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Effect of Some Growth Regulators and Systemic Copper Complexes on Reducing Floral Malformation, Yield and Quality of "Alphonse" Mango (*Mangifera indica* L.)

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Abstract

The present study was carried out during 2019 and 2020 seasons on Alphonse mango trees to evaluate the effect of some growth regulators and systemic copper complexes on floral malformation, yield and quality. Vegetative growth characters were superior with 200 NAA ppm and 100 ppm cofret. However, total chlorophyll, total carbohydrates and C/N ratio recorded the highest values with 200 ppm NAA. Macro elements N, P, K and Mg % were higher with GA3 at 100 ppm, whereas the highest values of micro elements Fe, Zn, Mn and Cu (ppm) were obtained with perfecto-one at 100 ppm. The number of total panicles/tree was increased with NAA 200 ppm and perfecto-one 100 ppm treatments than other treatments. The number and percent of malformed panicles/tree were significantly decreased with the applied treatments than in control.. An increasing in total indoles, total phenols and polyphenol oxidase activity were recorded with 200 ppm NAA and 100 ppm perfecto-one treatments than in others. Final fruit set% and the number of fruits /tree were increased with the treatments of 200 ppm NAA and 100 ppm perfecto-one. However, the highest values of fruit weight were recorded by GA3 and perfecto-one both at100 ppm treatments, whereas the highest yield/tree values were recorded by NAA 200 ppm and 100 ppm perfecto-one. Finally, fruit quality involved TSS, acidity, L-ascorbic acid, total sugars and total carotenoids were greatly improved with the applied treatments than in control.

Keywords: Mangos, Alphonse, Growth regulators, Systemic copper, Malformation, Yield.

1 Introduction

Mango (*Mangifera indica* L.) is a delicious tropical fruit belonging to the Anacardiaceae family. Mango is considered the queen of fruit because it is very popular all over the world as it is an abundant source of minerals, vitamins and is distinguished by its excellent flavor, sweet aroma and nutritional value. The mango is a complex tree and it is always puzzling to understand its vegetative growth and reproduction pattern and its various disturbances. (Mukherjee and Litz 2011).

Mango deformation is one of the most destructive diseases of this crop worldwide. (Ploetz and Freeman 2009), it affects the inflorescences and the vegetative parts of the plant. Although the trees are not killed, the vegetative stage of the disease impedes the growth of the canopy and the flowering stage greatly reduces the fruit yield, significant economic losses can occur because the deformed inflorescences do not bear fruit. The panicles become greener with more crowded branches. These panicles also contain many unopened flowers and are male-dominated and rarely bisexual (Katoch et al 2019). This occurs due to the hormonal imbalance associated with Fusarium infection (*F. mangiferae*) resulting in a metabolic disorder that leads to poor formation and thus reduced productivity and quality of mangoes (Singh 2000). All growth regulators and biological testers significantly reduced the incidence of mango deformation with a significant increase in the yield of fruit produced. (Azmy 2015). The flowering period of the mango is related to both weather and environmental conditions (Chacko 1991). Also, Litz (1997) discovered that in winter, warm periods may promote early flowering. Inhibition of flowering by gibberellin is associated with increased vegetative growth where GA_3 delayed the emergence of flowers (Nkansah et al 2012) as it is considered as one of the by-products of diterpenoid compounds as their role as a variety of physiological activities (Upreti et al 2013).

The response of gibberellins in the flowering process depends mainly on Growth stage concentrations, and climatic conditions of the area, it is believed that an increase in gibberellin concentrations may increase or maintain the production and synthesis of supplementary hormones which can enhance the partitioning of assimilates to suit for inhibition of flowering. With increase in the stem age, the concentration of gibberellins also increases within the buds. (Sanjay et al 2018). However, Gibberellins play a major role in stimulating the auxin reaction that helps regulate growth as they are naturally developed hormones (Weiss and Ori 2007).

Gibberellins promote stem elongation, stem germination, leaf stretching, flowering, pollen, seed development, and delays fruit ripening. (Yruela 2009). However, Nkansah et al (2012) showed that, spraying mango trees with GA3 at 40 ppm led to a significant increase in fruit set percentage and reduced fruit drop, it was also shown that flowering delay depends on GA3 concentration and application time.

