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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.* P - 3536

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Abstract
An experiment was conducted during *Kharif* season (July – October) 2021 to study the "Effect of different levels of Phosphorus and Zinc on Physico-Chemical Properties of Soil, Growth and Yield of Maize (*Zea mays* L.) *Var.* P – 3536*"* on crop research farm department of Soil Science & Agricultural chemistry. The experiment was laid out in Randomized Block Design having three levels of Phosphorus @ 0%, 50%, 100% and three levels of Zinc @ 0%, 50% and 100% respectively. The treatment combinations were replicated three times and allocated at random in each replication. The result shows that the application of different levels combination of Phosphorus and Zinc fertilizer increased growth, yield of Maize and improved soil chemical properties. However, some parameter of soil physical properties decreased. It was recorded from the application of Phosphorus and Zinc fertilizer in treatment T_9[P @ 100% + Zn @ 100%] maximum Bulk density 1.25 Mg m^{-3}in0-15 cm and 1.26 Mg m^{-3} in 15-30 cm, Particle density 2.25 Mg m^{-3} in 0-15 cm and 2.26 Mg m^{-3} in 15-30 cm,% pore space 75.14% in 0-15 cm and 74.28% in 15-30 cm, Water holding Capacity 48.59% in 0-15 cm and 46.97% in 15-30 cm, pH 7.13 in 0-15 cm and 7.02 in 15-30 cm, EC 0.41 dSm^{-1} in 0-15cm and 0.40dSm^{-1} in 15-30 cm,% Organic Carbon 0.903% in 0-15 cm and 0.890% in 15-30 cm, Available Nitrogen291.590 kg ha^{-1}in 0-15cm and 286.90 in 15-30cm kg ha^{-1}, Available Phosphorus29.68 kg ha^{-1} in 0-15 cm and 28.78 kg ha^{-1} in 15-30 cm, Available Potassium225.63 kg ha^{-1} in 0-15 cm and 220.03 kg ha^{-1} in 15-30 cm. It was also revealed that the application of Phosphorus with Zinc was excellent source for fertilization than fertilizers. The economy of different treatment concerned, the treatment T_9 provides highest net profit of Rs. 36,011 with Benefit Cost ratio 2.011:1

Keywords: Physico-chemical properties of soil, phosphorus, zinc, yield

Introduction
Maize (*Zea mays* L.) is ranked 3rd as a post-grain grain crop and is not only grain but also used as a vegetable and fodder crop. Maize, originally from the United States, was bred nearly 7,000 years ago, and it provides nutrients for humans and animals. It is also used as a source of raw materials for the production of oil, protein, starch, food additives, alcoholic beverages and fat sources (Pandey *et al*., 2005) [12].

In India, the current pattern of consumption of maize is poultry, pork, fish feed 52%, human feed 24%, cattle feed and starch 11% and the seed and liquor industry is 1%. It is rich in vitamin A, vitamin E, nicotinic acid, riboflavin and contains much higher Phosphorus than rice and sorghum. Its fodder and grass 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, so 56% carbohydrate and 56% has very nutritious food and tobacco. Apart from cereals, fodder and fodder, there is great value in the textile, starch and dye industries. (Rai 2006) [13].

Maize is grown in almost every province of India occupying an area of 6 m ha 1 per cent with a production and production rate of 9.7 mt. and 1.7 t ha^{-1}, respectively. (Kumar *et al*., 2007) [7].

Plant growth behavior is influenced by the use of Phosphorus (Hajabbasi and Schumacher, 2007; Gill *et al*., 2007). Phosphorus supplementation increases plant length, grain weight per grain, dry matter yield and grain yield (Sharma and Sharma, 2008; Singh and Dubey, 2009; Sharma and Gupta, 2008). The inclusion of High Phosphorus reduces the amount of sodium adsorption and increases plant production in saline sodic soils (Chaudhry *et al*., 2009) [4].

