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Studies on Growth and Yield of Groundnut as Influenced by Phosphorus Management Practices

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ABSTRACT

A field experiment was conducted during *rabi* 2016-17 and 2017-18, respectively on sandy loam soils at Agricultural College Farm, Bapatla to study growth and yield of groundnut as influenced by phosphorus management practices. 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. During *rabi* season with groundnut crop, each sub plot was divided into three sub-sub plots and total thirty six treatments were laid 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 and growth characters like plant height, drymatter accumulation, number of branches plant $^{-1}$ 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) during both the years and pooled data of study. During *rabi,* 100 % RDP showed significantly higher plant height, drymatter accumulation, number of branches plant^{-1} and yield over control and it was on a par with 50 % RDP during both years and pooled data.

Key words: *Groundnut, Kharif phosphorus sources and levels, Yield and Growth characters.*

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 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 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 and 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 into 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 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 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 and growth attributes.

MATERIAL AND METHODS

The 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 into three sub-sub plots and total 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 plan.

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 and entire dose of phosphorus as basal as per the treatments in the form of single super phosphate.

RESULTS AND DISCUSSION

Plant Height (cm)

Plant height of groundnut recorded at different intervals of crop growth *i.e.* 30, 60, 90 DAS and at harvest was significantly influenced by residual effect of different sources and levels of phosphorus to preceding rice as well as P doses applied to succeeding *rabi* groundnut during both the years of study (Table 1). Interaction was found to be non significant.

Groundnut plants grew significantly taller with *kharif* sources of phosphorus at all growth stages. Taller plants were recorded with *in-situ* green manuring + biofertilizer (PSB) which was on par with the treatment *in-situ* green manuring during both the years and pooled data of study. The lowest plant height of groundnut plant was observed in the treatments applied with inorganic fertilizer through SSP and biofertilizer (PSB) alone in both the years of experimentation. Among the residual effect of *kharif* levels of phosphorus, 150 % RDP recorded significantly higher plant height which was closely followed by 100 % RDP and was superior to 50 % RDP. During *rabi,* among the doses of phosphorus, 100 % RDP recorded significantly higher plant height which was closely followed with 50 % RDP and was superior to control. Similar trend was observed for 60, 90 DAS and at harvest during the two years and also in pooled data of crop growth.

Significantly higher plant height was recorded with *in-situ* green manuring + PSB. This increase in growth of groundnut might be due to release of nutrients slowly particularly N and biofertilizers that helped in greater release of P besides secreting plant growth promoting hormones such as IAA, gibberellins, vitamins and by these microbes might have helped in increasing the plant height. The organic manure released organic acids which in turn might have lead to increase in soil acidity and consequently converted insoluble forms of phosphorus into soluble forms, which finally manifested in increasing the plant height. Similar findings were in consonance with those of Dubey (1997), Baskhar *et al*. (2000) and Dhadge and Satpute (2014).

Among the doses of phosphorus in *rabi,* 100 % RDP recorded significantly higher plant height which was closely followed with 50 % RDP and was superior to control. This might be due to the reason that phosphorus helped in cell division and cell enlargement which finally lead to increase in the growth of plant. Similar findings were also reported by Salve and Gunjal (2011) and Hasan and Ismail (2016).

Drymatter accumulation (kg ha^{-1})

Residual effect of sources and levels of phosphorus imposed to *kharif* rice and P doses applied to *rabi* groundnut have significantly influenced the drymatter accumulation at different growth stages of groundnut *i.e.*, 30, 60, 90 DAS and harvest during both the years and pooled data of study (Table 2). But their interaction was found to be non significant.

Drymatter accumulation increased progressively with advance in the age of the crop upto harvest. Drymatter accumulation was the maximum with the combination of *in-situ* green manuring + biofertilizer (PSB) which was on par with the treatment *in-situ* green manuring during both the years and also in pooled data of study. The lowest drymatter accumulation of groundnut was observed in the treatment inorganic fertilizer through SSP and Biofertilizer (PSB) alone in two years of experimentation. Among the levels of phosphorus, 150 % RDP recorded significantly higher drymatter accumulation which was closely followed with 100 % RDP and was superior to 50 % RDP. Among the doses of phosphorus during *rabi,* 100 % RDP recorded significantly higher drymatter accumulation which was closely followed with 50 % RDP and was superior to control.

