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# GROWTH, YIELD AND QUALITY OF *Rosa hybrida* L. AS INFLUENCED BY VARIOUS MICRONUTRIENTS

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The study was undertaken to investigate the effect of foliar application of different micronutrients (B, Zn & Fe; 0.5%, 1.5% and 1%, respectively) on plant growth and flowering of three rose (*Rosa hybrida* L.) cultivars viz. Kardinal, Amalia and Rosy Cheeks. Nutrients were applied alone and with different combinations after 6, 8 and 10 weeks of pruning. Plant height, number of leaves branch$^{-1}$, leaf area, number of flowers plant$^{-1}$, flower stalk length and leaf Zn contents were maximum with B + Zn application followed by only B application which also resulted early flower production as compared to rest of the treatments while bud diameter, flower diameter, as well as fresh & dry weight of flowers were maximum with B application alone followed by combination of B + Zn application. Leaf chlorophyll contents, Flower quality, flower stalk diameter and Leaf B & Fe contents were highest when plants were sprayed with combination of all micronutrients. Plants without micronutrients application produced poor quality vegetative growth and less number of flowers. Regarding cultivars, Rosy Cheeks responded well to micronutrients as compared to Amalia and Kardinal. It is concluded that application of micronutrients could help better to improve flower yield and quality of roses.
**Keywords:** Rose, boron, zinc, iron, nutrition, flowering

## INTRODUCTION

Rose, a symbol of affection, elegance, inspiration, sensuality, spirituality and source of aesthetic gratification for human beings, is one of the leading cut flowers in global floriculture trade. It belongs to family Rosaceae and genus Rosa, which contains 200 species and more than 18,000 cultivars (Gudin, 2000). It has always been the most favorite flower in the subcontinent. There is hardly any event where roses are not displayed in varied fashion. Cut rose flowers play an important role in event decoration and add charm to different occasions like marriage ceremonies, arrival and departure of different dignitaries, birthdays, Valentine's Day etc. Pakistan being an agricultural country with diverse agro climatic conditions has a great potential for the production of cut rose flowers. According to a survey, roses are being grown as cut flowers on 1,300 acres of land in Punjab (Khan, 2005).

Alongwith other plant management practices, proper ratio of macro and micronutrients is indeed a secret of success and help to increase yield by enhancing the number and size of flowers. In order to maximize productivity and quality, adequate quantities of nutrients must be supplied to plants. Foliar application is one of the best ways to supply micronutrients to plants (Cabrera *et al.,* 1993). Spraying of three-year-old hybrid tea roses cv. Raktagandha with $ZnSO_4$, $FeSO_4$ and $MnSO_4$ or $CuSO_4$ one month after pruning was the most effective to stimulate secondary shoot production and increasing bud length, flower diameter, number of petals flower$^{-1}$ and flower production (Cabrera *et al.,* 1993; Nelson, 1998). Pre-harvest sprays of micronutrients applied twice after pruning to 3-year-old roses cv. Raktagandha, on flower improved the quality and longevity of flowers Singh and Bhattacharjee (1997). Boztok and Cokuysal (2006) reported maximum stem length, number of extra class and first class flowers as well as total yield with application of highest K/Ca ratio (3/1) to greenhouse grown roses. Plants treated with micronutrients exhibited better results with respect to growth, flowering and yield compared to control (Mukesh *et al.,* 2001). Kumar and Arora (2000) observed that foliar application of 0.2% $FeSO_4$ singly or in various combinations at three or six leaf stages of gladiolus induced flowering earlier.

In our country, most of the soils have high pH ultimately binding naturally present micronutrients with soil particles and make them unfavorable to plants required for various metabolic processes. Due to this, flower development and quality of roses is badly affected. To overcome this situation, alternate mean is provision of these micronutrients in the form of foliar spray. Keeping in view the socio economic value of cut rose flowers and emerging needs to standardize the agro technology for commercial rose cultivation, this study was designed to compare the response of some

commercial rose cultivars to foliar application of various micronutrients, for optimization of pre-harvest micronutrients requirement to obtain better flower yield and quality and to investigate the role of specific micronutrients on floral attributes of rose.

