INFLUENCE OF ZINC AS SOIL AND FOLIAR APPLICATION ON GROWTH AND YIELD OF OKRA (Abelmoschus Esculentus L.)

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Abstract
An experiment was carried out at New Developmental Farm (NDF) Horticulture section Khyber Pakhtunkhwa, Agricultural University Peshawar, during summer 2011 to study the influence of zinc as soil and foliar application on growth and yield of okra (Abelmoschus Esculentus L.). The experiment was laid out in randomized complete block design with split plot arrangement with three replications. Methods of zinc application (soil application and foliar application) were assigned to main plots whereas, zinc levels (0, 2, 4, 6 and 8 kg ha\textsuperscript{-1}) subjected to sub plots. The data on days to 50 \% flowering, plant height (cm), number of leaves plant\textsuperscript{-1}, number of branches plant\textsuperscript{-1} and total pod yield (tones ha\textsuperscript{-1}) was significantly increased by different methods of zinc application. Soil application of zinc gave more number of days (51.53) to 50 \% flowering, whereas, more plant height (168.27 cm), number of leaves plant\textsuperscript{-1} (29.20), number of branches plant\textsuperscript{-1} (3.46) and total fresh pod yield (13.47 tones ha\textsuperscript{-1}) was recorded in foliar method of zinc application. A significant response to various levels of zinc was also observed for most of vegetative and reproductive attributes of okra. However, the application of Zn at the rate of 2 kg ha\textsuperscript{-1} showed more plant height (177.40 cm), number of leaves plant\textsuperscript{-1} (34.83), number of branches plant\textsuperscript{-1} (4.63) and total pod yield ha\textsuperscript{-1} (14.81 tons). More number of days (51.17) to 50\% flowering was observed in untreated plants and in plants fertilized with zinc at 4 kg ha\textsuperscript{-1}. It is concluded from experimental results that 2 kg ha\textsuperscript{-1} zinc when applied as a foliar spray resulted in higher fresh pod production of okra under the agro climatic conditions of Peshawar.

Key Words: Okra, vegetative parameters, yield, zinc application method and zinc levels

INTRODUCTION

Okra (Abelmoschus esculentus L.) belongs to family Malvaceae came to existence in the tropical Africa and grown in Mediterranean region while its wild forms are also found in India. The edible portion of okra (summer crop) is the young tender pods which is usually cooked in curries, stewed and used in soups. Okra is a good and rich source of protein, minerals, iodine and vitamins A, B and C. The brown or black white-eyed seeds of okra are used as a substitute for coffee when ripped. Fiber is provided by the okra stem usually used in the paper industry (Qayyum, 1990). The total production of okra in Pakistan is 114.657 thousand tones and is cultivated on an area of 15.081 thousand hectare. The total area under okra cultivation in Khyber Pakhtunkhwa is 2.126 thousand hectare with a production of 18.156 thousand tons annually (MINFA, 2009). Okra can grow vigorously in all type of soil, but prefer well
manure medium loam and friable soil. It is slightly acid tolerant plant and optimum pH ranges from 6-6.8 (Sadiq et al. 1998). For the appropriate growth, pod development and flowering, 21-30 °C should be the average monthly temperature (Tindall, 1983 and Nonnecke, 1989).

Micronutrients increase the crop yield by 15-30% in calcareous soils (Malakouti, 2008). Zinc deficiency rate was characterized as a 30 % in the world (Sillanpaa, 1982). Zinc plays an important role in the plant, of which the most significant is its activity as component of a number of enzymes (dehydrogenase, peptidase and phosphohydrolases). About 70 % soils in Pakistan under cultivation are deficient in zinc (Rashid, 1996). Foliar application of nutrients are considered to be the best recurrent method rather a soil for supplying nutrients to plants, in larger amount (Swietlik and Faust, 1984). Due to quick response to fertilizer and uniform distribution, foliar application has an advantage of low application rate, similarly hidden hunger can also be handled effectively (Umer et al. 1999). So, further investigation is needed to explore the effect of Zinc as soil vs. foliar application for better growth and fresh pod yield of okra.

