DOI: 10.2478/cerce-2018-0002
Available online: www.uaiasi.ro/CERCET_AGROMOLD/
Print ISSN 0379-5837; Electronic ISSN 2067-1865

Original Article

Cercetări Agronomice în Moldova
Vol. LI , No. 1 (173) / 2018: 29-36

IMPACT OF ZINC UPTAKE ON MORPHOLOGY, PHYSIOLOGY AND YIELD ATTRIBUTES OF WHEAT IN PAKISTAN

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Received Sep. 21, 2017. Revised: Jan. 29, 2018. Accepted: Feb. 21, 2018. Published online: Mar. 30, 2018

ABSTRACT. A pot experiment was conducted in the Old Botanical Garden, University of Agriculture Faisalabad, to assess the effect of zinc uptake on morphological, physiological and yield attributes of wheat (*Triticum aestivum* L.). Two varieties of wheat, *i.e.* W-141 and W-142, procured from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan, were used during this study. The soil used during experiment was field soil from university fields having sandy loam texture. The experiment was laid out in a completely randomized design (CRD) with five treatments and four replicates. Different treatments of zinc were applied on different intervals. After 25 and 35 days of germination, the plants were subjected to three levels of $ZnSO_4$ (0, 400 mgL^{-1}, 600 mgL^{-1}). During the experiment, the harvests were taken after 10 days of intervals for morphological and physiological analysis. After the maturity of plants, final harvest was taken and yield attributes were recorded. Data of various morphological, physiological and yield attributes were statistically analyzed. The results showed that zinc toxicity had adverse effects on the wheat varieties. The variety W-141 was a little bit tolerant to zinc toxicity, as per shown by the results, as compared to W-142, which suffered by the toxicity of zinc. It was also revealed by the results that zinc affects the morphological, physiological and yield attributes of wheat when applied in toxic concentration.

Keywords: foliar applied; toxicity; harvests; adverse effects.

INTRODUCTION

Nutrient imbalance may hinder the normal metabolic functions of plants (Malewar, 2005; Zengin & Kirbag, 2007). Long term use of fertilizers, pesticides, waste material sludge, industrial effluent, like tanning and smelting outlets, contaminate the agricultural lands

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with heavy metals like Zn, Ni, Cd, Co, Cu, Pb and As (Bell *et al.,* 2001; Schwartz *et al.,* 2001; Passariello *et al.,* 2002).

The general symptoms of zinc toxicity on shoot and leaves are stunting, rolling, chlorosis and death of tips of leaves (Ye *et al.,* 1997). Due to zinc toxicity, the metabolic processes are repressed, the growth of plant is stunted, which results in senescence. The development of roots and shoots is also affected (Choi *et al.,* 1996; Ebbs & Kochain, 1997; Fontes & Cox, 1998). Zinc toxicity also gives rise to deficiency of other micronutrients, like Cu, Fe and Mn (Ebbs & Kochain, 1997). The chlorosis mainly occurring in shoots and leaves is due the deficiency of Fe (Marschner, 1986). Zinc generates ROS and it also moves proteins from its sites. Zinc toxicity causes discoloration of young leaves and it also decreases tissue water content. Due to zinc toxicity, phosphorous and megnesium levels changes in the plant tissue (Marschner, 1995). Elevated zinc levels inhibit the growth, but it does not affect seed germination and also helps in plumule and radical formation.

Zinc being a primary nutrient in plants, small amount of it is required for supporting the process of growth and quality of plant (Dang *et al.*1993). Zinc is also considered to be a limiting factor for the production of crops in many regions of the world (Mandal *et al.*, 2000). Zinc has the role in functional, structural and regulatory functions. It is also a component of major enzymes (Grotz & Guerinot, 2006), such as anhydrases, dehydrogenases, oxidases and peroxidases (Hewitt, 1983).

The functioning and activity of Zn in the enzymatic reactions is done by the geometry and binding properties of Zn^{+2} ligand. This ligand have three sites of binding structural, catalytic and cocatalytic (Auld, 2001; Maret, 2005). These Zn sites ensure exact protein folding by amino acid residues histidine, aspartic acid or glutamic acid. These sites are present in a wide range of proteins, membrane lipids and DNA/RNA molecules (Klug, 1999; Englbrecht *et al*., 2004).

