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Response of Groundnut Varieties to Phosphorus Management in Groundnut-Baby Corn Cropping Sequence

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ABSTRACT

The experiment was conducted during 2019 and 2020 (March to August) at Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya, Jhargram, West Bengal, India to find out the response of phosphorus management on growth and yield of groundnut varieties and its residual effect on succeeding baby corn. The three main plot treatments (variety- TAG 24, TG 51, TG 37A) and six subplot treatments of phosphorus dose were laid out in split plot design with three replications. Highest plant height (70.3 cm), number of branches plant^{-1} (8.5), crop growth rate (3.67 g m^{-2} day^{-1}), pod yield (2007 kg ha^{-1}), haulm yield (2876.22 kg ha^{-1}), kernel yield (1360.76 kg ha^{-1}) and oil yield (689.36 kg ha^{-1}) were obtained with groundnut variety TG 51. Whereas phosphorus dose (100% RDF+PSB @ 25 g kg^{-1} of seed+FYM @ 2 t ha^{-1}) provided highest value for the above characters. Interaction effect was significant for pod yield and kernel yield. The residual effect on succeeding baby corn was found maximum for variety TAG 24 and treatment (100% RDF+PSB @ 25 g kg^{-1} of seed+FYM @ 2 t ha^{-1}) applied to previous groundnut. So, application of phosphorus @ 60 kg ha^{-1} along with P.S.B @ 25 g kg^{-1} of seed and F.Y.M @ 2 t ha^{-1} may be successful for groundnut variety TG 51 alone and TAG 24 in sequence with baby corn.

KEYWORDS: Groundnut, phosphorus, variety, yield, residual effect, baby corn

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1. INTRODUCTION

Phosphorus is one of the most essential nutrients needed for quality of crops especially for oilseeds (Jahish et al., 2017 and Pal et al., 2018). Fixation of atmospheric nitrogen by legume is badly affected by phosphorus deficiency (Adjei-Nsiah et al., 2018). Phosphorus plays important role in plant root development especially for legume crop (Ajay et al., 2018). The importance of phosphorus in maintaining soil productivity was mentioned by (Taliman et al., 2019).

Phosphorus application at the rate 60 kg ha^{-1} in groundnut crop gave highest plant height, number of branches $plant^{-1}$ and biomass weight (Ibrahim et al., 2019). Application of P_2O_5 @ 60 kg ha^{-1} resulted higher growth and yield parameters of groundnut (Nazir et al., 2022). After addition of water soluble inorganic phosphorus into soil, complex exchange between it and the various soil phosphorus pools takes place (Shivay, 2010). More than 80% of phosphorus becomes unavailable for plant uptake after its application to soil (Gulati et al., 2008). Yield parameters were higher with application of fertilizer based on site specific nutrient management for a target yield of 2.5 t ha^{-1} of groundnut pod (Patil et al., 2018). Higher growth and yield parameters of groundnut through use of SSP @ 50 kg ha^{-1} along with FYM were reported (Ghotmukale et al., 2020). Application 100% RDF+5 ton ha^{-1} of FYM increased pod and haulm yield (Nagar et al., 2019). Microorganism like DGR culture helped to solubilize the unavailable phosphorus (Bai et al., 2019) which in turn improves available soil phosphorus. Positive role of phosphate solubilizing bacteria like Phospobacterium was reported in converting unavailable phosphorus present in soil into available form (Alori et al., 2017). Application of phosphorus through inorganic and organic sources significantly enhanced growth and yield attributes of groundnut (Sharma et al., 2020). Application of PSB to groundnut cultivation enhanced groundnut pod yield and phosphorus use efficiency (Reddy et al., 2020). Higher grain yield of soybean was obtained with rhizobium inoculation and phosphorus application (Ulzen et al., 2018). Maximum pod yield, kernel yield and haulm yield were registered with integrated use of FYM @ 5 t ha^{-1}+50% inorganic phosphorus and DGR culture (Yadav et al., 2018). Bose and Kannan, 2020 got significant higher kernel yield and oil yield of groundnut with application of phosphorus up to 50 kg ha^{-1} along with AM application of 10 kg ha^{-1}.

