Research Article

Quality and yield of wheat crop as affected by different zinc application methods and levels

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Abstract

A field trial was performed at new developmental farm, The University of Agriculture Peshawar during winter 2012 to assess quality and yield of wheat crop as affected by different zinc application methods i.e foliar, soil and priming with Zn. In priming wheat (serin-2010) seeds were soaked in 1 and 5 % Zn solution for 16 hours prepared from ZnSO₄. In case of foliar application 2.5 and 5 kg ha⁻¹ of ZnSO₄.7H₂O were used whereas in case of soil application, 5 and 10 kg ha⁻¹ of Zn as ZnSO₄.7H₂O was surface applied before sowing wheat crop. The NP and K were also used as a basal dose @ of 120:90:60 kg ha⁻¹ respectively. The result showed that biological yield, grain yield, soil extractable Zn, uptake of phosphorous and Zn were significantly enhanced when Zn was applied as foliar spray @ of 2.5kg ha⁻¹ followed by 5kg ha⁻¹ as compared to soil application and control treatments. Similarly, foliar application of Zn @ of 2.5 kg ha⁻¹ resulted in maximum, biological yield (7516.7 kg ha⁻¹), grain yield (4490 kg ha⁻¹), soil extractable Zn (1.003 mg kg⁻¹), phosphorous in leaf tissue (451.36 mg kg⁻¹) and Zn in leaf tissue (T6= 46.63 mg kg⁻¹) followed by Zn application @ of 5 kg ha⁻¹. Soil application and control treatments resulted minimum biological yield, grain yield, soil extractable Zn, uptake of phosphorous and Zn. From these results it was concluded that quality and yield of wheat crop were significantly enhanced when zinc was applied as a foliar spray @ of 2.5 kg ha⁻¹ as compared to other methods. Foliar spray at @ of 2.5 kg ha⁻¹ is recommended in zinc deficient soils to get better quality and yield of wheat crop.

Keywords: Wheat; ZnSO₄.7H₂O; Biological yield; Grain yield

Introduction

Wheat (*Triticum aestivum* L.) is the most important crop among cereal belongs to

family Poaceae and is considered as a staple food of Pakistan and at world level. It is also one of the major sources of protein and

carbohydrates both for human beings and animals. It is grown in Pakistan on an area of 9062 thousand hectares. 23.4 million tons is its total production with a 2585 kg ha⁻¹ average yield [1]. Due to unsuitable row spacing and seed rate its yield is low in Pakistan. These two factors are the most important management factors which are affecting wheat agronomic characteristics [2-4]. In Khyber Pakhtunkhwa, its average yield is 1565 kg ha⁻¹ and is sown on area of 769.5 hectare with a total production of 1204.5 tons [5]. Zinc is one of the crucial and important elements which are needed in small amount for the growth of plant. Plant absorbs it in divalent form (Zn²⁺). Various metabolic functions such as Hydrogenase, auxin metabolism, cytochrome Synthesis, and the ribosomal fraction stabilization are stimulated by this element (Tisdale *et al.*, [6]. Plant life processes that is photosynthesis, Synthesis of chlorophyll, metabolism of nitrogen and its uptake is affected greatly by this element. Its deficiency reduces contents of proteins and its synthesis [7].

Zinc deficiency exhibits, necrosis, poor growth and interveinal chlorosis of lower leaves. Due to its deficiency reddish or brownish spot often occurs on the lower leaves which reduce the seed production [8]. Its deficiency is also common where wheat is grown on calcareous soils. As a result of this a large population of the world lacks its adequate nutrition Maqsood *et al.* [9]. A national survey revealed that in Pakistan its deficiency in 37% of children's and 41% in mothers [10]. Foliar application on wheat crop with different micronutrients is better than the application of soil and it is effectively used to overcome the deficiency in subsoil [11, 12].

Objectives of this study is to:

Assess the effect of Zn on wheat yield and its uptake under alkaline calcareous soil.

To evaluate different application methods viz soil, foliar and soaking of seeds in Zn solution under the given soil and climatic condition.