Maize can grow successfully in areas with an annual rainfall of 60 cm which should be well distributed throughout the growing season. Plants need more than 50% of their required amount of water in about 30-35 days after sowing and insufficient soil moisture in the grain

filling phase results in poor yield of shriveled grain. Corn needs bright sunny days for rapid photosynthetic growth. Prolonged cloudy weather is bad for the crop but moderate sunlight and possible rainfall are the best way to grow it.

Phosphorus plays a major role in energy storage and transmission and is closely related to cell division and corn development. Phosphorus is a component of nucleic acid, phytin and phospho-lipid. Phosphorus compound acts as a "energy compound" within plants. Phosphorus is essential for energy conversion, carbohydrate metabolism, fat utilization, plant respiration and early maturation of corn. (Ahmad *et al*., 2010) [1].

Zinc plays an important role in the proper functioning of many enzyme systems, the synthesis of nucleic acids and auxin (plant hormones), protein analysis and normal plant growth and development. Phosphorus and zinc, although important for plant growth, are contraindicated in some cases, such as when P is given in high doses and Zn absorption is low or insufficient. This may be due to the low rate of Zn transfer from the roots to the top, i.e., the accumulation of zinc in the roots and the low Zn uptake. Plants absorb Zn in the form of Zn^{2+}.

Materials and Methods

The current study entitled "The Impact of Different Levels of Phosphorus and Zinc on Physico-Chemical Properties of Soil, Growth and Yield in Maize (*Zea Mays*. L)" includes field research conducted in Soil Science and Agricultural Chemistry Research. The farm, SHUATS, Prayagraj during Kharif Season 2020, was 25º24'30"N latitude, 81º51'10"E longitude, and 98 m above sea level. Details of the test site, soil and climate are described in the chapter as well as the exploration design, building plan, cultural practices and techniques used in the boundaries. The Prayagraj region is below the subtropical belt in South East Uttar Pradesh, experiencing extreme summer temperatures and inclement winters. The maximum local temperature is 46 ℃ - 48 ℃ and is rarely as low as 4 ℃ - 5 ℃. The relative humidity was between 20-94%. The average rainfall in this area is approximately 1100mm. It comes under a tropical climate receiving an average annual rainfall of 1100mm, the heaviest rainfall from July to the end of October. Occasionally, however, the rain was rare in winter. The winter months were cold and the summer months were very hot and dry. The minimum temperature during the growing season was 27.1 ℃ and the minimum was 39.94 ℃. Humidity minimum was 57.70% and maximum was 75.37%.

Two different factors were considered: (i) Phosphorus levels (0%, 50%, 100%). (ii) Zinc (0%, 50% and 100%). The trial consisted of 9 treatments and the field was placed in a Randomized Block Design with three duplicates and the treatment assigned accordingly. The size of each building was 2 x 2 m^2. Seeds were sown in the fields at intervals of 50 cm x 20 cm. Common recommended dosages of Phosphorus such as SSP (Single Super Phosphate) and Zinc (Zinc Sulphate) were used as a treatment combination which was then used as a base dose before sowing seeds.

Nitrogen was applied in separate doses, the first after 35 days of sowing and the second dose 42 days after sowing similar to the RDF. Different activities of cultural integration such as irrigation, cultivation, pest control and so on are performed as required. The amount of harvest was recorded in each plot after harvest. Soil at a depth of 0-15cm and 15-30cm is taken both before and after harvesting to determine soil boundaries. The various parameters analysed were Bulk density, particle density, % Pore Space, PH, E.C, % Organic Carbon, Nitrogen, Phosphorus and Potassium, Zinc.

