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Interactive Effect of Phosphorus and Zinc on Yield, Quality and Fertility Status of Soil after Harvest of Soybean

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Abstract A field experiment was conducted during the *kharif* of 2014 to study the interactive effect of phosphorus and zinc on yield, quality and nutrient use efficiency of soybean. The experiment was laid out in randomized block design (RBD) with seven treatments randomized in three replications. The levels of phosphorus were 100, 125, 150% RDP with and without zinc @ 5 kg ha^{-1}. The source of phosphorus was SSP and zinc was applied through $ZnSO_4$. The treatments comprised of unfertilized control. From the present investigation the following conclusion is drawn that application of 100% RDP i.e. 30 : 75 : 30 NPK kg ha^{-1} with 5 kg zinc ha^{-1} were recorded higher soybean yield, quality and improved soil fertility status after harvest of soybean. High levels of available phosphorus in soil or high dose of phosphorus application may induce zinc deficiency in the soil characterized by low concentration of available zinc.

Keywords Phosphorus, Zinc, Yield, Soil fertility, Soybean.

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Introduction

Soybean (*Glycine max* L.) is one of the important oil seed as well as leguminous crop. Soybean is a world first rank crop as a source of vegetable oil and in India it occupies number one position among oilseed crops. World's soybean area and production is 71.85 m ha and 154.32 mt respectively. Soybean is cheapest source of vegetable oil and protein. It contains about 40% protein well balanced in essential amino acids, 20% oil rich with poly unsaturated fatty acids. In India, soybean occupies an area of 9.67 m ha with production of 10.22 m t and productivity of 1.12 t ha^{-1}. The major soybean growing states are Madhya pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh and Chhattisgarh.

The plants require essential nutrients viz., primary, secondary and micro nutrients. One of the fertilizers that are used a lot in various crop plants is phosphorus, which is applied as phosphorus fertilizers to the soil. Phosphorus is considered as an essential nutrient for growth and development of plant. It is an integral part of nucleic acid and essential for cellular respiration and metabolic activiy. It is involved in many enzymatic reaction, CO_2 fixation, sugar metabolism, energy storage and transfer. Unfortunately, in the past, this fertilizer was used in crop fields without conducting soil tests and there were no correct and appropriate recommendations concerning the use of phosphorus fertilizers. This led to a rate of phosphorus application far greater than what was required, so that in many regions the available phosphorus in the soil is many times more than the critical level [1].

Apart from primary and secondary nutrients, deficiency of Zn is now becoming widespread, particularly due to intensive cultivation [2]. Micronutrient deficiency has become a limiting factor for crop productivity in many parts of the world. Of the microelements, Zn is the most widespread productivity constraint in rainfed production [3]. The deficiency of micronutrients may emerge when the supply of micronutrients to the soil is less compared to removal through crop harvest which in turn limits crop productivity [4]. The problem in the areas like arid and semi-arid regions where soil pH value and $CaCO_3$ content are high and organic matter content is low [5]. Many research workers reported a wide spread deficiency of zinc in Maharashtra soils and subsequently observed response of various crop to the zinc application . Zinc deficiency is increasing in soil under many crops and cropping system. Zinc is a trace element needed in small but critical concentrations and if the amount available is not adequate, plants will suffer from physiological stress brought about by the dysfunction of several enzyme systems and other metabolic functions in which Zn plays a part [6].

Materials and Methods

The present study effect of various doses of P with Zn and it's interactive effect on yield, quality and nutrient use efficiency of soybean investigation was conducted during the *kharif* of 2014 on Research Farm, Department of Soil Science and Agricultural Chemistry, Dr PDKV, Akola.

