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RESEARCH ARTICLE

Effect of 4-chlorophenoxyacetic acid and brassinosteroids on Fruit set, yield and quality of "Keitt" mango fruits

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Abstract

The present experiment was conducted on six-years-old "Keitt" mango trees at El-Bostan region, El-Behira governorate, Egypt to study the effect of 4-chlorophenoxyacetic acid (4-CPA) and brassinosteriods (BR) on fruit set, yield and quality of "Keitt" mangos. The following seven treatments were used, control, brassinoloide at 1 mg/L, brassinoloide at 2 mg/L, 4-chlorophenoxyacetic acid at 10 mg/L, 4-chlorophenoxyacetic acid at 20 mg/L, brassinoloide at 1 mg/L + 4-chlorophenoxyacetic acid at 10 mg/L and brassinoloide at 2 mg/L + 4-chlorophenoxyacetic acid at 20 mg/L. The treatments were applied twice at full bloom and after fruit set with ten days. The results showed that pre-harvest application of 2 mg/L brassinoloide increased fruit set, fruit retention, yield, average fruit weight, average fruit size and ascorbic acid. Pre-harvest applications of 4-chlorophenoxyacetic acid either at 10 mg/L or 20 mg/L increased fruit set, retention, yield, fruit weight, size, fruit firmness and ascorbic acid. The formulation containing 4-chlorophenoxyacetic acid plus brassinoloide either at low concentration or high concentration enhanced fruit set, yield, firmness, fruit physical and chemical quality of "Keitt" mangos fruit.

Keywords: Brassinosteroids; Mangos; set; 4-chlorophenoxyacetic acid.

1. Introduction

Mango flower and fruitlets abscission are a serious problem occurs during all stages of development especially after fruit set and causes great loss to the growers (Bains *et al.,* 1997: Wahdan and Melouk, 2004). Several factors affect fruit abscission such as unfavorable climatic conditions, serious diseases, lack of pollination, inadequate soil moisture and nutrient deficiency (Whiley, 1986; Singh and Singh, 1995; Marcelis *et al.,* 2004). Plant growth regulator plays an important role in fruit growth and development such as modifying physiological process, flower development, fruit set and development (Leclerc *et al.,* 2006; Ouzounidou *et al.,* 2008). 4-chlorophenoxy acetic acid (synthetic auxin) is a plant growth regulator plays an important role in alleviation of stress, increasing fruit set and fruit size (Picken and Grimmett, 1986; Karakurt, 2000; Ramin, 2003; Sasaki *et al.,* 2005). Brassinosteroids are a new class of plant growth regulators that regulate many physiological properties in plant processes including stimulating elongation, decreasing fruit drop, increasing fruit set, enhancing fruit quality and alleviating biotic and abiotic stresses (Bartwal *et al.,* 2013; Wang *et al.,* 2013; Symons *et al.,* 2006; Chumpookam *et al.,* 2017; Baghel *et al.,* 2019). Thus, the objective of this experiment was to study the influence of 4-chlorophenoxyacetic acid (4-CPA) and brassinosteroids on fruit set, yield and quality of "Keitt" mango fruits.

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2. Materials and Methods

The present trial was conducted during the 2020 and 2021 seasons, respectively at El-Bostan region, El-behira governorate, Egypt on six-years- old "Keitt" mango trees (Mangifera indica L) grown in sandy soil under a drip irrigation system. The rootstock was succary. The trees were spaced at 3m * 3m. The following pre-harvest foliar spray treatments were used:

Water only (control)

1- Brassinoloide (BR) 1 mg/l
2- Brassinoloide 2 mg/l
3- 4-chlorophenoxyacetic acid (4-CPA) 10 mg/l
4- 4-chlorophenoxyacetic acid 20 mg/l
5- Brassinoloide 1 mg/l + 4-chlorophenoxyacetic acid 10 mg/l
6- Brassinoloide 2 mg/l + 4-chlorophenoxyacetic acid 20 mg/l

The treatments were sprayed at two times at full bloom (22, 4, 2020 and 11, 4, 2021 seasons, respectively) and after fruit set with 10 days. At harvest time, five fruits were randomly taken from each replicate in both seasons and transported to the laboratory to determine the quality characteristics of "Keitt" mango fruits.

