EFFECT OF GROWTH REGULATORS ON SEX-RATIO AND YIELD OF BOTTLE GOURD [*Lagenaria siceraria* (Mol.) Standl.]

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DIVISION OF OLERCULTURE

THESIS

SUBMITTED TO THE FACULTY OF POST-GRADUATE STUDIES
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Registration No. 2001/A/618/M

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2003

DEDICATED
TO MY
BELOVED PARENTS

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir,
Shalimar, Srinagar 191 121.

CERTIFICATE-I

This is to certify that the thesis entitled **"Effect of Growth Regulators on Sex-Ratio and Yield in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.],"** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture (Olericulture)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, is a record of *bona fide* research carried out by **Mr. Shahid Majid Kakroo** (Registration No. 2001/A/618/M) under my supervision and guidance and that no part of the thesis has been submitted for any other degree or diploma.

It is further certified that such help and information received during the course of investigation have been duly acknowledged.

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Chairman
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CERTIFICATE-II

We, the members of the Advisory Committee of **Mr. Shahid Majid Kakroo** a candidate for the degree of **Master of Science in Agriculture (Olericulture)**, have gone through the manuscript of the thesis entitled **"Effect of Growth Regulators on Sex-Ratio and Yield in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the degree.

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This is to certify that all the corrections and modifications suggested by the external examiner in the thesis script of **Mr. Shahid Majid Kakroo** (Registration No. 2001/A/618/M), entitled **"Effect of Growth Regulators on Sex-Ratio and Yield in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]"** have been taken care of before final binding of the same.

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he Thesis : "Effect of growth regulators on sex-ratio and yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

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ABSTRACT

To study the response of different growth regulators namely Ethephon (150, 300 and 450 ppm), Maleic Hydrazide (200, 300 and 400 ppm) and Tri-iodobenzoic Acid (25, 50 and 75 ppm) for increasing the female: male flower ratio and to ascertain their effect on fruit yield and yield attributing traits in bottle gourd, the present investigation entitled "Effect of growth regulators on sex-ratio and yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out during kharif 2002 using two varieties viz. SH-BG-1 and Local at Vegetable Experimental Farm, Division of Olericulture, SKUAST(K).The experiment was laid in randomized block design with three replications. The growth regulator treatments were applied at 4-true leaf stage and followed by second spray fifteen days after.

Observations were recorded on various growth and yield characters for each replication. Mean data was used for statistical analysis. The analysis of variance revealed significant effect of treatments on all the characters under study. In general Ethephon was found to significantly modify the sex-ratio in favour of female flowers and also increased fruit girth, fruit weight, number of fruits per plant and fruit yield per plant. TIBA caused increase in number of fruits per plant and yield per plant while MH resulted in decrease of vine length and increase in fruit length and fruit weight.

On the basis of present investigation it may be concluded that Ethephon @ 150 ppm proved to be most effective for increasing sex-ratio, yield and most of the yield attributing traits followed by TIBA @ 25 ppm in both the varieties of bottle gourd.

Dr. A. K. Singh Signature of Student

Major Advisor

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"In the name of Almighty Allah, the most Beneficent and Merciful"

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Chapter-I

INTRODUCTION

Vegetables are considered protective supplementary food because they contain large quantities of minerals, vitamins and essential amino-acids which are needed for normal metabolic process. Vegetables are good source of roughages and fibres thus promoting digestion and preventing constipation. There are large number of vegetable groups and cucurbits from an important group of vegetables. Cucurbits include gourds, cucumber, squash, melons etc. Bottle gourd is one of the important cucurbitaceous vegetable grown throughout the world.

Bottle gourd botanically known as [*Lagenaria siceraria* (Mol.) Standl.] is one of the most ancient cultivated vegetable found in both new world and old world. It has probably originated in Africa or America (Cutler and Whitaker, 1962;Haiser,1980).

It is one of the important cucurbitaceous vegetable grown throughout the India. It is a warm season crop and is grown in all parts of India. But in areas with mild climate it can be grown throughout the year and fruits are available in the market round the year. The tender fruits are used for cooking as vegetable and for preparing sweet meals, raita and pickles. It is even dried especially in the hilly areas for use during off-season. Dry shells of the fruits are used to make utensils and containers in some parts of world. Bottle gourd is an easily digestible vegetable and prevents constipation. It has good amount of vitamin-B and minerals like Ca, P and Fe. It has a cooling effect and is also recommended during convalescence. Leaves in the form of decoction with sugar are used for curing Jaundice. (Chauhan, 1972).

In Kashmir, bottle gourd is grown over an area of 250 hectare with a production of 4200 tonnes (Anonymous, 1999) and it forms the element of nearly every vegetable garden both for home and for commercial consumption.

