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Effect of Gibberellic Acid on the Flowering and Yield Performance of Hybrid Variety of *Momordica charantia*

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***Abstract* – A field experiment of a trellised bitter gourd using gibberellic acid (GA_3) an exogenous plant growth regulator (PGR) was conducted from December 2016 to May 2017 at Paoay, Ilocos Norte, Philippines. Bitter gourd is a good source of vitamins and minerals which are good to health. The study was conducted to attain the following objectives: 1) to determine the effect of GA_3 on flowering and fruit yield of bitter gourd; 2) to determine the best concentration that give high yield of the tested crop; and 3) to determine the profitability of growing bitter gourd using GA_3. Four concentrations (0, 10 ppm, 25 ppm, and 50 ppm) of GA_3 were used and laid out in Randomized Complete Block Design and replicated thirce. A plot size of $20m^2$ was used with 1.5 m distance between plots and blocks. One plant per hill was transplanted in 1 m between rows and 0.75 m between hills. Spraying was done at 20, 40, and 60 days after transplanting. GA_3 application had positive effect on the number of staminate flowers, number of fruits per hill, and fruit yield. GA_3 at 10 ppm resulted to more number of staminate flowers but further increased of concentration to 25 ppm produced comparable flowers. More number of fruits/hill and fruit yield per hectarewere attained using 50 ppm than no application. Application of the PGR significantly increased the fruit yield.GA_3 application was profitable than no application.**

***Keywords* – Bitter Gourd, Concentrations, ppm**

I. INTRODUCTION

The Philippines particularly in Ilocos Region is one of the regions who are growing various vegetables and bitter gourd is one of them. Ilocos Norte produced of 3,118.400 MT which rank as top eight producing province of bitter gourd while Nueva Ecija (13,001.16 MT) as the leading producer (PSA, 2015).

Momordica charantia or bitter gourd or bitter melon belongs to Cucurbitaceae family and it contains innumerable vitamins, minerals and healing properties which are necessary for the human health. In addition, this is cultivated by the farmers because it is good source of income. Today, the attention of human nutrition and the use of vegetables including this crop are increasing due to its benefits. According to Ayushueveda (2009) cited by Bureau of Plant Industry of the Department of Agriculture in the Philippines (BPI-DA) 100 grams of bitter gourd comprises the following nutrients: calcium (19 mg); selenium (0.2 mcg); magnesium (17 mg); manganese (0.059 mg); zinc (0.8 mg); pantothenic acid (0.212 mcg); total carbohydrates (4g); sodium (5 mg); iron (0.43); copper (0.36 mg); dietary fiber (3g); Foliate (72 mcg); and protein (1g). The crop bears simple and alternate leaves 4-12 cm across, with 3-7 deeply separated lobes. Plant bears separate yellow male and female flowers. The fruit has a distinct warty looking exterior and an oblong shape.

Aside from the use of inorganic fertilizer which improves the growth and yield performance of crops is the use of plant growth regulators (PGRs). This could be an alternative way to increase crop production. One PGR that is widely and commercially utilized is gibberellic acid or GA_3 which modify the growth, yield and yield contributing characters of plant.

Phytohormones enhance the rapid changes in physiological and biochemical characters and improve crop productivity (Khandaker *et al*. 2012). One of the phytohormones is gibberellins like compounds, gibberellic acid (GA_3). Their name derives from the pathogenic fungus *Gibberella fujikuroi*, from which they were first isolated (Pandolfini, 2009). In plants, gibberellins levels increase upon fertilization and triggers development of fruit which changed the horticulture industry (http:// www.biology.tutorvista.com).

Some of the following physiological effects of GA_3 are: a) overcome dormancy with high concentrations and rapid germination of seeds, b) premature flowering; c) increase fruit set, increase growth (elongation of intact stems/ intermodal growth), and d) induces seedlessness of fruits which could have effect on the fruit yield and quality of the produce (Bonde, 1996; and Chudasama and Thaker, 2007), fruit development (Hooley, 1994). Additionally, foliar application of gibberellins stimulates and synchronizes flowering and fruit set as well as enhancing photosynthesis and growth (Yuan and Xu, 2001). The mentioned effects of GA_3 in crops could increase the production which may meet the demand of consumers. Gibberellins are associated with various plant growth and development processes such as seed germination, floral initiation, floral organ development, fruit development and induction of some hydrolytic enzymes in the aleurone of cereal grains (Matsuoka, 2003 cited by Chudasama and Thaker, 2007).

