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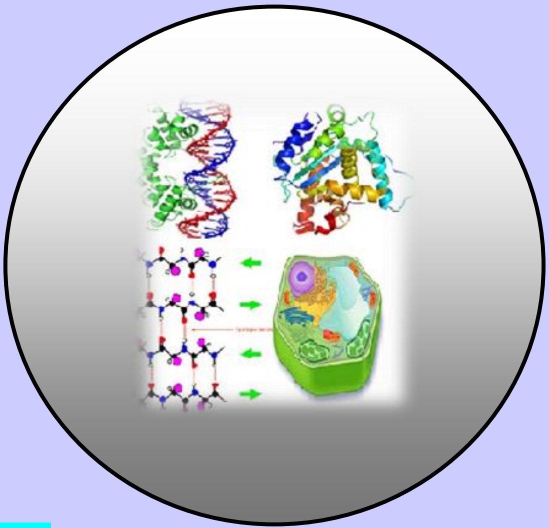

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Dr. S.N. Pandey
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RESEARCH PAPER

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Zinc Fertilization Impact on Growth and Biochemical Attributes of Wheat Grown on a North-Indian Soil

S.N. Pandey
Department of Botany, Plant Physiology Unit, University of Lucknow,
Lucknow-226007, U.P., India

ABSTRACT

A clay pot experiment was carried out on assessment of soil in North-Indian plain (Lucknow district, U.P. state) and fertilization with zinc (Zn) levels viz. nil, 2.5, 5, 10 and 20 mg Kg^{-1} soil as $ZnSO_4$, and to study their effects on growth, Zn status in soil and wheat tissu and biochemical responses of wheat (Triticum aestivum L.). Soil (native) was loamy-sand in texture, moderately calcareous ($CaCO_3$ 1.2%), very low in organic matter content (.24 %) and deficient in zinc (0.38 ppm). After fertilization, zinc status of soil increased with increase in doses of zinc. Wheat plants showed poor growth (shoot length and dry matter yield) and exhibited visible symptoms such as chlorosis and necrosis in young leaves at native soil. The biochemical responses (total chloroohyll, protein and sugar content) of wheat also increased with zinc fertilization doses in soil up to 10 mg Zn Kg^{-1} soil, where as these parameters started to decline at high dose of zinc in soil (20 mg Kg^{-1}). Maximum reproductive yield (seeds and seed weight, inflorescence length and number) of wheat observed at soil amended with zinc at the rate 10 mg Kg^{-1}. Therefore, study concluded that, alluvial soil of North- Indian plains required zinc fertilization after assessment of soil.
Key Words: Zinc, Growth, Reproductive Yield, Biochemical Constituents and Wheat.

INTRODUCTION

Alluvial plain in north-India has high potential for cultivation of several crops throught the year. Wheat is a commonly growing crop in such areas of semi-arid zones. A huge population and industrial sector depends largely on quantity and quality of wheat production. But most of the portion of this area is deficient in zinc at variable status (Pandey, 2006; Pandey et al., 2009). The deficiency of zinc limits crop productivity, Verma and Pandey, 2016). Zinc is an essential plant nutrients, constituents and activator of several enzymes involved in a large number of biochemical activities (Sharma, 2006). The uptake and translocation of zinc is highly affected by soil conditions and genetic constitution of plants (Singh and Pandey, 2011). Several reports indicated the uptake of zinc is dose dependent (Hart et al., 1998, Pandey et al., 2017). More than two hundred enzymes are known to contain zinc as a cofactor (Valee and Auld, 1990). Plants, grown in zinc-deficient soil, show changes in activity of several other enzymes which is not has any specific role of zinc (Sharma, 2006). The deficiency or elevated levels of zinc decrease growth and yield of crops, the degree of toxicity or deficiency effects also affected with soil properties. Keeping in view, and least information available on recent soil properties and status of zinc in north Indian plains, study was carried out to assessment of soil status and suitable dose of zinc fertilizer and their effect on growth, reproductive yield and biochemical responses of wheat crop.

