Original Research Article

Effect of foliar spray of micronutrients and plant growth regulators on flowering, fruit set and fruit quality of Olive Cultivars (*Olea europaea* L.)

ABSTRACT

Olive (Olea europaea) is a small evergreen tree native to the Mediterranean region, known for its distinctive and valuable fruit, the olive. The olive tree has been cultivated for thousands of years and holds great cultural and economic significance in various parts of the world. The use of micronutrient and plant growth regulators sprays in olive cultivation is a common practice to address nutrient deficiencies, enhance plant health, increase flowering and fruit quality. These sprays contain essential minerals like iron, zinc, manganese, and boron, which are readily absorbed by the olive trees through their leaves. These sprays help to correct imbalances, improve nutrient uptake, and boost overall growth and fruit development. They are particularly effective in regions with poor soil conditions or where specific micronutrient deficiencies are prevalent, ensuring healthy olive trees and optimal yield of high-quality fruits. Therefore, the present investigation was carried out at the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during the *Winter*-2022 with a view to determine the effect of different micronutrient applications olive for its growth quality. On the basis of the present investigation, it is concluded that among the various treatments applied to enhance the Flowering, Fruit set, fruit Yield, Fruit quality and Oil quality of Olive cultivars, treatment T_{10} (Boron @ 150 ppm + Zinc @ 150 ppm + NAA@ 150 ppm + GA3 @ 150 ppm) was found to be superior among others, followed by treatment T_5 (Boron @ 100ppm + Zinc @ 100 ppm + NAA @ 100ppm + GA3 @ 100ppm) and treatment T_0 (control) was found to be inferior. It is also concluded that among all cultivars, Arbequina cultivar was found best. Thus, treatment T_{10} (Boron @ 150 ppm + Zinc @ 150 ppm + NAA@ 150 ppm + GA3 @ 150 ppm) with Arbequina cultivar is best recommended for overall flowering and fruiting characters of Olive like, Days to flowering, Number of flowers per panicle, Fruit drop percentage, Fruit diameter, Fruit length, Fruit weight, Fruit yield per tree, Fruit yield per hectare, Oil content, TSS of fruit.

Keywords: *Olive, micronutrients, Plant growth regulators, Boron, Zinc, NAA, GA_3.*

