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PLANT GROWTH REGULATORS TO IMPROVE THE GROWTH AND BERRY OF STRAWBERRY

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ABSTRACT

Nuruzzaman M, Islam MS, Shilpi S, Mehraj H, Jamal Uddin AFM (2015) Plant growth regulators to improve the growth and berry of strawberry. *Int. J. Sustain. Crop Prod.* 10(1), 33-39.

An experiment was conducted to study the influence of different growth chemicals on growth, fruit yield and quality attributes of strawberry. Different growth regulators such as, Gibberelic acid (GA_3) (F_1), 4-Chloro phenoxy acetic acid (4-CPA) (F_2) and Flora (Nitrobenzene 20% w/w) (F_3) were used as foliar feeding. To find out the effect of these growth chemicals only fresh water was used as control (F_0). Among the growth regulators, GA_3 significantly influenced the flower bud, number of flower and berry. Individual fruit weight (9.1 g) was highest in Flora but the highest total fruit weight (343.9 g) and degree of brix (6.8%) were with 4-CPA. Though Foliar feeding of GA_3 increases the various growth, flowering and fruiting attributes but 4-Chloro phenoxy acetic acid ultimately increases the total yield also degree of brix. So 4-CPA could be used for strawberry production to get higher yield.

Key words: *GA_3, 4-CPA, nitrobenzene, yield and quality*

INTRODUCTION

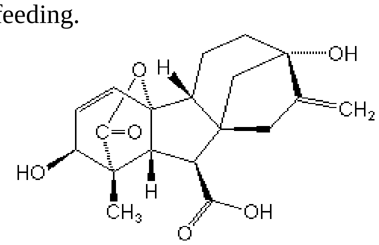
Strawberry (*Fragaria* × *annanassa*) is one of the most popular fruit in the world. Though strawberry is a short day plant but it has limited vegetative growth during this short day period that caused less production with low quality (Singh *et al.* 2007; Asrey *et al.* 2004). In Bangladesh, strawberry production is about 10-12 t/ha (BARI 2011) which is possible to increase. This low production of strawberry may be due to lack of timely available planting materials, short winter period, inappropriate cultural practices, improved variety and technology. Genetic factors and cultural practices control the growth, yield and fruit quality in strawberry (Avigdori-Avidov, 1986) but strawberry cultivars are significantly influenced by plant growth regulators (Jamal Uddin *et al.* 2012) which may affect directly the floral induction, fruit size, quality and production. Application of growth regulators has been practiced commercially to increase the production and quality of crops. Gibberellic acid has a significant role in plant heights, number of runners, number of flowers, fruit set percentage, number of fruits, fruit size, fruit weight and fruit quality (Ouzounidou *et al.* 2010; Sharma and Singh, 2009; Kasim *et al.* 2007; Usenik *et al.* 2005; Paroussi *et al.* 2002). 4-CPA (4-chloro phenoxy acetic acid) reduced pre-harvest fruit drop also increased number of fruits and yield (Sasaki *et al.* 2005). 4-CPA help to overcome the problems associated with yield and fruit quality due to high temperature and/or excess light intensity (Sanada *et al.* 2011). Flora is a commercially available liquid fertilizers in Bangladesh those provide complimentary blend of both macro and micronutrients to solve overall plant nutrition (Jamal Uddin *et al.* 2014). The present work was carried out to investigate the effect of different growth regulators on physical growth, yield and fruit quality of different strawberry germplasm.

MATERIALS AND METHODS

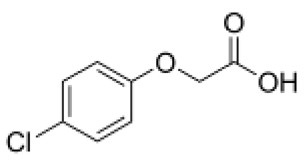
Experimental site, period, design and genetic materials: A pot experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh from October, 2009 to April, 2010 using completely randomized design (CRD) with three replications. Strawberry cultivar "Festival" was used on the experiment which was collected from Krishibid Upokoron Nursery, Agargaon, Dhaka-1207, Bangladesh.

