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EFFECT OF PHOSPHORUS AND ZINC ON GROWTH AND YIELD OF SUMMER GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT
A field experiment was conducted in the crop research farm of SHUATS, Prayagraj to know the effect of Phosphorus and Zinc on growth and yield of Summer groundnut. The experiment consisted of 12 treatments which includes three levels of Phosphorus (30, 40 and 50 kg/ha) and four levels of Zinc (0, 20, 25 and 30 kg/ha). The treatment receiving 50 kg Phosphorus + 30 kg Zinc/ha produced significantly higher plant height (35.58 cm), Pod yield (3.24 t/ha), total number of pods/plant (29.56) and 100 kernel weight (39.35 g). However, Net returns (139103.93 rs/ha) and B: C ratio (1.80) was also obtained maximum with the application of 50 kg phosphorus + 30 kg Zinc/ha. This experiment shown treatment receiving 50 kg Phosphorus + 30 kg Zinc/ha was more productive and economic.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume native to South America. It is grown in most tropical, sub-tropical and warm temperate regions of world between 400 N and 400 S latitudes. Groundnut is one of the most important oilseed crop of India. which occupies first in terms of area and second in terms of production. Groundnut crop area in India is at 40.12 lakh ha in 2018-2019. Similarly, production and yield are estimated at 37.70 lakh tones and 931 kg/ha respectively. Inadequate and/or imbalance use of fertilizers has been identified as one of the critical constraints in groundnut production and Now a days, country is facing edible oil crisis as well as increasing population demand for edible oil. Thus, to overcome this challenges suitable and improved techniques for groundnut production should be adopted by farmer. Zinc deficiency in soil is one of constraint in India and to improve quality of oil in groundnut zinc and proper amount of NPK is important. Balanced nutrition is considered as one of the basic needs "to achieve the potential yield" (Yadav *et al.*, 2017). Phosphorus is important for root and kernel development and it leads to early flowering and pegging. Groundnut showed response to the application of phosphorus at 40 to 75 kg/ha. Zinc aids the synthesis of plant growth substances and enzyme systems and is essential mineral for IAA (Indole Acetic Acid) synthesis which plays a certain role in plant growth and development as a regulator of numerous biological processes. The adequate availability of zinc to young and developing plants might be a certain promise for sufficient growth and development. The positive response of Zinc application to groundnut has been reported by Christopher *et al.*, 2019. Keeping in view the above fact, the experiment was conducted to assess the effect of phosphorus and Sulphur on growth, yield attributes and yield of groundnut.

MATERIALS AND METHODS

A field experiment was conducted at Crop Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) which is located at 25°24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level, during summer (zaid) season of 2019 on sandy loam soil, having moderately basic pH (7.2), organic carbon (0.48%), available nitrogen (213 kg/ha), phosphorus (13.6 kg/ha), potassium (215.3 kg/ha) and Sulphur (0.76 ppm). The climate of the region is semi-arid subtropical. Treatments comprised of T_1 - 30 kg P_2O_5/ha + 0 kg $ZnSO_4$/ha, T_2 - 30 kg P_2O_5/ha + 20 kg $ZnSO_4$/ha, T_3 - 30 kg P2O5/ha + 25 kg $ZnSO_4$/ha, T_4 - 30 kg P_2O_5/ha + 30 kg ZnSO4/ha, T_5 - 40 kg P_2O_5/ha + 0 kg $ZnSO_4$/ha, T_6 - 40 kg P2O5/ha + 20 kg $ZnSO_4$/ha, T_7 - 40 kg P_2O_5/ha + 25 kg $ZnSO_4$/ha, T_8 -40 kg P_2O_5/ha + 30 kg $ZnSO_4$/ha, T_9 - 50 kg P_2O_5/ha + 0 kg $ZnSO_4$/ha, T_{10} - 50 kg P_2O_5/ha + 20 kg $ZnSO_4$/ha, T_{11} - 50 kg P_2O_5/ha + 25 kg $ZnSO_4$/ha and T_{12} - 50 kg P_2O_5/ha + 30 kg $ZnSO_4$/ha. These were replicated three times in Randomized Block Design. Recommended dose of fertilizers were applied at the time of sowing in the form of Urea, SSP, MOP and Zinc sulphate (for Zinc). Seeds were placed in row to row spacing 30 cm and plant to plant spacing 10 cm.

