

Tomato fruit parthenocarpy and yield increase in response to chlorophenoxyacetic acid

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ABSTRACT

An experiment was conducted to evaluate the influence of rate and time of application of chlorophenoxyacetic acid (CPA) on the fruit set, yield and quality of tomato (variety, Improved Pope). The application of CPA enhanced fruit set, reduced the number of days to fruit maturity and consequently increased the yield and yield components of tomato. The optimum concentration of the chemical was 75 ppm. It was more effective when applied during anthesis than one week after anthesis.

CPA application regardless of concentration caused the production of parthenocarpic fruits. It did not significantly affect fruit quality in terms of peel color development, firmness, visual quality rating and weight loss.

Keywords: chlorophenoxyacetic acid, fruit set, plant growth regulator, parthenocarpy, tomato

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetables grown throughout the world. In the Philippines, it ranks first in terms of area of production among the major vegetable crops (Philippine Statistical Yearbook, 1999). It is a profitable cash crop to small farmers.

The tomato fruit can be eaten fresh or cooked and can be processed into pastes, catsups, sauces, soup, juice, pickles and many other products. Aside from its being an excellent source of vitamins A and C (AVRDC, 1991), it also contains high amounts of lycopene, a substance known to help the body fight against certain diseases (Stahl and Sies, 1996).

In the tropics, tomato production is beset by many problems, the most important of which is low fruit set at high temperatures, particularly during nighttime. Fruit set is one of the key components determining the final yield in tomatoes (Picken, 1984). The biggest challenge therefore for tomato production is how to improve fruit set during periods of high night temperature.

In recent years, the use of plant growth regulators has been the most promising alternative for improving fruit set in many crops (Weaver, 1972; Kuo *et al.*, 1986). Auxins, in natural or synthetic forms have been successfully used to improve fruit set in a number of crops (AVRDC, 1995; del Rosario *et al.*, 1977; Joseph and Peter, 1980; Abit, 1981). Other PGR's that have been successfully used are gibberellins (Weaver, 1972; AVRDC, 1995) and cytokinins (Weaver, 1972; Arumin *et al.*, 1985) However, the response of crops to application of plant growth regulators to improve fruit set varies with cultivars and locations. Most of the studies on the use of PGR's to improve fruit set in tomatoes were done in other countries and very limited studies have been conducted under local conditions.

This study was conducted to evaluate the influence of rates and timing of application of chlorophenoxyacetic acid (CPA) on fruit set, yield and fruit quality of tomato.

MATERIALS AND METHODS

Land preparation

An area of 361 m² was plowed and harrowed to pulverize the soil clods and remove weeds. Plowing and harrowing were done two times at weekly

interval. The area was divided into three blocks, each block consisting of 10 plots measuring 1.5 meters by 2.5 meters. Alleyways of 0.5 meters between plots and 1 meter between blocks were provided for ease in the management of the experiment.

Seedling production and transplanting

Improved Pope variety was used in this study. Seedlings were raised using the modified cellular method. Healthy and uniformly sized seedlings were transplanted into the prepared plots spaced at 0.4 m between hills and 1 m between rows.

Experimental design and treatments

The experiment was laid out in a split plot design with three replications. The treatments were as follows:

Main plot: Time of CPA application

T1 - at anthesis

T2 - one week after anthesis

Sub-subplot - Level of Chlorophenoxyacetic Acid

L0 - distilled water (control)

L1 - 25 ppm

L2 - 50 ppm

L3 - 75 ppm

L4 - 100 ppm

Field cultural management practices

Fertilizer application was based on the recommended rate of 90-120-60 kg per ha of N, P₂O₅, K₂O. At transplanting, 60-60-60 kg/ha of N, P₂O₅, K₂O was applied. Four weeks after, 30-30 kg/ha N and P₂O₅ using urea and solophos, respectively, were sidedressed. Additional 30 kg P₂O₅/ha using solophos was applied at flowering.

Watering and handweeding were done as often as necessary. The plants were trellised three weeks after transplanting. Four wooden posts were installed per row and intertwined with wire. The stems were tied to the wire with plastic straw for additional support.

