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SEED PRIMING WITH ZINC ION ON GROWTH PERFORMANCE AND NUTRIENT ACQUISITION OF MAIZE IN ARIDISOLS

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Abstract

Worldwide, maize is a common cereal crop and likewise in Pakistan. Zinc is essentially vital for optimum growth and development of crops. Deficiency of Zn is prevalent in Pakistan. In order to determine growth and yield response of maize as a result of seed priming with Zn, a field experiment was conducted under arid climatic conditions. Priming of maize seeds was done with Zn metal using different solutions. Total 7 treatments with 4 replications were applied using randomized complete block design (RCBD), T_1= untreated seeds with recommended dose of NPK (control), T_2= Priming with 1% solution of ZnSO4 + NPK, T_3= Priming with 2% solution of ZnSO4 + NPK, T_4= Priming with 3% solution of ZnSO4 + NPK, T_5= Priming with 0.5% solution of Zn-EDTA + NPK, T_6= Priming with 1.5% solution of Zn-EDTA + NPK, T_7= Priming with 3% solution of Zn-EDTA + NPK. Standard procedures were employed for recording observations regarding plant growth parameters. Statistical software statistics 8.1 was employed for analysis of compiled data and least significant difference was adopted for comparison of means. Priming of maize seeds with 4% of $ZnSO_4$ solution resulted in maximum plant growth and grain yield. However, maximum concentration of Zn was observed in grain where priming was done with Zn-EDTA solution. Mineral content of maize seeds significantly upgraded with priming of seeds with Zn containing solutions. Further, growth and yield parameters of maize were also improved significantly by this approach.

Key words: Maize, Nutrient, Priming, Growth, Yield, Zinc.

Introduction

Maize is a famous and widely adopted crop in the world. It produces more yields other than any grain crop. Many cultivars are available with various surface, hues and grain shape and size. White and yellow shades of maize crop are generally favored worldwide. In numerous nations, it is generally utilized as vegetable harvest (Ajouri *et al.*, 2004). Maize is gaining popularity in numerous nations, for example, in Pakistan, where tremendous expansion in population requires more food supplies are needed to fulfill the food utilization. Maize grains are nutritious having 5.6% oil, vitamin A, C and E, 70% starch, 12% protein, 4.0% sugar, 4.9% fiber and 2.6% ash (Alloway, 2004).

Yield of maize is largely determined by effective crop stand that mainly depends upon optimum availability of nutrients ((Finch-Savage & Bassel, 2016). Lopsidedness utilization of fertilizer significantly decreases the yield of maize. It is likewise seen that the maize crop needs optimum supply of NPK as well as micronutrients (extraordinarily the Zn) for good performance (Farooq *et al.*, 2012). It is archived by the various scientists that zinc insufficiency normally impacts both mankind and vegetation (Alloway, 2004). Among grains, deficiency of Zn is prevalent in countries like Pakistan due to native poor status of soils. This Zn poor diet ultimately leads to Zn deficiency and malnutrition in humans (Haris, 2006). Zn is essentially required for proper plant growth. Plants mainly take up divalent type of zinc (Zn^{2+}). Because of the calcareousness nature of our soils, widespread insufficiency of Zn is prevalent. Obstacles for Zn deficiency include aridity, calcareousness, high pH, saltiness and sodicity (Rafiq, 2010).

As Zn deficiency is becoming common, therefore, artificial supplementation of Zn is fundamental. Zinc has indispensable impact in the development and yield improvements in maize. The strategies which are being utilized are extremely customary for improving yields. Numerous new strategies have found, for example, foliar application, band situation and seed priming. All these strategies are well documented for good results in terms of increasing Zn content in crops and resultantly better growth, development and yield (Farooq *et al.*, 2012). Better germination of seedling is footstep for the better development and yields. Good germination ultimately determines the quality and quantity of yield. Water imbibition is key step for achieving good germination. Role of Zn is inevitable in this regard (Asghar *et al.*, 2010). For this reason, various procedures are employed to improve the germination and development of the plants including seed priming (Harris *et al.*, 2007; Dimpka & Bindraban, 2016).

Seed priming is famous and attainable strategy used to improve the seed development and advancement worldwide (Kumar *et al.*, 2020). It is exceptionally basic and compelling strategy for poor growers in developing countries (Haris, 2006). In this procedure, seed are immersed in the nutrient added solutions for a prescribed times and afterward dried back to spare the excessive dampness before planting (Farooq *et al.*, 2019). It is documented that contrasted with unprimed seeds, primed seeds showed better crop stand and ultimately yields. Immersing the seeds in water improves biochemical makeup in the seed that is demonstrated as fundamental for seed early development, for example, initiation of proteins, water take-up, satisfy the water prerequisite and so forth. Therefore, the primed seed shows improved seedling emergence (Imran *et al.*, 2013; Muhammad *et al.*, 2015).

Seed priming strategies are effective methods to accomplish the early seed germination. There are three stages in germination strategy: (I) water take-up, (ii) start of metabolic cycle and (iii) quick radical improvement and proficient development. In this technique, seed are immersed in water for a likely an ideal opportunity to finish first period of the germination. Other than improving germination rate, this technique additionally promotes quick development, early blossoming and higher yields of grain than seeds that are unprimed Almendros *et al*., (2013). Seed priming is a basically a pre-planting seed treatment strategy. In contrast to conventional dry seeds, such prepared seeds have more quality and ability to rise quickly and homogeneously exceptionally in the event of cruel natural conditions. Seed priming with various supplements have positive effect on seed germination and subsequent development (Ajouri *et al*., 2004).

This technique is gaining fame in Asia and likewise in Pakistan. Harris *et al*., (2001) and Harris *et al*., (2007) reported an improvement in maize yield (about 70%) by employment of this technique. Similarly, it has been documented by Sime & Aune (2019) that nutrient seed priming improved agronomic growth parameters and produce in maize. Thus, it can be concluded that a cost effective technique of micronutrient value addition to plants is nutrient seed priming. This technique also contributes to Zn fortification of human diet (Dimkpa & Bindraban, 2016). Additionally, better resistance to different kind of stresses can also be achieved by employing this technique.

Present study was executed in order to determine efficacy of maize seed subjected to priming with Zn solutions of varying concentrations on growth, yield and nutrient acquisition of maize.

Materials and Methods

Experimental site and design: In order to determine effectiveness of priming of maize seeds with Zn metal on growth and yield of hybrid maize, an experiment was carried out under arid field conditions at College of Agriculture, UOS in 2018. Soil was tested before and after experiment for different parameters of physical and chemical nature by adopting literature suggested procedures. Priming of maize seeds were done with different Zn solutions of various concentrations including T_1= untreated seeds with recommended dose of NPK (control), T_2= Priming with 1% solution of ZnSO4 + NPK, T_3= Priming with 2% solution of ZnSO4 + NPK, T_4= Priming with 3% solution of ZnSO4 + NPK, T_5= Priming with 0.5% solution of Zn-EDTA + NPK, T_6= Priming with 1.5% solution of Zn-EDTA + NPK, T_7= Priming with 3% solution of Zn-EDTA + NPK. Standard procedures were employed for recording observations regarding plant growth parameters. Statistical software statistics 8.1 was employed for analysis of compiled data and least significant difference was used for comparison of means.

