

FLORAL BEHAVIOR AND RESPONSE TO PLANT GROWTH
REGULATORS OF SOME SELECTED CUCURBITACEOUS
VEGETABLES



A Thesis
Submitted to the Agrotechnology Discipline
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In partial fulfillment of the requirements for the degree of
Master of Science in Horticulture

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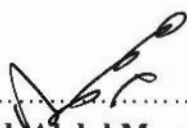
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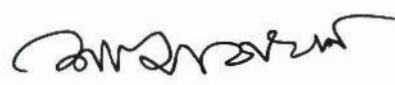
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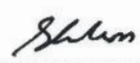
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***DEDICATED TO
ALL THE FARMERS
OF BANGLADESH***

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ABSTRACT

The present study was conducted to investigate the floral behavior and response to plant growth regulators of some selected cucurbitaceous vegetables at the Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna during March 2016 to August 2016. The study included two separate experiments where the experiment-1 was conducted to observe the floral behavior of eight cucurbitaceous vegetables namely sponge gourd, sweet gourd, cucumber, bottle gourd, snake gourd, wax gourd, ribbed gourd and bitter gourd. The experiment-2 consisted of two factors, viz four concentrations of plant growth regulators (4-CPA) as control, 100 ppm, 200 ppm and 300 ppm and the other factor was five cucurbitaceous vegetables namely sponge gourd, sweet gourd, bottle gourd, bitter gourd and ribbed gourd. Most of the cucurbitaceous vegetables, showed flower opening in the morning (4.00 a.m.-8.00 a.m.), except ribbed gourd (open in the afternoon, 4.00 p.m.-6.00 p.m.) and snake gourd (open in night, 7.00 p.m.-8.00 p.m.). The duration of anthesis of male flower was the highest in bitter gourd (100-110 min) and the lowest in sweet gourd (10-20 min). The longest duration of anthesis in female flower was showed by snake gourd (60-120 min) and the lowest by sweet gourd (20-25 min). The maximum number of flower per plant (100.8), number of male flower (53.33), number of female flower (53.00) and number of fruit per plant (32.22) were found in ribbed gourd. The maximum weight of fruit per plant (14.22 kg) and yield were recorded from bottle gourd (5.689 t/ha). The maximum ratio of male/female flower (1.21) was found in snake gourd and the minimum in bitter gourd (0.74). The 300 ppm 4-CPA showed better performance for maximizing the number of male flower (34.09), number of female flower (36.27), number of fruit per plant (23.93), average length of fruit (20.53 cm), average breadth of fruit (5.73 cm), weight of fruit per plant (12.87 kg) and yield (5.15 t/ha) of cucurbitaceous vegetables under study.



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ABBREVIATIONS

cm = Centimeter	IAA = Indole acetic acid
Kg = Kilogram	GA = Gibberellic acid
Viz = Namely	
<i>et al.</i> = And others	
BCR = Benefit cost ratio	
DAS = Days after sowing	
DMRT = Duncan's new multiple range test	
LSD = Least significance difference	
TSP = Triple Super Phosphate	
Mop = Muriate of potash	
ppm = parts per million	
AEZ = Agro Ecological Zone	
SRDI = Soil Resources Development Institute	
4-CPA = 4-chlorophenoxy acetic acid	
RCBD = Randomized Complete Block Design	
CV = Co-efficient of Variation	
NS = Non-significance	
PGR = Plant Growth Regulators	
BBS = Bangladesh Bureau of Statistics	
NAA = Napthalene acetic acid	
MH = Maleic Hydrazide	
CCC = Cycocel	

CHAPTER 1

INTRODUCTION

Vegetables are very cheap and dominant source of vitamins and minerals for human health. Nutritionists suggest that an adult person should eat at least 285 g of vegetables per day for maintaining good health whereas in Bangladesh an individual consumes only an average of 70 g per day including potato and sweet potato (Hossain and Prokash, 1990). In Bangladesh, vegetables are cultivated in 8,85,127 acres of land and annual production of vegetables is only 27,26,723 metric tons (MT) and most of the vegetables are produced in winter (BBS, 2010). Vegetable production in Bangladesh is far below of actual requirements. In 2013- 2014, total vegetable (summer and winter season) production area was 7.56 lac hectares of land with total production of 13.8 million tons (BBS, 2014). Our daily requirement of vegetable is 235 gm/day/person for an adult as recommended by Bangladesh Council of Nutrition (2011). Among the vegetables cucurbits are the most important group especially for its leafy vines and fruits (green and yellow) with high nutritious values (β -carotene), long shelf-life and acceptable palatability to all levels of consumers (Anonymous, 2006). Cucurbits belong to the family Cucurbitaceae, which primarily include 16 crop species (Nasiruddin, 1995), and they are the important vegetables in terms of production and year-round availability in Bangladesh.

Cucurbits have a good nutritive value as well as medicinal value too. All the cucurbits have a good market value which encouraged the farmer to cultivate gourds in large scale. The total area of cucurbit crops is around 81,720 hectares and the total production is about 3,08,096 tons. Although cucurbits are summer crop but some of them can be grown throughout the year

because of their photo insensitiveness. The climate of Bangladesh is favourable for growing most of the vegetable crops specially cucurbits.

The cucurbitaceae consists of approximately 125 genera and 960 species, mainly in the regions of tropical and subtropical. All species are sensitive to frost. Most of the plants in this family are annual vines but there are also woody lianas, thorny shrubs, and trees. Many species have large, yellow or white flowers. The stems are hairy and pentangular. Tendrils are present at 90° to the leaf petioles at nodes. Leaves are exstipulate alternate simple palmately lobed or palmately compound. The flowers are unisexual, with male and female flowers on different plants (dioecious) or on the same plant (monoecious). The female flowers have inferior ovaries. The fruit is often a kind of modified berry called a pepo (Kalloo, 1999).

Among the cucurbits. Pumpkin (*Cucurbita moschata*) is widely grown in the tropics and subtropics, its fruit color is most often dark green, light yellow, or pale orange. It grows well throughout the entire tropical and subtropical region of the world.

Every 100 gram edible portion of matured sweet gourd contain 1.4 g protein, 100 mg calcium, 30 mg phosphorus, 50 micro g beta carotene and 2 g vitamin C. It is also an excellent source of many natural poly-phenolic flavonoid compounds such as, β carotenes, crypto xanthin, lutein and zea-xanthin. The fruit is a good source of B-complex group of vitamins like folates, niacin, vitamin B-6 (pyridoxine), thiamin and pantothenic acid. It is also rich source of minerals like copper, calcium, potassium and phosphorus. Pumpkin seeds indeed are an excellent source of dietary fiber and mono-unsaturated fatty acids, which are good for heart (Kim, 1996).

Cucumber (*Cucumis sativus* L.) is a major vegetable crop worldwide and grows rapidly, (Wehner and Guner, 2004). The crop is the second most important vegetable crop after tomato in

Western Europe and is the fourth most cultivated vegetable in the world after tomatoes, brassicas and onions (Wehner, 2007). Cucumber is a great source of vitamins and minerals which contains 0.6 g protein, 2.6 g carbohydrate (CHO), 12 calorie energy, 18 mg calcium (Ca), 0.2 mg Fe, 0.02 mg thiamin, 0.02 g riboflavin, 0.01 mg niacin and vitamin per 100 g of edible portion (Rashid, 1999). Ridge gourd (*Luffa acutangula* L.) contains Vitamin A, C and iron. Bitter gourd (*Momordica charantia* L.) contains considerable amount of water (83-92%), carbohydrates (4.0-10.5%), protein (1.5-2.0%), fat (0.2-1.0%), minerals (0.5-1.0%) and fiber (0.8-1.7 %) (Gopalan *et al.* 1982). Among all cucurbitaceous vegetables, bitter gourd contains the maximum amount of minerals and vitamins (Banerjee and Mangal, 1986).

Snake gourd (*Tricosanthes anguina* L.) contains considerable amount of protein (0.5%), fat (0.3%), minerals (0.5%), fibre (0.5%) and carbohydrates (3.3%) (Gopalan *et al.* 1982). Ash gourd [*Benincasa hispida* (Thumb) Cogn.] contains a reasonable amount of Carbohydrate (1.9 g), protein (0.4 g), fat (0.1 g), mineral (0.3 g) per 100 g edible portion and also considerable amount of vitamin A, B and C (Rahman, 1996).

Plant growth regulators are organic compounds other than nutrients which in small amount promote/inhibit or otherwise modify any physiological response in plants. The role of growth regulators in various physiological and biochemical process in plant is well known from its identification. Growth regulators are known to have an effect on the production of earliest flower, yield (Gedam *et al.*, 1998), ratio of male/female flower (Bisaria, 1974), number of fruits, weight of fruit (Gopalkrishnan and Choudhury, 1978). Initiation of flower bud, development of flowers and fruits are controlled by physiological process. In many agricultural plants, these processes can often be used to alter by proper application of plant growth substances. Exogenous application of growth regulators has sifted the sex expression towards femaleness by increasing

the production of female flower and suppressing that of male flowers in various cucurbitaceous vegetables (Prakash, 1974).

However, very limited research was conducted to investigate the floral behavior and improve the fruit set, male/female ratio, yield of different cucurbitaceous vegetables by the application of plant growth regulators (4-CPA).

In cucurbits, the rate of fruit drop varied due to improper pollination and lack of fertilization. Lack of proper pollination may lead to the drop of female flower, which ultimately reduces yield. So floral behavior is necessary to find out suitable time of flower opening for artificial pollination. It helps to increase in fertilization and fruit set (Balasubrahmanyam, 1990).