Soil preparation and fertilization: Soil was prepared and pots were filled 7 days before transplanting. Cow dung @ 1 kg/pot and NPK were applied during the final soil preparation at the rate of N- 120 kg/ha (i.e., 0.5 g/pot), P- 60 kg/ha (i.e., 0.25 g/pot), K- 40 kg/ha (i.e., 20 g/pot). The whole amount of P and K were applied during final pot preparation. Urea was applied in 3 equal installments 30, 45 and 60 days after transplanting. pH of the soils were in between 6.0- 6.5. Saplings were planted at 20 October, 2009.

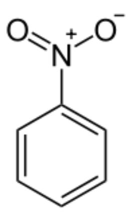
Treatments of the experiment: Different growth regulators *viz.* F_0; control (Fresh water), F_1; Gibberelic acid (GA_3), F_2; 4-Chloro phenoxy acetic acid (4-CPA), F_3; Flora (Nitrobenzene 20% w/w) had been used as foliar feeding.



Gibberelic acid



4-Chloro phenoxy acetic acid



Nitrobenzene

During fruit ripening, the experimental pots were covered with net to protect the fruits from bird, squirrel and rats. Experimental crop was infested by grey mold during the flowering stage. Disease was controlled by spraying Endofil M-45 (mancozeb 80%). Crop was also attacked by leaf feeder during the growing stage. The larvae were controlled by Pyrithrum @ 1.5 ml/L.

Doses and methods of application of chemicals

Name of the Chemicals	Doses*	Application Time
Gibberelic acid (GA_3)	75 ppm	Two times, 20 and 40 days after transplanting
4-Chloro phenoxy acetic acid (4-CPA)	25 ml/L	Three times, 15-day interval and starts from 7 days before first flowering
Nitrobenzene 20% w/w (Flora)	3 ml/L	Three times at 25-30-day interval after transplanting

*****These doses and application time were followed as per the company (manufacturer) recommendation

Data collection: Plant height and crown length was measured in cm by using scale. Number of leaves, flower buds, flowers and fruits per plant were recorded by counting all the leaves and flower bud, flowers and fruits from each plant. Leaf area was measured by using Leaf Area Meter (CL-202) by destructive method and expressed in cm^2. Days to first inflorescence initiation, flowering, fruiting and fruit ripening was obtained by counting the days from date of transplanting the saplings. Brix percentage was measured by portable refractometer (ERMA, Tokyo-Japan) as manufacture's guide. Shelf life was measured at normal day temperature by keeping and observing the fruits quality and mean was calculated. Every fruit weight was obtained with the help of electric balance. Fruit length, diameter and pedicel diameter were measured by Digital Caliper-515 (DC-515) in millimeter. Strawberry generally grows determinate type and terminal inflorescences develop at the top of the primary crowns (Guttridge 1955). The axillary buds differentiate just below the inflorescences on the primary crown and develop into secondary crowns. After several leaves have formed on the secondary crowns, the secondary inflorescences differentiate at their tops (Kurokura *et al.* 2005). Other axillary buds grow just below the second inflorescences and develop into the tertiary crowns and inflorescences. The primary, secondary, and tertiary inflorescences are called the first, second, and third fruit clusters, respectively, when the fruits are borne in each cluster.

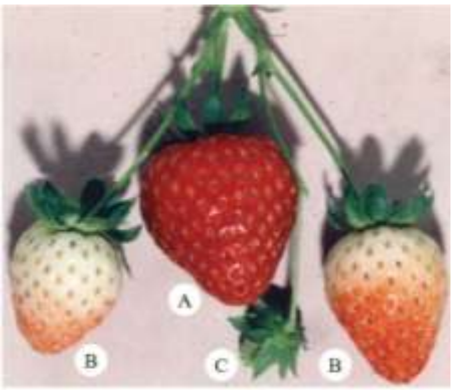


Plate 1. Strawberry fruit cluster (A) primary, (B) secondary and (C) tertiary fruit

Total fruit weight of each pot was obtained by addition the weight of total primary, secondary and tertiary fruits. Fresh weight of each fruit was obtained from average fruit weight in the case of each type of fruits. Percentage of primary fruit, secondary fruit and tertiary fruits were calculated the from the rule bellow.

