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Original Contribution

STUDY ON FOLIAR APPLICATION NITROGEN, BORON AND ZINC ON OLIVE TREE

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ABSTRACT
This experiment was conducted to study the effects of foliar spray of boric acid (0, 2000,4000 mg l^{-1}), zinc sulphate (0, 2000,4000 mg l^{-1}) and urea (0, 5000, 7500 mg l^{-1})on initial and final fruit set, shot berries %, yield, and fruit oil of olive. The experiment was conducted in randomized complete design with four replications on olive orchards. In first year, the most initial fruit set was observed in control and the lowest one was seen in 4000 mg l^{-1}zinc sulphate +7500 mg l^{-1}urea. The least shot berry percent was observed in 2000 mg l^{-1}zinc sulphate+2000 mg l^{-1}boric acid+7500 mg l^{-1}urea, respectively. The most yield and fruit oil percentage were seen in 2000 mg l^{-1}zinc sulphate alone and 2000 mg l^{-1}boric alone respectively.

Key words: Boric acid, Olive, Urea, Zinc sulphate

INTRODUCTION

Olive's nutrient requirements are lower than that for many other fruit trees, but shortage in these requirements costs the tree major physiological disorder (1). Fertilization, especially nitrogen, is a cultivation technique that greatly affects the olive tree productivity (2). The high importance of N involve fertilization has been confirmed in more recent studies. Rodrigues *et al.* (3) found that a significant and progressive decrease in olive yield when N was eliminated from fertilization plan for four years, in comparison with treatments where N was applied annually. Jasrotia *et al*. (4) also found a significant increase in olive productivity with increasing nitrogen doses. Oil content and quality are also influenced by the addition of fertilizers. Indeed, nitrogen promotes higher levels of oleic and stearic acid in drupe and its deficiency is associated of elevated levels of palmitic and linoleic acid (2). Quoted by Fernandez- Escobar (5) good nitrogen fertilization can, in fact sustain soil fertility management, avoiding unnecessary waste of fertilizer and improves the level of crop yield. Although, olive is well adapted to a wide range of growing condition and soils, nutritional disorders caused by boron deficiency are quite common (6-8). The deficiency is usually described as abnormal fruit development or "monkey face" and seems to be cultivar depended. Leaf-tip yellowing, shoot die back, fruit drop and break abnormalities in addition to death of the terminal bud that results in a" bushy" appearance, are common symptoms of B deficiency (7). Furthermore, the supply of boron needed for reproductive growth in many crops is more than that needed for vegetative growth (9-12) and the same may be true in olive. Boron application increases fruit set and yield in several fruit and nut crops, including almond, filbert, Italian prune and sour cherry (7, 12, 13). In many of these experiments, foliar applications of boron were effective in tree that showed no obvious vegetative symptoms of boron deficiency (10, 14). The role of Zn is in plant that is affects the synthesis of tryptophan which is a precursor of indole acetic acid and the formation of the growth substance is directly influenced by Zn. It has also an important role in starch metabolism in plant. It is well known that zinc acts as co-factor of many enzymes and affects many biological processes such as photosynthesis reaction, nucleic acid

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metabolism, protein and carbohydrate biosynthesis (15). Foliar application of micronutrients is a valuable practice; against the micronutrient deficiency curing micronutrient deficiency through foliar application is a common practice in getting profitable yield and good quality fruit (16). Foliar spray is advantageous over soil application because of rapid responses, effectiveness and elimination of deficiency symptoms due to certain micronutrients (17, 18). Also, the actual fertilization practices in olive orchards are based mainly on tradition, repeating the same fertilization program every year, and also testimonial of the neighbors (5). The excessive application of non-needed fertilizers causes environmental degradation (15). It negatively affects olive oil quality and flower quality (5, 19). Therefore, the aims of the present research were to study the effect of foliar spraying of urea, boric acid and zinc sulphate either individually or additively on fruit set, shot berries, fruit oil and yield of olive trees.

MATERIALS AND METHODS

This research was carried out on 14 year-old olive trees (*Olea europaea* L.cv. Shengeh) grown in a soil with the following properties: 93% sand, 5% clay , 2% silt, pH=8.27 and EC=1.04 dsm^{-1}. The trees spacing was set to 7m ×7m apart under a drip irrigation system in Fasa Pishgaman orchard located in Fars province of Iran. All treated trees were subjected to the same cultural practices. This research was done in 3×3 factorial arranged in complete block design with 3 replication in 2 years. Before the onset of experiment, according to soil and water mineral elements analysis, the elements which were suited to this project were selected. Treatments include foliar application of zinc sulphate(0, 2000, 4000 mg l^{-1}) , boric acid (0, 2000, 4000 mg l^{-1}) and urea (0, 5000, 7500 mg l^{-1}). Foliar application was done in early morning and in control trees with distilled water. Trees were sprayed before pit hardening (when 90% of flowering opening). Quantitative characteristics that were assayed in this study were yield, initial fruit set, final fruit set, shot berries, fruit oil percentage in olive fruit. At harvest, fruits from each treatment were harvested separately and fruit yield was measured for each treatment. Olive samples were also collect at harvest and were used to determine the oil olive content. Fruit set was determined as the percentage of fruit remaining based either on total flower count. The received data's were analysis with SAS software ver 9.1. Comparisons were carried out with LSD test at 5% possibility.