Table 1: Treatment Combinations

Treatments	Treatment Description
T_1	Control
T_2	Phosphorus@ 0%+ Zinc @ 50%
T_3	Phosphorus @0%+ Zinc @ 100%
T_4	Phosphorus @ 50%+Zinc @ 0%
T_5	Phosphorus @ 50%+ Zinc @ 50%
T_6	Phosphorus @50%+ Zinc @ 100%
T_7	Phosphorus @ 100%+Zinc @ 0%
T_8	Phosphorus @ 100%+ Zinc @ 50%
T_9	Phosphorus @100%+ Zinc @ 100%

Results and Discussion

Physical Properties of Soil: Table 2 and Fig 1 Indicate the estimated value by a depth of 0-15cm and 15-30cm. The Maximum Bulk density was found in T_1(Phosphorus @ 0% + Zinc @ 0%) is 1.62 Mg m^{-3} in 0-15 cm and 1.68 Mg m^{-3}in 15-30 cm. The minimum bulk density was found in T_9(Phosphorus @ 100% + Zinc @ 100%) is 1.25Mg m^{-3}in 0-15cmand 1.26 Mg m^{-3}in 15-30 cm respectively. The Maximum Particle Density is found in T_1(Phosphorus @ 0% + Zinc @ 0%) in 2.25Mg m^{-3} in 0-15cmand 2.26Mg m^{-3}in 15-30cm. The Minimum Particle Density are found in T_9 (Phosphorus @ 100% + Zinc @ 100%)is 2.62 Mg m^{-3} in 0-15cm and 2.68Mg m^{-3}in 15-30cm. The Maximum pore space (%) of soil found at T_9 (Phosphorus @ 100% + Zinc @ 100%) is 75.140% in 0-15cm and 74.28%in 15-30cm. The minimum (%) of pore space was found in T_1(Phosphorus @ 0% + Zinc @ 0%)is 44.830% in 0-15 cm and 43.21% in 15-30cm. The maximum water holding Capacity (%) of the soil is found in T_9 (Phosphorus @ 100% + Zinc @ 100%) is 48.59% in 0-15 cm and 46.97% in 15-30cm and the minimum Water Holding Capacity was found in T_1(Phosphorus @ 0% + Zinc @ 0%) is 40.12% in 0-15cm and39.10% in 15-30cm. This improvement of soil material in the treatment of T_9 (Phosphorus @100% and Zinc @ 100%) may be due to the use of 100% Phosphorus and 100% Zinc. These findings are similar to Kahlepure *et al*., 2013, Mashih *et al*., 2016, Akinpelu *et al*., 2013.

Table 2: Effect of Phosphorus and Zinc on Bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), % Pore Space and Water holding capacity (%)

Treatments	Bulk Density (Mg m^{-3})		Particle Density (Mg m^{-3})		Pore Space (%)		Water Holding Capacity (%)	
	0-15cm	15-30cm	0-15cm	15-30 cm	0-15cm	15-30cm	0-15cm	15-30cm
T_1	1.62	1.68	2.62	2.68	44.83	43.21	40.12	39.10
T_2	1.52	1.59	2.52	2.59	46.84	46.14	41.15	40.78
T_3	1.48	1.53	2.48	2.53	52.02	51.54	41.12	40.15
T_4	1.43	1.50	2.43	2.50	57.81	56.23	45.47	43.25
T_5	1.39	1.47	2.39	2.47	60.73	59.45	44.15	42.34

T_6	1.36	1.40	2.36	2.40	63.67	62.46	46.48	44.87
T_7	1.33	1.36	2.33	2.36	68.25	67.69	45.50	43.59
T_8	1.28	1.30	2.28	2.30	70.18	69.12	46.15	44.65
T_9	1.25	1.26	2.25	2.26	75.14	74.28	48.59	46.97
F test	NS	NS	NS	NS	S	S	S	S
S.Em ±	-	-	-	-	0.534	0.562	0.155	0.153
C.D @ 5%	-	-	-	-	2.457	2.981	0.331	0.330