Bottle gourd is a monoecious and highly cross pollinated crop and generally bears more number of male flowers than the female flowers. The staminate and pistillate flowers are differentiated at different nodes, thus node number to the first male and female flower has been used as an index of sex expression.

Bottle gourd is known to possess a wide ratio of male to female flowers. As a result there are less number of fruits and the total yield per plant. It is therefore imperative to induce more female flowers than male flowers either through chemical application or by developing a variety having large number of female flowers. Since the varietal improvement programme is time consuming, the other quick alternative method i.e. the use of plant growth regulators which are known to be effective in modifying sex expression and sex ratio in cucurbits (Arora *et al.,* 1987) would be most effective in achieving the desired objective.

Keeping the above facts in view, the present investigation was undertaken to increase the number of female flowers in bottle gourd by the application of certain growth regulators. Thus the study on effect of growth regulators was carried out with the following objectives:

1. To study the effect of growth regulators on the number of male and female flowers per plant.
2. To study the effect of growth regulators on growth and maturity, and

3. To study the effect of growth regulators on yield and its components.

Chapter-II

REVIEW OF LITERATURE

Cucurbits exhibit a wide array of sex forms and diversity in sex expression. In monoecious cultivars of bottle gourd, staminate and pistillate flowers are borne at separate nodes. However, staminate flowers are found in very high proportion as compared to pistillate flowers. It is now well established that the sex expression in cucurbits is governed by the genetical cause with environmental factors playing the modifying role. Application of plant growth regulators has been found to modify the sex expression in cucurbits.

The first report on modification of sex via exogenous chemical application was reported as early as 1949. Auxin application shifted sex ratio in cucumbers towards femaleness (Laibach and Kribben, 1949). Since then, a wide range of plant growth substances have been found to modify the sex ratio in cucurbits.

A brief review of the effect of growth regulators on the vegetative growth, sex expression and sex-ratio, fruit characters and yield is presented below:

Wittwer and Bukovac (1958) reported that exogenous application of gibberellins adds upto the quality of endogenous gibberellin-like substances within the plant and causes the stimulation of staminate flower production.

Mc Murray and Miller (1968) reported that the synthetic ethylene releasing compound 2-chloroethyl phosphonic acid (Ethephon) provided an effective means of female flower production in both monoecious and andro-monoecious cultivars.

In 1969 they found that most effective concentration of ethrel for increasing the yield were 120, 180 and 240 ppm. These concentration resulted in greater number of female flowers and hence increased the yield per acre in C*ucumis sativus*.

Rudich *et al.* (1969) reported that the application of ethrel in cucumber and squash produce only female flowers for the first 2-3 weeks of flowering in case of monoecious types. The optimum treatments for cucumber were 2 foliar sprays of ethrel @ 250 or 500 ppm applied at first and third leaf stages.

Freytag *et al.* (1970) reported that CEPA @ 500 ppm, TIBA @ 25 and 50 ppm; and CCC @ 250 ppm were most effective in increasing the production of pistillate flowers. However, higher concentration of all these chemicals caused significant reduction in both pistillate and staminate flowers.

Ghosh and Bose (1972) used foliar sprays of B-nine (diaminozide) at 1250, 2500 or 5000 ppm on cucumber seedlings at 2-leaf stage and again at 4-leaf stage. All the concentrations markedly promoted the number of pistillate flowers and maximum femaleness was obtained with 1250 ppm. Snap melon (C*ucumis melo* var. momordica) showed a marked increase in the number of pistillate flowers when treated with 1250 or 5000 ppm concentration.

Pandey and Singh (1973) reported that increase in the number of female flowers and a sex ratio of 1:26 at 400 ppm MH +100 kg of N/ha.

Bhandary *et al.* (1974) carried out an investigation to test the effect of various concentrations of ethrel on sex expression in German variety “9307” of cucumber. Staminate flowers appeared early in plants treated with lower concentration. Ethrel was used effectively to synchronize the flowering time of different varieties. Saimbhi and Thakur (1974) reported that the foliar application of TIBA and CCC increased the production of female flowers and also increased fruit weight and yield in bottle gourd.

Ejsmond (1974) reported that application of 1000 ppm ethrel resulted in shortening the internodes.

More and Sheshadri (1975) applied 200-250 ppm ethrel in muskmelon and observed increase in the number of female flowers at lower nodes, whereas the staminate flowers decreased. Singh *et al.* (1975) reported that some plant growth regulators increased the number of female flowers, fruit set and yield in summer squash. Verma (1975) found reduced plant height in cucumber after ethrel spray at higher concentrations whereas, plant height was not affected by GA_3.

