ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-2931 (Print)
ISSN: 2521-294X (Online)
CODEN: MJSAEJ

Malaysian Journal of Sustainable Agriculture (MJSA)

DOI: http://doi.org/10.26480/mjsa.02.2020.94.98

CrossMark

RESEARCH ARTICLE

EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENT (ZINC AND BORON) IN FLOWERING AND FRUIT SETTING OF MANDARIN (*CITRUS RETICULATA BLANCO*) IN DAILEKH, NEPAL

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ARTICLE DETAILS

Article History:

Received 08 January 2020
Accepted 10 February 2020
Available online 01 March 2020

ABSTRACT

A research was conducted in PM-AMP, Project Implementation Unit, Citrus Zone, Dailekh during the spring season 2019 to find out the effect of foliar application of micronutrient in flowering and fruit setting of mandarin (*Citrus reticulata* Blanco) in Dailekh, Nepal. The experiment was laid out in one factor randomized complete block design (RCBD) with five treatments and four replications. The treatments consist of foliar application of sole and combined application of Zinc and Boron namely: control (water spray), 0.15% Zn, 0.04% B, 0.1% Zn + 0.02% B and 0.05% Zn + 0.04% B. Twenty trees of same age and height were chosen from the north-facing slope. The soil of research orchard was sandy loamy. The solution for spray was made using standard procedures. Foliar application of the micronutrients was done twice, the first application was done before 45 days of the flowering and second application was done after 2 days of full bloom. The data was first entered in MS excel and R-stat was used for further analysis of the parameters. The results revealed that the different combination of micronutrient significantly influenced flowering, fruit setting percentage and the fruit drop percentage. The application of either Boron or Zinc or the combination of both were effective for enhancing flowering and fruit set as well as reducing the fruit drop in mandarin.

KEYWORDS

fruit drop, yield, citrus, soil nutritional status.

1. INTRODUCTION

Citrus is one of the important fruit crops of hilly areas of Nepal. Citrus fruits are cultivated in the tropical and sub-tropical region having suitable soil, geographical and climatic condition. The climatic conditions of mid-hills having altitude 800 to 1500 masl are considered favourable for all types of citrus cultivation. The three most important species of citrus culture in Nepal are mandarin (*Citrus reticulata),* sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*). Among them, mandarin takes the first position in terms of area coverage and production. Fruit contributes about 7% of total agriculture gross domestic product. Among them, citrus contributes 23.34% in total fruit production whereas mandarin shows 68.64% of the total citrus production.

The total production of the citrus plant in the FY 2072/73 was 2,313,838 from 197 nurseries (NCRP, 2016). The average productivity of citrus fruit is 8.8 Mt/ha (NCDP, 2016). The average productivity of mandarin in Nepal and Dailekh district is 9.42 Mt/ha and 10.06 Mt/ha respectively (MoALD, 2017). Dailekh district experienced the rise in the cultivation area of mandarin by 5.08% in the fiscal year 2016/17 as compared to FY 2015/16. But the productivity has been decreased from 3.72 Mt/ha in FY 2015/16 to 3.55 Mt/ha in FY 2016/17 (DADO, 2017). The productivity of mandarin in the global scenario is 13.06 Mt/ha (FAOSTAT, 2017).

The productivity of the citrus trees depends upon many abiotic (climate, soil, nutrition and irrigation management) and biotic factor (rootstock, cultivar, insect, pest and disease management) (Albrigo, 1999). Among them an adequate supply of micronutrients like zinc, boron, iron etc. are most important to produce good quality fruits (Babu and Yadav, 2005). Boron has an efficient role in the growth and production which increases the pollen germination and pollen tube elongation as well as increases the fruit set, seeds, fruit development and ultimately the production. Boron increased and changed sugars composition that exists in the nectar where the flowers attract more insects and it influences the pollen production and their viability (Mohammad et al., 2018).

