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Effects of different levels of Phosphorus and Zinc on physico-chemical properties of soil, growth and yield of Maize (*Zea mays* L.) Var. Shivani

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Abstract
An experiment was conducted during *Rabi* season (October – March) 2017-18 to study the "Effect of different levels of Phosphorus and Zinc on the physico-chemical properties of soil, Growth and yield of maize (*Zea mays* L.). Var. Shivani" on crop research farm Department of Soil Science & Agricultural Chemistry, the design applied was 3x3 factorial Randomized Block Design having three factors with three levels of Phosphorus @ 0%, 50%, and 100 % ha^{-1} and three levels of Zinc @ 0%,50% and 100% ha^{-1} respectively. The best treatment was T_8 -P_2+ Z_2 [@ 100% phosphorus ha^{-1}+ 100% Zinc ha^{-1}] that showed the highest yield regarding, gave the best results with respect to plant height 169.58 cm, number of leaves per plant 14.41, leaf length per plant 54.5 cm, no. of grains per cob 313.66 cm and cob length 16.5 cm, it gave highest yield, 49.61 q $ha^{-1,}$ as grain yield and 73.6 q ha^{-1} as straw yield. In post-harvest soil properties, the important parameter on chemical properties on maize crop different treatment of phosphorus and zinc, EC and pH, organic carbon (%), was found non-significant. available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), potassium (kg ha^{-1}) and zinc (ppm) was found significant. pH, EC, organic carbon (%), available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), potassium (kg ha^{-1}) and zinc (ppm ha^{-1}) was recorded as 7.13,0.217, 0.643, 340.59, 36.68, 178.63 and 1.53 respectively in the treatment T_8 -P_2+ Z_2 [@ 100% phosphorus ha^{-1}+ 100% Zinc ha^{-1}]. The economy of different treatment concerned, the treatment T_6 (P_2+ Z_2) provides highest net profit of 47275.08 with cost benefit ratio of 1: 2.61.

Keywords: soil properties, maize, phosphorus and zinc

Introduction
Maize (*Zea mays* L.) is an important cereal crop in world after wheat and rice. The importance of maize lies in its wide industrial applications besides serving as human food and animal feed. It is the most versatile crop with wider adaptability in varied agro-ecologies and has highest genetic yield potential among the food grain crops. As the demand for maize is growing globally due to its multiple uses for food, feed and industrial sectors, we need to produce more from same or even less resources. New production technologies offer great promise for increasing productivity to meet the growing demands of world consumers. For decades, corn growers have worked for continuous improvement and greater efficiency.

Maize ranks fourth in India after rice, wheat and sorghum. Maize is of American origin having been domesticated about 7000 years ago. Maize is a versatile crop as it grown across a range of agro ecological zones. Every part of the maize plant has economic value; the grain, leaves, stalk, tassel and cobs are used to produce large variety of food and non- food products. Presently, in India maize is mainly used for preparation of poultry feed and extraction of starch.

Maize is one of the world's leading crop cultivated over an area of 139 m ha with a production of about 600 mt. of grain. USA leads the largest area, followed by Brazil, China, Mexico and India. Maize is grown in almost all states of India occupying an area of 6 m ha with the production and productivity of 9.7 mt. and 1.7 t ha^{-1}, respectively. (Kumar *et al*., 2007) [6].

In India, current consumption pattern of maize is poultry, pig, fish feed 52%, human consumption 24%, cattle feed and starch 11% and seed and brewery industry 1%. Maize is called 'queen of cereal' as it is grown 1throughout the year due to its photo-thermosensitive character and highest genetic yield potential among the cereals.

In India, maize is cultivated throughout the year in most of states of the country for various purposes including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products. Corn area, production and productivity in India has shown a steady upward trend in recent years.

Along with this, it is rich in vitamin A, vitamin E, nicotinic acid, riboflavin and contains fairly high phosphorus than rice and sorghum. Its fodder and hay contain 7-10% protein, 15-36% fiber, 2.09 to 2.62% ether extract, 0.42-0.70% Calcium, 0.28-0.29% phosphorus, 0.45% Magnesium, 1.34% Potassium and 56% carbohydrate, therefore, it has very nutritive fodder and hay. Besides food grain, fodder and feed, it has prime importance in textile, starch and dye industries. (Rai 2006) [10].

Rabi maize is grown on an area of 1.2 mha with the grain production of 5.08million tonnes, with an average productivity of 4.00 tha-1. The predominant Rabi maize growing states are Andhra Pradesh (45.5%), Bihar (20.1%), Tamil Nadu (9.3%), Karnataka (8.5%), Maharastra (7.7%), West Bengal (5.3%)

Phosphorus has a great role in energy storage and transfer and closely related to cell division and development of maize. Phosphorus is a constituent of nucleic acid, phytin and phospho-lipid. Phosphorus compound act as “energy currency” within plants. Phosphorus is essential for transformation of energy, in carbohydrate metabolism, in fat metabolism, in respiration of plant and early maturity of maize. (Singh *et al*., 2010) [14].