Cucurbitaceous vegetables naturally produce larger number of male flowers than female flowers. This flowering behavior is not advantageous and economical, because it results in lower fruit set and yield. To have the higher yield the male and female flower ratio is needed to be synchronized. Maleness and femaleness can usually be altered by environmental variables such as temperature, photoperiod, and nutrition or by the application of plant growth regulators. 4-CPA has great effects to increase flower number, male/female ratio, fruit size, fruit set and yield. To increase the yield and to avoid flower and fruit dropping, application of 4-CPA at right concentration and right time is important (Bisaria, 1974).

Considering the above discussion, the present experiment has been undertaken with the following objectives:

1. To explore the floral behavior of some selected cucurbitaceous vegetables.
2. To determine the impact of plant growth regulators on flowering and fruit setting of some selected cucurbitaceous vegetables.

CHAPTER 2

REVIEW OF LITERATURE

The major vegetables grown in the Kharif season are the cucurbits. Some of the available research works in this connection have been reviewed with the hope that these may contribute useful information to the present study. The literature pertaining the present study have been presented in this chapter in the following sub-headings.

2.1 Floral biology

Arora and Papiiah (1983) noted in sponge gourd that days to first male and female flowering ranged from 56 to 118 days and 61 to 125 days, respectively.

Akand (1993) reported in ridge gourd that first male flower opened within 42 to 46 days, and the first female flower opened within 48 to 52 days, while for hybrids it ranged from 40 to 45 days and 43 to 51 days for male and female flower anthesis, respectively. Chauhan (1989) reported that flowering started within 60 to 80 days after seed sowing.

Hossain and Rashid (1974) noted that the male and female plant of kakrol required an average of 75 and 53 days, respectively for first flowering after emergence of the plant from the soil.

Rahman *et al.* (1990) reported that days to male flowering was earlier than days to female flowering in the genotypes of ridge gourd studied. Saha and Uttam (1991) noted that teasel gourd plants required an average of 58 to 76 days from above ground emergence of plants to produce female flowers. Rashid (1993) reported in ash gourd that the flowering starts between 45 to 50 days after sowing. Seshadri (1986) noted that flowering in cucurbits normally starts in about 40 to 45 days after sowing depending on the weather conditions.



Prasad and Singh (1990) observed in pointed gourd that the first flower appeared at 5th to 18th node based on various varieties. Krisna *et al.* (1989) reported in ridge gourd that the number of node at which first male and female flowers opened was an average of 7 to 16.

Rashid (1993) noted that sponge gourd is monoecious with staminate and pistillate flowers in the same plant. The flowers were large, short or long pedicellate and yellow in colour. Calyx comprised of five united but deeply lobed sepals in male but separated in female flowers. Corolla consisted of five separate bell shaped petals. Stamens were five in number and anthers were free. Ovary was long, filiform and covered with soft hairs.

Rice *et al.* (1992) noted in snake gourd that the unisexual flowers were axillary, white and up to 5cm in diameter, staminate flowers were borne on long raceme but pistillate flowers were single. The flowers had frilled edges and the inner surface of the petals and the ovary were hairy.

Rashid (1976) reported that the flowers of pointed gourd is white in colour and 1.5 to 2.0 inches in diameter, each comprised of five sepals five petals. Staminate flowers comprises of three stamens. Prasad *et al.* (1990) noted in pointed gourd that the ovary breadth varied from 0.4 to 0.7cm.

Bhandari (1979) observed that ridge gourd are monoecious plants with staminate and pistillate flowers. Staminate flowers are solitary. The flowers are yellow or white in colour and short or long pedicellate. Calyx comprises of five united sepals. Corolla consists of five petals. Stamens are three in number. Ovary is inferior. Stigmas are three in number.

Rashid (1993) reported in ash gourd that the flowers are monoecious with staminate and pistillate types. Corolla is composed of five free petals and the calyx consists of five sepals. Three stigmas are present on style.

Rashid (1993) observed that sponge gourd are monoecious with staminate and pistillate flowers in the same plants. The flowers were larger short or long pedicellate. Calyx comprised of five sepals in both staminate and pistillate flowers. Corolla consisted of five separate petals.

Rashid (1993) observed that the calyx of the ridge gourd comprises of five sepals. Stamens are three in number. Alam (1997) observed in pointed gourd that anthesis of both male and female flowers began at 6.00 to 7.00 pm but completed in male flowers within 8.30 to 9.30 pm and in female flower within 9.00 to 10.00 pm. Rahman (1996) reported in ash gourd that 91.5 to 97% pollen viability was found after 12 hours of anthesis. Chauhan (1989) noted that flowers of both sponge and ridge gourd open from 4.30 a.m. to 6.00 a.m.

Bhandari (1979) noted that anthesis of ridge gourd starts from 4 pm and continues till 6 pm. It is followed by anther dehiscence which commences 10-15 minutes before the anthesis and complete half an hour after anthesis. Seshadri (1986) noted in pointed gourd that anthesis takes place during night and night temperature favors anthesis. Randhawa *et al.* (1982) found in ash gourd that the anthesis took place between 4.30 to 7.30am with anther dehiscence between 3.00 to 5.00 am. Panthak and Singh (1950) observed in pointed gourd that both male and female flowers opened in the early hours in the night. Randhawa *et al.* (1982) observed in ash gourd that the stigma was receptive from 8 hour before anthesis and continued up to 18 hours after anthesis. Pathak and Singh (1950) reported in pointed gourd that the stigma remained receptive from 7 hours before opening till 51 hours after opening of flower. Joshi and Singh (1967) found that in both sponge the stigma became receptive 7 hour before anthesis and remained so far 40 hours after anthesis.

Rashid and Hussain (1974) noted in kakrol that stigma became receptive 12 hours before anthesis and remained so up to 24 hours anthesis. Pollen after 17 hours of anthesis was found to cause fruit set where as 18 hours old pollen failed to set fruit.

Hossain (1996) observed in ridge gourd that the stigma became receptive 5 hours before anthesis and remained so up to 24 hours after anthesis. He noted that pollen remained functionally viable up to 6 hours of dehiscence.

2.2 Number of flowers per plant

Gedam *et al.* (1998) conducted an experiment in 1992 where bitter gourd plants were sprayed 40, 55, 70, 80 and 100 days after sowing with 15, 25 and 35 ppm GA3, 50, 100 and 150 ppm NAA, 50, 100 and 150 ppm Ethephon, 100, 200, 200 and 300 ppm Maleic Hydrazide, 2, 4 and 6 ppm boron and with water (control). GA3 at 35 ppm produced the earliest female flower and NAA at 50 ppm produced the earliest male flower. Fruit maturity was the earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yields were also the highest in these treatments.

The ratio of male and female flower reduced when maleic hydrazide at 150 ppm was sprayed on the plant of bitter gourd as reported by Prasad and Tyagi (1963).

Al-Masoum and Al-Masri (1999) reported that cucumber cv. Beit Alpha was grown in a greenhouse in 1996-97 and ethephon applied at 250 ppm, 350 ppm and 450 ppm at the seedling stage (2-4 true leaves). Data were collected on the total yield, early yield, late yield, number of female flowers, number of male flowers, days to the first male flowers, days to first female flowers, number of nodes to the first female flower, number of nodes to the first male flower and plant height. All the cases positive result was found from ethephon treated plants. Ethephon induced femaleness (pistillate flowers) on the main stem that led to greater fruit production.

Ravindran (1971) reported that bitter gourd seedlings were sprayed with ethrel at concentrations ranging from 200 ppm to 600 ppm. Stunting, growth retardation and pollen sterility were induced in proportion to the dose applied and the production of male flowers was significantly reduced.

Bisaria (1974) found that foliar spray of NAA 100 ppm increased the number of female flower per plant and the sex ratio is reduced in cucurbits.

Pandey *et al.* (1976) stated that the effects were compared of seed soaking for 24 hrs in solutions of 2, 4-D at 1.5 ppm, MH and NAA. each at 200 ppm and GA3 at 50 ppm and foliar spraying with 2, 4-D at 0.5-1.0 ppm, applied at the 2 true leaf and 4-5 true leaf stages. The number of pistillate flowers of *Lagenaria cylindrica* (*Lagenaria aegyptiaca*) was increased by seed treatment with MH and NAA at 200 ppm and by spraying with NAA at 100 and 150 ppm, MI1 at 100-200 ppm and GA3 10 ppm; staminate flower numbers were decreased by MH at 200 ppm. NAA at 100 ppm and GA3 at 10 ppm. The ratio of pistillate:staminate flower numbers was increased by all treatments except 2, 4-D and GA3 at 25 and 50 ppm. Fruit set was enhanced by all treatments except GA3 at 50 ppm and 2, 4-D. Yields were increased by seed treatment with NAA at 200 ppm and by spraying with NAA and MH at 150 and 200 ppm, respectively.

An investigation to study the influence of various chemicals (Ethrel, NAA, Cycocel, MH, PCPA, Ascorbic acid and Boron) on the growth, flowering and yield of bitter gourd was conducted. PCPA at 100 ppm improved plant growth significantly. The treatment of CCC at 250 and 500 ppm produced female flowers about 12 days earlier in comparison to control plant. Maximum fruit yield per plant (3123 gm) was produced under Cycocel 250 ppm followed by Ascorbic acid 25 ppm and Cycocel 250 ppm (Mangal *et al.*, 1981). Ahamed *et al.* (2011) found the range of first flowering among twenty genotypes of pumpkin was at 52.0-73.7 days.

Lower *et al.* (1970) reported that cultivar of cucumber Galaxy treated with ethephon at a concentration of 120 ppm at the one-leaf stage of at subsequent leaf stages increased pistillate flower formation.

