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Influence of phosphorus fractions on P uptake and yield in groundnut monocropping system by the long term effect of manure and fertilizers

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Abstract
A field experiment was conducted to know the influence of P fractions on P uptake, yield and nutrient content. The nutrient uptake in plant at harvest was recorded the N uptake in plant was varied from 32.92 to 87.52 kg ha^{-1} and the P uptake was 8.09 to 25.23 kg ha^{-1} and the K uptake in plant was ranged from 26.64 to 76.26 kg ha^{-1}. The NPK content in plant was varied from 1.39 to 1.81%, 0.37 to 0.54% and 1.18 to 1.72% respectively. The pod yield of ground nut at harvest was ranged from 1099 to 2683 kg ha^{-1}. The haulm yield of groundnut was ranged from 2019 to 4889 kg ha^{-1}. Before sowing pod yield was positively correlated with the P fractions like Al-p (0.536**), Fe-P (0.470**), Occluded P (0.540**), Ca-P (0.515**), organic P (0.314*) and total P (0.380*). At harvest positive relationship between the pod yield with the P fractions except with the Ca-P (0.033). Before sowing while the P uptake did not correlate with the Al-P (0.130), Fe-P (0.184), Occluded P (0.112), Ca-P (0.117), negative relation with the organic P (-0.403**) was observed. At harvest P uptake was not correlated with any of the fraction but negative relationship with the organic P (-0.320*).

Keywords: Groundnut, inorganic P fractions (Al-P, Fe-P, occluded P and Ca-P), NPK uptake, NPK content, pod yield, haulm yield, correlation

Introduction
Long term field experiment is being carried out since 1981 at regional agricultural research station, tirupathi under groundnut mono cropping system, groundnut, (*Arachis hypogaea* L.) is the major oil seed cum cash crop for millions of small scale farmers in the semi arid tropics. India has prime position in area (5.53 million ha) and production (9.62 million tonnes) of ground nut with an average productivity of 1750 kg ha^{-1}. Andhra Pradesh holds a key position in area (1.38 million ha), production (1.23 million tonnes) and with productivity of 890 kg ha^{-1} (annual report, 2014) [2] The uses of ground nut are diverse: all parts of the plant could be used. The kernel is a rich source of edible oil, containing 36 to 54 per cent and 25 to 32 per cent protein. Phosphorus is an essential major element for plant growth. Phosphorus like any other plant nutrient is present in soil in two major components organic P and inorganic P. Plants mainly depend on inorganic P forms like saloid-P, Al-P, Fe-P Ca-P fractions for their P requirements. The availability and fractions of soil P may change due to long-term continuous P fertilization besides its effect on yield (Fan *et al*., 2003, Lai *et al.*, 2003) [6, 51].

Material and Methods
In a randomized block design a long term field experiment was laid out at regional agricultural research station, tirupathi with eleven treatments replicated four times. The treatments include. T_1: control (no manure and fertilizers), T_2: Farm yard manure (FYM) @ 5 t ha^{-1} (once in 3years), T_3: 20 kg Nitrogen (N) ha^{-1}, T_4: 10 kg Phosphorus (P) ha^{-1}, T_5: 25 kg Potassium (K) kg ha^{-1}, T_6; 250 kg gypsum ha^{-1}, T_7; 20 kg N + 10 kg P ha^{-1}, T_8: 20 kg N + 10 kg P + 25 kg K ha^{-1}, T_9; 20 kg N + 10 kg P + 25 kg K + 250 kg gypsum ha^{-1}, T_{10}; 20 kg N + 10 kg P + 25 kg K + 100 kg lime ha^{-1}, T_{11}; 20 kg N + 10 kg P + 25 kg K + 250 kg gypsum + 25 kg $ZnSO_4$ ha^{-1} (once in three years). Hence treatments with FYM, N, P, K and gypsum either alone or in combination with lime and zinc sulphate were imposed.
Soil samples were collected from each plot at two depths *viz*. 0-15 cm and 15-30 cm depths before sowing and at harvest of crop during *Kharif*-2014 and studied the influence of P fractions on nutrient content, uptake and crop yield at harvest. Fractions of P were analysed as procedures prescribed by Chang and Jackson (1957).

