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Melatonin and Gibberellin Employing to Mitigate Heat Stress Effects on "Canino" Apricot

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Abstract

The fruit yield of apricot trees may decrease as a result of temperature stress. Through improving growth, productivity, and fruit quality, some compounds may play a significant part in resolving that issue. Therefore, this study was conducted during two successive growing seasons (2017 and 2018) in order to lessen the effects of heat stress on the production and fruit quality of Canino apricot trees cultivated on the farm of the Horticulture Research Station at El Kanater El Khayreia, Egypt, by foliar spray of hormonal substances and antioxidants i.e. (melatonin "MEL" or gibberellic acid" GA3 "each at concentration (25 mg/L) at pre-dormancy stage. It could be concluded that spraying Canino apricot trees at pre-dormancy stage (August) with both of GA3 and MEL enhanced the vegetative growth, as well as it improved flower quality compared with untreated control during the two cultivated seasons, also, melatonin improved growth and fruit set, yield, and fruit quality, followed by gibberellic acid compared with Control.

Keywords: *Prunus Armeniaca;* L.; Melatonin; Gibberellin; Growth; Yield; Fruit quality.

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1. Introduction

Perennial crops like stone fruits are among those that are temperature-sensitive [1]. Plant phenology adjustment, such as timing of leafing, blooming, harvest and fruit production, and decrease in winter chilling, all contribute to the risk of temperature change in horticultural crops [2]. Horticultural crops respond differently to temperature stress depending on a number of variables, including crop growth stage, type of plant tissue, and temperature stress type. Yield in apricots can be affected by many environmental and physiological factors [2-7]. High temperature often accelerates the initiation processes, which results in less antioxidant activity from the existing or newly added antioxidants [8, 9]. Recently, a natural compound as an antioxidant and growth promoter like Melatonin (MEL.) is used to protect the crops during moderate and high heat conditions, and increase yield. Melatonin is an indole molecule that has a structure with other vital compounds including tryptophan, serotonin, and indole- 3-acetic acid (IAA), as it has the ability to adjust plant growth and development according to the dose of addition [10]. Exogenous melatonin may alter the amount of endogenous free IAA, according to a theory put out by Arnao and Hernandez - Ruiz [11]. Melatonin is known to play a dual function in protecting plants from biotic and abiotic stress [12]. Melatonin plays a role in a variety of plant processes, including postponing flower induction [13]. Three kinds of melatonin-related roles in plants may be identified: growth-promoting auxin roles [14], free radical-scavenging roles as the first line of defence against oxidative stress [15], and thirdly, MEL is thought to have a role in a variety of physiological processes in plants, including root and shoot growth [16], blooming, the formation of flowers and fruits, and the postponement of leaf senescence [13] or maintenance of developmental stages in fruit tissues [17]. Among its various roles, MEL promotes cell redox status stabilisation and tissue protection against reactive oxygen that builds up in stressful environments. The developmental processes throughout both vegetative and reproductive growth are impacted by exogenously administered MEL. Gibberellins (GA3) are naturally occurring growth hormones that play a key part in triggering the auxin response. This reaction aids in the growth and development of

many plants and has a direct impact on the quality, yield, internode elongation, blooming, and fruiting of plants. The utilization of GA3 in agricultural techniques has the potential to boost fruit yield and enhance fruit quality. Numerous researchers have also claimed that it enhances fruit size, production, and quality either directly by influencing growth and development processes or indirectly by controlling crop load and plant vigour [18-20]. Additionally, it has a wide range of physiological impacts on blooming, growth, germination, stem lengthening, leaf expansion, and cell expansion [21]. Exogenous GA3 treatment to plants increases the activity of several important enzymes and photosynthesis [22]. Gibberellins were used for breaking the pre-dormancy of apple [23]. Einhorn, *et al.* [24] found that applications of GA3 at low rate (20 ppm) on the late-maturing sweet cherry improved fruit quality. Gibberellins largely influence growth by regulating cell elongation and division, which has an impact on yield, its constituents, and the quality of different grape cultivars [25]. The experiment was conducted to identify the effect of MEL and GA3 when sprayed at pre-dormancy stage through data on growth, yield, and fruit quality.