The application of GA_3 is proven to improve the performance of plants in terms of growth and yield. For better documentation of the performance of bitter gourd using hybrid variety is the conduct of this study. Generally, this study aimed to determine the effectiveness of GA_3 on bitter gourd under the condition of Paoay, Ilocos Norte, Philippines. Therefore, this study was conducted specifically, it aimed to 1) determine the effect of GA^3 on flowering and yield performance of bitter gourd; 2) identify the best concentration of GA_3 that give high fruit yield of bitter gourd; and 3) determine the profitability of growing bitter gourd using GA_3.

The results of the study will contribute ideas and knowledge to growers with the use of GA_3 on bitter gourd to improve their crop's performance, hence higher income and good quality produce. Moreover, best concentration

that provide high yield will ultimately affect the return of growing bitter gourd which affects the adoption.

II. Materials and Methods

The study was conducted in #8 San Agustin Paoay, Ilocos Norte from December 2016 to May 2017. The area is usually planted with rice, corn and vegetables. The area has clay soil textural class.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into three blocks and each block was further divided into four unit plots (Figure 2). Experimental units have a size of 4m x 5m ($20m^2$). The distance between blocks was 1.5m and 1.5m between plots having a total area of 367 m^2. Four concentrations (0ppm, 10 ppm, 25 ppm, and 50 ppm) were used.

Cultural Management

Variety Used

Hybrid variety (Bonito F_1) of bitter gourd was used as tested crop variety. This variety is highly productive, up to 4 times higher yield compare to the traditional native bitter gourd. Bonito F_1 is highly prolific and it has strong tolerance against pest and diseases that can extend the productive life resulting to long harvesting period.

Land Preparation

One time plowing of the experimental area was done using tractor, and harrowing was followed after plowing.

Seedling Production

Seeds were soaked in 10 ppm GA_3 for eight hours except for the control. One seed was sown per container having 1 part of soil and 1 part carbonized rice hull (CRH), and a part of vermicompost. The containers were kept in shaded place. The seedlings were watered every other day during the seedling period.

Transplanting and Replanting

Seedlings with four leaves were transplanted in the field at early in the morning or late in the afternoon. One seedling per hill was transplanted at a distance of 1m between rows and 0.75m between hills. Replanting was done in seven days after transplanting (DAT) to have a uniform maturity of plants and complete the plant population.

Installation of Trellis

Bamboo poles were used to provide support and keep the fruit and foliage off the ground. The trellis had 1.8–2.0 m high, constructed with stakes forming an A-shape structure. Wire was used to secure adjoining stakes.

Preparation and Application of GA_3

A gram of GA_3 was pulverized and dissolved in small amount of alcohol. Afterwards, this was mixed in a liter of water to produce 1,000 ppm of GA_3. GA_3wassprayed three times (20, 40, and 60 DAT) at early in the morning or late in the afternoon. The concentration of GA_3used was dependent on the treatments. This was calculated using the formula (Table 1).

Table 1. Preparation of gibberellic acid.

CONCENTRATION	FORMULA
10 ppm GA_3	$C_1V_1=C_2V2$
C_1 = 1,000 ppm C_2 = 10ppm V_1 = ? V_2 = 2 L	1,000 ppm (?) = (10ppm) (2,000ml) (?) = $\frac{20{,}000 \text{ ppm ml}}{1.000\text{ppm}}$ V_1 =20 ml Water = 1,980 ml
25 ppm GA_3 C_1 = 1,000 ppm C_2 = 25ppm V_1 = ? V_2 = 2 L	$C_1V_1=C_2V2$ 1,000 ppm (?) = (25ppm) (2,000ml) (?) = $\frac{50{,}000 \text{ ppm ml}}{1.000\text{ppm}}$ V_1 =50 ml Water = 1,950 ml
50 ppm GA_3 C_1 = 1,000 ppm C_2 = 50ppm V_1 = ? V_2 = 2 L	$C_1V_1=C_2V2$ 1,000 ppm (?) = (50ppm) (2,000ml) (?) = $\frac{100{,}000 \text{ ppm ml}}{1{,}000\text{ppm}}$ V_1 =100 ml Water = 1,900 ml

Fertilizer Application

All the plants were applied equally with fertilizer such as complete fertilizer, urea, and muriate of potash. Complete fertilizer with a rate of 15 g/hill was applied at 14 (DAT). Side dress was done at 21 (DAT) and every two weeks thereafter at 15 grams per hill using muriate of potash and urea.

