	50.35	9.72	15.30	45.98
T_2: 75 % of 20 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	146.97	324.00	632.05	24.30	9.26	11.87	34.19	51.77	11.13	18.89	46.03
T_3: T_2 + PSB	171.28	373.10	717.64	26.52	10.37	12.52	35.81	52.17	13.69	21.91	46.07
T_4: 30 kg P_2O_5 ha^{-1}	195.20	433.23	771.51	28.59	11.46	15.50	36.47	55.49	15.62	24.39	46.10
T_5: 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	233.87	472.51	847.31	31.37	12.76	18.04	38.12	57.92	17.19	26.54	46.13
T_6: T_5 + PSB	264.22	530.27	925.32	32.34	14.17	23.15	40.47	66.78	19.79	30.49	46.19
T_7: 50 kg P_2O_5 ha^{-1}	237.48	505.53	875.91	35.62	16.92	21.42	36.70	58.58	17.98	27.92	46.12
T_8: 75 % of 50 kg P_2O_5 ha^{-1} through CF + 25 % through FYM	244.34	520.01	881.51	32.91	14.73	21.74	36.89	61.78	18.42	28.18	46.15
T_9: T_8 + PSB	256.57	526.42	898.73	33.01	15.32	22.23	37.18	62.39	18.98	29.17	46.17
S Em ±	4.67	8.81	10.33	33.74	15.46	0.57	0.99	1.10	0.93	1.36	**NS**
CD (P=0.05)	14.01	26.42	30.97	1.15	0.66	1.71	2.98	3.03	2.80	4.07	**NS**

CF: Chemical Fertilizers, **FYM:** Farmyard Manure, **PSB:** Phosphorus Solubilising Bacteria. RDNK and FYM @ 10 t ha^{-1} common to all treatments

The data on number of branches per plant of groundnut at 30, 60, 90 DAS and at harvest, as influenced by application of different phosphorus levels through integrated nutrient management (INM) packages are presented in Table 3. Among the levels of P, supply of P @ 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB (T_6) recorded higher number of branches per plant (5.94, 6.39, 6.81 and 6.92 branches plant^{-1} of groundnut at 30, 60, 90 DAS and at harvest, respectively) followed by T_9 treatment. The availability phosphorus increased due to combined use of inorganic P along with FYM and PSB might have solubilised the insoluble and fixed P present in the soil. Akbari *et al.* (2002) reported that application of FYM increased the availability of P to crop. The role phosphorus is very evident in increasing growth, development and photosynthesis and which might have reflected on higher number of branches per plant. Similar results also reported by Salve and Gunjal (2011), Munda *et al.* (2004), Mishra (1994), Bajrang *et al.* (2013), Chesti *et al.*(1995), Pulla Rao *et al,* (1995), Meena *et al.(*2004) and Singh *et al.* (2012). Significantly lower number of branches (5.90, 5.99, 6.14 and 6.18 branches plant^{-1} at 30, 60, 90 DAS and harvest, respectively) was recorded when low dose of P (20 kg P_2O_5 ha^{-1}) applied to soil.

Leaf area recorded at 30, 60 and 90 DAS are given in Table 2. Significantly higher leaf area was recorded with treatment T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB (264.22, 530.27 and 925.32 cm^2 $plant^{-1}$, respectively at 30, 60 and 90 DAS) followed by the T_9 (75 % of 50 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB). Significantly lower leaf area was recorded due to application of low dose of P @ 20 kg P_2O_5 ha^{-1} (127.04, 281.25 and 504.67 cm^2 $plant^{-1}$ at 30, 60 and 90 DAS, respectively). Leaf area increased due to high and continuous availability of P and as it plays an important role in growth, development and photosynthesis. Similar results were also obtained by Chesti *et al.* (1995), Munda *et al.*, (2004), Salve and Gunjal (2011) and Iman and Ahmed (2014).

The pertaining data (Table 2) on number of nodules per plant and root length as influenced by different phosphorus levels through integrated nutrient management (INM) packages are given in Table 4. Significantly higher number of nodules per plant (35.62 nodules $plant^{-1}$) of groundnut was recorded due to treatment T_6 (75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB) followed by T_9 treatment. And significantly lower number of nodules (24.30 nodules $plant^{-1}$) was recorded in treatment T_1 supplied with low dose of P (20 kg P_2O_5 ha^{-1}). This might be due to inorganic P fertilizers applied with FYM and PSB increased the P availability and P play an important role in nodules formation thereby increases in the number of nodule in groundnut. Dekhane (2011) also obtained similar results and reported in garden pea; increase in the number of nodules with increase in phosphorus levels. Similar results were also noticed by Nkaa *et al.* (2014), Baboo and Mishra (2001).

Significantly higher value of root length (16.92 cm) was recorded in the treatment T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB. Significantly lower root length (9.26 cm) was recorded due to supply of low dose of P @20 kg P_2O_5 ha^{-1}. Phosphorus application and PSB in combination tended to enhance root development and root length and phosphorus also enhances the biological nitrogen fixation in addition to higher availability of phosphorus by solubilization and mobilization mechanisms in soil. Similar results were obtained by Salve and Gunjal (2011).

Effect of phosphorus levels through INM packages on yield and yield attributes of groundnut

The results on yield parameters like number of pods per plant, test weight, shelling percentage, pod yield and haulm yield as influenced by P levels applied through INM packages are given in Table 2.