In general, higher levels of auxins were found in healthy panicles of mango as compared to malformed panicles, also in addition to the lower levels of lAA in affected tissues and enlarged. Accordingly, it has been suggested by Kumar et al (2013) that, the deformation may be due to the low level of auxins, which leads to hormonal imbalance. The use of chemicals as a foliar application has been shown to be effective in reducing mango deformation disease, as it may delay or advance the onset of flowering (Sanjay et al 2018). However, Mahrous (2004) reported that foliar spray of naphthalene acetic acid and IBA before flower bud differentiation at a rate of 100 & 200 ppm reduce the incidence of deformation

Newman et al (2012) showed that foliar applications with fungicides such as Phosphamidon significantly reduce the incidence of floral malformation. NAA is a plant hormone (synthetic auxin) mainly used for vegetative propagation of rooting plants from cuttings and stems. The effect of NAA on plant growth depends largely on the time of application and concentration. It is proven that it greatly increases the composition of cellulose fibers in plants. In the majority of fruit plants, fruit droplets are controlled by spraying it into different fruit crops at different concentrations. It is applied after blossom fertilization, as it effects of increased yield the different of fruit crops (Maibangra and Ahmed 2000, Mahaveer et al 2017)

Copper is an essential element for all life forms, found in exists as Cu^{2+} and Cu^{+}. Copper plays a necessary role for the normal growth and development of plants, as it performs physiological and biochemical functions in plant organisms as well as participates in the processes of photosynthesis, respiration and transport of carbohydrates and conversion of nitrogen compounds, in addition to being a regulator of DNA synthesis. Copper is also involved in many enzymes in plants as a constituent of the protein component, especially those involved in electron flow, redox reactions in chloroplasts and mitochondria as well as cell wall and cytoplasm in plant cells (Rehman et al 2019). At the cellular level, copper is essential in the signaling machinery for protein trafficking, transcription, iron mobilization and oxidative phosphorylation. Hence, plants need copper molecules as essential nutrients for normal growth and development, when this ion is not available, specific deficiency symptoms appear on plants, most of which affect the reproductive organs of young leaves reduced the incidence of mango malformation (Sari et al 2007).In contrast, in the case of an excess of copper, plants are subjected to oxidative stress due to the increase in the production of reactive oxygen species which leads to the impairment of key processes related with photosynthesis (Raven et al 1999, Ruyters et at 2013). For that, the main target of this work was to evaluate the effects of NAA, GA3 and two copper complexes on floral malformation, yield and quality of "Alphonse" mangos.

2 Materials and Methods

This study was conducted during the seasons of 2019 and 2020 on adult Alphonse mango trees grown in a private farm at El-khatatba district, Menofiea Governorate. The trees were 10 years old at the beginning of the experiment and planted at 7X7 m^2 (86 trees / fed) under drip irrigation system, healthy, similar in growth and free from various injuries. All horticultural practices such as irrigation, fertilization, pest and diseases controls were done. Hobbs (2003).

The experimental design was adapted as follow:

1. Control: spacing the trees with tap water
2. Spraying NAA (naphthalene acetic acid) at 100 ppm.
3. Spraying NAA (naphthalene acetic acid) at 200 ppm.
4. Spraying GA3 (Gibberellic acid) at 50 ppm.
5. Spraying GA3 (Gibberellic acid) at 100 ppm.
6. Spraying Cofect (Copper complex) at 50 ppm.
7. Spraying Cofect (Copper complex) at 100 ppm.
8. Spraying perfecto-one (Copper complex) at 50 ppm.
9. Spraying perfecto-one (Copper complex) at 100 ppm.

The nine treatments were arranged in a complete randomized block design with four replicates (9 treatments X 4 replicate = 36 trees, each replicate was represented by one tree. All normal horticulture practices were done as usual in this respect. All spray treatments were done at first of January and repeated on the same trees in first of February in both studied seasons. The trees were sprayed in the morning after removal of dew, until run off with 20 liters / tree of different treatments. The following measurements were recorded during the two studied seasons:

2.1. Vegetative growth parameters

Four main branches (newly uniform in growth, diameter and foliage density and distribution around the periphery of each tree) were chosen and labeled at the beginning of experiment. At first of July for both tested seasons the following vegetative growth characters were measured:

- Average shoot length (cm)
- Average shoot thickness (cm) from 5 cm of the bottom.
- Average the number of leaves / shoot
- Average leaf area (cm^2)

2.2. Fruit set and yield components

- **Final fruit set.** Ten distributed fruit shoots around the tree were chosen and labeled at flowering stage. The number of perfect flowers per each panicles were counted, before harvest , the fruit retention for each panicle was calculated and final fruit set was estimated: Final fruit set % = Total fruit retention numbers / number of perfect flowers
- Number of fruits/tree
- Average fruit weight (g)

- Total yield (Kg / tree) was estimated by harvest all fruits at maturity stage and weighing the total yield per each tree

2.3. Leaf minerals

Leaf mineral contents samples of thirty leaves from the middle part of adult shoots (6-7 months were selected at random from each replicate at first of July. The leaves were washed, dried at 70°C till constant weight, grinned and digested according to Rebbeca (2004).

2.3.1. Macro elements N, P, K, Ca and Mg%

- Total nitrogen (g/100 g dry weight) was determined using the micro-kjeldahl method as described by Wilde et al (1985)
- Potassium content was determined by Flame photometer as percentage according to method of Jackson, (1967)
- Phosphorus: was estimated as the method described by Bringham (1982). Calcium and magnesium (g/100g dry weight), were determined using an atomic absorption spectrophotometer which described by Chapman and Pratt (1982).

