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Research Article

Improving the production of barley genotypes by foliar application of micronutrients

Anjum[1], Bashir Ahmad[1], Muhammad Islam[1*], Muhammad Ibrar[2], Zahid Hussain[3] and Wajid Ali Shah[3]
1. Department of Agronomy, The University of Agriculture, Peshawar-Pakistan
2. Department of Horticulture, The University of Agriculture, Peshawar-Pakistan
3. Department of Agronomy, Bacha Khan University, Charsadda-Pakistan
**Corresponding author's email*: islamswati439@yahoo.com

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Abstract

A field experiment on "improving the production of barley genotypes by foliar application of micronutrients" was carried out at Agronomy Research Farm, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa-Pakistan, during 2013-14. Two barley genotypes [G1=2-Row barley and G2=6-Row barley] and foliar application of two micronutrients Zn and Cu [MN_1=Control (water spray), MN_2=4 kg Zn ha^{-1}, MN_3=1.0 kg Cu ha^{-1}, MN_4=4 kg Zn ha^{-1} + 1.0 kg Cu ha^{-1}] were tested in the experiment. The experiment was laid out in a randomized complete block design (RCBD) replicated three times. The plot size 1.8m x 3m, having 30 cm row to row distance was used. Results evaluated that 2-row barely produced maximum numbers of tillers plant^{-1} (7), plant height (98.9 cm), long spikes (9.1cm), and thousand grains weight (52.5 g), while 6-row was efficient to produced more grains spike^{-1} (54) and grain yield (3990 kg ha^{-1}). Application of micronutrients revealed that combine application of zinc and copper improved yield and yield components of barley. Maximum tillers plant^{-1} (7), plant height (92.3 cm), spike length (9.0 cm), grains spike^{-1} (44), thousand grains weight (53.8g) and grain yield (3934kg ha^{-1}) was produced by combine application of Zn and Cu followed by sole Zn application as compared to control. Therefore it can be concluded from the results that 6-row barley performed better in terms of grain yield and combine application of Zn and Cu enhanced all yield components.

Keywords: Barley (*Hordeum vulgare* L.); Genotypes; Micronutrients; Yield and yield components

Introduction

Barley (*Hordeum vulgare* L.) is the important cereal crop of dry areas in many countries of Middle East, West Asia and North Africa [1] and is essential for the livelihood of many poor farmers due to its tolerance to drought, so it could replace wheat as the dominant crop [2]. It is considered as one of the most important cereals for primary sources of food in the world. It is a key source of food in many African countries and in Pakistan it is mainly grown for grain and straw for small ruminants in winter with the green fodder [3]. Local varieties show no response or little to fertilizer [4]. Few improved varieties of barley are now available and some of these are resistant to cold, drought and disease [3]. There is therefore considerable potential for the adoption of improved varieties and technology to contribute for improving the livelihoods of farmers in Khyber Pakhtunkhwa and similar environments. There are two genotypes of barley (two row and six row barley).Two row barley have two rows of main florets which present on the opposite sides of the rachis, fertile and produce seeds. There are two axillary (side branch) florets with each of these main florets. The axillary florets are infertile in two row barley and fertile in six row types [5]. Two-row barley seeds are symmetrical and of an even size, so they have a tendency to absorb water at same rate and germinate. Six-row barley is symmetrical center but the two lateral rows of seeds are a little shorter and thinner so they are different in water uptake and germination speed [6]. Micronutrients play a vital role in plant nutrition and plant production. Agricultural soils generally show iron, copper and zinc deficiency. The deficiency of micronutrients may be primary which occur due to their low contents or secondary which caused by soil different factors that reduces their availability to plants [7]. Zinc and copper are important in many plant enzyme systems which act as bridges to connect the enzyme with the substrate upon which it is to act. Zinc is one of the important essential trace elements for the normal healthy growth and reproduction of crop plants. It is required by the plant tissues in relatively small concentrations (5-100 mg kg^{-1}) [8]. Zinc concentration of plants is also affected by organic matter, water situation, and texture of the soils [9]. Normal growth and metabolism of plants is affected by copper which is an essential micronutrient. The requirement of these micro elements can be restored by application to the soil or spray on the foliage. The role of essential microelements copper and zinc was proved in forming of more than 200 enzymes [10]. Lack of copper hinders nitrogen uptake and protein synthesis. It plays an important role in transpiration metabolism and electron transport. Micronutrient deficiency can greatly disturb plant yield and quality, and the health of domestic animals and humans [11]. Thus keeping in view the importance of Zn and Cu in crop production the present experiment was conducted to study the effect of foliar application of Zn and Cu on barley genotypes.