Table 1. Plant height (cm) of groundnut at different stages of crop growth as influenced by phosphorus management in rice- groundnut sequence

Treatment	2016-17				2017-18				Pooled data			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Source of phosphorus to rice												
S1 - Inorganic phosphorus	7.5	13.3	16.6	17.1	9.2	14.2	18.3	19.4	8.4	13.8	17.5	18.3
S2- Green manuring	8.6	15.3	21.7	22.2	10.7	17.1	23.9	24.3	9.7	16.2	22.8	23.3
S3 - Soil application of PSB	8.1	14.0	18.9	20.4	9.8	16.1	21.3	22.1	8.9	15.0	20.1	21.3
S4- Green manuring + PSB	9.3	15.7	22.8	23.2	11.1	17.5	24.5	25.4	10.2	16.6	23.6	24.3
S.Em±	0.1	0.2	0.6	0.6	0.1	0.2	0.6	0.6	0.1	0.2	0.6	0.5
CD (p = 0.05)	0.5	0.6	1.0	2.1	0.4	0.8	1.0	1.0	0.4	0.6	2.0	1.8
CV (%)	8.2	5.8	14.7	14.1	6.0	6.9	13.3	12.3	6.5	5.8	14.0	11.4
Levels of phosphorus to rice												
L1 - 50% RDP	8.0	13.8	19.2	20.5	9.1	15.6	21.2	22.2	8.6	14.7	20.2	21.4
L2 - 100% RDP	8.6	14.6	20.0	21.4	10.6	16.2	22.0	23.2	9.6	15.4	21.0	22.3
L3 - 150% RDP	8.5	15.4	20.8	21.7	11.0	16.9	22.7	23.9	9.8	16.1	21.7	22.8
S.Em±	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.2
CD (p = 0.05)	0.5	0.9	1.0	1.0	0.7	0.8	1.0	1.0	0.5	0.8	1.0	0.6
CV (%)	11.6	11.9	9.5	8.8	13.4	10.1	8.7	8.3	11.3	10.7	9.1	5.3
Doses of phosphorus to rabi groundnut												
F1 – Control	7.7	13.5	18.7	19.1	8.9	14.4	20.7	21.8	8.3	13.9	19.7	20.5
F2 – 50% RDP	8.6	14.8	20.3	21.0	10.7	16.8	22.3	23.4	9.7	15.8	21.3	22.2
F3 – 100% RDP	8.8	15.5	21.1	22.2	11.1	17.5	22.9	23.5	9.9	16.5	22.0	22.9
S.Em±	0.2	0.3	0.3	0.5	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3
CD (p = 0.05)	0.5	0.9	0.7	1.4	0.6	0.8	0.8	0.7	0.5	0.8	0.7	0.7
CV (%)	12.6	13.5	7.6	12.7	12.7	10.1	7.3	6.3	12.3	11.5	7.3	6.7
Interaction												
S*L	NS											
S*F	NS											
L*F	NS											
S*L*F	NS											

Table 2. Drymatter accumulation (kg ha^{-1}) of groundnut at different stages of crop growth as influenced by phosphorus management in rice- groundnut sequence