2.3.2. Micro nutrients Fe, Zn, Mn and Cu (ppm) were determined in digested solution and measured using an absorption spectrophotometer according to Chapman and Pratt (1982).

2.4. Physical panicles properties

- Number of total panicles/tree
- Number of malformed panicles/tree
- Malformed panicles %

2.5 Chemical components

- Total indoles (mg/100gfwt), was colorimetrically determined in panicles according to Selim et al (1978)
- Total phenols (mg/100gfwt), was determined in panicles colorimetrically followed the methods of Folin-Denis as described by Daniel and George (1972).
- Poly phenol oxidase activity (PPO activity) Unit mg protein-1 min-1 was colorimetrically determined in panicles according to Erzengin (2009).
- Total chlorophyll (mg/100 g fresh weight) was determined in leaves according to Moran and Porath (1980).
- Total carbohydrates (g/100 g dry weight), was determined in dried shoot powder according to Smith et al (1979).
- C/N ratio was calculated by dividing shoot total carbohydrate on leaf total nitrogen

2.6. Fruit pulp Chemical constituents

- Total soluble solids %, titratable acidity content (as g citric acid /100 g pulp fresh weight) and L-Asrobic acid content (mg / 100 g pulp fresh weight) was determined according to AOAC (2005)
- Total sugars %, Smith et al (1979)
- Total carotenoids content (mg / 100 g pulp fresh weight), was colormetrically determined according to Wellburn (1994).

2.7 Statistical analysis

Data were analyzed for statistical significant differences using MSTAT-C software (MSTAT, Michigan University East Lansing). Duncan multiple rang test (DMRT) at 5% level was completed to define any significant difference among various treatments, according to Snedecor and Cochran (1990).

3 Results and Discussion

3.1. Vegetative growth parameters

As it shown in **Table 1**, NAA, GA3 and Copper complexes greatly affected vegetative growth parameters of Alphonse mangos daring 2019 and 2020 seasons. The highest values of shoot length in the both studied seasons were obtained with NAA at 200 ppm treatment followed by perfecto-one at 100 ppm with significant difference between them in first season of study. However, in the second season the highest shoot length value (46.8 cm) was obtained with NAA 200 ppm followed by NAA at 100 ppm (41.9 cm).

Table 1. Effects of some growth regulators and systemic copper complexes on some vegetative growth parameters of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	Average shoot length (cm)		Shoot thickness (cm)		Number of leaves/ shoot		Leaf area (cm^2)	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	30.9 f	35.3 e	0.51 c	0.61 c	19.2 f	20.3 e	73.6 f	65.2 d
NAA 100 ppm	38.9 b	41.9 b	0.62 b	0.79 a	21.1 ef	23.2 d	80.4 bc	70.3 c
NAA 200 ppm	41.7 a	46.8 a	0.63 b	0.83 a	22.6 de	25.3 c	81.7 b	73.7 b
GA_3 50 ppm	37.5 c	41.6 bc	0.79 a	0.73 ab	30.8 a	36.6 a	84.5 a	79.5 a
GA_3 100 ppm	32.7 e	37.8 f	0.51 c	0.64 bc	22.9 c-e	29.5 b	75.4 ef	66.6 d
Cofret (Cu) 50 ppm	33.7 e	38.9 e	0.51 c	0.63 bc	23.8 b-d	30.4 b	76.3 e	65.7 d
Cofret (Cu) 100 ppm	36.6 cd	40.7 c	0.71 ab	0.72 a-c	31.7 a	34.7 a	83.6 a	78.6 a
Perfect-one (Cu)50 ppm	35.6 d	39.3 de	0.63 b	0.62 bc	24.7 bc	25.3 c	77.2 de	67.8 cd
Perfect-one (Cu)100 ppm	38.6 b	40.2 cd	0.67 ab	0.61 c	25.6 b	25.5 c	78.8 cd	65.9 d

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

All applied treatments greatly improved shoot thickness of Alphonse mango than control in the two studied seasons. However, the highest values of shoot thickness in first season was obtained with GA3 50 ppm (0.79 cm) followed by cofret 100 ppm (0.71 cm) without significant difference between them. Moreover, in the second season, the highest shoot thickness values (0.79 and 0.83 cm) were obtained with 100 and 200 ppm NAA.

A great increase in the number of leaves /shoot due to the applied treatments compared with control was obtained in the two studied seasons. In first season of study, the highest numbers of leaves /shoot (30.6 and 31.7) were obtained with GA3 50ppm and cofret 100 ppm without significant differences between them. The same trends of results were also obtained in the second season of study.

However, leaf area values of Alphonse mango trees greatly increased with all applied treatments than control in both studied seasons. However, the highest values of leaf area (84.5 and 83.6 cm^2) in the first season, and (79.5 and 78.6 cm^2) in the second season were obtained with GA3 50ppm and cofret 100 ppm, respectively, without significant differences between them.