Chemical analysis of soil

Composite soil samples were collected before layout of the experiment to determine the intial soil properties. The soil samples were collected from 0-15 cm and were dried under shade, were powdered with wooden pestle and mortar, passed through 2 mm sieve and were used for analysis. Available organic carbon were analyzed for by rapid titration method (Sparks, 1996), Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956), available phosphorus by Olsen's method as outlined by Jackson (1967), available potassium was determined by extracting with neutal normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) and available $ZnSO_4$ was estimated by Atomic Absorption Spectrophotometer method as outlined by Lindsay and Norvell (1978).

Statistical analysis

Experimental data collected was subjected to statistical analysis by adopting Fishers method of Analysis of variance (ANOVA) as outlined by Gomez and Gomez (2010). Critical Difference (CD) values were calculated the 'F' test was found significant at 5% level.

RESULTS AND DISCUSSION

Plant height

Observations regarding the plant height of groundnut are given in the table 1 and there was an increasing trend of the values at successive stages. The analysis on plant height was found to be significantly higher in all the different growth intervals with the higher level of phosphorus and zinc except at 15 DAS interval. At harvest highest and significant plant height (35.58 cm) was recorded with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha. Which was significantly superior over rest of the treatments. The increase in plant height due to Phosphorus application may be attributable to the fact that P is known to help in the development of more extensive root system and nodulation and thus enables plants to absorb more water and nutrients from depth of the soil. Kabir *et al*. (2013) was reported that plant height increased with the application of 50 kg phosphorus/ha.

Number of nodules/plant

Observations regarding the number of nodules per plant of groundnut are given in the table 2 and data showed an increasing tendency from 15 to 45 DAS and thereafter, it decreased. At 45 DAS highest no. of nodules (54.67) was recorded with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha. Which was significantly superior over rest of the treatments except with the application of 50 kg Phosphorus/ ha + 25 kg Zinc/ha (52.33), 40 kg Phosphorus/ha + 30 kg

Table 1: Effect of Phosphorus and Zinc on plant height of Groundnut

TREATMENTS	Plant height (cm)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1: 30 kg Phosphorus/ha + 0 kg Zinc/ha	7.01	11.17	17.79	21.12	23.73	24.01
T_2: 30 kg Phosphorus/ha + 20 kg Zinc/ha	7.62	11.55	18.72	22.11	23.95	24.38
T_3: 30 kg Phosphorus/ha + 25 kg Zinc/ha	6.92	10.31	17.89	21.41	23.97	24.41
T_4: 30 kg Phosphorus/ha + 30 kg Zinc/ha	7.55	11.59	17.79	21.91	24.74	25.31
T_5: 40 kg Phosphorus/ha + 0 kg Zinc/ha	7.08	11.22	18.93	22.79	25.64	26.26
T_6: 40 kg Phosphorus/ha + 20 kg Zinc/ha	7.37	11.29	18.44	23.31	25.8	26.31
T_7: 40 kg Phosphorus/ha + 25 kg Zinc/ha	7.85	12.39	19.33	23.03	25.93	26.37
T_8: 40 kg Phosphorus/ha + 30 kg Zinc/ha	7.63	11.93	20.09	25.33	29.71	30.56
T_9: 50 kg Phosphorus/ha + 0 kg Zinc/ha	7.11	10.97	18.43	22.19	25.29	25.75
T_{10}: 50 kg Phosphorus/ha + 20 kg Zinc/ha	7.6	11.25	19.02	22.52	25.11	25.52
T_{11}: 50 kg Phosphorus/ha + 25 kg Zinc/ha	7.75	12.09	19.15	26.62	30.56	31.17
T_{12}: 50 kg Phosphorus/ha + 30 kg Zinc/ha	7.93	12.91	22.96	29.54	33.85	35.58
SEm (±)	0.34	0.4	0.66	0.71	0.84	1.12
CD (5%)	NS	1.17	1.94	2.08	2.46	3.28