Freytag *et al.* (1970) carried out an experiment on cucumber sex-expression modified by growth regulators. They found that TIBA 10 ppm and 100 ppm treated plant produced less number of female flowers which treatment with ethrel at 100 ppm increased femaleness.

2.3 Ratio of male/female flowers

Pandey and Singh (1973) found that soil application of up to 100 kg/N increased the number of pistillate and staminate flower and the yield; the sex ratio was not affected in bottle gourd. Maleic hydrazide approximately doubled the proportion of female flowers and also increased yield. Combined application of N and maleic hydrazide gave a further increased in the proportion of female flowers and the highest yield.

Choudhury and Pahatak (1959) reported the effects of growth regulators on sex expression of cucumber. They observed that MH 200 ppm and NAA 100 ppm significantly increased number of female flowers and MH 600 and 800 ppm, NAA 100 ppm and IAA 200 ppm greatly suppressed the number of male flower over control. All treatments increased the female to male flower ratio when compared with the control.

Choudhury *et al.* (1967) reported that NAA 100 ppm, IAA 100 ppm and 200 ppm and MH 50 ppm and 200 ppm were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber. The effects subsequently increased the percentage of fruit set and ultimately the yield.

and 1500 ppm in sponge gourd and bottle gourd. Earliest node for first female flower was observed at 1000 ppm in sweet gourd and snake gourd but at 1500 ppm in bottle gourd.

Rajkumar *et al.* (2007) found significant differences among genotypes for all the characteristic in snake gourd. The heritable estimate was high for all the characters except days to first female flower.

Ramchandran and Gopal Krishnan (1979) also reported significant variability among 25 diverse genotypes of bitter gourd.

Akter *et al.* (2013) conducted an experiment on the genetic divergence among thirty accessions of pumpkin at the Research Farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, during the growing season 2011-12. High genotypic coefficient of variation (GCV) and high heritability coupled with high genetic advance in percent of mean were observed for beta-carotene followed by non-reducing sugar, number of male flowers per plant and number of female flowers per plant which indicated that these characters were under additive gene control and selection for genetic improvement for these traits might be effective.

Banik (2003) found high heritability coupled with high genetic advance for fruit length (GCV and PCV 29.92, and 30.04; h^2 99.19%) in snake gourd. Asmaul Husna (2009) found GCV (16.49) and PCV (17.50) in male flower and GCV (15.84) and PCV (17.39) in female flower of bottle gourd plant. Significant variation for fruit length and diameter were noticed in bitter gourd (Mangal *et al.* 1981) sponge gourds (Arora *et al.* 1983; Prosad and Singh, 1990), ribbed gourd and bottle gourd (Rahman *et al.* 1991). Rahman *et al.* (1986) indicated high GCV and PCV for both length (31.73 and 33.75) and diameter (39.23 and 41.96) of fruits in bottle gourd.

Brokowski (1974) recommended ethephon 120 ppm for fruit production of cucumber. He also reported that complete male flower sterility and maximum production of female flowers can occur with 240 ppm ethephon.

Bhandary *et al.* (1974) observed that the first female flower appeared earlier while male flower appearance was delayed after ethephon treatments 100-300 ppm sprayed at seedling stage in cucumber. Bisaria (1976) reported that MH 200-300 ppm and chloroflurenol 40-200 ppm induced femaleness in cucumber plant.

Rudich (1990) reported that the application of Ethrel (2-chloroethane phosphonic acid), an ethylene-releasing compound, to monoecious cultivars of cucumber and squash and an andromonoecious cultivar of muskmelon, caused a shift towards femaleness in all three species. The increase in femaleness manifested itself in several symptoms: a decrease in the number of staminate (male) flowers, an increase in the number of pistillate (female) or hermaphrodite (perfect) flowers, and a change in flowering pattern, namely, formation of female flowers at lower nodes in cucumber and squash and formation of hermaphrodite flowers on the main axis in muskmelon where normally only male flowers are formed in this cultivar.

2.4 Days to male/female flowers opening

Augustine *et al.* (1973) found that MCEB (5-methyl-7 chloro-4- ethoxycarbonylmethoxy-2, 1, 3-benzothiadiazole) had no effect on the androecious phenotype of cucumber while ethephon 500 ppm induced pistillate flowers. The effect of MCEB and ethphon treatment was a marked reduction in the number of staminate flowers. Ethylene induced pistillate flowers except when there was a 48-hour period between application of ethephon and MCEB In gynoeocious phenotype, MCEB 75 ppm induced staminate flowers, ethephon had no effect, and the effect of

growth was slightly retarded at 5000 ppm. They reported that application of N-l- naphthalene acetic acid had positive effect on fruit set and development in cucumber.

Chowdhury and Faruque (1972) reported that the percentage of seedless fruit increased with the increase in GA3 concentration from 50 ppm to 100 ppm. However the fruit weight was found to decrease by GA3 in cucumber.

2.6 Average length/ breath / weight of fruit

Gopalkrishnan and Choudhury (1978) reported that in contrast with 'TIBA, Ci A in general produced the largest number of male flowers; GA at the lowest concentration of 10 ppm produced more number of female flowers in first year. In the first year MH 100 ppm to 600 ppm as well as NAA and IAA at 50 ppm to 150 ppm induced a reduction in the mean number of female flowers. Treatment with TIBA at 50 ppm, 100 ppm and 200 ppm excelled all the other treatments in producing a favorable female to male flower ratio. IBA from 50 ppm to 200 ppm gave a significant increased in the number of fruits and weight of fruits of water melon.

Verma *et al.* (1984) found that ethrel 100 ppm delayed the appearance of first male and female flowers. MH 200 ppm and Boron 3 ppm and 4 ppm produced the earliest female flowers but at a higher node, while ethrel 100 ppm induced the first staminate and pistillate flower at the lowest nodes at 6.5 and 9.5 respectively. Boron 4 ppm also proved superior to all the other chemicals in producing the maximum fruits and yield. Ethrel and MH 100 ppm did not response much. One local and exotic varieties of snake gourd was treated with 0.1% and 0.2% of potassium naphthalene (knap). The number of fruits per plant and average weight of fresh fruit increased significantly following treatment with 0.1% knap in both varieties.

Rahman *et al.* (1991) reported that male flower were earlier than female flower in several genotypes of bottle gourd, ribbed gourd and sweet gourd. They reported significant variations for that character among the genotypes of bitter gourd, sweet gourd, ribbed gourd and bottle gourd. Significant variation for fruit length and diameter were also observed. They also reported that bitter gourd, sweet gourd, ribbed gourd and bottle gourd genotypes differed significantly for fruit breadth and weight per fruit.

Saha *et al.* (1992) observed high GCV and PCV for fruit length (30.34 and 31.76) and low for fruit diameter (8.87 and 10.23) in pumpkin. They estimated high h^2_b for both length (11.27 %) and diameter (75.07 %). They also found high genetic advance for fruit length (59.72) but low for fruit diameter (15.82).

Fifteen diverse genotypes of ridge gourd were evaluated by Devmore *et al.* (2010) in Dapoli, Maharashtra, India, for their variability, heritability and genetic advance for 15 traits: days to 1st male flower, nodal position for first male flower, days to first female flower, nodal position for first female flower, vine length, primary branches per vine, node number per vine, days to fruit development, days to first fruit harvest, fruit number per vine, fruit length, fruit breadth, fruit weight, 100-seed weight and fruit yield per vine. Based on the nature and magnitude of genetic variability, heritability accompanied with genetic advance as percentage of mean, fruit length, vine length, fruit number per vine, days to first fruit harvest, node number per vine, primary branches per vine would offer scope for selection in breeding for high fruit yield in ridge gourd.

Wang (2001) conducted an experiment on the effect of CPPU (forchlorfenuron) application on growth and endogenous phytohormone contents of *M. charantia* cv. *Kaihua Changbai* was determined. Application of CPPU to the ovary at anthesis within the concentration of 10-50

mg/litre accelerated fruit growth by increasing the length, diameter and fresh weight of fruits, while 100 mg/litre inhibited fruit growth. HPLC analysis showed that the endogenous ZT (zeatin) content of fruit was lowered and the endogenous ABA (abscisic acid) content was improved by CPPU treatments at the concentration of 20 and 100 mg/litre, and that the endogenous contents of 1AA and GA3 (gibberellic acid) were significantly improved by application of CPPU at 20 mg/liters, reaching a peak value 6 days after anthesis.

Susnnta *et al.* (1998) reported that foliar application of silver nitrate (50 mg/litre, an inhibitor of ethylene-induced plant responses) reduced the vegetative phase and extended the flowering phase of *Momordica charantia* L. Silver nitrate promoted female flowering, fruit setting, and fruit development. It also increased the length, girth, weight and quality of fruits.

Brian *et al.* (1954) found that GA3 failed to induce root growth in proportion to vegetative growth in bitter gourd.

Susmita *et al.* (1998) reported that foliar application of silver nitrate (50 mg/litre; an inhibitor of ethylene-induced plant responses) reduced the vegetative phase and extended the flowering phase of *Momordica charantia* L. Silver nitrate promoted female flowering, fruit setting, and fruit development. It also increased the length, girth, weight and quality of fruits.

2.7 Yield

Suresh and Pappiah (1991) conducted a trial with bitter gourd cv. MDU 1, where N and P₂O₅ were applied at 0, 40 and 80 and 0, 30 and 60 kg/ha. respectively and maleic hydrazide was sprayed at 0, 100 and 200 ppm solution. The highest yield was obtained with 80 kg N/ha, 30 kg P₂O₅/ha and 200 ppm Mi l.