To investigate proper doses of Zn for the given application methods

Methods and materials

The experiment was conducted at new developmental farm of Khyber Pakhtunkhwa University of agriculture Peshawar, during winter 2012. Before the start of trial a composite soil sample was taken from the experimental site and analyzed for various physico-chemical characteristic besides the concentration of Zn and phosphorous which were 0.896 mg kg⁻¹ and 10.38 mg kg⁻¹ in composite soil sample. Three Zn application methods including seed priming, foliar and soil were used in the experiment. In the seed priming techniques, seeds were soaked in the desired Zn solution (1 or 5 % solution) for 16 hours and then dried back to original moisture level through sun drying. In foliar spray (2.5 Kg ha⁻¹ and 5Kg ha⁻¹ of ZnSO₄.7H₂O), the plots were first sprayed just with water to know the amount of solution to be needed to cover the entire plot. After knowing the amount of water, the required concentrations were prepared and sprayed in morning. In case of soil application, the required amount (5 and 10 kg ha⁻¹ of ZnSO₄) was mixed with soil and then uniformly broadcasted in the treatment plots allocated to soil application. Plot size was 4m x 3m. Sowing was done on flat beds in rows spaced 30 cm. First irrigation was given few days after sowing while the subsequent irrigation was adjusted according to the need of the crop and avoiding the over irrigation strictly. All the other agronomic practices were kept normal and uniform for all the treatments. The basal dose of fertilizer i.e. half of N and full dose of P and K (60, 90 and 60 kg respectively) were applied at the

time of sowing while remaining half of N was applied at knee high stage.

Data was recorded on the following parameters:

AB-DTPA extractable Zn

Zn (a micronutrient) was extracted in AB-DTPA solution as explained by Soltanpur and Schawab [13]. Zn concentration was

calculated by atomic absorption spectrophotometer (perkin elmer 2138) using cathode lamp of respective element and acetylene gas. The machine was calibrated with standard of the respective element before analysis of said element in AB-DTPA soil solution (Table 1).

Table 1. Methods of zinc application and its rates

Treatments	Methods	Zn levels
T1	Control (dry seeds)	0
T2	Control (water soaked)	0
T3	Control (water spray)	0
T4	Seeds priming with Zn	1%
T5	Seeds priming with Zn	5%
T6	Foliar Zn	2.5Kg ha ⁻¹
T7	Foliar Zn	5Kg ha ⁻¹
T8	Soil Zn	5 kg ha ⁻¹
T9	Soil Zn	10 kg ha ⁻¹

Zn concentration in leaf tissue

0.5 g oven dry and fully ground leaf sample was taken into 150 ml conical flask and added to it 15 ml of concentrated hydrochloric acid (HCL) and left over night. 5 ml of HClO₄ (per chloric acid) along with two ml of concentrated sulphuric acid (H₂SO₄) were added to it. Heated it till it was digested, which was proved due to its fumes layering in the given beaker. Heat was given continuously till the disappearance of fume and the liquid became clear. The liquid was cooled and added to it about fifty ml of distill water and filtered it with Watman filter paper-42. The filtrate was collected in 100 ml volumetric flask and made its volume with distil water [14]. Zn was determined after wet digestion by atomic absorption spectrophotometer (perkin Elmer 2138) using cathode lamp of respective element and acetylene gas. The machine was calibrated with standard of the respective element before analysis of said element in AB-DTPA soil solution.

Phosphorous concentration in leaf tissue

0.5 g oven dry and fully ground leaf sample was taken into 150 ml conical flask and added to it 15 ml of concentrated hydrochloric acid (HCL) and left over night. 5 ml of HClO₄ (per chloric acid) along with two ml of concentrated sulphuric acid (H₂SO₄) were added to it. Heated it till it digested which is proved due to its fumes layering in the given beaker. Heat was given continuously till the disappearance of fume and the liquid became clear. The liquid was cooled and added to it about fifty ml of distill water and filtered it with Watman filter paper-42. The filtrate was collected in 100 ml volumetric flask and made its volume with distil water [14]. To measure phosphorous 1 ml sample was taken in 25 ml of volumetric flask and added to it four ml ascorbic acid mix reagent and diluted it up to the mark. Reading was taken when bluish color was produced.