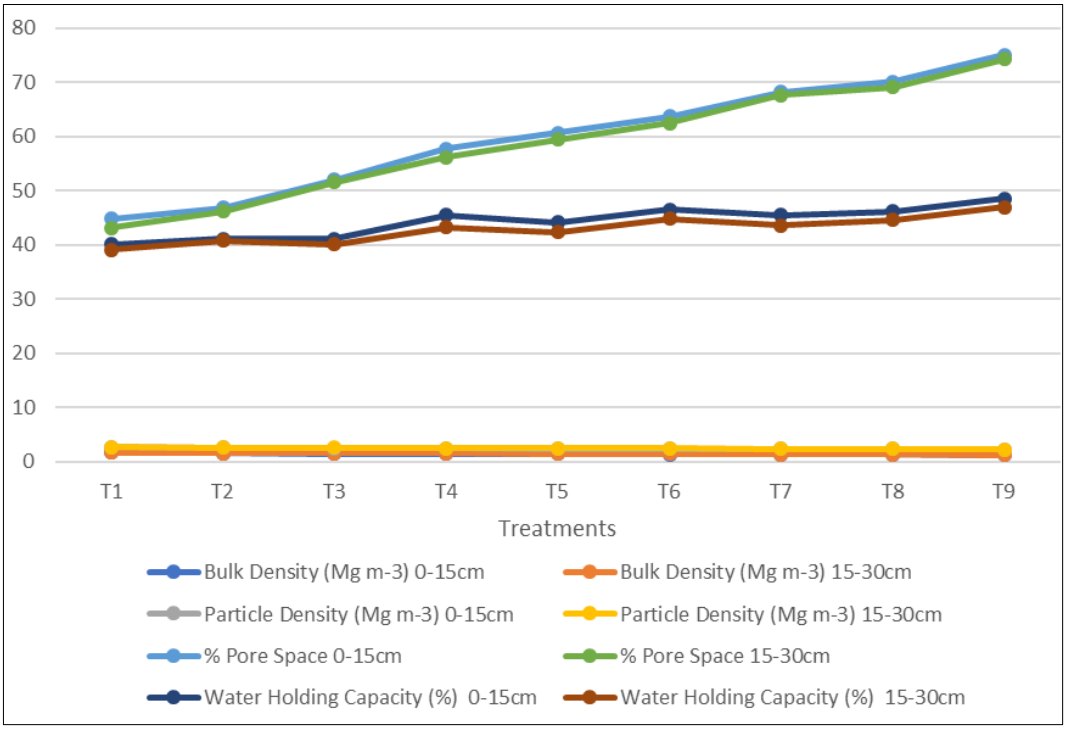

Fig 1: Effect of Phosphorus and Zinc on Bulk density (Mg m^{-3}), Particle density (Mg m^{-3}),% Pore Space and Water holding capacity (%)

Chemical Properties of Soil

Table 3 and Fig. 2 Indicate the estimated value by a depth of 0-15cm and 15-30cmand Maximum pH of the soil found at T_9(Phosphorus @ 100% + Zinc @ 100%) is 7.67 in 0-15cm, 7.70 in 15-30 cm and the minimum pH of the soil was found in T_1(Phosphorus @ 0% + Zinc @ 0%)is 7.02 in 0-15cm, 7.13 in 15-30 cm respectively. The Maximum EC of soil after crop harvesting was found in T_9(Phosphorus @ 100% + Zinc @ 100%) is 0.41dSm^{-1}in 0-15cm, 0.40dSm^{-1}in 15-30 cm and the minimum EC of soil found in T_1(Phosphorus @ 0% + Zinc @ 0%) is 0.27dSm^{-1} in 0-15 cm, 0.25dSm^{-1}in 15-30 cm respectively. The Maximum (%) of Organic Carbon soil was found in T_9 (Phosphorus @ 100% + Zinc @ 100%) is0.903% 0-15 cm, 0.890%in 15-30 cm and the minimum (%) Organic carbon was found in T_1(Phosphorus @ 0% + Zinc @ 0%) is 0.683% in 0-15 cm, 0.630% in 15-30 cm respectively. Similar findings were reported by Shinde *et al*., 2016, Singh *et al*., 2017 [16], Singh *et al*., 2016 [17].