3.2. Chemical constituents

As it shown in **Table 2**, a great effect to the treatments of NAA, GA3, cofret and perfecto-one on total chlorophyll, total carbohydrates, N% and C/N ratio of Alphonse mangos during the two studied seasons were obtained. Leaf total chlorophyll recorded highest values due to the applied treatments than control. However, the highest leaf chlorophyll contents (1.12 and 1.10 mg/100 g f wt) were obtained in first season with NAA 200 ppm and perfecto-one 100 ppm, respectively without significant differences between them. Whereas, the highest values of leaf total chlorophyll in second season were obtained by GA3 50 ppm (1.10 mg / 100 g fwt) and cofret 100 ppm (1.20 mg / 100 g fwt) without significant difference between them.

Table 2. Effects of some growth regulators and systemic copper complexes chemical constituents on of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	Total Chlorophyll (mg/100g fwt)		Total Carbohydrates (%)		N (%)		C/N ratio	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	0.92 c	0.93 d	23.4 e	21.4 e	1.59 e	1. 67 c	14.7 d	12.8 d
NAA 100 ppm	0.99 c	0.98 cd	27.4 d	25.9 d	1.77 bc	1.69 c	15.4 cd	15.3 c
NAA 200 ppm	1.12 a	1.04 bc	33.2 a	34.8 a	1.92 a	1.86 a	17.3 a	18.7 a
GA_3 50 ppm	1.00 bc	1.10 ab	28.8 cd	31.7 b	1.88 a	1.87 a	15.3 cd	17.0 ab
GA_3 100 ppm	0.96 c	0.96 cd	24.3 e	22.8 e	1.66 de	1.74 bc	14.6 d	13.1 d
Cofret (Cu) 50 ppm	0.98 c	0.98 cd	28.6 cd	26.5 d	1.76 cd	1.74 bc	.160 bc	15.2 c
Cofret (Cu) 100 ppm	1.00 bc	1.20 a	30.1 bc	30.5 bc	1.78 bc	1.82 ab	16.9 ab	16.8 b
Perfect-one (Cu)50 ppm	0.96 c	0.96 cd	27.9 d	29.4 c	1.81 ab	1.76 bc	15.4 cd	16.7 b
Perfect-one (Cu)100 ppm	1.10 ab	1.02 b-d	31.8 ab	32.3 b	1.87 ab	1.81 ab	17.0 a	17.8 a

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

Shoot total carbohydrates content was significantly improved with all applied treatments than control in both studied seasons. However, NAA 200 ppm was superior to other treatments in recoding the highest shoot total carbohydrates (33.2% in first season and 34.8% in the second one). In contrary, the least values of shoot total carbohydrates (24.3 and 22.8%) for both seasons were obtained due to GA3, at 100 ppm treatments which were similar to control. Leaf nitrogen content, data showed that evident increases were obtained with all applied treatments than control in both studied seasons. The higher N% values were obtained with NAA 200 ppm and GA3 50 ppm in both seasons without significant differences between them. C/N ratio values were greatly increased with all applied treatments than control in both seasons. However, NAA 200 ppm and perfecto-one at 100 ppm exhibited the higher values of C/N ratio than other treatments, without significant difference between them. It is well know that the increase in C/N ratio could be considered a good indicator for good flowering and reducing fruit abscission and consequently high yield.

In similar findings, Mutasa-Göttgens and Hedden (2009) reported that gibberellins lead to reproductive competence dependent on developmental events as well as in floral determination and commitment. After flower initiation, a functional GA signaling pathway is not required for the specification and differentiation of flower organs, but is necessary for the normal development of these organs (Guillermo et al 2007). However, Copper (Cu) involved in many physiological processes in plants, therefore it is considered a necessary active antioxidant. Copper acts as a structural component of regulatory proteins and is involved in photoelectron transport, mitochondrial respiration, cell wall metabolism, hormone signaling, and oxidative stress responses (Raven et al 1999). Copper ions are classified as cofactors in many of enzymes such as copper/zinc superoxide dismutase (SOD), cytochrome C oxidase, amino oxidase, lactase, polyphenol oxidase and plastocyanin (Xie et al

2009). Copper is an essential micronutrient for plant growth and development. It plays an important role in the formation of lignin in the cell wall (Kunito et al 2001).

Singh and Dhillon (1992) demonstrated that the lower level of carbohydrates in the deformed parts compared to the healthy parts due to the hydrolysis of starch to simple sugar to meet the energy requirements sufficient for the excessive growth of malformed panicle

3.3. Macro nutrients content (P, K, Ca and Mg%)

Table 3 show that all applied treatments greatly increased the level of P, K, Ca and Mg % in both seasons than central. The highest value of P % (0.32%) was obtained with GA3 at 100 ppm in first season, whereas no significant differences were obtained in second season either between different treatments or control.