2. Materials and Methods

2.1. Plant

Canino apricot (Prunus armeniaca, L.) trees were cultivated on a farm at the Horticulture Research Station in El-Kanater El-Khayreia, Kalubeia Governorate, Egypt. They were grafted on a local apricot rootstock and were around thirteen years old, symmetric, and in good health. This research was conducted over the course of two consecutive growth seasons (2017 and 2018).

2.2. Foliar Spray Compounds

In order to lessen the effects of heat stress on growth, productivity, and quality, foliar sprays of the hormones and antioxidants gibberellic acid (GA_3) and melatonin (MEL) were applied in each season in the middle of August (pre-dormancy stage). GA_3 (product from Science Lab. com, Inc. Chemical Laboratory Equipment, 14025, Smith Road, Houston, Texas 77396, USA). MEL (product from ScienceLab.com, Inc. Chemical Laboratory Equipment, 14025, Smith Road, Houston, Texas77396, USA). This was done in comparison to the water-sprayed trees (control). Triton B was used as a wetting ingredient in all spray solutions at a concentration of 0.1% to reduce surface tension. Each tree under treatment got 20 L of the applied solution, which was misted until runoff in the early morning hours. This experiment was conducted using a complete randomised block design with three treatments, each of which had three replicates where the tree is one replicate. For all trees, comparable horticultural procedures were used, as advised by Egypt's Ministry of Agriculture. All of the trees were irrigated using a flood irrigation system.

2.3. Growth

Three branches/tree/year that were two years old were assessed. Branches were uniform in all cases, measuring between 100 and 120 cm in length and 20 to 25 cm in diameter, and they were positioned at similar heights and various orientations. At full bloom, when 50 % of the flower buds were opened, total numbers of flower buds were counted (percentage of buds opening were recorded and determined at the completion of flowering “full bloom”). percentage of total number vegetative buds opening was recorded and determined after bud burst stage. After 30 days of full bloom, fruit set was calculated as the ratio of fruits to total flower buds (fruits/buds). Data were recorded on shoot length extension (cm.); number of leaves extension were measured during mid-June in each season.

2.4. Fruit Yield

When fruit was being picked from trees, the yield observations were made. Fruits were picked from each tree, instantly weighed, and represented as kilograms per tree.

2.5. Fruit Physical Characteristics

Twenty fruits from each tree were sampled during harvest and delivered in plastic bags to the lab for testing. Samples were weighed on a top pan balance for fruit weight, and the average weight was given in grammes per fruit (g). Fruit diameter: Using Vernier callipers, the average fruit diameter was determined and represented in centimetres per fruit (cm/fruit). Fruit firmness: a pressure tester (Magness-Taylor Pressure tester, Model FT 327) was used to determine fruit flesh firmness in pounds per $inch^2$ ($Lb/inch^2$).

2.6. Fruit Chemical Analyses

By placing a few drops of fruit juice on the prism of a Carl Zeiss hand refractometer (0 to 32 Brix), total soluble solids (TSS) of fruit juice were calculated. Prior to usage, distilled water was used to calibrate the refractometer. Titratable acidity (TA): In an electric blender, five grammes of fruit pulp were fully homogenized with distilled water before the amount was increased to 50 ml. After that, the mixture was run through Whatman No. 1 filter paper. Then, phenolphthalein was used as an indicator to titrate five milliliters of the sample until a pink end point appeared. By utilising phenolphthalein as an indicator and titrating the fruit pulp extract with 0.5N NaOH, the TA of the fruit was calculated. The proportion of anhydrous citric acid was used to indicate this, as stated in A.O.A.C. [26].

2.7. Statistical Analysis

Each season's data was subjeced to a variance analysis in accordance with Snedecor and Cochran [27], and significant differences between means were identified using the Duncan's multiple test range [28].