Materials and methods

A field experiment on “improving the production of barley genotypes by foliar application of micro-nutrients” was conducted at Agronomy Research Farm, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa Pakistan, during 2013-14. Two barley genotypes [G1=2-Row barley and G2=6-Row barley] and foliar application of two micronutrients Zn and Cu [MN_1=Control (water spray), MN_2=4 kg Zn ha^{-1}, MN_3=1.0 kg Cu ha^{-1}, MN_4=4 kg Zn ha^{-1}+1.0 kg Cu ha^{-1}] were tested in the experiment. The experiment was laid out in a randomized complete block design (RCBD) replicated three times. The plot size 1.8m x 3m, having 30 cm row to row distance was used. Zinc sulfate and Copper sulfate were used as source of Zn and Cu respectively. These micro nutrients were applied before boot stage. All other agronomic practices were uniformly maintained for all plots. Data were collected on tillers $plant^{-1}$, plant height (cm), spike length (cm), grains number $spike^{-1}$, thousand grains weight and grain yield (kg ha^{-1}). Data on number of tillers $plant^{-1}$ were recorded by counting tillers of 5 randomly selected plants in each plot and then averaged. Plant height was measured in randomly selected 10 plants from ground to the top of plant with the help of meter rod apart from awns at maturity. Spike length was measured in randomly selected 10 spikes from end to top without awns length and was averaged. Grains spike^{-1} was recorded by counting grains in randomly selected five spikes in each plot and was averaged simply. Thousand grains weight was recorded on electronic balance after counting thousand grains from the seed lot of each sub plot through laser counting machine. The four central rows of each plot were harvested, sun dried and threshed. The grain weighed and converted in to kg ha^{-1} using the following formula:

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain yield} \times 10000}{\text{R-R distance (m)} \times \text{row length (m)} \times \text{No. of rows}}$$

Statistical analysis

Data was statistically analyzed according to the procedure described by [12] for randomized complete block design and means were separated by least significant differences test ($P \leq 0.05$) upon significant F-test.

Results and discussion

Tillers plant^{-1}

Barley genotypes, foliar spray of micronutrients and G x MN interaction had significant effect on tillers plant^{-1} (Table 1). Higher number of tillers plant^{-1}(7) was produced by 2 row barley while minimum number of tillers plant^{-1}(6) was produced by 6-row barley. These results are in line with [13] who reported that number of shoots was higher for 2-row as compared to 6-row barley. Application of micronutrients revealed that more tillers plant^{-1}(7) were produce by sole application of zinc as well as combine application of Zn + Cu. Considerably lower number of tillers plant^{-1}(6) recoded where micronutrients were not applied or Cu was applied alone. Our findings are similar with [14] who reported that micronutrients in form of soil fertilizer or solution spray increased number of tillers. Regarding the interaction between G x MN, more number of tillers plant^{-1} were recorded in all genotypes when Cu and Zn were applied in combination (Figure 1a).

Table 1. Tillers plant^{-1}, plant height and spike length of barley genotypes as affected by micronutrients

Treatments	Tiller plant plant^{-1}	Plant height (cm)	Spike Length (cm)
Barley Genotypes (G)			
2-Rows barley	7 a	98.90 a	9.1 a
6-Rows barley	6 b	83.60 b	8.2 b
LSD value	0.3	1.4	0.18
Micronutrients (MN)			
Control (no use of nutrients)	6 b	90.12 b	8.4 c
Copper (Cu)	6 b	91.23 ab	8.6 bc
Zinc (Zn)	7 a	90.34 b	8.7 b
Cu + Zn combination	7 a	92.3 a	9 a
LSD value	0.43	2	0.26
LSD value for interaction			
G x MN	*	ns	*

Means with different letters differ significantly according to Least Significant Difference (LSD) test (*P<0.05*), ns stands for non-significant difference, and* at $P < 0.05$ level, respectively