Seed priming protocol: For achieving seed priming, maize seeds were dipped in solutions of 1, 2 and 3% ZnSO4, and 0.5, 1.5 and 3% Zn EDTA for 12 h at 25±2°C. Seed weight to solution volume ratio was 1:5 (w/v). For seed priming, seeds were immersed in desired solution or water followed by removal and three times surface washings with subsequent re-drying to achieve its original weight. Seeds without such treatment were employed for control.

Yield and yield parameters: Plant height and stem diameter of 10 randomly selected plants were recorded and means values were calculated. Cobs were collected from 10 randomly selected plants from each plot and subjected to sun drying. Weight was recorded after conversion into t ha^{-1}. Afterward, dried cobs were subjected to maize sheller and shelling was performed mechanically. Grains thus obtained were weighed using digital balance and weight was recorded after conversion into t ha^{-1}. Cobs were separated from plants and weight of cobs from 10 randomly selected plants was noted from each plot after converting into t ha^{-1}.

Soil and plant analysis: Soil and plant samples were collected from each plot and subjected to analysis. Soil and plant analysis were performed using procedures given in Hand book No. 60 of U.S. Salinity Laboratory Staff (1954).

The nitrogen % in each grain sample was determined through Kjeldahl method (Jackson, 1962), protein % was calculated by multiplying nitrogen % with a factor of 6.25 (Wright & Stuczynski, 1996). Determination of phosphorus content in maize plant was done by employing spectrophotometer (Beckman photometer 1211) using standard method as given by Ryan *et al*., (2001). Potassium content of maize leaves were determined using flame photometer by following the protocol 54a (Handbook 60) for plant sample digestion and then protocol 58a (Handbook 60) were used for estimation of K.

Table 1. Soil analysis before experimentation.

Sr. No.	Determinations	Unit	Value
1.	Saturation percentage	%	29.0
2.	pH_s	-	8.15
3.	EC_e	dS m^{-1}	1.28
4.	Clay	%	25.0
5.	Silt	%	22.0
6.	Sand	%	53.0
7.	Textural class	-	Sandy clay loam
8.	Organic matter	%	0.7
9.	Available Phosphorus/	mg kg^{-1}	7.9
10.	Olsen P	mg kg^{-1}	1.5
11.	Zn Available K	mg kg^{-1}	200

Wet digestion procedure was used for full recovery of micronutrients from plant samples. Digested plant samples were analyzed for Zn content by atomic absorption spectrophotometer that was calibrated with series of respective standard solutions and standard curve was established. Zn content was calculated by using following formula:

$$\text{Zn } (\mu g\ g^{-1}) = \frac{\text{Concentration from calibration curve (mg } L^{-1}) \text{ x Dilution factor}}{\text{Weight of sample digested (g)}}$$

Statistical Analysis

Analysis of variance (ANOVA) technique was used for testing of means regarding impact of nutrient seed priming with Zn metal on maize growth and yields. Data was further subjected to least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

Results and Discussion

Plant height (cm): Data regarding impact of seed priming of maize with different concentrations and types Zn solutions on plant height of maize was depicted in (Fig. 1). Positive impact on plant height was recorded using this approach. This improvement was apparent with either source of Zn. Minimum plant height was observed in T1 (Control) with numerical value of 176 cm that was reached to the maximum value of 204.9 cm in T4 where ZnSO4 was applied at the rate of 4% concentration along with recommended rates of NPK. This treatment was followed by T3 receiving 2% solution of $ZnSO_4$ along with recommended NPK with value of 199.59 cm. It was noticed that priming of seed resulted in positive results with either source of Zn ($ZnSO_4$ and Zn- EDTA). However, $ZnSO_4$ at either concentration proved better than Zn-EDTA in terms of enhancing plant height. Findings of this study support the fact that Zn is essentially required for better growth and yield of crops. Such an enhancement in plant height may result from role of Zn in increasing intermodal distance. Badshah and Ayub (2013) also reported an increase in plant height by application of Zn seed priming. Likewise, conclusions of Arif *et al*., (2005) and Ali *et al*., (2007) also support these findings. Results of Mohsin *et al*., (2014) also confirmed that priming of seeds subjected to Zn sources improved plant height in maize efficiently.

Stem diameter (cm): Data pertaining to effect of Zn seed priming of maize accompanied with recommended rates of NPK on maize stem diameter was plotted in (Fig. 2). It was noticed that fortification of maize seeds with Zn through technique of seed priming resulted in significant improvement in stem diameter of maize plants. The trend was similar to that of plant height of maize. Highest stem diameter (3.5 cm) was noticed in T4 receiving 4% ZnSO4 as a source of Zn along with NPK mineral fertilizers at recommended rates. Treatment T3 (ZnSO4 @ 2%) was next in this regard with value of 3.3. Reversely, application of treatment T1 (control) without any supplementation of Zn resulted in lowest stem diameter in maize with value of 2.13 cm. Badshah & Ayub (2013) also reported improvement in yield parameters by application of Zn seed priming. Similarly, conclusions of Arif *et al*., (2005) and Ali *et al*., (2007) and Mohsin *et al*., (2014) also support these findings.

Cob weight (g): (Fig. 3) reflected the data regarding effect of Zn seed priming of maize along with NPK at recommended rates on cob weight of maize. An improvement in cob weight was observed as a result of Zn fortification. Maximum cob weight (349.33 g) was attained in those plants where ZnSO4 was applied with 4% concentration accompanied with NPK at recommended rates. While, minimum cob weight (204.33 g) was recorded in T1 (control) receiving NPK @ recommended rate without any Zn supplement. One of the essential yields determining parameter in maize is cob weight. Improvement in cob weight with Zn seed priming is resulted from increased uptake of Zn by plants (Mohsin *et al*., 2014). Such an improvement contribute to better uptake of nutrients like N and thus better grain production and overall yield related parameters of maize (Siddiqui *et al*., 2009). These results were also supported by Grzebisz *et al*., (2008) and Potarzycki & Grzebisz (2009).

No. of grains per cob: Data about effect of Zn seed priming along with recommended rates of NPK on no. of grains per cob of maize was plotted in (Fig. 4). It was found that fortification of maize seeds with Zn through technique of seed priming resulted in significant improvement in no. of grains per cob of maize plants. Maximum no. of grains per cob of maize (661.67) was observed in T_4 receiving 4% $ZnSO_4$ as a source of Zn along with NPK mineral fertilizers at recommended rates. Treatment T_3 ($ZnSO_4$ @ 2%) was next in this regard with value of 605. On the other hand, application of treatment T_1 (control) without any supplementation of Zn resulted in lowest no. of grains per cob in maize with value of 350.66. Again $ZnSO_4$ as a source of Zn proved better than Zn EDTA in terms of enhancing no. of grains per cob of maize plants.