Table 3: Effect of Phosphorus and Zinc on pH (1:2.5), EC (dSm^{-1}), % Organic Carbon

Treatments	pH		EC		% Organic Carbon	
	0-15cm	15-30cm	0-15 cm	15-30cm	0-15cm	15-30cm
T_1	7.70	7.67	0.27	0.25	0.683	0.63
T_2	7.63	7.56	0.28	0.26	0.673	0.65
T_3	7.27	7.13	0.29	0.28	0.710	0.66
T_4	7.28	7.18	0.30	0.29	0.753	0.69
T_5	7.30	7.28	0.32	0.30	0.783	0.70
T_6	7.28	7.19	0.33	0.31	0.797	0.75
T_7	7.17	7.15	0.37	0.35	0.823	0.80
T_8	7.15	7.15	0.40	0.38	0.893	0.85
T_9	7.13	7.02	0.41	0.40	0.903	0.89
F test			S	S	S	S
S.Em ±	-	-	0.509	0.510	0.024	0.023
C.D @ 5%	-	-	2.921	2.922	1.302	1.300

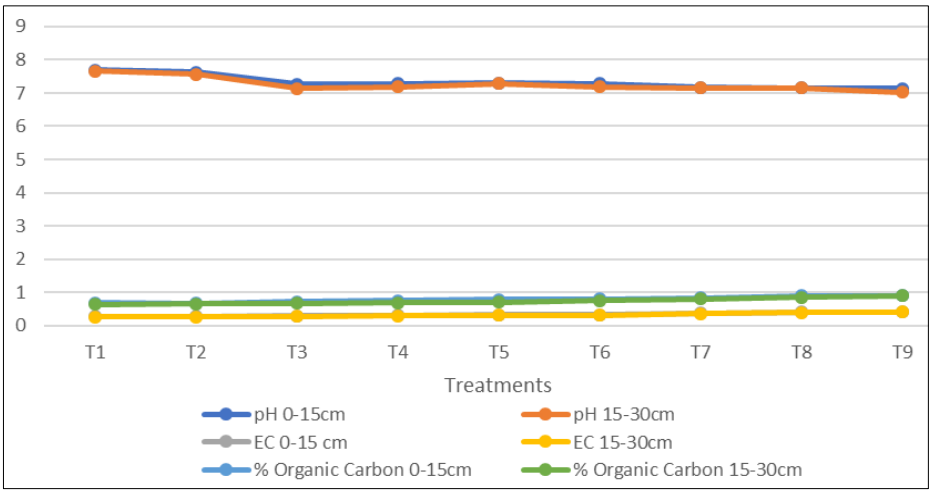

Fig 2: Effect of Phosphorus and Zinc on pH (1:2.5), EC (dSm^{-1}), % Organic Carbon

Tables 4 and Fig 3 Indicate the estimated value by a depth of 0-15cm and 15-30cm and the Maximum Nitrogen in the soil was found in T_9 (Phosphorus @ 100% + Zinc @ 100%) is291.590kg ha^{-1}in 0 -15cm, 286.90kg ha^{-1}in 15-30cm and the Minimum Nitrogen was found in T_1(Phosphorus @ 0% + Zinc @ 0%)261.46kg ha^{-1}in 0-15 cm, 260.40kg ha^{-1}in 15-30 cm respectively. The Maximum Phosphorus was found in T_9 (Phosphorus @ 100% + Zinc @ 100%)is 29.68kg ha^{-1}in 0-15cm, 28.78kg ha^{-1}in 15-30 cm and the minimum Phosphorus was obtained in T_1(Phosphorus @ 0% + Zinc @ 0%) is21.37kg ha^{-1}in 0-15 cm, 19.45kg ha^{-1}in 15-30 cm respectively. The Maximum Potassium was found in T_9(Phosphorus @ 100% + Zinc @ 100%)in 225.63kg ha^{-1}0-15 cm, 220.03kg ha^{-1}in 15-30 cm and the minimum Potassium of the soil found in T_1(Phosphorus @ 0% + Zinc @ 0%)is 261.460kg ha^{-1} in 0-15cm, 260.40kg ha^{-1}in 15-30 cm respectively. The Maximum Zinc found in the soil was obtained in T_9(Phosphorus @ 100% + Zinc @ 100%)is 1.530mg ha^{-1} in 0-15cm, 1.423mg ha^{-1}in 15-30 cm and the minimum Zinc of the soil was found in T_1(Phosphorus @ 0% + Zinc @ 0%) is 0.607mg ha^{-1} in 0-15 cm, 0.570mg ha^{-1}in 15-30 cm respectively. Similar findings were also reported by Masih *et al*., 2016, Kumar *et al*., 2016 [6], Haruna *et al*., 2013, Singh *et al*., 2017 [16].