3. Results and Discussion

Figure 1 shows the effect of spraying Canino apricot trees with melatonin and gibberellic acid during bud's pre-dormancy stage (August) on growth and fruit setting during 2017/2018 season. It is evident from the obtained results that spraying Canino apricot trees with melatonin was the superior among all treatments, especially regarding shoot length, and fruit set, while the second place was accessed by gibberellic acid. Spraying with water (control) was the lowest among treatments for the same three characteristics. There were no clear differences among treatments concerning the percentage of vegetative and flower buds, and number of leaves.

The second season results (Figure 2) show the positive effect of spraying Canino apricot trees with GA_3 or melatonin during bud's pre-dormancy stage (August) on shoot length, number of leaves, percentage of vegetative and flower buds, and fruit set compared with control. There were no clear differences between treatments in all characters in the second season, except for shoot length, which had a key role for both melatonin and gibberellic acid in obtaining the best results.

According to our research, throughout the two cultivated seasons of 2017/2018 and 2018/2019, foliar treatments of GA_3 and melatonin increased vegetative growth and boosted flower quality compared to the untreated control. By promoting or inhibiting growth and development, the administration of these hormones at low doses permits physiological processes to proceed at a typical rate [29]. The encouragement of stem development is the characteristic trait of gibberellins [30]. Auxins encourage the growth of flowers, thin tree fruit, and long shoots [31]. Numerous researchers examined the effects of GA_3 on different crops and came to the conclusion that GA_3 enhanced plant development [32, 33]. According to Rajput and Singh [34], treatment with GA_3 at 20 ppm improved shoot length in 16-year-old trees of ber cv. Banarasi Karaka. The balance between endogenous inhibitors and gibberellins may be one of the agents influencing floral bud induction and differentiation in the olive. This conclusion might be drawn from the fact that GA_3 spraying inhibits blooming and increases the hormones responsible for vegetative development. The ability to switch from floral to vegetative buds or to delay the floral transition by exogenous GA_3 in the "on" year may thus be helpful to combat the alternate bearing occurrence [35]. When olive trees were sprayed with GA_3 at a rate of 75 ppm at the beginning of December, vegetative growth increased [35]. Abd El-Naby, *et al.* [36], concluded that spraying Valencia orange trees with gibberellic acid showed the best vegetative growth, followed in descending order by spraying with melatonin. It is generally known that GA_3 is employed as a plant growth regulator to promote cell division and cell elongation, which have a favorable impact on the characteristics of vegetative development. It has an impact on a variety of plant growth processes, such as stem elongation through promoting cell division and elongation, blooming, fruit development, and pre-dormancy breaking [37]. More dry matter accumulates as a result of GA_3's favorable effects on plant vegetative development, which may be the primary factor in fruit yield. Additionally, since melatonin has both lipophilic and hydrophilic properties, it may be simple for the molecule to pass through morphological and physiological barriers with little difficulty, leading to its rapid transport into plant cells. One melatonin molecule has the capacity to scavenge up to 10 free radicals [38]. In addition to directly scavenging free radicals, melatonin's antioxidant activity can also increase antioxidant enzyme activity, protect antioxidant enzymes from oxidative damage, improve mitochondrial transport chain efficiency, and decrease free radical production [39]. Melatonin administration was the most noticeable treatment on the vegetative development of the apricot [40].

Spraying Canino apricot trees at pre-dormancy stage (August) with melatonin (Figure 3) showed a pivotal role in affecting the yield and its properties, and this was evident in the first season (2017/2018), where melatonin gave the highest fruit number, fruit weight and yield, followed by gibberellic acid compared with control.

Like the first season, Figure 4 shows spraying Canino apricot trees with melatonin at pre-dormancy stage (August) in 2018/2019 season which also achieved the best results concerning productivity (total number of fruits, fruit weight and yield), followed in descending order by gibberellic acid compared with control (spraying with water).

Spraying Canino apricot trees at pre-dormancy stage (August) with melatonin (Figure 3) showed a pivotal role in affecting the yield and its properties, and this was evident in the first season (2017/2018), where melatonin gave the highest fruit number, fruit weight and yield, followed by gibberellic acid compared with control.