$$\text{\% of primary fruit (wt. basis)} = \frac{\text{Total weight of primary fruit}}{\text{Total weight of fruit}} \times 100$$

$$\text{\% of secondary fruit (wt. basis)} = \frac{\text{Total weight of secondary fruit}}{\text{Total weight of fruit}} \times 100$$

$$\text{\% of tertiary fruit (wt. basis)} = \frac{\text{Total weight of tertiary fruit}}{\text{Total weight of fruit}} \times 100$$

Statistical analysis: Collected data for various characters were statistically analyzed using MSTAT-C programme. Mean for all the treatments were calculated and the analysis of variance for each of the characters was performed by F test. Differences between treatments were evaluated by Duncan's Multiple Range test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height: Plant height was significantly affected by the growth chemicals treatments. Longest plant (26.8 cm) was observed in GA_3 treated plants and shortest plant was found in control, that means without chemical (Table 1). There was no significant variation in terms of plant height between 4-CPA and Flora treated plants. GA_3 increases plant height (Paroussi *et al.* 2002) of strawberry (Jamal Uddin *et al.* 2012); cherry tomato (Mehraj *et al.* 2014b); gladiolus (Sultana *et al.* 2013); gerbera (Mehraj *et al.* 2013); wheat (Islam *et al.* 2014). As GA_3 enhance the cell elongation, rather than 4-CPA and Flora, so the highest plant height was obtained from GA_3 treatment than the other treatments. El-Shabasi *et al*. (2008) reported that GA_3 application increased petiole length which may be responsible for the plant height. The plant height depends on petiole length of strawberry.

Crown length: Crown length of strawberry differs significantly for growth chemicals used as foliar feeding compared to control and among the chemicals. Longest crown (8.8 cm) was found in F_1 (GA_3) treatment and shortest crown (2.6 cm) was found in control (F_0) (Table 1). GA_3 has a positive effect on crown length as GA_3 enhance cell division. Porlingis and Boynton (1961) reported that higher the concentration of applied GA_3, the faster the growth rate of stem.

Leaf number: Maximum leaf number (16.1/plant) was found from the plants treated with 4-CPA which was statistically similar with F_3 treatment (15.3/plant) and minimum leaf number (11.3/plant) was found from the plants treated with GA_3 (Table 1). Leaf number was found more when the plants were treated with 4-CPA and flora. As GA_3 increases the crown length so distance between node to node increases, ultimately the number of node decreases.

Leaf area: Significant variation was showed by different growth chemicals for leaf area. Maximum plants leaf area (84.9 cm^2) was found when the plants were treated with GA_3 whereas minimum from F_0 (60.3 cm^2) (Table 1). GA_3 application increased leaf area in strawberry (Sharma and Shing, 2009; Paroussi *et al.* 2002) and gerbera (Mehraj *et al.* 2013).

Table 1. Effect of different growth chemicals on the growth of strawberry

Treatments	Plant height (cm)	Crown length (cm)	No of leaf/plant	Leaf area (m^2)
F_0	18.4 c	2.6 d	13.3 b	60.3 d
F_1	26.8 a	8.8 a	11.3 c	84.9 a
F_2	21.8 b	3.6 b	16.1 a	81.1 b
F_3	20.6 b	3.1 c	15.3 a	74.9 c
CV (%)	10.2	12.4	11.8	2.1
LSD 0.05	1.9	0.5	1.4	1.3

F_0, Control; F_1, GA_3; F_2, 4-CPA and F_3, Flora

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Flower bud initiation: Flower bud initiation was earliest (76.8 days) when the plants were sprayed with GA_3 and was statistically insignificant with F_2 treatment. Flower bud initiation was delayed and it had taken 89.1 days when the plants were just sprayed with only fresh water (Fig. 1). There was found no significant variation among the F_0 and F_3 treatment. Strawberry plant had taken 77.0-87.0 days for flower bud initiation by foliar feeding of GA_3 at different concentrations (Jamal Uddin *et al.* 2012) also can produce flower bud within 60.5 days (Ahsan *et al.* 2014) and 64.3 days (Mehraj *et al.* 2014a) after transplanting. GA_3 reduced the time needed for inflorescence emergence (Paroussi *et al.* 2002) in cherry tomato (Mehraj *et al.* 2014b); gerbera (Jamal Uddin *et al.* 2014; Mehraj *et al.* 2013).