Mishra *et al.* (1976) reported that application of ethrel, B-Daminozide and Chlormequat at concentrations of 400, 200 and ppm, respectively resulted in reduce plant growth in cucumber.

Randhawa and Singh (1976) observed that the spray of GA_3, CCC and MH caused increase in vine length, suppressed apical growth and improved the sex-ratio, respectively in bottle gourd.

Singh and Singh (1977) reported that the number of days to first harvest in bottle gourd cv. Kalyanpur Long Green was reduced and fruit length and number and yield per hectare were increased by treatments with urea @ 250 ppm or succinic acid @ 900 ppm, the best treatment being succnic acid @ 600 ppm for 12 h.

Gopalkrishnan and Choudhary (1978) worked on watermelon and reported that TIBA @ 50-2000 ppm applied at 2-4 true leaf stage, increased female flowers and fruit yield.

Sadhu and Das (1978) reported that seed dip treatment and foliar spray of ethephon (50-250 ppm) increased number of female flowers in long melon (*Cucumis melo* var. Utilissimus). Sharma *et al.* (1980) used three growth regulators and nitrogen fertilizer on *Lagenaria siceraria* cv. Pusa Summer Prolific Long and found general increase in female flower number and an increased yields. The most effective treatment was 300ppm ethephon or 25ppm NAA combined with 100 kg N/ha.

Verma and Choudhary (1980) observed that ethrel treatments (50, 100, 150 and 200 ppm) were most effective in increasing the number of female flowers, produced more number of fruits (2.0 – 3.0/ plant) and increased fruit weight per plant (209-374 g) in cucumber.

Sidhu *et al.* (1981) treated squash melon with MH, NAA, GA_3 and ethrel at various concentrations which stimulated main axis, induced female flowers at lower nodes and increased the female flowers and average number of fruits per plant.

Arora *et al.* (1982) studied the effect of MH on vegetative growth, flowers and fruiting of bottle gourd cv. Pusa Summer Prolific Long and found elongation of main axis at 150 mg/litre and maximum number of fruits per plant at 50 mg/ litre.

Rute *et al.* (1982) conducted studies with ex-plants of cucumber female line T1 grown under a 16-21 h day. The highest number of female flowers (94, 71) were found in plants grown under 12 h day and treated with ethrel.

Dubey (1983) applied ethrel at 125-500ppm on *Luffa cylindrica* cv. Pusa Chikeni at 2-4 true leaf stage which stimulated production of more female flowers and increased fruit yield.

Edelstein *et al.* (1984) conducted a green house trial on *Cucurbita pepo* cv. Vegetable Spagheti and treated the plants with ethephon at 0, 150, 300 and 600 ppm at 2-10 leaf stages. Application at 2, 4 or 6 leaf stage reduced the internodal length and plant height but not the number of nodes. Production of staminate flowers was delayed.

Patil *et al.* (1984) reported that ethephon applied at 100-400 ppm was effective for appearance of female flowers at lower nodes and also increased the number of female flowers in cucumber.

Saimbhi (1984) reported that ethephon changed the sex, induced earliness and increased yield of various cucurbits. Ethephon applied as foliar spray at 1-3 leaf stage at 125-1000 ppm induced complete sex reversion, suppression of staminate flowers and increase in pistillate flowers in cucumber, muskmelon, squash and summer squash.

Singh and Singh (1984) sprayed the cucumber seedlings at 2 and 4 leaf stages with NAA (25-100 ppm), MH (50-100 ppm) and ethephon (50-150ppm). All the treatments showed early appearance of first female flower and gave lower sex-ratio than that in the control. Verma *et al.* (1984) applied ethrel, MH, GA_3 and Silver nitrate at 2- and 4- leaf stage to bitter gourd cv. Pusa Domousmi. Ethrel was found most effective in enhancing the pistillate flowers, fruit number and fruit yield.

Talalova (1984) reported that ethrel when applied to cucumber at 200, 300 or 400 ppm shortened the lateral branches, increases the number of female flowers and fruits that ultimately result in higher yield per hectare.

Arora *et al.* (1985) studied the influence of ethrel, GA_3, MH and NAA on cv. Pusa Summer Prolific Long of bottle gourd. They found that early flowering was induced by MH at 150 mg/litre whereas NAA at 50 mg/litre delayed flowering. The highest yield was obtained with MH at 150 mg/litre followed by MH at 50 mg/litre and ethephon at 250 mg/litre.

Singh (1985) reported that Khira Poona plants treated with ethrel at 100-150 ppm were dwarf and dense in growth in comparison to control. The number of branches increased more than double as compared to control.