MATERIALS AND METHODS

A clay pot culture experiment was conducted in glass-top wire house. Pots (10 Kg size) were lined with polythene and filled with soil collected from Badshahbagh area of Lucknow district. The composite soil sample analyzed for their some important physical and chemical properties (Table 1). Experiment was carried out in triplicates in randomized factorial design. Five levels of zinc applied in above assessed soil viz. nil, 2.5, 5, 10 and 20 ppm as $ZnSO_4$. Before sowing the seeds, nitrogen, phosphorus and potassium fertilizers were applied in soil in ratio 50:50:50, respectively. Wheat (*Triticum aestivum* L.) plants grown in above zinc-fertilized soils were observed for visible symptoms, growth (shoot length and dry matter yield), biochemical constituents (total chlorophyll, protein and sugar contents) and reproductive yield parameters (Inflorescence number and length, seeds and seed weight). Two plants in each pot were maintained till the maturity at harvesting 135 days. When visible symptoms started appear, plants were analyzed for biochemical parameters at 60 days of growth. Total chlorophyll content was determined by the method of Lichtethaller and Wellburn (1983). Protein content was estimated in wheat leaves by the folin phenol reagent method (Lowry et al., 1951). Sugar content was estimated by the method of Dubois et al. (1956). Plants were harvested at maturity for reproductive yield. For the determination of tissue zinc, oven dried shoot part of plant digested with nitric and perchloric acid (4:1 ratio), and zinc estimated with using atomic absorption spectrophotometer (Parkin Elmer- 250). Data were statistically analyzed, mean value (n=3) presented in the table. Value was tested for their significance by LSD (least significant difference).

RESULTS

Properties of native soil

Alluvial soil of Lucknow district (native soil) was sandy loam in texture, alkaline in reaction (pH 7.6), low in organic matter content (< 0.4%) and mild calcareous (Table 1). The soil was highly deficient in zinc (DTPA extractable, available zinc 0.38 ppm). The status of available Cu and Fe was determined 0.52 and 5.61 ppm in soil, respectively. After harvesting the wheat crop, soil developed available Zn 0.37, 0.62, 0.86, 1.12 and 1.84 ppmin soil fertilized with nil, 2.5, 5.0, 10 and 20 mg Kg^{-1}, respectively.

Symptoms on plants

Wheat plants grown at native soil without zinc fertilization showed stunted growth, necrotic areas in interveinal areas, yellowing in middle and old leaves. These symptoms did not appeared on plants with zinc-fertilized soils, observed at 60 days of growth. Whereas, chlorosis and browning of leaf tips in younger leaves started after 80 days of growth on wheat at zinc fertilization in soil (20 mg Kg^{-1}). The maximum visible growth of wheat was observed at soil added with 10 mg Zn Kg^{-1}. Zinc amendment prevented visible symptoms on wheat, and magnitude of response increased with increase in Zn levels in soil up to 10 mg Zn Kg^{-1}.

Growth Responses

Growth of wheat plants became influenced by zinc fertilization. Shoot length and dry matter yield showed increasing trend with increase in zinc levels from 0 to 20 mg Kg^{-1} soil. Maximum shoot length and dry weight yield of wheat was determined at soil amended at the rate 10 mg zinc Kg^{-1} soil. The growth responses of wheat also improved at zinc fertilized soil as compared to native soil.

Biochemical responses of wheat

Total chlorophyll content increased by zinc amended in soil at various levels (2.5, 5, 10 mg Zn Kg^{-1}). Maximum increase in total chlorophyll content was determined in wheat leaves by 28% at 10 mg Zn Kg^{-1} soil. Protein content was also increased by zinc, which was showing maximum value at 10 mg Zn Kg^{-1} soil, and increased with increase in zinc levels in soil. Sugar content in leaves followed similar trend as protein and sugar content in wheat leaves. A high reduction in sugar content by 58% was observed in wheat at 20 mg Zn Kg^{-1} soil over plants grown at 10 mg Zn Kg^{-1} . The all biochemical constituents (total chlorophyll, protein and sugar contents) was found to be maximum with tissue concentration 45.5 µg Zn g^{-1} dry weight, where soil was amended with zinc at the rate 10 mg Kg^{-1}.

Tissue zinc and reproductive yield

Wheat showed maximum production (Length and number of inflorescence, number and weight of seed) at 10 mg Zn Kg^{-1} in soil. At this amendment level, tissue zinc was determined 45.5 µg Zn g^{-1} dry weight. Whereas lowest reproductive was observed in plants at native soil without zinc amendment, also showed low tissue zinc (15.6 µg Zn g^{-1} dry weight). Increased reproductive yield of wheat was also found at higher dose of zinc in soil (20 mg Kg^{-1}) over control (native soil), but these were started to decline by 40, 40, 35 and 32% in inflorescence number, inflorescence length, seed number $inflorescence^{-1}$ and 100 seed weight, respectively as compared plants grown at 10 mg Zn Kg^{-1} soil. The tissue concentration of wheat shoot at 20 mg Zn Kg^{-1} soil was 65.3 µg Zn g^{-1} dry weight. Therefore soil amended above 10 mg Zn Kg^{-1} did not supported growth, chlorophyll, protein, sugar contents and reproductive yield of wheat.

