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The effect of ZN in the form of soil application alone and in combination of foliar spray at different growth stages on growth and dry matter yield of wheat

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Abstract
Wheat (*Triticum aestivum* L.) is a widely adapted crop. It is grown from temperate, irrigated to dry and high-rain-fall areas and from warm, humid to dry, cold environments. Zinc (Zn) deficiency is major risk factor to crop production and human health. It is an essential micronutrient, which is equally important for the plants, animal and human beings (Alloway, 2004). Globally about 2 billion people are considered to suffer from the Zn deficiency diseases. Biofortification is a recent approach aimed at increasing the bio-available nutrients, such as Fe and zinc, in these staple crops rather than using fortificants or supplements (Waters and Sankaran, 2011; White and Broadley,2005). The various data are recorded on after the foliar application of Zn on different growth stages and dry matter content *viz.* Plant height (cm), Plant tillers, Grain yield (gm) and Straw yield (gm). It can be concluded from the present study that adequate Zn availability during vegetative phase is important for good wheat growth and yields. Wheat favourably responded to soil applied Zn in different combination of dose. Application of Zn @50 kg ha-1 and two foliar spray @ 0.5% $ZnSO_4$ at PF and DS stages in combination was found to be the best treatment regarding growth and yield of wheat.

Keywords: Wheat, foliar application, bio fortification

Introduction

Wheat (*Triticum aestivum* L.) is the most extensively cultivated cereal crop worldwide due to its wider adaptability to difference agro-climatic and soil condition. It is being consumed in various forms by more than thousand million populations in the world. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates, and 20% of the food calories consumed globally (Breiman and Graur, 1995) [3]. Zinc is one of essential plant micronutrients and its importance for crop productivity is similar to that of major nutrients. Intensive agriculture coupled with the continuous use of N, P, K fertilizers has remarkably increased the production but simultaneously brought about problems related to micronutrient deficiencies, particularly that of Zn in soil. Zinc application to Zn deficient soil has been found to boost the growth of plants and yield of crops to a great extent. Globally about 2 billion people are considered to suffer from the Zn deficiency diseases (Muller and Krawinkel 2005) [6]. This situation is more alarming in developing countries, where Zn deficiency is fifth most important factor causing ailments, especially in children and women (WHO, 2002). In India, analysis of over 2,50,000 soil sample from 20 states so that 48% soil are Zn deficient with DTPA- Zn values below 0.6 mg kg-1 (Singh 2009). Shukla *et al.* (2014) [10] reported that about 43% soil in India are potentially Zn deficient. Agricultural intensification during the past few decades, without micronutrient in the fertilizer schedule, has enhanced Zn malnutrition in the Indian population (Rattan *et al.*, 2012) [9]. Wheat and rice, the major staple food of India, contain about 60-70% of daily calorie uptake. But, the cereal grains are low in Zn content and anti-nutritive compounds like phytates, which reduce the bio-availability of Zn. This has led to Zn-deficiency related human and animal disorder in many countries especially in India and China, even in soil well supplied with Zn. Biofortification is a recent approach aimed at increasing the bio-available nutrients, such as Fe and zinc, in these staple crops rather than using fortificants or supplements (Waters and Sankaran 2011; White and Broadley, 2005) [13, 14]. Being the major staple, wheat contributes more than two-thirds of Fe and almost one-third of calcium required by adult in low socio-economic groups of the population in northern India (Nitika *et al.* 2008).

Therefore, the composition and nutritional quality of what grain has significant impact of human health and well-being, especially in the developing world.

The field experiment was conducted in Rabi season of 2018-2019 on research plot of UdaiPratap (Autonomous) College, Varanasi (U.P.) adjoining the Department of Agricultural Chemistry and Soil Science. The different combination of foliar spray on Zn *viz.* T0 = Control (RDF, Recommended dose of fertilizer), T1 = RDF + Zinc Sulphate @25 kg ha-1, T2= RDF + Zinc Sulphate @50 kg ha-1, T3= RDF+ T1 + 3 (FS, Foliar spray) @ 0.5% ZnSO4 at (PF- Pre Flowering stage, HS- Heading stage and MS- Milking stage), T4 = T2 + 2 FS @ 0.5% ZnSO4 PF and DS and T5= RDF + Zinc Sulphate@75kg ha-1 + F S @ 0.5% at HS. The soils of Varanasi formed on alluvial, deposited by river Ganga have predominance of illite, quartz and feldspars.

Illite minerals are partly inherited from micas which are predominant in the sand and silt fractions. The experiment was conducted under randomized block design (RBD) with six treatment combinations. Treatments were replicated thrice making the total number of 18 plots. The various data are recorded on after the foliar application of Zn on different growth stages and dry matter content *viz.* Plant height (cm), Plant tillers, Grain yield (gm) and Straw yield (gm).

Results and Discussion

Zinc is one of essential plant micronutrients and its importance for crop productivity is similar to that of major nutrients. Intensive agriculture coupled with the continuous use of N, P, K fertilizers has remarkably increased the production but simultaneously brought about problems related to micronutrient deficiencies, particularly that of Zn in soil.

A clear difference was observed in all the parameters studied during the different treatments of Zn on different growth stages and dry matter content *viz.* Plant height (cm), Plant tillers, Grain yield (gm) and Straw yield (gm).

