

Research Article

Response of wheat varieties to different zinc application methods

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Citation

Nauman Aziz, Shazma Anwar, Shaheen Kashmir, Junaid Ahmad, Beena Saeed and Shehryar Khan. Response of wheat varieties to different zinc application methods. Pure and Applied Biology.

<http://dx.doi.org/10.19045/bspab.2018.700207>

Received: 06/10/2018

Revised: 06/12/2018

Accepted: 08/12/2018

Online First: 12/12/2018

Abstract

An experiment on response of different wheat varieties to zinc application methods was evaluated at Agriculture University Peshawar Pakistan in 2016-17. The experimental design was RCB with 3 replications. Zinc application methods (control, 1% foliar with ZnSO₄, 1% priming with ZnSO₄, 15 kg ha⁻¹ soil application, 1% foliar with ZnSO₄ + 1% priming with ZnSO₄, 1% foliar with ZnSO₄ + 15 kg ha⁻¹ Zn application to soil, 1% priming with ZnSO₄ + 15 kg ha⁻¹ Zn soil application, 1% foliar with ZnSO₄ + 1% priming with ZnSO₄ + 15 kg ha⁻¹ Zn soil application) & varieties (Atta Habib & Zincol) were used in the experiment. Plant height, spike m⁻², grains spike⁻¹, 1000 seed weight, biological yield and grain yield showed significant response to zinc application methods and varieties. Taller plant (98.8 cm), spikes m⁻² (358), grains spike⁻¹ (57), 1000 seed weight (49.1 g), biological yield (10067 kg ha⁻¹) and grain yield (4319.3 kg ha⁻¹) were recorded in plots treated with 1% foliar with ZnSO₄ + 1% priming with ZnSO₄ + 15 kg ha⁻¹ Zn soil application of ZnSO₄. Considering wheat varieties plant height (94 cm), tillers m⁻² (317), spikes m⁻² (301), grains spike⁻¹ (52), biological yield (9073.3 kg ha⁻¹) and grain yield (4103.5 kg ha⁻¹) recorded from Zincol. It is concluded that Zincol wheat variety with application of 1% foliar with ZnSO₄ + 1% priming with ZnSO₄ + 15 kg ha⁻¹ Zn soil application of ZnSO₄ performed better in terms of yield and thus recommended for general cultivation.

Keywords: Foliar; Priming; Varieties; Zinc application; Zincol

Introduction

In cereals wheat is the most important crop worldwide. Among wheat producing countries Pakistan ranks 8th, contributes almost 3.17% wheat production of the world. In Pakistan wheat crop is a leading food grain and occupies central position in economy. In Pakistan during 2015-16 wheat is cultivated on about 8.66 million hectares with total production of 23.517 million tons [1]. While in Khyber Pakhtunkhwa it was cultivated on 0.758 million hectares with average production of 1607.5 kg ha⁻¹. Wheat, as a food crop is

mostly used for its good taste and source of calories, proteins and vitamins. Low quality of wheat and flour-milling by-products are used as source of feed for livestock.

Micronutrients are used for growth and regulation of plant's vital physiological processes. They are necessary in low amounts, but equally important like macronutrients [2]. Deficiency of micronutrients in Pakistan is due to calcareous soils, high pH, low organic matter, salt stress and imbalanced application of NPK fertilizers [3]. Zinc is one of the most important micronutrient in

biological zones and is receiving more attention throughout world [4, 5]. Deficiency of Zn affects about 1/3 of the total world's populations [6, 7]. In soils due to low solvability of Zn plant cell growth reduction and development is one of the Zn deficiency symptom [8]. In human beings Zn deficiency is very common especially in those countries with high consumptions of cereal-based foods. Therefore, there is a great need to improve cereal crops with adequate Zn nutrition. Deficiency of Zn is also a critical constraint to wheat production. In cereals based cultivated soils all over the world it is widely accepted that deficiency of Zn in soil is the most commonly occurring micronutrient deficiency. The unavailability of soil Zn resulting in severe losses in terms of economic and decreased plant growth and yield production.

