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M Venkata Lakshmi
Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India

Ch Pulla Rao
Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India

PVN Prasad
Department of Agronomy, Agricultural College Farm, Andhra Pradesh, India

P Prasuna Rani
Geospatial Technology Centre Guntur, Andhra Pradesh, India

Y Ashoka Rani
Department of Crop physiology, Agricultural College, Bapatla, Andhra Pradesh, India

Corresponding Author:
M Venkata Lakshmi
Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India

Studies on yield, nutrient content and nutrient uptake of groundnut as influenced by phosphorus management practices in rice-groundnut sequence

M Venkata Lakshmi, Ch Pulla Rao, PVN Prasad, P Prasuna Rani and Y Ashoka Rani

Abstract
A field experiment was conducted during *Kharif* 2016-17 and 2017-18 respectively on sandy loam soils of the Agricultural College Farm, Bapatla to study the yield, nutrient content and nutrient uptake of groundnut as influenced by phosphorus management practices in rice-groundnut sequence. The experiment was laid out in a Split-split plot design in *rabi* groundnut and the treatments were replicated thrice. The treatments consisted of four main plots residual effect of *Kharif* sources and levels of phosphorus S_1 : Inorganic fertilizer phosphorus through SSP, S_2 : Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1}, S_3 : Biofertilizer (PSB) @ 750 ml ha^{-1}, S_4 : Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1} + Biofertilizer (PSB) @ 750 ml ha^{-1} and three subplots levels of phosphorus L_1 : 50% Recommended dose of P, L_2 : 100% Recommended dose of P and L_3 : 150% Recommended dose of P. Each of the *Kharif* sub plot was divided into three sub-sub plots during *rabi* season with groundnut crop and total thirty six treatments were laid out in a Split-split design**.** Results of the experiment showed that residual sources and levels of phosphorus to preceeding rice crop *i.e., in-situ* green manuring + PSB showed superior performance in terms of yield, nutrient content and nutrient uptake such as nitrogen, phosphorus and potassium uptake of groundnut but was on a par with that of application of *in-situ* green manuring and significantly superior over inorganic fertilizer through SSP and biofertilizer (PSB) alone during both the years and pooled data of study. During *rabi* treatments among the doses of phosphorus 100 % RDP showed significantly higher yield, nutrient content and nutrient uptake of groundnut and it was on a par with 50 % RDP over control during both the years and pooled data.

Keywords: yield, nutrient content, nutrient uptake, phosphorus management and groundnut

Introduction
Groundnut (*Arachis hypogea* L) is one of the most important legume crop in India occupying an area of 4.76 million hectares with a total production of 7.40 million tonnes with productivity of 1555 kg ha^{-1}. Andhra Pradesh is one of the leading states with 0.87 million hectares under groundnut producing 0.49 million tonnes with a productivity of 564 kg ha^{-1} (Ministry of Agriculture and Farmers Welfare, Government of India, 2016-17). Therefore, crop diversification by inclusion of an oilseed crop in rice-based cropping system might add to our efforts towards self sufficiency in oilseed production. At present, more than 50 per cent medium rice land area in Andhra Pradesh remains fallow after the harvest of winter rice and this land can be utilized for cultivation of groundnut crop. In other parts of India, groundnut has been successfully grown in rice fallows under medium land situation. Groundnut is not only an oilseed crop but also a member of leguminaceae family. So, inclusion of groundnut after winter rice in rice-based cropping system will not only serve the purpose of the augmenting oilseed production in Andhra Pradesh, but also leave a desirable legume effect on the health of continuous growing of monocropping of rice
Phosphorus is an essential nutrient. It is involved in the supply and transfer of energy for all biochemical processes in plants and hence, it is called as the "energy currency of living cells". It stimulates early root growth and development, encourages more drymatter accumulation promotes early flowering, maturity and good pod development. Further, optimum response to added nitrogen could be obtained only when adequate amount of P is supplied. Therefore, P availability from soils to the plant is the key to sustain higher yields. Plants utilize less amounts of phosphatic fertilizers that are applied and the remaining portion is rapidly converted in to insoluble complexes in the soil. Slow mobility of applied phosphorus and its marked fixation results in low crop recoveries in the order of 20-25%. Phosphate solubilizing bacteria (PSB) solubilize insoluble phosphorus and increase its availability phosphorus in the soil and inturn the overall phosphate use efficiency. Green manures represent a promising