Verma *et al.* (1985) observed that among the several growth regulators applied to cv. Selection 124 of cucumber at 4-leaf stage, only ethephon at 100-

200 ppm delayed the appearance of staminate flowers, increased 2-3 times the number of pistillate flowers, reduced sex ratio and produced plants with shorter internodes.

Yonemori and Fujieda (1985) reported that ethephon applied to *Momordica charantia* at 200 ppm significantly promoted female flowers as compared to male flowers.

Arora *et al.* (1987) reported that application of ethrel at 100 mg/lit in ridge-gourd markedly advanced the appearance of pistillate flowers at lower nodes, increased number of fruits, fruit weight and total yield and also reduced days taken to first picking of fruit.

Sreeramulu (1987) studied the effect of ethrel on sex expression in sponge-gourd. He found that ethrel not only increased the number of pistillate flowers but also hastened the appearance of first female flower compared to the controls.

Arora and Pratap (1988) studied the effect of ethephon on vegetative growth, flowering and sex-expression of pumpkins. They found increase in number of female flowers, reduction in male: female sex ratio and increase in yield with the application of ethephon.

El-Ghamriny et.al.(1988) while studying the effect of ethrel at 150 ppm at 2-leaf stage in monoecious variety Khira Poona observed significant induction of pistillate buds and his study confirmed that sex differentiation takes place 2-leaf stage.

Kumar and Rao (1988) studied the effect of ethrel and nutrients on growth, sex expression and yield of ridge-gourd. The highest mean number (36.0) of fruits per vine was obtained with an application of ethrel (50 ppm) at the 4-leaf stage. Potassium nitrate at 250 ppm was found to be most effective treatment which gave 32.7 fruits per vine-while untreated control yielded 16.6 fruits per vine.

Saimbhi and Gill (1988) conducted a field trial at Jallundar in 1983 and 1984 and observed that application of 5 ppm Tricotinal or 1 ml Cytozyme [a mixture of bacterial enzymes, trace elements, cytokinins and auxins] had no effect on sex expression or fruit yield in *Cucurbita pepo* cv. Punjabi No. 1. However, application of 390 ppm ethephon advanced the production of female flowers and delayed and reduced the male flowers formation. Ethephon also increased the number of fruits per plant and yield.

Sharma *et al.* (1988) reported that in 2-years field studies with bottle gourd cv. Pusa Summer Prolific Long, the plants were treated with several growth regulators, some at 2 to 4 true leaf stage and some at 35-45 DAS. The highest average yields were obtained with NAA at 50 mg/litre and with Atonik at 0.1% while as control recorded lesser yield.

Arora *et al.* (1989) reported the reduction of sex ratio when ethrel was sprayed at 250 ppm and 100 ppm on pumpkin seedlings. Kabir *et al.* (1989) observed highest yield when cv. Pusa Domousmi plants were treated at 2- and 4- leaf stage with NAA (10-20 ppm) and ethrel (100, 200 ppm).

Ratnapale and Silva (1989) studied the effect of ethephon on sex-expression of cucumber (cv. LY 58) and observed that 100 ppm ethephon sprayed at 2-3 true leaf stage followed again 6 days later delayed the production of male flowers per plant.

Sarkar *et al.* (1989) observed that growth regulator ethrel when applied to pointed-gourd at 25, 50 and 100 ppm of concentration increased sex ratio (female: male from 1:1 to 1: 0.33).

Singh and Choudhary (1989) reported that the vine length, fruit weight, number of fruits per vine and yield per vine (kg) increased in cucurbits by the use of ethephon at 100 ppm or MH at 50 ppm.

Vadigeri and Madalgeri (1989) reported that application of ethrel at 400 ppm to the seedlings of cucumber cvs. Poinsette and Belgaum Local at 4-6 leaf stage significantly increased the number of female flowers.

Gawankar *et al.* (1990) applied ethrel (ethephon) at 125, 250 or 500 ppm, TIBA at 50, 100 or 200 ppm or GA at 25, 50 or 100 ppm to the pumpkin and observed that ethrel at 500 ppm concentration showed highest TSS content.

Mandal *et al.* (1990) recorded highest number of fruits per plant, total yield and high fruit weight per plot in bottle gourd with the spraying of 10-20 ppm ethrel.

Singh *et al.* (1991) reported increase in growth and yield parameters when Mixtalol was sprayed at 45 days after sowing than at 20 days after sowing.

Das and Maury (1993) reported that 150 ppm ethrel spray on the *Cucurbita moschata* increased number of fruits per plot and the yields.