Trees may suffer from issues related to high temperature stress, which might reduce fruit production and, as a result, existing and augmented antioxidant activity [9]. High temperatures during plant growth can impact hormone levels, primary and secondary metabolite concentrations, respiration, water relations, and membrane stability [41]. Numerous researchers examined the effects of GA_3 on certain plants and came to the conclusion that GA_3 increased plant production [32, 33]. Fruit weight and yield were reportedly boosted when 16-year-old trees of the ber cv. Banarasi Karaka were treated with GA_3 at 20 ppm, according to Rajput and Singh [34]. Çolak [42], applied melatonin and gibberellic acid to the leaves of jumbo blackberries and discovered that these treatments most effectively raised the quantity and weight of fruits, whereas GA_3 5 ppm and MEL 10 ppm had the greatest impact on fruit size (length and breadth). Biostimulators can encourage the production of phytohormones, make it easier for nutrients to be taken up from the substrate, increase yield, and enhance product quality. Additionally, they act as agents to make plants more resistant to unfavourable circumstances like high temperatures, drought, heavy metals, etc. [43]. Melatonin can lessen the detrimental effects of climate change on plant yield [12, 40, 44-46].

Abd El-Naby, *et al.* [47] showed that fruit set percentage of navel orange was improved using GA_3 and Mel, and this resulted in improving number of fruits, fruit weight and tree yield. So, the use of GA_3 and melatonin at low concentration were favourable to produce high yield and maintained good fruit quality comparing with unsprayed

trees. According to Abd El-Naby, *et al.* [36], spraying Valencia orange trees with gibberellic acid produced the maximum yield, followed in decreasing order by spraying with melatonin.

Regarding fruit quality, Figure 5 indicated that spraying Canino apricot trees at pre-dormancy stage (August) in 2017/2018 season with melatonin exhibited the best fit of fruit diameter, fruit firmness, and juice total soluble solids, followed by gibberellic acid compared with control.

Like 2017/2018 experimental season, Figure 6 shows spraying Canino apricot trees with Melatonin which gave the highest fruit firmness, the lowest juice titratable acidity and the highest juice total soluble solids, followed in descending order by gibberellic acid compared with control.

Thus, the firmness, size, flavor, and beauty of the fruit play a major role in determining fruit quality and consumer acceptability of apricots. The main elements influencing productivity and marketability for growers are also fruit size and firmness. The impact of GA_3 on raising TSS is attributed to the vines' ability to store more carbohydrates and their increased rate of photosynthesis [48]. These auxins are recognized for their capacity to expand cells [49, 50], and promote date palm [51, 52], and Clementine mandarin fruit development [53]. To raise the size of grapes and the firmness of apricots, GA_3 is often utilized in fruit species [54, 55]. Fruit qualities improved when olive trees were sprayed with GA_3 at a concentration of 75 ppm on the first of December [35]. Additionally, because of the antioxidant characteristics of melatonin, it helps maintain cellular redox state and shield tissues from reactive oxygen, which builds up in a stressed environment. Melatonin is thought to benefit human health as well as food quality (a component of functional foods). This substance's molecular structure is comparable to that of the auxin, which suggests that it could function similarly in plants. Especially in the first season, the majority of produced navel orange fruit attributes did not substantially change between GA_3 and MEL treatments [47].

4. Conclusions

In general, it might be summarized that GA_3 spraying had the best results in terms of tree growth and yield, followed by MEL spraying. We advise spraying these materials, especially MEL and in descending order GA_3, on apricot trees to get a good growth and a higher yield because their use as biostimulators could be a good, practical, and affordable method useful in agriculture. The majority of characteristics of the resulting fruits did not significantly differ between all treatments. It has been shown that the employing of melatonin as an effective biostimulator, antioxidant and growth promoter in agriculture was beneficial and positive in reducing the effect of heat stress on yield and quality of apricot. Spraying Canino apricot trees with melatonin at pre-dormancy stage (August) improved growth (shoot length, number of leaves, percentage of vegetative and flower buds) and fruit set, and yield (fruit weight and number), and fruit characteristics (diameter, firmness, titratable acidity and total soluble solids), followed by gibberellic acid compared with control.