## MATERIALS AND METHODS

Present research work was conducted in the greenhouse, Rose Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad (latitude 31°30N, longitude 73°10E and altitude 213m) where the average maximum and minimum temperatures were 30±2°C and 16±2°C, respectively. The average maximum and minimum relative humidity were 73 and 39%, respectively during study period. The plants of three *Rosa hybrida* L. cultivars Kardinal, Amalia and Rosy Cheeks were grown in sand filled trenches (developed in the greenhouse by digging soil) having a length, width and depth of 15.0, 1.0 and 0.6 m, respectively. These trenches were lined with polythene sheet and one year old plants were transplanted at a spacing of 30cm between plants in 60cm spaced rows. Next year, all plants were uniformly pruned to equal height (15 cm above bud union) during first week of January. After six weeks of pruning, when plants started sprouting, first micronutrients application was made according to the treatments up to runoff level while two further applications were repeated at two weeks interval after 1$^{st}$ application. There were three cultivars of *Rosa hybrida* L. viz. Kardinal, Amalia and Rosy Cheeks and seven treatments of micronutrients alongwith a control viz. control (no micronutrients application), B (0.5%), Zn (1.5%), Fe (1%), B + Zn, B + Fe, Zn + Fe and B + Zn + Fe. Boron was applied in the form of Boric Acid ($H_3BO_3$), Zn in the form of Zinc Sulphate ($ZnSO_4.7H_2O$) and Fe in the form of Ferrous Sulphate ($FeSO_4.7H_2O$). The experiment was set up in a Completely Randomized Block Design and the treatment design was a factorial combination of three cultivars and seven micronutrient supplies alongwith a control with no micronutrient application. There were ten plants per treatment and each treatment was replicated thrice. Compound fertilizer having NPK @ 17:17:17 was used as source of macronutrients which was equally applied to all plants alongwith canal water through fertigation @ 2 g $L^{-1}$ of irrigation water (canal water having 0.4 dS $m^{-1}$ EC and 6.9 pH). All other cultural practices like weeding, plant protection measures etc. were same for all treatments during entire period of study. Plants were allowed to grow and data regarding plant height (cm), number of leaves branch$^{-1}$, leaf area ($cm^2$), leaf total chlorophyll contents (mg $g^{-1}$), days to flower emergence, number of flowers plant$^{-1}$, bud diameter (cm), flower diameter (cm), fresh weight of a flower (g), dry weight of a flower (g), flower quality, flower stalk length (cm) and flower stalk diameter (cm) were collected using standard procedures. Leaf B, Zn and Fe contents (mg $L^{-1}$) were also measured by loading the digested leaf samples on atomic absorption spectrophotometer (Chapman and Parker, 1961).
Data collected were analyzed statistically by using the method described by Steel *et al*. (1997).

## RESULTS

The observations recorded on plant height revealed significant (P≤0.01) differences among different micronutrients as well as cultivars. Among different micronutrients, application of B + Zn and B produced taller plants having height of 69.80 and 68.83 cm, respectively (Table 1). Rosy Cheeks proved taller with 78.73 cm plant height whereas Amalia and Kardinal proved short stature cultivars with 53.94 cm and 53.50 cm plant height, respectively (Table 2) and were

**Table 1. Growth indices of *Rosa hybrida* L. as influenced by foliar application of various micronutrients**

| | Plant height (cm) | Number of leaves branch$^{-1}$ | Leaf Area ($cm^2$) | Leaf total chlorophyll contents (mg $g^{-1}$) | Days to flower emergence | Number of flowers plant$^{-1}$ flush$^{-1}$ |
|---|---|---|---|---|---|---|
| Control | 49.63 c | 20.16 cd | 49.74 bd | 42.36 d | 63.08 a | 7.74 d |
| B (0.5 %) | 68.83 a | 27.15 a | 59.83 abc | 55.47 bc | 56.98 b | 11.76 ab |
| Zn (1.5%) | 62.74 ab | 25.28 ab | 58.15 abc | 49.38 c | 58.34 b | 9.40 cd |
| Fe (1%) | 58.02 bc | 24.88 ab | 58.13 abc | 66.23 ab | 58.33 b | 7.95 d |
| B+Zn | 69.80 a | 28.41 a | 62.45 a | 61.66 b | 55.68 b | 13.01 a |
| B+Fe | 66.14 ab | 20.31 cd | 49.34 d | 58.88 b | 56.75 b | 9.50 cd |
| Zn+Fe | 61.76 ab | 18.35 d | 46.48 d | 62.04 b | 63.14 a | 8.81 d |
| B+Zn+Fe | 59.54 ab | 22.34 bc | 53.67 bcd | 69.47 a | 59.51 ab | 12.95 a |

