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Application of Plant Growth Regulators on the Parthenocarpic Fruit Development in Teasle Gourd (Kakrol, *Momordica dioica* Roxb.)

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An experiment was conducted with a view to find out the possibility of inducing parthenocarpic fruit in teasle gourd (kakrol, *Momodrica dioica* Roxb.). The experiment was laid out at BSMRAU, Gazipur, Bangladesh during summer season of 2001 and 2002. Seven plant growth regulators (PGR's) viz. auxins (NAA: naphthaleneacetic acid and 2,4–D: 2,4–dichlorophenoxyacetic acid), cytokinins (CPPU: N–(2–chloro–4 pyridyl)–N' phenyl urea, Fulmet: forchlorophenuron), gibberellin (GA_3: gibberellin A_3) and auxin transport inhibitors (TIBA: 2, 3, 5–triiodobenzoic acid and MH: maleic hydrazide) with three concentrations (25, 50 and 100 ppm) were sprayed at three times (a day before, at and a day after anthesis) with split–split plot design. Out of seven, only three PGR's (2,4–D, Fulmet and CPPU) were effective to parthenocarpic fruit development. Fruit size and weight increased with increase of concentration of PGR's except 2,4–D. Induced parthenocarpic fruits had no seeds. Control treatments (water spray) produced no fruits. The results revealed the possibility of developing parthenocarpy or seedless fruit using PGR's in teasle gourd.

INTRODUCTION

Teasle gourd (*Momordica dioica* Roxb) belongs to the genus *Momordica* in Cucurbitaceae. It is also known as kakrol or spine gourd. It shows dioecious, annual and viny habits, and propagated vegetatively through tuberous root. It is rich in carotene, protein, carbohydrate (Rashid, 1993) and vitamin C (154.7 mg/100 g of edible portion) (Bhuiya *et al*., 1977). Teasle gourd is one of the popular and delicious summer vegetables in Bangladesh with higher demand. It is two times more profitable than rice, wheat and any other summer vegetables (Das, 1988). Nowadays it is considered as an exportable vegetable for its longer keeping quality. Teasle gourd has a number of problems relating to its yield and fruit quality. Among the problems, presence of a large number of seeds in the fruits (decrease palatability) and regular cumbersome hand pollination (increase cost of production) are noticeable. Besides, early fruit development and seed formation restrict the development of additional fruits in cucumber (Denna, 1973; Tiedjens, 1928). This may be due to competition for metabolites by early developing fruit over later fruits or to the production of plant hormones by developing seeds, which inhibit further development (McCollum, 1934). Development of seedless fruit and unnecessary hand pollination can be achieved by genetically (natural parthenocarpy) or by chemically induced parthenocarpy.

There are many methods available to produce parthenocarpic fruits in many crops. They are the uses of synthetic growth promoting factors (Lipari and Paratore, 1988), transport inhibitors of growth promoting factors (Robinson *et al*., 1971, Cantliffe, 1977), mutants capable of parthenocarpic development (Lin *et al*., 1988), pollination with incompatible pollen (Taso, 1980), X–ray irradiated mentor pollen (Morishita and Sugiyama, 1997; Sugiyama and Morishita, 2002) or plants altered in their ploidy level (Kihara, 1951).

In absence of natural or genetic parthenocarpy, alternate method should be adopted to have seedless fruit. Parthenocarpy can be induced in many crops (cucumber, tomato, bottle gourd, brinjal, *Cucurbita*, watermelon, etc.) by applying exogenous auxins (Homan, 1964; Elassar *et al*., 1974; Takashima and Hatta, 1955; Miyazaki, 1965; Terada and Masuda, 1941), gibberellins and cytokinins (Choudhury and Phatak, 1959; Elassar *et al*., 1974; Kulkarni and Rameshwar, 1978; Yu, 1999; Hayata *et al*., 2000) and also auxin transport inhibitors (Robinson *et al*., 1971; Cantliffe, 1977; Beyer and Quebedeaux, 1974).

Exogenous application of PGR's on parthenocarpic fruit development in teasle gourd has not yet been sufficiently investigated or reported. Considering the above facts, the present study was undertaken to examine the effects of exogenous PGR's (auxins and cytokinins) on the expression of parthenocarpy in teasle gourd.

MATERIALS AND METHODS

Plant materials and cultivation

The experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University

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(BSMRAU, former IPSA) research farm, Bangladesh, during March to September of 2001 and 2002. The tuberous roots of Rangpuri (Cl 3) genotype were used in this study. They were planted in earthen pots (containing a 1:1 mixture of soil and decomposed cowdung) on February 10, 2001 and February 8, 2002, respectively and watered. The tuberous roots began to sprout 20–25 days after potting. The sprouted tuberous roots were transplanted in pits (30×30×30 cm) in the experimental field on March 8, 2001 and March 10, 2002. The spacing between row to row and plant to plant was 2.0 m and 1.5 m, respectively.