approach to maintain sustainable nutrient supply for crop growth. The P in green manure could potentially be delivered to the soil in a form which is readily available to plants and soil microorganisms. The nutrients which play most important role in the nutrition of groundnut crop are nitrogen, phosphorus and potassium. Amount of N fixed by root nodules and N content of the soil determines rate of nitrogen to be supplied through different sources. Phosphorus play beneficial role in the root development, nodulation and stimulation of the symbiotic nitrogen fixation. It enhances root development and nodulation, improves the supply of nutrients and water increase in photosynthetic area resulting in more dry matter accumulation and yield (Rajanikanth *et al*., 2008) [17]. Phosphorous appear to be a limiting factor in yield. It promotes root development, flowering and fruiting and aids in setting of kernels. It is reported (Nair *et al*., 1970) [15] that, phosphorus has a very critical role to play in a view of the fact that lack of phosphorus results great reduction in nodulation and nitrogen fixation. Thus, the phosphatic fertilizers play an important role in achieving higher yield of groundnut crop. Phosphorus fertilization occupies an important place amongst the non-renewable inputs in modern agriculture. Crop recovery of added phosphorus seldom exceeds 20 per cent and it may be improve by the judicious management. It play beneficial role in the root development, nodulation and stimulation of the symbiotic nitrogen fixation. Phosphate solubilizing bacteria (PSB) are a group of beneficial bacteria capable of hydrolysing organic and inorganic phosphorus from insoluble compounds. The present study was therefore, designed to find out the response of *Kharif* sources, levels of phosphorus and doses of phosphorus to *rabi* groundnut with regard to yield, nutrient content and nutrient uptake of groundnut.

Material and Methods

A field experiment was conducted at the Agricultural College Farm, Bapatla. Experiment was laid out in a Split-split plot design in *rabi* groundnut and the treatments were replicated thrice. The treatments consisted of four main plots and three subplots residual effect of *Kharif* sources and levels of phosphorus S_1: Inorganic fertilizer phosphorus through SSP, S_2: Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1}, S_3: Biofertilizer (PSB) @ 750 ml ha^{-1}, S_4: Green manuring *in-situ* with dhaincha @ 25 kg seed ha^{-1} + Biofertilizer (PSB) @ 750 ml ha^{-1}, L_1: 50% Recommended dose of P, L_2: 100% Recommended dose of P and L_3: 150% Recommended dose of P. During *rabi* season with groundnut crop, each sub plot was divided in to three sub-sub plots *i.e*, F_1 (control), F_2 (50 % RDP) and F_3 (100 % RDP) total of thirty six treatments**.** A very popular variety, groundnut (TAG-24) was used for the study. The experimental field was ploughed by a tractor drawn rotovator by individual sub plots without disturbing bunds. The levelled field was then divided into the required number of sub plots in to three sub-sub plots as per the layout plans.

Nitrogen and potassium were applied as per the recommendation (30-50 kg N and K_2O ha^{-1}) in the form of urea and muriate of potash respectively full dose as basal application to the experimental plots before sowing of crop. Entire dose of phosphorus as basal as per the treatments in the form of single super phosphate.

Chemical analysis of plant material

Nitrogen, phosphorus and potassium content and uptake at different stages of growth *viz.*, 30, 60, 90 DAS and at maturity were estimated by following methods detailed below.

Methods adopted for plant analysis

Element	Method adopted	Reference
Nitrogen	Modified Micro Kjeldhal Colorimetric procedure	Bremner and Mulvaner (1982)
Phosphorus	Vanado Molybdo Phosphoric Yellow Colorimetric method	Jackson (1973)
Potassium	Flame Photometric Method	Muhr *et al*. (1965)

Nutrient Uptake

From the results of plant analysis, nitrogen, phosphorus and potassium uptake was calculated as indicated below.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient contentration (\%)} \times \text{Weight of drymatter (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Pod yield (kg ha^{-1})

Pod yield of groundnut was significantly influenced by different sources and levels of phosphorus applied to *Kharif* rice as well as P doses imposed to *rabi* groundnut (Table 1) in both the years and pooled but not their interaction.