RESULTS AND DISCUSSION

In first year, the most initial fruit set (93.61%) was observed in control and the lowest one (44.01%) was seen in 4000 mg l^{-1}zinc sulphate and 7500 mg l^{-1}urea. In second year, the highest initial fruit set (87%) was seen at 5000 mg l^{-1}urea alone, but there was no significant difference with 2000 mg l^{-1}boric acid+2000 mg l^{-1}zinc sulphate (86.69%) (**Table 1**).

Table1. *Effects of foliar application of urea, boric acid and zinc sulphate on initial fruit set of olive fruit in two years.*

Treatment	Initial fruit set First year	Initial fruit set Second year
Zn0 B0 N0	93.61 a	82.69 c
Zn0 B0 N5000	72.99g	87a
Zn0 B0 N7500	55.74n	75.03j
Zn0 B2000 N0	50.23q	57.58p
Zn0 B2000 N5000	55.99n	77.12h
Zn0 B2000 N7500	76.80d	84.3b
Zn0 B4000N0	82.57b	83.32b
Zn0 B4000 N5000	59.24m	68.05m
Zn0 B4000 N7500	74.5f	63.02o
Zn2000 B0 N0	60.13m	70.69 l
Zn2000B0 N5000	78.81c	78.97f
Zn2000 B0 N7500	54.35o	77.83g
Zn2000 B2000 N0	52.34p	86.96a
Zn2000B2000 N5000	71.66h	69.90 l
Zn2000 B2000 N7500	49.13r	83.69b
Zn2000B4000 N0	70.69i	80.72d
Zn2000 B4000 N5000	62.51l	82.65c
Zn2000B4000N7500	75.71e	84.31b
Zn4000 B0 N0	66.55j	80.79d
Zn4000 B0 N5000	71.36hi	78.95f
Zn4000 B0 N7500	44.01 s	82.09 c
Zn4000 B2000 N0	66.6j	72.92 k
Zn4000 B2000 N5000	77.5d	79.65e
Zn4000 B2000N7500	71.54hi	73.83k
Zn4000B4000 N0	63.58k	65.63n
Zn4000 B4000 N5000	51.57p	81.88c
Zn4000 B4000 N7500	72.68m	77.08i

In each column, means followed by different letters differ significantly at P≤0.05 according to LSD test.

The highest (90.51%) and lowest (62.84%) final fruit set were observed in 4000 mg l^{-1}zinc sulphate+5000 mg l^{-1}urea and 4000 mg l^{-1}zinc sulphate with 2000 mg l^{-1} boric acid and 7500 mg l^{-1}urea respectively. In second year, the most final fruit set occurred in 4000 mg l^{-1}boric acid+5000 mg l^{-1}urea (73.69%) (**Table 2**).

The most and least shot berries percent (28.66, 2%) were observed in control and 2000 mg l^{-1}zinc sulphate+2000 mg l^{-1}boric acid+7500 mg l^{-1}urea respectively. In 2010, the highest shot berries percent was seen in 2000 mg l^{-1}zinc sulphate with 7500 mg l^{-1}urea (**Table 3**).

***Table 2**. Effects of foliar application of urea, boric acid and zinc sulphate on final fruit set of olive fruit in two years.*

Treatment	Final fruit set First year	Final fruit set Second year
Zn0 B0 N0	65.33r	35.67 o
Zn0 B0 N5000	76.75i	47.68 k
Zn0 B0 N7500	77.69h	55.39 g
Zn0 B2000 N0	83.34c	46.05 l
Zn0 B2000 N5000	65.77q	39.10 m
Zn0 B2000 N7500	86.47b	63.95 d
Zn0 B4000N0	74.7k	56.12 g
Zn0 B4000 N5000	68.11n	73.69a
Zn0 B4000 N7500	66.84o	50.01i
Zn2000 B0 N0	79.87f	62.6 e
Zn2000B0 N5000	79.37fg	51.49h
Zn2000 B0 N7500	82.62d	66.43 c
Zn2000 B2000 N0	70.05m	36.96n
Zn2000B2000 N5000	77.4hi	64.12d
Zn2000 B2000 N7500	76.08ij	45.28 l
Zn2000B4000 N0	75.82j	59.31f
Zn2000 B4000 N5000	78.64g	62.12e
Zn2000B4000N7500	73.62 l	52.31h
Zn4000 B0 N0	78.85g	66.67c
Zn4000 B0 N5000	90.51a	59.14f
Zn4000 B0 N7500	66.63p	52.66h
Zn4000 B2000 N0	63.89s	32.72p
Zn4000 B2000 N5000	81.03e	70.56b
Zn4000 B2000N7500	62.84t	63.75d
Zn4000B4000 N0	69.53mn	49.05i
Zn4000 B4000 N5000	70.71m	53.24h
Zn4000 B4000 N7500	80.98 e	48.07k