Flowering: Different growth chemicals also were found effective for days to flowering from seedling transplanting to flower opening in different strawberry varieties and significant variation was found in them. Days required from bud initiation to flower opening was lowest (76.8 days) in GA_3 treated plants which was statistically similar (79.3 days) with F_2 treatment and maximum days (89.1 days) required for F_0 treatment (Fig. 1). Days required for flowering of strawberry varied and it ranged in 85.5-98.4 days (Hossan *et al.* 2013); 66.1-69.0 days (Ahsan *et al.* 2014); 64.3-77.9 days (Mehraj *et al.* 2014a). Foliar application of GA_3 reduced days for first flowering in cherry tomato (Mehraj *et al.* 2014b) and gerbera (Jamal Uddin *et al.* 2014).

Fruiting: Days to fruiting of strawberry showed significant variation for different growth chemicals used as foliar feeding. Maximum days to fruiting (96.3) from seedling transplanting was recorded from F_0 which was closely followed (94.9) by F_3. Again, the minimum days (83.2) was found from F_1 which was statistically identical (84.7) with F_2 (Fig. 1). Fruiting period was also varied and it ranged from 73.7-76.9 days (Ahsan *et al.* 2014) and 69.2-83.5 days (Mehraj *et al.* 2014a) in strawberry. Foliar feeding of GA_3 reduced the time for fruit setting in cherry tomato (Mehraj *et al.* 2014b).

Fruit ripening: Different growth chemicals used as foliar feeding showed significant variation in terms of days to fruit ripening from seedling transplanting of strawberry. The maximum days to (123.6) was recorded from F_0

which was closely followed F_3 (121.3). Again, the minimum days (105.6) was obtained from F_1 which was statistically identical (109.1) with F_2 (Fig. 1). Foliar feeding of GA_3 reduced the time for fruit ripening in cherry tomato (Mehraj *et al.* 2014b).

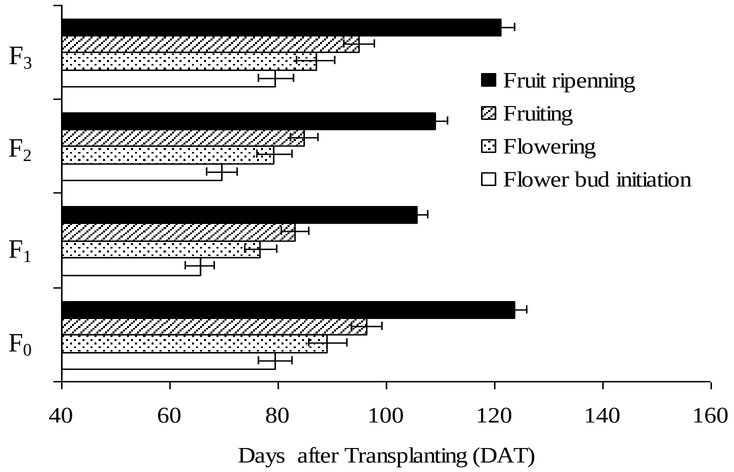


Fig. 1. Effect of growth chemicals on the days to flower bud initiation, flowering, fruiting and fruit ripening from days after seedling transplanting

Flower bud: Effect of different growth regulators found to be significant. The plants bear maximum flower bud (43.5) when they were sprayed with GA_3 (F_1) and there was no significant difference with F_2 treatment. Lowest number of flower bud (32.6) was found when the plants were sprayed with only fresh water (F_0) though there was no significant difference with F_3 treatment (Table 2). Number of flower bud is one of the key factors for the yield and number of flower bud increased due to the application of GA_3 (Paroussi *et al.* 2002).

Flower number: Growth regulators significantly influenced the production of flower per plant. Plant treated with GA_3 (F_1) produced maximum number of flower (40.8) per plant which was statistically similar with F_2 while minimum number of flower (23.8) per plant was obtained from F_0 (Table 2). This result trend that the plants treated with GA_3 bears more flowers. This might cause that as the plant bears more flower bud under F_1 treatment so flower was more under this condition and this result also same in case of F_2 treatment. Similar opinions were also put forwarded by Paroussi *et al.* (2002). More number of flower bud was found in gerbera by the foliar application of GA_3 (Jamal Uddin *et al.* 2014; Mehraj *et al.* 2013).