The highest pod yield of 1860 and 2080 kg ha^{-1} during 2016-17 and 2017-18, respectively was recorded with the application of *in-situ* green manuring + biofertilizer (PSB) which was however, comparable to *in-situ* green manuring (1769, 1979 kg ha^{-1}) but, were distinctly superior to inorganic fertilizer through SSP (1406, 1516 kg ha^{-1}) and Biofertilizer (PSB) (1519, 1649 kg ha^{-1}) alone in both years of experimentation. Among the doses of phosphorus 100 % RDP recorded significantly higher pod yield (1698 kg ha^{-1}) which was closely followed with 50 % RDP (1676 kg ha^{-1}) and was superior to control 1022 kg ha^{-1}. The lowest pod yield of 1022 and 1072 kg ha^{-1} during 2016-17 and 2017-18, respectively under control.

The % increase in pod yield due to F_3 and F_2 treatment over control was_166.1 and 163.9 respectively during 1st year, 173.9 and 172.0 respectively during 2 nd year.

Among the phosphorus sources highest pod yield with *in-situ* green manuring + PSB might increased root nodulation through better root development and congenial availability of the major plant nutrients and their uptake which might enhanced growth and better flowering, higher number of gynophores penetration into soil, increased the number of pod formation and increased the various yield structure resulting in higher pod yields of groundnut. Similar findings were also reported by Kausale *et al.* (2009) [9], Singh and Singh (2012) [20] and Singh *et al*. (2013) [21].

Lowest pod yield with inorganic fertilizer through SSP might be due to phosphorus fixation in soil and unavailable form in the soil solution.

Among the doses of phosphorus, imposed to *rabi* groundnut crop 100 % RDP recorded significantly higher pod yield which was closely followed with 50 % RDP and was found to be significantly superior to control may be due to P fertilizer attributed to activation of metabolic process, where its role in buildings phospholipids and nucleic acids. Moreover, P is an important nutrient for all crops particularly legumes and is a key constituent of ATP and plays significant role in energy transformation in plant leads to increased pod yield or may be favourable effect of P on number and weight of nodules and nitrogen activity which in turn might have reflected positively on yield attributes and finally increased the pod yield. These results obtained in the present study corroborates the findings of Gobarah *et al.* (2006) [6], Hasan and Ismail (2016) [7], Rakesh kumar *et al.* (2016) [18] and Trinhcong (2017) [22].

Haulm yield (kg ha^{-1})

Haulm yield of groundnut was significantly influenced by different sources and levels of phosphorus applied to *Khaif* rice as well as doses of P imposed to *rabi* groundnut (Table 1) in both the years and pooled data of study.

Haulm yield was the highest (2750, 2905 and 2827 kg ha^{-1}) with *in-situ* green manuring + biofertilizer (PSB) which was, however, comparable to *in-situ* green manuring (2735,2900 and 2818 kg ha^{-1}) but, were distinctly superior to inorganic fertilizer through SSP (2369, 2549 and 2459 kg ha^{-1}) and Biofertilizer (PSB) (2423, 2683 and 2553 kg ha^{-1}) alone in during 2016-17, 2017-18 and pooled data of study respectively.

Among the doses of phosphorus 100 % RDP recorded significantly higher haulm yield (2620, 2810 and 2715 kg ha^{-1}) which was closely followed with 50 % RDP (2607, 2797 and 2702 kg ha^{-1}) and was found to be superior to control (1996, 2013 and 2005 kg ha^{-1}) during both the years and pooled data of study respectively.

