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Modifying Sex Expression of Papaya (*Carica Papaya*) Through Application of Plant Growth Regulators

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ABSTRACT

Papayas are polygamous herbs having plants that produces flower but does not develop into fruits. Due to this condition, farmers have to plant up to five seedlings per hill if they process their own seeds or be forced to buy expensive F1 seeds from seed companies. Plant growth regulators play an important role in the sex expression of plants. Thus, a study was conducted to determine the effects of different plant growth regulators (Ethrel, Indole Butyric Acid and Kinetin) at different concentrations (50 ppm, 100 ppm and 200 ppm) on the sex ratio of papaya and the number of days for it to flower. Flowering of papaya ranged from 93 to 115 days from transplanting. Papaya plants applied with 100 ppm IBA at 0.25 ml per application (appearance of first to fourth true leaf) resulted to 108% more female flowers than those not applied with PGR. On the other hand, application of IBA at the same rate and concentration produced lesser hermaphrodite and male flowers at 10% and 3.33%, while those not applied with PGR produced 33.67% and 23.33%, respectively. This means that with the use of 100 ppm IBA, farmers will be able to process their own papaya seeds with higher chance of producing plants that will produce fruits. This, in turn, will reduce their dependency to multi-national seed companies as their sole source of papaya planting material.

Keywords: papaya, plant growth regulators, polygamous herb, sex expression

INTRODUCTION

Papaya (*Carica papaya* L.) is a major fruit of the Philippines that is available throughout the year. It is easy to grow, fast-growing, produces fruits in a short period, polygamous herb and has high production per herb per year. Furthermore, other than being attractively colored and delicious, its fruits are also highly nutritious.

The fact the papaya are polygamous herbs means that female plants only produces female flowers which eventually develops into fruits. Male plants, on the contrary, produce male flowers which do not develop into fruits. Hermaphrodite plants, on the other hand, produces bisexual flowers that may revert to male flowers. This polygamous characteristic of papaya has been considered the stumbling block of small scale papaya production since only female and hermaphrodite plants produces fruits. Thus, it is recommended by PCARRD (2006) to plant three to five seedlings per hill since the sex of the papaya plants can only be determined once it reaches reproductive stage.

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The role of plant growth regulators on cucurbits is well studied. PGRs are known to enhance earliness of flower, yield (Gedam *et al*., 1998), ratio of female to male flowers (Bisaria, 1974) number of fruits, weight of fruits (Gopalkrisman and Choudhury, 1978). Auxins causes profound changes in plant growth and development (Zhao, 2010). However, none has been reported yet on its effect on polygamous herb like papaya.

Generally, the study aimed to determine the effects of different kinds and varying concentrations of plant growth regulators (PGR's) on the sex expression of papaya. Specifically, it aimed to determine the effects of the treatments on the number of days to flowering, and the number of female and hermaphrodite plants to occur.

MATERIALS AND METHODS

Study Site

The study was conducted in a 500 m^2 land at Cebu Technological University – Barili Campus. The soil texture in the area is clayey, with neutral to slightly alkaline soil (pH 7 – 8). Papaya plants generally favor soils that are slightly acidic to near neutral (pH 6 – 7). Thus substantial application of chicken dung (500 g/hill) was done basally to augment this not very favorable soil conditions for papaya production.

Cultivars

Seeds from fruits of solo papaya which were abundant in the campus were processed. Production of female plants was the main objective for sex modification of Solo variety since the female plants produces shorter but more rounded fruits which are preferred by the international market as compared to its narrower and somewhat elongated hermaphrodite counterpart. Even though a system of producing only hermaphrodite and female plants of papaya is well-established, the procedure of bagging, facilitated pollination and timing of pollination can be tiring if not difficult to common farmers.

Seed Production

Seed processing was done instead of buying seeds from commercial seed growers. This is to achieve variability in the sex expression of papaya plants. Papaya fruits were harvested at color break and allowed to ripen for seed extraction. The extracted seeds were soaked for five days for easy removal of mucilage. After soaking, the seeds were thoroughly cleaned to remove the mucilage. The seeds were then washed in clean water for complete removal of mucilage. This was necessary since mucilage contains germination inhibitors (PCAARRD, 2006).Cleaned seeds were air-dried for five days before planting.