Combined application of 100% RNPK @ 20:20:40 kg ha^{-1} along with FYM @ 5 t ha^{-1}, gypsum, Rhizobium and PSB inoculation was pointed as beneficial (Mohanty et al., 2022). Application of 50% of NPK (20-40-40 kg ha^{-1}) along with FYM @ 4 t ha^{-1} in single or split dose enhanced pod and haulm yield of groundnut (Sireesha et al., 2017). Positive interaction between groundnut variety and phosphorus application on yield attributes was reported (Kyei-Boahen et al., 2017 and Yaro et al., 2021). Groundnut varieties TAG 24, TG 51 and TG 37A are very much suitable for West Bengal. Small seeded groundnut should be used for table purpose and medium to bold size seed for higher oil (Mahatma et al., 2020). Baby corn can be successfully grown after groundnut as cereal-legume cropping sequence is always desirable. So an experiment was performed to evaluate the varietal performance of groundnut varieties to different phosphorus management and its residual effect on succeeding baby corn crop.

2. MATERIALS AND METHODS

2.1. Study site

The experiments were conducted during March to August, 2019 and 2020, respectively at Regional Research Station (RRS), Bidhan Chandra Krishi Viswavidyalaya (BCKV), Jhargram, West Bengal, India which is under Red and Laterite zone of West Bengal, India. It is situated at 22°48' N latitude and 86°59' E longitude and at an elevation of 78.77 m above the mean sea level. The annual average rainfall varies from 1000 mm to 1200 mm, mostly being precipitated during June to September. Mean monthly temperature ranges from 8.6 to 38.7 degrees centigrade (2019) and 9.9 to 35.6 degree centigrade (2020). Generally monsoon onsets in this area by 2nd week of June with some seasonal variation found during different years.

2.2. Experimental plot

Soil erosion is a major problem and fertility status of soil is poor as well as water retention capacity. Soil is sandy loam in nature having low amount of organic carbon (0.45%), with available nitrogen (110–120 kg ha^{-1}), phosphate (10–15 kg ha^{-1}), potash (150–200 kg ha^{-1}) etc. Soil is acidic in nature, soil pH is around 5.5. Drainage facility is moderate.

2.3. Details of experiment

There were two experiments each year starting with groundnut in the month of March followed by baby corn in the month July. Both experiments were laid out in split plot design with three replications; plot size was 5×3 m^2. In the first experiment, there were three main plots (variety) and six sub plot treatments (phosphorus dose). The three groundnut varieties were - TAG 24 (V_1), TG 51(V_2), TG 37A(V_3) and six phosphorus doses were- P_1: Pure Control of P (phosphorus) with full dose NK (nitrogen and potassium), P_2: 100% RDP (recommended dose of phosphate) , P_3: 75% RDP (recommended dose of phosphate) i.e.60 kg ha^{-1}+full dose NK+PSB (phosphate solubilizing bacteria) @ 25 g kg^{-1} of seed, P_4: 75% RDP+full dose NK+FYM (farmyard manure) @ 2 t ha^{-1}, P_5: 75% RDP+full dose NK+PSB @ 25 g kg^{-1} of seed +FYM @ 2 t ha^{-1}, P_6: 100% RDF+PSB @ 25 g kg^{-1} of seed+FYM @ 2 t ha^{-1}. All the plots got similar dose of nitrogen and potassium. Recommended dose of fertilizer (RDF) was followed at the rate 20-60-40 kg of NPK ha^{-1}. Farm yard manure (FYM) was applied @ 2 t ha^{-1} according to treatments. Phosphate Solubilizing Bacteria (PSB) was applied at the rate 25 g kg^{-1} of groundnut seed. Total treatment combinations were 18 with 3 replications, so total number of plots was 54. Seed rate was followed @ 100 kg ha^{-1} for groundnut. Spacing was maintained at 30×5 cm^2. After harvesting of groundnut, baby corn was sown on the same layout without breaking the bund of respective plots. Baby corn (variety: VNR-4226) seeds were sown at 20 kg ha^{-1} at a spacing of 50×25 cm^2 with a fertilizer dose of 120-0-40 kg of NPK ha^{-1}.