The NPK content was estimated by plant digestion method Kelplus distillation unit, Vanado molybdo phosphoric yellow colour method and flame photometer (Jackson, 1973) [7]. The uptake of nutrients in plants at harvest was calculated by using.

$$\text{Uptake of nutrients (kg ha}^{-1}) = \frac{\text{Nutrient concentration x weight of dry matter (kg ha}^{-1})}{100}$$

The pod yield by manually separating pods and haulm yield through drying from each net plot and weighed Data was analysed statistically for test of significance following the Fisher's method of analysis of variance as outlined by Panse and Sukhatme (1985) [11].

Results and Discussion

The highest value of N content was recorded in T_{11} (1.81) and the lowest value in T_8(1.39). The highest P content in T_9 (0.54) and lowest in T_7 (0.37) and the highest value of K content was recorded in T_7 (1.72) Where as the lowest in T_8(1.18). The highest value of N uptake was regarded in T_{11} (87.52) and Where as the lowest in control T_1(32.92). The P uptake highest was noticed in T_2(25.28) and lowest in T_5 (8.09). The K uptake highest value was recorded in T_2 (76.26) and lowest in control T_1 (26.64). The highest pod yield of ground nut was recorded in T_{10} 2683 kg ha^{-1}, and lowest in control T1 1902 kg ha^{-1}. The highest haulm yield was recorded in T_2 4889 kg ha^{-1}, and lowest in control T_1 2019 kg ha^{-1}.

The N and K content was not significantly varied among the treatments, but the P content was significantly varied among the treatments. The N uptake was significantly varied among the treatments, uptake of N was highest in NPK combined with gypsum and zinc sulphate compared to other treatments, the results were in accordance with Reddy *et al.* (1992) [13], Jagadeeswari *et al.*(2000) [8] and parvathi. (2013) [12]. The uptake of P and K in groundnut crop increased significantly with increase in P level (Jain *et al.* 1990) [9]. Application of FYM and inorganic fertilizers influenced the NPK concentrations in plant at harvest in long term fertilizer experiment in tirupati (Babu *et al* 2007) [3]. The present results were in confirmation with the earlier reports.

The pod yield and haulm yield of groundnut was significantly varied among the treatments. The highest pod yield recorded T10 might be attributed to well supply of all nutrients. The groundnut crop was responded well due to supply of nutrients through inorganic fertilizers especially in the treatments, N + P + K + gypsum + $Znso_4$, N + P + K + gypsum, N + P + K+ lime and N + P + K. The above findings were in accordance with the results of Babu *et al.* (2008) [4], Akbari *et al.*(2010) [1] and Sharma *et al.*(2011) [14].

The pod yield was significantly and positively correlated with the P fractions like Al-p (0.536**), Fe-P (0.470**), Occluded P (0.540**), Ca-P (0.515**), organic P (0.314*) and total P (0.380*), but not with available P (0.117) recorded at the time of sowing. While the P uptake did not correlate with the Al-P (0.130), Fe-P (0.184), Occluded P (0.112), Ca-P (0.117), but significantly negative correlation with the organic P (-0.403**) was observed. All tese positive relations might be contributed for the crop growth. An attempt was made to study the inter relationship between the different P fractions with the P uptake and yield through multiple regression. Total P was correlated with P uptake (0.083**) at sowing. Positive relation was also observed between occluded P and yield (0.038**). Multiple regression equation R^2 shows that the P fractions under study before sowing contributes to the extent of 37.8% for P uptake, 43.1% towards yield. At harvest 34.2% for P uptake, 43.9% for yield. This indicates that the P fractions under study might also be contributed for the P uptake and yield.

Table 1: influence of long-term application of manure and fertilizers on nutrient content at harvest of groundnut crop *kharif*-2014

Treatments	N (%)	P (%)	K (%)	N Uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1 Control	1.63	0.47	1.32	32.92	9.47	26.64
T_2 FIM @ 5 t ha^{-1} (once in 3 years)	1.79	0.53	1.57	70.22	25.23	76.26
T_3 N @ 20 kg ha^{-1}	1.59	0.42	1.55	39.72	10.49	38.71
T_4 P@ 10 kg ha^{-1}	1.58	0.41	1.50	48.70	12.6	46.24
T_5 K @ 25 kg ha^{-1}	1.56	0.40	1.34	33.16	8.09	28.47
T_6 Gypsum @ 250 kg ha^{-1}	1.66	0.41	1.27	43.23	10.62	33.06
T_7 NP	1.58	0.37	1.72	67.18	15.59	73.11
T_8 NPK	1.39	0.51	1.18	49.50	18.87	42.02
T_9 NPK+G	1.73	0.54	1.60	67.12	20.71	62.05
T_{10} NPK+L	1.58	0.49	1.59	60.46	18.70	60.84
T_{11} NPK+G+$ZnSO_4$	1.81	0.51	1.57	87.52	21.03	60.91
G M	1.62	0.46	1.47	54.52	15.58	49.84
SEm±	0.26	0.06	0.15	10.11	2.55	8.45
CD (P=0.05)	NS	NS	NS	29.21	7.37	24.40