Germination

The seeds were sown in plastic cups containing sterilized vermicast and garden soil (1:1)

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as medium. To maintain high temperature and humidity, which are favorable for germination, it was covered with plastic sheets. This took approximately two weeks. The plastic sheets were removed one week after sowing.

The seedlings were kept under shade house and watered every other day. To boost seedling growth, they were watered with starting solution (10 mg complete fertilizer/ 10L water) three days after germination. After four weeks from germination, the seedlings were hardened by gradually exposing them to full sunlight for five days, after which they were transplanted to the field.

Land Preparation

The area was plowed and harrowed twice to pulverize the soil. Hole of about 30 cm in diameter and 40 cm deep was prepared for every seedling. This was incorporated with 500 g chicken dung and mixed with top soil one week before transplanting to improve soil structure.

Transplanting

This was done one week after basal application of chicken dung and after five days of hardening the seedlings. Transplanting was done in the afternoon and the seedlings were watered immediately to avoid transplanting shock. Watering was done every three days thereafter if rain does not occur. Watering was done once a week from one month onwards.

Table 1. Recommended fertilizer application for papaya (PCARRD, 2006)

Stage of Growth	Fertilizer Rate	Fertilizer Material
Transplanting	50 g/plant basally applied	Ammonium sulfate (21-0-0)
2^{nd} to 6^{th} month	100 g/plant/month	Complete fertilizer (14-14-14)
4^{th} month	30 g/plant	Borax
7^{th} month onwards	200 g/plant/month + 100g/plant/month	Complete fertilizer + Ammonium sulfate

Experimental Design and Treatments

The study was laid out in Randomized Complete Block Design (RCBD) with three replications and 10 treatments at 10 sample plants per treatment per replication.

The treatment will be as follows:

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Plant Growth Regulator	Concentration
None	
Ethrel	50 ppm
	100 ppm
	200 ppm
Kinetin	50 ppm
	100 ppm
	200 ppm
IBA	50 ppm
	100 ppm
	200 ppm

Application of treatments was done four times: at first, second, third and fourth true leaf stage. The volume of application was at 0.25 ml per application at the growing portion (shoot apex) of the papaya. Jadav *et al.* (2010) reported that application of PGRs on cucumber during its two and four true leaf stage was effective in inducing femaleness expression of cucumber flowers. Moreover, according to Fujieda (1966), plants at first, second and third leaf stage have already differentiated flower primordial up to the ninth, 12th and 15th node respectively. He also mentioned that in the second and third leaf stages, sex of flowers has already been determined up to the fourth and seventh node respectively.

Furthermore, application of PGRs was done at the seedling stage of papaya (up to fourth leaf stage only) to ensure that residues of exogenously applied hormones (PGRs) are removed/eliminated before fruit initiation and eventual harvesting.

Data Collection

Data collected included number of days to flowering, and the number of female, hermaphrodite and male plants.

1. Number of days to flowering – this was determined by counting the number of days from transplanting until the appearance of the first flower of a plant.

2. Number of female and hermaphrodite plants – this was determined by counting the number of male, female and hermaphrodite plants as affected by the different treatments of the study.

Statistical Analysis

Data were recorded, tabulated, consolidated and statistically analyzed through Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) at 0.05 and 0.01 level of significance. Comparisons among means were done using Duncan's Multiple Range Test (DMRT) to determine the specific significant differences among treatment means.

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RESULTS AND DISCUSSION

Papaya plants coming from seeds processed from existing solo papayas in CTU-Barili Campus produced the three sexes: female, hermaphrodite and male as shown in Figure 1.