INTRODUCTION

Olive is native to the Mediterranean region; botanical name of Olive is *Olea europaea* and it belongs to family Oleaceae. it is an evergreen tree with a height ranging from 12-15 meters. Olive is characterized by its silvery-green leaves, tiny whitish flowers and small oval shaped fruits. Olive trees are evergreen in nature and they can tolerate adverse edaphic conditions including, high temperature and draught, these abilities of olive trees make them one among the hardy crops and bear fruits even during the tough environmental challenges. Olive trees are alternate bearers, they produce heavy yield for one year and lesser yield in succeeding year. Olive is of major agricultural importance in the Mediterranean region as the source of olive oil (Bertrand *et al*. 2002). Olive is one among the oldest cultivated crops known to the mankind, it holds a significant historical, cultural, medicinal and economic importance in numerous countries. Olive is most widely cultivated in Mediterranean countries namely, Spain Greece, Italy, Turkey, Portugal, and Tunisia. In India olive cultivation is pertained to Parts of Rajasthan, Himachal Pradesh, Uttar Pradesh, and Delhi. The area and production under olive in the world is 10,839,026 ha and 18,083,800 tons respectively (F.A.O. 2021). Olives are primarily used for oil extraction apart from oil extraction olives are also consumed as snacks, pickles Although, olive tree has been designated as a drought tolerant yet, it requires sufficient soil moisture during certain stages of growth. Unfortunately, majority of olive plantations were undertaken on hill slopes, in the drought prone areas of mid hills and valley areas of the state. Furthermore, these areas are completely devoid of irrigation facility. An erratic trend of monsoon and winter rains has become more conspicuous in the last decade which further aggravated the problem of poor growth and bearing of olive trees. Acute water stress during autumn coupled with scanty or insufficient and irregular rainfall distribution. Boron induces pollen tube growth resulted from its role on tryptophan synthesis as an auxin precursor biosynthesis. The main function of boron is related to cell wall strength and development, cell division, sugar transport and hormones development, RNA metabolism, respiration, indole acetic acid (IAA) metabolism and as part of the cell membranes. Lewis (1980) speculated that B may be required in stigma and styles to physiologically inactivate callus present in pollen tube walls that would otherwise elicit phytoalexin production to inhibit pollen tube growth. The boron requirement is much higher for reproductive growth period than for vegetative growth and increases flower production and retention, pollen tube elongation and germination, and seed and fruit development. Several investigators studied the effect of zinc and/or boron on fruit set, productivity and fruit quality in many plant species. Talaie *et al*. (2001) showed that foliar spray of B and Zn decreased fruit drop and increased fruit quality in the 'Zard' olive. Hassan *et al*. (2010) found that boric acid treatments increased pollen germination than control and increased percentage of retained fruits in 'Picual' olive. Abd El-Migeed *et al*. (2015) on 'Picual' olive reported that boric acid spray at 300 mgl-1 increased fruit length. Osman (1999) on olive found that boron treatments either as foliar or soil applications increased percentage of retained fruits. Khayyat *et al*. (2015) reported that boric acid at 1500 mgl-1 on 'Shahany' date palm increased pulp weight, pulp/seed ratio; fruit length and diameter. Plant growth regulators or Phytohormones play a very important role in modification or regulation of the physiological processes in plants. Among Phytohormones NAA and GA3 play a key role in Flowering, and Fruit set of Olive. Plant growth regulators are applied to plants through various methods but, Plant growth regulators when applied through Foliar spray gives desired results within a short span of time since, they are easily absorbed by plant tissues when applied directly on different plant parts. NAA plays a major role in strengthening the root system by new root initiation in the plants. It enables proper functioning of roots which transport water, nutrients and other needed elements for vegetative and floral growth of the tree. NAA application in olive is mostly done for the purpose of fruit thinning in order to avoid overcrowding of fruits on the branch. Application of NAA reduces excess number of fruits on the branch thus promoting the growth of evenly spaced fruits on branch and directly plays a major role in increasing the overall fruit quality of Olive Arnon *et al*. (2009). Gibberellic acid plays a major role when applied on Olive trees through Foliar spray. It promotes cell enlargement and mesocarp development of Olives, which is a desirable character in increasing the fruit size and fruit quality of Olive. GA3 also helps in reduction of fruit drop and increases the fruit retention in Olive trees. Since GA3 directly regulates elongation, enlargement and growth of cells thus increasing the fruit length and diameter of the olive fruits. Ramezani *et al*. (2010).

MATERIAL AND METHODS

The present investigation was done to understand the plant growth, fruit yield and quality of olive using different sprays of micronutrients and plant growth regulators. The details of the materials used, and the methods adopted in the investigation, which was carried out at Horticultural Research Farm, Department of

Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Winter* season of 2022. The design used in study was randomized block design (RBD) each treatment was replicated thrice. The data were statistically analysed (by the method suggested by Fisher and Yates (1963)**.** The treatments comprised of T_0 (Control), T_1 (Boron @ 100 ppm), T_2 (Zinc @ 100 ppm), T_3 (NAA @100 ppm), T_4 (GA_3 @ 100 ppm), T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA_3 @100 ppm), T_6 (Boron @ 150 ppm), T_7 (Zinc @ 150 ppm), T_8 (NAA @150 ppm), T_9 (GA_3 @ 150 ppm) and T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm). Spraying was done prior to fruit harvest at time of formation of fruit. Observations were recorded at different stages of growth periods for characters like days to flowering, number of flowers per panicles, days to flowering to fruiting, fruit length, fruit diameter, fruit weight. Chemical parameters like oil content, TSS etc were also calculated. Fruit weight was calculated after harvest using electronic balance. TSS was measured using refractometer.