Akola is situated in the subtropical region at 22°42′ North latitude and 77°02′ East longitudes and at an altitude of 307.42 m (agromet observatory) above mean sea level. The climate of Akola is semi-arid and characterized by three distinct seasons' viz. hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from november to February. Average annual precipitation is 812.4 mm (average of 30 years). The normal mean monthly maximum temperature is 42.5°C during the hottest May.While the normal mean monthly minimum temperature is 10.6°C in the coldest December.The experiment consist of seven treatments each replicated thrice in a randomized block design (RBD) having individual plot size 3.6 × 4.5 m. The treatment combinations were T_1-(Control), T_2 - 100% RDP, T_3 -125% RDP, T_4 -150% RDP, T_5 -100% RDP + 5 kg Zn ha^{-1}, T_6-125% RDP + 5 kg Zn ha^{-1} and T_7 -150% RDP + 5kg Zn ha^{-1} (100% recommended dose of fertilizer for soybean N : P : K 30 : 75 : 30 kg ha^{-1}). N and K dose was same in all plots except control (T_1). N, P_2O_5, Zn applied through urea, SSP, MOP and zinc sulfate respectively. Experimental soil alkaline in nature , EC 0.38dSm^{-1} organic carbon status was moderate . Available status of nutrients in soil before sowing N,P,S and micronutrient Zn were moderately deficient and potassium availability was good. The soil samples were collected after harvest of soybean during *kharif* of 2014. These samples were analyzed for N, P, K and Zn. The crop was harvested at maturity, yield data and quality parameter were recorded.

Results and Discussion

Yield of soybean

The data regarding the grain and straw yield of soybean was influenced by various treatments was given in Table 1. The effect of phosphorus with and without zinc on grain and straw yield of soybean was found to be significant over control (T_1). It was further increasing with every successive increase in dose of

Table 1. Yield of soybean as influenced by various treatments.

Treat-ments		Yield of soybean ($q\ ha^{-1}$) Grain	Straw
T_1	-Control	4.72	7.82
T_2	-100% RDP	7.11	11.30
T_3	-125% RDP	7.24	11.48
T_4	-150% RDP	6.87	10.73
T_5	-100% RDP + 5 kg Zn ha^{-1}	7.68	12.57
T_6	-125% RDP + 5 kg Zn ha^{-1}	7.81	12.78
T_7	-150% RDP + 5 kg Zn ha^{-1}	7.36	11.94
	SE (m ±)	0.067	0.092
	CD at 5%	0.21	0.28

Table 2. Quality parameters (i.e. test weight, protein and oil content) of soybean as influenced by various treatments.

Treat-ments		Test weight (g)	Protein (%)	Oil (%)
T_1	-Control	11.55	38.89	19.02
T_2	-100% RDP	11.78	39.32	19.38
T_3	-125% RDP	11.81	39.41	19.42
T_4	-150% RDP	11.79	39.38	19.40
T_5	-100% RDP + 5 kg Zn ha^{-1}	11.83	40.34	19.89
T_6	-125% RDP + 5 kg Zn ha^{-1}	11.84	40.62	19.94
T_7	-150% RDP + 5 kg Zn ha^{-1}	11.81	40.19	19.91
	SE (m ±)	0.005	0.113	0.018
	CD at 5%	0.016	0.35	0.053

phosphorus from 100% RDP to 125% RDP but decreases in treatment 150% RDP. A significant increases in grain yield (7.81 q ha^{-1}) and straw yield (12.78q ha^{-1}) was obtained with application of 125% RDP + 5 kg Zn ha^{-1} (T_6) but at par with application of 100% RDP + 5 kg Zn ha^{-1} (T_5). A similar report showed that combined application of phosphorus and zinc caused significant results in respect of yield agreement with the findings reported by Chandra and Khandewal [7].

Quality parameters

Data regarding the quality parameters like test weight (100 grain wt), protein and oil content in soybean grain as influenced by various treatments was presented in Table 2.

Test weight

The effect of phosphorus with and without zinc on test weight of grain was found to be significant over control. Test weight of soybean ranged from (11.55 to 11.84%). The significantly highest test weight (11.84 g) of soybean grains was found with application of 125% RDP + 5 kg Zn ha^{-1} (T_6) over other treatments, but was found statistically at par with application of 100% RDP + 5 kg Zn (T_5) . Zn is required for the biosynthesis of plant growth regulator (IAA) and carbohydrate and N metabolism which lead to high yield and yield components. Hundred seed weight is one of the most important yield components in pulse. Overcoming limitation to plant nutrients through the application of appropriate fertilizers increased assimilate production and photosynthesis efficiency at the seed filling stage. Similarly, this result confirmed with Calhor [8].

Protein content

The effect of phosphorus with and without zinc on protein content in grain of soybean was found to be significant over control. Protein content in soybean grain was ranged from 38.89 to 40.62%. The significantly maximum protein content (40.62%) in soybean grains was found with application of 125% RDP + 5 kg Zn ha^{-1} (T_6) over remaining treatments, but statistically found at par with application of 100% RDP + 5 kg Zn ha^{-1} (T_5), where as lowest protein content was found in treatment control. This could be due to zinc application in soil enhanced the zinc concentration in the plant which associated with RNA and ribosome induction the result of which accelerated in protein synthesis, similar result quoted by Pable and Patil [9].