1000 grain weight (g): Data regarding impact of Zn seed priming on 100 grains weight of maize was depicted in (Fig. 5). An improvement in 1000 grain weight was noticed as a result of seed priming approach. This improvement was apparent with either source of Zn. Minimum 1000 grain weight was observed in T1 (Control) with numerical value of 90.33 g that was reached to the maximum value of 169.66 g in T4 where ZnSO4 was applied at the rate of 4% concentration along with recommended rates of NPK. This treatment was followed by T3 receiving 2% solution of $ZnSO_4$ along with recommended NPK with value of 153.33 g. It was noticed that priming of seed resulted in positive results with either source of Zn ($ZnSO_4$ and Zn- EDTA). However, $ZnSO_4$ at either concentration proved better than Zn-EDTA in terms of enhancing 1000 grain weight of maize. These results are in confirmation with findings of Afzal *et al*., (2013) who also reported and improvement in yield and yield parameters of maize as a result of nutrient seed priming with $ZnSO_4$. According to Tahir *et al*., (2009), this might be due to better nutrition that resulted in increased cob length, cob diameter and 1000 grain weight which is contributed to production of healthy plants and better produce.

Stem weight (g): Effect of priming of maize seeds with different sources and concentrations of Zn along with recommended rates of NPK on stem weight of maize was plotted in (Fig. 6). It was found that fortification of maize seeds with Zn through technique of seed priming resulted in significant improvement in stem weight of maize plants. Minimum stem weight of maize (229.33 g) was observed in treatment T_1 (control) without any supplementation of Zn. On the other hand, application of 4% $ZnSO_4$ as a source of Zn along with NPK mineral fertilizers at recommended rates (T_4) resulted in maximum stem weight of maize with value of 364.66 g. Treatment T_3 ($ZnSO_4$ @ 2%) was next in this regard with value of 336 g. Again $ZnSO_4$ as a source of Zn proved better than Zn EDTA in terms of enhancing no. of grains per cob of maize plants. Improvement in stem weight with Zn seed priming is resulted from increased uptake of nutrients like N, P, K and Zn by plants (Mohsin *et al*., 2014). Such an improvement may be contributed from better uptake of nutrients like N and thus plant growth and overall yield related parameters of maize (Siddiqui *et al*., 2009). These results were also supported by Grzebisz *et al*., (2008) and Potarzycki & Grzebisz (2009).

Grains yield (t ha^{-1}): Data reflecting role of Zn seed priming along with recommended rates of NPK on improvement of grain yield was plotted in (Fig. 7). Effect of different Zn containing solutions was prominent in terms of increasing grain yield compared to control and adjudged statistically significant. Minimum noted value for grain weight (121 t ha^{-1}) was recorded for T_1 (control treatment) receiving only NPK at recommended rates without any supplementation with Zn. Zn seed priming with $ZnSO_4$ @ 4% solution (T_4) along with recommended dose of NPK was resulted in maximum grain yield 223.33 t ha^{-1}. Treatment T_3 ($ZnSO_4$ @ 2% solution) was next in this regard showing value of 197.33 t ha^{-1}. Betterment in cob weight and 100 grain weight subsequently contributed to enhanced grain yield of maize. This enhancement is attributed to increased carbohydrate formation and subsequent translocation to grains formation place (Pedda-Babu *et al*., 2007). Improvement in grain yield may resulted from good nutrition and better seedling growth and development consequent upon application of Zn primed seed along with recommended doses of NPK nutrition. That is apparent from better plant height and leaves in maize (Fageria *et al*., 2006). Trehan & Sharma (2000) also supported an enhancement in yield of maize by applying Zn. Finding of Haris (2006), Harris *et al*., (2007), Zeb & Arif (2008) and Afzal *et al*., (2013) also support these results.

Zinc in plant biomass (ppm): Data pertaining to role of Zn seed priming on Zn concentration in maize plant biomass was depicted in (Fig. 8). An improvement in Zn content in maize plant biomass was noticed as a result of seed priming approach. This improvement was apparent with either source of Zn. Minimum Zn concentration was noticed in T1 (Control) with numerical value of 18 ppm that was reached to the maximum value of 32 ppm in T4 where ZnSO4 was applied at the rate of 4% concentration along with recommended rates of NPK. This treatment was followed by T3 receiving 2% solution of $ZnSO_4$ along with recommended NPK with value of 27 t ha^{-1}. It was noticed that priming of seed resulted in positive results with either source of Zn ($ZnSO_4$ and Zn-EDTA). However, $ZnSO_4$ at either concentration proved better than Zn-EDTA in terms of enhancing Zn content in plant biomass of maize. Mirzapour & Khoshgoftar (2006) also reported an increase in Zn concentration of sunflower as a result of seed priming with Zn.

Zinc in grains (ppm): Data concerning effect of Zn seed priming on Zn concentration in maize grain biomass was depicted in (Fig. 9). An improvement in Zn content in maize grain biomass was noticed as a result of seed priming approach. This improvement was apparent with either source of Zn. Minimum Zn concentration was noticed in T1 (Control) with numerical value of 23 ppm that was reached to the maximum value of 33.2 ppm in T4 where ZnSO4 was applied at the rate of 4% concentration along with recommended rates of NPK. This treatment was followed by T3 receiving 2% solution of $ZnSO_4$ along with recommended NPK with value of 32.05 ppm. It was noticed that priming of seed resulted in positive results with either source of Zn ($ZnSO_4$ and Zn-EDTA). However, $ZnSO_4$ at either concentration proved better than Zn-EDTA in terms of enhancing Zn content in plant biomass of maize. There is direct relation between Zn applied and Zn concentration in grain as applied Zn preferentially translocated and deposited in grain (Dvorak *et al*., 2003). Soleimani (2012) also concluded that grain Zn concentration increased as a result of Zn addition in any form. Imran *et al*., (2013); Imran *et al*., (2015), Shrestha *et al*., (2019) and Imran *et al*., (2018) also reported many fold increase in Zn seed content of maize as a result of Zn seed priming.

N concentration in leaves (%): Effect of maize seed priming with Zn nutrient on N concentration of maize leaves was plotted in (Fig. 10). It was observed that N concentration of maize leaves improved significantly as a result of seed priming technique. Lowest nitrogen concentration (0.43%) was recorded in T1 (control) where only recommended NPK fertilizers were applied without seed priming with Zn. That was reached to the maximum nitrogen concentration of 0.72% in T4 receiving ZnSO4 @ 4% as a source of Zn along with recommended dose of mineral NPK followed by T3 (ZnSO4 @ 2% along with recommended NPK) with numerical value of 0.66% N content. This betterment in N content of plants was due to improvement in nutritional status of growth media as a result of balance nutrition as compared to control where no additional sources of nutrients were applied. Results of this study are in line with fact that supplementation with Zn resulted in improved N uptake at grain formation stage and resultantly enhanced maize yield (Siddiqui *et al*., 2009).

P concentration in leaves (%): Data pertaining to role of Zn seed priming accompanied with application of mineral fertilizers at recommended rates on phosphorus concentration of maize leaves was indicated in (Fig. 11). The effect was declared as statistically significant regarding improvement in P concentration of maize leaves consequent upon seeds fortification with Zn in addition to mineral fertilizers application at recommended rates. The maximum recorded value for grain weight (0.27%) was recorded for T1 (control treatment) receiving only NPK at recommended rates without any supplementation with Zn. Zn seed priming with Zn-EDTA @ 1.5% solution (T5) along with recommended dose of NPK was resulted in minimum P concentration in maize leaves with value 0.2%. This increase in plant P content was due to balanced nutrition in growth environment that improved the nutrient content in maize plants as compared to control where no external source of nutrients was applied. Similar results are reported by Siddiqui *et al*., (2009).