2.4. Observations made

The groundnut plant samples were collected at an interval of 30 days after sowing (DAS) at 30, 60 and 90 DAS for recording observations on plant height, number branches plant^{-1} and dry weight of plants. At harvesting stage plant samples were taken for making observations on pod plant^{-1}, kernel plant^{-1}, pod yield, kernel yield, oil yield, seed index and harvest index. Pod and stover yield were also recorded plot wise. In the second experiment, data on maize was taken on number of cobs plant^{-1}, cob yield, seed index and fodder yield.

The pooled analysis of experimental data on different parameters of both the years were calculated using the split plot design and the significance of different sources of variation was tested by error mean square by Fisher Snedecors 'F' test at probability level of 5%. Test of significance of the treatment differences was done on the basis of t-test. The significant differences between the treatment means were compared with the least significant difference (LSD) at a 5% level of probability (p<0.05). The difference between two treatment means higher than the respective LSD value was considered as significant.

3. RESULTS AND DISCUSSION

3.1. Effect on plant height and number of branches plant^{-1}

Plant height and number of branches plant^{-1} were recorded at 30, 60 and 90 DAS respectively. The different groundnut varieties and phosphorus doses showed significant variation in plant height, number of branch plant^{-1} (Table 1). As per data in Table 1 groundnut variety TG 51 registered highest plant height of 70.3 cm and number of branches plant^{-1} of

Table 1: Effect of phosphorus fertilization on growth, yield contributing characters and yield of groundnut varieties

Treatments	Plant height (cm) at harvest	No. of branch plant^{-1}	Pod plant^{-1}	Kernels pod^{-1}	Seed index (g)	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Harvest index (%)
Main plot: Variety (V)										
V_1	67.8	8.3	20.75	2.05	37.92	1923.46	1268.81	2593.07	616.65	42
V_2	70.3	8.5	23.23	2.10	40.55	2007.00	1360.76	2876.22	688.67	41
V_3	64.4	8.0	20.71	1.98	37.30	1727.57	1072.26	2529.50	504.93	40
SEm±	0.75	0.06	0.36	0.01	0.43	31.54	22.12	48.79	13.13	0.01
CD (p=0.05)	2.47	0.20	1.18	0.04	1.39	102.87	72.13	159.13	42.83	0.02
Sub-plot: Phosphorus dose (P)										
P_1	62.0	7.4	17.95	1.93	30.69	1402.05	849.56	2388.62	358.75	35
P_2	72.0	8.8	22.84	2.06	40.03	1986.51	1339.40	2745.70	662.53	42
P_3	63.8	7.7	20.52	2.00	38.67	1748.22	1079.99	2501.02	503.39	41
P_4	65.4	8.1	20.47	2.05	39.45	1805.02	1148.99	2567.78	549.90	41
P_5	71.0	8.7	22.98	2.11	40.86	2109.66	1430.22	2780.95	732.83	43
P_6	72.3	8.9	24.62	2.13	41.84	2264.60	1555.49	3013.52	813.08	43
SEm±	0.88	0.16	0.38	0.03	0.53	35.87	24.52	53.25	13.853	0.01
CD (p=0.05)	2.48	0.45	1.09	0.08	1.50	101.48	69.37	150.64	39.188	0.02
Interaction	NS	NS	S	NS	S	S	S	NS	S	NS

V_1: TAG 24; V_2: TG 51; V_3: TG 37A; P_1: Pure control of P (phosphorus); P_2: 100% RDP @ 60 kg ha^{-1}; P_3: 75% RDP+PSB @ 25 g kg^{-1} of seed; P_4: 75% RDP+FYM @ 2 t ha^{-1}; P_5: 75% RDP+PSB @ 25 g kg^{-1} of seed+FYM @ 2 t ha^{-1}; P_6: 100% RDP+PSB @ 25 g kg^{-1} of seed+FYM @ 2 t ha^{-1}; NS: Not significant; RDP: Recommended dose of phosphorous; V: Variety; DAS: Days after sowing; P: Phosphorus levels