Means sharing similar letter are statistically non-significant at P<0.05

**Table 2. Growth response of various cultivars of *Rosa hybrida* L. subjected to foliar application of various micronutrients**

| | Plant height (cm) | Number of leaves branch$^{-1}$ | Leaf Area (cm$^2$) | Leaf total chlorophyll contents (mg g$^{-1}$) | Days to flower emergence | Number of flowers plant$^{-1}$ flush$^{-1}$ |
|---|---|---|---|---|---|---|
| Kardinal | 53.50 b | 19.36 c | 48.54 c | 53.60 c | 55.02 c | 8.05 c |
| Amalia | 53.94 b | 22.60 b | 53.72 b | 59.82 b | 58.15 b | 11.73 a |
| Rosy Cheeks | 78.73 a | 28.12 a | 61.91 a | 67.24 a | 63.77 a | 9.90 b |

Means sharing similar letter are statistically non-significant at P<0.05

statistically at par with each other. B + Zn and B application produced shoots having maximum leaves (28.41 and 27.15, respectively) followed by Zn and Fe alone which produced 25.28 and 24.88 leaves branch$^{-1}$ and were statistically at par with each other (Table 1). Regarding cultivars, Rosy Cheeks produced maximum leaves branch$^{-1}$ (28.12) followed by Amalia (22.60) while Kardinal produced minimum number of leaves branch$^{-1}$ (19.36) as shown in Table 2. Application of B + Zn produced leaves of maximum area (62.45 cm$^2$) followed by B, Zn and Fe alone which had leaves with 59.83, 58.15 and 58.13 cm$^2$ area, respectively, while Zn + Fe, B + Fe and control (no micronutrients application) produced leaves having minimum area (46.48, 49.34 and 49.74 cm$^2$, respectively) as presented in Table 1. Regarding cultivars, Rosy Cheeks produced maximum leaf area (61.91 cm$^2$) followed by Amalia (53.72 cm$^2$) while Kardinal produced leaves with minimum area (48.54 cm$^2$) as shown in Table 2. As for as leaf total chlorophyll contents were concerned, foliar application of B + Zn + Fe produced leaves having maximum leaf chlorophyll contents (69.47 mg g$^{-1}$) followed by different combinations of two micronutrients together rather than application of individual or no micronutrient application (Table 1). While among cultivars, Rosy Cheeks produced maximum leaf total chlorophyll contents (67.24 mg g$^{-1}$) followed by Amalia (59.82 mg g$^{-1}$) while Kardinal produced minimum leaf total chlorophyll contents (53.60 mg g$^{-1}$) as shown in Table 2.