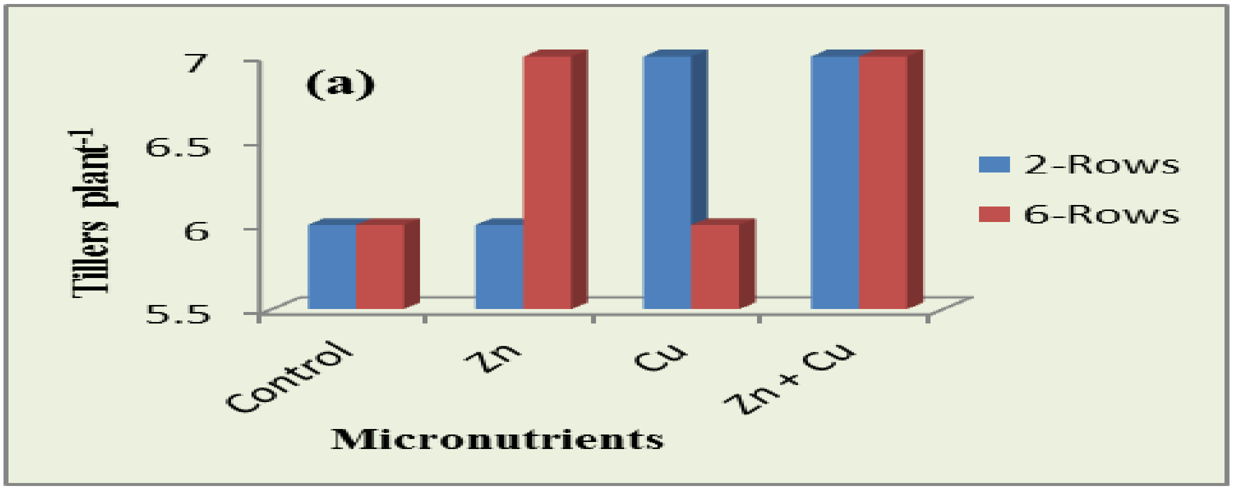

Figure 1a. Tillers plant^{-1} of barley genotypes as affected by micronutrients

Plant height (cm)

Data regarding plant height of barley as affected by genotypes and micronutrients are presented in Table 1. Barley varieties had also a significant effect on plant height Taller plants were produced by 2-row barley (98.9cm) and short stature plants were produced by 6-row barley (83.6 cm). It might be due to the genetic superiority of 2-row barley. Findings are similar with **[15]** who reported that 2-row barley has potential to produce maximum dry matter. Foliar spray of micronutrients had a significant effect on plant height. Zinc and Copper combine foliar spray improved plant height more than the remaining treatments. Greater plant height (92.3 and 91.23 cm) was recorded with sole application of Cu and Zn+Cu in combination. Control and Zn application lead to lower plant height (90.12 and 90.34 cm respectively). It might be due to zinc and Copper which improve nitrogen absorption, protein synthesis and photosynthesis. Findings are similar to **[16, 17]** who stated that addition of these nutrients improved yield components. The interactive effect of G x MN was found non-significant.

Spike length (cm)

Data concerned with spike length of barley as affected by genotypes, application of micronutrients are presented in Table 1. Statistical analysis of data showed spike length of barley significantly varied by genotypes, micronutrients application and G x MN interaction. Two-row barley genotype produced lengthy spikes (9.1 cm) while 6-row barley produced shorter spikes (8.2 cm). These findings are supported by **[18]** who found significant variation in spike length of barley varieties. Spike length was also significantly affected by foliar spray of micronutrients. Application of Zn and Cu in combination produced long spikes (9 cm), followed by sole application of Zn or Cu (8.6 and 8.6 cm, respectively) however, shorter spikes were observed in control plots. Such enhancing effect might be due to the influence effect of zinc on metabolism and biological activities and stimulating effect of copper on enzyme activities which in turn encourage vegetative growth of plants **[19]**. The results are agreed with **[20-22]**. For interaction between G x MN, spike length was enlarged in both genotypes with combine application of Zinc and Copper (Figure 1b).