Growth and development of citrus fruit follow a typical sigmoid growth curve, divided into three clear-cut stages (Bain, 1958). Nutrient management is a major problem of citrus production in Nepal (Chhetri et al., 2019). Likewise, in Dailekh, nutrient management is also the main problem in citrus production. The soil of this region has low organic matter content. Also, the limited amount of micronutrient present in soil can't get absorbed due to irrigation problem as well as dry soil condition. Nutrient management is a major problem of citrus production in Nepal (Chhetri et al., 2019). High flower drop, fruit drop and low productivity of mandarin is due to the deficiency of Zinc and Boron in the soil (Soni et al., 2017).

Quick Response Code	Access this article online	
	Website: www.myjsustainagri.com	**DOI:** 10.26480/mjsa.02.2020.94.98

Cite the Article: Om Kala Ruchal, Subodh Raj Pandey, Reja Regmi, Rajendra Regmi, Bishnu Bahadur Magrati (2020). Effect Of Foliar Application Of Micronutrient (Zinc And Boron) In Flowering And Fruit Setting Of Mandarin (*Citrus Reticulata Blanco*) In Dailekh, Nepal. *Malaysian Journal of Sustainable Agriculture, 4(2): 94-98.*

2. Materials and Methods

2.1 Research site

The research was conducted in the Ranukhana, Dailekh which is 6 km far from Dullu Bazaar. The research site is at 1300 masl. The mean maximum and minimum temperatures are 25 and 5 degrees respectively and annual rainfall is 1200mm. Its geographical coordinate is 28.86°N and 81.62°E.

2.2 Weather condition of the site

The research site was situated in the sub temperate climate of hill ecological zone. It is characterized by three distinct seasons; spring, summer and monsoon. Monthly data on different parameters such as minimum, maximum and average temperature and relative humidity recorded from Dailekh meteorological station are presented (Figure 1).

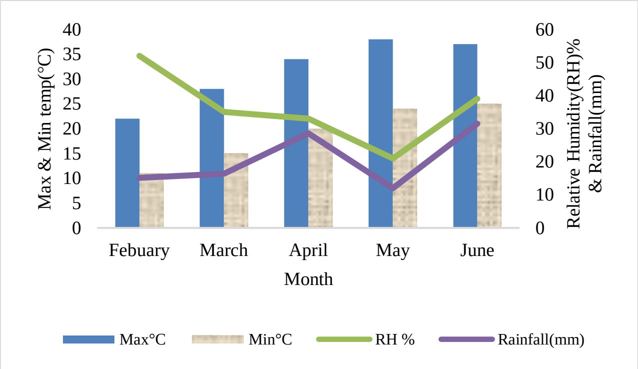

Figure 1: Meteorological data during the investigation period

2.3 Soil sample analysis

The soil of the research site was sandy loam. The soil sample was taken from a depth of 1m from three randomly selected spots at the experimental site. The soil sample was tested in the Central Agricultural Laboratory, Hariharbhawan, Kathmandu. The results indicate that the soil was slightly acidic, medium organic matter content, medium nitrogen, low phosphorus, medium potassium, low zinc and low boron (Table 1).

Table1: Characteristics of the soil of the research site

Soil Properties	Available Nutrient	Rating
PH	6.1	Slightly Acidic
Organic matter (%)	2.87	Medium
Nitrogen (%)	0.14	Medium
Phosphorous (%)	0.19	Low
Potassium (%)	1.641	Medium
Zinc (ppm)	0.207	Low
Boron (ppm)	0.255	Low

Rating source: (Central Agricultural Laboratory, Hariharbhawan, Kathmandu, 2019)

2.4 Selection of tree

Five years old twenty trees of similar age, size, height and vigour were selected and each tree was tagged according to the treatment.

2.5 Experimental details

The experiment was laid out in Randomized Complete Block Design (RCBD) with five treatments and four replications consisting of 20 trees altogether. Each tree is considered as one replication. The research was conducted at the farmer's mandarin orchard.