Table 1: Effect of treatments on plant height at various stages of crop growth

Treatment	Plant height (cm)			
	30DAS	60DAS	90DAS	120DAS
T0	22.83	47.66	70.5	71
T1	24.08	50.08	71.33	71.76
T2	24.25	50.16	72.91	73.08
T3	24.50	52	73	73.25
T4	24.75	53.58	74.25	75.33
T5	24.58	52.33	73.16	73.58
S.Em±	0.2282	0.6367	0.2875	0.3114
CD (P=0.05)	0.5084	1.4185	0.6405	0.6937

DAS – Day after sowing

Observation on plant height as affected by different treatments was recorded at 30, 60, 90 and 120 days after sowing (DAS).

A perusal of data revealed that the plant height at 30 DAS under various treatments ranged from 22.83 to 24.75 cm. Application of various levels of zinc in the form of soil applied and foliar spray showed significant superiority over T0 (without Zn). Treatment T4 recorded maximum plant height at this stage and was found to be significant over T0, and T1 treatment.

The data presented in table 2 indicates that plant height at 120 DAS under various treatments ranged from 71 to 75.33 cm. soil applied zinc alone and combined with foliar spray significantly increased the plant height when compared with without zinc application. Minimum plant height was recorded with T0 whereas maximum with T4. Treatment T4 was found to be significantly superior over all the treatments.

Table 2: Effect of different treatments on number of tillers at various stages of crop growth

Treatment	Number of tillers per plant			
	30DAS	60DAS	90DAS	120DAS
T0	2	3.08	3.25	3.33
T1	2.16	3.16	3.58	3.66
T2	2.25	3.25	3.66	3.75
T3	2.41	3.41	3.83	3.91
T4	2.58	3.96	4.91	5.50
T5	2.50	3.58	4	4
S.Em±	0.1137	0.1278	0.2252	0.2604
CD (P=0.05)	0.2533	0.2847	0.5017	0.5801

DAS – Day after sowing

Observations regarding number of tillers per plant at 30, 60, 90 and 120 DAS have been presented in table 2.

It is evident from the table that under various treatments number of tillers ranged from 2 to 2.58 at 30 DAS. Results indicated that application of zinc in the form of soil application and with foliar spray significantly increased the number of tillers as compared to control (T0) where zinc was not applied. Maximum increase was recorded with treatment T4.

Results presented above clearly indicates that application of Zn (soil applied alone and in combination of foliar spray at different growth stages) significantly increased the growth parameters *viz*; plant height and number of tillers. Singh (2012) [11], Parmar *et al*. (2016) [8] calcium required by adult in low socio-economic groups of the population in northern India (Nitika and Balail (2017) reported significant increase in growth parameters in various crops due to application of zinc in general and foliar application in particular. Maximum increase was recorded in case of T4. This enhancement in plant growth due to zinc application in booting stage indicates the importance of zinc in nitrogen and phosphorus utilization by plants. Zn recovery was considerably higher with soil + foliar application compared to soil application only.

This could be due to Zn application in soil enhanced Zn concentration in the plant which is associated with RNA and ribosome induction result which in turn might have accelerated in protein synthesis. Similar results are quoted by Sonune *et al*. (2001) [12] who reported increased conversion of N to protein compound and build - up of free amino acids and amides in the plant with Zn application.

Table 3: Effect of treatments on dry matter (straw and grain) yield

Treatment	Grain (q ha-1)	Straw (q ha-1)
T0	27.08	31.66
T1	27.11	40.83
T2	30.75	43.33
T3	30.80	44.16
T4	32.50	46.66
T5	30.83	45.83
S.Em±	0.8876	1.5138
CD (P=0.05)	1.9775	3.7227

Dry matter yield

Grain yield

The results obtained in respect of the effect of zinc application on grain yield of wheat are shown in table 3.

It is evident from the table 6 and figure 4 that the grain yield varied from 27.08 to 32.50 q ha-1. Maximum yield of grain (32.50 q ha-1) obtained with the treatment T4. However significantly poor grain yield has been obtained with the treatment T0. The effect of various treatments on grain yield was found in the order of T4>T5>T3>T2>T1>T0 and respective values were 32.50, 30.83, 30.80, 30.75, 27.11, 27.08 q ha-1.T4 was found to be significantly superior over T1 and T0 treatments.

Straw yield

Data depicted in table 3 revealed that effect of different treatments on straw yield were found in the order of T4>T5>T3>T2>T1>T0 and the values were 46.66, 45.83, 44.16, 43.33, 40.83, 31.66 q ha-1 respectively. Results clearly indicated that soil alone and with foliar applied zinc at different stages of crop growth significantly and positively affected the straw yield. Maximum yield was recorded with T4 when zinc was applied at pre flowering stage and milking stages @0.5% foliar spray along with soil application. This might be due to involvement of Zn in physiological processes such as enzymes activation involved in sucrose, membrane integrity, chlorophyll formation, stomata regulation and starch utilization, while enhanced accumulation of assimilate in grain which results in heavier grains.

Maralian (2009) [5] showed that foliar application of Zn increased grain yield of wheat. Cakmak (2008) [4] reported the highest increase in grain yield with soil and soil +foliar application of Zn.

Haslett *et al.* (2001) also reported an increase in biomass by Zn application in soil without or with foliar sprays in wheat. Soleymani and Shahrajabian (2012) noticed foliar application of Zn increased of leaves and stem dry yield of sorghum.

Conclusion

It can be concluded from the present study that adequate Zn availability during vegetative phase is important for good wheat growth and yields. Wheat favorably responded to soil applied Zn in different combination of dose. Application of Zn @50 kg ha-1 and two foliar spray @ 0.5% ZnSO4 at PF and DS stages in combination was found to be the best treatment regarding growth and yield of wheat.

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