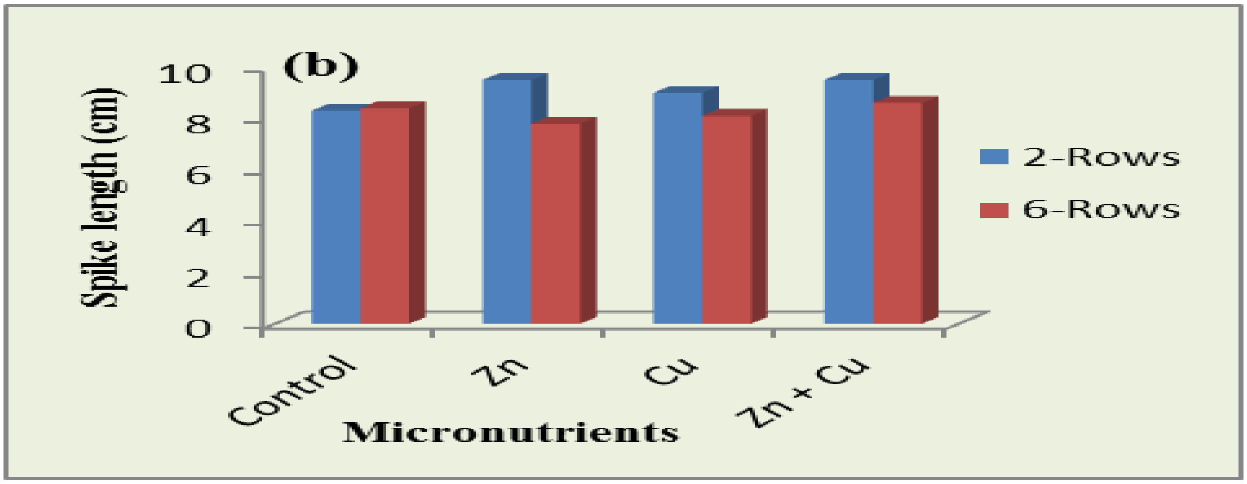

Figure 1b. Spike length of barley genotypes as affected by micronutrients

Grains spike^{-1}
Table 2 revealed grains spike^{-1} of barley considerably varied by genotypes and micronutrients application, whereas G x MN interaction was non-significant. Among the genotypes, 6-row barley produced more number of grains spike^{-1} (54) while lesser (29) were produced by 2-row barley. Usually 2-row barley has a lower number of grains spike^{-1} compensated by higher tillering capacity and 1000 grains weight [23]. Regarding foliar application of micronutrients, More grains (44) were counted for combine application of Zn and Cu, followed by sole application of Zinc (43) while minimum (39) for control. Our results are supported by [24] who found significant increase in grains spike^{-1}, 1000 grains weight and grain yield of barley through Zinc and Copper solution spray.

Table 2. Number of grains spike^{-1}, 1000 grains weight and grain yield of barley genotypes as affected by micronutrients

Treatments	Grains spike^{-1}	Thousand grains weight (g)	Grain yield (kg ha^{-1})
Barley Genotypes (G)			
2-Rows barley	29 b	52.5 a	3681 b
6-Rows barley	54 a	52.1 b	3990 a
LSD value	1.65	0.4	126
Micronutrients (MN)			
Control (no use of nutrients)	39 c	51.4 bc	3688 b
Copper (Cu)	41 bc	52.2 b	3801 ab
Zinc (Zn)	43 ab	52.3 b	3920 a
Cu + Zn combination	44 a	53.3 a	3934 a
LSD value	2.3	0.88	178
LSD value for interaction			
G x MN	ns	**	*

Means with different letters differ significantly according to Least Significant Difference (LSD) test ($P<0.05$), ns stands for non-significant difference, and* at $P < 0.05$ level, respectively

Thousand grains weight (g)

It is evident form statistical analysis of the data that thousand grains weight of barley differed significantly among genotypes, foliar spray of micronutrients (Table 2). Two-row barley produced heavier thousand grains weight (52.2 g) as compared to 6-row barley (52.1 g). These results are in agreement with the investigations of **[13]** who stated that there is negative co relation between numbers of grains spike^{-1} and thousand grains weight due to which the thousand grains weight of 6-row barley was inferior. Foliar application of micronutrients had also a significant effect on thousand grains weight of barley. Heavier thousand grains weight was produced by combine application of Zinc and Copper (53.3 g) as compared to control (51.4 g). **[25]** reported similar results. Zinc may enhance chlorophyll content and also may increase level of indole acetic acid (IAA) a vital hormone necessary for growth and development **[16]**. In case of G x MN interaction, thousand grains weight was increased in both genotypes with combine application of Zinc and Copper (Figure 1c).