The plants were supported by bamboo sticks. When the plants were about 1 m high they were allowed to climb on rope net hanged vertically up to 2.5 m from the soil surface. Fertilization and other cultivation techniques (intercultural operations) were followed as recommended by Hussain and Rashid (1974).

Experimental design and treatments

The experiment was carried out in a split–split plot design with three replications. The treatments are as follows:

Time of application: A day before anthesis, at anthesis and a day after anthesis

Different PGR's: In 2001, auxins (NAA: naphthaleneacetic acid and 2,4–D: 2,4–dichlorophenoxyacetic acid), cytokinins (CPPU: N–(2–chloro–4 pyridyl)–N' phenyl urea and Fulmet: forchlorfenuron), gibberellin (GA_3: gibberellin A_3) and auxin transport inhibitors (TIBA: 2, 3, 5–triiodo benzoic acid and MH: maleic hydrazide) were tested. Each PGR of 50 ppm concentration was applied to ten ovaries at the time of anthesis and ovary length and diameter were recorded 5, 10 and 15 days after spray. Only three PGR's (2,4–D, Fulmet and CPPU) induced parthenocarpic fruit. In 2002, therefore, 2,4–D, Fulmet and CPPU were used.

Spraying concentrations: 25, 50 and 100 ppm. The concentrations in molar form for 2,4–D are respectively101, 202 and 404 μM and for CPPU or Fulmet are 113, 226 and 452 μM, respectively.

Time of spraying was arranged in the main plot (main plots contain 27 plants per replication i.e. three plants/concentration/PGR in a replication, 3–5 first flashed flowers were sprayed in each plant), and different PGR's (9 plants/replication) and spraying concentrations (3 plants/replication) were applied to sub plot and sub–sub plot, respectively. The 2,4–D was dissolved in ethanol while CPPU was dissolved in 1% DMSO (Dimethyl sulfoxide) to make stock solution. Ten to fifteen ovaries in three plants selected randomly at first fruiting stage were treated (0.5 ml per ovary) in each treatment with three replicates. All the treated flowers were bagged in the afternoon one day before anthesis, re–bagged after application and kept bagging up to 3–4 days to prevent from open pollination.

Data collection and analysis

Fruit set percent, length, diameter and weight of fruit were recorded 5, 10 and 15 days after spraying. The mean data of 10–15 ovaries for each treatment were analyzed using standard statistical procedure of ANOVA and Duncan's Multiple Range Test (DMRT) to compare means of treatments and their interactions.

RESULTS AND DISCUSSION

2,4–D, Fulmet and CPPU induced parthenocarpic fruit (Table 1). The treated ovaries remained green and increased their size up to 15 days without developing seeds. While the ovaries treated with water (control), NAA, GA_3, TIBA and MH turned yellow and dried up even 5 days after spaying.

The detailed experiment was conducted in 2002 with 2,4–D, Fulmet and CPPU.

Table 1. Response of different PGR's in parthenocarpic fruit development (2001)

	Fruit set (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Seed
2 4–D	87.6	16.4	50.2	26.6	Absent
Fulmet	86.2	5.1	34.6	16.0	Absent
CPPU	73.1	6.2	32.2	16.6	Absent
NAA	0	–	–	–	–
GA3	0	–	–	–	–
TIBA	0	–	–	–	–
MH	0	–	–	–	–
Water (control)	0	–	–	–	–

Effect of time of spraying on parthenocarpy

The mean effect of time of spraying was statistically significant except on fruit length (Table 2). Fruit set was the highest (90.7%) when the PGR's were sprayed at anthesis followed by the spraying a day after anthesis. It was evident that percent fruit set and subsequent fruit development was directly related to the amount of PGR's (particularly auxin) present in the ovary (Gustafson, 1939, Kim *et al.*, 1992). It has been reported that parthenocarpic *pat–2* tomato fruits showed slightly higher auxin (IAA) just before anthesis but more than 10 times higher IAA content at anthesis in comparison to control fruits (Mapelli *et al.*, 1974).

Regarding fruit set, the treatments a day before anthesis and at anthesis were statistically similar. This indicated that the exogenous signal (PGR's, auxin analogues) triggered an increase in endogenous IAA and enhanced its activity in the ovary, which was responsible for promoting the highest fruit set and development at anthesis. This interpretation was consistent with that of Gustafson (1939) and Kim *et al.* (1992).