2.6 Treatment details

T_1: Control (Water spray)
T_2: 0.15% Zn
T_3: 0.04% B
T_4: 0.1% Zn + 0.02% B
T_5: 0.05% Zn + 0.04% B

2.7 Preparation of Zinc and Boron Spray Solution

Following formula were used to calculate the borax and zinc spray solution

- Amount of borax = $\frac{\text{\% of boron required}}{\text{\% of boron in borax}}$ X 1000
- According to Boyle's law, the required volume of zinc was calculated as:

$$C_1V_1 = C_2V_2$$

Where,
C_1 is the initial concentration
V_1 is the initial volume
C_2 is the final concentration
V_2 is the final volume

Double chelates double-action zinc contains 10% zinc and Di-Sodium Tetra Borate Penta Hydrate (borax) contains 14.6% boron. So, zinc (Zn) and boron (B) were applied in the form of liquid zinc and borax through foliar spray technique. Ordinary tap water was sprayed in treatment T_1. Treatment T_2 and T_3 were sprayed at a single rate and T_4 and T_5 at different combination. 0.15% Zinc spray was prepared by dissolving 15ml of liquid zinc in 1 litre of water. 0.1% zinc spray was prepared by dissolving 10ml of zinc in 1 litre of water. 0.05% Zinc spray was prepared by dissolving 5ml of zinc in 1 litre of water. 0.04% boron spray was prepared by dissolving 2.74gram of borax in 1 litre of water. 0.02% boron spray was prepared by dissolving 1.37 gram of borax in 1 litre of tap water. The Sticker was used in the spray solution to prevent the solution from being washed off. 3ml sticker was used in a litre of water.

2.8 Method of micronutrient application

The mandarin trees were of medium height. Foliar application of the micronutrient was done in such a way that every leaf of the tree was wetted with the required solution with the help of foot sprayer. The volume of spray solution was determined according to the age of the tree. Therefore, 2 litres of spray solution was sprayed for 5-years old plant.

2.9 Time of application

Flowering generally occurred in the second week of April. Foliar application of the micronutrients was done twice, the first application was done on 16 February 2019 before 45 days of the flowering and second application was done on 12 April 2019 after 2 days of full bloom (Sajid et al., 2010).

2.10 Observation Parameter

2.10.1 Total number of flowers per branch

The five branches were tagged and the total numbers of flowers were manually counted by using the ladder. The average total number of flower per branch was calculated.

2.10.2 Number of male flowers per branch

The total number of male flowers in the tagged branches was manually counted and the average number of male flower per branch was calculated.

2.10.3 Number of hermaphrodite flowers per branch

The total numbers of hermaphrodite flowers on the tagged branches were counted manually and the average number of hermaphrodite flower per branch was calculated.

2.10.4 Fruit set per branch

The fruit set on the tagged branches was manually counted. The number of flowers per branch was also counted. Then, the fruit set per branch is expressed in the form of percentage.

$$\text{Fruit set percentage} = \frac{\text{Total number of developing fruit set per branch}}{\text{Total number of flowers per branch}} \times 100$$

2.10.5 Flower drop per branch

Flower drop per branch was calculated in the form of a percentage.

2.10.6 Days to first flowering

The time required for the first flowering from first spraying was recorded.

2.10.7 Days to first fruit set

The time required for the first fruit setting from second spraying was recorded.

2.10.8 Fruit drop per branch

Fruit drop was calculated and it was also expressed in percentage.

2.11 Data analysis

Data were collected at 10 days interval which was started from 1st April 2019. The data was first recorded in MS Excel and analyzed by using Analysis of variance (ANOVA) using R-stat. Means of treatment were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

3. Results and Discussion

3.1 Days to flowering from first spraying and days to fruit set from second spraying

Days to flowering and days to fruit set were statistically similar among different treatments. The mean value for days to first flowering from first spraying was found 45.05 days and varied from 43.50 days (0.04%B) to 46 days (control). The mean value for days to first fruit set from second spraying was found 7.55 days and varied from 6.50 days (0.04%B) to 9 days (control) (Table 2). The characteristics of the spring flush are largely determined by the combined effect of climate and flower induction and bud sprouting. Deviations from these relationships may come from the effect of additional environmental factors and through the effect of cultural practices (Jahn, 1973).