Treatment	2016-17				2017-18				Pooled data			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Source of phosphorus to rice												
S_1 - Inorganic phosphorus	1500	3922	5048	5478	1607	4022	5158	5618	1553	3972	5103	5548
S_2- Green manuring	1913	4895	7366	8116	1983	5095	7561	8391	1948	4995	7463	8253
S_3 - Soil application of PSB	1827	4499	6135	6655	1917	4656	6275	6845	1872	4577	6205	6750
S_4- Green manuring + PSB	2030	5092	7463	8313	2090	5242	7713	8633	2060	5167	7588	8473
S.Em±	50.68	87.97	103.53	106.28	50.63	91.38	96.4	104.32	50.65	89.6	99.82	104.56
CD (p = 0.05)	175.4	304.4	358.3	367.8	175.2	316.2	333.6	361	175.3	310.1	345.4	361.8
CV (%)	14.5	9.9	8.3	7.7	13.9	10.0	7.5	7.4	14.2	10.0	7.9	7.5
Levels of phosphorus to rice												
L_1 - 50% RDP	1725	4432	6327	6964	1800	4582	6500	7195	1762	4507	6413	7080
L_2 - 100% RDP	1810	4589	6557	7195	1895	4739	6731	7426	1853	4664	6644	7310
L_3 - 150% RDP	1917	4785	6625	7262	2002	4940	6799	7494	1960	4863	6712	7378
S.Em±	37.95	57.17	53.53	56.79	37.96	57.93	49.05	52.1	37.96	57.36	51.04	53.41
CD (p = 0.05)	113.8	171.4	160.5	170.3	113.8	173.7	147.1	156.2	113.8	171.9	153	160.1
CV (%)	12.5	7.83	4.9	4.8	12.0	7.3	4.4	4.2	12.3	7.4	4.6	4.4
Doses of phosphorus to *rabi* groundnut												
F_1 – Control	1634	4176	5675	6313	1719	4326	5849	6544	1676	4251	5762	6429
F_2 – 50% RDP	1852	4780	6808	7445	1937	4936	6981	7676	1895	4858	6894	7561
F_3 – 100% RDP	1966	4850	7026	7663	2041	5000	7199	7894	2004	4925	7113	7779
S.Em±	38.13	50.17	83.2	67.23	38.12	50	82.26	72.27	38.12	50.33	82.54	69.37
CD (p = 0.05)	108.4	142.6	236.6	191.2	108.4	142.2	233.9	205.5	108.4	143.1	234.7	197.2
CV (%)	12.6	6.87	7.7	5.6	12.0	6.3	7.4	5.9	12.3	6.5	7.5	5.7
Interaction												
S*L	NS											
S*F	NS											
L*F	NS											
S*L*F	NS											

Table 3. Number of branches per plant^{-1} of groundnut at different stages of crop growth as influenced by phosphorus management in rice-groundnut sequence

Treatment	2016-17				2017-18				Pooled data			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Source of phosphorus to rice												
S_1 - Inorganic phosphorus	3.8	5.8	7.2	7.8	4.5	5.8	7.1	7.7	4.2	5.8	7.1	7.8
S_2- Green manuring	5.5	8.5	10	10.8	7.2	9.5	11	11.7	6.3	9	10.5	11.2
S_3 - Soil application of PSB	4.6	7.1	8.6	9.3	5.6	7.6	9	9.7	5.1	7.4	8.8	9.5
S_4- Green manuring + PSB	5.5	8.9	10.6	11.4	7.5	10.5	12.1	12.8	6.5	9.7	11.4	12.1
S.Em±	0.11	0.11	0.11	0.09	0.11	0.1	0.1	0.1	0.11	0.11	0.1	0.1
CD (p = 0.05)	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.3
CV (%)	12.3	7.7	6	5	9.2	6.2	5.2	4.9	10.5	6.8	5.4	5.4
Levels of phosphorus to rice												
L_1 - 50% RDP	4.6	7.4	8.9	9.6	6	8.1	9.6	10.3	5.3	7.7	9.2	9.9
L_2 - 100% RDP	4.9	7.7	9.1	9.9	6.3	8.4	9.8	10.5	5.6	8	9.5	10.2
L_3 - 150% RDP	5	7.8	9.3	10.1	6.4	8.5	10	10.7	5.7	8.2	9.6	10.3
S.Em±	0.08	0.09	0.09	0.09	0.1	0.08	0.09	0.09	0.09	0.09	0.09	0.09
CD (p = 0.05)	0.25	0.28	0.26	0.28	0.29	0.25	0.27	0.27	0.26	0.26	0.26	0.26
CV (%)	10.5	7.4	5.8	5.7	9.3	6	5.4	5.1	9.5	6.6	5.5	5.5
Doses of phosphorus to *rabi* groundnut												
F_1 – Control	4.6	7.4	8.9	9.6	6	8.1	9.6	10.2	5.3	7.7	9.2	9.9
F_2 – 50% RDP	4.8	7.6	9.1	9.8	6.2	8.3	9.8	10.5	5.5	8	9.4	10.2
F_3 – 100% RDP	5.1	7.8	9.3	10.1	6.4	8.6	10	10.7	5.8	8.2	9.7	10.4
S.Em±	0.09	0.09	0.09	0.1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
CD (p = 0.05)	0.25	0.26	0.25	0.28	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.25
CV (%)	11.1	7.3	5.7	6	8.9	6.3	5.5	5.1	9.7	6.7	5.5	5.5
Interaction												
S*L	NS											
S*F	NS											
L*F	NS											
S*L*F	NS											