The objectives of current study was to evaluate the effect of foliar spray of zinc on morphological, physiological and yield attributes of wheat (*Triticum aestivum* L.) W-141 and W-142, as both varieties were never evaluated for the optimized Zn concentration.

MATERIALS AND METHODS

An experiment was carried out to assess the effect of toxicity of zinc by using $ZnSO_4$ (0, 400 ppm, 600 ppm) on two wheat varieties (W-141 and W-142). Wheat were grown in small pot in the Old Botanical Garden of Agriculture University, Faisalabad. Pots were filled with soil in equal amount and 10 seeds were sown in each pot and laid down in a completely randomized design with five treatments and four replicates. The foliar spray of zinc sulphate solution were carried out after 25 and 35 days of germination using hand sprayer.

At maturity stage, the data was recorded for spike length, number of tillers, spike grain number, grain yield per plant and flag leaf area. The data was collected in intervals when harvests were taken. Number of tillers per plant were counted, number of grains per spike were counted and recorded, spike length was measured with the help of meter rod and was recorded. Length of each plant was recorded in centimeters, grain yield per plant per treatment was estimated by using analytical balance. Yield of each plant was taken in grams and flag leaf length and width was measured with the help of meter rod and was recorded. The area was calculated by multiplying the length and width. The area was recorded in centimeters square.

Analysis and data of variance of parameters was computed using the COSTAT v 6.303 (Cohort software, Monterey, California). Analysis of variance was carried out and means were compared using least significant difference.

RESULTS

The effect of Zn levels on physiological growth parameters were computed to evaluate the toxicity intensity associated with high concentrations of Zn.

Spike length (cm)

In the zinc concentrations, highest reduction was shown by T3 and T4, *i.e.* 14.6% and 15.62% reduction, respectively, as compared to control, while gradual reduction was seen in T1 and T2, *i.e.* 1.04% and 6.25%, respectively, as compared to control. A comparison between variety means indicated higher spike length reduction in W-142, as compared to W-141.

Table 1 - Statistical comparison of means of control and all concentrations of zinc on spike length

	T0	T1	T2	T3	T4	Variety means
W-141	12.5	11.75	10.25	9.5	9.25	11.55a
W-142	12.25	12.25	11.25	11.25	10.75	10.65b
Treatment means	12a	11.875a	11.25ab	10.25b	10.125b	
% Difference		1.04%	6.25%	14.6%	15.62%	

Number of grains/spike

In the zinc concentrations, highest reduction was shown by T2 and T3, *i.e.* 21.45% and 27.63% reduction, respectively, as compared to control. While gradual reduction was seen in T1, *i.e.* 1.82% respectively, as compared to control. A comparison among varieties means indicated that number of grains per spike reduced considerably in W-141, as compared to W-142 under different levels of zinc. The variety treatment interaction showed that different levels of zinc affected the both varieties.

Table 2 - Statistical comparison of means of control and all concentrations of zinc on grains/spike

	T0	T1	T2	T3	T4	Variety means
W-141	33.75	28	27	23.25	22	31.15a
W-142	39.5	35	27.75	27	26.5	26.8b
Treatment means	34.375a	33.75a	27b	24.875c	24.875c	
% Difference		1.82%	21.45%	27.63%	27.63%	

Number of tillers

In the zinc concentrations, highest reduction was shown by T3 and T4, *i.e.* 18.75% and 23.43% reduction, respectively, as compared to control. While gradual reduction was seen in T1 and T2, *i.e.* 10.94%, respectively, as compared to control. A comparison between variety means indicated higher number of tillers reduction in W-142, as compared to W-141.

Table 3 - Statistical comparison of means of control and all concentrations of zinc on number of tillers

	T0	T1	T2	T3	T4	Variety means
W-141	8.5	6.75	6.75	6.25	6	7.1
W-142	7.5	7.5	7.5	7	6	6.85
Treatment means	8a	7.125ab	7.125ab	6.5b	6.125b	
% Difference		10.94%	10.94%	18.75%	23.43%	

Grain yield per plant (g)

In the zinc concentrations, highest reduction was shown by T3 and T4, *i.e.* 19.18% and 39.46% reduction, respectively, as compared to control. While gradual reduction was seen in T1 and T2, *i.e.* 2.71% and 12.24%, respectively, as compared to control. A comparison among varieties means indicated that grain yield per plant reduced considerably in W-141, as compared to W-142 under different levels of zinc. The variety treatment interaction showed that different levels of zinc affected the both varieties.