The effects of NAA (25 and 100 ppm) and Maleic hydrazide (50 and 100 ppm), applied at the 2-true leaf stage, and sowing date (15 day intervals from 10 September to 25 October) on the growth of *Lagenaria siceraria* (cv. Kiyari Lao) was investigated by Baruah and Das (1997) during rabi 1994-95 in India. They observed that plants sprayed with NAA at 25 ppm and MH at 50 ppm produced the best yields (5.48 and 4.86 kg/plant, respectively). Yield decreased with later sowing dates from 5.49 to 2.62 kg/plant.

Islam (1995) conducted a trial with different concentrations of GA3 like 0, 10, 25, 50 and 100 ppm. He stated that application of GA3 was effective in improving the yield and yield components of bitter gourd when applied at low concentration of 10 ppm. The inhibitory effect of GA3 applied at the rate of 100 ppm was observed on production of fruits with lesser number of filled seeds, dry matter of seeds, weight of 100 seeds, seed yield and percent seed vigor index. Irrespective of concentration, the application of GA3 reduced the total number of staminate flowers. The ratio between the staminate and pistillate flowers as well as fruit setting was low. The number, length, diameter and weight of fruits were not influenced by GA3 application.

Arora *et al.* (1988) stated that in 2 season field trials with cv. *Lagenaria cylindrica* (*Lagenaria aegyptiaca*) Pusa Chikni, the plants were sprayed with 5 different growth regulators at the 2 and 4 true leaf stages. The total yield (av. 2.39 kg/plant) was the highest in plants treated with Ethrel (ethephon) at 100 ppm. The average control yield was 0.69 kg/plant.

Saleh and Abdul (1980) conducted an experiment with GA3 (25 and 50 ppm), which were applied 3 times in June to early July. They reported that GA3 stimulated plant growth. It reduced the total number of flowers per plant in snake gourd, but increased the total yield compared to the control. GA3 also improved the fruit quality.

Patil *et al.* (1987) conducted an experiment in a field trial with the cultivar pride of India applied GA3 and NAA each at 25, 50, 75 and 100 ppm one month after transplanting. Both the GA3 and NAA increased the plant height significantly. The maximum plant height and head diameter and head weight were noticed with GA3 at 50 ppm followed by NAA at 50 ppm. Significant increase in number of outer and inner leaves were noticed with both GA3 and NAA. Head formation and head maturity were 13 and 12 days earlier with 50 ppm GA3. Maximum number of leaves and maximum yield (23.83 t/ha) were obtained with 50 ppm GA3.

Mangel *et al.* (1981) conducted an investigation to study the influence of various chemicals (Ethrel, NAA, Cycocel, MH, PCPA, Ascorbic acid and Boron) on the growth, flowering and yield of bitter gourd. PCPA at 100 ppm improved plant growth significantly. The treatment of CCC at 250 and 500 ppm produced female flowers about 12 days earlier in comparison to control plant. Maximum fruit yield per plant (3123g) was produced under Cycocel 250 ppm followed by Ascorbic acid 25 ppm and Cycocel 500 ppm.

Lilov and Donchev (1984) observed that by the application of GA3 at 20, 40 or 100 mg/L the yields were reduced compared with the non-treated control in bottle gourd.

It was revealed from the discussion made above few works have so far been done on floral behavior and response to plant growth regulators of some selected cucurbitaceous vegetables in Bangladesh especially in the khulna region. So, the present experiment were undertaken.

CHAPTER 3

MATERIALS AND METHODS

Details of different materials and methodologies followed during the experimental period have been presented in this chapter.

3.1 Experimental site

The experiment was carried out at the Germplasm centre of the Agrotechnology Discipline, Khulna University during March 2016 to August 2016. It is situated in Ganges tidal flood plain (Agro-ecological zone). It is located at latitude 22°48'35" N, longitude 89°33'51" E and altitude 8m above sea level.

3.2 Climate and weather of the site

The experimental site is under the sub-tropical climate which is characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season (April to September) and scanty rainfall, associated with moderately low temperature and short day period during the Rabi season (October to March).

3.3 Characteristics of soil

The experimental field was medium high land of clay-loam soil of gray colour having pH 8.0.

3.4 Treatments of the experiment

Experiment-1: Floral behavior of selected cucurbitaceous vegetables

Treatment: Eight (8) selected cucurbitaceous vegetables viz. sweet gourd (মিষ্টি কুমড়া), wax gourd (চাল কুমড়া), Cucumber (শসা), ribbed gourd (ঝিঙে), sponge gourd (ধুন্দুল), bitter gourd (করলা), snake gourd (চিচিঙ্গা), bottle gourd (লাউ).

Design of the experiment: The experiment was carried out in RCBD which consisted of 8 treatments with 3 replications.

Experiment-2: Evaluation of the influence of plant growth regulators on growth, flowering and fruit production

This experiment consisted of five cucurbitaceous vegetables and four concentrations of plant growth regulator (4-CPA).

Factor A:

Five cucurbitaceous vegetables viz. sponge gourd, sweet gourd, bottle gourd, bitter gourd, ribbed gourd.

Factor B:

Four concentrations of 4-CPA viz. $T_0 = \text{Control}$

$T_1 = 100 \text{ ppm (4- CPA)}$

$T_2 = 200 \text{ ppm (4- CPA)}$

$T_3 = 300 \text{ ppm (4- CPA)}$

Design: This experiment was conducted in two-factor RCBD with three replications.

3.5 Plant materials

Seeds of five selected cucurbitaceous vegetables were collected from local market of Khulna city. Local cultivars were used for all vegetables.

3.6 Design and layout of the experiment

The cucurbitaceous vegetables were planted in pits which were 50cm × 50cm in size and pit to pit distance was 4m.

3.7 Land preparation

In case of both of the experiment, soil was prepared for planting with spade. Dry roots, grasses, stubbles and other particulate materials were removed from the pit soil. Soil was exposed to the sun for one week. Then pits were made according to the design of each experiment.

3.8 Manures and fertilizer application

Manures and fertilizers	Rate/ha	Per pit
Well decomposed cowdung	20 ton	32 kg
Urea	175 kg	280 g
TSP	175 kg	280 g
MoP	150 kg	240 g
Gypsum	150 kg	240 g
ZnO	3 kg	48 g
Boric acid	12 kg	192 g

One third of cowdung, half of TSP, one third of MoP and all of gypsum, Zn and Boric acid were applied during final land preparation. Rest of the cowdung and TSP and half of the rest MoP were applied at the time of pit preparation, urea and rest of the MoP were applied in pit at 10, 30, 50 and 70 days after sowing (DAS).

3.9 Sowing of seed

Seeds were soaked in water for 24 hours to ensure better germination. Five seeds were sown in each pit. One seedling per pit was kept and the others were uprooted and filled the gaps. The pits were kept under mulch up to germination of seeds. The shade were prepared by rice straw and coconut leaf. They were watered regularly during the seedling-raising period.

3.10 Intercultural operations

After germination of the seeds, different intercultural operations were accomplished for better growth and development of the plants.

3.11 Gap filling

Gap filling was done as and when necessary with healthy seedlings.

3.12 Weeding

Hand weeding was done as and when needed.

3.13 Irrigation

For both of the experiments, the pits were irrigated as and when needed.

3.14 Pest control

There was a plan to protect the plant from the attack of insects-pests specially red pumpkin beetle, fruit flies and fruit borer by spraying pesticide viz ' Linothrin 10 EC'. Since there was no incidence of disease, no fungicide was applied in the crop field during the experimental period.

3.15 Harvesting

The crop was harvested at the marketable maturity of each vegetable. Harvesting was done when fruits turn into light green from deep green. Harvesting was done at seven days interval from every plant of every pit for collecting data.

3.16 Collection of experimental data

Data were recorded on the following parameters.

In Experiment-1:

3.16.1 Time of flowering in a day

Time of flowering in a day was recorded.

3.16.2 Opening time of male flower

Male flower opening time was recorded.

3.16.3 Male flower functional duration

Duration of male flower opening was recorded.

3.16.4 Opening time of female flower

Female flower opening time was recorded.

3.16.5. Female flower functional duration

Duration of female flower opening was recorded.

3.16.6 Days to first flowering

Number of days from sowing to time required to first flower was recorded for every plant and the average was calculated.

3.16.7 Number of flowers per plant

Total numbers of flower produced per plant were counted and recorded.

3.16.8 Number of male and female flowers

Total number of male and female flowers were counted per plant. It was done at three or four days interval after first flowering to ensure all flowers to be counted.

3.16.9 Days to male and female flowers opening

Days required for first male and female flower opening was recorded from sowing date to first flowering days.

3.16.10 Sex ratio male and female flower

Sex ratio was recorded.

3.16.11 Days of first fruit setting

Days to first fruit setting was recorded from sowing date to first fruiting date in every plant.

3.16.12 Number of fruit per plant

The number of fruits in every plant was counted at every harvest and thus the total number of fruits per plant was recorded and average number of fruits was calculated.

3.16.13 Length and diameter of fruit

The length and breadth of fruit in each plant was counted at every harvest and thus the average length and breadth of fruit was calculated.

3.16.14 Weight of fruit per plant

After each harvest, the weight of fruits per plant was recorded and then the average weight per fruit was calculated.

3.16.15 Fruit yield

To estimate yield, all the fruits in every harvest were considered. Thus the average yield per plant/pit was measured. The yield per hectare was calculated considering the area covered by one plant spacing.

In Experiment-2:

3.16.16 Days to first flowering

Number of days from sowing to time required to first flower was recorded for every plant and the average was calculated.

3.16.17 Number of male and female flowers

Total number of male and female flowers were counted per plant. It was done at three or four days interval after first flowering to ensure all flowers to be counted.