8.5 at 90 DAS respectively (Table 1) followed by variety TAG 24 and TG 37A. Variation in plant height may be due to difference in nutrient uptake and their utilization efficiency by the respective variety. This work confirmed the findings of Patra et al. (2011) and Dalei et al. (2014) who revealed that application phosphorus fertilizer in groundnut cultivation gave better plant height and number of branches. Combined application of 100% RDP @ 60 kg ha^{-1}, PSB @ 25 g kg^{-1} of seed and FYM @ 2 t ha^{-1} (P_6) recorded significantly highest plant height of 72.3 cm and number of branch plant^{-1} of 8.9 among the all treatments (Table 1) followed by P_2, P_5, P_4, P_3 and control (P_1) at 90 DAS (Table 1). The beneficial role of combined application of phosphorus with FYM was reported by Ghotmukale et al. (2020) who received better result for growth parameter with application phosphorus as DAP with FYM. Interaction effect was found non-significant. Scheduling of phosphorus in a judicious manner increased plant height and number of branch plant^{-1} due to vigorous root growth and development which in turn helped to absorb more water, nutrients and enhanced photosynthesis and shoot elongation.

3.2. *Effect on pod yield, haulm yield kernel yield and oil yield*

Table 1 revealed that groundnut varieties caused significant variance in pod yield, haulm yield, kernel yield and oil yield. As per Table 1, TG 51 variety registered pod yield (2007.00 kg ha^{-1}), haulm yield (2876.22 kg ha^{-1}), kernel yield (1360.76 kg ha^{-1}), oil yield (688.67 kg ha^{-1}) followed by variety TAG 24 (1923.46 kg ha^{-1}, 2593.07 kg ha^{-1}, 1268.81 kg ha^{-1} and 616.65 kg ha^{-1} respectively) and TG 37A (1727.57 kg ha^{-1}, 2529.50 kg ha^{-1}, 1072.26 kg ha^{-1} and 504.93 kg ha^{-1} respectively). However the variation in these parameters may be related to efficiency of the variety to utilize either added phosphorus or locked up phosphorus in soil solution which ultimately controlled dry matter production and then transformation of photosynthates to reproductive structure. Regarding formation of oil, lecithin played an important role. Different groundnut varieties reacted differently in lecithin formation as a result oil yield by the groundnut varieties was different.

Combined application of 100% RDP @ 60 kg ha^{-1}, PSB @ 25 g kg^{-1} of seed and FYM @ 2 t ha^{-1} i.e. treatment P_6 recorded highest pod yield (2264.60 kg ha^{-1}), haulm yield (3013.52 kg ha^{-1}), kernel yield (1555.49 kg ha^{-1}) and oil yield (813.08 kg ha^{-1}) followed by P_5, P_2, P_4, P_3 and P_1 respectively. This may be due to the fact that scheduling of phosphorus in full dose along with PSB and FYM registered more dry matter production, number of pods plant^{-1}, number of kernels pod^{-1} and 100 kernels weight as compare to other treatments. Application of PSB helped to unlock the phosphorus into soil solution which in conjugation with FYM had enhanced the growth and yield parameters and lecithin formation. It was opined by (Kausale et al., 2009) that groundnut reacted well to a reduced fertilizer schedule of 75% RDF (18.75 kg N^{-1} and 37.5 kg P ha^{-1}) along with 10 t FYM ha^{-1} and inoculation of PSB for more pod yield. Variation in kernel weight between application of no phosphorus and use of phosphorus at different levels was reported by (Intodia et al., 1995 and Patra et al., 1995).

This finding was also confirmed by Asante et al. (2020) who opined that combined application of phosphorus @ 30 kg ha^{-1} and rhizobium inoculation increased the groundnut yield by 64 to 68%. Similar trends were obtained from the findings of Bose and Kannan (2020) who got significant higher kernel yield and oil yield of groundnut with application of phosphorus up to 50 kg ha^{-1} along with AM application of 10 kg ha^{-1}. Yadav et al. (2018) also confirmed these findings through their observations where they reported that maximum pod yield, kernel yield and haulm yield were obtained with integrated use of FYM @ 5 t ha^{-1}+50% inorganic phosphorus and DGR culture. Enhancement in oil yield with seed inoculation of PSB was also referred by Chouksey et al. (2017).