Author Contributions

All authors participated in the field work and chemical analysis, Also, Yehia performed data collection in the field; Amr performed the statistical analysis; Abd El-naby designed this work and supervised the experiment; Abd El-naby and Amr read and approved the final manuscript

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Conflicts of Interest

“The authors declare no conflict of interest.”

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Figure-1. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on growth and fruit set of Canino apricot during 2017/2018 season

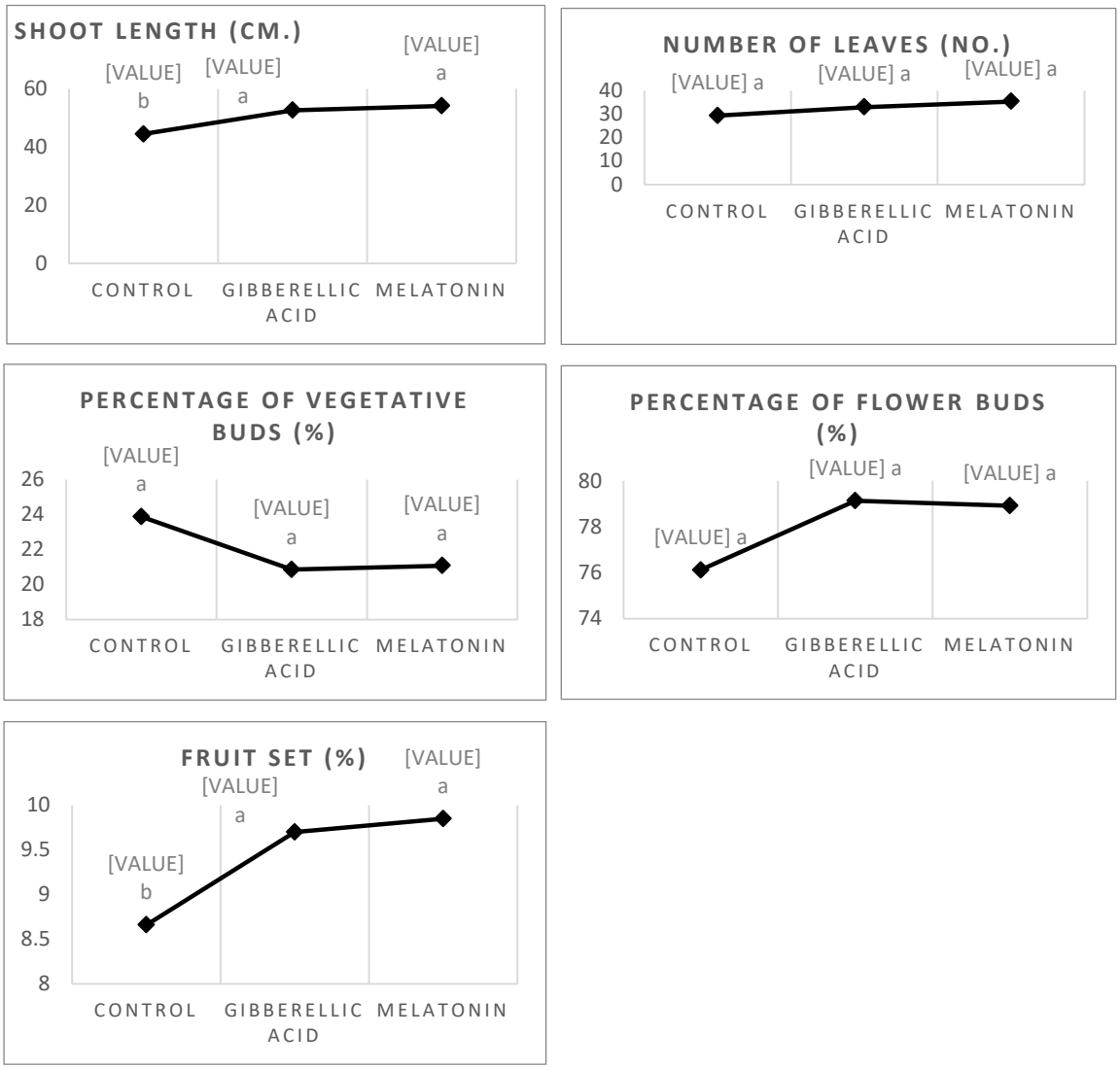

Figure-2. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on growth and the fruit set Canino apricot during 2018/2019season

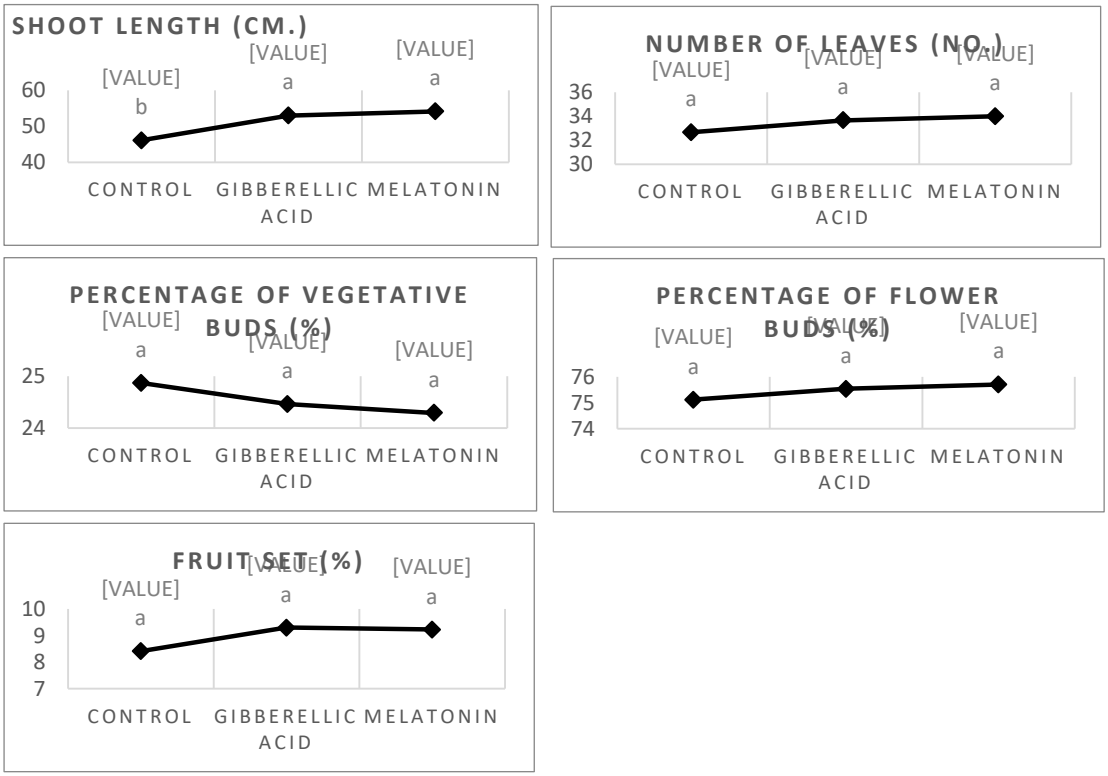

Figure-3. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on Canino apricot yield during 2017 /2018 season