Table 4: Effect of Phosphorus and Zinc Sources of nutrients on Nitrogen (kg ha^{-1}), Phosphorus (kgha^{-1}) and Potassium (kg ha^{-1})

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kgha^{-1})		Potassium (kg ha^{-1})		Zinc (mg ha^{-1})	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
T_1	261.460	260.40	21.37	19.45	155.71	154.65	0.607	0.570
T_2	266.673	264.57	27.87	26.98	165.56	164.56	1.163	1.103
T_3	269.063	265.16	22.50	20.12	176.10	175.67	1.450	1.345
T_4	266.860	262.13	24.58	23.00	185.23	184.24	1.230	1.19
T_5	279.963	270.92	26.73	22.87	199.97	197.34	1.237	1.159
T_6	280.447	276.65	24.33	23.56	204.17	200.90	1.480	1.368
T_7	288.193	284.80	27.70	23.72	215.36	210.86	1.503	1.48
T_8	290.430	285.98	28.26	26.82	218.51	215.12	1.230	1.149
T_9	291.590	286.90	29.68	28.78	225.63	220.03	1.530	1.423
F test	S	S	S	S	S	S	S	S
S.Em ±	2.788	2.786	0.784	0.80	4.731	4.729	0.028	0.026
C.D @ 5%	4.598	4.592	2.146	2.148	14.305	14.301	0.051	0.049

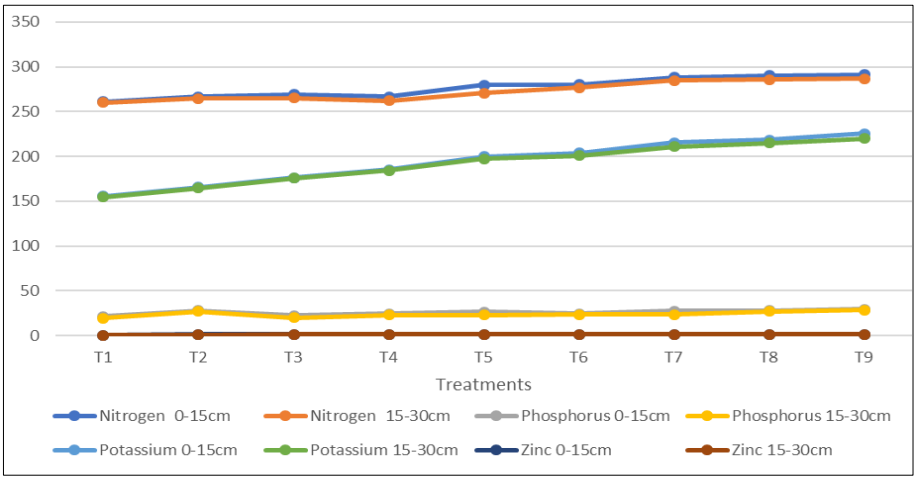

Fig 3: Effect of Phosphorus and Zinc Sources of nutrients on Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}) and Potassium (kg ha^{-1})

Conclusion

Based on this study, it concludes that the current paper highlights the positive effect of Phosphorus and Zinc in the Maize planting area. The combined use of RDF, Phosphorus @ 100% (50 kg ha^{-1}) and Zinc @ 100% (25 kg ha^{-1}) is an excellent nutrient to improve growth, growing yields and the potential for maize compared to other medicinal compounds.

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