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Biofortification of zinc with different phosphorous sources on growth and yield of groundnut (*Arachis hypogaea* L.)

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Abstract
The present experiment was carried out at the Central Research Farm, SHUATS, Allahabad during *Kharif* 2018. The experiment was consisting of two methods of zinc application soil (25kg ha^{-1}) and foliar (0.25%) and different sources of phosphorous namely DAP, SSP and PROM (Phosphorus Rich Organic Manure) (P- 16.5%) laid out in Randomized block design with ten treatment combinations and the number of replications was three. Maximum Kernel yield was recorded in Treatment T7 (DAP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) and treatment T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) however, treatment T9 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) is statistically at par to the height value.

Keywords: Phosphorous, Zinc, DAP, SSP, PROM, groundnut

Introduction
Groundnut (*Arachis hypogaea* L.) is an important food legume crop of the world grown on about 24 million hectare (ha) of land under different agro-climatic regions in Asian (11.5 m ha), African (11.5 m ha) and North and South American (1.1mha) countries and on large scale in India, China, Nigeria, USA, Myanmar, Indonesia, Sudan, Senegal, Argentina and Vietnam. In India alone it is grown on about 6.5mha. Although the average groundnut productivity of the world is around 1500 kg ha^{-1}, it is less than 1000 kg ha^{-1} in more than 50% of the groundnut growing countries due to vagaries of weather conditions and poor soil fertility. However, because of its high-energy, protein and mineral contents at a comparatively low price, the demand of groundnut, as food crop, is increasing worldwide. Phosphorus is an important nutrient next to nitrogen for plants. Indian soils are poor to medium in available phosphorus. It is an indispensable, constituent of nucleic acid, ADP and ATP. It has beneficial effects on nodule stimulation, root development, growth and also hastens maturity as well as improves quality of crop produce. thus the study of phosphorus to legumes is more important than that of nitrogen as later is being fixed by symbiosis with rhizobium bacteria. PROM has to be a better source of phosphate application. the Indian soils are deficient in organic carbon. The rock phosphate which is a cheaper source of phosphorus but cannot be applied directly into the soil therefore enrichment of organic manure with rock phosphate can solve the both problems of the deficiency of phosphorus and organic carbon content of the soil.

Zinc is an essential nutrient for plant and human health and about two billion people worldwide are at the risk of Zn deficiency. In India, zinc is now considered as the fourth most important yield-limiting nutrient after nitrogen, phosphorus and potassium respectively. Among oilseeds, groundnut in particular suffers from Zn deficiency (Singh, 2007) [9]. According to WHO report on the risk factors responsible for development of illnesses and diseases, Zn deficiency rank 11th among the 20 most important factors in the world and 5th among the 10 most important factors in developing countries (Anon, 2002) [9]. Zinc plays significant role in various enzymatic and physiological activities of the plant. Zinc catalyzes the process of oxidation in plant cells and is vital for transformation of carbohydrates, regulates the consumption of sugar, increases source of energy for the production of chlorophyll, aids in the formation of auxins which produce more plant cells and more dry matter, that in turn will be stored in seed as a sink and promotes absorption of water (Singh and Lal, 2007) [10]. Biofortification- Greek word "bios" means "life" and Latin word "fortificare" means "make strong". Thus biofortification is the process of increasing bio available concentration of essential elements in edible portion of crop plant through agronomic or genetic/molecular approach. Application of fertilizers to soil and/or foliar to improving grain nutrient concentration and the potential of nutrient containing fertilizers for increasing nutrient concentration of grains.

Materials and methods

The present investigation was carried out during *kharif*, 2018-19 at College Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The farm situated at 25^0 57' N latitude, $87^0$50' E longitude and at an altitude of 98 meter above mean sea level. This area is situated on the right side of the river Yamuna and opposite side of Allahabad city. All the facilities required for crop cultivation are available. The experiment was laid out in Randomized block design with ten treatment combinations and the number of replications was three. The treatment consists of two method of zinc application soil (25kg ha^{-1}) and foliar (0.25%) and different sources of phosphorous namely DAP (P-46.5%), SSP (P-16.2%) and PROM (Phosphorus Rich Organic Manure) (P- 16.5%). Groundnut variety was Kadiri-6 with duration of about 90 to 110 days in Kharif and 115 to 128 days during rabi season and suitable for both rainfed as well as irrigated situations. The yield potential of 2 to 2.5 q ha^{-1}. Fertilizer details (i) nitrogen is applied according to recommended dose of one hectare through urea and D.A.P. for management of fertility status of field (ii) Phosphorus as per treatment. phosphorus was applied through D.A.P, S.S.P and P.R.O.M. fertilizer as per treatments as basal application in furrows. Zinc was applied as soil application in certain treatments and after 45 DAS foliar application was spared in certain treatments. The experimental soil was sandy loam in texture, pH 7.20, organic carbon (0.42 %) available nitrogen (129.79 kg/ha), available potassium (150.64 kg K_2O/ha) and medium in phosphorus (16.01 kg P_2O_5 /ha).

