Enhanced Femaleness Expression of Papaya (*Carica Papaya* var. Legazpi Special) Seed through 100 ppm IBA Application

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ABSTRACT

Papayas are polygamous herbs that produce plants that produce flower that does not develop into fruit. This is why farmers resort to buying expensive F1 seeds produced by multi-national seed companies instead of following the five seedlings per hill recommendation that promises 1.65 out of 5 likelihood of female papaya plant. Sex expression in plants has been reported to be influenced by auxins. Thus, the effects of Indole Butyric Acid (IBA, an Auxin) at concentrations 50 ppm, 100 ppm and 200 ppm in the sex ratio of papaya and the number of days for it to flower were determined. Flowering of papaya ranged from 83 to 90 days from transplanting. Papaya plants applied with 100 ppm IBA at 0.25 ml per application (appearance of first to fourth true leaf) resulted in 108% more female plants than those not treated with IBA. IBA application at the same rate and concentration produced lesser hermaphrodite plants at 10%. Male plant count also declined to 3.33%. Untreated plants, on the other hand, produced 33.67% hermaphrodite plants and 23.33% male plants. This means with the application of 100 ppm IBA, farmers will be able to process their papaya seeds with 1.67 out of 2 chances that these will grow into female papaya plant. This, ultimately, will reduce their dependency on multi-national seed companies as their sole source of papaya planting material.

Keywords: sex expression, plant growth regulators, seed processing, polygamous herb, papaya, Philippines

INTRODUCTION

Philippine papaya production is amongst the top ten in the world ranking eighth with a production volume of 130, 764 metric tons (DA- BAS, 2003) and by 2008, annual production peaked at 182, 907 metric tons. Papaya (*Carica papaya L.*) is the 5th major export fruit of the Philippines next to banana, pineapple, mango and citrus. It is a polygamous, fast- growing herb that is easy to grow with relatively high fruit production index. Harvest- grade fruits are available in at least nine months from field transplant and are available throughout the year. Papaya is a rich source of antioxidant nutrients and fiber aside from its digestive enzyme papain which is an ingredient in the brewing industry, meat tenderizing, pharmaceuticals and cosmetics (Evans and Ballen, 2013). Papayas being polygamous grow in three sexes. The female plants produce pistillate flowers that eventually develop into fruits while male plants grow staminate flowers that only develop pollens. On the other hand, hermaphrodite plants produce bisexual flowers that may develop into either fruits or just pollens. This polygamous characteristic has been considered the stumbling block of papaya production. Thus, the Philippine council for Agriculture, Aquatic and NaturalResources Research and Development or PCARRD (2006) recommends planting five seedlings per hill to get a 33% chance of having a female or hermaphrodite plant or buy commercially- produced F1 seeds.

Exogenous application of plant growth regulators (PGRs) like auxin can alter plant sex ratio of flowers, play a significant role in sex expression and the eventual yield of plants

(Shinde, Desai, Masalkar, and Chaudhari, 1994; Nickell, 1982). Effects of PGRs on sex expression inducing femaleness have been established in monogamous plants like cucumber and other members of the Cucurbitaceae family (Choudhury and Patil, 1962; Pike and Peterson, 1969; Byers, Baker, Sell, Herner, Diley, 1972). However, none has been reported yet on its effect on polygamous herbs like papaya, hence this study.

Objectives:

The study aimed to determine the effects of varying concentrations of Indole Butyric Acid on the sex expression of papaya.

MATERIALS AND METHODS

Study Site

The study was conducted on a 500 m^2 land at Cebu Technological University – Barili Campus. The area is clayey, with neutral to slightly alkaline soil (pH 7 – 8). Thus, substantial basal application of chicken dung (500 g/ hill) was done to augment this not favorable soil conditions for papaya production.

C***ultivars***

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

Seed Processing

Seed processing was done instead of buying seeds from commercial seed growers. This was done 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 mucilage. The seeds were washed with tap water for complete removal of mucilage. This process was necessary since mucilage contains germination inhibitors (PCAARRD, 2006).

Cleaned seeds were air-dried for five days before planting.