Gad *et al.* (1993) reported that 75, 150, 225 or 300 ppm ethrel spray markedly reduced the number of male flowers, increased the number of female flowers and fruits per plant, induced early picking and increased the fruit yield in summer squash. The most effective treatments were 225 and 300 ppm of ethrel.

Samdayan *et al.* (1994) showed that ethrel applied with nitrogen on bitter-gourd gave thickest rind and highest dry matter content, while 50 kg nitrogen per hectare gave the highest flesh weight, ascorbic acid and TSS content.

Das *et al.* (1995) observed early flowering induction by foliar application of some growth regulators in cucumber. Ethrel applied at 250 or 500 ppm resulted in production of female flowers at lower nodes than the control. These treatments also reduced the number of days taken to the appearance of first female flower.

Das and Das (1995) reported that sex expression in pumpkin was affected with ethrel treatment, flowering was earliest in control plants while GA_3 tended to increase sex ration (M:F) whereas, NAA and ethrel reduced sex ratio.

Navins *et al.* (1995) worked on the use of plant bioregulators in vegetable crop production and found that one of their significant role has been to accelerate flowering and sex expression for seed production, especially in cucurbits. They reported that the application of growth regulators in actual field production have been limited and only gibberellins and ethephon have been commonly used.

Das and Das (1996) reported that the application of 200 ppm ethrel produced highest fruit yields of 588.33 q/ha in pumpkin compared with 298.33 q/ha in control. Kshirsagar *et al.* (1996) studied the effect of growth regulator on sex-expression and fruiting in cucumber. 100, 200 and 300 ppm ethrel applied at 2-4 leaf stage delayed the appearance of first male flower and accelerated that of the first female flower. Ethrel also increased the number of female flowers per vine, total fruit set and yield of marketable fruits. Ethrel at 100 ppm showed highest marketable fruit yield (1.27 kg/vine).

Baruah and Das (1997) worked on the effect of plant growth regulators on growth, flowering and yield of bottle gourd at different sowing dates. Plants sprayed with NAA at 25 ppm or MH at 50 ppm produced the best yields, while as yield decreased with later sowing dates.

Joshi and Jadhao (2000) reported that the foliar application of growth regulators significantly increased the number of female flowers in bottle gourd. MH spray of 200 ppm was superior amongst the other growth regulators in enhancing the female to male ratio (1: 2.07).

Yamasaki *et al.* (2002) worked on molecular approach to the study of sex determination in cucumber plants and the relationship between the genotype and ethylene production in gynoecious, monoecious and andro-monoecious cucumbers was determined. Ethylene inhibited stamen development in monoecious cucumber but not in andro-monoecious ones.

Chapter-III

MATERIALS AND METHODS

The present investigation entitled " Effect of growth regulators on sex-ratio and yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out at the Vegetable Experimental Farm, Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar ,Srinagar, during kharif 2002.

Geographical location of the site

District Srinagar is situated between 34.5^0 N to 34.7^0 N at 1570 m above mean sea level and is flanked on south-east and north-east by the lofty Himalayan ranges. At the base of these ranges towards the north-east side is University Campus, Shalimar about 17 km from the main city.

Climate and Weather

The climate is temperate cum mediterranean type. During the experiment the hottest months were July and August with an average temperature of 31.3^0C and 28^0C and maximum rainfall of 18.6 mm and 112.10 mm, respectively. The meteorological data pertaining to the period of crop growth was provided by

Meteorological Observatory, Division of Agronomy, SKUAST-K, Shalimar.

Experimental Material

Two varieties of bottle gourd *i.e.,* SH-BG-1 and Local were used for

studying the effect of different growth regulators with different concentrations on sex ratio, growth and yield attributing traits.

Treatments

Ten treatments which included three different growth regulators (Ethephon,Maleic Hydrazide and Tri-iodobenzoic Acid) and a control were tried in a randomized block design with three replications. The treatments given were as under:-

T_1C_1	Ethephon	150 ppm
T_1C_2	Ethephon	300 ppm
T_1C_3	Ethephon	450 ppm
T_2C_1	MH	200 ppm
T_2C_2	MH	300 ppm

T_2C_3	MH	400 ppm
T_3C_1	TIBA	25 ppm
T_3C_2	TIBA	50 ppm
T_3T_3	TIBA	75 ppm
T_4	Control	

Where MH = Maleic Hydrazide; TIBA = Tri-iodobenzoic Acid

The above ten treatments were employed for both the varieties viz.

SH-BG-1 and Local. The treatments were given at 4- true leaf stage and again fifteen days after first spray.