Table 1: Pod yield (kg ha^{-1}) and Haulm yield (kg ha^{-1}) of groundnut as influenced by phosphorus management in rice-groundnut sequence

Treatment	Pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})		
	2016-17	2017-18	Pooled data	2016-17	2017-18	Pooled data
Source of phosphorus to rice						
S_1 - Inorganic phosphorus	1406	1516	1461	2369	2549	2459
S_2- Green manuring	1769	1979	1874	2735	2900	2818
S_3 - Soil application of PSB	1519	1649	1584	2423	2683	2553
S_4- Green manuring + PSB	1860	2080	1970	2750	2905	2827
S.Em±	29.40	30.23	29.75	49.78	47.77	48.76
CD (p = 0.05)	101.7	104.6	102.9	172.3	165.3	168.7
CV (%)	9.3	8.7	9.0	10.1	9.0	9.5
Levels of phosphorus to rice						
L_1 - 50% RDP	1612	1774	1693	2180	2270	2225
L_2 - 100% RDP	1615	1798	1707	2574	2774	2674
L_3 - 150% RDP	1687	1845	1766	2654	2834	2744
S.Em±	22.54	23.11	19.71	36.20	37.12	36.24
CD (p = 0.05)	67.6	69.3	59.1	108.5	111.3	108.6
CV (%)	8.3	7.7	6.9	8.5	8.1	8.2
Doses of phosphorus to *rabi* groundnut						
F_1 – Control	1022	1072	1047	1996	2013	2005
F_2 – 50% RDP	1676	1844	1760	2607	2797	2702
F_3 – 100% RDP	1698	1865	1781	2620	2810	2715
S.Em±	15.96	16.34	13.49	21.97	22.31	20.68
CD (p = 0.05)	45.4	46.5	38.4	62.5	63.5	58.8
CV (%)	5.8	5.4	4.7	5.1	4.9	4.7
Interaction						
S*L	NS					
S*F	NS					
L*F	NS					
S*L*F	NS					

Nutrient uptake

Nitrogen uptake

Nitrogen uptake (kg ha^{-1}) of groundnut pods and haulms at harvest was significantly influenced by residual effect of different sources and levels of phosphorus of *Kharif* rice on succeeding groundnut and P doses applied to groundnut (Table 2).

Application of *in-situ* green manuring + PSB was shown its superiority in recording the highest nitrogen uptake which was however, significantly superior compared with inorganic fertilizer through SSP, Biofertilizer (PSB) and *in-situ* green manuring which was comparable with each other. Mahanta and Rai (2008) [11] reported higher content and uptake of nutrients by the crop due to *in-situ* green manuring + PSB compared to inorganic fertilizer through SSP. These organic manures were reported to be responsible for enhanced nutrient uptake. The organic acids added to the soil by microbes may have significantly increased the nutrient release leading to higher uptake by the plant (Bolan *et al.*, 1994) [3]. Among the levels of phosphorus 150 % RDP recorded significantly higher nitrogen uptake which was closely followed with 100 % RDP and was superior to 50 % RDP.

Among the doses of phosphorus to *rabi* groundnut, 100 % RDP recorded significantly higher nitrogen content in pod and haulm (3.01, 1.75 %) and total nitrogen uptake (97 kg ha^{-1}) which was closely followed with 50 % RDP (2.99, 1.72 %) in pod and haulm, total nitrogen uptake (95.3 kg ha^{-1}) and was superior over control in pod and haulm (2.93, 1.67 %), total nitrogen uptake (63.3 kg ha^{-1}). The higher N uptake may be due to higher N content, drymatter and its translocation from vegetative parts to reproductive parts in the later stages of crop growth and development stage (Pathak and Pathak, 1972) [16]. The lowest nitrogen uptake was recorded with control (63.3 and 67.1 kg ha^{-1}) during 2016-17 and 2017-18, respectively.

Table 2: N content (%) and uptake (kg ha^{-1}) of groundnut as influenced by phosphorus management in rice-groundnut sequence