K% recorded the highest values with GA3 at 50 or 100 ppm in both seasons without significant differences between them. However, perfecto – one at 50 or 100 ppm reduced K% than control in both seasons without significant difference between them.

Great increase in Ca % was obtained with the tested treatments than control especially with cofret 100 ppm in first season and NAA 200 ppm in both studded seasons. Additionally, higher Mg % values (0.56 and 0.62 %) were obtained with NAA 200 ppm in both seasons. Also, cofret and perfecto – one systemic copper complexes were effective in increasing Mg % in leaf Alphonse mango but less than NAA 200 ppm.

3.4. Micro nutrients content (Fe, Zn, Mn and Cu ppm).

Table 4 show that all applied treatments significantly increased the level of Fe, Zn, Mn and Cu in Alphonse mango leaf in both seasons. However, the highest values of Fe (161 and 173 ppm) were obtained with perfecto one at 100 ppm in both studied seasons. However, the treatment of NAA 200 ppm recorded the highest values of Zn (26.9 and 29.8 ppm) in both seasons. Regarding Mn content, it is clear that the highest values of Mn (21.8 ppm) in first season was obtained with cofret 100 ppm, whereas in second season was recorded by perfecto-one(22.7 ppm). Finally, higher values of Cu content (13.4 and 12.9 ppm) were recorded by perfecto – one at 100 ppm in both seasons. Generally, cofret and perfecto – one systemic copper complex with all concentrations were effective logically findings in increasing the level of Cu content in leaf Alfonse mango than other treatments or control. A slight difference is observed in the mineral constituent from healthy and malformed tissue, despite a deficiency of micronutrients, an association with iron and zinc has been reported the causation of malformation (Ram and Yadav 1999). It has been observed that the use of nutrients in combination NAA can reduce malformation, nutrient deficiency is not considered a major cause of malformation (Kvas et al 2008).

Misra et al (2002) indicated that, the shoot carrying malformed panicles had lower in nitrogen levels than healthy tissues, there was no reduction in phosphorous and potassium levels. The disorder does not accompany a nutritional imbalance, but this may affect the occurrence of the disease as it has been observed that the amount of calcium is lower in the malformed tissue than in the healthy tissues, and it has been suggested that calcium deficiency may not be directly answerable although it may predispose the tissues to become oversensitive to this disorder.

3.5 Physical and chemical panicles properties

Data in **Table 5** show that all applied treatments greatly increased the number of panicles/tree than control and the best treatments were NAA 200 ppm and perfecto – one 100 ppm in both seasons without significant differences between them. On the other side of view, untreated Alphonse mango was recorded the highest values at malformed panicles/ tree compared with the applied treatments and these findings were true in both seasons. However, the least numbers of malformed panicles / tree were recorded with NAA 200 ppm in first

Table 3. Effects of some growth regulators and systemic copper complexes on macro nutrients P, K, Ca and Mg content (%) of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	P (%)		K (%)		Ca (%)		Mg (%)	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	0.23 c	0.26 a	1.33 bc	1.52 b	1.79 d	1.69 e	0.40 c	0.36 d
NAA 100 ppm	0.25 bc	0.28 a	1.48 ab	1.68 a	2.19 b	2.24 a	0.51 ab	0.54 b
NAA 200 ppm	0.28 ab	0.30 a	1.48 ab	1.68 a	2.32 a	2.21 a	0.56 a	0.62 a
GA_3 50 ppm	0.30 ab	0.31 a	1.56 a	1.70 a	1.86 cd	1.92 cd	0.49 ab	0.45 c
GA_3 100 ppm	0.32 a	0.32 a	1.56 a	1.70 a	1.94 c	1.78 e	0.42 c	0.47 c
Cofret (Cu) 50 ppm	0.25 bc	0.26 a	1.42 bc	1.56 ab	1.95 c	1.84 de	0.44 bc	0.49 bc
Cofret (Cu) 100 ppm	0.26 a-c	0.27 a	1.33 bc	1.56 ab	2.43 a	1.96 cd	0.46 bc	0.51 bc
Perfect-one (Cu)50 ppm	0.25 bc	0.26 a	1.33 bc	1.50 b	2.17 b	2.12 ab	0.47 bc	0.53 bc
Perfect-one (Cu)100 ppm	0.26 a-c	0.28 a	1.32 c	1.50 b	2.22 b	2.07 bc	0.48 bc	0.56 ab