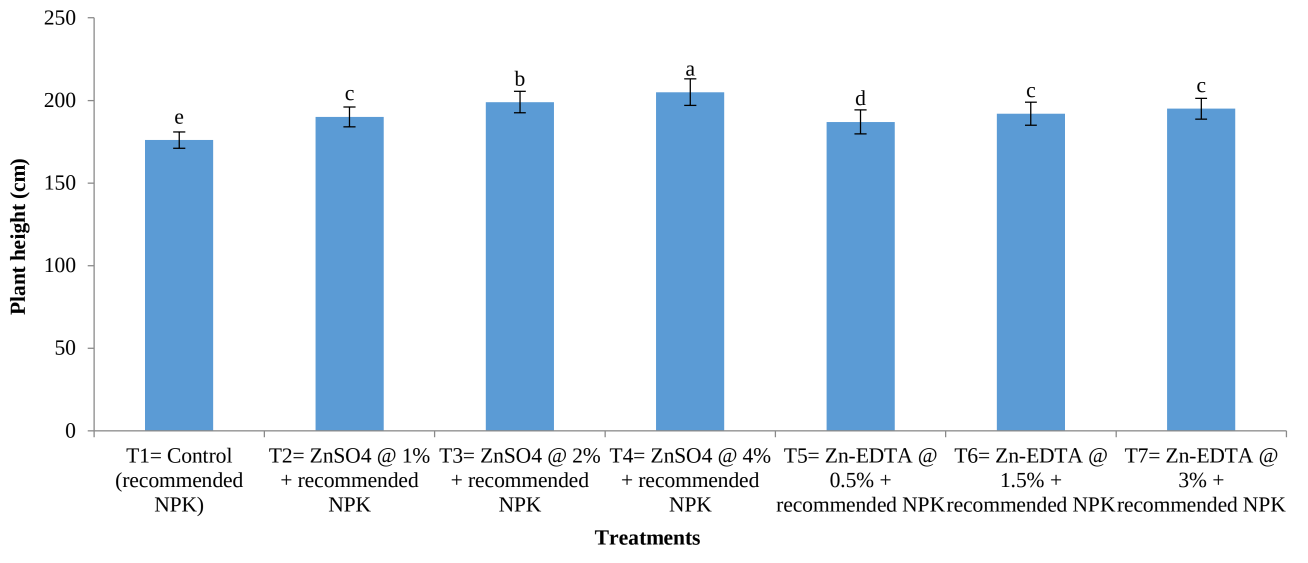

Fig. 1. Effect of Zn nutrient seed priming on plant height (cm) of maize under aridisols.

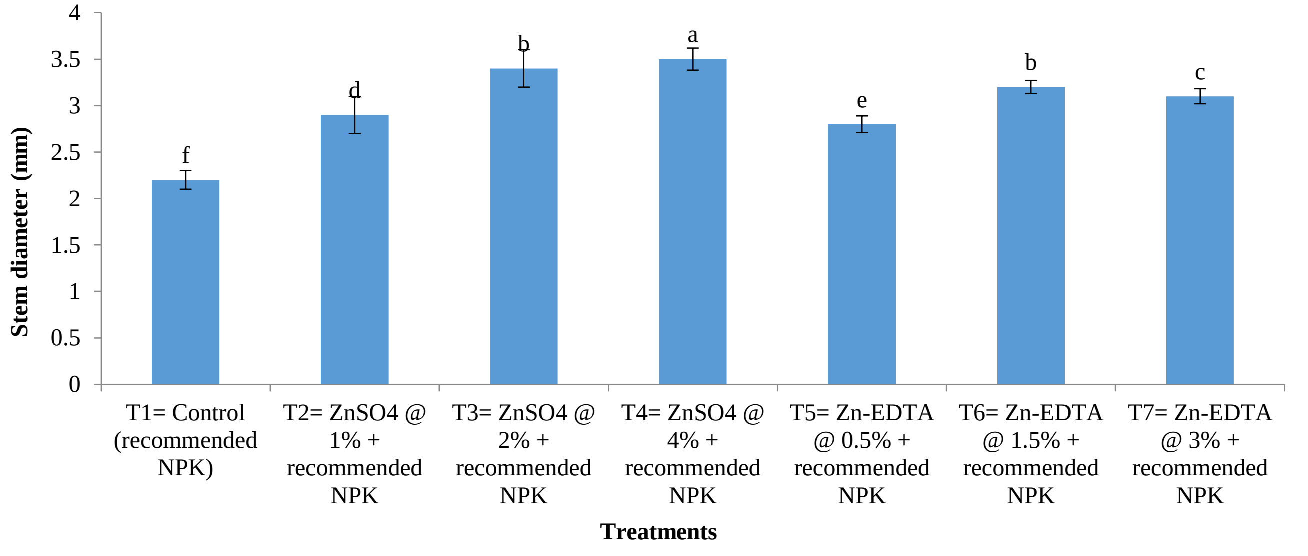

Fig. 2. Effect of Zn nutrient seed priming on stem diameter (mm) of maize under aridisols.

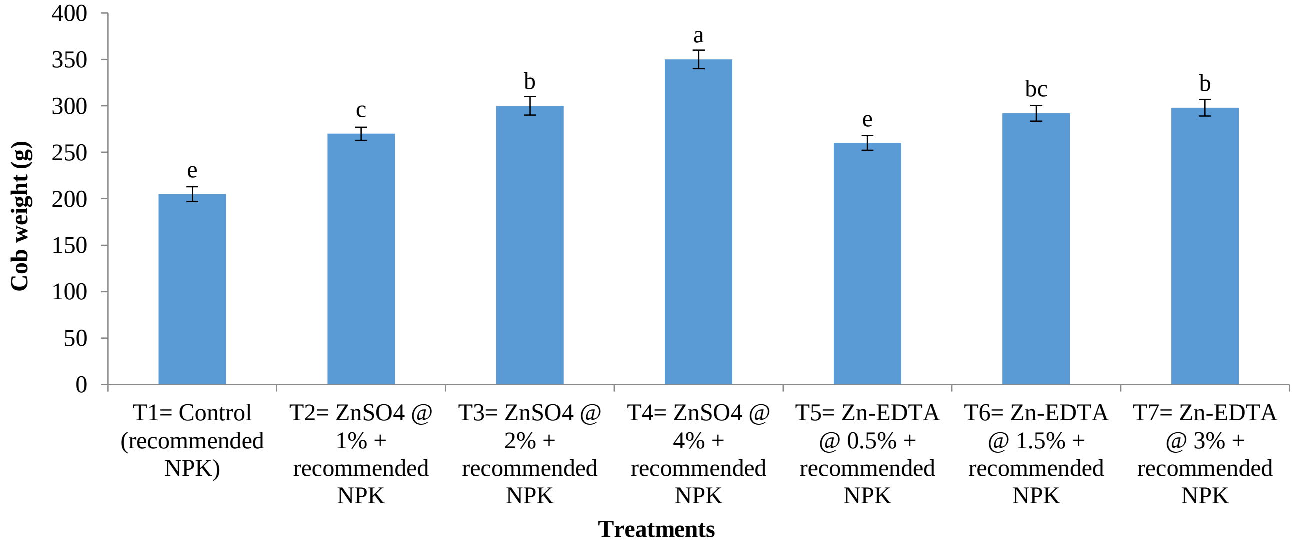

Fig. 3. Effect of Zn nutrient seed priming on cob weight (g) of maize under aridisols.