3.16.18 Number of fruit per plant

The number of fruits in every plant was counted at every harvest and thus the total number of fruits per plant was recorded and average number of fruits was calculated.

3.16.19 Length and diameter of fruit

The length and breadth of fruit in each plant was counted at every harvest and thus the average length and breadth of fruit was calculated.

3.16.20 Weight of fruit per plant

After each harvest, the weight of fruits per plant was recorded and then the average weight per fruit was calculated.

3.16.21 Fruit yield (t/ha)

To estimate yield, all the fruits in every harvest were considered. Thus the average yield per plant/pit was measured. The yield per hectare was calculated considering the area covered by one plant spacing.

3.17 Cost benefit analysis

Cost benefit analysis was done by the following formula:

Benefit cost ratio:

The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

3.18 Statistical analysis

The collected data on various parameters were statistically analyzed using MSTAT-C computer package program. The mean for all the treatments were calculated and analyzed. Analysis of variance for all the characters was performed by F-variance test. The significance of difference among the treatment means was measured by the Duncan New Multiple Range Test (DMRT) at 5% and/or 1% level of probability.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained due to the floral behavior of selected cucurbitaceous vegetables. Two experiments were conducted. The results of the experiments have been presented and discussed in this chapter under the following headings.

Experiment 1: Floral behavior of selected cucurbitaceous vegetables

4.1.1 Time of flowering in a day

Flowering time was mostly similar in various cucurbitaceous vegetables. But some are different. In the present experiment among the 8 cucurbitaceous vegetables 6 (sponge gourd, sweet gourd, bottle gourd, cucumber, wax gourd, bitter gourd) opened in the morning, ribbed gourd opened in the afternoon and snake gourd at night (Table 1).

4.1.2 Opening time of male flower

Anthesis is the period during which a flower is fully open and functional. The male flowers started open within the range of 5.00 a.m. to 6.30 a.m. in case of sponge gourd, 5.30 a.m. to 8.00 a.m. in sweet gourd, 4.00 a.m. to 6 a.m. in cucumber, 5.30 a.m. to 7.30 a.m. in bottle gourd, 7.00 p.m. to 8.00 p.m. in snake gourd, 4.33 a.m. to 5.30 a.m. in wax gourd, 4.00 p.m. to 6.00 p.m. in ribbed gourd and 4.00 a.m. to 7.30 a.m. in bitter gourd (Table 1).

4.1.3 Male flower functional duration

The duration of anthesis of male flower was the highest in bitter gourd (100-110 min) followed by sponge gourd (30-60 min), cucumber (40-50 min), ribbed gourd (25-45 min) and wax gourd

(20-30 min). The lowest duration was observed in sweet gourd (10-20 min) preceded by bottle gourd (15-30 min) and snake gourd (19-33 min) (Table 1).

4.1.4 Opening time of female flower

The anthesis of female flowers started within the range of 5.00 a.m. to 7.00 a.m. in case of sponge gourd, 5.00 a.m. to 7.00 a.m. in sweet gourd, 4.30 a.m. to 6.30 a.m. in cucumber, 5.00 a.m. to 7.00 a.m. in bottle gourd, 7.00 p.m. to 8.00 p.m. in snake gourd, 4.30 a.m. to 6.30 a.m. in wax gourd, 4.30 p.m. to 6.00 p.m. in ribbed gourd and 4.30 a.m. to 8.00 a.m. in bitter gourd (Table 1).

4.1.5 Female flower functional duration

The duration of anthesis of female flower was the highest in snake gourd (1-2 hour) followed by bitter gourd (90-110 min), cucumber (40-60 min) and sponge gourd (20-50 min). The lowest duration was observed in sweet gourd (20-25 min) and wax gourd (20-25 min) preceded by bottle gourd (20-30 min) and ribbed gourd (20-45 min) (Table 1).

4.1.6 Days to first flowering

Days required for first flowering showed a significant variation in relation to different Cucurbitaceous vegetables (Appendix II). Cucumber took the longest period for first flowering (61.44 days) which was statistically similar to sweet gourd (55.11 days), wax gourd (55.00 days) and bottle gourd (54.22 days). The shortest period was found in ribbed gourd (32.89 days) which was statistically similar to snake gourd (38.22 days) preceded by sponge gourd (43.67 days) and bitter gourd (41.00 days) (Table 2). Olivira *et al.* (2005) also reported similar results from their experiments in cucurbits. The variation from one crop to another is important in different Cucurbitaceous vegetables due to genetic variation and varietal characteristics.

Table 1. Floral biology of different cucurbitaceous vegetables

Selected Species	Opening time of male flower (p.m.-a.m.)	Male flower functional duration (min)	Opening time of female flower (p.m.-a.m.)	Female flower functional duration (min)
Sponge gourd	5.00-6.30	30-60	5.00-7.00	20-50
Sweet gourd	5.30-8.00	10-20	5.00-7.00	20-25
Cucumber	4.00-6.00	40-50	4.30-6.30	40-60
Bottle gourd	5.30-7.30	15-30	5.00-7.00	20-30
Snake gourd	7.00-8.00	19-33	7.00-8.00	1-2 (hour)
Wax gourd	4.33-5.30	20-30	4.30-6.30	20-25
Ribbed gourd	4.00-6.00	25-45	4.30-6.00	20-45
Bitter gourd	4.00-7.30	100-110	4.30-8.00	90-110

4.1.7 Number of flower per plant

Total number of flower per plant was recorded from different days after sowing and found significant among the cucurbits (Appendix II). Ribbed gourd produced maximum flower per plant (100.8) followed by snake gourd (61.11), sponge gourd (56.11) and cucumber (53.00) (Table 2). The minimum number of flower was recorded from sweet gourd (18.33) preceded by bottle gourd (23.44), wax gourd (27.11) and bitter gourd (33.33) (Table 2). Genetical variation and environmental factors may be the main causes of this variation in flower number among the studied cucurbits as reported by Banerjee and Mangal (1986).

4.1.8 Number of male flower

The number of male flowers among the cucurbits varied significantly (Appendix II). The highest number of male flower was found in ribbed gourd (53.33) followed by snake gourd (33.22), cucumber (26.11) and sponge gourd (25.22) (Table 2). It was the lowest in sweet gourd (9.11) preceded by bottle gourd (12.00), wax gourd (13.33) and bitter gourd (14.11). Number of male flower plays an important role in fruit setting of different cucurbitaceous vegetables (Choudhury *et al.*, 1967).

4.1.9 Number of female flower

There was significant variation among number of female flowers per plant (Appendix II). As the female flower increased, the fruit setting in plant also increased. The maximum number of female flower was found in ribbed gourd (53.00) followed by sponge gourd (30.89), snake gourd (27.89) and cucumber (26.89) (Table 2). The minimum number of female flower was found in sweet gourd (9.33) preceded by bottle gourd (11.44), wax gourd (13.78) and bitter gourd (19.22). Environmental factors and genetical variation are the main causes of this results. Choudhury *et al.* (1967) and McMurray and Miller (1969) reported similar results from their experiments.

4.1.10 Days to first male flower opening

Days required for 1st male flowering showed a significant variation among the different cucurbitaceous vegetables (Appendix II). The longest period was required to open the male flowers in cucumber (63.56 days) which was statistically similar to wax gourd (60.33 days) followed by bottle gourd (55.56 days) and sweet gourd (54.56 days) (Table 2). The shortest period was found in ribbed gourd (29.78 days) which was statistically similar to snake gourd

(32.44 days) preceded by bitter gourd (36.89 days) and sponge gourd (36.89 days). Some crop required many days and some crops required less days to opening male flower, which might happened due to environmental factors and genetical variations in crops (McMurray and Miller, 1969).

4.1.11 Days to first female flower opening

A significant variation was recorded from days to first female flower opening for different cucurbitaceous vegetables (Appendix II). The maximum days was required to open the female flower recorded from bottle gourd (63.56 days) followed by wax gourd (57.56 days), sweet gourd (55.11days) and cucumber (52.67 days) (Table 2). The shortest period was found in ribbed gourd (29.78 days) which was statistically similar to snake gourd (32.89 days) preceded by sponge gourd (36.00 days) and bitter gourd (38.11 days).

4.1.12 Sex ratio male/female flower

Ratio of male and female flower showed a significant variation among the different cucurbitaceous vegetables (Appendix II). The maximum (1.21) ratio of male/female flower was found in snake gourd which was statistically similar to bottle gourd (1.07), wax gourd (1.02), ribbed gourd (1.01), sweet gourd (1.00) and cucumber (0.98). The minimum ratio of male/female flower was observed from bitter gourd (0.74) which was statistically similar to sponge gourd (0.82) (Table 2).

Table 2. Flowering habit of different cucurbitaceous vegetables under study

Selected Species	Days to first flowering	No. of flower per plant	No. of male flower per plant	No. of female flower per plant	Days to first male flower opening	Days to first female flowers opening	Sex Ratio Male/female	Days to first fruit setting
Sponge gourd	43.67c	56.11c	25.22c	30.89b	36.89c	36.00de	0.82b	42.22c
Sweet gourd	55.11b	18.33h	9.111d	9.333g	54.56b	55.11bc	1.00ab	62.00a
Cucumber	61.44a	53.00d	26.11c	26.89c	63.56a	52.67c	0.98ab	59.44a
Bottle gourd	54.22b	23.44g	12.00d	11.44f	55.56b	62.44a	1.07ab	58.00a
Snake gourd	38.22cd	61.11b	33.22b	27.89c	32.44d	32.89ef	1.21a	62.44a
Wax gourd	55.00b	27.11f	13.33d	13.78e	60.33a	57.56b	1.02ab	59.00a
Ribbed gourd	32.89d	100.8a	53.33a	53.00a	29.78d	29.78f	1.01ab	48.00b
Bitter gourd	41.00c	33.33e	14.11d	19.22d	36.89c	38.11d	0.74b	51.78b
Level of significance	**	**	**	**	**	**	**	**
LSD value	5.84	2.06	6.24	2.02	3.43	3.17	0.5	5.40

** = Significant at 1% level

4.1.13 Days to first fruit setting

Timely fruit setting is very important for every crop. In cucurbitaceous vegetables days to first fruit setting was different from one another and was varied significantly (Appendix III). In this experiment, the maximum days to first fruit setting was recorded from snake gourd (62.44 days) which was statistically similar to sweet gourd (62.00 days), wax gourd (59.00 days), cucumber (59.44 days) and bottle gourd (58.00 days) (Table 2). The minimum days was recorded from sponge gourd (42.22 days) preceded by ribbed gourd (48.00 days) and bitter gourd (51.78 days).