Healthy and pulpy seeds were sown in the first week of May 2002 in a well prepared field at a spacing of 1.5m x 0.5 m in each row. 4-5 seeds were sown in each basin. After emergence, thinning was done to retain only one plant/hill and gaps that were created due to seedling mortality were also filled immediately. The package of practices as recommended by SKUAST-K were followed for raising the good crop.

Observations recorded

The observations were recorded on 3 plants in each row leaving the 2 plants on either side as border plants. Observations were recorded for all the selected parameters in each replication. The procedure followed for each parameter is as under:

i. Node number of appearance of first male flower

The node at which first male flower appeared was recorded as node number of first male and mean was worked out.

ii. Node number of appearance of first female flower

The node at which first female flower appeared was recorded as node number of first female flower and mean was worked out.

iii. Number of male flowers per plant

The number of male flowers per plant were counted from three plants

and the mean was calculated.

iv. Number of female flowers per plant

The number of female flowers per plant were counted from 3 plants and the mean was calculated.

v. Sex-ratio

The sex-ratio (F/M) was worked out on the basis of total female and male flowers for selected plants.

vi. Fruit length (cm)

Length of 3 randomly selected fruits was recorded for each plant and average was worked out for 9 fruits got from each replication.

vii. Fruit girth (cm)

Same fruits as above were used for recording fruit girth with the help of Verinear calipper by measuring at 3 points (upper, central and basal) and mean was worked out.

viii. Days to first fruit picking

Number of days taken from date of sowing to the date of first harvest of edible fruit in a plant was recorded as days to first fruit picking and mean was worked out.

ix. Fruit weight (kg)

The fruits selected for measurement of length and girth were utilized for

finding out the fruit weight of each treatment.

x. Number of fruits per plant

The fruits of each row were harvested at edible stage from plants. The number of fruits were counted at each picking, summed up and mean was worked out.

xi. Number of seeds per fruit

Randomly selected five fruits from each row (of 3 plants) were selected and dried for seed extraction. All the seeds were pooled, counted and divided by the number of fruits to give average number of seeds per fruit.

xii. Fruit yield per plant (kg)

Fruit weight recorded from all pickings was pooled for each row and total yield per plant was worked out.

xiii. Vine length

The length of main stem of each selected plant was measured in cm from soil level up to the tip and mean length was worked out.

xiv. Number of nodes on main axis

The total number of nodes on each of the three plants in a replication (row) were pooled and the average number of nodes per plant was recorded.

xv. Internodal distance (cm)

Internodal length was recorded in cm for each selected plant and average per plant was worked out.

Statistical Analysis

The experimental data was subjected to statistical analysis to find out as

to which of the treatments showed significant variation for different growth characters and yield attributes. The usual method of analysis of variances were followed and appropriate critical differences were also worked out as suggested by Gomez and Gomez, 1984.

Besides, mean values were worked out for each individual growth regulator by pooling the mean values of their different concentrations. These mean values of growth regulators irrespective of concentrations, were again subjected to statistical analysis and the critical differences were worked out for the same to compare the effects of these growth regulators with each other and with respect to control as well.

Chapter-IV

EXPERIMENTAL FINDINGS

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is a monoecious crop with more male flowers than female flowers. The staminate flowers are predominantly at lower nodes while pistillate flowers are borne at higher nodes resulting in fever fruits per plant and hence lower yields. For higher production of fruits it is desirable to have a high female to male flower ratio. Hence the present investigation entitled “Effect of growth regulators on sex-ratio and yield of bottle gourd” was carried out at Vegetable Experimental Farm, Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during kharief 2002. Observations were recorded on 15 economic traits viz. Node number of appearance of first male and female flower, number of male and female flowers per plant, sex ratio, days to first picking, fruit length, fruit girth, fruit weight, number of fruits per plant, fruit yield per plant, number of seeds per plant, vine length, number of nodes per plant and internodal distance.

The data collected on these characters was subjected to statistical analysis and the results obtained have been presented as under:

I. Analysis of Variance

The analysis of variance was done for all the 15 characters of both the varieties SH-BG-1 and Local and has been presented in Table-1 and Table-2 respectively. Analysis of variance revealed significant effects of all the growth regulator treatments on all the characters studied.

II. Mean performance and present change over control

Mean values for various growth regulator treatments for each variety of bottle gourd have been presented from Table-3 to Table-7.