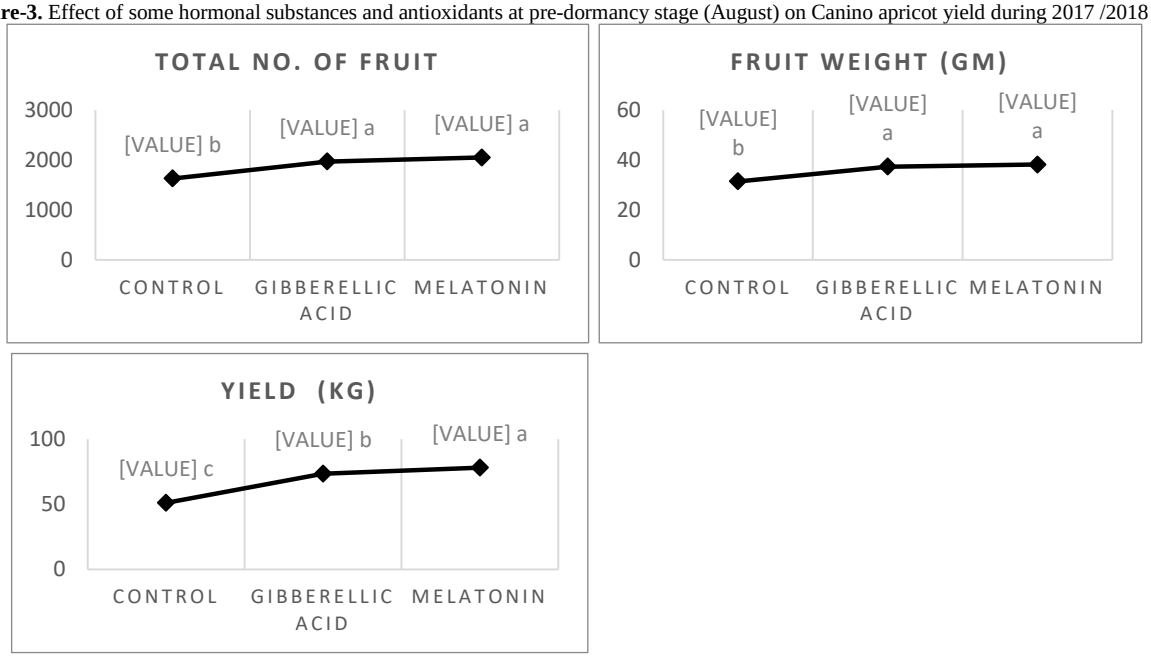

Figure-4. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on Canino apricot yield during 2018/2019season