Effect of PGR's on parthenocarpy

Besides auxins (indole–3–acetic acid and its analogues), exogenous cytokinins have also been used to induce parthenocarpic fruit development in many crops (Schwabe and Mills, 1981). The maximum fruit set was obtained with 2,4–D (91.8%) followed by Fulmet (90.2%), which was statistically similar but it was dif-

Table 2. Mean effect of time of application, PGR's and their concentrations on parthenocarpic fruit development (2002)

Treatment	Fruit set (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Seed
One day before anthesis	88.3 ab	7.2 b	37.5	18.2 b	Absent
At anthesis	90.7a	10.7 a	42.2	20.9 a	Absent
One day after anthesis	79.1 b	9.8 a	39.8	20.6 a	Absent
F test	*	**	NS	*	
2, 4–D	91.8 a	16.5 a	51.2 a	26.7 a	Absent
Fulmet	90.2 a	5.0 b	35.5 b	16.2 b	Absent
CPPU	76.1 b	6.1 b	32.7 b	16.7 b	Absent
F test	**	**	**	**	
25ppm	80.2 b	7.7 c	33.8 c	17.5 c	Absent
50ppm	88.9 a	8.7 b	40.3 b	20.0 b	Absent
100ppm	89.1 a	11.3 a	45.4 a	22.1 a	Absent
F test	**	**	**	**	
Mean	86.1	9.2	39.8	19.9	

*, ** and ***; significant at 5%, 1% and 0.1% level of probability, respectively. Mean separation by Duncan's multiple range test.

ferent from CPPU (76.1%) (Table 2). In teasle gourd, higher percent (88.9%) of fruit set was also observed by applying 2,4–D against NAA and IAA (Vijay and Jalikop, 1980). The larger fruit (16.5 g) was also obtained when the ovary was sprayed with 2,4–D. The size of fruit (fruit length and diameter) varied considerably under different PGR treatments. For fruit length, the result showed that 2,4–D produced longer fruits as compared to Fulmet and CPPU. The 2,4–D enhanced the fruit growth sharply up to 10 days after treatment and then slowly up to 15 days. But in case of Fulmet and CPPU initial growth was high until 5 days, which almost stopped at 10 days and not much further increment. The fruit diameter increased up to 10 days for all PGR's. Vijay and Jalikop (1980) observed higher fruit size by applying 2,4–D and 2,4,5–T than by NAA and IAA in teasle gourd.

The performance of cytokinin derivatives (Fulmet and CPPU) for different parameters was statistically similar except for fruit set percentage. CPPU and Fulmet are chemically similar, commonly called Forchlorofenuron, so their effect should be similar. The differences in their effect for fruit set percentage might be due to the adjuvant used, CPPU in DMSO and Fulmet in ethanol. Though CPPU is the cytokinin with strongest activity ever known (Takahashi *et al*., 1978) but in our study, the performance of Fulmet and CCPU was not much encouraging as compared to results reported in other crops (Chin *et al*., 1991; Lewis *et al*., 1996). CPPU induced more parthenocarpic fruits and also improved fruit set in Chinese white gourd (*Lagenaria leucantha*) than NAA, GA_3, BA, DPU and 4–PU (Yu, 1999).

Control treatment (water spray) did not produce fruits. It turned ovaries yellow after 5 days of the treatment and shrinked and then the ovaries dropped down quickly. So the data on water control were not incorporated in the statistical analysis and also in the Table 2.

Effect of concentrations of PGR's on parthenocarpy

PGR's sprayed at 100 and 50 ppm showed similar results in percent fruit set, but fruit set was low at 25 ppm (Table 2). The application of 100 ppm PGR's produced the largest fruit (11.3 g) while 25 ppm produced the smallest (7.7 g) fruit. Fruit size (length and diameter) and weights were increased with the increment of the concentrations of PGR's. Fruit size increased up to 10 days after spraying and beyond that it was almost stopped, which might be due to the limitation of assimilate supply and cell division by the PGR's for such long time. Vijay and Jalikop (1980) observed remarkable differences in fruit weight and fruit set with the application of different concentration of growth regulators in teasle gourd. It is likely that fruit size is an important factor to be considered in the determination of hormonal concentration for parthenocarpic development of fruits.

Elassar *et al*. (1974) reported that synthetic auxin when applied directly to flower of muskmelon at anthesis caused parthenocarpic fruits. Watkins and Cantliffe (1980) reported that exogenously applied NAA enhanced fruit set in *Cucumis sativus* L. Application of NAA and IAA on the ovary accumulated auxin in it which triggered fruit set and subsequent growth of *Cucumis sativus* (Kim *et al*., 1992).

The similar experiments were conducted in Kyushu University in 2000 and 2001 with different strains. The results were quite similar to those described above. Parthenocarpic fruit is obtainable by chemical treatment, although the fruit quality is not yet satisfactory.

CONCLUSION

In the present findings, 2,4–D showed better effect on growth and fruit set in teasle gourd than Fulmet and CPPU (cytokinins). Fruit size and weight were mostly increased with increase of concentration of PGR's. The results revealed that PGR's showed the possibility of developing parthenocary or seedless fruit in teasle gourd.

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