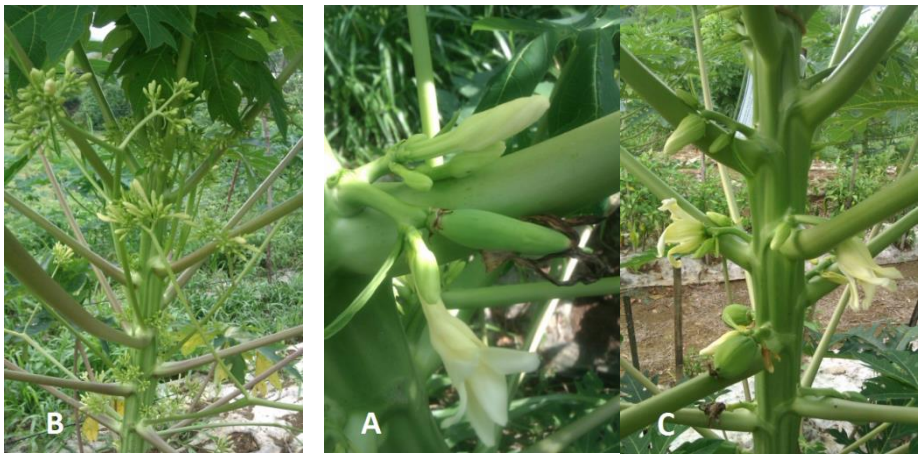

Figure 1. Female (A), hermaphrodite (B) and male (B) papaya plants

Moreover, Table 2 shows that it took about 82 to 92 days or a difference of only ten days for the first flowering of papaya plants treated with different plant growth regulators.

Table 2. Number of days to flowering of papaya plants as affected by different plant growth regulators at different concentrations

Treatments	Ave. Days to Flower Initiation
T0 - No PGR (Control)	89.71
T1 - 50 ppm Ethrel	88.52
T2 - 100 ppm Ethrel	87.43
T3 - 200 ppm Ethrel	92.83
T4 - 50 ppm Kinetin	84.61
T5 - 100 ppm Kinetin	82.75
T6 - 200 ppm Kinetin	86.54
T7 - 50 ppm IBA	86.12
T8 - 100 ppm IBA	88.96
T9 – 200 ppm IBA	82.60

C.V. (%) = 6.44

For the expression of female flowers (Figure 2), the Figure revealed that application of 100 ppm IBA resulted to significantly more female plants (83.33%) than the rest of the treatments. The lowest number of female plants was observed on those not applied with PGR (40%) and those treated with 200 ppm ethrel (33.33%). This means that excessive ethrel application (200 ppm) may result to reduced femaleness expression of papaya plants. Such findings were also reported on bitter gourd (Ghani *et al*., 2013). On the other hand, factors which raise the auxin levels available at the differentiating apex promote femaleness and suppress maleness (Heslop-Harison, 2008) as in the case of this study the application of IBA. Galun (1959) reported that naphthalene acetic acid (NAA) (100ppm) promoted female flower formation.

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Furthermore, in cucurbits, spraying of auxin increased the number of female flowers in cucurbits. Thus, auxin causes femaleness in plants (Competition Science Vision, 2003). Moreover, exogenous application of auxin and inhibitors of gibberellin biosynthesis promote monoecious strains to form pistillate flowers, that is, increase femaleness. Determinations of endogenous growth substances indicate that strains with genetically strong female sex expression contain more auxin (Byers *et al*., 1972).

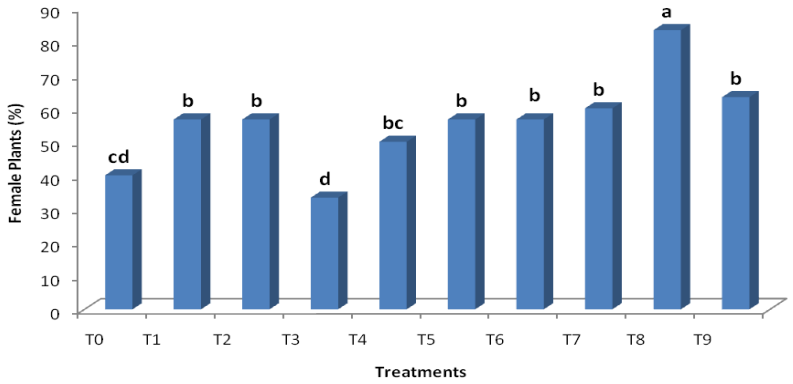

Figure 2. Percentage of Female Papaya Plants as Affected by Application of Different PGRs at Varying Concentrations

On the expression of hermaphrodite plants, it can be noted that the application of 100 ppm IBA produced the least (10%) while the application of 200 ppm Ethrel produced the most (46.67%) number of hermaphrodite plants (Figure 4).

This means that with application of IBA, regardless of concentrations, there will be more than 90% productive plants (Female and Hermaphrodite), with the use of 100 ppm IBA producing the most number of female plants. This also means that without the application of PGRs, there will be 23.33% male plants which will not be productive (none fruit-bearing).

