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EFFECTS OF FOLIAR APPLICATION OF ZINC ON YIELD AND YIELD RELATED TRAITS IN WHEAT (*TRITICUM AESTIVUMM* L.)

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Abstract

Grain per spike, biological yield, days to seed emergence, days to anthesis, 1000-grain weight and grain yield were significantly enhanced when Zn was supplied as a foliar application at the rate of 2.5 kg/ha followed by 5 kg/ha as compared to soil application and control treatments. Water soaking of wheat seeds resulted early emergence (7 days) and early flowering (109 days) compared to seed soaked in Zn solutions. Similarly, foliar application of Zn at the rate of 2.5 kg/ha resulted maximum plant height (96.33 cm), grain per spike (47), biological yield (7516.7 kg/ha), grain yield (4490 kg/ha) and 1000 grain weight (110 g) followed by Zn application at the rate of 5 kg/ha. Soil application and control treatments showed minimum plant height, grain per spike, biological yield, 1000-grain weight and grain yield. The priming (water soaking) of wheat seeds before sowing had a significant effects on early emergence and early maturity of wheat crop. Whereas foliar application at lower rate was beneficial compared to higher (5 kg/ha) application. The comparatively lower efficiency of soil application on yield and yield related parameters was due to its low availability or soil fixation. Lower foliar application at the rate applied in alkaline calcareous soils (chalky or containing $CaCO_3$) results in high yield of wheat crop.

Wheat (*Triticum aestivum* L.) is the most important major cereal crop which belongs to family Poaceae and it is the major staple food of Pakistan and at world level. It is also one of the essential and fundamental sources of protein and carbohydrates for human beings and animals. In Pakistan during 2009 it was grown on an area of 9062 thousand hectares with total grain production of 23.4 million tons and average yield of 2585 kg ha^{-1} (FBS 2009). Zinc is one of the important and significant element which is needed in small amount for plant growth. Mostly plants absorb zinc as Zn^{2+}. Various metabolic functions such as hydrogenase, auxin metabolism, cytochrome synthesis, and the ribosomal fraction stabilization are stimulated by zinc (Tisdale *et al*. 1984). 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 (Throne 1957). 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 (Maralin 2009, Pahlavan and Pessarakli 2009).

This experiment was conducted at New Developmental Farm, The University of Agriculture Peshawar, Pakistan during 2012. Before the initiation of experiment a composite soil sample was taken from the experimental site and analyzed for various physico-chemical characteristics besides the concentration of Zn and phosphorous which were 0.896 mg/kg and 10.38 mg/kg in composite soil sample. Three Zn application methods including seed priming, foliar and soil application were used in the experiment. In seed priming techniques, seeds were soaked in the desired Zn solution (1 or 5% solution) for 16 hrs and then dried back to its original moisture level through sun drying. In foliar spray (2.5 kg/ha and 5 kg/ha of $ZnSO_4.7H_2O$), 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

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required concentrations were prepared and sprayed in morning. In case of soil application the required amount (5 and 10 kg/ha of $ZnSO_4$) was mixed with soil and then uniformly broadcasted in the treatment plots allocated to soil application. Nine treatments (genotypes) were cultivated in randomized complete block design with 3 replications (Table 1). Experiment was laid out in randomized complete block design with three replications. Plot size was kept to be 4 m × 3 m with rows space of 30 cm and sowing was carried out on flat beds. First irrigation was given a few days after sowing, while the subsequent irrigations were applied according to the need of the crop by avoiding of over irrigation strictly. All the other agronomic practices were kept normal and uniform for all the treatments. The essential doses of fertilizer i.e. half dose (60 kg) of Nitrogen (N) and full dose (90 and 60 kg) of phosphorous (P) and potassium (K) were applied at sowing time while remaining half of nitrogen at knee stage, respectively. Data were recorded on days to emergence, days to anthesis, plant height, grain per spike, biological yield, grain yield and 1000 grain weight in each plot. According to simple RCB design the data were statistically analyzed by using statistic software. Upon obtaining significant F-value (LSD) least significant differences test was applied (Steel and Torrie 1984).

Table 1. Nine treatments were applied as below.

Treatments	Methods	Zn levels
T_1	Control (dry seeds)	0
T_2	Control (water soaked)	0
T_3	Control (water spray)	0
T_4	Seeds priming with Zn	1%
T_5	Seeds priming with Zn	5%
T_6	Foliar Zn	2.5 kg/ha
T_7	Foliar Zn	5 "
T_8	Soil Zn	5 "
T_9	Soil Zn	10 "

The result showed significant variations for days to emergence when different treatments were applied. Days to emergence ranged from 7 to 14. Minimum 7 days to emergence were observed in (T_2) water soaked, while maximum 14 days of emergence were observed in control (T_1) followed by T_3 (water spray) and T_8 (Table 2). It is evident from the results that seed priming had significant effect on germination and emergence. The highest germination rate was observed in seeds soaked in water (T_2) followed by priming with 1 and 5% of $ZnSO_4.7H_2O$ (T_4 and T_5). Harris *et al.* (2001) have reported similar results that wheat seed soaked in tap water overnight resulted in earlier emergence, deeper roots, earlier flowering and maturity, and higher yield when wheat seed were soaked in tap water overnight. The result obtained on days to anthesis is given in Table 2. Significant variations were observed for days to anthesis among the different treatments. Days to anthesis varied from 109 to 115. Minimum 109 days to anthesis were observed in (T_2) water soaked while the maximum days (115) were noted in T_3 (water spray), T_7 and T_8 (foliar application) followed by $T_{6,}$ T_4 and T_5 (Zn priming), respectively. Harris *et al.* (2001) have also observed comparable results that wheat seed soaked in tap water overnight resulted in earlier emergence, deeper roots, earlier flowering and maturity and higher yield. The results obtained on plant height are influenced by different levels of Zn treatments and method of applications given in Table 2. The result showed that there were similar to other yield parameters, when different Zn levels and method of applications were employed. Plant height ranged from 66.33 to 96.33 cm. Taller plants were found in T_6 (96.33 cm) whereas shorter plants were noted in control T_1