Note: G= Gypsum, L = Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

Table 2: influence of long term application of manure and fertilizers on yield of groundnut crop (*kharif*-2014)

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1 Control	1902	2019
T_2 FIM @ 5 t ha^{-1} (once in 3 years)	2508	4889
T_3 N @ 20 kg ha^{-1}	2152	2497
T_4 P@ 10 kg ha^{-1}	2524	3082
T_5 K @ 25 kg ha^{-1}	2232	2126

T_6 Gypsum @ 250 kg ha^{-1}	2450	2604
T_7 NP	2407	4251
T_8 NPK	2609	3560
T_9 NPK+G	2673	3879
T_{10} NPK+L	2683	3826
T_{11} NPK+G+$ZnSO_4$	2625	4129
G M	2433	3351
S.Em±	110	376
CD (P=0.05)	320	1088

Note: G= Gypsum, L = Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

Table 3: Correlation coefficient of different phosphorus fractions before sowing (0-15cm) depth with P uptake and pod yield

P fractions	r values (0-15 cm)
Al-P vs P uptake	0.130
Fe-P vs P uptake	0.184
O-P vs P uptake	0.112
Ca-P vs P uptake	0.117
Organic P vs P uptake	-0.403**
Total P vs P uptake	0.260
Available P vs P uptake	0.040
Al-P vs Pod yield	0.536**
Fe-P vs Pod yield	0.470**
O-P vs Pod yield	0.540**
Ca-P vs Pod yield	0.515**
Organic P vs Pod yield	0.314*
Total P vs Pod yield	0.380*
Available P vs Pod yield	0.117

** significant at 1% level * significant at 5% level

Table 4: Correlation coefficient of different phosphorus fractions at harvest (0-15cm) depth with P uptake and pod yield

P fractions	r values (0-15 cm)
Al-P vs P uptake	0.210
Fe-P vs P uptake	0.174
O-P vs P uptake	0.094
Ca-P vs P uptake	0.027
Organic P vs P uptake	-0.320*
Total P vs P uptake	0.261
Available P vs P uptake	0.258
Al-P vs Pod yield	0.427**
Fe-P vs Pod yield	0.305*
O-P vs Pod yield	0.587**
Ca-P vs Pod yield	0.033
Organic P vs Pod yield	0.367*
Total P vs Pod yield	0.316
Available P vs Pod yield	0.359*

** significant at 1% level * significant at 5% level

Table 5: Multiple linear regression between P fractions with P uptake and yield before sowing (0-15 cm depth)

P fractions	P uptake	yield
Al-P	0.582	0.624
Fe-P	0.303	0.183
O-P	0.573	0.584
Ca-P	0.155	0.208
Organic P	-	0.501
Total P	0.083***	0.635
Available P	0.930	0.91

R^2 = 0.378 R^2 = 0.431

PUptake=18.053+0.293(Al-P)-0.313(Fe-P)+0.311(O-P)+1.018(Ca-P)-0.908(organic P)+0.110(total P)-0.011(available P);

Yield=894.50+7.311(Al-P)+11.27(Fe-P)+8.37(O-P)+24.87(Ca-P)+4.11(organic P)+0.819(total P)-4.756(available P);

Table 6: Multiple linear regression between P fractions with P uptake and yield before at harvest (0-15 cm depth)

P fractions	P uptake	yield
Al-P	0.399	0.784
Fe-P	0.277	0.649
O-P	0.748	0.038**
Ca-P	0.815	0.053
Organic P	0.006***	0.707
Total P	0.115	0.904
Available P	0.278	0.297

R^2 = 0.378 R^2 = 0.431

Puptake=21.114+0.503(Al-P)-0.439(Fe-P)+0.253(O-P)+0.134(Ca-P)-0.735(organic P)+0.156(total P)+0.140(available P);

Yield=1687.96-4.34(Al-P)+4.88(Fe-P)+44.850(O-P)-30.56(Ca-P)+2.54(organicP)-0.312(total P)+3.61(available P);

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