The sexual differentiation is controlled by endogenous levels of auxins, which developed flowering primordial and during flowering act as anti- gibberellin substance. This anti-gibberellin effect suppressed staminate flowers and promotes more number of pistillate flowers (Kshirsagar et al., 1995). In the expression of female flower, result on cucumber by Jadhav et al. (2010) revealed that Ethrel 200ppm and 300ppm application produced the maximum yield 21.15 and 20.05 ton per hectare; while without PGR application produced the lowest yield of 11.47 and 12.79 ton per ha. An increase in fruit yield in treated plants may due to physiologically activation for the development of flowers and fruits per plant. These findings are in consonance with those of Kshirsagar et al., 1995 and Iwahori et al., 1969, in cucumber.

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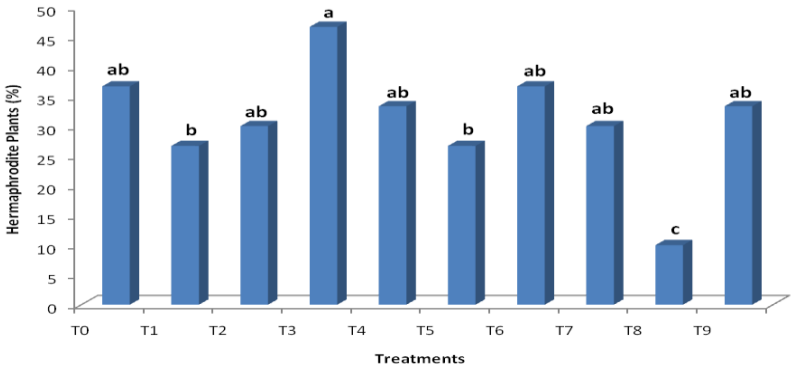

Figure 4. Percentage of Hermaphrodite Papaya Plants as Affected by Application of Different PGRs at Varying Concentrations

Ethylene and 20 chloroethylphosphonic acid (ethephon), an ethylene-releasing compound have recently been shown to promote femaleness in cucurbits; thus, the effect of Ethylene is similar to that auxin. Exogenous application of auxin increases ethylene causes many growth responses in plants and some responses to auxin are now attributed to auxin-induced ethylene synthesis (Byers *et al.,* 1972).

Even though ethrel application was also effective in polygamous herb like papaya, exogenous application of the hormone responsible for sexual differentiation (auxin) proved to be the most effective. Ghani *et al*. (2013) reported that the number of fruits and seed yield was significantly higher among all the PGRs (GA3, ethrel and NAA) but overall results revealed that application of NAA proved to be better for different yield and yield related traits in bitter gourd. Furthermore, it can be noted that for plants applied 100 ppm and 200 ppm IBA produced initially female flowers but was then followed by the appearance of hermaphrodite flowers (Figure 5). This clearly shows the effect of IBA application on the sex expression of papaya and at the same

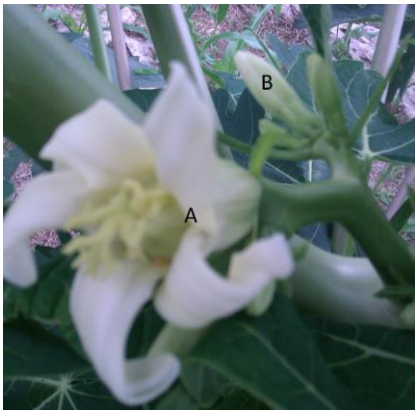

Figure 5. Expression of female flower (A) preceded by the appearance of hermaphrodite Flower (B)

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time the value of its application since hermaphrodite plants may have the tendency to become male while female plants does not have any tendency of becoming male and unproductive (PCAARRD, 2006). The first modification of sex expression by auxins was first reported on the increase in the proportion of female flowers formed by cucumber plants treated in early seedlings stages with IAA and NAA. In addition, the application of auxin was found to cause earlier formation of female flowers in cucumber lines that differ genetically in their sex expression (Thomas and Vince-Prue, 1996).

CONCLUSION

Generally, application of PGRs resulted to increased femaleness expression of plants but does not affect the number of days to flower initiation. However, excessive application of ethrel (200 ppm) may reduce the number female papaya plants. Moreover, application of IBA at 100 ppm is the most effective type and concentration of PGR that enhance femaleness expression of papaya plants. These findings will serve a basis for future research into reducing dependency of farmers to commercial seed producers and towards a more sustainable papaya production.

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