Results and Discussion

At 60 DAS highest plant height was noticed in T5 (SSP + Zinc 0.25% Foliar application) and T2 (SSP+ Zinc 25 $kgha^{-1}$ soil application), T7 (DAP + Zinc 25 $kgha^{-1}$ soil application + Zinc 0.25% Foliar application), T8 (SSP + Zinc 25 $kgha^{-1}$ soil application + Zinc 0.25% Foliar application), T9 (PROM + Zinc 25 $kgha^{-1}$ soil application + Zinc 0.25% Foliar application) are at par with the highest value. The results are in close conformity with the findings of Parthasarathi *et al.*, (2012) [7], Singh *et al*., (2014) [11].

The observations regarding plant dry weight are being presented in the table 1. Further, at 60 DAS T6 (PROM + Zinc 0.25% Foliar application) recorded significantly highest dry weight, this was followed by T9 (PROM + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application), T7 (DAP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) and T3 (PROM + Zinc 25 $kgha^{-1}$ application) were at par with highest value. The increase in dry matter production with P might be due to better nodulation of crop owing to better availability of a P. the improvement in nodulation might have resulted in higher amount nitrogen fixation and there by better vegetative.

Table 1: Effect of Different sources of Phosphorous and applications of zinc on Growth attributes of Groundnut.

		60 DAS			30-60 DAS
Treatment	**Plant Height (cm)**	**Dry weight (g $plant^{-1}$)**	**Root Nodules (No./Plant)**	**CGR (g cm^{-2} day^{-1})**	**RGR (g g^{-1} day^{-1})**
DAP + Zinc soil application	48.70	23.59	78.33	2.18	0.026
SSP+ Zinc soil application	49.77	24.95	76.89	2.22	0.023
PROM + Zinc soil application	48.66	26.42	68.89	2.46	0.026
DAP + Zinc foliar application	49.15	24.22	72.89	2.24	0.026
SSP + Zinc foliar application	51.69	25.36	59.33	2.39	0.027
PROM+ Zinc foliar application	46.25	27.59	62.89	2.65	0.029
DAP + Zinc soil +foliar application	51.00	26.47	63.00	2.34	0.023
SSP + Zinc soil +foliar application	50.73	24.33	70.78	2.24	0.026
PROM+ Zinc soil +foliar application	51.38	26.52	63.56	2.54	0.029
Control	46.59	20.47	59.44	1.81	0.023
SEm±	0.69	0.68	3.99	-	-
CD (p=0.05)	2.04	2.01	11.85	-	-

Phosphorous 40 kg ha^{-1}, Zinc 25kg ha^{-1} soil application, Zinc 0.25% Foliar application

growth and dry matter production. Similar results have been reported in previous studies Tomar *et al.*, 1990 [13]; Patra and Sinha (2012) [8]. The observations regarding Crop growth rate Maximum CGR was recorded in treatment T6 (PROM + Zinc 0.25% Foliar application) and Relative growth rate (g g^{-1} day^{-1}) was observed Maximum in treatment T6 (PROM + Zinc 0.25% Foliar application) and T9 (PROM + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) at 30-60 DAS. Highest Number of Nodules $Plant^{-1}$ was observed in treatment T1 (DAP along with Zinc 25 $kgha^{-1}$ application), However, T2 (SSP along with Zinc 25 $kgha^{-1}$ application), T3 (PROM along with Zinc 25 $kgha^{-1}$ application), T4 (DAP + Zinc 0.25% Foliar application) and T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) were statistically at par with highest value. These results are corroborated with the findings of Mukherjee and Rai (2000) [5].

The observations regarding yield attributes and oil content are being presented in the table 2. Maximum mature pods $plant^{-1}$ was recorded in Treatment T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) however treatment T9 (PROM + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) and treatment T5 (SSP+ Zinc 0.25% Foliar application) are statistically at par to highest value. Maximum test weight was recorded in Treatment T9 (PROM + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application), however treatment T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application), treatment T7 (DAP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application), treatment T6 (PROM+ Zinc 0.25% Foliar application), treatment T5 (SSP+ Zinc 0.25% Foliar application) and treatment T4 (DAP+ Zinc 0.25% Foliar application) were statistically at par to highest value. Maximum shelling percentage was recorded in treatment T7 (DAP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application), however, Treatment T9 (PROM + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) and treatment T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application are statistically at par to highest value. The results are in close conformity with the findings of Majumdar *et al.*, (2001) [4] and Kausale *et al.*, (2009) [2]. Maximum Pod yield was recorded in Treatment T8 (SSP + Zinc 25 $kgha^{-1}$ application + Zinc 0.25% Foliar application) however

treatment T9 (PROM + Zinc 25 kgha^{-1} application + Zinc 0.25% Foliar application) and treatment T7 (DAP + Zinc 25 kgha^{-1} application + Zinc 0.25% Foliar application) are statistically at par to highest value. Maximum Kernel yield was recorded in Treatment T9 (PROM + Zinc 25 kgha^{-1} application + Zinc 0.25% Foliar application) and treatment T8 (SSP + Zinc 25 kgha^{-1} application + Zinc 0.25% Foliar application) These results are in agreement with those of Nayak *et al.,* (2009) [6] and Thakur *et al.,* (2010) [12] and Maximum oil content was recorded in Treatment T3 (PROM along with Zinc 25 kgha^{-1} application) however treatment T2 (DAP along with Zinc 25 kgha^{-1} application) is statistically at par to highest value.