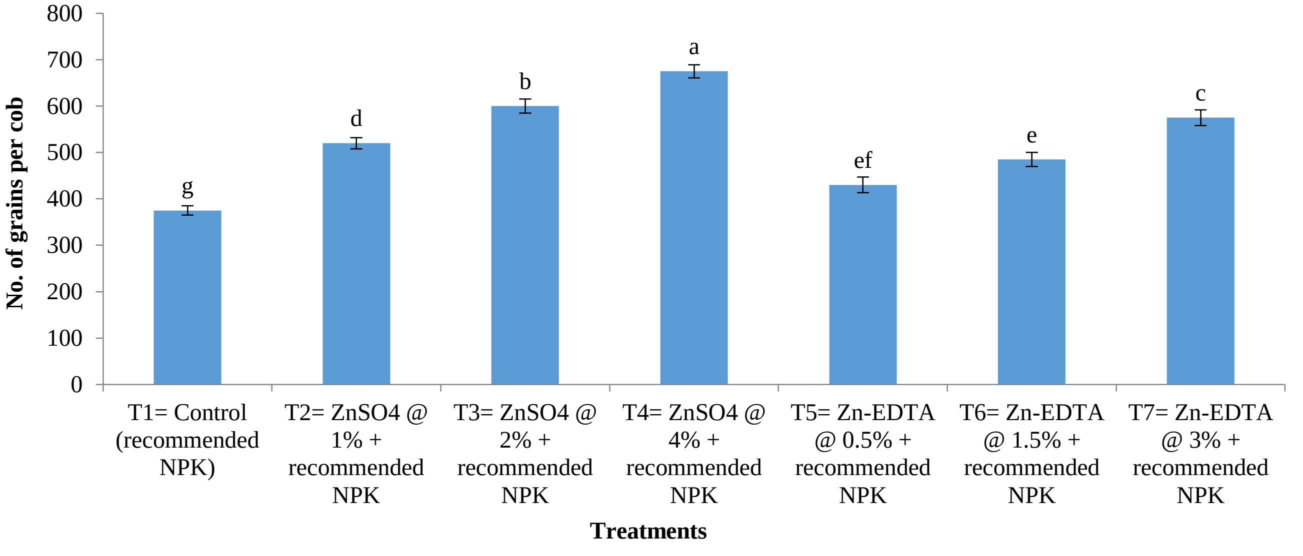

Fig. 4. Effect of Zn nutrient seed priming on no. of grains per cob of maize under aridisols.

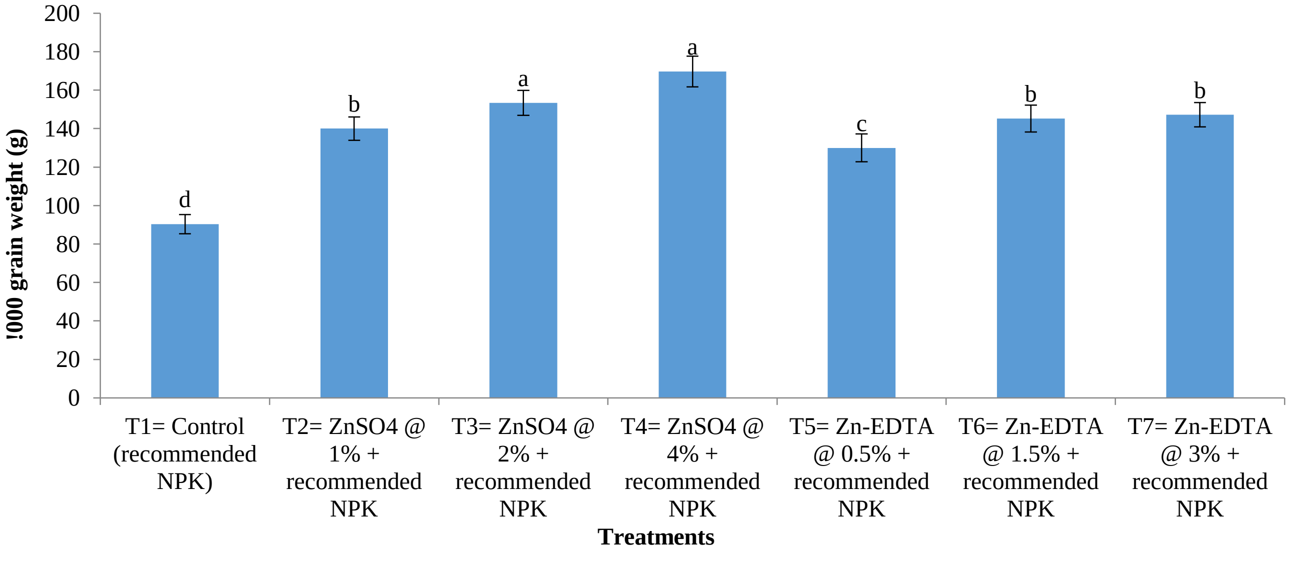

Fig. 5. Effect of Zn nutrient seed priming on 1000 grain weight (g) of maize under aridisols.

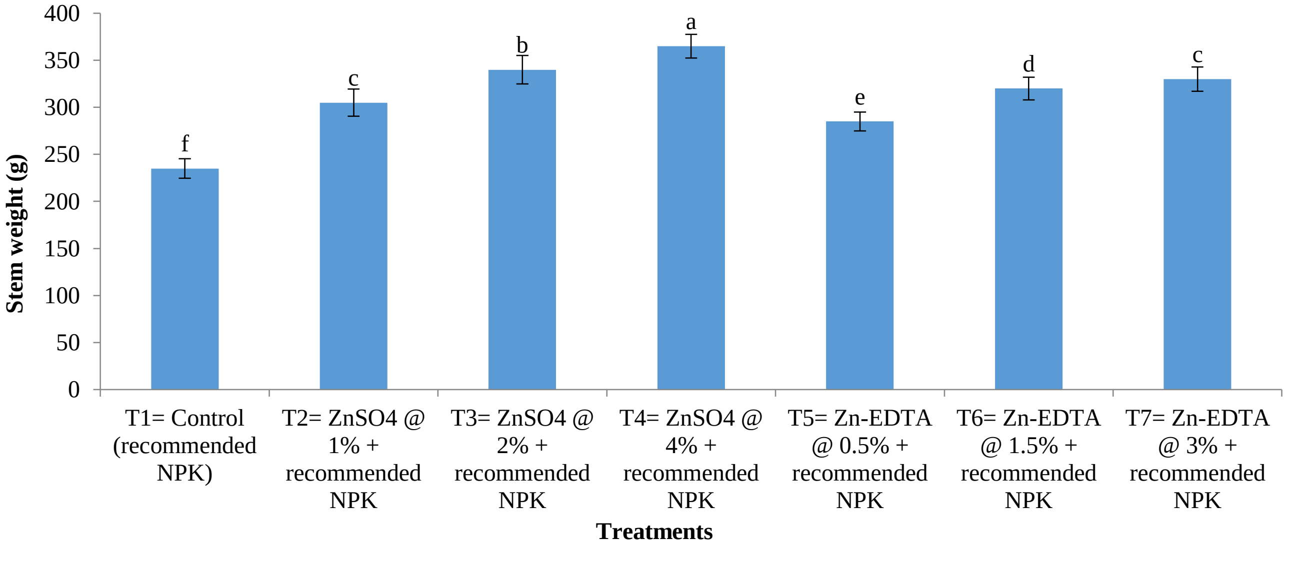

Fig. 6. Effect of Zn nutrient seed priming on stem weight (g) of maize under aridisols.