Results related to flower emergence revealed that plants sprayed with B + Zn produced early flowering after 55.68 days of pruning followed by B + Fe, B, Fe, Zn and B + Zn + Fe with 56.75, 56.98, 58.33, 58.34 and 59.51 days, respectively. Plants without micronutrients spray produced late flowering after 63.08 days (Table 1). Rosy Cheeks took maximum time to initiate flower emergence (63.77 days) followed by Amalia (58.15 days) while in Kardinal, flower emergence started in minimum time (55.02 days) which predicted its suitability for greenhouse production and for getting high yield per unit area (Table 2). Application of B + Zn produced maximum number of flowers plant$^{-1}$ (13.01) followed by B + Zn + Fe and B alone which produced 12.95 and 11.76 flowers plant$^{-1}$ flush$^{-1}$, respectively, while plants with no micronutrients application produced minimum flowers (7.74) plant$^{-1}$ flush$^{-1}$ (Table 1). Among cultivars, Amalia produced maximum number of flowers (11.73) plant$^{-1}$ flush$^{-1}$ followed by Rosy Cheeks (9.90) while Kardinal produced minimum number of flowers (8.05) plant$^{-1}$ flush$^{-1}$ (Table 2). Regarding flower bud diameter, application of B alone produced maximum bud diameter (3.56 cm) followed by B + Zn, B + Fe and B + Zn + Fe with 3.52, 3.52 and 3.46 cm diameter, which were statistically at par with each other. On the other hand, plants which received no micronutrients produced poor quality buds with 2.18 cm diameter (Table 3). Among cultivars, Rosy Cheeks produced maximum bud diameter (4.01 cm) followed by Kardinal (3.07 cm) and Amalia (3.04 cm) which were statistically at par with each other (Table 4). Regarding flower diameter, application of B + Zn + Fe and B alone produced maximum flower diameter (8.66 and 8.50 cm, respectively) and excelled rest of the treatments (Table 3). Among various cultivars of *Rosa hybrida*, Rosy Cheeks produced maximum flower diameter (8.82 cm) followed by Kardinal (7.82 cm) while Amalia produced minimum flower diameter (6.77 cm) as presented in Table 4. As for as fresh weight of a flower was concerned, application of B alone produced maximum fresh weight of a flower (5.30 g) followed by B + Zn (5.20 g) whereas plants having no micronutrients application produced minimum fresh weight of a flower (4.37 g) as presented in Table 3. While among cultivars, Rosy Cheeks produced maximum fresh weight of a flower (5.87 g) followed by Amalia (4.44 g) while Kardinal produced minimum fresh weight of a flower (3.91 g). Regarding dry weight of a flower, foliar spray of B produced maximum dry weight of a flower (2.29 g) followed by B + Zn with 2.16 g dry weight while control (no micronutrients) produced minimum dry weight of a flower (1.89 g) as shown in Table 3. Among cultivars, Rosy Cheeks produced

**Table 3. Floral indices of *Rosa hybrida* L. as influenced by foliar application of various micronutrients**

| | Bud diameter (cm) | Flower diameter (cm) | Fresh weight of a flower (g) | Dry weight of a flower (g) | Flower stalk length (cm) | Flower stalk diameter (cm) |
|---|---|---|---|---|---|---|
| Control | 2.18 c | 6.25 d | 4.37 cd | 1.89 cd | 32.88 d | 0.40 d |
| B (0.5 %) | 3.56 a | 8.50 a | 5.30 a | 2.29 a | 44.26 ab | 0.67 bc |
| Zn (1.5%) | 3.32 ab | 7.75 abc | 4.70 cd | 1.95 c | 41.33 bc | 0.56 c |
| Fe (1%) | 3.15 b | 7.08 cd | 7.27 d | 1.74 d | 37.63 c | 0.54 cd |
| B+Zn | 3.52 a | 8.31 abc | 5.20 ab | 2.16 ab | 46.73 a | 0.84 ab |
| B+Fe | 3.52 a | 7.40 bcd | 4.75 bcd | 1.93 cd | 42.05 b | 0.74 ab |
| Zn+Fe | 3.29 ab | 6.82 cd | 4.53 cd | 1.97 c | 43.01 ab | 0.73 ab |
| B+Zn+Fe | 3.46 a | 8.66 a | 4.82 bc | 2.07 bc | 43.34 ab | 0.86 a |

Means sharing similar letter are statistically non-significant at P<0.05

**Table 4. Floral characteristics of various cultivars of *Rosa hybrida* L. subjected to foliar application of various micronutrients**

| | Bud diameter (cm) | Flower diameter (cm) | Fresh weight of a flower (g) | Dry weight of a flower (g) | Flower stalk length (cm) | Flower stalk diameter (cm) |
|---|---|---|---|---|---|---|
| Kardinal | 3.07 b | 7.82 b | 3.91 c | 1.58 c | 42.96 a | 0.67 a |
| Amalia | 3.04 b | 6.77 c | 4.44 b | 1.82 b | 40.68 a | 0.65 a |
| Rosy Cheeks | 4.01 a | 8.82 a | 5.87 a | 2.70 a | 40.57 a | 0.69 a |

Means sharing similar letter are statistically non-significant at P<0.05

maximum dry weight of a flower (2.70 g) followed by Amalia (1.82 g) while Kardinal produced minimum dry weight of a flower (1.58 g) as presented in Table 4.