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

Table 4. Effects of some growth regulators and systemic copper complexes on micronutrient Fe, Zn, Mn and Cu (ppm) of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)	
	2019 season	2020 season	2019 season	2020 season	2019 Season	2020 season	2019 season	2020 season
Control	93 e	87 f	20.2 d	21.8 de	13. 6 d	14.8 d	6.6 e	5.9 d
NAA 100 ppm	121 d	127 de	24.6 a-c	27.2 ab	16.5 cd	15.7 d	10.7 bc	9.3 c
NAA 200 ppm	154 ab	162 ab	26.9 a	29.8 a	19.7 ab	21.4 ab	11.8 ab	12.2 ab
GA_3 50 ppm	132 cd	137 cd	25.3 ab	24.1 cd	17.3 bc	19.1 bc	9.6 cd	10.3 bc
GA_3 100 ppm	96 e	111 e	23.3 bc	20.8 e	16.6 c	18.9 bc	8.3 de	9.1 c
Cofret (Cu) 50 ppm	124 cd	134 cd	22.6 cd	24.2 cd	18.3 bc	20.4 a-c	10.3 bc	11.9 ab
Cofret (Cu) 100 ppm	138 b-d	151 bc	22.2 cd	23.8 cd	21.8 a	19.7 a-c	10.9 bc	12.4 a
Perfect-one (Cu)50 ppm	145 a -c	138 cd	24.1 bc	27.3 ab	18.9 a-c	17.8 cd	12.1 ab	12.5 a
Perfect-one (Cu)100 ppm	161 a	173 a	25.7 ab	26.1 bc	20.4 ab	22.7 a	13.4 a	12.9 a

Values followed by the same letter (s) of each column are not significantly different different according to Duncan multiple rang test (DMRT) at 5% level.

Table 5. Effects of some growth regulators and systemic copper complexes on the Physical panicles properties of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	No. of total panicles/tree		No. of malformed panicles/tree		Malformed panicles %	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 s eason
Control	223 f	194 e	96 a	89 a	43.0 a	45.9 a
NAA 100 ppm	271 bc	235 b	80 ef	77 c	29.5 cd	32.8 bc
NAA 200 ppm	319 a	276 a	76 f	68 e	23.8 e	24.6 d
GA_3 50 ppm	266 cd	232 bc	90 bc	83 b	33.6 bc	35.8 b
GA_3 100 ppm	244 e	211 d	92 ab	87 ab	37.7 b	41.2 a
Cofret (Cu) 50 ppm	253 de	219 cd	87 bc	74 cd	34.4 bc	33.8 bc
Cofret (Cu) 100 ppm	281 b	244 b	87 bc	74 cd	31.0 cd	30.3 c
Perfect-one (Cu)50 ppm	274 bc	237 b	86 cd	70 de	31.4 cd	29.5 cd
Perfect-one (Cu)100 ppm	307 a	266 a	82 de	66 e	26.7 de	24.8 d

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

season and perfecto-one 100 ppm in the second season. The percentage of malformed panicles followed a similar trend as those found in the number of malformed panicles/tree. Untreated Alphonse mango trees recorded 43.0 and 45.9 % of malformed panicles reduced to 23.8 and 24.6 % with NAA 200 ppm in both seasons and were superior to other treatment in this respect. The malformation of panicles is more serious problem than vegetative malformation (Mahrous 2004). Floral malformation appears significant distress fruit production since affected inflorescences usually do not set fruit. The panicles become greener and heavier with increased crowded branching, also these panicles have numerous flowers that remain unopened and are predominantly male and rarely bisexual (Chakrabarti 2011).

Table 6 explained the chemical changes of panicles due to the applied treatments, total indoles greatly increased with NAA 200 ppm and perfecto – one 100 ppm than other treatments or control. Also, perfecto – one treatment at 50 ppm was also effective in increasing total indole but with less effect than perfecto – one 100 ppm. Values of total phenols showed that all applied treatments increased it than control especially NAA 200 ppm and cofret 100 ppm and perfecto – one at 50 and 100 ppm. Polyphenoloxidase activity was significantly increased with all applied treatments than control, especially with perfecto – one 100 ppm in first season and cofret 100 ppm in second season. It is well known that total indoles, total phenols and PPO activity when increased with the applied treatments could be considered a good indicator for reducing malformed panicles%. It is well be cleared when calculate the regression between the malformed panicles and the other parameters. In general, higher levels of auxins were found in healthy panicles of mango as compared to malformed panicles, also in addition to the lower levels of lAA in affected tissues and enlarged. It is well be clear when calculate colorations between the different parameters.

Table 6. Effects of some growth regulators and systemic copper complexes on the Chemical panicles constituents of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	Total indoles (mg/100 g fwt)		Total phenols (mg/100 g fwt)		PPO activity (Unit mg protein-1 min-1)	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	0.274 f	0.317 d	0.863 d	0.966 f	11. 1 d	9.87 f
NAA 100 ppm	0.389 c	0.426 b	1.23 c	1.14 e	14.6 b	12.4 de
NAA 200 ppm	0.428 ab	0.509 a	1.51 a	1.41 cd	16. 9 a	14.9 bc
GA_3 50 ppm	0.411 bc	0.428 b	1.23 c	1.01 f	15. 7 ab	13.1 cd
GA_3 100 ppm	0.326 e	0.387 c	1.03 d	1.26	11.9 d	10.8 ef
Cofret (Cu) 50 ppm	0.365 d	0.414 b	1.28 bc	1.11 ef	12.4 cd	13.5 cd
Cofret (Cu) 100 ppm	0.424 ab	0.416 b	1.49 a	1.68 ab	16.9 a	17.2 a
Perfect-one (Cu)50 ppm	0.417 bc	0.432 b	1.44 ab	1.51 bc	14.3 bc	15.7 ab
Perfect-one (Cu)100 ppm	0.446 a	0.514 a	1.63 a	1.84 a	17.7 a	16.6 ab