Table 4. 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±	29.4	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	10.1	9	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	36.2	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					

Organic manure favours root development which resulted in increased root nodule number as more number of root nodules produced increased and N, P fertilizer and other nutrients or improve the physiological and metabolical processes in the plant system by creating a favourable environment for higher availability of nutrients which increase drymatter of plant or may be due to better nodulation of roots owning to increased availability of phosphorus. The improvement in nodulation of P-solubilizer might have resulted in nitrogen fixation and consequent increase in vegetative growth and drymatter production and also mediated by biological process as noticed by increased microbial activity. Similar findings were in consonance with those of Kausale *et al*. (2009), Singh *et al.* (2011) and Lingaraju *et al*. (2016).

Among the doses of phosphorus during *rabi*, 100 % RDP recorded significantly higher drymatter accumulation which was closely followed with 50 % RDP and was found to be superior to control. This might be due to higher root nodules due to increased levels of phosphorus which might have lead to higher drymatter production. Similar findings were obtained with those of Veerabhadrappa and Yeledhalli (2004) and Kabir *et al*. (2013).

Number of branches plant^{-1}

Number of branches plant^{-1} of groundnut recorded at different intervals of crop growth *i.e.* 30, 60, 90 DAS and at harvest was significantly influenced by residual effect of different sources and levels of phosphorus of *kharif* rice as well as P doses imposed

to succeeding *rabi* groundnut during both the years and in pooled data of study (Table 3). However interaction was found to be non significant.

Significantly higher number of branches were recorded with *in-situ* green manuring + biofertilizer (PSB) which was on par with the treatment *in-situ* green manuring during both the years and in pooled data of study. The lowest number of branches was observed with the treatments that received inorganic fertilizer through SSP and Biofertilizer (PSB) alone in two years of experimentation. Among the levels of phosphorus, 150 % RDP recorded significantly higher number of branches which was closely followed with 100 % RDP and was superior to 50 % RDP. During *rabi*, phosphorus @ 100 % RDP recorded significantly higher number of branches which was closely followed with 50 % RDP and was superior over control. The similar trend was continued at 60, 90 DAS and at harvest during two years and pooled study of crop growth. Similar findings were in consonance with those of Rao and Shaktawat (2001), Kamara *et al*. (2011) and Rezaul Kabir *et al*. (2013).

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 4) in both the years and in pooled data but their interaction was not significant.

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 which was closely followed with 50 % RDP and was superior to control. The lowest pod yield of 1541 and 1708 kg ha^{-1} during 2016-17 and 2017-18, respectively was in control.

Among the phosphorus sources, highest pod yield with *in-situ* green manuring + PSB which increased root nodulation through better root development and congenial availability of the major plant nutrients and their uptake which might have 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.* (2007), Singh and Singh (2012) and Singh *et al*. (2013).

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 that 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. These results obtained in the present study corroborates the findings of Hasan and Ismail (2016) and Trinhcong (2017).

CONCLUSION

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 and growth characters like plant height, drymatter accumulation, number of branches plant $^{-1}$ 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) during both the years and in pooled data of study. During *rabi,* 100 % RDP showed significantly higher plant height, drymatter accumulation, number of branches plant^{-1} and yield over control and it was on a par with 50 % RDP during both years and in pooled data.

LITERATURE CITED

Baskar M, Solaimalai A, Sivakumar C Sankaranarayan K and Sudhakar G 2000 Effect of phosphorus, zinc and phosphorus bacteria on soyabean-A review. *Agricultural reviews*, 21(1):60-65.