Information procured on flower quality revealed that application of B + Zn + Fe produced best quality flowers (7.10) as shown in Fig. 1. Among cultivars, Rosy Cheeks produced best quality (6.67) flowers followed by Amalia (6.53) while Kardinal produced poor quality flowers (5.61). As for as flower stalk length was concerned, B + Zn application produced flowers with maximum stalk length (46.73 cm) whereas control (no micronutrients) produced shortest flower stalks with 32.88 cm length (Table 3). Among cultivars, Kardinal produced flowers with 42.96 cm stalk length followed by Amalia (40.68 cm) and Rosy Cheeks (40.57 cm) which were statistically at par with each other. Regarding flower stalk diameter, application of B + Zn + Fe produced flowers with maximum stalk diameter (0.87 cm) followed by combinations of two micronutrients rather than their individual or no application. Among cultivars, Rosy Cheeks produced flowers with 0.69 cm stalk diameter followed by Kardinal (0.67 cm) and Amalia (0.65 cm) and all cultivars were statistically at par with each other.

Maximum leaf B contents (758.55 mg $L^{-1}$) were observed with application of B + Zn + Fe followed by combinations of two micronutrients used in the study rather than individual or no micronutrient application (Fig. 2). Regarding cultivars, Rosy Cheeks produced maximum leaf boron contents (469.79 mg $L^{-1}$) as compared to Amalia and Kardinal which produced 418.33 and 409.91 mg $L^{-1}$ leaf boron contents, respectively and were statistically at par with each other. Regarding leaf Zn contents, application of B + Zn produced maximum Zn contents (823.16 mg $L^{-1}$) followed by B + Zn + Fe, Zn and Zn + Fe which resulted 708.75, 561.95 and 275.34 mg $L^{-1}$ leaf Zn contents, respectively. On the other hand, B application, control (no micronutrient application), B + Fe and Fe application produced minimum Zn contents. Among cultivars, Kardinal had 362.18 mg $L^{-1}$ Zn contents followed by Rosy Cheeks and Amalia which had 306.85 and 306.36 mg $L^{-1}$ leaf Zn contents, respectively, and were statistically at par with each other (Fig. 3). Application of B + Zn + Fe produced maximum Fe contents (795.02 mg $L^{-1}$) followed by Zn + Fe, Fe and B + Fe which had 708.58, 629.06 and 559.90 mg $L^{-1}$ Fe contents, respectively. On the other hand, control (no micronutrient spray), B and Zn produced minimum Fe contents (47.72, 77.41 and 102.64 mg $L^{-1}$, respectively) as presented in Fig. 4. Regarding cultivars, Rosy Cheeks produced maximum Fe contents (472.41 mg $L^{-1}$) followed by Amalia (365.62 mg $L^{-1}$) and Kardinal (329.06 mg $L^{-1}$) which were statistically at par with each other.