1. Node number of appearance of first male flower

The data on node number of appearance of first male flower for both the varieties SH-BG-1 and Local is

given in Table-3. Application of growth regulators irrespective of concentrations and the chemicals used, in general significantly affected the node number of first male flower in both the varieties SH-BG-1 and Local (4.96th node and 4.95th node), as compared to control (4.43rd and 4.10th node) respectively. Among growth regulators irrespective of concentrations, TIBA significantly shifted the node number of first male flower to higher node (5.31st and 5.13rd node) as compared to control in both the varieties, followed by MH in variety SH-BG-1 (5.01st node) and Ethephon in Local (5.08th node). Among different concentrations, Ethephon @ 150 ppm was found most effective in shifting the node number of first male flower to higher node (6.30th and 5.73rd node) showing an increase of 42.21% and 39.82% followed by TIBA @ 25 ppm (5.63rd node and 5.40th node) showing an increase of 27.15% and 31.70% over control in both the varieties, respectively.

Table 1 : Analysis of variance with respect to different growth regulator treatments in bottle gourd cv. SH-BG-1

Source of Variation	D.F.	Vine length (cm)	Node no. of male flower	Node no. of female flower	No. of male flowers per plant	No. of female flowers per plant	Sex ratio (F:M)	No. of nodes per plant	Inter-nodal distance (cm)
Replications	2	79.40	0.2720	0.2590	0.14	0.0736	0.0008	1.85	1.01
Treatments	9	1397.20**	1.10**	3.16**	178.31**	1.22**	6.24**	9.81*	0.5578*
Error	18	43.70	0.2686	0.1894	2.26	0.2129	0.2959	2.91	0.7947

Source of Variation	D.F.	Days to first fruit picking	Fruit length (cm)	Fruit girth (cm)	No. of seeds per fruit	Fruit weight (kg)	No. of fruits per plant	Fruit yield per plant (kg)
Replications	2	1.20	6.80	0.2490	47.20	0.0270	0.0937	0.1609
Treatments	9	0.7440*	61.87**	0.3148*	4451.1**	0.0071*	0.1802*	0.7525*
Error	18	1.09	7.87	0.2230	20.60	0.0042	0.2093	0.2876

*, **= 5% level of significance and 1% level of significance, respectively.

Table 2 : Analysis of variance with respect to different growth regulator treatments in bottle gourd cv. local

Source of Variation	D.F.	Vine length (cm)	Node no. of male flower	Node no. of female flower	No. of male flowers per plant	No. of female flowers per plant	Sex ratio (F:M)	No. of nodes per plant	Inter-nodal distance (cm)
Replications	2	10.00	0.2813	0.0723	6.16	0.0203	0.3772	16.44	3.97
Treatments	9	2262.70**	0.4652*	0.6599*	107.81**	1.66**	4.57**	14.77**	0.5297*
Error	18	100.20	0.4669	0.3431	1.60	0.1055	0.2114	1.96	0.7399

Source of Variation	D. F.	Days to first fruit picking	Fruit length (cm)	Fruit girth (cm)	No. of seeds per fruit	Fruit weight (kg)	No. of fruits per plant	Fruit yield per plant (kg)

Replications	2	10.13	9.16	0.2839	13.4	0.0022	0.0343	0.2153
Treatments	9	12.80*	77.74**	1.01**	3507.2**	0.0028**	0.0661*	0.0725**
Error	18	7.13	0.2292	0.2292	34.1	0.0015	0.0817	0.1367

*, **= 5% level of significance and 1% level of significance, respectively.

Ethephon @ 450 ppm recorded first male flower at lowest node (3.53rd node),a decrease of –20.24% in variety SH-BG-1 and (4.40th node) showing an increase of 7.31%. With the increase in concentration of ethephon, MH and TIBA, there was decrease in the node number of appearance of first male flower in both the varieties.

2. Node number of appearance of first female flower

The data on node number of appearance of first female flower in both the varieties SH-BG-1 and Local is given in Table-3. Irrespective of the concentration and the chemicals used, the growth regulator application significantly affected the node number of appearance of first female flower in both the varieties SH-BG-1 and Local (5.10th and 5.09th node) as compared to control (7.31st and 8.66th node) respectively. When the individual growth regulators were analysed, Ethephon was found to have significantly shifted the node number of first female flower to lower node (4.51st and 4.61st node) followed by MH (5.30th and 4.87 node) in both the varieties. Among different concentrations, Ethephon @ 150 ppm was most effective in shifting the node number of first female flower to lower node (3.77th and 3.30th node) showing a decrease of –48.48% and –61.89% over control followed by TIBA @ 75 ppm (4.10th node) in variety SH-BG-1 and MH @ 200 ppm (4.53rd node) in Local. TIBA @ 25 ppm shifted the node number of appearance of first female flower to highest node (6.20th and 6.30th node) in both the varieties. Node number of first female flower showed an increase with the increase in concentration of ethephon and MH whereas, the node number decreased with increase in concentration of TIBA in both the varieties.