Table 1. Physico-chemical properties of soil used in the experiment.

					DTPA Extractable nutrients (ppm)		
Parameters	Texture	pH	O.M.	$CaCO_3$	Zn	Cu	Fe
Average Value	Loamy Sand	7.6	0.2%	1.2%	0.38	0.52	5.61

Table 2. Effect of zinc addition in Lucknow soil on some biochemical constituents in wheat Leaves at 65 days of the growth.

Parameters	Zinc addition in soil (ppm)					LSD
	Nil	2.5	5	10	20	P< 0.05
Total chlorophyll (mg g^{-1} F.W.)	1.54	1.82	2.20	2.38	1.80	0.56
Protein (µg g^{-1} D.W.)	10.2	14.6	18.4	20.7	15.8	2.5
Sugar (µg g^{-1} D.W.)	4.8	6.6	10.5	11.8	5.2	0.6

Table 3. Effect of zinc-fertilization on zinc status in soil and plant tissue, growth and yield of wheat at harvest.

Parameters	Zinc addition in soil (ppm)					LSD
	Nil	2.5	5	10	20	P<0.05
Available zinc In soil	0.37	0.62	0.86	1.12	1.84	0.31
Height (cm)	28.5	35.6	37.5	38.6	32.5	1.8
Dry weight (g)	15.6	22.5	25.8	25.9	18.4	3.5
Length of Inflorescence (cm)	4.8	5.8	7.5	8.1	5.2	1.2
Inflorscence number $plant^{-1}$	2	3	5	5	3	1.0
100 seed weight (g)	2.8	3.8	4.7	4.8	3.1	0.8
Number of grains $Inflorescence^{-1}$	22	30	40	41	28	4.5
Zinc in shoot (µg g^{-1} dry weight)	15.6	22.8	36.4	45.5	65.3	10.5

DISCUSSION

The soil used in the experiment was highly deficient in zinc (0.38 ppm), as critical range of available Zn in soil reported by Agarwala and Sharma < 0.8 ppm. The properties of soil such as low organic matter, calcareousness in soil and sandy loam texture also resembled with earlier report (Pandey et al., 2015). The growth depression (decreased shoot length and dry matter yield) of wheat at Zn-deficient native soil could be due to the low zinc and less availability to plant roots under alkaline soil condition (Marschner, 1995). Visible symptoms appeared on early stage of wheat growth resembled zinc deficiency as reported earlier (Sharma, 2006) Decrease in biochemical constituents (chlorophyll, protein and sugar contents) could be attributed due to role of zinc in their biosynthetic pathway (Cakmak et al., 1989; Sharma, 2006). Decrease in growth supported by decreased chlorophyll content, which could be adversely affected photosynthesis of plants due to abnormalities in chlorophyll structure (Shrotri et al., 1978; Hu and Sparks, 1991). Protein cotent decreased in wheat at Zn-deficient soil and increased at Zn-fertilized soil indicted role of zinc in biosynthetic pathway of protein. The result was also in consonance with Marschner et al. (1996) and Kannaujiya and Pandey (2013) reported decrease in protein content due to zinc deficiency in soil. Decrease in tissue Zn may decreased protein content, it could might be due to the Zn-induced changes in ribosomes and nucleic acid metabolism (Bisht et al., 2002). Wheat plants under the influence of Zn-deficient soil showed decrease in sugar content, result supported with decrease in chlorophyll content in wheat leaves which could lead reduction in photosynthesis (Sharma, 2006). Zinc deficiency leads reduction of carbonic anhydrase activity which catalyzes the production of bicarbonate in C_4 plants, and contributes to a CO_2 concentration mechanism at the site of carboxylation by RuBP carboxylase by facilitating the conversion of HCO_3^- to CO_2 , therefore induce low sugar input in leaf cell (Sharma, 2006). Zinc is also involved in sucrose biosynthesis and starch metabolism (Shrotri et al., 1980). In wheat leaves, chlorophyll, protein and sugar content was started to decline at higher dose of Zn in soil (20 mg Zn Kg^{-1}), it may be due to the zinc toxicity on cellular metabolism (Pandey and Gautam, 2009). Therefore study concluded that, soil in north Indian plain (Lucknow district) was highly deficient in zinc. It needed zinc fertilization maximum up to 10 mg Zn Kg^{-1} soil, after the assessment of zinc status in soil.

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Corresponding author: Dr. S.N. Pandey, Department of Botany, Plant Physiology Unit, University of Lucknow, Lucknow-226007, U.P., India
Email: snpandey511@gmail.com