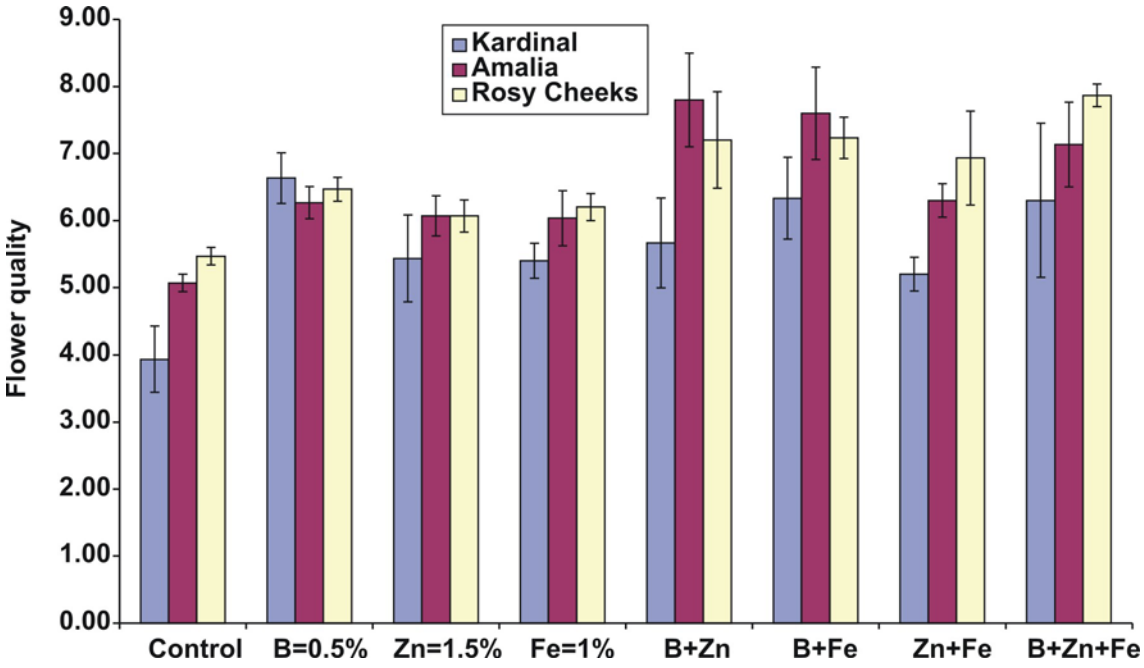


**Fig. 1. Flower quality of different cultivars of *Rosa hybrida* as influenced by foliar application of various micronutrients**

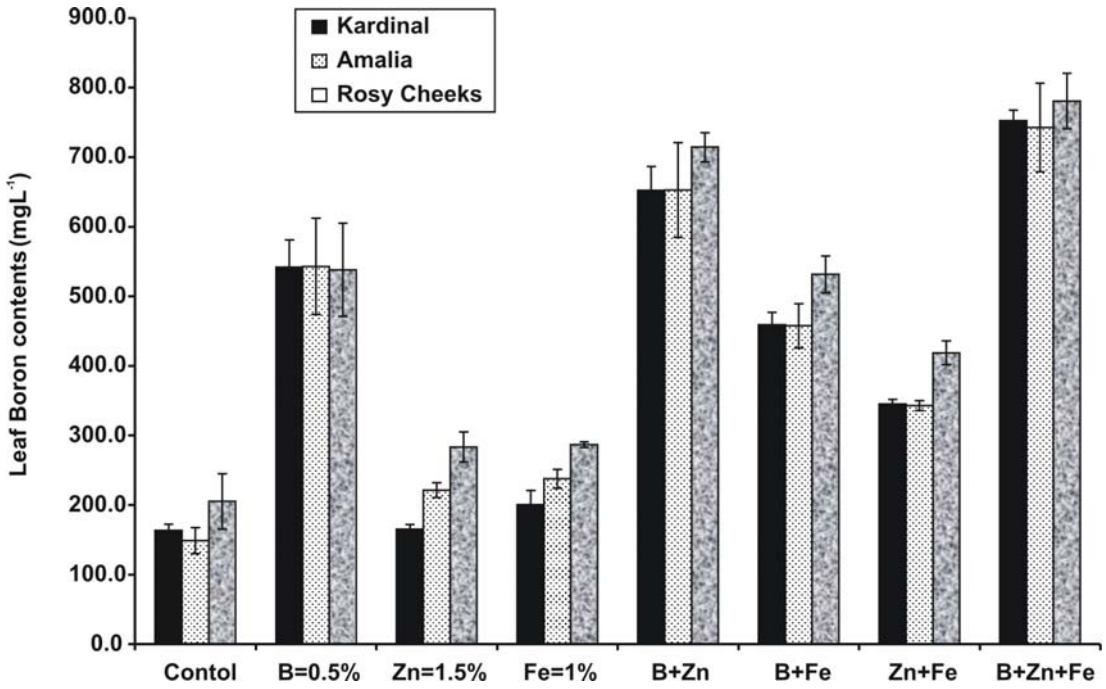


**Fig. 2. Leaf boron contents ($mgL^{-1}$) of different cultivars of *Rosa hybrida* as influenced by foliar application of various micronutrients**