Table 3. Yield and yield contributing characteristics of some cucurbitaceous vegetables

Selected Species	No. of fruit per plant	Average length of fruit/plant (cm)	Average breadth of fruit (cm)	Weight of fruits/plant (kg)	Yield of fruit (t/ha)
Sponge gourd	23.00c	19.96b	2.88c	5.00e	2.00e
Sweet gourd	11.44d	15.14c	7.18a	11.11b	4.44b
Cucumber	23.33c	12.06d	2.90c	8.44cd	3.37cd
Bottle gourd	12.00d	19.80b	6.80a	14.22a	5.68a
Snake gourd	26.56b	22.11a	2.75c	8.22cd	3.28cd
Wax gourd	9.556e	13.28d	5.87b	9.11c	3.64c
Ribbed gourd	32.22a	22.06a	2.88c	10.78b	4.31b
Bitter gourd	28.11b	7.989e	2.93c	8.00d	3.20d
Level of significance	**	**	*	*	*
LSD value	1.82	1.40	0.54	0.92	0.37

** = Significant at 1% level

* = Significant at 5% level

Days to first fruit setting was varied among the cucurbits may be due to their genetic characters and other nutritional behavior (Nasiruddin, 1995).

4.1.14 Number of fruit per plant

Different cucurbitaceous vegetables showed a significant variation in regard to number of fruits per plant (Appendix III). The highest number of fruit was recorded from ribbed gourd (32.22) followed by bitter gourd (28.11), snake gourd (26.56) and cucumber (23.33) (Table 3). The lowest number of fruit was found in wax gourd (9.556) preceded by sweet gourd (11.44), bottle gourd (12.00) and sponge gourd (23.00).

4.1.15 Average length of fruit

Different cucurbitaceous vegetables showed a significant variation in relation to average length of fruit (Appendix III). The longest fruit was found in snake gourd (22.11 cm) which was statistically similar to ribbed gourd (22.06 cm) that was closely followed by sponge gourd (19.96 cm) and bottle gourd (19.80 cm) (Table 3). The shortest was found in bitter gourd (7.989 cm) preceded by cucumber (12.06 cm), wax gourd (13.28 cm) and sweet gourd (15.14 cm). The average length of fruits of various cucurbitaceous vegetables is different from one another due to their genetical, environmental and nutritional condition (Wehner and Guner, 2004).

4.1.16 Average breadth of fruit

Different cucurbitaceous vegetables showed a significant variation in regard to average breadth of fruit (Appendix III). The maximum breadth of fruit was found in sweet gourd (7.182 cm) which was statistically similar to bottle gourd (6.803 cm) that was followed by wax gourd (5.874 cm) (Table 3). The minimum breadth was found in snake gourd (2.757 cm) which was

statistically similar to ribbed gourd (2.886 cm) and sponge gourd (2.888 cm), cucumber (2.901 cm) and bitter gourd (2.939 cm).

4.1.17 Weight of fruit per plant

Different cucurbitaceous vegetables showed a significant variation on weight of fruit per plant (Appendix III). The highest fruit weight was recorded from bottle gourd (14.22 kg) which was followed by sweet gourd (11.11 kg) and ribbed gourd (10.78 kg) that was closely followed by wax gourd (9.111 kg) (Table 3). The lowest fruit weight was found in sponge gourd (5.000 kg) which was preceded by bitter gourd (8.000 kg), snake gourd (8.222 kg) and cucumber (8.444 kg).

4.1.18 Yield of fruit

Yield for different cucurbitaceous vegetables showed a significant variation (Appendix III). The maximum yield was recorded from Bottle gourd (5.68 t/ha) which was followed by sweet gourd (4.44 t/ha), ribbed gourd (4.31 t/ha) and wax gourd (3.64 t/ha) (Table 3). The minimum yield was recorded from sponge gourd (2.00 t/ha) which was statistically similar to bitter gourd (3.200 t/ha), snake gourd (3.28 t/ha) and cucumber (3.37 t/ha).

Experiment 2: Evaluation of the influence of plant growth regulators on growth, flowering and fruit production

This experiment was conducted to determine the effect of plant growth regulators on growth, flowering and yield of selected cucurbitaceous vegetables. The results have been presented, discussed and possible interpretations have been given under the following sub-headings:

4.2.1 Days to first flowering

Different cucurbitaceous vegetables showed a significant variation on time of first flowering (Appendix IV). The highest duration was required for first flowering for sweet gourd (54.58 days) which was statistically similar to bottle gourd (53.50 days) (Table 4). The shortest period recorded from ribbed gourd (33.33 days) preceded by bitter gourd (36.83 days) and sponge gourd (35.17 days).

There were significant variations among the different concentration of 4-CPA in respect of days to first flowering (Appendix IV). Time of first flowering showed a gradual increasing trend for different concentration of plant growth regulators in comparison to the control. The minimum (40.60 days) time of first flower was recorded from the application of 200 ppm 4-CPA which was statistically similar to 100 ppm 4-CPA (41.07 days) and 300 ppm 4-CPA (41.53 days) (Table 5). The maximum (47.53 days) time of first flower was recorded from control. The results indicated that application of plant growth regulators reduced the time to first flower comparing to the control. It is a desirable characters because it help to increase yield of the crop.

Combined effect of cucurbitaceous vegetables and growth regulators was non-significant in respect of days to first flowering (Appendix IV). However, numerically the maximum (59.67 days) time for first flowering was found in sweet gourd with no application of 4-CPA (control)

and the minimum (30.00 days) time of first flowering was recorded from ribbed gourd with the application of 300 ppm 4-CPA (Table 6).

4.2.2 Number of male flower

Different cucurbitaceous vegetables showed a significant variation in number of male flower (Appendix IV). The highest number of male flowers was observed from ribbed gourd (62.33) followed by sponge gourd (30.42) (Table 4). The minimum number of male flower was recorded from sweet gourd (18.17) which was statistically similar to bottle gourd (18.92) and bitter gourd (21.50).

There was significant variation among the different concentration of 4-CPA (Appendix IV). The minimum (29.60) male flower was recorded from no application of 4-CPA which was closely followed by 100 ppm 4-CPA (31.60) and the maximum male flower in number (34.09) was recorded from the application of 300 ppm 4-CPA preceded by 200 ppm 4-CPA (32.08) (Table 5). The results indicated that minimum male flower was produced in control than the plants treated with growth regulators.

Combined effect of cucurbitaceous crops and plant growth regulators was non-significant in respect of number of male flower (Appendix IV). However, numerically the highest (64.67) number of male flower was found in ribbed gourd with the application of 200 ppm 4-CPA and the minimum (14.00) number of male flower was recorded from bitter gourd with the application of 100 ppm 4-CPA (Table 6).

4.2.3 Number of female flower

Different cucurbitaceous vegetables showed significant variation in number of female flower (Appendix IV). The highest number of female flowers was recorded from ribbed gourd (51.83) followed by sponge gourd (40.25) (Table 4). The minimum number of female flower was recorded from sweet gourd (18.33) which was statistically similar to bottle gourd (18.92) and preceded by bitter gourd (25.17).

Different levels of plant growth regulators showed significant variation on number of female flowers (Appendix IV). The minimum (23.60) female flower was recorded from the control (Table 5). The maximum (36.27) female flower was obtained from the application of 300 ppm 4-CPA followed by 200 ppm 4-CPA (33.07) and 100 ppm 4-CPA (30.67), respectively.

Combined effect of cucurbitaceous crops and plant growth regulators was non-significant in regards to number of female flower (Appendix IV). However, numerically the highest (59.00) number of female flower was found in ribbed gourd with the application of 300 ppm 4-CPA and the lowest (13.34) number of female flower was recorded from bottle gourd with no application of 4-CPA (Table 6).

4.2.4 Number of fruit per plant

Different cucurbitaceous vegetables showed significant variation in number of fruit per plant (Appendix IV). The maximum number of fruit was found in ribbed gourd (29.33) followed by bitter gourd (25.58) and sponge gourd (25.08) (Table 4). The minimum number of fruit was recorded from sweet gourd (11.92) which was statistically similar to bottle gourd (14.08).

There was significant variation among the different concentration of 4-CPA (Appendix IV). Fruits per plant showed a gradual increasing trend for different concentration of plant growth regulators comparing the control. The maximum (23.93) fruits per plant was recorded from the application of 300 ppm 4-CPA that was closely followed by 200 ppm 4-CPA (21.87) and 100 ppm 4-CPA (21.67), respectively (Table 5). The minimum (17.33) fruits per plant was recorded from no application of 4-CPA.

Combined effect of cucurbitaceous crops and plant growth regulators was non-significant in regards to number of fruit per plant (Appendix IV). However, numerically the maximum (32.34) number of fruit per plant was found in ribbed gourd with the application of 300 ppm 4-CPA and the minimum (8.34) number of fruit was recorded from sweet gourd with no application of 4-CPA (Table 6).