Fruit number: Effect of growth chemicals on the number of fruits/plant was also found to be significant. Maximum number of fruits (36.6) was recorded from F_1 which was statistically similar with F_2 treatment (35.1) and the minimum (23.8) number of fruits was obtained from F_0 (Table 2). Application of 75 ppm GA_3 provided maximum number of fruit in strawberry (Jamal Uddin *et al.* 2012). GA_3 showed a tendency to increase the number of strawberry fruits (Miranda-Stalder *et al.* 1990) and cherry tomato (Mehraj *et al.* 2014b).

Brix: Percentage of brix of strawberry fruits varied significantly with the application of different growth chemicals. Maximum brix percentage (6.8%) was found in 4-CPA (F_2). Minimum of brix percentage (3.4%) was found in control (F_0) treatment (Table 2). Foliar application of 75 ppm GA_3 provided maximum brix in strawberry fruit (Jamal Uddin *et al.* 2012).

Shelf life: Shelf life showed significant variation with control for different foliar feeding. The shelf life was highest (2.4 days) in F_2 which was statistically identical with flora (F_3) while lowest shelf life (1.7 days) was observed under F_0 treatment (Table 2).

Table 2. Effect of different growth chemical on the bearing habit and fruit quality of strawberry

Treatments	Number of			Fruit weight (g)	Brix (%)	Shelf life (Days)
	Flower bud	Flower	Fruit			
F_0	32.6 b	29.4 c	23.8 c	8.0 b	3.4 d	1.71 c
F_1	43.5 a	40.8 a	36.6 a	6.6 c	5.2 c	2.08 b
F_2	42.6 a	40.1 a	35.1 a	9.1 a	6.8 a	2.41 a
F_3	35.3 b	33.3 b	28.4 b	9.2 a	6.2 b	2.35 a
CV (%)	9.1	8.9	9.1	4.7	11.3	12.38
$LSD_{0.05}$	2.9	2.6	2.3	0.3	0.5	0.22

F_0, Control; F_1, GA3; F_2, 4-CPA and F_3, Flora

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Total fruit weight: Total fruit weight varied significantly with the application of different growth chemicals. Maximum fruit weight per plant of strawberry (343.9 g) was found in 4-CPA (F_2) whereas lowest fruit weight per plant (200.4 g) was found under control condition (Table 3). Though maximum number of fruit per plant was obtained from GA_3 but it reduces the fruit weight (Prolings and Boynton, 1961; Turner 1963; Jonkers 1965; Castro *et al.* 1976; Tehranifer and Battey, 1997). On the other hand, maximum average fruit weight was obtained from the plants that were treated with flora (Nitrobenzene 20% w/w) but less number of fruit was obtain from that plant and in terms of average fruit weight no significant variation was between flora and 4-CPA treatments. Progress report of AVRDC (1990) claimed that 4-CPA increases fruit set and fruit size in tomato. As a result, the total fruit weight was maximum when the plants were sprayed with 4-chlorophenoxy acetic acid (4-CPA).

Fruit length and diameter: Fruit length and diameter showed significant variation with control for different foliar feeding. Longest fruit (33.9 mm) was found in F_1 which was statistically similar with F_2 and F_3. Shortest fruit was observed in F_0 (Table 3). Highest (25.4 mm) diameter of fruit was found in F_3 which was statistically similar with F_2 and the lowest (17.5 mm) diameter of fruit was found in F_1 (Table 3). Mehraj *et al.* (2014a) was found maximum 32.4 mm fruit length and maximum 26.9 mm fruit diameter of strawberry which showed a resemblance of this study. Application of GA_3 may cause excessive elongation of the fleshy receptacle which may reduce the diameter.