Foliar application of different nutrients to plants is another option when deficiency of nutrient cannot be met properly by nutrients applications to the soil [4]. When the roots cannot provide the required nutrients to plant, in such circumstances foliar spraying of microelements is very helpful [9, 10]. When zinc fertilizer is applied to crop at later stages, Zn deposition in grains particularly increases. Past studies conducted on Zn cleared that maximum accumulation of Zn take place during grain development stage and the concentration of Zn in wheat grains accumulates more at milky stage of grain development. From the foliar spray of Zn it has been shown that in the late growth stages like at milk and dough stage resulted in much more enhancement in grain Zn concentration than application of Zn at earlier growth stages when compared [11]. A potential problem is that increasing in Zn concentration in flour may affect negatively its processing traits [8]. Zn is more effective in increasing Zn concentration in seeds by its foliar application at all seed development stages. In seeds the highest Zn concentration can be achieved when applied at the first stages of development of seed [12]. Currently,

increasing grain Zn concentration is most important global challenge in order to minimize Zn deficiency related health problems. Since wheat crop have very low amount of Zn in grains and growing wheat on Zn deficient soils reduces Zn concentration in Zn. Hence foliar application of Zn to wheat is fundamentally important for both good crop productivity and better human health. Keeping in view the importance of Zn for better wheat production, this research study is designed to study the main and interactive effect of wheat varieties to different zinc application methods.

Materials and methods

Response of wheat varieties to different zinc application methods was evaluated at Agronomy Research Farm, The University of Agriculture, Peshawar during winter season 2016-17. The experiment consisted of these factors. Factor A; Zinc Application Methods, Zn₁=Control, Zn₂=1% foliar with ZnSO₄, Zn₃=1% priming with ZnSO₄, Zn₄=15 kg ha⁻¹ Zn soil application, Zn₅=1% foliar with ZnSO₄+1% priming with ZnSO₄, Zn₆=1% foliar with ZnSO₄+15 kg ha⁻¹ Zn soil application, Zn₇=1% priming with ZnSO₄+15 kg ha⁻¹ Zn soil application, Zn₈=1% foliar with ZnSO₄+1% priming with ZnSO₄+15 kg ha⁻¹ Zn soil application. Factor B; Wheat Varieties, V₁=Atta Habib, V₂=Zincol. All the treatment combinations were randomly allotted to the experimental units using randomized complete block design with 3 replications. Plot size was maintained 3m x 3m. For foliar application and Zn priming, 1% solution from ZnSO₄.7H₂O source was prepared. The solution was diluted with water while keeping in view the treatments and volume to wet the plot area completely. The foliar Zn treatment was applied in the late afternoon within different growth stages. Wheat varieties Atta Habib and Zincol were sown at the rate of 120 kg ha⁻¹ with 30cm R-R distance. The nitrogen and phosphorus was applied at the rate of 120 kg ha⁻¹ and 90 kg ha⁻¹. Urea and DAP was used as a source of nitrogen and phosphorous. All of the

phosphorous and half dose of nitrogen was applied at sowing time and the remaining dose was applied later at 2nd irrigation. All other agronomic practices were kept normal and uniform for all the treatments.

Statistical analysis

Data was statistically analyzed [13] and means were computed using LSD test ($P < 0.05$).

Results

Plant height (cm)

Data on plant height of wheat as influenced by different zinc application methods and varieties are given in (Table 1). The data shows that zinc application methods and varieties shows significant affect plant height of wheat. Highest plant height (98.8 cm) was recorded in plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while the lowest was recorded with no zinc application. Similarly taller plants (94 cm) were recorded for

Zincol and short stature plants were recorded for Atta Habib (91 cm). V x Zn was found non-significant.

Number of productive tillers (m⁻²)

Table 1 shows data on number of productive tillers per m² of wheat as influenced by different zinc application methods. The data shows that zinc application methods and varieties significantly affected number of productive tillers m⁻² of wheat. More number of productive tillers m⁻² (368) were observed in plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while lower (281) were recorded with no zinc application. In case of varieties maximum number of tillers per m² was recorded for Zincol (317) and lower were recorded for Atta Habib (313). The interaction of v x Zn was found non-significant.