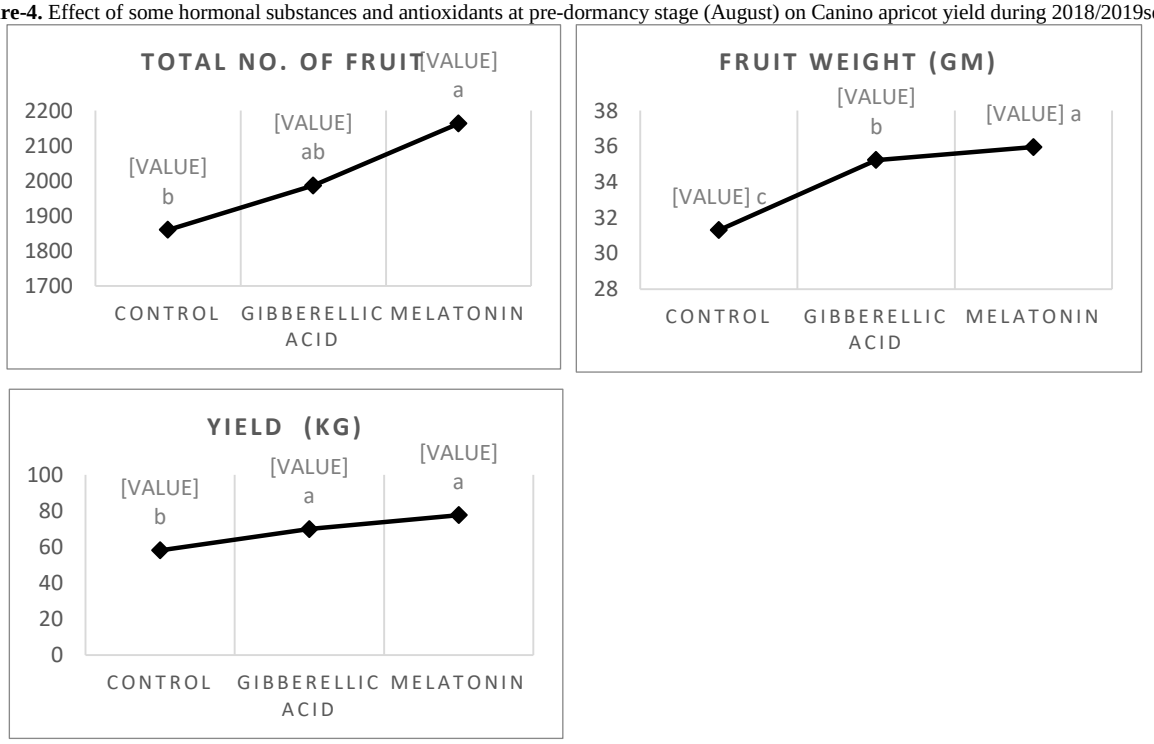

Figure-5. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on fruit quality of Canino apricot during 2017 /2018 season

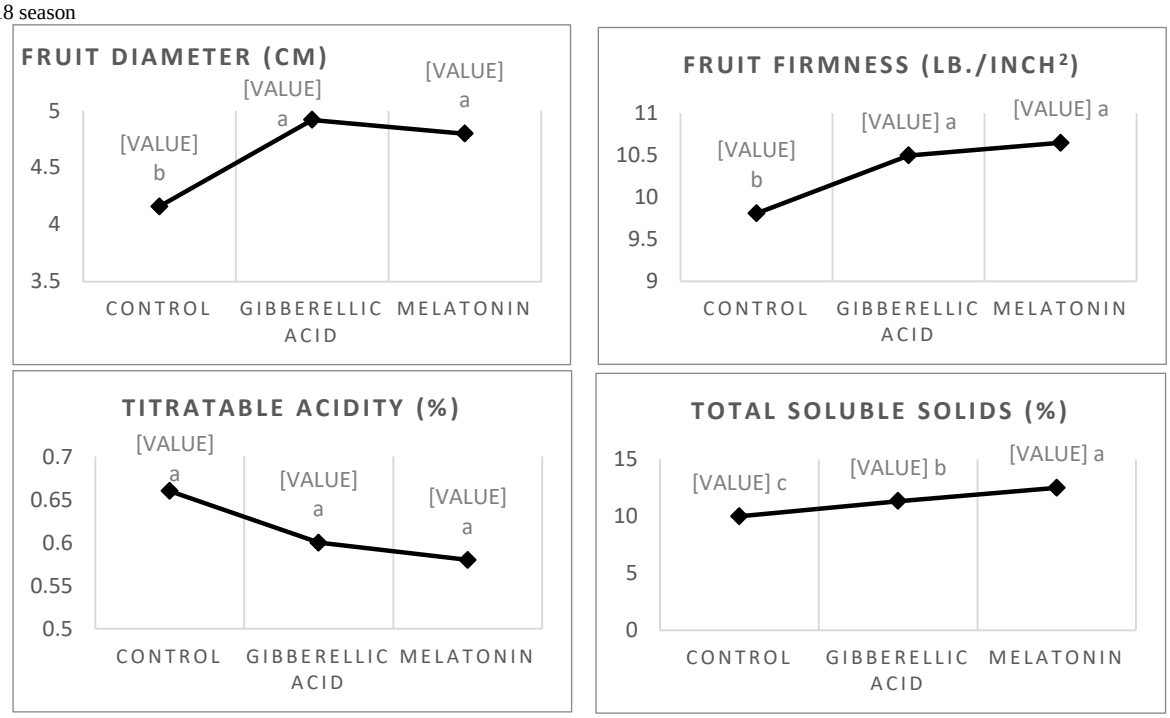

Figure-6. Effect of some hormonal substances and antioxidants at pre-dormancy stage (August) on fruit quality of Canino apricot during 2018/2019 season