The observation regarding economics viz., cost of cultivation, Gross returns, Net returns and benefit cost ratio are given in table 3. Among treatment combination the highest total cost of cultivation (45023 INR ha^{-1}) was obtained in treatment T7 (DAP + Zinc 25 kgha^{-1} application + Zinc 0.25% Foliar application). Among treatment combination the highest net returns (54213 INR ha^{-1}) was obtained in treatment T6 (PROM + Zinc 0.25% Foliar application). Among treatment combination the highest benefit cost ratio (1.40) was obtained in treatment T6 (PROM + Zinc 0.25% Foliar application).

Table 2: Effect of Different sources of Phosphorous and applications of zinc on yield attributes, Pod yield and oil content of Groundnut

Treatment	Pods/plant (No.)	Kernels/ pod (No.)	100 kernels weight (g)	Shelling (%)	Pod Yield (t/ha)	Kernel yield (t/ha)	Oil (%)
DAP + Zinc soil application	20.64	1.9	37.98	68.83	1.86	1.28	42.1
SSP+ Zinc soil application	21.27	1.8	37.42	67.24	1.79	1.20	45.4
PROM + Zinc soil application	21.10	1.9	37.34	67.00	1.88	1.26	46.1
DAP + Zinc foliar application	22.33	2.0	39.02	65.30	1.77	1.15	45.2
SSP + Zinc foliar application	22.73	2.0	38.97	67.21	1.81	1.22	43.5
PROM+ Zinc foliar application	22.67	1.9	38.81	68.14	1.90	1.30	45.3
DAP + Zinc soil +foliar application	23.33	2.0	39.18	71.03	1.94	1.38	44.0
SSP + Zinc soil +foliar application	23.50	2.0	38.85	70.83	1.95	1.38	44.8
PROM+ Zinc soil +foliar application	23.27	2.0	39.19	70.76	1.94	1.37	43.4
Control	18.90	1.8	37.33	62.22	1.54	0.96	45.0
SEm±	0.27	0.055	0.32	0.49	0.01	0.0098	-
CD (P=0.05)	0.80	0.16	0.95	1.46	0.02	0.029	-

Phosphorous 40 kg ha^{-1}, Zinc 25kg ha^{-1} soil application, Zinc 0.25% Foliar application

Table 3: Effect of Different sources of Phosphorous and applications of zinc on Economics of Groundnut.

Treatment	Cost of cultivation (INR)	Gross Return (INR)	Net return (INR)	B : C Ratio
DAP + Zinc soil application	44821.00	90954	46133	1.03
SSP+ Zinc soil application	44400.00	87531	43131	0.97
PROM + Zinc soil application	44340.00	91932	47592	1.07
DAP + Zinc foliar application	39341.00	86390	47049	1.20
SSP + Zinc foliar application	38920.00	88509	49589	1.27
PROM+ Zinc foliar application	38860.00	93073	54213	1.40
DAP + Zinc soil +foliar application	45023.00	94866	49843	1.11
SSP + Zinc soil +foliar application	44602.00	95355	50753	1.14
PROM+ Zinc soil +foliar application	44545.00	94703	50158	1.13
Control	39139.00	75143	36004	0.92

Phosphorous 40 kg ha^{-1}, Zinc 25kg ha^{-1} soil application, Zinc 0.25% Foliar application

Summary

Maximum dry weight (57.59 g Plant^{-1}) was recorded in Treatment 8 (SSP + Zinc at 25 kg ha^{-1} in combination with 0.25% as foliar application) at 90 DAS which recorded highest Crop Growth Rate (3.70 g cm^{-2} day^{-1}) and Relative Growth Rate (0.0125 g g^{-1} day^{-1}). Also, maximum number of Pods/plant (23.50 Pods/plant), Kernels/pod (2.0 Kernels/pod), Pod yield (1.95 t ha^{-1}) and kernel yield (1.38 t ha^{-1}) was recorded in this treatment. Highest Gross Returns (95355.00 INR) was also recorded in this treatment.

Conclusion

Application of Single super Phosphate (SSP) as phosphorous source along with 25kg ha^{-1} Zinc soil application and 0.25% Zinc foliar application recorded highest pod yield (1.95 t/ha). Highest Gross Return (95355.00 INR) was also recorded in this treatment. Since the data obtained in the experiment is on one-year study, the experiment needs to repeated to conform the findings.

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