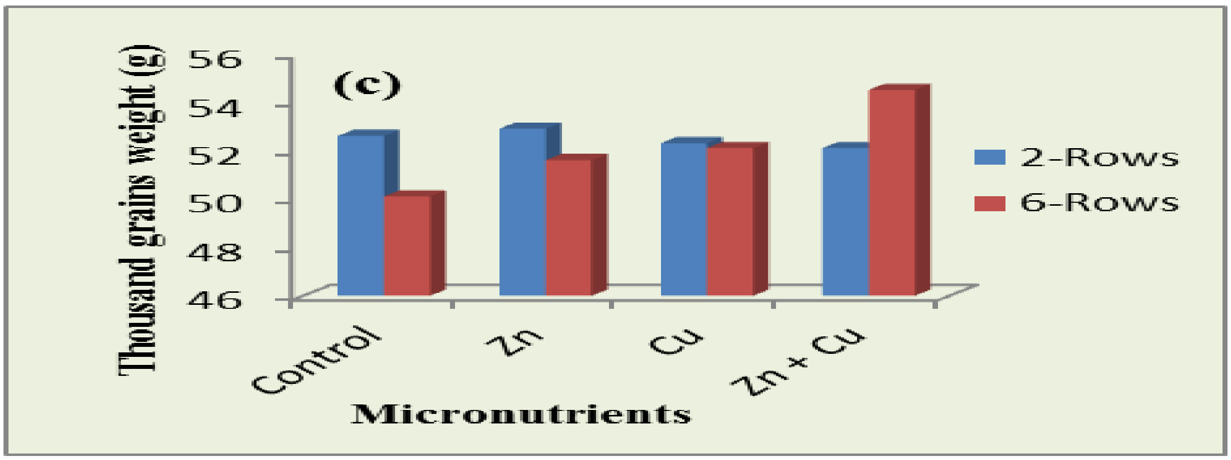

Figure 1c. Thousand grains weight of barley genotypes as affected by micronutrients

Grain yield (kg ha^{-1})

Grain yield of barley considerably differed among genotypes and micronutrients application (Table 2). Regarding barley genotypes, higher grain yield (3990 kg ha^{-1}) was produced by 6-row barley while lower grain yield (3681 kg ha^{-1}) was produced by 2-row barley. It might be due to the more number of grain rows in 6-row barley than 2-row. Results are in line with **[13]** who reported that 6-row barley produced maximum grain yield than 2-row barley. With reference to the application of micronutrients, more grain yield was produced by Zn+Cu application (3934 kg ha^{-1}) and sole application of Zinc, while less was produced by control (3688 kg ha^{-1}). Zinc takes part in conversion of ammonia to nitrate in plant **[16, 26]**. Addition of Copper to barley would increase grain yield components **[17, 26]**. The interactive effect of G x MN showed that grain yield was increased in both genotypes with combine application of Zinc and Copper (Figure 1d).

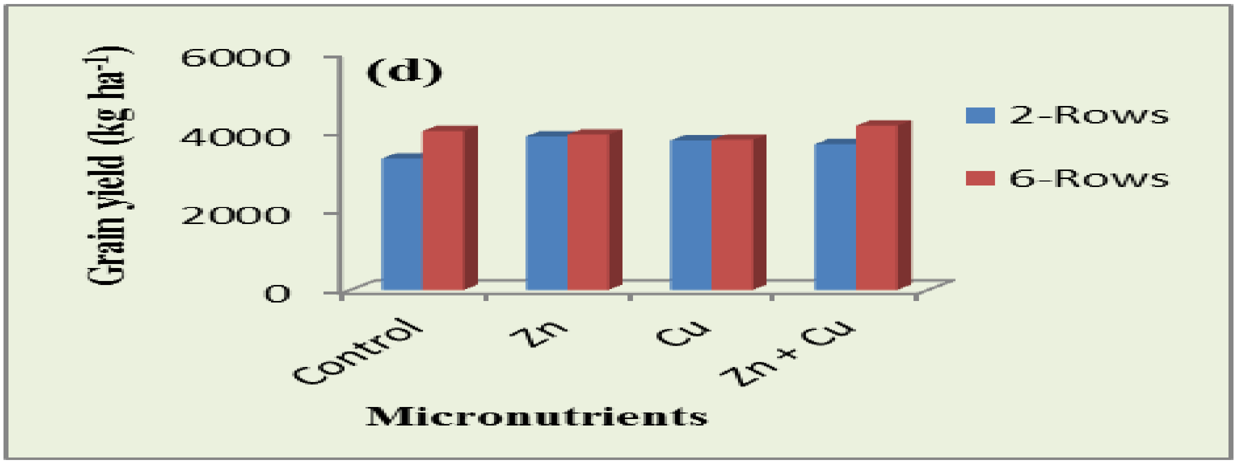

Figure 1d. Grain yield of barley genotypes as affected by micronutrients

Conclusion and recommendations

It has been concluded from the above results that foliar spray of micronutrients (Zn & Cu) in combination produced higher grains spike^{-1}, biological yield and grain yield. In genotypes of barley, 6-row barley performed better in terms of number of grains spike^{-1} and grain yield than 2-row barley. Thus 6-row barley and the application of Zn+Cu are recommended for higher production of barley.

Authors' contributions

Conceived and designed the experiments: Anjum & B Ahmad, Performed the experiments: Anjum, Data collection and field inspections: Anjum, M Islam & M Ibrar, Statistical Analysis of the data: Anjum, B Ahmad, WA Shah, & Z Hussain, Contributed reagents/ materials/ analysis tools: M Ibrar & B Ahmad, Wrote the paper: Anjum & M Islam.

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