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

Accordingly, it has been suggested by Kumar et al (2013) that the deformation may be due to the low level of auxins, which leads to hormonal imbalance. The use of chemicals as a foliar application has been shown to be effective in reducing mango deformation disease, as it may delay or advance the onset of flowering (Sanjay et al 2018). Foliar spray of naphthalene acetic acid before flower bud differentiation at a rate of 100 & 200 ppm reduce the incidence of deformation (Mahrous 2004). Newman et al (2012) showed that foliar applications with fungicides such as Phosphamidon significantly reduce the incidence of floral malformation.

PPO, defined as responsible for the synthesis of phenolic compounds in vivo, is considered a secondary metabolite (Bist and Ram 1986). The organic matter represented in the manures and fertilizers are used every year to produce new vegetative growth as well as the subsequent flowering and fruiting process in regular carriers, while these materials are kept in the "off" year of the alternate carriers (Kvas et al 2008). Accordingly, the decreased activity (PPO) in regular bearers may be due to the mitigation of the polyphenols in the "on" year and vice versa (Iqbal et al 2011) Besides, PPO may participate in auxin formation (IAA) by acting on tryptophan and high concentration of auxin promotes vegetative growth, which may inhibit flowering and fruiting process in mango (Ram and Yadav 1999). The higher incidence of malformation in normal bearing cultivars may be due to decrease PPO enzyme activity, which might have resulted in poor synthesis of phenolic compounds. These compounds are generally responsible for the defense mechanism in plants (Sharma et al 2008).

3.6 Yield component

Data in **Table 7** declare that yield components greatly affected with all applied treatments than control. Final fruit set recorded 2.6

and 2.5% for NAA 200 ppm and perfecto – one 100 ppm in first season, respectively against 1.5% for control. In second season, perfecto – one 100 ppm recorded 2.7% and NAA 200 ppm recorded 2.5% against 1.7 % for control. Number of fruits/tree was significantly increased with all applied treatments than control especially with NAA 200 and perfecto-one 100 ppm in first and second seasons. The increase of the number of fruits/tree attributed mainly, to the increase of final fruit set which follow the same trend. Average fruit weight values were varied between different treatments andcontrol, the treatments of NAA at 100 or 200 ppm and cofret 100 ppm produced fruits with similar weights to control. However, the highest fruit weights were recorded with perfecto – one 50 ppm and GA3 100 ppm in first season of study. Generally, total yield/ tree was significantly increased with all applied treatments than control especially with perfecto – one 100 ppm treatment which recorded 38.6kg/tree compared to 22.4 Kg/tree in control. The increases in total yield/ tree in Alphones mango due to the applied treatment are a good findings to mango producers who suffering from the great reduction in Alphonse mangos production

It is clear from the above that the presence of the copper element has a positive effect on increasing fruit set, fruit retention thus reducing the fruit drop. This may be due to the improved effect on the nutritional status of trees, which was reflected in increased fruit growth and fruit retention. In this regard, it was reported that the amelioration of the fruit set ratio could be explained as a result of raise pollen germination. (Rahman et al 2019).

With regard to the mango malformation and its effect on fruit set Ansari et al (2015), cleared that, mango deformation is associated with *F. mangiferae* that may lead to hormonal imbalance most likely ethylene as it is considered to be responsible for the deformation of the functional morphology of the panicle. Besides, the signal transduction mechanism caused by ethylene imbalance leads to morphological and physiological changes in the mango flower reproductive organs and thus failure of fruitfulness and fruit set.

3.7. Fruit chemical constituents

As it shown in **Table 8**, an evident increase in TSS and a decrease in titratable acidity of Alphonse mangos due to the applied treatment with control. The treatment of GA3 50 ppm recorded the highest values of TSS (18.7 at 19.7 %) and the least values of titratable acidity (0.49 with perfect 50ppm in first season and 0.52% with NAA 100ppm in second season). However, in the second season of study no significant differences were detected either between different treatments or with control. Ascorbic acid values were greatly increased with all used treatments than control, Control fruit recorded 33.2 mg/100 ml juice of L – ascorbic acid and reached to 42.4 mg /100 mljuice in GA_3 100 ppm treated fruit in first season. Total sugars was greatly increased with all applied treatments than cantor in both seasons, the grant effect was obtained with GA_3 100 ppm in first season (13.6%) and perfecto–one 50 ppm (14.7%) in second season. Total carotenoids values were higher in all used treatments than control in both studied seasons where NAA 100 ppm was superior to the other treatments in both seasons.