Dhadge S M and Satpute N R 2014 Effect of integrated nutrient management on growth, yield and quality of summer groundnut (*Arachis hypogaea*). *International Journal of Agricultural Sciences.*10 (1) : 314-316.

Dubey S K1997 Co inoculation of phosphorus solubilizing bacteria with Brady rhizobium japonicum to increase phosphate availability to rainfed soyabean on vertisols. *Journal of the Indian Society of Soil Science*. 46(3) : 474-476.

Hasan Md and Ismail B S 2016 Effects of phosphorous fertilizer on growth and yield of groundnut. *AIP Conference Proceedings* 1784 (1) : 10.1013.

Kabir R, Yeasmin S, Mominul A K M and Abdur Rahman Sarkar Md 2013 Effect of Phosphorus, Calcium and Boron on the Growth and Yield of Groundnut (*Arachis*

hypogea L.). *International Journal of Bio-Science and Bio-Technology* . 5 (3) : 51-58.

Kamara E G, Olympio N S and Asibuo J Y 2011 Effect of calcium and phosphorus fertilizer on the growth and yield of groundnut (*Arachis hypogea L.)*. *International Research Journal of Agricultural Science and Soil Science*. 1(8) : 326-33.

Kausale S P. Patel C L, Kote G M, Lomte D M, Awasarmal V B 2007 Influence of different levels and sources of phosphorus, pressmud and phosphorus solubilizing microorganisms on nodulation, yield and quality of groundnut. *Legume Research - An International Journal* 30 (2) : 113-117.

Kausale S P, Shinde S B, Patel C L and Borse N S 2009 Effect of integrated nutrient management on nodulation, drymatter accumulation and yield of summer groundnut at south Gujarat conditions. *Legume Research*. 32 (3) : 227-229.

Lingaraju N N, Hunshal C S and Salakinkop S R 2016 Effect of biofertilizers and foliar application of organic acids on yield, nutrient uptake and soil microbial activity in soyabean. *Legume Research* 39 (2) : 256-261.

Ministry of Agriculture and Farmers Welfare, Government of India, 2016-17.

Rao S S and Shaktawat 2001 Effect of organic manure, phosphorus and gypsum on growth, yield and quality of groundnut (*Arachis hypogaea l*.). *Indian Journal of Plant Physiology* 6(3): 306-311.

Rezaul Kabir, Sabina Yeasmin, Mominul Islam A K M and Abdur Rahman Sarkar Md 2013 Effect of Phosphorus, Calcium and Boron on the Growth and Yield of Groundnut (*Arachis hypogea* L.). *International Journal of Bio-Science and Bio-Technology* . 5(3) : 51-59.

Salve Y V and Gunjal B S 2011 Effect of different levels of phosphorus and potassium on summer groundnut (*Arachis hypogaea* L.). *International Journal of Agricultural Science.* 7: 352-355.

Singh G P, Singh P L and Panwar A S 2011 Response of groundnut (*Arachis hypogaea*) to biofertilizer, organic and inorganic sources of nutrient in north east India. *Legume Research.* 34 (3) : 196 – 201.

Singh A K and Singh R S 2012 Effect of phosphorus and bio inoculants on yield, nutrient uptake and economics of long duration pigeonpea (*Cajanus cajan*). *Indian Journal of Agronomy.* 57(3): 265–69.

SinghG P, Singh P L and Panwar A S 2013 Seed yield, quality and nutrient uptake of groundnut (*Arachis hypogaea L.)* as affected by integrated nutrient management in mid hill altitude of Meghalaya, India. *Legume Research*. 36(2):147-152.

Trinhcong Tu 2017 Effect of rock phosphate to corn and groundnut on basaltic soil in vietnam. *Journal of Fertilizer & Pesticides.* 8(3):181-184.

Veerabhadrappa B H and Yeledhalli N A 2004 Effect of soil and foliar application of nutrients on growth and yield of groundnut. *Karnataka Journal of Agricultural Sciences*. 18(3) : 814-816.

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