Fresh weight of primary, secondary and tertiary fruit: Fresh weight of primary fruit varied significantly with the application of different growth chemicals. Table-8 shows that maximum fruit weight of strawberry (15.3 g) was found in 4-CPA (F_2). Lowest fruit weight (10.1 g) was found in GA_3 treatment (F_1) (Table 3). Fresh weight of secondary fruit varied significantly with the application of different growth chemicals. Maximum secondary fruit weight of strawberry (10.1 g) was found in flora (F_3) followed by 4-CPA (F_2; 9.5 g) while lowest in F_1 (7.8 g) (Table 3). Fresh weight of tertiary fruit varied significantly with the application of different growth chemicals. Maximum secondary fruit weight of strawberry (10.1 g) was found in 4-CPA (F_2; 6.5 g). Lowest fruit weight (4.7 g) was found in GA_3 treatment (F_1) (Table 3). Nuruzzaman *et al.* (2011) was also differentiated the strawberry fruit into primary, secondary and tertiary fruit and found significant variation. Foliar feeding of GA_3 @ 75 ppm provided maximum fruit weight (Jamal Uddin *et al.* 2012) while foliar application increases the fruit weight of cherry tomato (Mehraj *et al.* 2014b).

Table 3. Effect of different growth chemicals on fruit characteristics of strawberry[Y]

Treatments[X]	Fruit length (mm)	Diameter of fruit (mm)	Total Fruit weight (g)	Average weight (g)		
				Primary fruit	Secondary fruit	Tertiary fruit
F_0	32.0 b	24.0 b	200.4 c	12.2 c	8.8 c	5.5 c
F_1	33.9 a	17.5 c	254.5 b	10.1 d	7.8 d	4.7 d
F_2	33.2 a	25.1 a	343.9 a	15.3 a	9.5 b	6.5 a
F_3	33.5 a	25.4 a	271.9 b	13.5 b	10.1 a	6.0 b
CV (%)	3.0	3.5	8.2	5.5	7.5	7.3
$LSD_{0.05}$	0.8	0.7	18.1	0.6	0.6	0.3

[X] F_0, Control; F_1, GA3; F_2, 4-CPA and F_3, Flora

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

% of primary, secondary and tertiary fruit: Percentage of primary, secondary and tertiary fruit varied significantly with the application of different growth chemicals. Maximum % of primary fruit (30.4%) was found in 4-CPA (F_2) which was statistically similar with control (29.4%) and flora (28.8%) whereas Minimum (26.6%) was found in (Fig. 2). Highest % of secondary fruit (40.3) was found in F_3 which was statistically similar with F_1 (39.8%) and F_0 (38.7%). The lowest % of secondary fruit (36.1%) was found in F_2 (Fig. 2). The % of tertiary fruit was highest (33.9 %) in F_1 treatment and the lowest % of tertiary fruit was observed under F_0 treatment (Fig. 2).

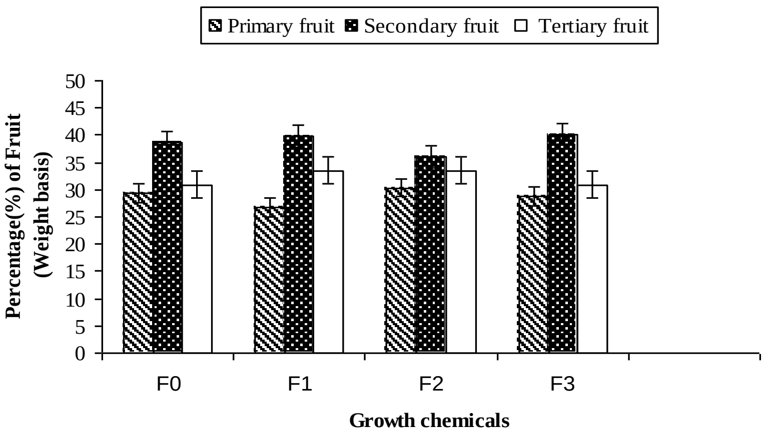


Fig. 2. Effect of different growth chemicals on the % (weight basis) of primary, secondary and tertiary fruit of strawberry (F_0-Control, F_1-GA_3, F_2-4-CPA and F_3-Flora)

CONCLUSION

From the above result and discussion it can be concluded that maximum total fruit weight and highest brix percentage and shelf life were provided by the foliar application of 4-CPA. Application of flora also performed well in case of individual fruit weight and shelf life but it provided maximum average fruit weight of secondary fruit. Foliar application of 4-CPA was found as best for production of strawberry.

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