Role of phosphorus is very much connected with formation of lecithin, essential for oil formation in groundnut. Therefore integrated use of phosphorus in a judicious manner had made significant difference in oil percentage of kernels resulting variation in oil yield. Similar trend was expressed by Jain et al. (1990) who pointed out the role of phosphorus in oil content of groundnut. Significant interaction was found between groundnut variety and phosphorus dose on pod yield, kernel yield and oil yield.

3.3. *Effect on number of pod plant^{-1}, kernel pod^{-1}, seed index and harvest index*

Groundnut varieties experienced significant variance in number of pods plant^{-1}, kernel nuts^{-1} and seed index (Table 1). TG 51 variety had highest number of pod plant^{-1} (23.23, 2.10 and 40.55) followed by variety TAG 24 (20.75, 2.05 and 37.93) and TG 37A (20.71, 1.98 and 37.30), but there was no significant variation in number of pods plant^{-1} between the variety TAG 24 and TG 37A but all the varieties were statically different from each other in case of number of kernels pod^{-1}. However the variation in pod and kernel number and seed index were genetically controlled and depended on how efficiently the variety could use either added phosphorus or locked up phosphorus in soil solution which ultimately controlled the photosynthetic rate and then partitioning of photosynthates to reproductive structure. Kaushik and Chaubey (2000) opined similarly that genetical variation in groundnut varieties mostly controlled the hundred kernel weight. Meresa et al. (2020) also depicted similar types of findings where they reported significant variance in number of kernel pod^{-1}, seed index with combined application of phosphorus and foliar zinc fertilizers to three different groundnut genotypes.

The level of phosphorus significantly influenced the number of pods plant^{-1}, kernel nuts^{-1} and seed index (Table 1). Combined application of 100% RDP @ 60 kg ha^{-1}+PSB @ 25 g kg^{-1} of seed and FYM @ 2 t ha^{-1} produced maximum number of pods and kernel plant^{-1} (24.62, 2.13 and 41.84 g) followed by treatment P_5, P_2, P_4, P_3 and control for kernel nuts^{-1} and seed index, and P_4 and P_3 was reverse for number of pods plant^{-1} (Table 1). This result was in corroboration with the findings of Sharma et al. (2020) who reported highest number of pod plant^{-1} (20.58), kernel pod^{-1} (2.16) with application of phosphorus 50% through inorganic and rest through vermin compost. In their study they also got enhanced pod plant^{-1} and kernel pod^{-1} with inoculation of seed with PSB. This result had relevance with the works of Prasad et al. (2016). Higher number of pods plant^{-1}, kernels pod^{-1}, seed index was also reported by Poonia et al. (2022) with combined application of RDF+PSB @ 2.5 kg ha^{-1}+AMF @ 4 kg ha^{-1} fertilizer management practice. Such type trends were found in the study of Intodia et al. (1995) and Patra et al. (1995) who found variation with no phosphorus and application of phosphorus at different dose to groundnut crop with respect to number of pods plant^{-1} and seed index. Similar results were referred by Meena et al. (2014) who got significantly higher number of kernel nuts^{-1} with application of phosphorus 60 kg ha^{-1} in comparison to 40 kg ha^{-1}. Similarly Mouri et al. (2018) also depicted in their findings that increase in phosphorus application up to 60 kg ha^{-1} increased the number of peg plant^{-1}, number of pod plant^{-1}, seed index, and pod yield of groundnut. However variation in number of nuts per plant may be due to pivotal role of phosphorus to flowering and pod formation stage.

Regarding harvest index (H.I) different groundnut varieties failed to register any significant effect on harvest index (Table 1), however it was highest for variety TAG 24 and lowest for TG 37A. All the phosphorus dose presented statistically at par effect on harvest index (varied from 0.41 to 0.43) as depicted in Table 1, whereas control treatment showed least harvest index (0.35). However higher harvest index was due to enhancement in pod yield and haulm yield.

Interaction effect between groundnut variety and phosphorus dose was significant for number pods plant^{1} and seed index and non-significant for number kernels plant^{-1} and harvest index (Table 1).