RESULTS AND DISCUSSION

A) Flowering attributes

1. Days to flowering, number of flowers per panicles

Days to flowering showed that there were significant differences among the treatments. The minimum days to flowering (13.33) was recorded under the treatment T_{10} (Boron@150ppm + Zinc@150ppm + NAA@150ppm + GA_3@150ppm) which is at par with T_5 (Boron@100ppm + Zinc@100ppm + NAA@100ppm + GA_3@100ppm) (15.33) followed by the treatment T_9 (GA_3@150ppm) (18.33) T_8 (NAA @150 ppm) (19.33) respectively. The maximum days to flowering (28.67) was recorded under the treatment T_0 (Control) followed by the treatments T_1 (Boron@100ppm) (26.67) and T_2 (Zinc@100ppm) (26.00) respectively. The maximum number of flowers per panicle (26.00) was recorded under the treatment T_{10} (Boron@150ppm + Zinc@150ppm + NAA@150ppm + GA_3@150ppm) which is at par with treatment T_5 (Boron@100ppm + Zinc@100ppm + NAA@100ppm + GA_3@100ppm) (24.33) which is followed by the treatment T_9 (GA_3@150ppm) (22.00) flowers respectively. The minimum number of flowers per panicle (9.33) was recorded in the treatment T_0 (Control) and followed by the treatments T_1 (Boron@100ppm) (13.33) followed by T_2 (Zinc@100ppm) (15.67) flowers respectively. The maximum flowers per panicle was observed in T_{10} [Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm +GA_3 @ 150 ppm]. Significant improvement in flowering and fruiting components such as the number of flowers per shoot, fruit set (%), fruit drop (%) and fruit retention (%) as influenced by increasing levels of NAA and boron treatments was observed. Combined form of micronutrients and GA_3 plays a vital role in prompting proper growth, increasing flower production and retention, pollen tube elongation and germination, and seed and fruit development by Regulating plant's hormone levels. Not only it regulates the flowering but also plays an important role in controlling the flower drops. The similar experiment was also conducted by **Aftab, 1994** and found the use of zinc, boron and growth regulators on flowering, fruiting, and maturity of litchi. The obtained results are close with that obtained by Shaheen (1995), Osman (1999), and Hassan (2000) on Olive. The minimum days to flowering in T_{10} might be since Boron plays an essential role in plant's life cycle and very essential for normal growth of plants. **[Fageria *et al.* (2007), McLaughlin *et al.* (1999)].** While Significant improvement in flowering and fruiting components such as the number of flowers per shoot, fruit set (%), fruit drop (%) and fruit retention (%) as influenced by increasing levels of NAA and boron treatments was observed during the present investigation. Similar results were also seen in the experiment conducted by **Badal and Tripathi (2021)** on olive (*Psidium guajava* L. *cv* L-49).

B) Fruiting attributes

2. Percent of fruit drop, Fruit weight, fruit length, fruit diameter and fruit volume.

Fruit drop Percentage showed that there were significant differences among the treatments. Minimum fruit drop percentage (19.67) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5(Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (21.33), T_9 (GA3 @ 150 ppm) (25.67) which was at par with T_8 (NAA @150 ppm) (27.00). Maximum fruit drop percentage (37.00) was recorded under the treatment T_0 (Control) followed by T_3 (NAA @100 ppm) (34.33) is followed by T_1 (Boron @ 100 ppm) (34.67). The least percent of fruit drop were observed in the treatment T_{10} [Zn @ 150 ppm+ B @ 150 ppm + NAA @150 ppm +GA_3 @ 150 ppm]. Environmental factors are key responsible for the fruit drop in most of the species. Application of GA_3 with the combination of micronutrients have shown greater responses against the fruit drop. Similar results were also obtained in **(Nagy & Kovacs, 2005).**