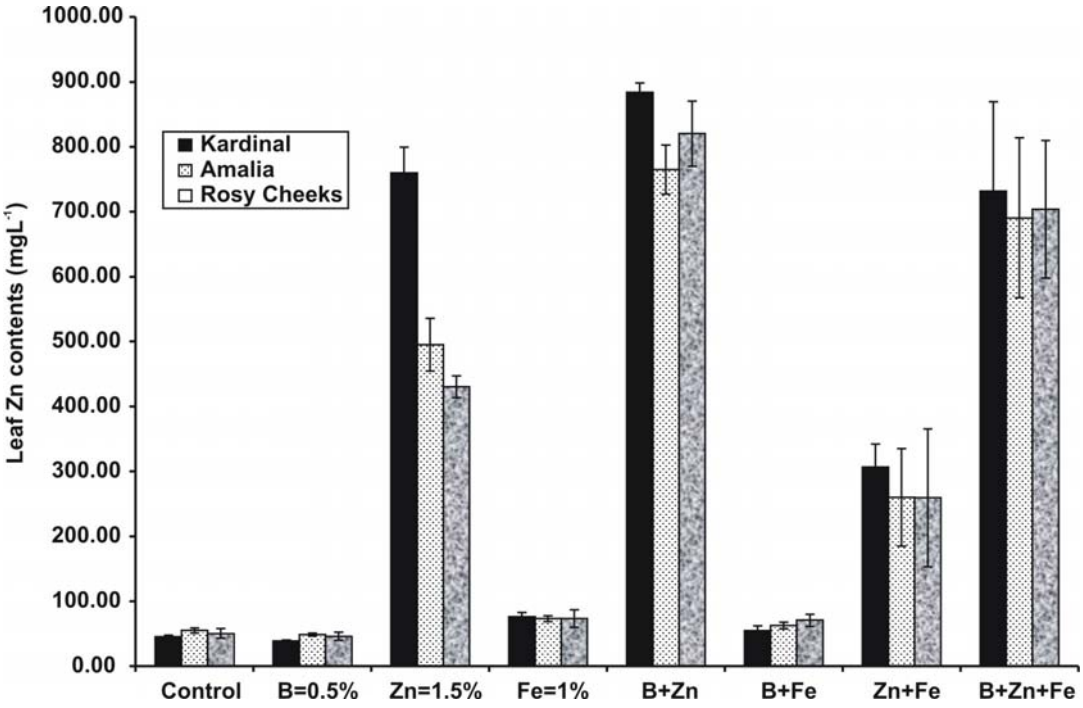


**Fig. 3. Leaf Zn contents ($mgL^{-1}$) of different cultivars of *Rosa hybrida* as influenced by foliar application of various micronutrients**