The plants were sprayed with Lannate and Dithane M-45 following the recommended rates to control insect pests and fungal diseases, respectively. Spraying was done at weekly interval from one week after transplanting up to flowering stage.

Preparation and application of chlorophenoxyacetic acid (CPA)

Desired concentrations of chlorophenoxyacetic acid (CPA) solutions were prepared immediately before use with water as diluent and solvent. Tween 20 at 0.1% was added to the solution as surfactant. Previous studies by Kinet et al. (1978) showed that Tween 20 had no effect on inflorescence development and fruit set in tomato.

The treatment solutions were applied to each flower cluster individually using a hand sprayer with a fine spray nozzle at anthesis (when 2 to 3 flowers are open) or one week after anthesis. Spraying was done until the flowers were sufficiently wet.

Harvesting

The fruits were harvested at the mature green stage. Harvesting by hand was done once a week until the last harvest. Fruits were then sorted as either marketable or non-marketable. The non-marketable fruits were those which were very small in size (equatorial diameter less than 1 cm), diseased or with physical damage.

Sampling and data analysis

Data on horticultural characteristics and yield parameters were taken from five sample plants while data on fruit characteristics from ten sample fruits per treatment during the second harvest.

RESULTS AND DISCUSSION

Fruit set and fruit retention

The application of CPA significantly increased percentage fruit set and fruit retention and shortened the period to fruit maturity of tomato relative to the control plants (Table 1). Plants applied with CPA at anthesis had significantly

higher percentage fruit set compared to plants applied with CPA one week after anthesis. This was probably because at one week after anthesis, many of the flowers had already abscised.

The level of CPA application was found to significantly affect percent fruit set and retention and the number of days to fruit maturity (Table 1). Plants applied with CPA at 75-100 ppm had the highest percent fruit set which was more than 6 times compared to the control. The lower concentrations of 25-50 ppm resulted to higher percent fruit set relative to the control, but were less effective compared to the aforementioned higher concentrations. Thus, as far as this parameter is concerned, the optimum concentration of CPA is 75 ppm. CPA application also significantly increased percent fruit retention relative to the control with the different concentrations having comparable effects. In addition, the application of CPA hastened the period to fruit maturity. Fruits of plants applied with high concentration of 75-100 ppm CPA matured the earliest followed by those applied with CPA at 25-100 ppm. The control plants took the longest time to fruit maturity. This result agrees with the findings of Weaver (1972). Goodwin (1978) speculated that exogenous auxin application might have triggered a rapid growth of the ovary as a result of increased cell division and enlargement allowing the fruit to attain full size and maturity earlier. The time of CPA application did not significantly affect the percent fruit retention and number of days to fruit maturity.

Fruit characteristics

Application of CPA one week after anthesis resulted to the production of bigger and heavier fruits compared to application of the chemical at anthesis (Table 2). This was probably because fruits produced in plants applied one week after anthesis were fewer resulting to lesser competition for assimilates.

The fruits produced in the control plants were significantly lighter and smaller compared to those applied with the chemical (Table 2). The sizes and weights of the fruits were doubled by CPA application. In general, there were very little differences in the weight and size of tomato fruits applied with CPA at different concentrations.

Fruits produced from plants treated with CPA at all concentrations were seedless or parthenocarpic (Figure 1a) in contrast to the fruits produced by the control plants which all produced seeds (Figure 1b). The presence of seeds were only observed in the control plants. The time of application of CPA did not affect the number of seeds per fruit and the number of



Figure 1a. Fruits treated with CPA



Figure 1b. Untreated Fruits

Table. 1. Percent fruit set, percent fruit retention and number of days to fruit maturity of tomato (Improved Pope) as influenced by time and level of chlorophenoxyacetic acid (CPA) application

Treatments	Fruit set (%)	Fruit Retention (%)	Days to maturity
Time of application			
At anthesis	61.16a	75.86	22.18
One week after anthesis	35.60b	78.03	22.26
Level of CPA			
Control	10.27c	50.23b	26.96a
25 ppm	47.76b	82.08a	21.62b
50 ppm	49.84b	83.44a	21.56b
75 ppm	68.17a	84.99a	20.77c
100 ppm	68.96a	85.90a	20.52c
CV (%)	10.18	3.61	1.56

Treatment means in the same column within a sub-group designated by a common letter(s) and those without letter designation are not significantly different (DMRT, 5% level).