3.4. Residual effect on baby corn

3.4.1. Number of cobs plant^{-1}, cob yield green fodder yield and seed index

In the second experiment, number of cobs plant^{-1}, cob yield and green fodder yield and seed index were significantly varied by the residual effect of different groundnut varieties grown in the previous cropping system (Table 2). Data in Table 2 indicates that variety TAG 24 registered highest number of cobs plant^{-1}, cob yield, green fodder yield and seed index of (1.82, 4455.29 kg ha^{-1}, 2009.59 kg ha^{-1} and 17.59 g respectively) followed by variety TG 37A (1.74, 3827.52 kg ha^{-1}, 20827.01 kg ha^{-1} and 17.31 g respectively) and TG 51(1.68, 3519.59 kg ha^{-1}, 18366.21 kg ha^{-1} and 16.68 g respectively). It was found that residual effect of all the varieties provided significantly different effect on number of cobs plant^{-1}, cob yield, green fodder yield and seed index of baby corn (Table 2). This significant variation may be due to the fact that baby corn performed as per nutrients available in soil left by the previous respective groundnut variety after harvesting. Phosphorus schedule followed at previous groundnut crop significantly influenced the number of cobs plant^{-1}, cob yield, green fodder yield and seed index of baby corn (Table 2). Treatment P_6 recorded maximum number of cobs plant^{-1} (1.96), cob yield (5173.88 kg ha^{-1}), green fodder yield (25131.77 kg ha^{-1}) and seed index (20.11 g) followed by P_5, P_2, P_3, P_4 and control, whereas treatment P_5 and P_2 presented reverse effect for number of cobs plant^{-1}. (Table 2). The beneficial effect of residual effect of organics on groundnut maize cropping sequence was reported by (Patra et al., 2017). Singh et al. (2016) also reported the enhancement in yield component

Table 2: Residual effect of groundnut variety and phosphorus fertilization on yield contributing characters and yield of baby corn

Treatments	Cobs plant^{-1}	Cob yield (kg ha^{-1})	Green fodder yield (kg ha^{-1})	Seed index (g)
Main plot: Variety (V)				
V_1	1.82	4455.29	20090.59	17.59
V_2	1.68	3519.59	18366.21	16.68
V_3	1.74	3827.52	20827.01	17.31
SEm±	0.00	74.26	229.318	0.23
CD (p=0.05)	0.02	242.18	747.848	0.71
Sub-plot: Phosphorus dose (P)				
P_1	1.60	2195.23	15973.76	13.71
P_2	1.80	4374.73	20225.93	18.11
P_3	1.68	3807.70	18550.52	17.30
P_4	1.66	3550.88	18193.04	17.04
P_5	1.79	4502.38	20492.60	18.29
P_6	1.96	5173.88	25131.77	19.11
SEm±	0.03	53.96	135.616	0.54
CD (p=0.05)	0.09	152.64	383.638	1.58
Interaction	NS	S	S	NS

of maize crop due to residual effect of groundnut-maize cropping system. The residual effect of PSB and to some extent FYM along with nutrients available for next crop i.e. baby corn made the difference among these attributes of baby corn. This was supported by the work of Kalhapure et al. (2014) who noticed in one of their findings that seed yield of maize crop was significantly influenced by the residual effect of the treatments applied to groundnut crop in groundnut-maize cropping system.

Application of PSB to different level of phosphorus played dual role by enhancing the phosphorus availability through unlocking fixed phosphorus and taking it into soil solution and increasing nitrogen level through nodule formation. The interaction between the residual effect of groundnut variety and phosphorus dose failed to register any significant effect on number of cobs plant^{-1} and seed index of baby corn. Application 75% RDF and 25% N through FYM, azospirillum and PSB to groundnut crop produced significant higher cob yield and stover yield of succeeding maize crop in groundnut-maize cropping sequence (Dhadge and Sapute, 2014)

4. CONCLUSION

Scheduling of phosphorus @ 60 kg ha^{-1}+PSB @ 25 g kg^{-1} of seed and FYM @ 2 t ha^{-1} provided highest yield attributes of groundnut variety TG 51, groundnut variety TAG 24 performed better in groundnut- baby corn cropping sequence. FYM performed little better than PSB with phosphorus in groundnut cultivation while PSB showed better impact on succeeding baby corn. However conjugation of PSB and FYM with reduced dose of phosphorus was advantageous to application of 100% RDP.

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