Irrigation

Irrigation was done whenever it is necessary. Irrigation was followed immediately after application of fertilizer.

Pest Management

Insect pests. The common insect pests of bitter gourd are aphids, fruit fly, leaf folder, and thrips. These pests were managed by spraying of insecticide following the manufacturer's recommendation indicated on the label.

Disease. The disease of bitter gourd observed was namamarako or NMK disease caused by Cucurbit aphid borne yellow virus (CABV). The disease was managed by spraying pesticides. Manual removing of infected leaves was done.

Occurrence of weeds. The occurrence of weeds was managed by manual weeding.

Harvesting

Marketable fruits were harvested at 40 DAT. Fruits that are fully developed are thick, green, and juicy. Frequency of harvesting with an interval of two to three days was followed or depends on the size of the fruits if they are harvestable.

Data Gathering Procedures

Growth Performance

Number of Days to Emergence of Male and Female Flower

Number of days to emergence was recorded from sowing until first emergence of male and female flowers.

Number of Staminate and Pistilate Flowers

This was taken by counting the number of staminate and pistilate flowers for one week starting at first emergence of male and female flowers.

Number of Days from Flowering to First Harvesting

This was taken from first flowering to first harvesting.

Yield Performance

Number of Fruits per Hill

Counting the number of fruits per hill was done from second and third priming to get the total fruits. The number of fruits per hill was calculated using the formula.

$$\text{Number of fruits per Hill} = \frac{\text{Total number of fruits in 20 m}^2}{\text{Population density}}$$

Number of Fruits per Kilo

The number of fruits per kilo was recorded from third to last priming. The fruits were free from damage of insects and injury.

Fruit Weight

After each harvest, 10 randomly selected fruits per plot were weighed using digital weighing scale.

Fruit Length and Diameter

Number of Seeds per Fruit

Length and diameter of 10 randomly selected fruits per plot was measured using foot ruler and vernier caliper, respectively. The number of seeds per fruit however was gathered by counting the filled seeds of every young fruit. Five fruit samples were used.

Yield per Hectare

The formula below was used to compute the yield per hectare.

$$\text{Yield (kg/ha)} = \frac{\text{FY x 10000 m}^2}{\text{20 m}^2}$$

FY = Fruit yield

Data Analysis

Statistical Analysis

Growth and yield performance data were analyzed by using analysis of variance in Randomized Complete Black Design. Where F-test showed significant results treatment mean difference was further tested using Least Significance Difference (LSD) test. The statistical analysis was done using STAR program**.**

Production Economics

The economics of production per hectare was evaluated u-

-sing cost and return analysis. The economic variables include net income, production cost by kg^{-1} fruit, and return on investment (ROI).

Gross Income (GI) = Yield x Price per kg

Net Income (NI) = GI – Total cost of Production (TCP)

$$\text{Production Cost kg}^{-1} = \frac{TCP}{Yield}$$

$$\text{ROI} = \frac{NI}{TCP} \times 100$$

III. Results and Discussion

Number of Days to Emergence of Male and Female Flower

The emergence of male and female flowers was not affected by application of GA_3 (Table 2). Based on the experiment of Gedam *et al.* (1998) at 35 ppm of GA_3 produced the earliest female flower.

Number of Days from Flowering to First Harvesting

The plants had comparable number of days from flowering to first harvesting (Table 2). It is contrary with Islam (1995) that numbers of staminate flower are decreased by GA_3 at 10 ppm and irrespective of GA_3 concentration reduces the total number of staminate flowers, respectively. However, it is in contrast to the study of Biradar (2008) that GA_3 at 20 ppm has maximum number of female flowers.

Number of Staminate and Pistillate Flowers

The number of staminate flowers was significantly affected by application of GA_3 but showed otherwise on pistillate flowers (Table 3). More staminate flowers were produced if the plants are applied with GA_3 than no application. No significant differences were observed if the concentration is more than 10 ppm. Different concentrations of GA_3 increased the number of male flower induction (Sure *et al.,* 2013).