Table 4 - Statistical comparison of means of control and all concentrations of zinc on grain yield/plant

	T0	T1	T2	T3	T4	Variety means
W-141	1.2475	1.155	1.0575	0.915	0.6675	1.115a
W-142	1.1275	1.2675	1.2425	1.0975	0.84	1.0085b
Treatment means	1.245a	1.21125b	1.0925c	1.00625d	0.75375e	
% Difference		2.71%	12.24%	19.18%	39.46%	

Flag leaf area (cm^2)

In the zinc concentrations, highest reduction was shown by T3 and T4, *i.e.* 45.25% and 46.96% reduction, respectively, as compared to control. While gradual reduction was seen in T1 and T2, *i.e.* 5.76% and 28.58%, respectively, as compared to control. A comparison between variety means indicated higher flag leaf area reduction in W-141, as compared to W-142.

Table 5 - Statistical comparison of means of control and all concentrations of zinc on flag leaf area

	T0	T1	T2	T3	T4	Variety means
W-141	16.125	15.125	11.8	8.475	8.125	12.045
W-142	15.975	15.125	11.125	9.1	8.9	11.93
Treatment means	16.05a	15.125a	11.4625b	8.7875c	8.5125c	
% Difference		5.76%	28.58%	45.25%	46.96%	

DISCUSSION

Zinc is primary nutrient in plants, small amount of it is required for supporting the process of growth and quality of plant (Dang *et al.*, 1993). The average range of Zn in the whole grain of wheat is about 20 to 35 mg/kg (Rengel *et al.*, 1999; Çakmak *et al.*, 2004; Silspour, 2007). The experimental studies shows that the foliar spray of zinc applied in high concentration is toxic to wheat. Regarding the number of grain/spike, the work done by Potarzycki & Grzebisz (2009) on maize and Keram *et al.* (2012) got the same results as the above experiment. The experiments done by Shaheen *et al.* (2007) and Singh *et al.* (2014) got the similar results regarding number of tillers. The work done by Broadley *et al.* (2006) and Tewari *et al.* (2008) showed the same results as given above regarding the flag leaf area. The results shown by morphological and physiological also show that zinc has adverse effects if applied in large quantities. Vaillant *et al.* (2005) and Kherbani *et al.* (2015) they reported the same results regarding the root length under the zinc stress. Vaillant *et al.* (2005) did his work on *Datura* and Kherbani *et al.* (2015) on barley, they both got the same results. The experiments done by Tewari *et al.* (2008) and Kherbani *et al.* (2015) showed similar results regarding the shoot length of wheat under zinc stress. Tewari *et al.* (2008) did work on mulberry species and got same results regarding shoot length. Kherbani *et al.* (2015) did his work on barley with same conclusions. The experiments done by Hermle *et al.* (2007) on *Salix viminalis* and Vaillant *et al.* (2005) on *Datura* species shows the similar results. The rate of transpiration is not effected, as shown by Azzarello *et al.* (2012) and

Sagardoy *et al.* (2008), as is stomatal conductance Miladinova *et al.* (2014) and Tewari *et al.* (2008) shown similar results.

Chlorophyll *a*, chlorophyll *b*, carotenoids, total chlorophyll and chlorophyll *a/b* ratio are not effected by zinc concentration, the result is in accordance with the experiments done by Vaillant *et al.* (2005), Tewari *et al.* (2008) and Sagardoy *et al.* (2008). When analysis of ions of root and shoot was done there was a significant decrease of calcium ions was seen, as per the study of Tlustoš *et al.* (2006) reported. There was a considerable reduction in sodium levels in root and shoot. Cayton *et al.* (1985) reported the same results. Shoot and root potassium levels were also reduced, as indicated by Potarzycki and Grzebisz (2009) in their experiments. Broadley *et al.* (2006) reported that root and shoot phosphorus are affected adversely, as zinc levels were increased; same results were seen in the experiment conducted.

CONCLUSION

From the above findings it can be concluded that high concentrations of Zn were proved to be toxic for both varieties, but W-141 was more susceptible towards toxic impacts of Zn, as compared with W-142. It's clear from results that Zn has significant effect on yields of both varieties the yield decreased considerably with increase in amount of zinc.

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