Germination

The air-dried seeds were then sown in plastic cups containing sterilized vermicast and garden soil (1:1) as medium. In order to maintain high temperature and humidity that favor germination, it was covered with plastic sheets. The plastic sheets were removed one week from 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. Raised mounds were made at 30 cm high to avoid water logging during the rainy season. Holes of about 30 cm in diameter and 40 cm deep were prepared for every seedling. The holes were incorporated with 500 g chicken dung and mixed with top soil one week before transplanting to improve soil texture.

Transplanting

This was done one week after basal application of chicken dung and after five days of hardening. 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.

Fertilizer Application

Fertilizers were applied based on the recommended rate of fertilization.

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)
2nd to 6th month	100 g/plant/month	Complete fertilizer (14-14-14)
4th month	30 g/plant	Borax
7th 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 (3) replications and four (4) treatments at 10 sample plants per treatment per replication.

The treatmentswere as follows:

T0 - Control0 ppm
T1 - Indole Butyric Acid 50 ppm
T2 - Indole Butyric Acid 100 ppm
T3 - Indole Butyric Acid 200 ppm

Applications of treatments were done four times: at first,second, third and fourth true leaf stage of the papaya seedlings. 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 the application of PGRs on cucumber during its two and four true leaf stage was effective in inducing femaleness expression of cucumber flowers. The concentration range should be from 10 to 200 ppm to be effective. 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 nodes, respectively.

Application of PGRs at seedling stage may ensure the absence of residual traces the chemical. Harvesting of the fruits will commence at least nine months after PGR application. This duration will give ample time for chemical residues to dissipate.

Data Gathered

Data collected included number of days to flowering, and the number of female and hermaphrodite 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. Total number of productive plants – this was the number of female and hermaphrodite plants.
3. Number of female and hermaphrodite plants – this was determined by counting the number of 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). Comparisons among means were done using Student Newman Keul's (SNK) Test to determine the specific significant differences among treatment means at 5% level of significance.

RESULTS AND DISCUSSION

Papaya plants coming from processed Lagazpi Special variety seeds produced the three different sexes: female, hermaphrodite and male as shown in Figure 1.

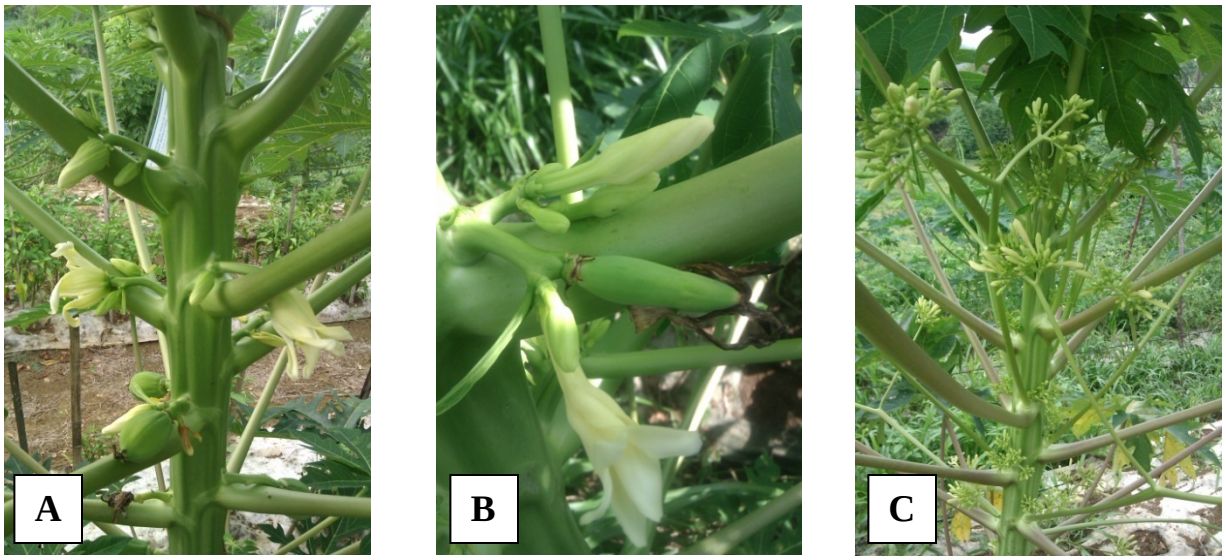


Figure 1. Female (A), hermaphrodite (B) and male (C) papaya plants

Moreover, it took 83 to 90 days or a difference of only ten days from the first flowering to the last flowering of papaya plants (Table 2).