Table. 2. Fruit characteristics of tomato (Improved Pope) as influenced by time and rate of chlorophenoxyacetic acid (CPA) application

Treatments	Fresh weight (g/fruit)	Fruit size (cm)		No of seeds /fruit	% Parthenocarpy
		Length	Diam.		
Time of application					
At anthesis	34.37b	3.93b	3.06b	18.25	80
One week after anthesis	41.87a	4.45a	3.71a	18.43	80
Level of CPA					
Control	22.14c	2.08c	1.46c	91.71a	0b
25 ppm	41.78b	4.47b	3.90b	0b	100a
50 ppm	41.79ab	4.49b	4.08b	0b	100a
75 ppm	42.52ab	5.19a	4.13a	0b	100a
100 ppm	43.04a	5.28a	4.24a	0b	100a
CV (%)	6.65	6.67	8.21	8.05	0

Treatment means in the same column within a sub-group designated by a common letter(s) and those without letter designation are not significantly different (DMRT, 5% level).

parthenocarpic fruits. Such effect of auxin on parthenocarpy phenomenon in tomatoes especially at high temperature was also reported by AVRDC (1988). It is probable that a high temperature fruit set occurred even without pollination and fertilization due to the exogenous application of auxin. According to Kuo *et al.* (1986) poor pollen and ovule development and style elongation caused by high temperature may be responsible for parthenocarpic fruit formation from heat stressed flowers in which fruit set and ovary growth have been induced by exogenous auxins. Furthermore, even if the development of pollen and ovule were normal, the rapid enlargement of the ovary caused by exogenous auxin may also prevent fertilization, thus resulting to parthenocarpy (Bangerth and Sjut, 1978).

Yield and yield components

Plants applied with CPA during flower anthesis produced more fruits, and had higher yield per plant as well as total fruit yield relative to those applied with CPA one week after anthesis (Table 3). The number and weight of non-marketable fruits, however, were not affected by time of CPA application.

The number and weight of marketable and non-marketable fruits as well as the total fruit yield per plant and total yield in tons per hectare were dramatically improved by the application of CPA. The application of the CPA caused more than four times improvement in the aforementioned yield and yield component parameters of the crop, depending upon the concentration of the chemical. The number and weight of marketable fruits, fruit yield per plant and total yield did not significantly differ in plants applied with 75 ppm and 100 ppm CPA while no significant differences were observed on the number and weight of non-marketable fruits in plants applied with CPA at all levels. The improvement of the yield of the crop with CPA application is attributed to the promotive effect of auxin on fruit set and development. Findings of this study lend support to the report of Thomas (1982) that an increase in fruit set is one of the key components deciding the final yield of the crop.

The time and level of CPA application had significant interaction effect on percent fruit set, fruit size, weight, and number of marketable fruits, fruit yield and total yield (Tables 4 and 5). Data indicate that the optimum concentration of CPA when applied at anthesis was 75 ppm. Increasing it further to 100 ppm did not show any significant improvement in the aforementioned parameters. Although a similar trend was observed in plants applied with CPA one week after anthesis, improvement in the said parameters

Table 3. Yield and yield components of tomato (Improved Pope) as influenced by time and rate of chlorophenoxyacetic acid (CPA) application

Treatments	No of fruits		Wt. of fruits		Fruit Yield (kg/plt)	Total Yield (t/ha)
	Market-able	Non-Marketable	Market-able	Non-Marketable		
Time of Application						
At anthesis	41.60a	13.65	1.81a	0.37	2.18a	22.32a
1 week after anthesis	31.03b	13.34	1.17b	0.40	1.57b	13.55b
Level of CPA						
Control	10.09d	3.35b	0.24c	0.92a	0.32c	3.00c
25 ppm	41.04c	15.62a	1.51b	0.47b	1.92b	16.04b
50 ppm	42.32bc	16.63a	1.42b	0.46b	1.87b	17.45b
75 ppm	43.43ab	15.49a	2.16a	0.47b	2.63a	27.90a
100 ppm	44.69a	16.48a	2.18a	0.52b	2.67a	25.00a
CV (%)	3.45	9.71	6.65	12.19	6.64	12.86

except fruit weight, length and diameter with increase in the concentration of the chemical were significantly lesser.