Table 2: Effect of different micro-nutrient on days to first flowering and first fruit set

Treatments	Days to first flowering from first spraying	Days to first fruit set from second spraying
Control	46.00	9.00
0.15% Zn	44.50	7.25
0.04% B	43.50	6.50
0.05% Zn + 0.02%B	45.50	7.00
0.1% Zn + 0.04% B	45.75	8.00
F-test	NS	NS
CV (%)	9.9	15.1
LSD	6.87	1.76
SEM	0.88	0.31
Grand Mean	45.05	7.55

Means followed by a common letter(s) within a column are non – significantly different based on DMRT at P = 0.05, NS: Non-significant, CV: Coefficient of variation, LSD: Least significant differences, SEM: Standard error of mean

3.2 Effect on flowering

Flowering of the mandarin was found to be significantly influenced with foliar application of the micronutrient at 44 days from first spraying. At 44 DAS, the mean value for the total number of flowers per branch was 155.7. The highest number of flower per branch was observed with spray of 0.15% Zn (252.50) which was statistically similar with 0.05% Zn + 0.02% B (182.50) and 0.1% Zn + 0.04% B (158.75).The lowest total number of flower per branch was observed in control (46.25) (Table 3). Significant variation was found for the total number of flowers at 54days of first spraying. At 54 DAS, the mean value for the total number of flowers per branch was 224.47. The highest total number of flower per branch was observed with spray of 0.04% B (332.25) which was statistically similar with 0.15%Zn(222), 0.05% Zn + 0.02% B, 0.1% Zn + 0.04% B. The lowest total number of flower per branch was observed in control (79) (Table 3).

At 54 DAS, the foliar application of Zn and B had a significant effect on the total number of hermaphrodite flower per branch. The mean value of the total number of the hermaphrodite flower was 215.44. The highest total number of hermaphrodite flower per branch was observed with foliar spray of 0.04%B(323.10) which was statistically at par with 0.15%Zn (212.75), 0.05% Zn + 0.02% B (230.75), 0.1% Zn + 0.04% B (234.80). The lowest total number of hermaphrodite flower per branch was observed in control (75.80) (Table 3). At 54 DAS, the foliar application of Zn and B had a significant effect on the total number of male flower per branch. The mean value of the total number of the male flower was 128.7. The highest total number of male flower per branch was observed with foliar spray of 0.05% Zn + 0.02% B (164.55) which is statistically similar with 0.15% Zn(144.10), 0.04% B (146.15) and 0.1% Zn + 0.04% B (139.4). The lowest total number of flower per branch was observed in control (79) (Table 3). The effective role of adding zinc contributes to pollination through its influence on the formation of the pollen tube. Boron promotes the pollen germination as well as the pollen tube growth as found which is in line with the result (Mohammed et al., 2018). The high concentration of Zn and low concentration of B reduced the percent of rosette per plant, closely followed by the plants received low concentration of Zn and high concentration of B contradicts with our result (Ibrahim et al., 2007).

Table 3: Effect of different micronutrients in the flowering of mandarin

Treatment	Total flower at		Hermaphrodite flower	Male flower
	44 DAS	54 DAS	54 DAS	54 DAS
Control	46.25^{c}	79^{b}	75.80^{b}	49.30^{b}
0.15% Zn	252.50^{a}	222^{a}	212.75^{a}	144.10^{a}
0.04% B	138.50^{bc}	332.25^{a}	323.10^{a}	146.15^{a}
0.05% Zn + 0.02% B	182.50^{ab}	242.15^{a}	230.75^{a}	164.55^{a}
0.1% Zn + 0.04% B	158.75^{ab}	246.75^{a}	234.80^{a}	139.40^{a}
F-test	*	*	*	**
CV (%)	43.5	35.4	37.5	23.6
LSD	104	122	124	46.8
SEM	22.07	25.42	25.06	11.12
Grand Mean	155.7	224.47	215.44	128.7

Means followed by a common letter(s) within a column are non – significantly different based on DMRT at P = 0.05, NS: Non-significant, CV: Coefficient of variation, LSD: Least significant differences, SEM: Standard error of mean, DAS: Days of first spraying

3.3 Effect on flower drop

Non-significant variation was found for flower drop percentage per branch. The mean value for flower drop was 29.41% and varied from 19.17% (0.1% Zn + 0.04%) to 53.13% (control). ANOVA showed no differences among treatments indicating no variation (Table 4).