treatment (66.33 cm). Results obtained with regard to plant height in T_7 was statistically comparable to T_8. Similarly, T_1 and T_3 produced identical plant height. Statistically non-significant variations ($p > 0.05$) were reported for plant height. The result obtained on grain per spike is given in Table 2. Statistical analysis of the data showed significant differences among the means of all treatments and maximum number of grains/spike were significantly increased by foliar application of Zn. The grain per spike ranged from 36 to 47 g. The highest number of grain per spike was produced in T_6 and T_7 (43), T_9 (43) and the results of both Zn level applied as foliar spray were comparable statistically followed by T_8 (41) supplied as soil application. The minimum number of grains/spike were produced in T_3 (33) water spray and T_2 (31) water soaking treatment. Similar results have been reported by Soleimani (2006) for higher grains/spike when Zn was applied as Zn foliar spray. This may be due to better utilization of Zn in soil application there is likelihood of soil Zn fixation as the soil under investigation was calcareous with alkaline pH. The result recorded on biological yield is given in Table 2. Significant variations were observed among the different treatments. Biological yield ranged from 2662.3 to 7516.7 kg/ha. Minimum value of 2662.3 kg/ha of biological yield was recorded in (T_1) control) while in T_6 maximum biological

Table 2. Effect of different Zn application methods on yield and yield contributing parameters days to emergence (DE), days to anthesis (DA), plant height (PH), grain per spike (GS), biological yield BY), grain yield (GY) and 1000-grain weight (GW) of wheat.

Treatments	DE	DA	PH (cm)	GS (g)	BY (kg/h)	GY (kg/h)	1000-GW (g)
T_1	14 a	112 c	66.33 e	36 def	2662.3 f	1730 f	53.33 c
T_2	7 d	109 d	70.33 d	34 ef	2700 f	1786.7 f	57.67 c
T_3	14 a	115 a	67.33 e	33 f	2763.3 f	1836.7 f	49 c
T_4	11 bc	112 c	91.33 c	37 cdef	4216.7 e	3678.3 e	93.33 ab
T_5	11 bc	113 bc	93.7 b	40 bcde	4321.7 e	3833.3 de	80.67 b
T_6	13 ab	114 ab	96.33 a	47a	7516.7a	4490 a	110 a
T_7	13 ab	115 a	94.96 ab	43ab	6746 b	4158.3 b	106.67 a
T_8	14 a	115 a	93.60 b	41 abcd	6200 c	4023.7 bc	100 a
T_9	13 a	111 c	94.5 ab	43 abc	5893.3	3943.3 cd	93.33 ab
LSD	1.394	1.485	2.245	6	258.55	189.77	17.014

Means followed by similar letters are not significantly different at $p \leq 0.05\%$ level.

yield was recorded of 7516.7 kg/ha (Zn foliar application) followed by T_7 (6746 kg/ha). Rajpur *et al*. (1995) also observe similar result that biological yield was increased with the foliar application of Zn, N and K. The superiority of Zn application as foliar spray over other treatments may be due to its full and efficient utilization whereas soil application may encounter soil fixation. The results obtained on grain yield kg ha^{-1} as influenced by different methods and levels of Zn applications are presented in Table 2. Grain yield ranged from 1662.3 - 2512.7 kg/ha. Grain yield showed significant increase when Zn was applied as foliar spray. The maximum grain yield was recorded in T_6 (2512.7 kg/ha) and T_7 (6175 kg/ha) followed by T_5 (2321.7 kg/ha) and T_4 (5677.5 kg/ha), while minimum grain yield (1662.3 kg/ha) was recorded in T_1 (control) and T_2 (1700 kg/ha). Tourn *et al*. (2001), Zorita *et al*. (2001) and Grewal *et al*. (1997) also observed similar result and found higher grain yield with Zn foliar application. The results obtained on 1000-grain weights are given in Table 2. The result showed significant variation among the means of all treatments. Data on 1000-grain yield ranged from 49 to 110 g. For Zn foliar application 1000-

grain yields showed significance increase. Maximum grain was recorded in T_6 (110 g) and T_7 (106.67 g) followed by T_8 (100 g) while minimum grain yield (49 g) was recorded in T_3 (control water spray). Kenbaev and Sade (2002) and Hosseini (2006) also observed similar result and found heavier grain in treatments receiving Zn as foliar spray.

On the basis of our results we conclude that these morphological, yield and yield related parameters showed positive and significant response to zinc foliar spray when it was applied at the amount of 2.5 kg/ha. This quantity is the most appropriate to apply in alkaline calcareous soils to get better wheat crop yield, to eliminate food security problems.

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