Fruit quality

No significant differences were observed among the different treatments in terms of fruit quality. Peel color development, visual quality rating, firmness and weight loss during storage at ambient room temperature of fruits from plants applied with different levels of CPA at anthesis and one week after anthesis were not significantly different from the control. Fruits in all treatments attained the full ripe stage (C16) after 12-14 days and had a postharvest life of 14-15 days (Table 6). The results suggest that chlorophenoxyacetic acid can be applied to increase fruit set and yield of tomato without affecting the quality of the fruits.

Table 4. Interaction effect of time and level of chlorophenoxyacetic acid application on the percent fruit set and fruit size of tomato

Treatments	Fruit Set (%)	Fruit Size		
		Weight (g)	Length (cm)	Diameter (cm)
CPA applied at anthesis				
Control	10.34e	22.40d	2.07d	1.47d
25 ppm	59.86b	38.49c	3.88c	2.94c
50 ppm	59.46b	36.36c	4.04c	3.34c
75 ppm	81.06a	38.96b	4.92b	3.94b
100 ppm	82.90a	39.22b	4.71b	3.99b
CPA applied 1 week after anthesis				
Control	9.40e	21.89d	2.10d	1.44d
25 ppm	35.91d	47.27a	4.27b	3.94b
50 ppm	36.32d	47.23a	4.94b	4.50ab
75 ppm	40.94c	48.81a	5.46a	4.83a
100 ppm	43.42c	49.12a	5.47a	4.85a

Treatment means within a column designated by a common letter(s) are not significantly different (DMRT, 5% level).

Table 5. Interaction effect of time and level of chlorophenoxyacetic acid application on the number and weight of marketable fruits and total yield of tomato

Treatments	Weight of Marketable Fruits/plant	No. of Marketable Fruits/plant	Total fruit Yield (kg/plant)	Total fruit Yield (t/ha)
CPA applied at anthesis				
Control	0.25d	10.10e	0.33e	4.60e
25 ppm	1.76b	48.04b	2.25b	34.20b
50 ppm	1.74b	48.22b	2.09c	30.10b
75 ppm	2.54a	50.18b	3.19a	48.50a
100 ppm	2.78a	51.57a	3.24a	46.90a
CPA applied 1 week after anthesis				
Control	0.23d	10.19e	0.32e	3.60e
25 ppm	1.17c	34.04d	1.59d	17.90d
50 ppm	1.18c	36.41c	1.65d	15.40d
75 ppm	1.55b	36.67c	2.02c	25.20c
100 ppm	1.72b	37.82c	2.27b	25.90

Treatment means within a column designated by a common letter(s) are not significantly different (DMRT, 5% level).

Table 6. Number of days to CI 6 and VQR 3 of tomato (Improved Pope) as influenced by time and level of chlorophenoxyacetic acid (CPA) application

Treatments	Days to Color Index 6 (CI6)	Days to VQR 3
Time of Application		
At anthesis	12.50	15.02
1 week after anthesis	12.59	14.99
Level of CPA		
Control	12.14	15.00
25 ppm	12.21	15.05
50 ppm	12.17	15.05
75 ppm	12.15	15.10
100 ppm	12.20	15.09
CV (%)	8.52	11.09

CONCLUSIONS

Results of this study show that the application of chlorophenoxyacetic acid (CPA) at 25-100 ppm particularly during anthesis enhanced fruit set and consequently improved the yield and yield components of the crop. In addition, the chemical caused the production of parthenocarpic or seedless fruits. The optimum concentration of the chemical was 75 ppm.

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