Oil content

Significant increase oil content in soybean grain was recorded with the application of phosphorus with and without zinc over the control. Oil content in soybean grain was ranged from 19.02 to 19.94%. The significantly maximum oil content (19.94%) in soybean grains was found with application of 125% RDP + 5 kg Zn ha^{-1} (T_6) over remaining treatments, but statistically found at par with application of 100% RDP + 5 kg Zn ha^{-1} (T_5) and 150% RDP + 5kg Zn

Table 3. Available nutrients in soil after harvest of soybean as influenced by various treatments.

Treat-ments	Available nutrients (kg ha^{-1}) N	P	K	DTPA-Zn (mg kg^{-1})
T_1 -Control	215.33	13.82	376.65	0.58
T_2 -100% RDP	233.49	15.57	386.51	0.60
T_3 -125% RDP	234.64	16.77	388.61	0.59
T_4 -150% RDP	232.18	17.05	385.12	0.58
T_5 -100% RDP+5 kg Zn ha^{-1}	235.63	16.13	392.41	0.62
T_6 -125% RDP+5 kg Zn ha^{-1}	236.56	16.81	393.68	0.61
T_7 -150% RDP+5 kg Zn ha^{-1}	234.51	17.14	390.17	0.60
SE (m±)	0.658	0.343	1.105	0.008
CD at 5%	2.03	1.06	3.41	0.02

ha^{-1} (T_7). However, interaction effect between zinc and phosphorus in respect of oil and protein content was found to be significant [10].

Soil fertility status

Data pertaining to available nitrogen, phosphorus, potassium and zinc in soil after harvest of soybean as influenced by various treatments was given in Table 3.

Available nitrogen

Available nitrogen in soil after harvest of soybean was found significantly higher with application of phosphorus with and without zinc over control. Available nitrogen increases in soil with increasing the phosphorus level with zinc but decrease with the application of 150% RDP. The significantly higher available nitrogen (236.56 kg ha^{-1}) in soil after harvest of soybean was recorded in treatment 125% RDP + 5 kg Zn ha^{-1} (T_6) over remaining treatments, but it was statistically at par with application of 125% RDP (T_3) and 100% RDP + 5 kg Zn ha^{-1} (T_5). This may be due to the beneficial effect of phosphorus with and without zinc in improving soil properties and enhancing the availability of nitrogen in soil [11].

Available phosphorus

Available phosphorus in soil after harvest of soybean was significantly increases by application of phosphorus with and without zinc over control. The highest available phosphorus (17.14 kg ha^{-1}) was recorded in the treatment 150% RDP + 5 kg Zn ha^{-1} (T_7) over remaining treatments but found statistically at par with treatments T_3,T_4,T_5 and T_6.These results were more or less similar to those quoted by Sharma et al. [12] reported that the conjunctive use of inorganic fertilizers and organic manure along with bio fertilizers and micronutrients gave highest available N, P, K, S and Zn in soil as compared to other treatment combinations.

Available potassium

Available potassium in soil after harvest of soybean was found to be significant with application of phosphorus with zinc. Available potassium increased in soil with increasing the phosphorus level with and without zinc but decreased with application of 150% RDP. The highest available potassium (393.68 kg ha^{-1}) was recorded in treatment 125% RDP + 5 kg Zn ha^{-1} (T_6) over remaining treatments but statistically it was at par with application of 100% RDP + 5 kg Zn ha^{-1} (T_5) . Similar result reported by Shahi et al. [13], they reported the increase in available potassium in soil with increasing the dose of zinc.

Available zinc

Available zinc in soil after harvest of soybean was found more availability of zinc with application of phosphorus with zinc. Zinc availability decreases with application of each successive phosphorus level but it was increased with application of zinc. The highest value of available zinc (0.62 mg kg^{-1}) was recorded in the treatment soil application of 100% RDP + 5 kg Zn ha^{-1} (T_5). However, it was at par with application of 125% and 150% RDP + 5 kg Zn ha^{-1} respectively. Available zinc in soil increased might be due to soil application of zinc but numerical decrease with application of high level of phosphorus. Similar result was observed by Rathod et al. [14].

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