Table 2: Effect of Phosphorus and Zinc on nodulation pattern of groundnut

TREATMENTS	Number of nodules/plant					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1: 30 kg Phosphorus/ha + 0 kg Zinc/ha	6.67	22.33	40.78	16.89	8.67	6.33
T_2: 30 kg Phosphorus/ha + 20 kg Zinc/ha	7.56	20.56	45.11	18.11	6.78	5.78
T_3: 30 kg Phosphorus/ha + 25 kg Zinc/ha	7.89	22.89	46.22	16.67	6.89	5.89
T_4: 30 kg Phosphorus/ha + 30 kg Zinc/ha	6.56	22.56	43s.22	18.22	8.78	5.78
T_5: 40 kg Phosphorus/ha + 0 kg Zinc/ha	9.44	23.11	46.56	17.22	7.33	5.11
T_6: 40 kg Phosphorus/ha + 20 kg Zinc/ha	10.89	25.78	44	16.67	7	5
T_7: 40 kg Phosphorus/ha + 25 kg Zinc/ha	9.78	28.56	44.89	17	7.78	6.22
T_8: 40 kg Phosphorus/ha + 30 kg Zinc/ha	10	21.78	51.56	18	10.67	7
T_9: 50 kg Phosphorus/ha + 0 kg Zinc/ha	13.11	26.11	46.33	17.89	7.44	6.44
T_{10}: 50 kg Phosphorus/ha + 20 kg Zinc/ha	11	26.89	50.44	17.44	7.56	7.22
T_{11}: 50 kg Phosphorus/ha + 25 kg Zinc/ha	10.22	28.78	52.33	18.44	8	7.44
T_{12}: 50 kg Phosphorus/ha + 30 kg Zinc/ha	13.67	32.11	54.67	19.67	8	7
SEm (±)	0.66	1.17	2.09	1.19	0.83	0.54
CD (5%)	1.94	3.43	6.12	NS	NS	NS

Table 3: Effect of Phosphorus and Zinc on plant dry weight of groundnut

TREATMENTS	Plant dry weight (g/plant)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1: 30 kg Phosphorus/ha + 0 kg Zinc/ha	0.04	0.71	3.19	12.24	14.12	17.62
T_2: 30 kg Phosphorus/ha + 20 kg Zinc/ha	0.06	0.9	3.41	13.17	15.2	18.14
T_3: 30 kg Phosphorus/ha + 25 kg Zinc/ha	0.13	0.94	3.08	13.12	15.08	18.39
T_4: 30 kg Phosphorus/ha + 30 kg Zinc/ha	0.07	1.1	3.16	12.93	15.24	18.22
T_5: 40 kg Phosphorus/ha + 0 kg Zinc/ha	0.08	1.01	3.38	12.69	14.34	17.94
T_6: 40 kg Phosphorus/ha + 20 kg Zinc/ha	0.07	1.03	3.63	13.11	15.19	19
T_7: 40 kg Phosphorus/ha + 25 kg Zinc/ha	0.06	1.26	4	14.06	16.14	17.66
T_8: 40 kg Phosphorus/ha + 30 kg Zinc/ha	0.1	1.23	5.51	19.91	22.08	23.02
T_9: 50 kg Phosphorus/ha + 0 kg Zinc/ha	0.09	1.19	4.63	13.31	14.06	19.93
T_{10}: 50 kg Phosphorus/ha + 20 kg Zinc/ha	0.09	1.34	4.31	15.1	17.01	21.06
T_{11}: 50 kg Phosphorus/ha + 25 kg Zinc/ha	0.1	1.6	7.65	18.89	20.27	25.94
T_{12}: 50 kg Phosphorus/ha + 30 kg Zinc/ha	0.1	1.87	7.38	19.52	22.21	26.47
SEm (±)	0.02	0.07	0.43	0.75	1.2	1.24
CD (5%)	NS	0.19	1.27	2.19	3.53	3.63

Table 4: Effect of phosphorus and Zinc on yield attributes and yield of groundnut