Number of Fruits per Hill

Number of fruits per hill was significantly ($P< 0.05$) affected by the application of GA_3 significantly (Table 4). Higher number of fruits per hill of plant was achieved if they are applied with GA_3 than no application. Concentrations 25 and 50 ppm produced significantly produced high number of fruits /hill than lower concentration (10 ppm) and no application. Biradar (2008) and Tomar and Ramrigy (1997) had the same result that GA_3 produced maximum number of fruits per plant at 20 ppm and shows significantly greater number of fruits /plant and yield than untreated tomato plants, respectively. In contrast with the result of Islam (1995) that the number of fruits was not influenced by GA_3 application.

Weight per Fruit

Negative response of bitter gourd on fruit weight was observed (Table 4). Same result is observed by Islam (1995) that weight of fruits is not influenced by GA_3 application. Showed otherwise with the results of Nagamani *et al.*, (2015) in bitter gourd and Kumar *et al.* (2014) in tomato that GA_3 at 50 ppm increase fruit weight.

Fruit Length and Diameter

All plants that are either treated or untreated with GA_3 had comparable fruit length and diameter (Table 4). Islam (1995) reported the same result that the length and diameter of fruits were not influenced by GA_3 application. But to Nagamani *et al.* (2015) GA_3 increased the fruit length and width of bitter gourd.

Number of Seeds per Fruit

No significant difference was observed on the number of seeds per fruit. However, the seed number of Rabbiteye blueberry was reduced with the application of GA_3 (Cano-Medrano and Darnell, 1998). It was found that GA_3(50, 100, 200, 400) ppm applied on Fuerte at full bloom increased the parthenocarpic avocado fruits 40 to 80 times while four repeated, at weekly intervals, sprays of 100 ppm of gibberellic acid increased parthenocarpic fruits more than 200 times (Loupassaki, *et al.* 1995).

Yield per Hectare

GA_3 significantly ($P<0.01$) affect the fruit yield of bitter gourd (Figure 1). High fruit yield was attained with the use of this PGR. Plants applied with GA_3 had higher fruit yield than untreated ones. Concentrations of 25 and 50 ppm significantly produced higher fruit yield than lower concentration and no application. No application of GA_3 had comparable yield with 25 ppm concentration. Every increase of concentration there was an increased of yield but no significant differences from 25 ppm to 50 ppm. High fruit yield is attained with the use of GA_3 as based on the experiment of Tomar and Ramgiy (1997) and Kumar *et al.* (2014) in tomato. Same also with the result of Nagamani *et al.* (2015) and Shafeek *et al.* (2016) that at 50 and 60 ppm effectively enhanced the fruit yield in bitter gourd and squash, respectively. But according to Dostogir *et al.* (2006) that at higher concentration (>40 ppm) bitter gourd fruit yield declined.

Moreover, bitter gourd fruit yield is maximum using GA_3 at 20 ppm. $GA_3$is a natural plant hormone which is synthesized in plants and it is well known that the application of GA_3 improves fruit yield and quality in many cucurbitaceous and other horticultural crops (Biradar, 2008).

The increase yield in bitter gourd as cited by Biradar (2008) that GA_3 is probably due to an increase in carbohydrate metabolism and accumulation of carbohydrates (Mishra *et al.,* 1972), auxin directed mobilization of metabolites from source to sink (Weaver, 1973 and Vasantkumar and Sreekumar, 1981). Crop yield depends not only on the accumulation of photosynthates during the crop growth and development, but also on its partitioning in the desired storage organs. These are influenced by the efficiency of metabolic processes within the plant. The growth retardants are capable of redistribution of dry matter in the plant thereby bringing about improvement in yield (Chetti, 1991 and Chandrababu *et al.,* 1995, cited by Biradar (2008).

Cost and Return Analysis

Application of GA_3 was profitable than no application (Table 5 and Figure 2). There was higher income than no application particularly at 50 ppm. Every increase of GA_3 concentration there was an increased of return. High profitability was attained by the use of 25 ppm. High profit was due to high yield of plants.

Table 2. Number of days to emergence of male and female flower and number of days from flowering to first harvest of bitter gourd using different concentration of GA_3.

TREATMENT (GA_3 Concentration)	DAYS TO EMERGENCE OF MALE FLOWER (DAT)	DAYS TO EMERGENCE OF FEMALE FLOWER (DAT)	NUMBER OF DAYS FROM FLOWERING TO FIRST HARVESTING
	ns	ns	ns
No GA3	27	34	18
10 ppm GA_3	26	31	18
25 ppm GA_3	26	30	18
50 ppm GA_3	26	29	17
CV (%)	2.21	5.72	16.17

ns- not significant
CV- coefficient of variation

Table 3. Number of staminate flower of bitter gourd starting at first emergence of staminate flower using different concentrations of GA_3.