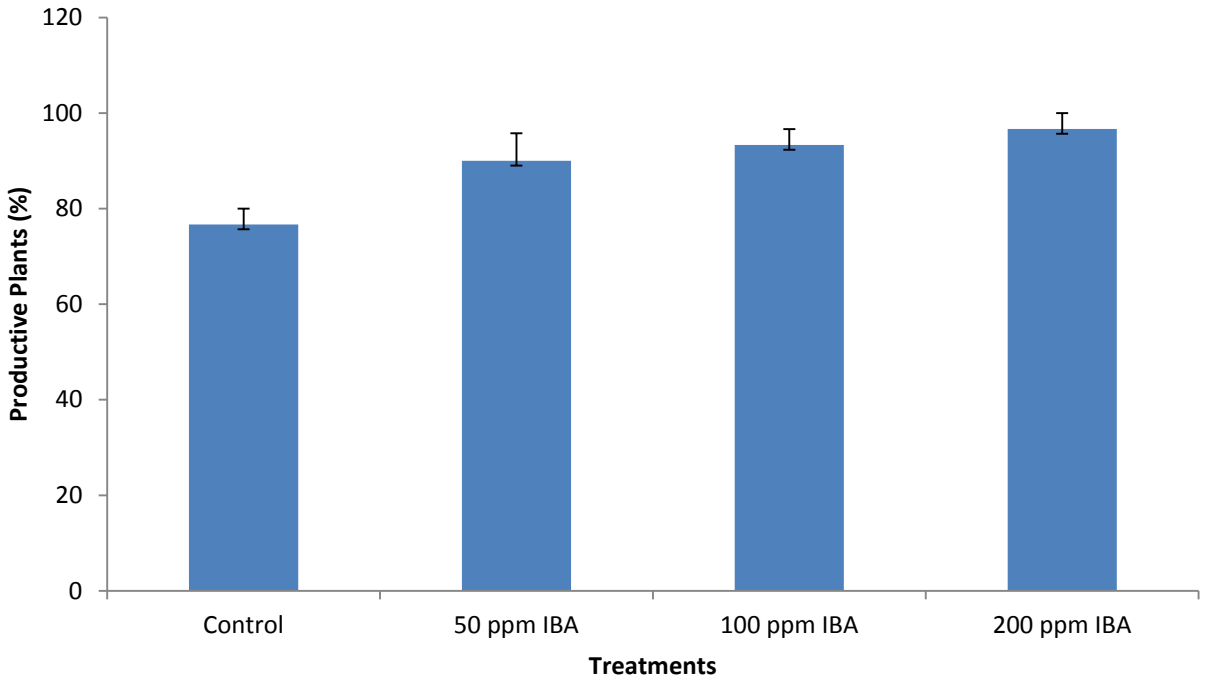
Furthermore, productive papaya plants ranged from 77% to 97%. All IBA treated papaya seedlings produced more than 90% productive plants (Figure 2).

Table 2. Number of days to flowering of papaya plants as affected by different concentrations of Indole Butyric Acid

Treatments	Ave. Days to Flower Initiation
T0 - No PGR (Control)	89.71±1.48SE
T7 - 50 ppm IBA	86.12±1.48SE
T8 - 100 ppm IBA	88.96±1.48SE