MATERIAL AND METHOD

To study the “Influence of Zinc as soil and foliar application on growth and yield of okra (Abelmoschus esculentus L.)” an experiment was conducted at New Developmental Farm (NDF) Horticulture section, The university of Agriculture Peshawar-Pakistan during 2011, to find out the optimum dose and most suitable method of zinc application for better growth and fresh pod yield of okra.

Number of days to 50% flowering: Ten plants in each plot was selected at random and their dates to 50 % flowering was recorded, by counting the number of days from date of sowing to 50 % flowering.

Plant height (cm): The plant height was recorded on ten randomly selected plants in each treatment from ground level to the tip of plants by means of measuring tape and average height of a plant was calculated in centimeters.

Number of leaves plant\(^{-1}\): The data were determined by counting the number of leaves of ten randomly selected plants for all treatments in each replication and their average was calculated.

Number of branches plant\(^{-1}\): Total number of branches was counted from ten randomly selected plants of each treatment and their average was calculated.

Fresh Pod Yield (tones ha\(^{-1}\)): The fresh pod yield collected of all pickings from each treatment was recorded and total fresh pod yield from each plot was recorded in tones and yield ha\(^{-1}\) was calculated by using the following formula.

\[
\text{Yield tones ha}\(^{-1}\) = \frac{\text{pod weight per sub plot}}{\text{Area of sub-plot (m}\(^2\)\) \times 10000m}\(^2\)}
\]

Statistical procedure: Analysis of variance technique was used for data analysis, if differences were noticed between treatments and their interaction. Least significant difference test was used for the comparison of their means. Statistical computer software, MSTATC (Michigan State University, USA), was used for calculating both the ANOVA and LSD (Steel et al. 1997).
RESULTS AND DISCUSSION

Number of days to 50 % flowering: The data on number of days to 50% flowering indicated that significant differences were observed in okra with different levels of zinc, methods of application as well as their interaction (Table 1). The highest number of days (51.5d) to 50% flowering was observed in plots where zinc was applied as soil while the foliar application of zinc resulted in earlier 50% flowering (50.1d). The flowering delayed (51.2 d) in control plants (untreated with zinc) and it was at par with the plots each received zinc at the rate of 4, 6, and 8 kg ha\(^{-1}\) but statistically different from plots where zinc applied at the rate of 2 kg ha\(^{-1}\), where earlier flowering occur (49.83). Interaction between zinc levels and method of application revealed that highest number of days (51.67 days) to 50% flowering was observed in the plants, received zinc 0, 4 and 8 kg ha\(^{-1}\) as a soil application whereas, the lowest days to 50 % flowering (48.33) noted in the plant where foliar spray of zinc used at the rate of 2 kg ha\(^{-1}\). The decrease in days to 50 % flowering might be due to the fact that zinc is the activator of certain biological activities that induce flowering but as its levels are further increased so as a micronutrient toxicity also get increased hence it may affect the days to flowering. The decrease in number of days to 50 % flowering may be that foliar applied zinc get absorbed directly and quickly by the leaves of okra and hence induces the biological activities for flowering. In soil application the availability of zinc get decreased by high level of soil pH, lime content and phosphates which have a negative effect on the availability of zinc. The results obtained by Yousaf et al. (2007) are of primary importance who reported that zinc application significantly increased the okra growth and yield components of okra. The results are in line with Nasreen et al. (2009), reported that by the application to zinc, boron and poultry manure significantly increased the vegetative growth components as well as bulb yield of onion.