Treatment	2016-17					2017-18					Pooled data				
	Pod		Haulm		Total	Pod		Haulm		Total	Pod		Haulm		Total
	Content	Uptake	Content	Uptake	uptake	Content	Uptake	Content	Uptake	uptake	Content	Uptake	Content	Uptake	uptake
Source of phosphorus to rice															
S_1- Inorganic phosphorus	2.93	41.2	1.69	39.9	81.1	2.76	41.8	1.74	44.4	86.2	2.85	41.5	1.71	42.2	83.7
S_2- Green manuring	2.98	52.7	1.73	47.3	99.9	3.27	64.7	1.75	50.8	115.6	3.13	58.7	1.74	49.1	107.8
S_3 -Soil application of PSB	2.97	45.2	1.71	41.3	86.5	3.12	51.5	1.72	46.2	97.7	3.05	48.3	1.71	43.8	92.1
S_4- Green manuring +PSB	3.02	56.3	1.74	47.9	104.2	3.33	69.4	1.76	51.3	120.7	3.18	62.8	1.75	49.6	112.5
S.Em±	0.02	1.06	0.03	1.73	2.63	0.15	3.34	0.03	1.66	3.95	0.08	1.97	0.03	1.67	3.0
CD (p = 0.05)	NS	3.67	NS	5.97	9.11	NS	11.57	NS	5.75	13.67	NS	6.83	NS	5.79	10
CV (%)	3.6	11.3	9.8	20.3	14.7	24.9	30.6	9.0	17.9	19.5	13.5	19.4	9.0	18.8	15.6
Levels of phosphorus to rice															
L_1 - 50% RDP	2.95	47.3	1.69	41.9	89.3	3.10	55.4	1.72	46.0	101.4	3.03	51.4	1.71	44.0	95.3
L_2 - 100% RDP	2.97	48.0	1.72	44.4	92.4	3.11	56.6	1.75	48.6	105.3	3.04	52.3	1.74	46.5	98.8
L_3 - 150% RDP	3.01	51.1	1.73	46.1	97.2	3.15	58.5	1.76	50.0	108.6	3.08	54.8	1.74	48.0	102.9
S.Em±	0.03	0.85	0.02	0.81	1.54	0.03	0.78	0.02	0.83	1.25	0.02	0.70	0.02	0.62	1.3
CD (p = 0.05)	NS	2.55	NS	2.43	4.61	NS	2.34	NS	2.50	3.76	NS	2.10	NS	1.77	4
CV (%)	5.5	10.5	8.3	11.0	9.9	5.3	8.2	8.1	10.4	7.2	4.0	7.9	8.2	8.1	8.1
Doses of phosphorus to *rabi* groundnut															
F_1 – Control	2.93	30.2	1.67	33.3	63.3	3.07	32.9	1.70	34.2	67.1	3.00	31.4	1.69	33.8	92.4
F_2 – 50% RDP	2.99	47.1	1.72	45.1	95.3	3.14	58.4	1.75	49.2	107.6	3.06	54.3	1.74	47.1	101.4
F_3 – 100% RDP	3.01	47.8	1.75	45.7	97.0	3.16	59.5	1.78	49.9	109.4	3.08	55.4	1.76	47.8	103.2
S.Em±	0.03	43.5	0.02	0.63	0.88	0.03	0.74	0.02	0.65	0.89	0.02	0.54	0.02	0.62	0.8
CD (p = 0.05)	NS	1.91	0.06	1.79	2.50	NS	2.09	0.06	1.84	2.54	0.06	1.54	0.06	1.77	2
CV (%)	5.6	8.3	7.4	8.6	5.7	5.3	7.8	7.3	8.0	5.1	3.9	6.1	7.4	8.1	4.6
Interaction															
S*L	NS														
S*F	NS														
L*F	NS														
S*L*F	NS														

Phosphorus uptake

Phosphorus uptake (kg ha^{-1}) by the crop followed the similar trend as that of nitrogen during both the years of the study (Table 3a, 3b). Application of *in-situ* green manuring + PSB was distinctive in recording the highest phosphorus uptake at 30, 60 and 90 DAS which was however, significantly superior compared to inorganic fertilizer through SSP, Biofertilizer (PSB) and *in-situ* green manuring which was comparable with each other. Higher P uptake due to higher number of branches, drymatter production, pod yield, haulm leads to higher p uptake or may be due to solubilization of fixed phosphorus by P-solubilizer due to secretion of organic acids. Similar findings corroborate with the studies of Sharma and Namdeo (1999) [19] and Bhatt (2012) [2].

Among the doses of phosphorus applied in *rabi* groundnut, 100 % RDP recorded significantly higher phosphorus uptake in pod and haulm (6.9 and 5.1 kg ha^{-1}) which was closely followed with 50 % RDP (6.4 and 4.6 kg ha^{-1}) and was found to be superior to control (3.5 and 2.9 kg ha^{-1}) during first year. Similar trend was observed during second year and pooled data. Similar findings corroborate with the studies of Aulaksh and Pasricha (1998) [1].