T9 – 200 ppm IBA	82.60±1.48SE

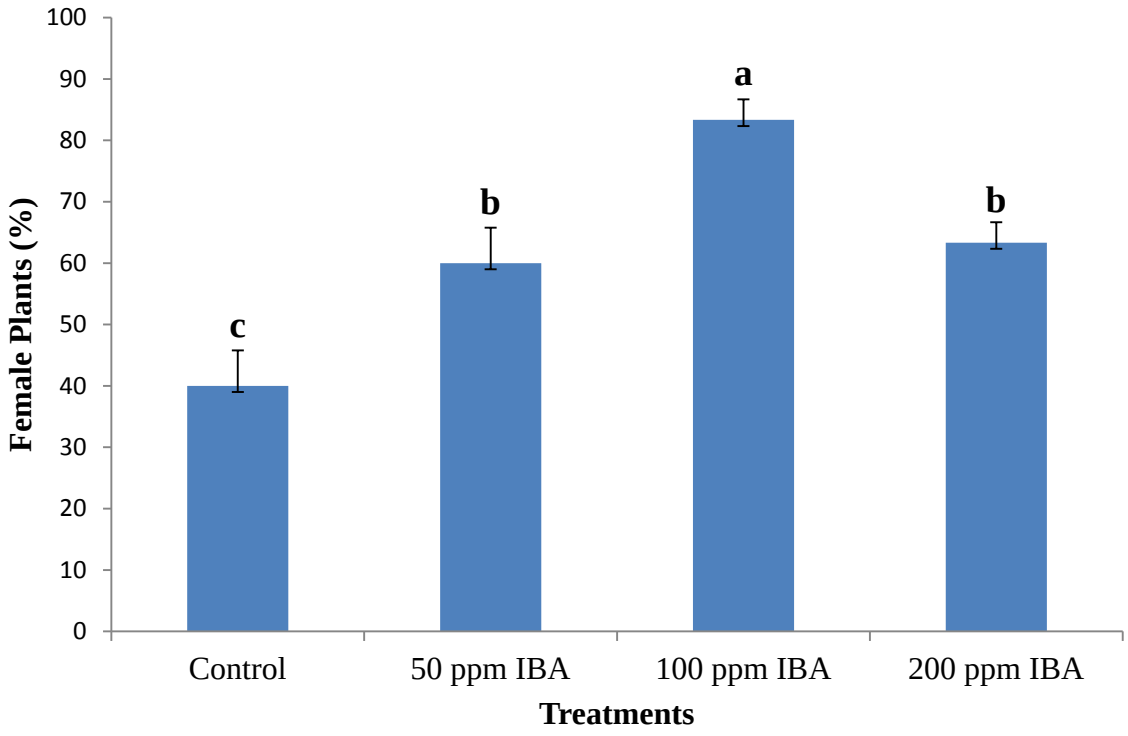
C.V. (%) = 4.19



C.V. (%) = 8.36
Bars in ±SE

Figure 2. Percentage of productive papaya plants as affected by different concentrations of Indole Butyric Acid

For the expression of female flowers, results reveal that the application of 100 ppm IBA resulted to significantly more female plants (83.33%) than the rest of the treatments (Figure 3). The lowest percentage of female plants were observed on those not applied with PGR (40%). This suggests that IBA application at 100 ppm can more than double the amount of female plants. Factors that increase the auxin levels at the apical meristem will enhance femaleness and inhibit maleness (Heslop-Harison, 2008), as in the case of this study the exogenous application of auxin - IBA. Galun (1959) reported that naphthalene acetic acid (NAA) (100ppm) promoted female flower formation. Furthermore, in cucurbits, spraying of auxin increased the number of pistillate flowers. Moreover, exogenous application of auxin and inhibitors of gibberellin biosynthesis promote monoecious strains to form pistillate flowers, that is, increase femaleness. In addition, determinations of endogenous growth substances indicate that strains with genetically active female sex expression contain more auxin (Byers et al., 1972).