Plant height (cm): The data regarding plant height revealed that methods of zinc application, zinc levels and also their interaction significantly influenced the plant height of okra (Table 2). The application of zinc as foliar spray resulted in more plant height (168.27 cm) as compared to plant height (161.84 cm) from soil application. The highest plant height (177.40 cm) was observed in plants that received zinc at the rate of 2 kg ha\(^{-1}\) followed by 175.27 cm in plants fertilized with zinc at the rate of 4 kg ha\(^{-1}\) however, statistically at par with each other. While the lowest plant height (145.07 cm) was observed in control plants. The maximum plant height (181.77 cm) was observed in plants where zinc was applied as foliar spray at the rate of 2 kg ha\(^{-1}\), which was different from the rest of the treatments. However, the least plant height (142.87 cm) was observed in control plants. The increment in plant height in relation to the application of zinc is due to the formation of auxin in the apical portion of the plant (Lindsay, 1972). This promotes the height of the plant but as the dose of zinc exceeds from its optimum level or absence of zinc application reduces the plant height. It might be due to the toxic effect as well as unavailability of zinc respectively. Foliar applied zinc may promote plant height due to ease in availability of zinc to plant leaves which works in promotion of plant height. On the other hand soil applied zinc is less available to plants due to lime content and applied phosphorous fertilizer. El-Tohamy et al. (2009) reported that essential oil, growth and yield of onion plants significantly increased by the application of Fe, Zn and Mn compared to control plants which were in close relation with our results. Similarly increasing zinc levels resulted in increasing plant height, of okra (Naruka et al., 2000).

Number of leaves plant\(^{-1}\): Methods of zinc application, zinc levels and their interaction had a significant effect on number of leaves plant\(^{-1}\) of okra (Table-3). More number of leaves plant\(^{-1}\) (29.2) were observed in plants where zinc was applied as foliar spray as compared to soil application (26.7). More number of leaves plant\(^{-1}\) (34.8) was recorded in plots where zinc was applied at the rate of 2 kg ha\(^{-1}\), followed by plots where zinc was applied at rate of 4 kg ha\(^{-1}\) (32.3) which were statistically at par with each other. The least number of leaves plant\(^{-1}\) (20.3) were recorded in untreated plots. More number of leaves plant\(^{-1}\) (41.0) was recorded in plots where foliar spray of zinc was applied at rate of 2 kg ha\(^{-1}\) while the plants in control treatments in soil application method gave the least number of leaves plant\(^{-1}\) (19.0). Metabolism of protein and carbohydrates, RNA and Ribosome formation might
be the reason for the formation of more number of leaves, which was activated by zinc (Lindsay, 1972), resulting in increase in number of leaves as compared to the controlled and high levels of zinc. The direct availability of zinc due to foliar spray increase the absorption rate as well as formation of more number of leaves as compared to soil applied zinc. Our results matched with the findings of Yousaf et al. (2007) who found that zinc foliar application significantly enhanced the growth and yield components of okra. Similarly Alam et al. (2010) found that the response of micronutrients for onion growth and yield in calcareous soils are significantly influenced by the application of zinc.

Table 1: Zinc levels and their application methods affected the number of days to 50 % flowering of okra.

<table>
<thead>
<tr>
<th>Zn methods</th>
<th>Zinc application rate (kg ha⁻¹)</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>2 kg ha⁻¹</td>
</tr>
<tr>
<td>Foliar</td>
<td>21.67</td>
<td>41.00</td>
</tr>
<tr>
<td>Soil</td>
<td>19.00</td>
<td>28.67</td>
</tr>
<tr>
<td>Means</td>
<td>20.33 c</td>
<td>34.83 a</td>
</tr>
</tbody>
</table>

LSD value for zinc levels at 5% level of probability = 0.724
LSD value for interaction at 5% level of probability = 1.024
Means followed by the same letter (s) do not differ significantly from one another at 5% probability level, using LSD test.

Table 2: Effect of Zinc application rate and methods on number of days to 50 % flowering of okra.

<table>
<thead>
<tr>
<th>Zn methods</th>
<th>Zinc application rate (kg ha⁻¹)</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>2 kg ha⁻¹</td>
</tr>
<tr>
<td>Foliar</td>
<td>50.67</td>
<td>48.33</td>
</tr>
<tr>
<td>Soil</td>
<td>51.67</td>
<td>51.33</td>
</tr>
<tr>
<td>Means</td>
<td>51.17 a</td>
<td>49.83 b</td>
</tr>
</tbody>
</table>

LSD value for zinc levels at 5% level of probability = 3.304
LSD value for interaction at 5% level of probability = 4.673
Means followed by the same letter (s) do not differ significantly from one another at 5% probability level, using LSD test.