In each column, means followed by different letters differ significantly at P≤0.05 according to LSD test.

***Table 3.** Effects of foliar application of urea, boric acid and zinc sulphate on shot berries of olive fruit in two years.*

Treatment	Shot berries (%) First year	Shot berries (%) Second year
Zn0 B0 N0	28.66a	2.67f
Zn0 B0 N5000	3.33j	9.33cd
Zn0 B0 N7500	6h	5.33ef
Zn0 B2000 N0	20.66b	8d
Zn0 B2000 N5000	12.67e	2.67f
Zn0 B2000 N7500	16.67c	8d
Zn0 B4000N0	9.33g	12c
Zn0 B4000 N5000	10.67f	12c
Zn0 B4000 N7500	6.67h	4ef
Zn2000 B0 N0	10f	4ef
Zn2000B0 N5000	8.67g	14.67b
Zn2000 B0 N7500	12e	18.67a
Zn2000 B2000 N0	8.67g	10.67cd
Zn2000B2000 N5000	13.33e	5.33ef
Zn2000 B2000 N7500	2k	2.67f
Zn2000B4000 N0	16.67c	5.33ef
Zn2000 B4000 N5000	8.66g	10.67cd
Zn2000B4000N7500	15.33d	4ef
Zn4000 B0 N0	5.33i	13.33bc
Zn4000 B0 N5000	15.33d	4ef
Zn4000 B0 N7500	8e	9.33ef
Zn4000 B2000 N0	6.67h	8d
Zn4000 B2000 N5000	6.67h	6.67e
Zn4000 B2000N7500	6.67h	10.67cd
Zn4000B4000 N0	14d	12c
Zn4000 B4000 N5000	15.33d	8d
Zn4000 B4000 N7500	6h	10.67cd

In each column, means followed by different letters differ significantly at P≤0.05 according to LSD test.

The most oil fruit percentage (33.7%) was seen in2000 mg l^{-1}boric acid and also the lowest one was observed in 4000 mg l^{-1}boric acid+5000 mg l^{-1}urea without zinc sulphate (6.66%) (**Table 4**). The highest and lowest yield was seen in 2000 mg l^{-1}zinc sulphate (10983 g/tree) and 2000 mg l^{-1}zinc sulphate+4000 mg l^{-1}boric acid+5000 mg l^{-1}urea (1650 g/tree) respectively (**Table 4**).

Other treatments demonstrated significant difference with each other and control. Increased fruit set and yield following boron application have been reported for several fruit and nut crops, including almond (6, 13), filberts, Italian prunus (11), and sour cherry (12). Delgado *et al*. (20) suggested that boron is mobilized from young olive leaves during anthesis to supply the needs of flowers and fruits. Hu *et al*. (14) also showed that phloem re translocation of boron occurred in olive. This has been confirmed using foliar applied boron, which significantly enriched the developing olive flowers, fruits and growing shoots (7). Studies of other crops indicate that boron influences *in vivo* and *in vitro* pollen germination (21, 22). A plausible explanation for increased fruit yield may be that the applied boron was transported to developing flowers where it increased fruit set improving pollen viability and/ or pollen tube growth. Boron requirements for reproductive growth in many crops are more than that needed for vegetative growth (20, 23). Boron foliar application increased fruit set in olive cultivars such as "Manzanillo" (7), "Koronaiki" and "Boutilan" (24), grape fruit, orange "Hamlin" (25), Pear "Conference" (26) but there was no effect on fruit set in lemon "Lisbon" (25). Nitrogen is considered to be the most commonly applied nutrient in olive orchards (4-19). Application of nitrogen from urea prevents from abscission olive fruits and increased yield.