Among all the imposed treatments, application of P @ 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB (T_6) recorded significantly higher number of pods $plant^{-1}$ (23.15) followed by treatment T_9. Significantly lower number of pods $plant^{-1}$ was recorded in treatment T_1 supplied with lower dose of P @ 20 kg P_2O_5 ha^{-1} (11.14 pods $plant^{-1}$). This may be ascribed to increased P availability in soil from applied P as well as native P solubilised due to use of FYM and PSB and their subsequent uptake influenced the physiological processes that are directly related to biological nitrogen fixation, photosynthesis and translocation of carbohydrates for pod growth. Iman and Ahmed (2014) reported that increased number of pods per plant in groundnut due to P application. Similar results were also found by Jagdev and Singh (2000), Kumaran *et al.* (2000), Pulla Rao *et al.* (1995), Ghosh *et al.* (2004), Mir *et al.* (2010) and Bajrang *et al.* (2013).

Among the imposed treatments, treatment T_6 applied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB recorded significantly higher shelling percentage and test weight (66.78 % and 40.47 g, respectively) of groundnut followed by Treatment T_9 supplied with higher dose of P (50kg P_2O_5 +FYM and PSB). Significantly lower shelling percentage and test weight was recorded in T_1 supplied with low dose of P @20 kg P_2O_5 ha^{-1} (50.35 % and 33.70 g, respectively). The increased test weight and shelling percentage of groundnut might be due to higher P availability in soil in an easily soluble and available form due to combined use of FYM and PSB and their subsequent uptake by the crop. These observations are in line with those results of Subrahmaniyan *et al.* (2000), Jagdev and Singh (2000) and Sriramachandrasekaran (2001).

Application of different P levels along with FYM and PSB as INM packages significantly increased the pod yield and haulm yield (Table 2) of groundnut. Significantly higher pod yield and haulm yield were recorded in the treatment T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB (19.79 and 30.49 q ha^{-1}, respectively). But it was statistically on par with treatment T_9 supplied with 75 % of 50 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB (18.98 and 29.17 q ha^{-1}, respectively). Whereas, lowest yield was obtained due to application of low dose of P @ 20 kg P_2O_5 ha^{-1} (9.72 and 15.30 q ha^{-1}, respectively). This may be ascribed to increased P availability in soil from applied P as well as native P solubilised due to use of FYM and PSB and their subsequent uptake influenced the physiological processes that are directly related to biological nitrogen fixation, photosynthesis and translocation of carbohydrates for plant and pod growth. Further, FYM addition provided favourable soil conditions and increased the supply of plant nutrients and ultimately resulted in higher uptake of nutrients especially N might have influenced the yield positively. Increase in number of nodules per plant by integrated use organic and inorganic fertilizers also might be the reason for higher pod yield. Application of phosphorus

with organic sources which are played major role in acid formation like organic and inorganic acids by microbial activity during decomposition of organic materials thereby increases the nutrients availability to plants through mineralization mechanism. Those acids solubilise and mobilize the fixed phosphorus in soil, thereby increased the pod yield of the crop. These findings are in agreement with Mishra (1994), Jadhao *et al*. (1999), Ghosh *et al.* (2004), Rao and Shaktawat (2005), Bhatol *et al.*(1994), Choudhary *et al.* (2011), Hosamani and Janawade(2006), Murthy (2006), Ranjit *et al.* (2007), Singh *et al.* (2012) and Salve and Gunjal (2011).

Effect of phosphorus levels through INM packages on quality parameters of groundnut

Data on oil content and oil yield of groundnut are given in Table 2. The results revealed that highest oil content (46.19 %) was recorded in T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB followed by T_9 treatment but the effects were found to be non significant among the doses of P applied. The oil yield of groundnut significantly differed among the doses of P. Significantly higher oil yield (612.27 kg ha^{-1}) was observed due to application of 75 % P_2O_5 of 30 kg P_2O_5 ha^{-1} through CF + 25 % P_2O_5 through FYM + PSB (T_6) followed by treatment T_9. Significantly lower oil content (45.98 %) and yield were (224.82 kg ha^{-1}) recorded in T_1 supplied with low dose of P @ 20 kg P_2O_5 ha^{-1}

The oil content was higher due to the fact that higher P might have increased the higher N absorption which enhanced more Acetyl Co-A formation, which was directly related with oil formation. The other probable reason might be due to phosphorus playing an important role in phospholipids, fatty acids and esterification of fatty acids. These similar results corroborated with findings of Basu (2011).

Significantly higher protein content (21.46 %) was recorded in T_6 supplied with 75 % of 30 kg P_2O_5 ha^{-1} through CF + 25 % through FYM + PSB and it was on par with T_9 treatment. Whereas, T_1 treatment supplied with only 20 kg P_2O_5 ha^{-1} without FYM and PSB showed lower protein content (17.00 %) in groundnut kernel. Probable reason for increase in protein content is attributed that the nitrogen is an integral part of protein and involving in protein synthesis. Similar results were reported by Bajrang *et al.* (2013).

CONCLUSION

The results of the present experiment concluded that highest yield of the groundnut was recorded with higher dose application of the phosphorus through chemical fertilizers and FYM along with PSB. Remaining growth, quality and yield parameters showed highest with higher application of phosphorus. The compared to 50 kg ha^{-1} 30 kg ha^{-1} is best for increasing the yield and phosphorus availability.

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