Number of branches plant⁻¹: There was a significant variation in number of branches plant⁻¹ among the different doses of zinc, methods of application and the interaction between zinc levels and methods of zinc application (Table 4). The mean values for method of zinc application showed that when zinc was applied s foliar spray resulted in more number of branches plant⁻¹ (3.46) as compared to zinc applied to soil. The highest number of branches plant⁻¹ (4.63) were observed in plots where zinc was applied at rate of 2 ka ha⁻¹ which was statistically different from the rest of the treatments. The least number of branches plant⁻¹ (2.53) was recorded in plots received zinc at the rate of 4 kg ha⁻¹. The highest number of branches plant⁻¹ (5.33) were observed in plants where zinc was applied at the rate of 2 kg zinc ha⁻¹ as foliar spray which was at par with the rest of interaction treatments. However, the less number of branches plant⁻¹ (2.20) was recorded in plants, received zinc at the rate of 6 kg ha⁻¹ and 8 kg ha⁻¹ in soil. Zinc increases the number of branches plant⁻¹ due to the working of zinc in the formation of RNA, Ribosome and also works in the metabolism of carbohydrates, protein and phosphate fertilizer (Lindsay, 1972). This enhanced the nutritional status of the plants which resulted in more number of branches. The foliar application of zinc increased the availability of nutrients to the plant. Which is directly absorbed to the plant leaves and translocate the prepared food by different parts of the plant and hence growth of the plant occurs. The findings of Abbasi et al. (2005) are of primary importance, who reported that the application of Agripower significantly increased the number of branches of
okra. Similarly the application of Zn along with N, P, and S fertilizers would be profitable for garlic cultivation (Nasreen et al., 2009).

Fresh pod yield (t ha\(^{-1}\)): The data regarding fresh pod yield revealed that methods of zinc application, zinc levels and their interaction significantly influenced the total fresh pod yield of okra (Table 5). The foliar application of Zinc resulted in higher pod yield ha\(^{-1}\) (13.47 t ha\(^{-1}\)) as compared to soil application of zinc (12.45 t ha\(^{-1}\)). More pod yield ha\(^{-1}\) (14.81 t ha\(^{-1}\)) was observed in plants received zinc at the rate of 2 kg ha\(^{-1}\) which was significantly different from the rest of the treatments, followed by plants fertilized with zinc at the rate of 4 kg ha\(^{-1}\) (13.31 t ha\(^{-1}\)) while the lowest pod yield ha\(^{-1}\) (11.33 t ha\(^{-1}\)) was observed in control plants where zinc was not applied. More pod yield ha\(^{-1}\) (17.22 t ha\(^{-1}\)) was observed in plants where zinc was applied as foliar spray at the rate of 2 kg ha\(^{-1}\), which was different from the rest of the treatment followed by 14.05 kg with foliar applied zinc at the rate of 4 kg ha\(^{-1}\) while least pod yield ha\(^{-1}\) (11.26 t ha\(^{-1}\)) was observed in plants untreated with zinc in foliar application method. Zinc at optimum level increases the metabolic activities and is a part of different enzymes which plays a vital role in increasing the growth and yield of a plant. While increasing the zinc levels might cause toxic effects which drastically decrease the yield. The foliar application is efficient in reducing the deficiency of nutrients in plants due to quick and direct response of a plant to the applied fertilizer as compared to soil application method (Malakouti, 2008). The results of Selvi and Rani (2000) are in close relation with our results, who reported that yield, income and cost benefit ratio of okra plants were significantly affected from foliar applied microfood along with NPK as compared with soil application. Similarly Alam et al. (2010) reported that zinc application significantly increased the yield of onion in calcareous soils.