Potassium uptake

Data on potassium uptake also manifested the similar trend as was noticed with N and P uptake (Table 4). Overall, potassium uptake recorded with treatment *in-situ* green manuring + PSB was significantly higher than inorganic fertilizer through SSP, Biofertilizer (PSB), but these were comparable with *in-situ* green manuring. Among the doses of phosphorus to *rabi* groundnut, 100 % RDP recorded significantly higher potassium uptake (10.4, 33.9 kg ha^{-1}) in pod and haulm which was closely followed with 50 % RDP (9.4, 31.2 kg ha^{-1}) and was superior to control (5.8, 24.4 kg ha^{-1}). Similar trend was observed during second year and pooled data.

Table 3a: P content (%) of groundnut as influenced by phosphorus management in rice-groundnut sequence

Treatment	2016-17					2017-18					Pooled data				
	30 DAS	60 DAS	90 DAS	Pod	Haulm	30 DAS	60 DAS	90 DAS	Pod	Haulm	30 DAS	60 DAS	90 DAS	Pod	Haulm
Source of phosphorus to rice															
S_1 - Inorganic phosphorus	0.39	0.37	0.27	0.35	0.16	0.40	0.39	0.26	0.37	0.17	0.40	0.38	0.26	0.38	0.16
S_2- Green manuring	0.41	0.38	0.28	0.39	0.18	0.43	0.41	0.29	0.42	0.20	0.42	0.40	0.29	0.42	0.19
S_3 - Soil application of PSB	0.40	0.38	0.27	0.37	0.17	0.41	0.39	0.28	0.39	0.19	0.41	0.39	0.28	0.40	0.18
S_4- Green manuring + PSB	0.42	0.39	0.28	0.40	0.19	0.43	0.41	0.30	0.43	0.21	0.43	0.40	0.29	0.43	0.20
S.Em±	0.003	0.01	0.01	0.02	0.009	0.004	0.014	0.01	0.02	0.01	0.006	0.38	0.01	0.02	0.01
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.021	0.40	0.03	0.05	0.03
CV (%)	3.6	14.4	16.5	19.7	27.9	4.7	18.0	23.1	19.7	25.7	7.5	0.41	14.2	19.7	26.8
Levels of phosphorus to rice															
L_1 - 50% RDP	0.40	0.38	0.27	0.35	0.16	0.42	0.40	0.28	0.39	0.17	0.40	0.38	0.26	0.37	0.17
L_2 - 100% RDP	0.41	0.39	0.28	0.39	0.17	0.43	0.41	0.29	0.42	0.19	0.42	0.40	0.28	0.42	0.18
L_3 - 150% RDP	0.42	0.40	0.29	0.39	0.20	0.43	0.41	0.30	0.42	0.19	0.43	0.41	0.29	0.42	0.21
S.Em±	0.01	0.01	0.01	0.01	0.005	0.01	0.01	0.01	0.01	0.005	0.004	0.01	0.01	0.01	0.005
CD (p = 0.05)	NS	NS	NS	NS	0.01	NS	NS	NS	NS	0.01	0.01	0.02	0.02	0.04	0.01
CV (%)	10.2	10.9	18.4	19.2	16.8	8.8	10.5	16.7	17.9	15.5	5.9	10.4	12.8	17.8	16.2
Doses of phosphorus to *rabi* groundnut															
F_1 – Control	0.37	0.35	0.24	0.34	0.14	0.38	0.36	0.24	0.36	0.15	0.37	0.35	0.24	0.37	0.14
F_2 – 50% RDP	0.42	0.40	0.30	0.38	0.19	0.44	0.42	0.30	0.41	0.20	0.42	0.40	0.29	0.41	0.19
F_3 – 100% RDP	0.43	0.41	0.31	0.41	0.20	0.44	0.43	0.31	0.43	0.20	0.44	0.42	0.31	0.44	0.21
S.Em±	0.01	0.01	0.01	0.01	0.004	0.01	0.01	0.01	0.01	0.004	0.004	0.01	0.01	0.01	0.004
CD (p = 0.05)	0.02	0.02	0.02	0.03	0.01	0.03	0.02	0.03	0.03	0.01	0.01	0.02	0.02	0.03	0.01
CV (%)	8.5	10.8	17.0	15.5	13.4	12.9	10.1	20.2	14.5	12.3	5.6	8.2	12.1	14.4	12.8
Interaction															
S*L	NS														
S*F	NS														
L*F	NS														
S*L*F	NS														