Biological yield (kg ha⁻¹)

Biological yield was determined by harvesting two central rows in each sub plot

and then sun dried, weighed and changes into kg ha^{-1} by formula.

$$\text{Biological yield (kg/ha)} = \frac{\text{Dry weight mass (Kg)} \times 10000}{(\text{No of rows})(\text{RxR distance})(\text{Row length})}$$

Grain yield (kg ha^{-1})

By threshing the dried harvested materials of biological yield grain yield was determined. To note the grain yield in each treatment the seeds were cleaned after threshing and after that it is changed (kg ha^{-1}) by using the given formula as under

$$\text{Grain yield (kg/ha)} = \frac{\text{Grain yield (Kg)} \times 10000}{(\text{No of rows})(\text{RxR distance})(\text{Row length})}$$

Results and discussion

The result obtained on soil extractable Zn is given in Table 2. The result showed that there were significant variations among the means of all treatments. The extractable Zn content ranged from 0.613 to 1.003 mg kg^{-1} . Maximum value of soil extractable Zn was recorded in T6 (1.003) followed by T7 (0.94) and T9 (0.87) respectively. Similarly, minimum value of soil extractable Zn was recorded in T2 (0.613). Zn was deficient throughout all treatments as indicated in the Table 2. The deficiency of Zn might be due to high level of phosphorus or soil pH and hence its uptake was reduced. Thus our result were somehow in line with those of Salimpour *et al.* [15], Khorgamy and Farnis, [16], Das *et al.* [17], Marschner *et al.* [18], Sharma *et al.* [19] they observed similar result that accumulation of phosphorus in excess amount cause Zn deficiency. Similarly the result obtained on Zn in wheat leaves are given in Table 2. The result showed that there were significant variations when different treatments were applied. Zn in wheat leaves ranged from 30.96 to 46.6. Maximum Zn uptake was recorded in (T6) which was 46.63 followed by T7, T4 and T5 (respectively). Similarly minimum Zn uptake was recorded in (T1) which was 30.96. Data on Zn uptake clearly indicated that as the concentration of phosphorous increased in the soil, uptake of plant Zn decreased. It showed an antagonistic interaction between

Zn and phosphorous. Webb and Loneagan, [20], Marschner *et al.* [18], Hu *et al.* [21] and Bukvič *et al.* [22] observed similar result that uptake of phosphorous, its concentration and transportation increased in shoot and leaves due to the absence or low concentration of Zn which in plant lead to accumulation of toxin. Higher phosphorous concentration will lead only with Zn deficiency and not with micronutrient deficiencies. Similarly minimum uptake of Zn by wheat crop might also be due low level of organic matter or high level of lime contents in the soil. Katyal and Randhawa [23] observed similar result that simple organic compounds like hydroxy acids, phosphoric acids and also amino acids increase the mobility and solubility of Zn in soils while making complexes with Zn. Zn availability will increase with the increase of soil organic matter contents. Too high contents of organic matter in soils like peat and muck cause Zn deficiency due to the Zn binding on the solid state of humic substances. Shukla and Moris in [24] and [25] also observed similar result that in limed soils Zn movement was lower than acidic soils and thus the crop absorbed little amount of Zn. Zn uptake and its deficiency were due to the high amount of lime contents.

The result of phosphorous in wheat leaves showed that there were significant variations when different treatments were applied (Table 2). Phosphorus ranged from 233 to 451.36 mg kg^{-1} . Maximum phosphorus uptake was recorded in (T6) which was 451.36 followed by T8 and T7 respectively. Similarly minimum value of phosphorous was recorded in (T5) which was 233 (Table 2). Data on phosphorous uptake clearly indicated that as the Zn concentration decreased in the soil phosphorous uptake in plant increased. It means that there was antagonistic interaction between Zn and phosphorous. Webb and Loneagan, [20],

Marschner *et al.* [18], Hu *et al.* [21] and Bukvicl *et al.* [22] observed similar result that phosphorous uptake, its concentration and transportation increases in shoot and leaves due to the absence or low concentration of Zn which in plant lead to accumulation of toxin. Higher phosphorous concentration will lead only with Zn deficiency and not with micronutrient deficiencies. It means that as compared to phosphorous, permeability of cell membrane in root increased due to the increase of Zn deficiency.