### Table 3: Effect of Zinc application rate and methods on number of leaves plant\(^{-1}\) of okra.

<table>
<thead>
<tr>
<th>Zn Application methods</th>
<th>Zinc application rate (kg ha(^{-1}))</th>
<th>Control</th>
<th>2 kg ha(^{-1})</th>
<th>4 kg ha(^{-1})</th>
<th>6 kg ha(^{-1})</th>
<th>8 kg ha(^{-1})</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliar</td>
<td></td>
<td>11.40</td>
<td>17.22</td>
<td>14.05</td>
<td>12.50</td>
<td>12.19</td>
<td>13.47 a</td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td>11.26</td>
<td>12.40</td>
<td>12.57</td>
<td>12.99</td>
<td>13.05</td>
<td>12.45 b</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>11.33 d</td>
<td>14.81 a</td>
<td>13.31 b</td>
<td>12.74 c</td>
<td>12.62 c</td>
<td></td>
</tr>
</tbody>
</table>

LSD value for zinc levels at 5% level of probability = 7.275
LSD value for interaction at 5% level of probability = 10.29
Means followed by the same letter (s) do not differ significantly from one another at 5% probability level, using LSD test.

### Table 4: Effect of Zinc application rate and methods on number of branches plant\(^{-1}\) of okra.

<table>
<thead>
<tr>
<th>Zn Application methods</th>
<th>Zinc application rate (kg ha(^{-1}))</th>
<th>Control</th>
<th>2 kg ha(^{-1})</th>
<th>4 kg ha(^{-1})</th>
<th>6 kg ha(^{-1})</th>
<th>8 kg ha(^{-1})</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliar</td>
<td></td>
<td>142.87</td>
<td>181.77</td>
<td>175.40</td>
<td>176.83</td>
<td>164.50</td>
<td>168.27 a</td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td>147.27</td>
<td>173.03</td>
<td>175.13</td>
<td>160.20</td>
<td>153.57</td>
<td>161.84 b</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>145.07 d</td>
<td>177.40 a</td>
<td>175.27 a</td>
<td>168.52 b</td>
<td>159.03 c</td>
<td></td>
</tr>
</tbody>
</table>

LSD value for zinc levels at 5% level of probability = 0.249
LSD value for interaction at 5% level of probability = 0.350
Means followed by the same letter (s) do not differ significantly from one another at 5% probability level, using LSD test.
Table 5: Effect of Zinc application rate and methods on fresh pod yield of okra.

<table>
<thead>
<tr>
<th>Zn Application methods</th>
<th>Zinc application rate (kg ha(^{-1}))</th>
<th>Control</th>
<th>2 kg ha(^{-1})</th>
<th>4 kg ha(^{-1})</th>
<th>6 kg ha(^{-1})</th>
<th>8 kg ha(^{-1})</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliar</td>
<td></td>
<td>2.87</td>
<td>5.33</td>
<td>2.33</td>
<td>3.57</td>
<td>3.20</td>
<td>3.46 a</td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td>2.83</td>
<td>3.93</td>
<td>2.73 d</td>
<td>2.20</td>
<td>2.20</td>
<td>2.78 b</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>2.85 b</td>
<td>4.63 a</td>
<td>2.53 c</td>
<td>2.88 b</td>
<td>2.70 bc</td>
<td></td>
</tr>
</tbody>
</table>

LSD value for zinc levels at 5% level of probability = 0.406
LSD value for interaction at 5% level of probability = 0.574
Means followed by the same letter (s) do not differ significantly from one another at 5% probability level, using LSD test.

CONCLUSION

Zinc both soil and foliar application increased the fresh pod yield of okra however the foliar application of zinc was comparatively better than soil application in term of pod yield and growth characteristics of okra. Zinc application at rate of 2 kg ha\(^{-1}\) substantially enhanced fresh pod yield and growth characteristics of okra and hence the foliar application of zinc at rate of 2 kg ha\(^{-1}\) is recommended for higher okra productivity in agro-ecological condition Peshawar Valley.

REFERENCES