Table 1. Plant height (cm), Number of productive tillers m⁻², Number of spikes m⁻², Number of grains spikes⁻¹ as affected by different zinc application methods and wheat varieties

| Zn Application Methods (Zn) | Plant height (cm) | Productive tillers m ⁻² | Spikes m ⁻² | Grains spikes ⁻¹ |
|---|-------------------|------------------------------------|------------------------|-----------------------------|
| Control | 87.8 f | 281 f | 262 f | 45 e |
| 1% foliar with ZnSO ₄ | 89.7 e | 289 g | 276 e | 48 d |
| 1% priming with ZnSO ₄ | 90.5 de | 297 e | 275 e | 54 c |
| 15 kg ha ⁻¹ soil application | 90.0 e | 282 g | 262 f | 46 e |
| 1% foliar with ZnSO ₄ +1% priming with ZnSO ₄ | 92.2 d | 312 d | 297 d | 55bc |
| 1% foliar with ZnSO ₄ +15 kg ha ⁻¹ Zn soil application | 94.5 c | 330 c | 316 c | 55abc |
| 1% priming with ZnSO ₄ +15 kg ha ⁻¹ Zn soil application | 96.8 b | 358 b | 345 b | 56ab |
| 1% foliar with ZnSO ₄ +1% priming with ZnSO ₄ +15 kg ha ⁻¹ Zn soil application | 98.8 a | 368 a | 358 a | 57 a |
| LSD (0.05) | | | | |
| Varities (V) | | | | |
| Atta Habib | 91.0 b | 313.1 b | 296.7ab | 51.9 b |
| Zincol | 94.0 a | 317 a | 301.6 a | 52.8 a |
| LSD (0.05) | 0.88 | 2.84 | 3.09 | |
| Interaction (Zn x V) | ns | ns | ns | ns |

Number of spikes (m⁻²)

Number of spikes per m² of wheat as affected by various zinc application methods and varieties are given in (Table 1). The data shows that application methods of zinc and varieties effect significantly

number of spikes per m² of wheat. Maximum number of spikes m⁻² (358) were recorded when treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while lower (262.0) observed in no zinc applied plots. More number of spikes m⁻² (301) was

recorded for Zincol and lower (296) were recorded for Atta Habib. The combine effect of zinc on wheat varieties was found non-significant.

Number of grains spike⁻¹

Table 1 shows number of grains spike⁻¹ of wheat as affected by different zinc application methods. The data shows that zinc application methods and varieties significantly affected number of grains spike⁻¹ of wheat. Higher number of grains spike⁻¹ (57) were recorded when treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while less (45) were recorded at no zinc application. Higher number of grains spike⁻¹ (52.8) was recorded for Zincol and lower (51) were recorded for Atta Habib. The interaction of V x Zn was found non-significant.

Thousand grain weight (g)

Data regarding thousand seed weight of wheat as affected by various zinc application methods and varieties are given in (Table 2). The data shows that zinc application methods and varieties affected significantly thousand seed weight of

wheat. Heavier grains (49.1 g) were recorded in plants which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while lighter grains (40.0 g) were recorded in no zinc applied plants. More thousand grains weight (46.1 g) was recorded for Zincol and lower (44.5 g) was recorded for Atta Habib. The interaction of varieties with zinc application methods was found non-significant.

Biological yield (kg ha⁻¹)

Biological yield of wheat as influenced by different zinc application methods are presented in (Table 2). The data shows that zinc application methods and varieties significantly response to biological yield of wheat. More biological yield (10067 kg ha⁻¹) was recorded in plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least (7721 kg ha⁻¹) was recorded with no zinc application. Higher biological yield (9073 kg ha⁻¹) was recorded for Zincol and lower (8728 kg ha⁻¹) was recorded for Atta Habib. The combined effect of V x Zn was found non-significant.