Fruit diameter showed that there were significant differences among the treatments. Maximum fruit diameter (16.67) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) is at par with T_5(Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (15.67) followed by T_9 (GA3 @ 150 ppm) (14.00) and T_8 (NAA @150 ppm) (13.67) respectively. Minimum fruit diameter was recorded under the treatment T_0(control) (7.67) which is at par with T_1 (Boron @ 100 ppm) (8.00) and T_2 (Zinc @ 100 ppm) (8.33) respectively. Fruit length showed that there were significant differences among the treatments. Maximum fruit length (23.00) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (21.77), T_9 (GA3 @ 150 ppm) (20.33) and T_8 (NAA @150 ppm) (19.17) which was at par with T_7 (Zinc @ 150 ppm) (18.33). Minimum fruit length (12.83) was recorded under the treatment T_0 (Control)which is at par with T_1(Boron @ 100 ppm) (13.37). Maximum fruit weight (4.23) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (4.00), T_9 (GA3 @ 150 ppm) (3.57) which was at par in with T_8 (NAA @150 ppm) (3.40). Minimum fruit weight (1.63) was recorded under the treatment T_0 (Control) followed by the treatments T_1 (Boron@100ppm) (1.90) , T_2 (Zinc@100ppm) (2.23) respectively. Present investigation showed that the maximum fruit weight on an average (4.23kg) was obtained in T_{10} [Zn @ 150 ppm+ B @ 150 ppm + NAA @150 ppm +GA_3 @ 150 ppm] as compared to control (1.63kg). It might be due to use of growth regulators to improve the use of stored carbohydrates, nitrogen and other variables, **Singh (2013)** in *Citrus limon*, **Kaur Sukhjit (2017)** in Florida guard peach and **Siddiqua *et al.* (2018)** in dragon fruit, also recorded these results.

3. Fruit yield per tree and fruit yield per hectare

Maximum fruit yield per tree (3.10) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (2.57), T_9 (GA3 @ 150 ppm) (1.73) and T_8 (NAA @ 150 ppm) (1.50) respectively. Minimum fruit yield per tree (0.34) was recorded under the treatment T_0 (control) followed by T_2 (Zinc @ 100 ppm) (0.59). The maximum yield obtained was (12.40 q/ha) **T_{10}** [Zn @ 150 ppm+ B @ 150 ppm + NAA @150 ppm +GA_3 @ 150 ppm]. Fruit yield per hectare showed that there were significant differences among the treatments. Maximum fruit yield per hectare (12.40) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (10.27). Minimum fruit yield per hectare (1.37) was recorded under the treatment T_0 (control) followed by T_2 (Zinc @ 100 ppm) (2.35), T_3 (NAA @100 ppm) (2.45) respectively. The beneficial effect of boron and zinc in increasing fruit yield might be due to the higher availability of photosynthesis, and/or their role in increasing the percent of perfect flowers and these chemicals are also associated with hormone metabolism which promotes synthesis of auxin, essential for fruit set and growth. The results are in accordance with **Kazemi (2014).** Similar results of increased yield due to the application of $ZnSO_4$ were reported by **Pathak *et al.* (2004)** in olive.

C) Quality attributes

1. TSS, oil content

Oil content showed that there were significant differences among the treatments.

Maximum Oil content (20.83) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @ 100 ppm + GA3 @ 100 ppm) (19.70), T_9 (GA3 @ 150 ppm) (18.67) respectively. Minimum Oil content (10.20) was recorded under the treatment T_0(Control) followed by T_1 (Boron @ 100 ppm) (11.53). The results observed are also in agreement with that obtained by **Shaheen (1995)**, **Weisman *et al.* (2002)** and **Hassan (2000)** who found great increase in fruit oil content of olive trees due to boron treatments. Moreover, **Kamal (2002)** found that boron and Zinc with a combination of GA_3 applications increased the oil percentage in olive fruits.

TSS of fruit showed that there were significant differences among the treatments. Maximum TSS of fruit (13.80) was recorded under the treatment T_{10} (Boron @ 150 ppm+ Zinc @ 150 ppm + NAA @150 ppm + GA_3 @ 150 ppm) followed by T_5 (Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA3 @100 ppm) (13.37), T_9 (GA3 @ 150 ppm) (12.90) respectively. Minimum TSS of fruit (10.10) was recorded under the treatment T_0 (control) followed by T_1 (Boron @ 100 ppm) (10.60), T_2 (Zinc @ 100 ppm) (10.90) respectively. The combination of micronutrients and plant growth regulators have shown positive affect on the TSS of olive fruit. The maximum TSS have shown was 13.80 in the treatment T_{10} [Zn @ 150 ppm+ B @ 150 ppm + NAA @150 ppm +GA_3 @ 150 ppm] The studies pertaining to bio-chemical status of fruits reflected that TSS (%) was affected significantly by the micronutrients or the plant growth regulators in the finding of **Rajkumar *et al.* (2014)**