4.2.5 Average length of fruit

Different cucurbitaceous vegetables showed significant variation on average length of fruit (Appendix V). The maximum length of fruit was found in ribbed gourd (22.58 cm) which was statistically similar to sponge gourd (22.08 cm) and bottle gourd (21.92 cm) (Table 4). The minimum length was found in bitter gourd (11.42 cm) preceded by sweet gourd (17.92 cm).

Table 4. Yield and yield contributing characteristics of different cucurbitaceous vegetables under PGR treatments

Selected Species	Days to first flowering	Number of male flower	Number of female flower	Number of fruit per plant	Average length of fruit (cm)	Average breadth of fruit (cm)	Weight of fruit (kg)	Yield (t/ha)
Sponge gourd	35.17b	30.42b	40.25b	25.08b	22.08a	3.04b	6.58d	2.63d
Sweet gourd	54.58a	18.17c	18.33d	11.92c	17.92b	8.71a	14.83b	5.93b
Bottle gourd	53.50a	18.92c	18.92d	14.08c	21.92a	8.50a	17.08a	6.83a
Ribbed gourd	33.33c	62.33a	51.83a	29.33a	22.58a	3.08b	9.00c	3.60c
Bitter gourd	36.83b	21.50c	25.17c	25.58b	11.42c	3.06b	8.08cd	3.23cd
Level of significance	**	**	**	**	**	**	**	**
LSD value	1.81	5.37	2.68	2.31	0.90	0.58	1.87	0.75

** = Significant at 1% level

Plant growth regulators showed statistically significant variation on fruit length (Appendix V). Fruit length showed an gradual increasing trend for different concentration of plant growth regulators comparing to the control. The maximum (20.53 cm) fruit length was recorded from

the application of 300 ppm 4-CPA which was statistically similar to 200 ppm 4-CPA (19.93 cm) (Table 5). The minimum (17.27 cm) fruit length was observed from the control which was preceded by 100 ppm 4-CPA (19.00 cm).

Combined effect of cucurbitaceous vegetables and plant growth regulators was non-significant in respect of fruit length (Appendix V). However, numerically the maximum fruit length (23.33 cm) was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum fruit length (9.34 cm) was recorded from bitter gourd with no application of 4-CPA (Table 6).

4.2.6 Average breadth of fruit

Different cucurbitaceous vegetables showed significant variation on average breadth of fruit (Appendix V). The maximum breadth of fruit was found in sweet gourd (8.71 cm) which was statistically similar to bottle gourd (8.50 cm) (Table 4). The minimum breadth was found in sponge gourd (3.04 cm) which was statistically similar to bitter gourd (3.06 cm) and ribbed gourd (3.08 cm).

Plant growth regulators showed significant variation on fruit breadth (Appendix V). Fruit breadth showed an gradual increasing trend for different plant growth regulators compared to the control. The maximum (5.73 cm) fruit breadth was recorded from the application of 300 ppm 4-CPA which was statistically similar to 200 ppm 4-CPA (5.42 cm) and 100 ppm 4-CPA (5.25) (Table 5). The minimum fruit breadth (4.72 cm) was recorded with no application of 4-CPA (control).

Table 5. Effect of different concentrations of 4-CPA on selected cucurbitaceous vegetables in respect of their yield and yield contributing characters

Concentration of 4-CPA (ppm)	Days to first flowering	Number of male flower	Number of female flower	Number of fruit per plant	Average length of fruit (cm)	Average breadth of fruit (cm)	Weight of fruit (kg)	Yield (t/ha)
Control	47.53a	29.60d	23.60d	17.33c	17.27c	4.72b	9.93b	3.97b
100	41.07b	31.60c	30.67c	21.67b	19.00b	5.25a	10.87b	4.35b
200	40.60b	32.08b	33.07b	21.87ab	19.93a	5.42a	10.80b	4.32b
300	41.53b	34.09a	36.27a	23.93a	20.53a	5.73a	12.87a	5.15a
Level of significance	**	**	**	**	**	**	**	**
LSD value	1.61	5.31	2.39	2.07	0.80	0.52	1.67	0.67

**= Significant at 1% level

Combined effect of cucurbitaceous vegetables and plant growth regulators was non-significant in respect of fruit breadth (Appendix V). However, numerically the maximum fruit breadth (9.67 cm) was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum fruit breadth (2.84 cm) was recorded from sponge gourd with no application of 4-CPA (Table 6).

4.2.7 Weight of fruit per plant

Fruit weight for different cucurbitaceous vegetables showed a statistically significant variation (Appendix V). The highest fruit weight was recorded from bottle gourd (17.08 kg) which was followed by sweet gourd (14.83 kg) (Table 4). The lowest fruit weight was found in sponge gourd (6.58 kg) which was statistically similar to bitter gourd (8.08 kg) preceded by ribbed gourd (9.00 kg).

Fruit weight for different plant growth regulators showed statistically significant variation (Appendix V). Maximum (12.87 kg) fruit weight was recorded from the application of 300 ppm 4-CPA (Table 5). The minimum (9.93 kg) fruit weight was recorded from no application of 4-CPA (control) which was statistically similar to 100 ppm 4-CPA (10.87 kg) and 200 ppm 4-CPA (10.80 kg).

Combined effect of cucurbitaceous vegetables and concentration of plant growth regulator was non-significant in regards to weight of fruit (Appendix V). However, numerically the maximum (21.34 kg) fruit weight was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (5.33 kg) fruit weight was recorded from sponge gourd with no application of 4-CPA (control) (Table 6).

4.2.8 Yield of fruit (t/ha)

Yield of different cucurbitaceous vegetables showed statistically significant variation (Appendix V). Maximum yield was recorded from bottle gourd (6.83 t/ha) which was followed by sweet gourd (5.93 t/ha) (Table 4). The minimum yield was recorded from sponge gourd (2.63 t/ha) which was statistically similar to bitter gourd (3.23 t/ha) preceded by ribbed gourd (3.60 t/ha).



Yield for different plant growth regulators showed statistically significant variation (Appendix V). Yield showed an gradual increasing trend for different plant growth regulators comparing with the control. The maximum (5.15 t/ha) yield was observed from the application of 300 ppm 4-CPA (Table 5). The minimum (3.97 t/ha) yield was recorded with no application of 4-CPA (control) which was statistically similar to 100 ppm 4-CPA (4.35 t/ha) and 200 ppm 4-CPA (4.32 t/ha) respectively.

Combined effect of cucurbitaceous vegetables and concentration of plant growth regulators was non-significant in respect of yield (Appendix V). However, numerically the maximum (8.54 t/ha) yield was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (2.13 t/ha) yield was recorded from sponge gourd with no application of 4-CPA (control) (Table 6).

4.2.9 Benefit Cost Analysis

4.2.9.1 Gross return

Due to the combined effect of plant growth regulators and cucurbitaceous vegetables, the maximum gross return (2,13,500) was obtained from the bottle gourd with 300 ppm 4-CPA (C_3T_3) and the lowest gross return (Tk.74,550) was obtained from sponge gourd with the control (C_1T_0) (Table 7).

4.2.9.2 Net return

Different concentrations of plant growth regulators gave different types of net return. The highest net return (Tk.1,43,920) was obtained from bottle gourd with 300ppm 4-CPA (C_3T_3). The lowest net return (Tk.7,700) was found in sponge gourd with the control (C_1T_0) (Table 7).

4.2.9.3 Benefit cost ratio

The combined effect of plant growth regulators and cucurbitaceous vegetables, the highest benefit cost ratio (3.06) was obtained from the bottle gourd with 300 ppm 4-CPA (C_3T_3) and the lowest benefit cost ratio (1.11) was obtained from control (C_1T_0) (Table 7).

CHAPTER 5

SUMMARY AND CONCLUSIONS

Two experiments were conducted to study the floral behavior of different cucurbitaceous vegetables and the effect of plant growth regulators on some selected cucurbitaceous vegetables at the Germplasm Centre, Khulna University, Khulna during the period from March 2016 to August 2016. There were eight cucurbitaceous vegetables with three replications in Experiment-1 and five cucurbitaceous vegetables and four concentrations (0, 100, 200, 300 ppm) of plant growth regulator (4-CPA) in Experiment-2.

Both of the experiments were laid out in Randomized Complete Block Design. The size of the each pit was 50cm × 50cm. Pit to pit distance was 4m. Five seeds were sown in each pit. After emergence of seedlings, one seedling per pit was kept and the others were uprooted and filled the gaps, various intercultural operations were accomplished for better growth and development of the plant. Observations were made on days to first flowering, number of flowers per plant, number of male and female flowers, ratio of male and female flower, days to male and female flowers opening, days to first fruit setting, number of fruit per plant, length and diameter of fruit, weight of fruit and fruit yield. However in experiment-1, time of flowering in a day, anthesis of male flower, duration of anthesis of male flower, anthesis of female flower, duration of anthesis of female flower were recorded. The collected data were analyzed and evaluated by DMRT.

Cucurbitaceous vegetables exhibited significant variation in almost all parameters. Among the 8 cucurbitaceous vegetables, sponge gourd, sweet gourd, bottle gourd, cucumber, wax gourd, bitter gourd open flowers in the morning (4.00 a.m.-8.00 a.m.), ribbed gourd open in the afternoon (4.00 p.m.-6.00 p.m.) and snake gourd at night (7.00 p.m.-8.00 p.m.). The duration of anthesis of

male flower was the highest in bitter gourd (100-110 min) and the lowest in sweet gourd (10-20 min). The duration of anthesis of female flower was the highest in snake gourd (60-120 min) and the lowest in sweet gourd (20-25 min).