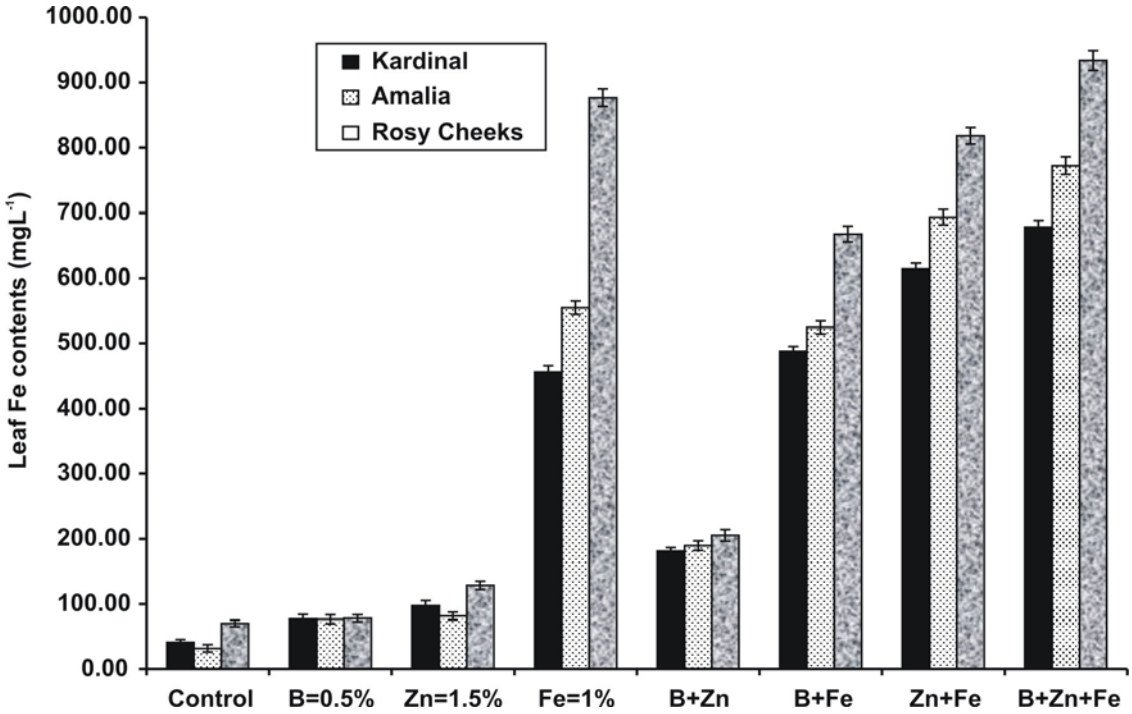


**Fig. 4. Leaf Fe contents ($mgL^{-1}$) of different cultivars of *Rosa hybrida* as influenced by foliar application of various micronutrients**

## DISCUSSION

Rose (*Rosa hybrida* L.) constitutes one third of total global cut flower production (Kras, 1999). In Pakistan, it is leading cut flower crop but yet no micronutrients are applied to improve yield and quality. As growth, yield and quality are greatly affected by nutrient management (Savvas, 2002), need was felt to optimize micronutrients application on commercially grown cultivars. As in the past, there was no need of micronutrients because these trace elements were naturally supplied by soil. But due to intensive cultivation, increase in salinity and soil pH, in most of soils, these nutrients are present but are not available to plants. Therefore, investigations were made by foliar application of boron, Zn and Fe on yield and quality of cut roses. While application of micronutrients, application of optimum concentrations are very important as their concentrations have great influence on growth and quality attributes like stalk length, stalk diameter and vase life (Marschner, 1995; Whitcomb *et al.,* 1975). Moreover, different cultivars respond differently to various concentrations and combinations with other nutrients (Marschner, 1995). Because of no use of micronutrients, growers fail to produce best quality and economically viable produce due to lack of information about proper concentrations of different micronutrients. Genotypic variation and micronutrient application are two key factors which play a dominant role in successful production of best quality cut roses Khoshgoftarmanesh *et al.* (2008). This experiment was conducted to optimize different combinations of micronutrients to be used for cut rose flower production. It was observed that B + Zn produced taller plants with maximum number of leaves branch$^{-1}$, leaf area, stalk length and took minimum time for flower emergence, while B + Zn + Fe produced maximum chlorophyll contents, flower quality and flower stalk diameter among different treatments; application of Boron alone produced maximum bud diameter, flower diameter, fresh and dry weight of a flower. Combination of all three micronutrients applied had also increased leaf B, Zn and Fe contents in all cultivars which confirmed the findings of Khoshgoftarmanesh *et al.* (2008). Positive results of micronutrients application on rose growth, yield and quality have been reported previously (Handerk, 1995; Singh and Bhattacharjee (1997), Wright *et al.* (1997); Mattson *et al.,* (2006) and Mukesh *et al.* (2001). Regarding different cultivars, Rosy cheeks produced maximum plant height, number of leaves branch$^{-1}$, leaf area, total chlorophyll contents, maximum days to flower emergence, bud diameter, flower diameter, fresh weight of a flower, dry weight of a flower, flower quality and flower stalk diameter and Amalia produced maximum number of flowers plant$^{-1}$. Kardinal had maximum fresh and dry weight ratio and flower stalk length. Response of different rose cultivars to various micronutrients is also very important factor which should be considered and optimized for individual cultivars for getting higher yields of better quality (Sarro *et al.,* 1989).

## CONCLUSION

Micronutrients application in the form of foliar spray improved various growth and quality indices and increased flower yield of *Rosa hybrida* L. cvs. ‘Kardinal’, ‘Amalia’ and ‘Rosy Cheeks’. Various combinations of micronutrients proved better with special reference to B + Zn and of all three micronutrients applied in this study, B application had more pronounced effect on growth and flowering of roses as compared to Zn and Fe. Regarding cultivars, Rosy Cheeks responded better to these micronutrients as compared to Amalia and Kardinal. Therefore, it can be concluded that combination of these micronutrients are more effective than their individual application except B in some cases and additional use of optimum concentration of these micronutrients proved better towards vigorous growth and maximum flower production of superior quality in rose.

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