2.1. Fruit set percentage

Three inflorescences on each tree were labeled and their initial number of fruitlets was recorded and counted after one month later.

Fruit set percentage = (No. of fruitlets after set with one month / No. of fruitlets after set with 10 days) * 100.

2.2. Fruit retention percentage

= (No. of. Fruits at harvest / No. of fruitlets after set with 10 days) *100.

2.3. Fruit yield (kg/ tree)

At harvest stage, all fruits on the tree were harvested and weighted.

2.4. Physical properties

Average fruit weight (g).

Average fruit size (cm^3).

Average seed weight (g).

Fruit firmness ($Ib/inch^2$) was determined using Effigi pressure tester (Mod. Ft 011).

2.5. Chemical properties

Fruit TSS (%) was measured using a handrefractometer.

Fruit acidity (%) as citric acid was determined according to (A.O.A.C., 1985).

Vitamin C (mg/100ml) was determined according to (A.O.A.C., 2007).

2.6. Statistical analysis

The trial was designed as a randomized completely block design (RCBD) with seven treatments and three replicates. Least Significant differences test at 0.05 level was used to compare between means according to Sndecor and Cochran (1980) and (SAS, 2000) program was used to perform statistical analysis.

3. Results

The data in Table 1 indicated that preharvest application of brassinoloide at 2ppm enhanced fruit set percentage, especially in the second season of study. 4-chlorophenoxyacetic acid (4-CPA) treatment either at 10ppm or at 20ppm increased fruit set percentage, whether applied alone or incorporated with brassinoloide. Moreover, the combinations of brassinoloide plus 4-chlorophenoxyacetic acid (4-CPA) treatments were superior in fruit set as compared with control and individual treatments, especially at high concentration.

Preharvest application of brassinoloide at 2ppm increased fruit retention percentage as compared with control and brassinoloide at 1ppm. The data also showed that high concentration of 4-chlorophenoxyacetic acid (4-CPA) at 20ppm significantly increased fruit retention percentage as compared with low concentration and control treatment. The formulation containing brassinoloide and 4-chlorophenoxyacetic acid (4-CPA) was able to increase fruit retention at harvest as compared with control and other individual treatments.

The data in Table 1 showed that the application of brassinoloide or 4-chlorophenoxyacetic acid (4-CPA) either alone or in one formulation at full bloom stage and after fruit set with ten days increased yield of "Keitt" mango trees in both seasons of study as compared with control treatment.

Table 1. effect of 4-chlorophenoxyacetic acid (4-CPA) and brassinosteroids on fruit set, fruit retention and yield of "Keitt" mango trees during the two seasons 2020 and 2021, respectively.

Treatments	Fruit set (%)		Fruit retention (%)		Yield (kg)	
	2020	2021	2020	2021	2020	2021
Control	10.83 d	14.63 e	7.63 d	12.03 e	12.00 f	13.33 e
BR (1 mg/l)	12.88 d	18.30 de	8.65 cd	12.76 e	13.00 f	15.66 d
BR (2 mg/l)	13.61 d	20.69 cd	11.30 c	17.30 d	13.66 de	15.33 d
(4-CPA) (10 mg/l)	21.76 c	27.80 b	16.23 b	22.58 b	15.00 cd	17.00 cd
(4-CPA) (20 mg/l)	22.15 c	24.88 bc	17.11 b	21.34 bc	15.66 bc	18.00 bc
BR (1 mg/l) + (4-CPA) (10 mg/l)	25.51 b	26.08 b	15.73 b	19.72 c	17.00 b	19.33 ab
BR (2 mg/l) + (4-CPA) (20 mg/l)	30.00 a	33.64 a	24.49 a	25.45 a	18.66 a	20.33 a

Values within a column with same letter (s) are not significantly different by LSD. ($p < 0.05$).

The application of brassinoloide at 2ppm either at full or at after fruit set increased average fruit weight as compared with control treatment. The lowest average fruit weight was obtained with control, and the highest average fruit weight was obtained by the formulation containing brassinoloide at 2ppm and 4-chlorophenoxyacetic acid (4-CPA) at 20ppm.