TREATMENT (GA_3 Concentration)	NUMBER OF STAMINATE FLOWER	NUMBER OF PISTILLATE FLOWER
	**	ns
No GA_3	30 b	13
10 ppm GA_3	75 a	15
25 ppm GA_3	78 a	15
50 ppm GA_3	80 a	14
CV (%)	14.50	13.36

**-Significant at 0.01 level of significance
ns - Not significant.
CV – coefficient variation.
Means with the same letter are not significantly different.

Table 4. Fruit characteristics of bitter gourd using GA_3.

TREATMENT (GA_3 Concentration)	NUMBER OF FRUITS PER HILL	WEIGHT PER FRUIT(g)	FRUIT LENGTH (cm)	FRUIT DIAMETER (cm)	NUMBER OF SEEDS PER FRUIT
	*	ns	ns	ns	ns
0ppm	15 b	280	8.77	3.03	7
10 ppm	16 b	290	8.70	3.03	3
25 ppm	21 a	290	8.70	3.00	3
50 ppm	23 a	300	8.70	3.07	5
CV (%)	14.51	6.97	4.54	6.84	43.19

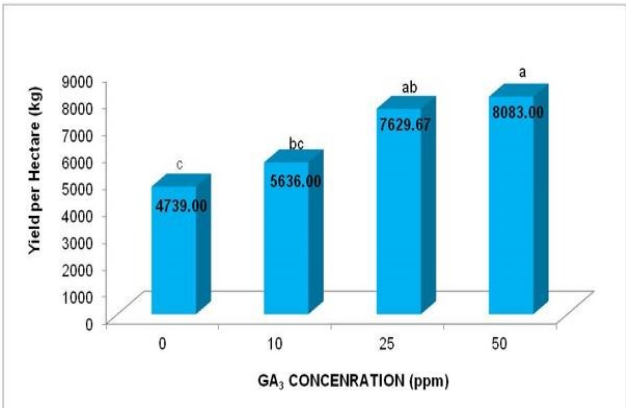

Fig. 1. Fruit yield (kg) per hectare of bitter gourd using GA_3.

IV. Conclusions

GA_3 had positive response on the flower and fruit yield of hybrid variety of bitter gourd under the condition of City of Batac, Ilocos Norte, Philippines. This PGR effectively affected the number of staminate flowers, number of fruits per hill, and fruit yield. Plants applied with GA_3 significantly produced higher yield than no application. Higher yield of the crop was attained using 25 ppm ofGA_3 but there were no significant differences as the concentration increased up to 50 ppm. Apply or not to apply GA_3 was profitable which gave more than 100 % return.

However, more return was achieved using GA_3 particularly at concentration of 25 ppm.

Table 5. Cost and net income of growing bitter gourd using GA_3.

PRODUCTION ECONOMICS (PhP)	No GA_3	10 ppm	25 ppm	50 ppm
Yield (kg/ha)	4739.00	5636.00	7629.67	8083.00
TCP	100,099.92	107,154.61	113,904.61	125,154.61
GI	189,560.00	225,440.00	305,200.00	323,320.00
NI	89,460.08	118,285.39	191,295.39	198,165.39

Price per kg of furits-PhP40.00; TCP-total cost of production; GI-gross income; NI-net income

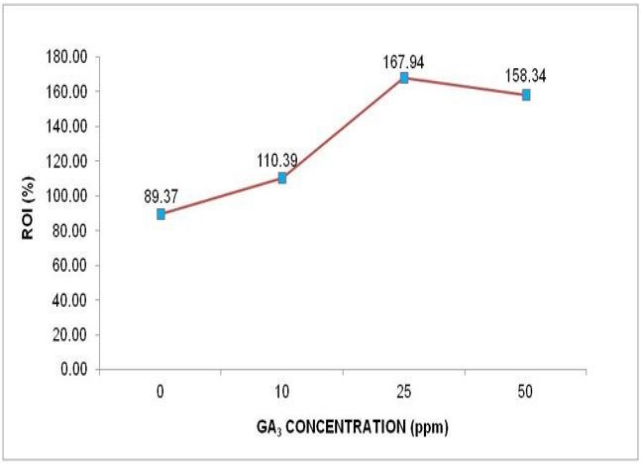

Fig. 2. Return of investment of growing bitter gourd using GA_3.

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