Table 3b: P uptake (kg ha^{-1}) of groundnut at different growth stages as influenced by phosphorus management in rice-groundnut sequence

Treatment	2016-17					2017-18					Pooled data				
	30 DAS	60 DAS	90 DAS	Pod	Haulm	30 DAS	60 DAS	90 DAS	Pod	Haulm	30 DAS	60 DAS	90 DAS	Pod	Haulm
Source of phosphorus to rice															
S_1 - Inorganic phosphorus	6.0	14.7	13.8	4.8	3.3	6.6	15.9	14.1	5.5	3.9	6.3	15.3	14.0	5.2	3.6
S_2- Green manuring	7.9	18.8	21.1	6.8	4.7	8.6	21.1	21.7	8.3	5.6	8.2	19.9	21.4	7.5	5.1
S_3 - Soil application of PSB	7.3	17.1	16.8	5.5	3.9	7.9	18.2	17.2	6.3	4.7	7.6	17.7	17.0	5.9	4.3
S_4- Green manuring + PSB	8.6	20.1	21.1	7.4	5.1	9.1	21.8	21.8	8.9	6.0	8.9	20.9	21.4	8.2	5.5
S.Em±	0.20	0.7	0.66	0.30	0.27	0.15	0.9	0.68	0.32	0.29	0.16	0.77	0.67	0.31	0.28
CD (p = 0.05)	0.70	2.4	2.30	1.02	0.94	0.50	3.2	2.37	1.12	0.99	0.55	2.68	2.33	1.07	0.96
CV (%)	14.1	20.1	18.9	25.2	32.9	9.4	24.9	19.0	23.1	29.6	10.6	21.8	19.0	24.0	31.1
Levels of phosphorus to rice															
L_1 - 50% RDP	6.8	16.8	17.1	5.6	3.7	7.5	18.3	18.2	6.9	4.4	7.0	17.0	16.9	6.0	4.0
L_2 - 100% RDP	7.5	17.8	18.6	6.3	4.1	8.1	19.4	19.1	7.5	4.8	7.8	18.6	18.9	6.9	4.5
L_3 - 150% RDP	8.1	19.0	19.3	6.6	5.1	8.7	20.6	19.8	7.8	5.4	8.4	19.8	19.6	7.2	5.5
S.Em±	0.18	0.4	0.60	0.24	0.14	0.20	0.5	0.61	0.25	0.19	0.18	0.44	0.60	0.24	0.15
CD (p = 0.05)	0.55	1.2	1.80	0.72	0.42	0.59	1.5	1.83	0.76	0.57	0.54	1.32	1.81	0.73	0.44
CV (%)	14.6	13.9	19.8	23.4	19.9	14.7	15.2	19.6	20.9	18.3	13.9	14.3	19.7	21.8	19.0
Doses of phosphorus to *rabi* groundnut															
F_1 – Control	6.0	14.4	13.6	3.5	2.9	6.5	15.6	14.0	3.9	3.1	6.2	15.0	13.8	3.9	2.8
F_2 – 50% RDP	7.8	19.1	20.4	6.4	4.6	8.5	20.7	20.9	7.6	5.4	8.1	19.4	19.5	7.0	5.0
F_3 – 100% RDP	8.4	20.1	21.8	6.9	5.1	9.2	21.7	22.3	8.1	5.6	8.9	20.9	22.0	7.5	5.5
S.Em±	0.19	0.4	0.48	0.20	0.10	0.25	0.4	0.49	0.22	0.11	0.21	0.36	0.5	0.21	0.11
CD (p = 0.05)	0.54	1.2	1.38	0.58	0.29	0.71	1.2	1.40	0.64	0.33	0.60	1.02	1.4	0.60	0.31
CV (%)	15.2	14.7	16.0	19.9	14.2	18.7	13.1	15.8	18.5	13.7	16.5	11.7	15.9	19.0	13.9
Interaction															
S*L	NS														
S*F	NS														
L*F	NS														
S*L*F	NS														