With regard to fruit size at harvest as influenced by preharvest application of brassinoloide or 4-chlorophenoxyacetic acid (4-CPA) at full bloom and after fruit set with ten days. The data in Table 2 showed that all preharvest treatments significantly increased the fruit size of "Keitt" mangos except brassinoloide at 1ppm as compared with control treatment. The data in table 2 showed that there was no significant change in fruit seed weight as a result of applying all preharvest treatments and control.

Table 2. effect of 4-chlorophenoxyacetic acid (4-CPA) and brassinosteroids on some physical characteristics of "Keitt" mango trees during the two seasons 2020 and 2021, respectively.

Treatments	Weight (g)		Size (cm3)		Seed Weight (g)		Firmness (Ib/inch2)	
	2020	2021	2020	2021	2020	2021	2020	2021
Control	382.33 e	395.33 e	384.00 d	399.66 e	9.16 ns	10.50 ns	8.96 d	9.16 c
BR (1 mg/l)	390.66 e	402.00 e	388.00 d	407.33 d	9.10 ns	10.60 ns	9.00 d	9.16 c
BR (2 mg/l)	395.33 de	410.00 d	399.33 c	415.00 c	9.00 ns	10.10 ns	9.03 cd	9.23 c
(4-CPA) (10 mg/l)	405.44 cd	413.33 cd	410.33 b	418.00 bc	9.26 ns	10.33 ns	9.16 c	9.33 bc
(4-CPA) (20 mg/l)	410.00 bc	420.00 bc	410.00 b	422.66 b	9.13 ns	10.23 ns	9.33 b	9.70 a
BR (1 mg/l) + (4-CPA) (10 mg/l)	420.00 ab	425.00 b	422.66 a	429.33 a	9.20 ns	10.43 ns	9.46 ab	9.60 ab
BR (2 mg/l) + (4-CPA) (20 mg/l)	428.33 a	435.00 a	428.00 a	435.00 a	9.16 ns	10.46 ns	9.53 a	9.70 a

Values within a column with same letter (s) are not significantly different by LSD. ($p < 0.05$).

The data in Table 2 indicated that no significant change in fruit firmness as a result of applying brassinoloide at 1ppm or 2ppm. Moreover, the application of 4-chlorophenoxyacetic acid (4-CPA) at 10ppm or at 20ppm incorporated with brassinoloide tended to increase “Keitt” fruit firmness.

Changes in “Keitt” mango fruit total soluble solids (TSS) was reported in Table 3. The data showed that all preharvest treatments except brassinoloide at 1ppm decreased fruit TSS as compared with control treatment.

Changes in “Keitt” mango fruit acidity percentage as influenced by preharvest treatments were shown in Table 3. The data indicated that there were no significant difference between brassinoloide at 1ppm, 2ppm, 4-chlorophenoxyacetic acid (4-CPA) at 10ppm and control. Moreover, the data showed that there was a significant increase in fruit acidity by 4-chlorophenoxyacetic acid (4-CPA) at 20ppm, brassinoloide at 1ppm and 2ppm plus 4-chlorophenoxyacetic acid (4-CPA) at 10ppm or 20ppm as compared with control treatment.

The data in Table 3 illustrated that all preharvest treatments increased the ascorbic acid percentage of “Keitt” mango fruit except brassinoloide at 1ppm as compared to the control treatment. The highest value ascorbic acid percentage was obtained by brassinoloide plus 4-chlorophenoxyacetic acid (4-CPA) at low or high concentration. The lowest value of ascorbic acid percentage was obtained by the control treatment.

Table 3. effect of 4-chlorophenoxyacetic acid (4-CPA) and brassinosteroids on some chemical characteristics of “Keitt” mango fruits during the two seasons 2020 and 2021, respectively.