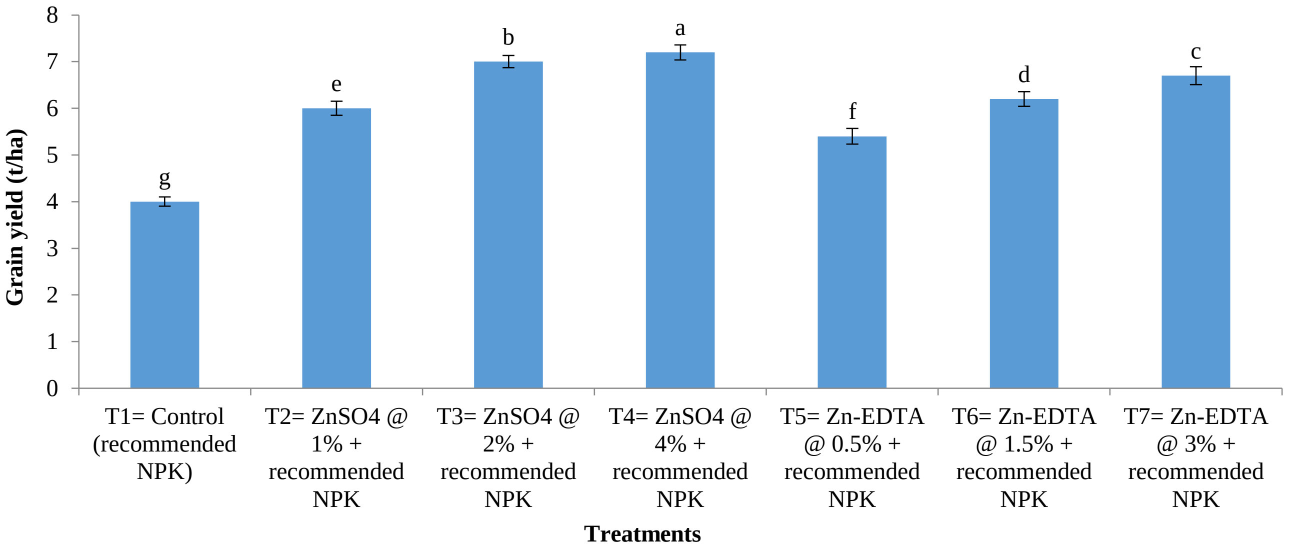

Fig. 7. Effect of Zn nutrient seed priming on grain yield (t ha^{-1}) of maize under aridisols.

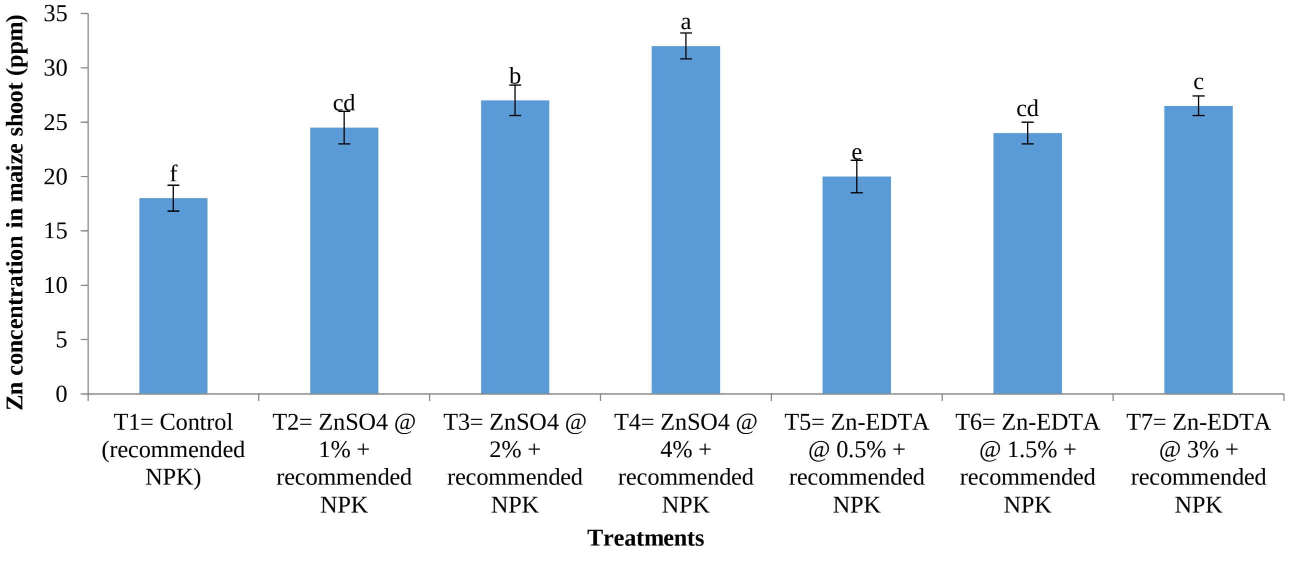

Fig. 8. Effect of Zn nutrient seed priming on Zn concentration (ppm) of maize shoot under aridisols.