Conclusion

On the basis of the present investigation, it is concluded that among the various treatments applied to enhance the Flowering, Fruit set, fruit Yield, Fruit quality and Oil quality of Olive cultivars, treatment T_{10} (Boron @ 150 ppm + Zinc @ 150 ppm + NAA@ 150 ppm + GA3 @ 150 ppm) was found to be superior among others, followed by treatment T_5 (Boron @ 100ppm + Zinc @ 100 ppm + NAA @ 100ppm + GA3 @ 100ppm) and treatment T_0 (control) was found to be inferior. It is also concluded that among all cultivars, Arbequina cultivar was found best. Thus, treatment T_{10} (Boron @ 150 ppm + Zinc @ 150 ppm + NAA@ 150 ppm + GA3 @ 150 ppm) with Arbequina cultivar is best recommended for overall flowering and fruiting characters of Olive like, Days to flowering, Number of flowers per panicle, Fruit drop percentage, Fruit diameter, Fruit length, Fruit weight, Fruit yield per tree, Fruit yield per hectare, Oil content, TSS of fruit.

Table 1 Performance of different micronutrients and plant growth regulators application on various flowering and fruit parameters of olive.

Treatment symbol	Treatment Details	Days to flowering	Flowers per panicle	Fruit drop (%)	Fruit Diameter (mm)	Fruit length (mm)	Fruit weight (g)	Fruit yield (Kg/tree)	Fruit yield (q/h)	Oil content (%)	TSS (°Brix)
T_0	Control	28.67	9.33	37.00	7.67	12.83	1.63	0.34	1.37	10.20	10.10
T_1	Boron @ 100 ppm	26.67	13.33	34.67	8.00	13.37	1.90	0.49	1.95	11.53	10.60
T_2	Zinc @ 100 ppm	26.00	15.67	31.33	8.33	14.00	2.23	0.59	2.35	12.73	10.90
T_3	NAA @100 ppm	25.00	16.33	34.33	9.67	15.07	2.60	0.61	2.45	13.17	11.17
T_4	GA_3 @ 100 ppm	23.00	17.00	31.00	10.00	16.33	2.80	0.87	3.49	14.60	11.50
T_5	Boron@ 100 ppm+ Zinc @ 100 ppm + NAA @100 ppm +GA_3 @100 ppm	15.33	24.33	21.33	15.67	21.77	4.00	2.57	10.27	19.70	13.37
T_6	Boron @ 150 ppm	21.33	20.00	30.00	11.00	17.43	3.00	1.01	4.04	15.20	11.80
T_7	Zinc @ 150 ppm	20.67	20.67	28.33	12.33	18.33	3.10	1.20	4.80	16.77	12.13
T_8	NAA @150 ppm	19.33	21.33	27.00	13.67	19.17	3.40	1.50	6.00	17.13	12.60
T_9	GA_3 @ 150 ppm	18.33	22.00	25.67	14.00	20.03	3.57	1.73	6.93	18.67	12.90
T_{10}	Boron @150 ppm+ Zinc @ 150ppm+ NAA @150 ppm + GA_3 @ 150 ppm	13.33	26.00	19.67	16.67	23.00	4.23	3.10	12.40	20.83	13.80
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		**1.28**	**1.17**	**0.97**	**0.66**	**0.40**	**0.08**	**0.07**	**0.31**	**0.13**	**0.09**
CD (5%)		**2.67**	**2.44**	**2.03**	**1.38**	**0.84**	**0.18**	**0.16**	**0.66**	**0.28**	**0.20**
CV		**7.26**	**7.60**	**4.09**	**7.03**	**2.86**	**3.62**	**7.69**	**7.69**	**1.09**	**1.01**

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