Table 4. *Effects of foliar application of urea, boric acid and zinc sulphate on yield and fruit oil of olive fruit.*

Treatment	Yield (g/tree)	Fruit oil (%)
Zn0 B0 N0	3366.67q	27.5e-j
Zn0 B0 N5000	5450i	24 i-k
Zn0 B0 N7500	3325r	26.55f-l
Zn0 B2000 N0	7666.67d	33.7a
Zn0 B2000 N5000	3416.67p	28.4c-h
Zn0 B2000 N7500	5216.67j	34.2 a
Zn0 B4000N0	2733.33u	25.95 f-l
Zn0 B4000 N5000	4533.33 l	6.66 l
Zn0 B4000 N7500	1781.7 y	29.3 c-g
Zn2000 B0 N0	10983.33 a	18.45n
Zn2000B0 N5000	6116.67 g	23.7 j-m
Zn2000 B0 N7500	5200k	23.2 lm
Zn2000 B2000 N0	7866.67 c	23.95 lm
Zn2000B2000 N5000	8266.67 b	28.95 c-g
Zn2000 B2000 N7500	5883.33h	30.95a-e
Zn2000B4000 N0	3466.67n	26.6 f-l
Zn2000 B4000 N5000	1650z	33.2 ab
Zn2000B4000N7500	7000e	31.7a-d
Zn4000 B0 N0	2566.67w	23.6 k-m
Zn4000 B0 N5000	2075x	29.75 b-f
Zn4000 B0 N7500	3300s	25.65 h-l
Zn4000 B2000 N0	3133.33t	23.4 lm
Zn4000 B2000 N5000	3450a	24.85 h-l
Zn4000 B2000N7500	6450f	20.3mn
Zn4000B4000 N0	2593.6v	28.2d-h
Zn4000 B4000 N5000	3950m	27.4 e-k
Zn4000 B4000 N7500	7550d	32.67abc

In each column, means followed by different letters differ significantly at P≤0.05 according to LSD test.

The final for olives has been improved for trees that received the nutrients compared to control in the two years of study. Foliar application of urea is a four-fold more efficient than soil application. In other reports absorption of urea twenty-fold more than other nutrients, and also urea can help to absorb other nutrients such as zinc and boron which are used as foliar application (9, 27). Application of nitrogen in comparison with other nutrient elements was more effective (28). Crop load or alternate fruiting of a given orchard is not a valid reason to alter N rate. In "On" years, the photo assimilates are derived primarily to the fruits whose growth needs less N than leaves. To growth more leaves, which occur in "Off" years, requires much more N (2, 15). In addition, the buffer capacity of the plant permits that crop is not affected in the short-term. Thus, what is important in an olive orchard is to know its average yield potential. Low productivity was attributed to lack of soil depth which is related to results of this project. The low yield was because of high ratio of shot berries which were produced due to high temperature during the flowering period. According, to this research the results were in agreement with above researchers. Zinc sulphate was more effective than boric acid and urea on olive yield and also zinc sulphate with boric acid and urea could increase oil percent. The lowest shot berries percent were seen in foliar application with boric acid alone or boric acid plus zinc sulphate. Increased in yield was shown in "Manzanilo" olive cultivar (16), in almond (9), grape (24) with foliar spray of both zinc sulphate and urea. Ulger *et al.* (29) who concluded that nutrients may have limited effect on floral formation. The major effect of olive tree nutritional status on productivity was found to be through the process of fruit setting. Oil accumulation in fruits during the "On" years in both cultivars increased consistently as the season progressed leveling "Off "at the latest harvest dates. During "Off" years oil percentage in fruits remained almost unchanged with respect to harvest date. According to Talaie *et al*. (27) there was no significant effect of foliar application on fruit oil content. The influence of nitrogen on oil percent depends on leaf phosphorous, if there is high nitrogen and low phosphorous in leaf, oil content will be more. Urea does not have any impact on fruit oil percent, this will be attributed to low concentration urea and insufficient number of foliar application times. This progress in oil content for the two years of study is due to the improvement of nutritional status in micro and macro nutrients. This is noticed further to fertilizing brought at just moment and during the critical stages of development of olive tree (30). Indeed, the accumulation of the oil in the olive is a process which depends on the quantity of the carbohydrates resulting from fruits and old leaves (30). Increased in yield might be due to more fruit set, larger fruit and more fruit weight, because of the role of boron and zinc on cell division and cell enlargement and the volume of intercellular spaces in mesocarpic cells increased. Also this phenomenon was related to very high mobility of photosynthetates in developing fruits that are active and strong sinks (3, 7, 17).

CONCLUSONS

The obtained results in the present research proved that foliar application of zinc sulphate at 2000 mg l^{-1}alone, boric acid plus urea at 5000 mg $l^{-1}$and zinc sulphate along with 2000 mg l^{-1}boric acid are the most effective ones in order to increases fruit set and yield and decreases shot berries percent. Also the combination of zinc sulphate, boric acid and

urea had positive effect on fruit set and yield and negative impact on parthenocarpic fruits. Under silt loam, calcareous and alkaline condition of soil it is recommended to apply foliar spray to the orchards in order to enhance the efficiency of micronutrients and avoid losses by leaching and interaction among the nutrients.

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