TREATMENTS	Number of pods/plant	Number of Kernels /pod	Seed index (g)	Pod yield (t/ha)	Haulm yield (t/ha)	HI (%)
T_1: 30 kg Phosphorus/ha + 0 kg Zinc/ha	25.22	1.7	31.54	2.61	5.53	32.33
T_2: 30 kg Phosphorus/ha + 20 kg Zinc/ha	25.44	1.77	33.28	2.65	5.71	31.7
T_3: 30 kg Phosphorus/ha + 25 kg Zinc/ha	23.56	1.67	33.9	2.76	5.86	32.15
T_4: 30 kg Phosphorus/ha + 30 kg Zinc/ha	24.33	1.73	33.77	2.69	5.4	33.34
T_5: 40 kg Phosphorus/ha + 0 kg Zinc/ha	26.78	1.7	34.88	2.71	5.64	32.52
T_6: 40 kg Phosphorus/ha + 20 kg Zinc/ha	24.78	1.87	36.06	2.79	5.66	33.04
T_7: 40 kg Phosphorus/ha + 25 kg Zinc/ha	24.56	1.73	36.98	2.62	5.55	32.18
T_8: 40 kg Phosphorus/ha + 30 kg Zinc/ha	26.22	1.93	38.53	3.01	6.43	31.94
T_9: 50 kg Phosphorus/ha + 0 kg Zinc/ha	23.33	1.8	33.89	2.87	6.64	30.17
T_{10}: 50 kg Phosphorus/ha + 20 kg Zinc/ha	25.33	1.87	36.89	2.77	6.01	31.49
T_{11}: 50 kg Phosphorus/ha + 25 kg Zinc/ha	28.89	1.87	38.59	3.17	6.6	32.46
T_{12}: 50 kg Phosphorus/ha + 30 kg Zinc/ha	29.56	1.98	39.35	3.24	6.81	32.31
SEm (±)	0.81	0.04	0.86	0.09	0.28	1.48
CD (5%)	2.37	0.11	2.52	0.25	0.83	NS

Table 5: Effect of Phosphorus and Zinc on Economics of Groundnut

TREATMENTS	Cost of cultivation	Gross Return	Net Return	Benefit Cost Ratio
T1: 30 kg Phosphorus/ha + 0 kg Zinc/ha	72785	174194.7	101409.7	1.39
T_2: 30 kg Phosphorus/ha + 20 kg Zinc/ha	74415.8	177042.5	102626.7	1.38
T_3: 30 kg Phosphorus/ha + 25 kg Zinc/ha	74822.6	184213.7	109391.1	1.46
T_4: 30 kg Phosphorus/ha + 30 kg Zinc/ha	75231.5	179136	103904.5	1.38
T_5: 40 kg Phosphorus/ha + 0 kg Zinc/ha	73785	180867.7	107082.7	1.45
T_6: 40 kg Phosphorus/ha + 20 kg Zinc/ha	75415.8	185695.7	110279.9	1.46
T_7: 40 kg Phosphorus/ha + 25 kg Zinc/ha	75822.6	174633.6	98811	1.3
T_8: 40 kg Phosphorus/ha + 30 kg Zinc/ha	76231.2	200991.1	124759.9	1.46
T_9: 50 kg Phosphorus/ha + 0 kg Zinc/ha	74785	192442.3	117657.3	1.57
T_{10}: 50 kg Phosphorus/ha + 20 kg Zinc/ha	76415.8	184939.7	108523.9	1.42
T_{11}: 50 kg Phosphorus/ha + 25 kg Zinc/ha	76822.6	211317.3	134494.7	1.75
T_{12}: 50 kg Phosphorus/ha + 30 kg Zinc/ha	77231.2	216335.1	139103.9	1.8
SEm (±)	174194.7	101409.7	1.39	
CD (5%)	177042.5	102626.7	1.38	

Zinc/ha (51.56) and 50 kg Phosphorus/ha + 20 kg Zinc/ha (50.44). The increase in nodulation with increasing phosphorus levels may be accrued to the Phosphorus availability, which plays an important role in nodules formation. Dekhane (2011); Nkaa *et al.*,2014; Baboo and Mishra (2001) also obtained the similar results in garden pea.