Partial control of mango deformation can be achieved by spraying the diseased parts with zinc and chelated copper, the used metal chelates reduced deformed tissues, as well as increased chlorophyll contents, carbohydrates, total nitrogen, protein nitrogen, nucleic acids (RNA and DNA). In addition, Marasas et al (2006) reported that, the use of Indole acetic acid (IAA) in treated plants and incorporates organic matter into soil, vector control, irrigation management, balanced chemical fertilization, new protection buds, weeds control and expected blooming enhancement (Noriega et al 1999), may maintaining disease severity below the level of economic loss (Youssef et al 2009).

Table 7. Effects of some growth regulators and systemic copper complexes on the yield components of "Alphonse" mangos, during 2019 and 2020 seasons

Treatments	Final fruit set %		No of fruits /tree		Fruit weight (g)		yield/tree (Kg)	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	1.5 f	1.7 d	90 f	87 e	248.9 bc	290.8 bc	22.4 e	25.3 d
NAA 100 ppm	2.3 bc	2.1 c	138 bc	107 cd	219.5 d	274.8 cd	30.3 cd	29.4 c
NAA 200 ppm	2.6 a	2.5 ab	156 a	128 ab	239.7 c	274.2 cd	37.4 a	35.1 ab
GA_3 50 ppm	2.2 c	2.4 b	132 c	122 bc	251.5 bc	291.0 bc	33.2 bc	35.5 ab
GA_3 100 ppm	1.7 ef	1.8 d	102 ef	93 de	277.5 a	309.7 ab	28.3 d	28.8 cd
Cofret (Cu) 50 ppm	1.9 de	1.8 d	114 de	93 de	266.7 ab	312.9 a	30.4 cd	29.1 cd
Cofret (Cu) 100 ppm	2.3 bc	2.3 bc	138 bc	117 bc	237.0 cd	305.1 ab	32.7 bc	35.7 ab
Perfect-one (Cu)50 ppm	2.1 cd	2.1 c	126 cd	107 cd	281.7 a	306.5 ab	35.5 ab	32.8 bc
Perfect-one (Cu)100 ppm	2.5 ab	2.7 a	150 ab	138 a	264.0 ab	268.9 b	38.6 a	37.1a

Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

Table 8. Effects of some growth regulators and systemic copper complexes on the Chemical fruit properties of "Alphonse" mangos during 2019 and 2020 seasons

Treatments	TSS (%)		Titratable Acidity (%)		Ascorbic Acid (mg/100 ml juice)		Total Sugars (%)		Total carotenoids (mg/100 g f.pulp)	
	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season	2019 season	2020 season
Control	16.2 d	17.3 d	0.71 a	0.68 a	33.2 e	36.5 f	10.2 c	11.2 d	0.48 d	0.52 d
NAA 100 ppm	17.5 bc	18.4 bc	0.62 ab	0.52 a	38.3 cd	46.6 e	11.4 bc	12.7 b-d	0.52 a	0.58 a
NAA 200 ppm	17.5 bc	19.5 ab	0.70 a	0.53 a	39.3 bc	41.8 de	12.6 ab	12.6 cd	0.53 a	0.56 ab
GA_3 50 ppm	18.7 a	19.7 a	0.70 a	0.62 a	41.2 ab	43.7 b-d	12.8 ab	13.2 a-c	0.49 cd	0.53 cd
GA_3 100 ppm	18.7 a	18.8 a-c	0.68 ab	0.63 a	42.4 a	45.6 ab	13.6 a	13.3a-c	0.49 cd	0.55 bc
Cofret (Cu) 50 ppm	16.6 cd	19.6 ab	0.55 ab	0.55 a	37.6 cd	42.6 c-e	12.7 ab	14.2 ab	0.50 b-d	0.51 d
Cofret (Cu) 100 ppm	17.8 ab	18.4 bc	0.56 ab	0.56 a	38.8 c	44.7 a-c	13.7 a	13.8 a-c	0.51 a-c	0.52 d
Perfect-one (Cu) 50 ppm	17.8 ab	18.3 cd	0.49 b	0.57a	36.7d	46.6ab	12.6ab	14.7 a	0.48 d	0.53 cd
Perfect-one (Cu)100 ppm	17.8 ab	18.2 cd	0.58 ab	0.54 a	37.6 cd	41.5 e	11.8 b	14.6 a	0.48 d	0.46 e

- Values followed by the same letter (s) of each column are not significantly different according to Duncan multiple rang test (DMRT) at 5% level.

4 Conclusions

It could be concluded that spraying Alphonse mango trees with NAA 200 ppm or 100 ppm perfecto-one copper complex at 100 ppm significantly decreased floral malformation phenomena and increased yield and improved fruit quality.

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