Table 4: Effect of different micronutrients on flower drop of mandarin

Treatment	Percentage of flower drop
control	53.13
0.15% Zn	27
0.04%Zn	26.66
0.05% Zn + 0.02% B	21.08
0.1% Zn + 0.04% B	19.17
F-test	Ns
CV (%)	59.1
LSD	26.8
SEM	4.2
Grand mean	29.41

Means followed by a common letter(s) within a column are non – significantly different based on DMRT at P = 0.05, NS: Non-significant, CV: Coefficient of variation, LSD: Least significant differences, SEM: Standard error of mean

3.4 Effect on fruit set

The fruit setting of the mandarin was influenced significantly due to the effect of Zn and B. At 66 DAS, the mean value of fruit setting per branch was 65.96%. The highest fruit setting per branch was observed with foliar application of 0.04% B (82.09%) and 0.1% Zn + 0.04% B (78.19%) which was statistically at similar with 0.05% Zn + 0.02% B(76.55%). The lowest fruit setting per branch was observed in control (42.17%) which was similar to that of 0.15% Zn (50.77%) (Table 5). At 76 DAS, the mean value of fruit setting per branch was 60.09%. The highest fruit setting per branch was seen in 0.04% B (74.66%) and 0.05% Zn + 0.02% B(73.90%) which was statistically similar with 0.15% Zn (67.28%).The lowest fruit setting per branch was observed in control (35.52%). However, it was statistically similar with 0.1% Zn + 0.04% B (49.10%) (Table 5). At 86 DAS, the mean value of fruit set per branch was 56.8%. The highest fruit set per branch was obtained with the foliar spray of 0.04 % B (71.32%), which was similar with 0.05% Zn + 0.02% B (64.06%) and 0.1% Zn + 0.04% B (63.24%). The lowest fruit set was observed in control (32.80%) (Table 5). At 96 DAS, the mean value of fruit set was 50.19%. The highest fruit set per branch was observed in 0.04% B (67.52) which was similar with 0.05% Zn + 0.02% B(55.82%) and 0.1% Zn + 0.04% B (55.58%). The lowest fruit set per branch was obtained in control (23.55%) which was at par with 0.15% Zn (48.58%) (Table 5). At 106 DAS, the mean value of fruit set per branch was 40.01%. The highest fruit set per branch was obtained with foliar spray of 0.04% B (55.27%) which was similar with that of foliar spray of 0.15% Zn (42.58%), 0.05% Zn + 0.02% B(47.32%) and 0.1% Zn + 0.04% B (47.61%). As usual, the lowest fruit set was obtained in control (11.28%) (Table 5).

Table 5: Effect of different micronutrients in fruit set from the first spray

Treatment	Percentage of fruit set at				
	66 DAS	76 DAS	86 DAS	96 DAS	106 DAS
control	42.17^{c}	35.52^{c}	32.80^{c}	23.55^{c}	11.28^{b}
0.15% Zn	50.77^{bc}	67.28^{ab}	52.55^{b}	48.44^{b}	42.58^{a}
0.04% B	82.09^{a}	74.66^{a}	71.32^{a}	67.52^{a}	51.27^{a}
0.05% Zn + 0.02% B	76.55^{ab}	73.90^{a}	64.06^{ab}	55.82^{ab}	47.32^{a}
0.1% Zn + 0.04% B	78.19^{a}	49.10^{bc}	63.24^{ab}	55.58^{ab}	47.61^{a}
F-test	*	*	**	**	*
CV%	26.4	26.6	21	21.3	38.3
LSD	26.8	24.6	18.4	16.4	23.6
SEM	4.96	4.75	3.8	4.14	4.39
Grand mean	65.96	60.09	56.8	50.19	40.01

Means followed by a common letter(s) within a column are non – significantly different based on DMRT at P = 0.05, NS: Non-significant, CV: Coefficient of variation, LSD: Least significant differences, SEM: Standard error of mean

The higher fruit set in response to the higher concentration of micronutrients application is probably due to translocation of hormones, food substances and other factors which stimulates fruit formation to the tissue of ovary in greater amount. The possible reason may be due to micro-element ascribed to better photosynthesis, lesser fruit drop, improve fruit size and quality characters. The beneficial role of boron is in pollination and zinc in growth-promoting substance. Similar results were observed which reported that fruit set % in the trees treated with 0.04% B was significantly higher than control which is in line with the result (Kumar et al., 2017).