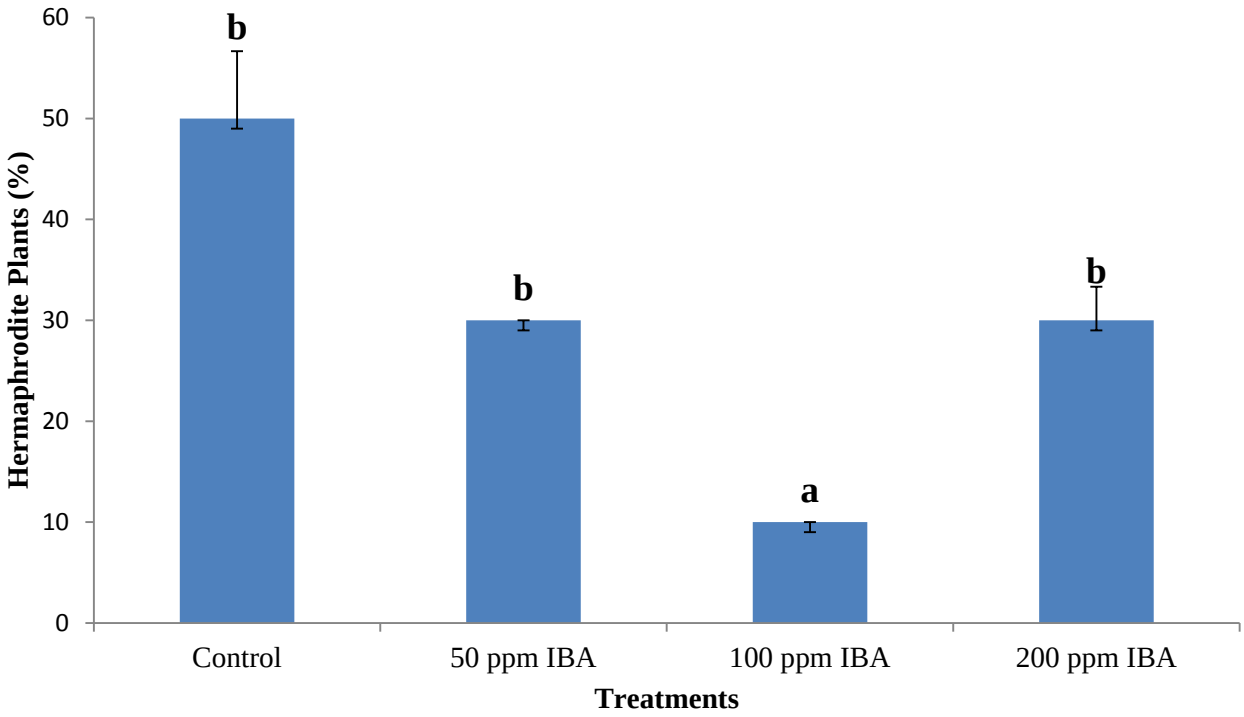


C.V. (%) = 15.04
Bars in ±SE

Figure 3. Percentage of female papaya plants as affected by different concentrations of Indole Butyric Acid

On the expression of hermaphrodite plants, it can be noted that the application of 100 ppm IBA produced the least percentage of hermaphrodite plants (10%) while the rest are not significantly different from each other (Figure 4).

This means that the tendency of hermaphrodite plants to revert into male plants can be suppressed through the application of 100 ppm IBA. It can be noted in the 40% fewer hermaphrodites than untreated plants. Furthermore, application of 100 ppm IBA produces the most number of female plants. While none application of IBA leads to higher percentage of unproductive plants (male) reaching to 23.33%.



C.V. (%) = 24.98
Bars in ±SE

Figure 4. Percentage of hermaphrodite papaya plants as affected by different concentrations of Indole Butyric Acid

Internal auxin levels direct sexual expression in plants. It develops flowering primordial and during flowering stage, it suppressed the effects of gibberellin that favor the formation of staminate flowers. Eventually, pistillate flowers dominate during inflorescence (Kshirsagar, Desai, Patil, Pawar, 1995; Jadav, Patel, parmar, Saiyad, 2010) found out that in the femaleness of cucumber, Ethrel application at 200 ppm and 300 ppm produced the maximum yield reaching 21.15 tons/ha and 20.05 tons/ha. An increase in fruit yield in treated plants may be due to physiological activation for the development of flowers and fruits per plant.These findings are in consonance with those of Kshirsagar et al. (1995) and Iwahori, (Lyons, William (1969) in cucumber. Ethylene and 20 chloroethylphosphonicacid (ethephon), an ethylene releasing compound has recently been shown to promote femaleness in cucurbits; thus, the effect of Ethylene is similar to that of auxin. Exogenous application of auxin increases ethylene that causes many growth responses in plants and some responses to auxin are now attributed to auxin- induced ethylene synthesis (Byers et al., 1972). Ghani, Amjad, Iqbal, Nawaz, Ahmad, Hafeez, Mazhar (2013) reported that the yield in bitter gourd were significantly higher

regardless of the plant hormone applied (GA, ethrel and NAA). However, overall results showed NAA to cause the highest yield in bitter gourd.