Treatments	TSS (%)		Acidity (%)		Vitamin C (mg/100ml)	
	2020	2021	2020	2021	2020	2021
Control	16.50 ns	17.40 a	0.77 b	0.79 c	41.71 e	42.47 d
BR (1 mg/l)	16.00 ns	17.00 ab	0.78 b	0.80 bc	42.16 de	42.77 d
BR (2 mg/l)	16.03 ns	16.83 b	0.78 b	0.80 bc	42.47 cd	43.83 c
(4-CPA) (10 mg/l)	15.93 ns	16.26 c	0.78 b	0.81 abc	43.07 bc	44.44 abc
(4-CPA) (20 mg/l)	15.86 ns	16.06 c	0.80 a	0.80 bc	43.38 ab	44.13 bc
BR (1 mg/l) + (4-CPA) (10 mg/l)	15.86 ns	16.10 c	0.80 a	0.82 ab	43.83 a	44.89 a
BR (2 mg/l) + (4-CPA) (20 mg/l)	17.06 ns	16.03 c	0.81 a	0.82 a	43.98 a	44.74 ab

Values within a column with same letter (s) are not significantly different by LSD. ($P < 0.05$).

4. Discussion

The increase in fruit set percentage of “Keitt” mangos showed in the present study by preharvest application of brassinoloide and 4-chlorophenoxy acetic acid either at full bloom or after fruit set directly may be due to decrease fruit abscission during flowering and through fruit set stages (Iwahori, 1990; Tepkae *et al.*, 2022). Plant growth regulators play an essential role in flower and fruit development, Chaudhary et al. 2006; Hasanuzzaman *et al.*, 2007). Preharvest application of brassinoloide at full bloom of 'Morita' navel orange decreased fruit drop (Sugiyama and Kuraishi, 1989). (Greene, 1988) reported that 4-CPA showed the greatest effects on fruit set and development in pear and tomato. Pre-harvest sprayed ‘Bing’ sweet cherry by 4-CPA increased fruit set by as much as 53% compared with control (Sabir *et al.*, 2021). Fruit set in tomatoes and pear were increased when treated with 4-CPA (Gemici *et al.*, 2006; Zhang and Whiting, 2011). The data in Table 1 also showed that there was a significant increase in fruit retention percentage at harvest with either brassinoloide or 4-chlorophenoxy acetic acid application. The positive role of preharvest treatments could be attributed to its influence on increasing fruit set percentage, improving the rate of photosynthesis and reducing ethylene production in addition to reduce the undesirable effect of environmental stresses on fruit growth and development (Bajguz and Hayat, 2009; Wang, 2012). (Attia and Adss, 2021) reported that preharvest application of brassinoloide at full bloom and during fruit set of “Anna” apples increased fruit retention percentage at harvest. The positive effect of such treatment on fruit set percentage and fruit retention percentage reflects on yield of “Keitt” mango fruit trees (Patel *et al.*, 2021). This result is in agreement with the findings of (Baliyan *et al.*, 2013; Sasaki *et al.*, 2005). Enhancing physical fruit properties of “Keitt” mangos such as fruit weight, fruit size and fruit firmness by preharvest treatments of brassinoloide and 4-chlorophenoxy acetic acid were previously reported by (Patel *et al.*, 2021) on “Dashehari” mango fruit, (Yamini *et al.*, 2021) on acid lime and (Attia and Adss 2021) on “Anna” apples. Yamini *et al.* (2021) reported that preharvest sprayed acid lime (Citrus aurantifolia Swingle) with brassinosteroids at 15 ppm at petal fall; fruit development and fruit maturation stages increased the fruit weight (52.36 g) over control (36.97 g). (Sabir *et al.*, 2021) reported that foliar application of 4- CPA improved fruit size of sweet cherry cultivar “Bing”. The data in (Table 3) indicated that brassinoloide and 4-chlorophenoxy acetic acid treatments enhancing ascorbic acid content of “Keitt” mango fruit (Zhu *et al.*, 2015). On the other hand, both brassinoloide and 4-chlorophenoxy acetic acid increased fruit acidity as compared with control.

5. Conclusion

The formulation containing 4-chlorophenoxyacetic acid plus brassinoloide either at low concentration or high concentration enhanced fruit set, yield, firmness, fruit physical and chemical quality of “Keitt” mangos fruit.

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Authors’ Contributions

All authors are contributed in this research

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest

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