Table 4: K content (%) and uptake (kg ha^{-1}) of groundnut as influenced by phosphorus management in rice-groundnut sequence

Treatment	2016-17					2017-18					Pooled data				
	Pod		Haulm		Total	Pod		Haulm		Total	Pod		Haulm		Total
	Content	Uptake	Content	Uptake	uptake	Content	Uptake	Content	Uptake	uptake	Content	Uptake	Content	Uptake	uptake
Source of phosphorus to rice															
S_1 - Inorganic phosphorus	0.58	8.1	1.26	29.8	37.8	0.59	8.9	1.28	32.5	41.5	0.63	8.5	1.27	31.2	39.6
S_2- Green manuring	0.61	10.7	1.27	34.6	45.3	0.63	12.4	1.30	37.6	49.9	0.61	11.5	1.28	36.1	47.6
S_3 - Soil application of PSB	0.59	8.8	1.26	30.5	39.3	0.61	9.9	1.28	34.3	44.2	0.64	9.3	1.27	32.4	41.8
S_4- Green manuring +PSB	0.62	11.4	1.30	35.6	47.0	0.64	13.2	1.32	38.7	52.0	0.63	12.3	1.31	37.2	49.5
S.Em±	0.01	0.19	0.01	0.79	1.00	0.01	0.28	0.03	1.03	1.27	0.28	0.28	0.02	0.28	1.12
CD (p = 0.05)	NS	0.66	NS	2.73	3.46	NS	0.96	NS	3.58	4.40	NS	0.96	NS	0.96	3.9
CV (%)	9.1	12.3	3.78	12.6	12.3	9.3	13.03	12.0	15.0	14.1	31.1	31.1	7.0	31.1	13.0
Levels of phosphorus to rice															
L_1 - 50% RDP	0.58	9.4	1.26	31.2	40.7	0.61	10.8	1.29	34.3	45.0	0.61	10.1	1.27	32.7	42.9
L_2 - 100% RDP	0.59	9.5	1.27	32.7	42.4	0.62	11.0	1.30	36.0	47.0	0.62	10.3	1.28	34.4	44.7
L_3 - 150% RDP	0.59	10.0	1.28	33.9	44.1	0.62	11.5	1.30	37.1	48.6	0.62	10.8	1.29	35.5	46.3
S.Em±	0.004	0.10	0.01	0.51	0.57	0.01	0.16	0.02	0.55	0.54	0.15	0.15	0.01	0.15	0.52
CD (p = 0.05)	NS	0.29	NS	1.54	1.71	NS	0.49	NS	1.65	1.60	NS	0.44	NS	0.44	1.6
CV (%)	3.9	7.26	2.84	9.4	8.1	6.5	8.83	8.5	9.2	6.9	19.0	19.0	4.0	19.0	7.0
Doses of phosphorus to *rabi* groundnut															
F_1 – Control	0.57	5.8	1.22	24.4	31.0	0.59	6.3	1.25	25.2	32.0	0.59	6.2	1.24	24.9	41.1
F_2 – 50% RDP	0.61	10.1	1.28	33.2	43.4	0.63	11.5	1.30	36.3	47.9	0.63	10.8	1.29	34.8	45.6
F_3 – 100% RDP	0.62	10.4	1.31	34.3	44.8	0.64	11.8	1.34	37.8	49.6	0.64	11.1	1.32	36.1	47.2
S.Em±	0.004	0.10	0.01	0.32	0.36	0.01	0.12	0.02	0.40	0.40	0.11	0.11	0.01	0.11	0.35
CD (p = 0.05)	0.01	0.28	0.02	0.90	1.04	0.01	0.35	0.06	1.14	1.14	0.31	0.31	0.03	0.31	1.0
CV (%)	3.6	7.2	2.70	5.8	5.2	5.1	6.73	9.4	6.7	5.1	13.9	13.9	5.4	13.9	4.7
Interaction															
S*L	NS														
S*F	NS														
L*F	NS														
S*L*F	NS														

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