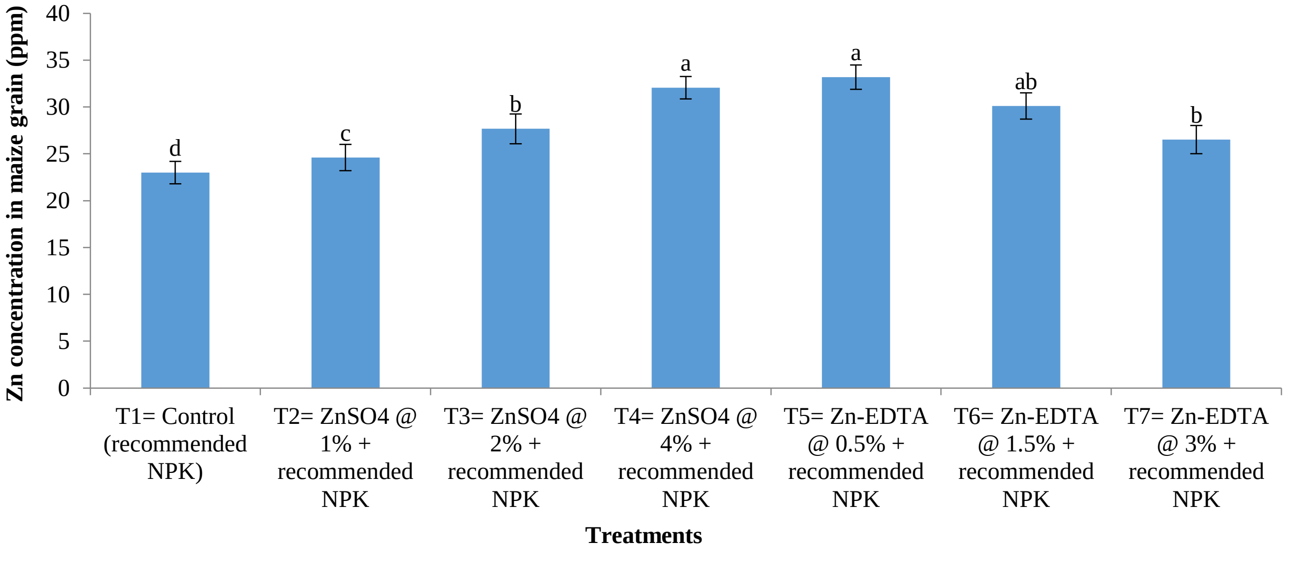

Fig. 9. Effect of Zn nutrient priming seed on Zn concentration (ppm) of maize grains under aridisols.

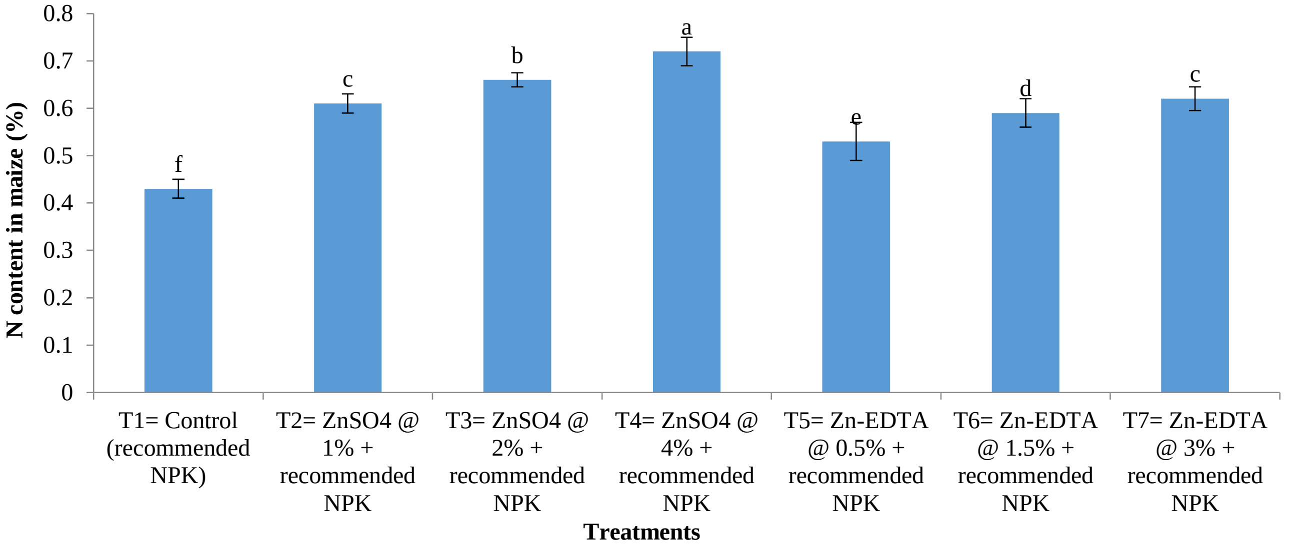

Fig. 10. Effect of Zn nutrient seed priming on N content (%) of maize leaves under aridisols.

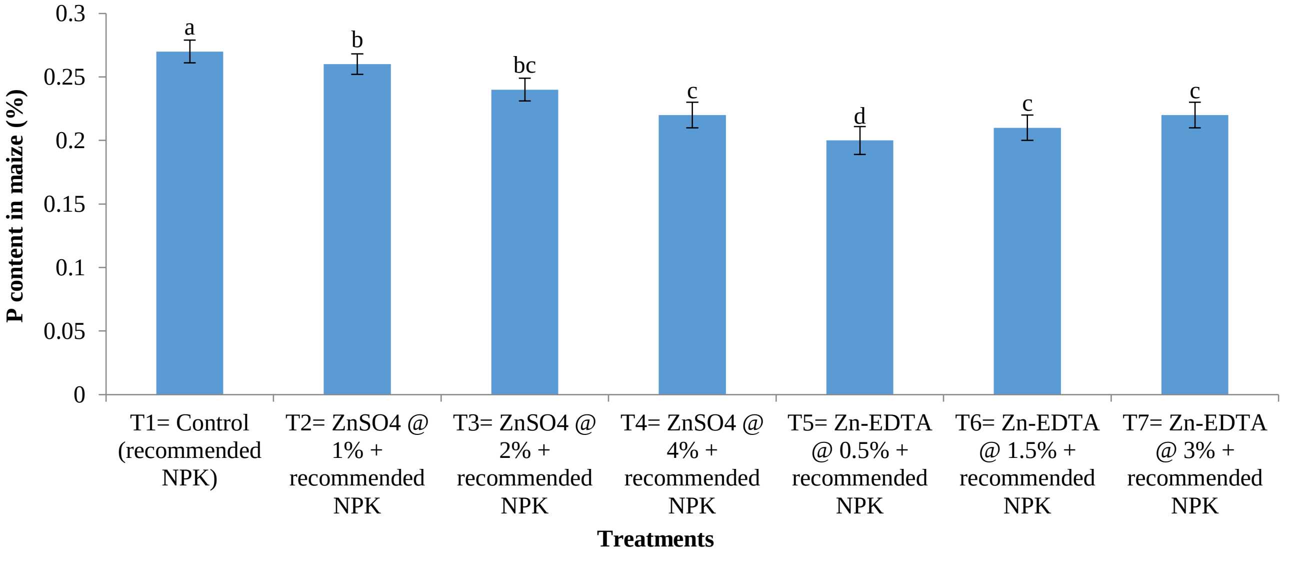

Fig. 11. Effect of Zn nutrient seed priming on P content (%) of maize leaves under aridisols.