Plant dry weight g/plant

As seen in table 3 dry weight of plant had consecutively increased from 15 DAS to harvest. At harvest highest dry weight (26.47 g/plant) was recorded with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha which was significantly superior over rest of the treatments except with the application of 50 kg Phosphorus/ha + 25 kg Zinc/ha (25.94 g/plant) and 40 kg Phosphorus/ha + 30 kg Zinc/ha (23.02 g/plant). Increasing phosphorus rates increased dry weight/plant. Kausale *et al.* (2009) reported that the application of 50 kg Phosphorus/ha significantly increased plant dry weight (29.33 g) over 30 kg Phosphorus/ha. The increase in dry matter production with phosphorus might be due to better nodulation of crop owing to better availability of phosphorus. The improvement in nodulation might have resulted in higher amount of nitrogen fixation and their by better vegetative growth and dry matter production. Zinc plays as an activator of several enzymes in plants and it is directly involved in the biosynthesis of growth substances such as auxin thereby producing more plant cells and enhanced dry matter (Christopher *et al.*, 2019).

Yield attributes and Yield

No. of pods/plant maximum was obtained with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha (29.56), which was significantly superior over all the treatments except application of 50 kg Phosphorus/ha + 25 kg Zinc/ha (28.89). No. of Kernals/pod maximum was obtained with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha (1.98), which was significantly superior over all the treatments except application of 40 kg Phosphorus/ha + 30 kg Zinc/ha (1.93), 40 kg Phosphorus/ha + 20 kg Zinc/ha (1.87), 50 kg Phosphorus/ha + 20 kg Zinc/ha (1.87) and 50 kg Phosphorus/ha + 25 kg Zinc/ha (1.87). Seed index (g) maximum was obtained with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha (39.35 g), which was significantly superior over all the treatments except 50 kg Phosphorus/ha + 25 kg Zinc/ha, 40 kg Phosphorus/ha + 30 kg Zinc/ha, 40 kg Phosphorus/ha + 25 kg Zinc/ha, 50 kg Phosphorus/ha + 20 kg Zinc/ha and 50 kg Phosphorus/ha + 0 kg Zinc/ha.

Pod yield (t/ha) maximum was obtained with application of 50 kg Phosphorus/ha + 30 kg Zinc/ha (3.24 t/ha), which was significantly superior over all the treatments except 40 kg Phosphorus/ha + 30 kg Zinc/ha (3.01). Haulm yield (t/ha) was obtained maximum with application of 50 kg Phosphorus/ ha + 30 kg Zinc/ha(6.81 t/ha) which was significantly superior over all the treatments except 50 kg Phosphorus/ha + 0 kg Zinc/ha (6.64 t/ha), 50 kg Phosphorus/ha + 25 kg Zinc/ha (6.60 t/ha), 40 kg Phosphorus/ha + 30 kg Zinc/ha (6.43 t/ha) and 50 kg Phosphorus/ha + 20 kg Zinc/ha (6.01 t/ha). Harvest index (%) was obtained maximum with application of 50 kg Phosphorus/ha + 25 kg Zinc/ha (32.46 %) and minimum was obtained with 50 kg Phosphorus/ha + 0 kg Zinc/ha (30.17 %). There was no significant difference between different treatment combinations. Increasing phosphorus fertilizers rates increased all yield components. Such favourable effects on yield and yield attributes could be due to the stimulation effects of P on number of nodules and nitrogen activity which in turn reflected positively on groundnut yield attributes. Furthermore, the increment in yield due to phosphorus fertilizer maybe attributed to the activation of metabolic processes, where its role in building phospholipids and nucleic acid in known. These findings endorse the results of Mirvat *et al.* (2006), kamdi *et al.* (2014) and El-Habbasha *et al.* (2005). Zn plays as an activator of several enzymes in plants, and it is directly involved in the biosynthesis of growth substances such as auxin which produces more plant cells and more dry matter that in turn will be stored in seeds as a sink. Thus, the increase in seed yield is more expected. Increasing in application of zinc fertilizer increased the yield and yield attributes might be due to the significant improvement in growth parameters through activation of various enzymes and the basic metabolic rate in plants, which in turn enhanced the pod yield due to greater availability of nutrients and photosynthates. Similar finding were reported by Christopher *et al.* (2019) and ved *et al.* (2002).

Effect of Phosphorus and Zinc on Economics of Groundnut

Application of 50 kg Phosphorus/ha + 30 kg Zinc/ha recorded significantly maximum net return (139103.93/ha), and Benefit-Cost Ratio (1.80) which was significantly superior over rest of the treatments. The higher pod yield adds in getting higher farm profit with increasing phosphorus levels recorded highest net returns. Similar findings were reported by Chowdhury *et al.* (2015).

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