The result of biological yield showed that there were significant variations when different treatments were applied (Table 2). Biological yield ranged from 2662.3 to 7516.7 kg ha⁻¹. Minimum value of biological yield was recorded in (T₁) control) which was 2662.3 kg ha⁻¹, while the maximum biological yield was recorded in T₆ 7516.7 kg ha⁻¹ (Zn foliar application) followed by T₇ (6746 kg ha⁻¹) as shown in Table 2. Rajput *et*

al. [26] also observed similar result that biological yield was increased with the foliar application of Zn, N and K. The superiority of Zn application as a foliar spray over other treatments may due to its full and efficient utilization whereas soil application may encounter soil fixation.

The result of grain yield showed that there were significant variations among the means of different treatments. It ranged from 1662.3 to 2512.7 kg ha⁻¹. Grain yield showed significant increase when Zn was applied as foliar spray. The maximum grain yield was recorded in T₆ (2512.7 kg ha⁻¹) and T₇ (6175 kg ha⁻¹) followed by T₅ (2321.7 kg ha⁻¹) and T₄ (5677.5 kg ha⁻¹), while minimum grain yield (1662.3 kg ha⁻¹) was recorded in T₁ (control) and T₂ (1700 kg ha⁻¹) as shown in Table 2. Tourn *et al.* [27], Zorita *et al.* [28] and Grewal *et al.* [29] also observed similar result and found higher grain yield with Zn foliar application.

Table 2. ABDTPA extractable zinc, Zinc (Zn) and Phosphorous (P) in leaf tissues, biological yield (B.Y) and grain yield (G.Y) as affected by different zinc application methods in wheat crop

Treatments	ABDTPA Ext Zn (mg Kg ⁻¹)	Zn in leaf tissues (mg Kg ⁻¹)	P in leaf Tissues (mg Kg ⁻¹)	B.Y (Kg ha ⁻¹)	G.Y (Kg ha ⁻¹)
T ₁	0.713 cde	30.96 d	299.10 bcd	2662.3 f	1730 f
T ₂	0.613 e	31.58 cd	279.87 cde	2700 f	1786.7 f
T ₃	0.75 cde	32.03 cd	298.61 bcd	2763.3 f	1836.7 f
T ₄	0.80 bcd	39.3 b	259 de	4216.7 e	3678.3 e
T ₅	0.64 de	38.31b	233 e	4321.7 e	3833.3 de
T ₆	1.003 a	46.63 a	451.36 a	7516.7 a	4490 a
T ₇	0.94 ab	41.5 ab	387.80 bc	6746 b	4158.3 b
T ₈	0.71 cde	36.3 bcd	347.88	6200 c	4023.7 bc
T ₉	0.87 abc	36.75 bc	261.30 de	5893.3 c	3943.3 cd
LSD	0.164	5.76	62.79	258.5	189.77

Means followed by similar letters are not significantly different at P ≤ 0.05

Conclusion and recommendation

From these results it was concluded that quality and yield of wheat crop were significantly enhanced when zinc was supplied as a foliar spray at the lower rate of

2.5 kg ha⁻¹ as compared to other methods. Foliar spray at the rate of 2.5 kg ha⁻¹ is recommended in zinc deficient soils to get better quality and yield of wheat crop.

Authors' contributions

Conceived and designed the experiments: L Zada & MJ Khan, Performed the Experiments: Rafiullah & HU Rahim, Analyzed the Data: M Ali & Samiullah, Contributed reagents/ materials/ analysis tools: IM Ahmad & N Khan, Wrote the paper: S Ahmad & Z Khan.

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