Furthermore, it can be noted that for plants applied 100 ppm and 200 ppm IBA produced female flowers initially, but was then followed by the appearanceof hermaphrodite flowers (Figure 5). This clearly shows the effect of IBA application on the sex expression of papaya and its importance. Its value can be seen in the reduction of the hermaphrodite plants that have the tendency to revert to male flowers (PCAARD, 2006). Whereas, there are no reports that female plants have the tendency to revert into male and become unproductive.The first modifications of sex expression by auxins werefirst reported on the increase in the proportion of female flowers formed by cucumber plants treated in early seedlings stages with IAA and NAA (Steward, 2012). In addition, the application ofauxin was found to cause earlier formation of female flowers in cucumber lines that differ geneticallyin their sex expression (Thomas and Vince-Prue, 1996).

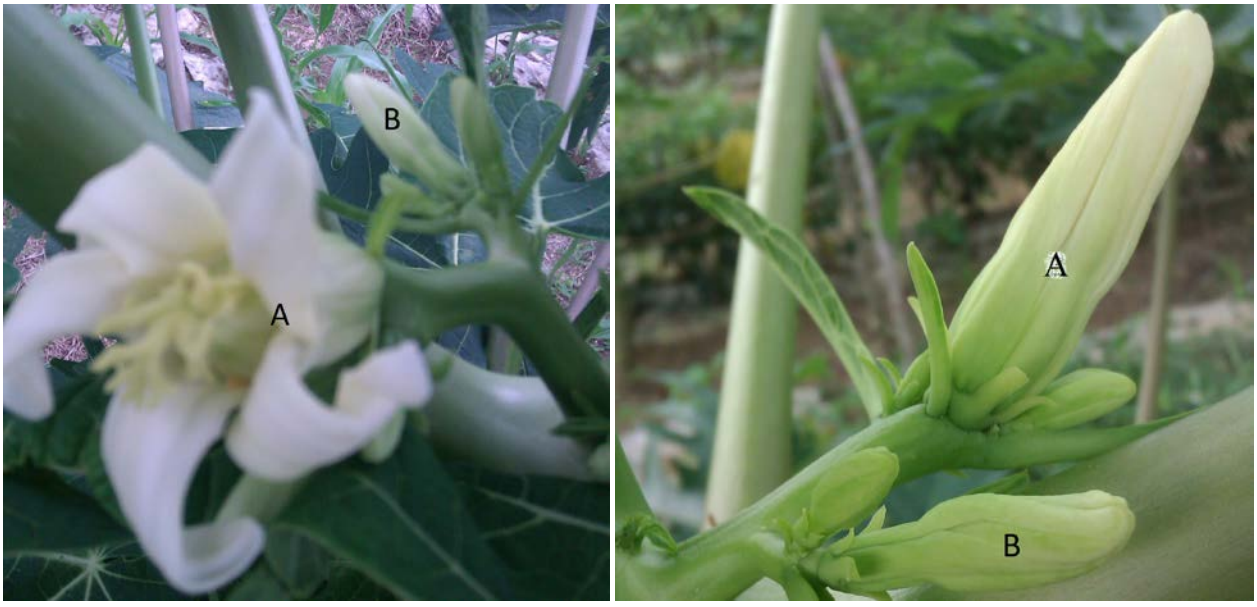


Figure 5. Expression of a female flower (A) preceded by the appearance of hermaphrodite Flower (B)

CONCLUSION

Application of IBA does not influence the number of days to flowering and total percentage of productive papaya plants. However, the application of 100 ppm IBA greatly altered the sex ratio of papaya plants by producing the highest percentage of female plants and

the least percentage of hermaphrodite plants. This reduces the tendency of productive papaya plants from reverting into male, unproductive, papaya plants.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Cebu Technological University – Barili Campus for the GAA fund appropriated for this research and for facilitating the conduct of the research.

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