Zinc play important role in the correct functioning of many enzyme systems, the synthesis of nucleic acids and auxins (plant hormones) metabolisms, protein analysis and normal crop development and growth. Phosphorus and zinc, though essential for plant growth, are antagonistic to each other in certain circumstances, such as when P is supplied in high levels and Zn uptake becomes slower or inadequate. This may be as a result of slower rate of translocation of Zn from roots to tops, i.e. zinc accumulation in the roots and lower Zn uptake. Plants absorb Zn in the form of Zn2+. The functional role of Zn includes auxins metabolism, nitrogen metabolism, influence on the activities of enzymes, cytochrome c synthesis and stabilization of ribosomal fractions and protection of cells against oxidative stress. Poor growth, interveinal chlorosis and necrosis of lower leaves are the common symptoms of Zn deficiency in field crops. (Paramasivan *et al*., 2011)

Materials and Methods

The experiment was conducted during Rabi season of 2017-18 at Crop research farm Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Allahabad. The experimental site is located in the sub – tropical region with 250 24’ N latitude 810 51’ E longitudes and 98 meter the mean sea level altitudes. The experiment was laid out in a 3¬2 Randomized Block Design factorial design with three levels of Phosphorus and Zinc with nine treatments, each consisting of three replicates. The total number of plots was 27. Maize (Zea mays L.) Var. Shivani.’ were sown in Rabi season plots of size 2 x 2 m with row spacing 50 cm and plant to plant distance 20 cm. The Soil of experimental area falls in order of Inceptisols and is alluvial in nature, both the mechanical and chemical analysis of soil was done before starting of the experiment to as certain the initial fertility status. The soil samples were randomly collected from 0-15cm depths prior to tillage operations. The treatment consisted of nine combination of T0 (@ 0 kg ha-1 P + 0 kg ha-1 Zn), T1 (@ 0 kg ha-1 P + 12.5 kg ha-1 Zn), T2 (@ 0 kg ha-1 P + 25 kg ha-1 Zn), T3 (@ 40 kg ha-1 P + 0 kg ha-1 Zn), T4 (@ 40 kg ha-1 P + 12.5 kg ha-1 Zn), T5 (@ 40 kg ha-1 P + 25 kg ha-1 Zn), T6 (@ 80 kg ha-1 P + 0 kg ha-1 Zn), T7 (@ 80 kg ha-1 P + 12.5 kg ha-1 Zn), T8 (@ 80 kg ha-1 P + 25 kg ha-1 Zn).

Physical and chemical analysis of soil samples (pre-sowing)

Table 1: Physical and Chemical analysis of soil

Analysis	Particulars	Results	Methods
Physical	Sand (%)	62	
	Silt (%)	23	
	Clay (%)	15	
	Texture of soil	Sandy loam	Bouyoucous (1927) [3].
	Particle density (Mg m^{-3})	2.62	Muthuaval (1992) [7].
	Bulk density (Mg m^{-3})	1.32	Muthuaval (1992) [7].
	Pore Space (%)	52	Muthuaval (1992) [7].
Chemical	Soil pH	7.18	Jackson (1958) [5].
	EC (dS m^{-1})	0.23	Wilcox (1950) [18].
	Organic carbon (%)	0.58	Walkley and Black (1947) [17].
	Available Nitrogen (kg ha^{-1})	280.26	Subbaih and Asija (1956) [15].
	Available Phosphorus (kg ha^{-1})	24.3	Olsen (1954) [8].
	Available Potassium (kg ha^{-1})	156.62	Toth and prince (1949) [16].
	Available Zinc (ppm)	0.31	Shaw and Dean 1952 and Holmes (1945)

Results and Discussions

Response on bulk density, particle density and pore space of soil after crop harvest

The result depicted in table 1 shows that the maximum bulk density of soil (Mg m^{-3}), was found for T_7 (@ 80 kg ha^{-1} P + 12.5 kg ha^{-1} Zn) which was 1.303 and minimum was found for T_0 (@ 0 kg ha^{-1} P + 0 kg ha^{-1} Zn) which was 1.210 (Mg m^{-3}). The interaction effect of phosphorus and zinc on bulk density (Mg m^{-3}) of soil was found non-significant.

The results show that the maximum particle density of soil (Mg m^{-3}), was found for T_8 (@ 80 kg ha^{-1} P + 12.5 kg ha^{-1} Zn) which was 2.617 and minimum was found for T_0 (@ 0 kg ha^{-1} P + 0 kg ha^{-1} Zn) which was 2.523 (Mg m^{-3}). The interaction effect of phosphorus and zinc on particle density (Mg m^{-3}) of soil was found non-significant.

The results show that the maximum pore space (%) of soil, was found for T_7 (@ 80 kg ha^{-1} P + 12.5 kg ha^{-1} Zn) which was 45.720 and minimum was found for T_2 (@ 0 kg ha^{-1} P+ 25 kg ha^{-1} Zn) which was 52.250. The interaction effect of phosphorus and zinc on pore space (%) of soil was found significant.