The highest days required for first flowering was recorded from cucumber (61.44 days) and the lowest in ribbed gourd (32.89 days). The maximum number of flower was observed from ribbed gourd (100.8) and the minimum from sweet gourd (18.33). The highest number of male flower was found in ribbed gourd (53.33) and the lowest in sweet gourd (9.111). The maximum number of female flower was found in ribbed gourd (53.00) and the minimum in sweet gourd (9.333). The maximum ratio of male/female flower was found in snake gourd (1.21) and the minimum from bitter gourd (0.74).

Days required for 1st male flower and female flower opening showed significant variation among the cucurbitaceous vegetables. The maximum days to male flower opening was found in cucumber (63.56 days) and the minimum in ribbed gourd (29.78 days). The maximum days to female flower opening was found in bottle gourd (63.56 days) and the minimum in ribbed gourd (29.78 days). The maximum days to first fruit setting was recorded from snake gourd (62.44 days) and the minimum from sponge gourd (42.22 days). The highest number of fruit was recorded from ribbed gourd (32.22) and the lowest in wax gourd (9.556). The maximum length of fruit was found in snake gourd (22.1 cm) and the minimum in bitter gourd (7.989 cm). The maximum breadth of fruit was found in sweet gourd (7.182 cm) and the minimum in snake gourd (2.757 cm). The highest fruit weight was recorded from bottle gourd (14.22 kg) and the lowest in sponge gourd (5.000 kg). The maximum yield was recorded from bottle gourd (5.689 t/ha) and the minimum from sponge gourd (2.000 t/ha).

In experiment-2, the maximum days required for first flowering was found in sweet gourd (54.58 days) and the shortest period in ribbed gourd (33.33 days). The highest number of male flowers was observed from ribbed gourd (62.33) and the minimum from sweet gourd (18.17). The highest number of female flowers was observed from ribbed gourd (51.83) and the minimum from sweet gourd (18.33). The maximum number of fruit was found in ribbed gourd (29.33) and the minimum from sweet gourd (11.92). The maximum length of fruit was found in ribbed gourd (22.58 cm) and the minimum in bitter gourd (11.42 cm). The maximum breadth of fruit was found in sweet gourd (8.71 cm) and the minimum in sponge gourd (3.04 cm). The highest fruit weight was recorded from bottle gourd (17.08 kg) and the lowest in sponge gourd (6.58 kg). The maximum yield was recorded from bottle gourd (6.83 t/ha) and the minimum from sponge gourd (2.63 t/ha).

The minimum time of first flower (40.60 days) was recorded from the application of 200 ppm 4-CPA and the maximum (47.53 days) from the control. The minimum (29.60) male flower was recorded from no application of 4-CPA (control) and the maximum (34.09) from the application of 300 ppm 4-CPA. The minimum (23.60) female flower was recorded from the control and the maximum (36.27) from the application of 300 ppm 4-CPA. The maximum (23.93) fruits per plant was recorded from the application of 300 ppm 4-CPA and the minimum (17.33) from the control. The maximum (20.53 cm) fruit length was recorded from the application of 300 ppm 4-CPA and the minimum (17.27 cm) from the control. The maximum (5.73 cm) fruit breadth was recorded from the application of 300 ppm 4-CPA and the minimum (4.72 cm) from the control. The maximum (12.87 kg) fruit weight was recorded from the application of 300 ppm 4-CPA and the minimum (9.93 kg) from the control. The maximum (5.15 t/ha) yield was observed from the application of 300 ppm 4-CPA and the minimum (3.97 t/ha) from the control.

Combined effect of cucurbitaceous vegetables and growth regulators was non-significant. However, numerically the maximum (59.67 days) time of first flowering was found in sweet gourd from the control and the minimum (30.00 days) from the ribbed gourd with the application of 300 ppm 4-CPA. The highest (64.67) number of male flower was found in ribbed gourd with the application of 200 ppm 4-CPA and the minimum (14.00) from bitter gourd with the application of 100 ppm 4-CPA. The highest (59.00) number of female flower was found in ribbed gourd with the application of 300 ppm 4-CPA and the lowest (13.34) from bottle gourd with no application of 4-CPA (control). The maximum (23.33 cm) fruit length was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (9.34 cm) from bitter gourd with no application of 4-CPA (control). The maximum (9.67 cm) fruit breadth was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (2.84 cm) from sponge gourd with the control. The maximum (21.34 kg) fruit weight was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (5.33 kg) from sponge gourd with the control. The maximum (8.54 t/ha) yield was found in bottle gourd with the application of 300 ppm 4-CPA and the minimum (2.13 t/ha) from sponge gourd with the control.

The following conclusion could be drawn on the basis of the results obtained from the present experiment:

- ❖ Among the 8 cucurbitaceous vegetables, sponge gourd, sweet gourd, bottle gourd, cucumber, wax gourd, bitter gourd open flowers in the morning (4.00 a.m.-8.00 a.m.), ribbed gourd open in the afternoon (4.00 p.m.-6.00 p.m.) and snake gourd at night (7.00 p.m.-8.00 p.m.).
- ❖ The duration of anthesis of male flower was the highest in bitter gourd (100-110 min) and the lowest in sweet gourd (10-20 min). The duration of anthesis of female flower was the highest in snake gourd (60-120 min) and the lowest in sweet gourd (20-25 min).
- ❖ The concentration 300 ppm 4-CPA gave the minimum time to produce first flower, and maximum number of flower, number of male flower, number of female flower, number of fruit per plant and yield of different cucurbitaceous vegetables.

The plants treated with plant growth regulator (300 ppm 4-CPA) produced higher yield compared to untreated control plants, it may provide substantial benefit to the farmers.

So, it is recommended to study all possible aspects for better understanding of cucurbitaceous vegetables. The experiments are needed to be carried out further to obtain precise information. Further field trials in different locations would ensure the best possible concentration of plant growth regulators as 4-CPA.

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APPENDICES

Appendix I. Chemical analysis of soil from experimental field

Initial soil test	Soil p ^H	EC(dS/m)	Organic matter (%)	Potassium (mg/100g)	Total Nitrogen (%)	Phosphorus (µg/ g soil)	Sulpher (µg/ g soil)	Zinc (µg/ g soil)
Experiment 1 and 2	8	5.3	2.02	0.37	0.117	9.44	243.23	0.20

Appendix II. Analysis of variance of the data on days to first flowering, number of flower per pit, number of male flower, number of female flower, days to male flower opening, days to female flower opening in Experiment-1

Source of Variation	Degrees of freedom	Mean Square						
		Days to first flowering	No. of flower per plant	No. of male flower	No. of female flower	Days to male flower opening	Days to female flower opening	Sex Ratio Male/female
Replication	8	28.222 **	12.111 **	43.28 **	9.941**	11.688**	6.378 *	1.1056 **
Treatment (A)	7	912.881 **	6644.83 9**	1960.50 0**	1815.39 7**	1659.325 **	1449.2 84**	0.1837 **
Error	56	38.238	4.741	43.670	4.580	13.156	11.279	0.0591
Total	71							

** = Significance at 1% level

* = Significance at 5% level

Appendix III. Analysis of variance of the data on days to first fruit setting, number of fruit per plant, average length of fruit, average breadth of fruit, weight of fruit (kg), yield (t/ha) in Experiment-1

Source of Variation	Degrees of freedom	Mean Square					
		Days to first fruit setting	No. of fruit per plant	Average length of fruit (cm)	Average breadth of fruit (cm)	Weight of fruit (kg)	Yield (t/ha)
Replication	8	10.639**	2.868**	9.165**	0.437*	1.733*	0.277*
Treatment (A)	7	476.722**	668.190**	243.686**	35.017*	66.563*	10.650*
Error	56	32.758	3.717	2.210	0.322	0.943	0.151
Total	71						

**= Significance at 1% level

*= Significance at 5% level

Appendix IV. Analysis of variance of the data on days to first flowering, number of male flower, number of female flower and number of fruit per pit in Experiment-2

Source of Variation	Degrees of freedom	Mean Square			
		Days to first flowering	Number of male flower	Number of female flower	Number of fruit per plant
Replication	2	9.5167 ^{NS}	22.2167 ^{NS}	126.3500**	21.3500 ^{NS}
Treatment	3	158.9944**	77.2000**	434.2000**	115.4222**
Crop	4	1310.2667**	4141.1417**	2580.0583**	711.8167**
Treatment × Crop	12	4.3000 ^{NS}	28.6306 ^{NS}	13.8250 ^{NS}	2.7278 ^{NS}
Error	38	4.7974	42.3570	10.5254	7.8588
Total	59				

**= Significance at 1% level

*= Significance at 5% level

NS = Non-significance

Appendix V. Analysis of variance of the data on average length of fruit, average breadth of fruit, weight of fruit (kg), yield (T/ha) in Experiment-2

Source of Variation	Degrees of freedom	Mean Square			
		Average length of fruit (cm)	Average breadth of fruit (cm)	Weight (kg)	Yield (T/ha)
Replication	2	0.8667 ^{NS}	1.9698*	6.8167 ^{NS}	1.0907 ^{NS}
Treatment	3	30.4611**	2.7178**	23.1278**	3.7004**
Crop	4	268.1000**	110.6240**	250.9417**	40.1507**
Treatment:Crop	12	0.6556 ^{NS}	0.6296 ^{NS}	6.6417 ^{NS}	1.0627 ^{NS}
Error	38	1.2000	0.4999	5.1500	0.8240
Total	59				

**= Significance at 1% level

*= Significance at 5% level

NS = Non-significance