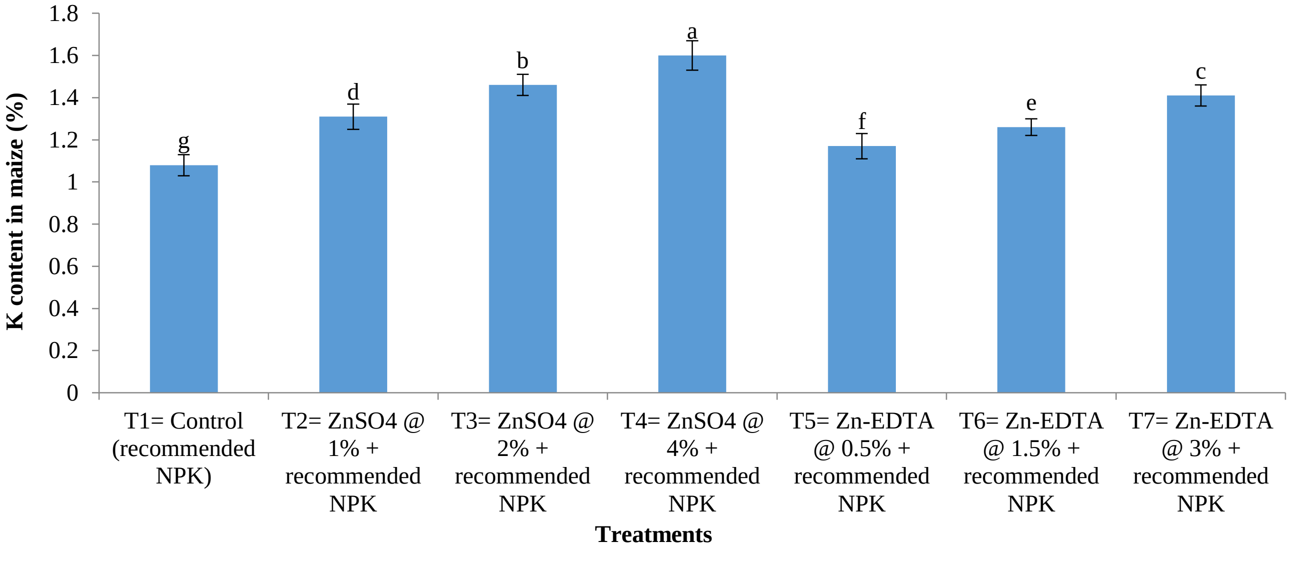

Fig. 12. Effect of Zn nutrient seed priming on K content (%) of maize leaves under aridisols.

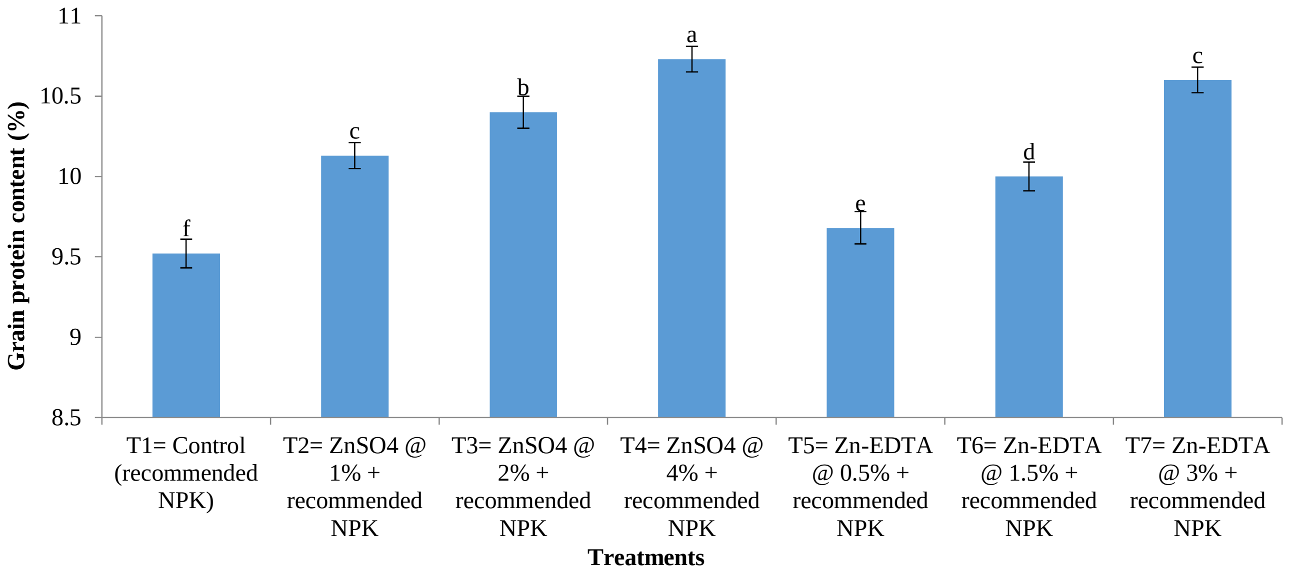

Fig. 13. Effect of Zn nutrient seed priming on grain protein content (%) of maize under aridisols.

K concentration in leaves (%): Data with reference to effect of seed priming with Zn solutions on K concentration in maize leaves was depicted in (Fig. 12). An improvement in K content of maize leaves was noticed as a result of seed priming approach. This improvement was apparent with either source of Zn. Minimum Zn concentration was noticed in T1 (Control) with numerical value of 1.08% that was reached to the maximum value of 1.6% in T4 where ZnSO4 was applied at the rate of 4% concentration along with recommended rates of NPK. This treatment was followed by T3 receiving 2% solution of $ZnSO_4$ along with recommended NPK with value of 1.46%. It was noticed that priming of seed resulted in positive results with either source of Zn ($ZnSO_4$ and Zn-EDTA). However, $ZnSO_4$ at either concentration proved better than Zn-EDTA in terms of enhancing Zn content in plant biomass of maize. This increase in plant K content was due to balanced nutrition in growth environment that improved the nutrient content in maize plants as compared with control where no external source of nutrients was applied. These results are in accordance with results of Siddiqui *et al*., (2009) and Sharifi *et al*., (2016).

Grain protein content: Effect of maize seed priming with Zn nutrient on grain protein content of maize was plotted in (Fig. 13). It was observed that grain protein content of maize improved significantly as a result of seed priming technique. Lowest grain protein content (9.52%) was recorded in T1 (control) where only recommended NPK fertilizers were applied without seed priming with Zn. That was reached to the maximum grain protein content of 10.73% in T4 receiving ZnSO4 @ 4% as a source of Zn along with recommended dose of mineral NPK followed by T3 (ZnSO4 @ 2% along with recommended NPK) with numerical value of 10.4% grain protein content. Role of Zn as a component of enzymes is known, which contributes to production of starch and maturity of seed. Priming of maize seeds resulted in early seed germination and better stand due to better hydration of seeds (Laware & Raskar, 2014). Hebbern *et al*. (2005) and Harris *et al*., (2007) also concluded positive outcomes of Zn seed priming on germination. This better germination due to imbibitions of water resulted in better crop stand and ultimately growth and yield. However, Conclusion of Sharifi *et al*., (2016) also suggested an increase in crude protein content of maize grains with Zn seed priming as compared to control (no priming). Findings of Siddique *et al*., (2009) also support these results.

Conclusion

Seed priming is famous and attainable strategy used to improve the seed development and advancement worldwide. Present study was executed in order to determine efficacy of maize seed subjected to priming with Zn solutions of varying concentrations on growth, yield and nutrient acquisition of maize. Zinc is essentially vital for optimum growth and development of crops. The results revealed that priming of maize seeds with 4% of $ZnSO_4$ solution resulted in maximum plant growth and grain yield.

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