Response on pH and EC at 25˚C (dS m^{-1}) of soil after crop harvest

The result depicted in table 2 shows that the pH and EC of soil in which the maximum pH and EC at 25˚C (dS m^{-1}) was found for T_4 (@ 40 kg ha^{-1} P + 0 kg ha^{-1} Zn) which were 7.30 and 0.220 and minimum was found for T_2 (@ 0 Kg ha^{-1} P + 25 Kg ha^{-1} Zn) and T_0 (@ 0 kg ha^{-1} P + 0 kg ha^{-1} Zn) respectively which were 7.053 and 0.170 respectively. The interaction effect of phosphorus and zinc on pH and EC was found non-significant.

Response of organic carbon (%), available nitrogen, phosphorus, potassium and Zinc (kg ha^{-1}) of soil after crop harvest

The result depicted in table 2 shows that the Maximum Organic carbon (%) in soil were found for T_4 (@ 40 kg ha^{-1} P + 0 kg ha^{-1} Zn) which were 0.733 kg ha^{-1} and minimum was found for T_2 (@ 0 kg ha^{-1} P + 25 kg ha^{-1} Zn) which were 0.623 kg ha^{-1}. Available nitrogen, phosphorus and zinc (kg ha^{-1}) in soil were found for T_8 (@ 80 kg ha^{-1} P +25 kg ha^{-1} Zn) which were 340.590, 36.683, 1.530 kg ha^{-1} respectively and minimum was found for T_0 (@ 0 kg ha^{-1} P + 0 kg ha^{-1} Zn) which were 261.460, 23.377, 0607 kg ha^{-1} respectively. Available Potassium were found highest in T_7 (@ 80 Kg ha^{-1} P + 12.5 Kg ha^{-1} Zn) and minimum was found for T_0 (@ 0 kg ha^{-1} P + 0 kg ha^{-1} Zn) which were 155.710 kg ha^{-1}. The interaction effect of phosphorus and zinc on available nitrogen and potassium was found significant and the interaction effect of phosphorus and Zinc on organic carbon (%), available phosphorus and zinc was also found significant. Combined application of phosphorus and zinc were found significant increase in available nitrogen and available potassium. The results are similar with the finding of Singh *et al.*, 2017 [13].

Conclusion

It is concluded from the experiment that treatment combination T_8 (@ 80 kg ha^{-1} P +25 kg ha^{-1} Zn) was found best for improvement of Particle density (Mg m^{-3}), Available nitrogen (Kg ha^{-1}), Available phosphorus (Kg ha^{-1}) and Available zinc (ppm ha^{-1}) in the soil. Whereas, treatment T_7 (@ 80 Kg ha^{-1} P + 12.5 Kg ha^{-1} Zn) was found best for improvement of Bulk Density (Mg m^{-3}), Pore Space (%), and Available potassium (Kg ha^{-1}) and treatment T_4 (@ 40 kg ha^{-1} P + 0 kg ha^{-1} Zn) was found best for improvement of pH, EC (dS m^{-1}), Organic carbon (%).

Table 2: Soil properties

Treatment	pH (w/v)	EC (ds m^{-1})	B.D (Mg m^{-3})	P.D (Mg m-^{3})	P.S (%)	O.C (%)	Nitrogen (Kg ha^{-1})	Phosphorus (Kg ha^{-1})	Potassium (Kg ha^{-1})	Zinc (ppm)
T_0	7.080	0.170	1.210	2.523	46.830	0.683	261.460	23.377	155.710	0.607
T_1	7.280	0.170	1.230	2.533	47.817	0.653	266.860	24.587	175.223	0.630
T_2	7.053	0.197	1.210	2.527	52.250	0.623	268.193	27.700	185.360	0.663
T_3	7.097	0.187	1.250	2.557	46.840	0.673	276.673	27.837	175.560	1.163
T_4	7.300	0.220	1.263	2.550	49.003	0.733	289.963	29.733	179.973	1.237
T_5	7.173	0.200	1.267	2.617	50.180	0.693	266.430	29.263	183.517	1.230
T_6	7.273	0.180	1.250	2.533	52.027	0.710	269.063	32.550	196.100	1.450
T_7	7.283	0.213	1.303	2.530	45.720	0.677	316.447	34.337	214.170	1.480
T_8	7.133	0.217	1.273	2.617	50.140	0.643	340.590	36.683	178.63	1.530
F-test	NS	NS	NS	NS	S	NS	S	S	S	S
S. Em. (±)	0.114	0.021	0.033	0.117	1.245	0.024	9.788	0.784	4.731	0.028
C.D. (at 5 %)	-	-	-	-	3.765	-	29.598	2.146	14.305	0.051

Note: The soil pH, EC, B.D, P.D, P.S, O.C, NS, S and ppm long form's as potential of hydrogen ion, Electrical conductivity, Bulk density, Particle density, Pore space, Organic carbon, Non-Significant, Significant and parts per million respectively.

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