Table 2. Thousand grains weight (g), biological yield (kg ha⁻¹), grain yield (kg ha⁻¹) and Harvest index (%) as affected by different zinc application methods and wheat varieties

| Zn Application Methods (Zn) | Thousand grains weight (g) | biological yield (kg ha ⁻¹) | Grain yield (kg ha ⁻¹) | Harvest index (%) |
|--|----------------------------|---|------------------------------------|-------------------|
| Control | 40.0 a | 7721 e | 3771 e | 48.8 |
| 1% foliar with ZnSO ₄ | 44.0 e | 8181 de | 3856 de | 47.2 |
| 1% priming with ZnSO ₄ | 45.2 d | 8626 cd | 3894 cd | 45.4 |
| 15 kg ha ⁻¹ soil application | 42.2 f | 7834 e | 3841 de | 49.1 |
| 1% foliar with ZnSO ₄ +1% priming with ZnSO ₄ | 46.3 c | 9155bc | 3992 c | 44.1 |
| 1% foliar with ZnSO ₄ +15 kg ha ⁻¹ soil application | 47.3 b | 9654ab | 4106 b | 42.7 |
| 1% priming with ZnSO ₄ +15 kg ha ⁻¹ soil application | 48.4 a | 9965 a | 4193 b | 42.1 |
| 1% foliar with ZnSO ₄ +1% priming with ZnSO ₄ +15 kg ha ⁻¹ soil application | 49.1 a | 10067 a | 4319 a | 42.9 |
| LSD (0.05) | | | | |
| Varities (V) | | | | |
| Atta Habib | 44.5 b | 8728.4 b | 3890.1 b | 44.9 b |
| Zincol | 46.1 a | 9073.3 a | 4103.5 a | 45.7 a |
| LSD (0.05) | 0.38 | 315.49 | 49.7 | Ns |
| Interaction (Zn x V) | ns | ns | * | Ns |

Grain yield (kg ha⁻¹)

Data of grain yield of wheat as influenced by various zinc application methods and varieties are present in (Table 2). The data on grain yield of wheat shows significant response to zinc application method and varieties. More grain yield (4319 kg ha⁻¹) was recorded in those plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while lower (3771 kg ha⁻¹) was recorded with no zinc application. More grain yield (4103 kg ha⁻¹) was recorded for Zincol and lower (3890 kg ha⁻¹) was recorded for Atta Habib. The interaction of V x Zn was found significant.

Harvest index (%)

The impact of different zinc application methods and varieties on harvest index of wheat is shown in (Table 2). The data of different zinc application methods shows significant impact on harvest index of wheat. Maximum harvest index (49.1 %) was observed at 15 kg ha⁻¹ ZnSO₄ soil application while minimum (42.1 %) was recorded in those plots where 1% priming with ZnSO₄ + 15 kg ha⁻¹ soil application was applied. Varieties showed no profound impact on harvest index of wheat. The interaction of V x Zn was found non-significant.

Discussion

In terms of literature view collected for comparison and clarifications, the results achieved in the previous chapter are briefly discussed here.

Different application methods of zinc and significantly affected the plant height of wheat varieties. Highest plant height was observed in those plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while the lowest was recorded at no zinc application. This might be due to that zinc enhanced the growth and development of crop which resulted in taller plant. [14] Also reported the similar result that application of zinc increased plant height of wheat. Taller plants were recorded for Zincol and small stature plants were recorded for Atta Habib variety. Our results are in line with [15] who observed

that maximum plant height was recorded in different varieties with zinc application.

Productive tillers m⁻² of wheat was improved significantly in result of different zinc application methods. Similarly in case of varieties the effect of productive tillers per m² was found significant. More number of productive tillers m⁻² were recorded in those plots treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least were recorded with no zinc application. [16] Observed that foliar application of zinc increased the number of tillers m⁻². While in case of varieties more number of productive tillers m⁻² was recorded for Zincol and less were recorded for Atta Habib. The difference in productive tillers m⁻² might be due to different genetic make-up of the varieties. However our results are in contradiction with [17] who observed that higher tiller m⁻² was recorded in different varieties with zinc application.