3.5 Effect on fruit drop

Significant variation was found for the final fruit drop percentage. The mean fruit drop was 49.52 and varied from 38.18% (0.04% B) and (0.1% Zn + 0.04% B) to 77.11 % (control) among many treatments. The maximum fruit drop percentage was 77.11 obtained in untreated treatment (control) whereas minimum fruit drop percentage was 38.19 obtained in treated treatment 0.04% B and 0.1% Zn + 0.04% B. However, it was statistically similar with 0.15% Zn and 0.05% Zn + 0.02% B (Table 6). Zn is a part of enzymes system which regulates the plant growth (Sajid et al., 2010). It is essential for the formation of chlorophyll and function of normal photosynthesis (Papadakis et al., 2005). The higher fruit retention in Zn treated trees may be ascribed to an increase in the synthesis of IAA which consequently improves the endogenous level of auxin at abscission zone to avoid fruit drop (Razzaq et al., 2005).

Table 6: Effect of different micronutrients in fruit drop of mandarin

Treatment	Percentage of fruit drop
Control	77.11^{a}
0.15% Zn	49.32^{b}
0.04% B	38.19^{b}
0.05% Zn + 0.02% B	41.42^{b}
0.1% Zn + 0.04% B	38.19^{b}
F-test	**
CV (%)	24.8
LSD	18.9
SEM	4.15
Grand mean	49.52

Means followed by a common letter(s) within a column are non – significantly different based on DMRT at P = 0.05, NS: Non-significant, CV: Coefficient of variation, LSD: Least significant differences, SEM: Standard error of mean

The minimum fruit drop was due to the positive response of zinc and boron in fruit setting of mandarin trees. Zinc enhances the synthesis of IAA which consequently improves the endogenous levels of auxin at abscission zone to avoid fruit drop. Stabilization, on the other hand, fulfils the requirement of carbohydrates. By the foliar application of boron, the fruit drop was reduced because boron plays an important role in the translocation of carbohydrate and auxin synthesis to sink and increased pollen viability and fertilization. These all pieces of evidence clearly show that Zinc and boron reduce the fruit drop in fruit trees which is in line with the result. Similarly, the foliar application of Zn and B significantly decrease the fruit drop percentage than untreated (Nijjar, 1998; Ahmad et al., 2012).

It is now common knowledge in agriculture that properly nourished crops may tolerate insect pests and diseases (Ashraf et al., 2013). Although field research has shown that supplemental foliar feeding can increase yield by 10 to 25 percent compared with conventional soil fertilization, foliar fertilization should not be considered a substitute for a sound soil-fertility program (Boaretto et al., 2001). Foliar fertilizer application also provides a more timely and immediate method for delivery of specific nutrients at critical stages of plant growth. Foliar nutrition programs are therefore valuable supplements to soil applications reducing the flower and fruit drop (Zerki, 2004).

4. Conclusion

Zinc and boron have an efficient role in the growth and production which increases the flowering and fruit set as well as reduce the problem of flower drop and fruit drop. Thus, it can be concluded that mandarin orchard at Dailekh is in big need of supplemental foliar application of micronutrient for the optimum yield of mandarin. As the micronutrient content in soil is very low, the application of the micronutrient was found to increase the flowering and fruit set. The spray of either zinc or boron or the combinations of both is effective for flowering and fruit set as well as reducing the fruit drop.

Recommendation

This study will help the students, researchers, farmers, PM-AMP and concerned stakeholders about the need for micronutrient and gives tentative dose to increase the yield in micronutrient deficient soil. Further research should be carried out to find a suitable dose of boron and zinc effective for reducing the flower and fruit drop.

Acknowledgement

We would like to acknowledge the Agriculture and Forestry University for providing financial support to complete this research. We would also like to acknowledge Prime Minister Agriculture Modernization Project, Project Implementation Unit, Citrus Zone, Dailekh for their constant support during the entire research.

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