Data showed that zinc application methods have significant impact on number of spike m⁻² of wheat varieties. Higher number of spikes m⁻² were recorded in those plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least were recorded at no zinc application. Our results are in line with [18] who reported maximum number of spike m⁻² zinc application methods. More number of spikes m⁻² were recorded for Zincol and the least were recorded for Atta Habib. [19] Reported that number of spike m⁻² of different varieties increased positively with the application of zinc.

Zinc application methods and varieties significantly affected number of grains spike⁻¹ of wheat. More grains spike⁻¹ was recorded when treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least were recorded with no zinc application. The increase in number of grains per spike may be due to high availability of zinc and the crop efficient used zinc. These results are in line with those of [20] who reported that application of different methods of zinc enhances the

number of grains spike⁻¹. More number of grains spike⁻¹ were recorded for Zincol and less recorded for Atta Habib. Probable reason for this is that different varieties have different genetical potential to use zinc efficiently. These results are in line with those of [20], who found that application of different methods of zinc to different varieties enhances the number of grains spike⁻¹.

Data showed the impact of zinc application methods and varieties on thousand grains weight of wheat. More thousand grains weight was recorded when treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least was recorded with no zinc application. This increase might be due to maximum amount of dry matter accumulation in seeds of the wheat because of high concentration of zinc. Similar results are recorded by [21], who found that application of zinc produced heavier grains. Heavier grains weight was recorded for Zincol and least was recorded for Atta Habib. [19] Also reported that Zinc application significantly increased thousand grains weight of wheat varieties. Biological yield of wheat was significantly affected by different zinc application methods. More biological yield was recorded in plots which were treated with 1% foliar + 1% priming + 15 kg ha⁻¹ soil application while least was recorded in no Zinc application. The reason for increase in biological yield might be that zinc application increased vegetative growth of the plant which resulted in greater biomass accumulation. Our results are in line with the result of [11] who reported that the unavailability of zinc may contribute to growth reduction in terms of lesser biomass production. More biological yield was recorded for Zincol and less was recorded for Atta Habib. The probable reason for the better response is that different varieties respond differently to zinc application method.

Grain yield of wheat varieties was affected by different application methods of zinc. More grain yield was recorded with 1%

foliar + 1% priming + 15 kg ha⁻¹ soil application method while less was recorded with no zinc application. Higher grain yield was observed for Zincol and least was recorded for Atta Habib. This might be due to the fact that different varieties have different genetic make-up and hence respond differently to different zinc application method. [22] Also reported that zinc application methods increased the grains yield of wheat significantly.

The different zinc application methods showed significant impact on harvest index of wheat. Higher harvest index was recorded at 15 kg h⁻¹ soil application while minimum was recorded in those plots where 1% priming with ZnSO₄ + 15 kg ha⁻¹ soil application was applied. Our results are in line with those of [23] who reported maximum harvest index for higher dose of zinc. While varieties showed non-significant impact on harvest index.

Conclusion

It is concluded from the above finding that Zinc application method of 1 % foliar + 1 % priming + 15 kg ha⁻¹ soil Zn application produced higher grain yield of wheat. Zincol variety produced more productive tiller m⁻², spike per m², and 1000 seed weight, grains spike⁻¹ and grain yield as compared to Atta Habib. Variety Zincol and Zinc application method consisting of 1 % foliar with ZnSO₄ + 1% priming with ZnSO₄ + 15 kg ha⁻¹ soil application is recommended for achieving maximum yield and yield components of wheat.

Authors' contributions

Conceived and designed the experiments: N Aziz & S Anwar, Performed the experiments: N Aziz, Analyzed the data: N Aziz, S Anwar & J Ahmad, Contributed materials/ analysis/ tools: S Kashmir, B Saeed & S Khan, Wrote the paper: S Anwar & J Ahmad.

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