3. Days to first fruit picking

The data on days to first fruit picking for both the varieties SH-BG-1 and Local is given in Table-3. The comparison of growth regulators application versus control revealed significant decrease in days to first fruit picking (67.03 and 70.92 days) as compared to control (71.33 and 74.67 days) in both the varieties SH-BG-1 and Local, respectively. All the three growth regulators irrespective of concentrations recorded significant decrease in days to first fruit picking with TIBA showing maximum decrease (65.77 and 69.66 days) and MH showing minimum decrease (69.00 and 72.00 days) in both the varieties respectively. Among individual concentration, TIBA @ 75 ppm reduced the days to first fruit picking (64.66 and 67.33 days) showing a decrease of –9.35% and –9.82% in both the varieties. In variety SH-BG-1, MH @ 400 ppm caused maximum delay in first fruit picking (70.00 days), while in Local, Ethephon @ 150 ppm caused maximum delay in first fruit picking (73.00 days) in Local. In case of ethephon and TIBA, there was decrease in days to first fruit picking with the increase in concentration whereas, in case of MH, there was increase in days to first picking with the increase in concentration in both the varieties.

Table 3: Mean values for node number of first male and female flower; and days to first fruit picking of bottle gourd cvs. SH-BG-1 and Local as affected by growth regulator treatments

Treatment	**Node number of first male flower**				***Node number of first female flower***				**Days to first fruit picking**			
	SH-BG-1	**Per cent change over control**	**Local**	**Per cent change over control**	**SH-BG-1**	**Per cent change over control**	**Local**	**Per cent change over control**	**SH-BG-1**	**Per cent change over control**	**Local**	**Per cent change over control**
Ethephon	6.30	42.21	5.73	39.82	3.77	-48.48	3.30	-61.89	68.33	-8.41	73.00	-2.24
150 ppm	3.87	-12.73	4.80	17.87	4.83	-33.88	4.93	-44.57	65.67	-7.94	71.33	-4.47
Ethephon 300 ppm	3.53	-20.24	4.72	10.48	4.94	-32.51	5.50	-36.48	65.00	-8.87	69.00	-7.59
Ethephon 450 ppm												
Mean	**4.56**	**-**	**5.08**	**-**	**4.51**	**-**	**4.61**	**-**	**66.33**	**-**	**71.11**	
MH 200 ppm	5.10	15.12	5.07	23.56	5.06	-30.69	4.53	-47.65	68.00	-4.20	70.66	-5.37
MH 300ppm	5.00	15.11	4.56	11.21	5.20	-28.86	4.96	-42.65	68.00	-4.66	72.66	-2.69
MH 400ppm	4.93	11.35	4.40	7.31	5.63	-22.94	5.10	-41.50	70.00	-1.86	72.66	-2.69
Mean	**5.01**	**-**	**4.68**	**-**	**5.30**	**-**	**4.87**	**-**	**69.00**	**-**	**72.00**	**-**
TIBA 25ppm	5.63	27.15	5.40	31.70	6.20	-15.18	6.30	-27.25	67.66	-5.14	73.00	-2.24
TIBA 50ppm	5.53	24.89	5.03	22.75	6.17	-15.64	5.86	-32.33	65.00	-8.87	68.66	-8.05
TIBA 75ppm	4.77	7.58	4.96	21.12	4.10	-43.91	5.23	-39.60	64.66	-9.35	67.33	-9.82

Mean	**5.31**	**-**	**5.13**	**-**	**5.48**	**-**	**5.79**	**-**	**65.77**	**-**	**69.66**	**-**
Control	**4.43**	**-**	**4.10**	**-**	**7.31**	**-**	**8.66**	**-**	**71.33**	**-**	**74.67**	**-**
G.R. (Mean)	**4.96**	**-**	**4.95**	**-**	**5.10**	**-**	**5.09**	**-**	**67.03**	**-**	**70.92**	**-**
C. D. (Treatment)	**0.81**	**-**	**1.07**	**-**	**0.74**	**-**	**1.00**	**-**	**1.71**	**-**	**2.04**	**-**
C. D. (G. R.)	**0.51**	**-**	**0.54**	**-**	**0.49**	**-**	**0.64**	**-**	**1.36**	**-**	**2.16**	**-**

G. R. = Growth Regulators

4. Number of male flowers per plant

In Table-4 the data on number of male flowers per plant for both the varieties SH-BG-1 and Local is presented. Application of growth regulators irrespective of concentrations and the chemicals used, significantly decreased the number of male flowers in both the varieties SH-BG-1 and Local (38.99 and 34.51) in comparison to control (48.26 and 43.66). Among growth regulators, Ethephon significantly decreased the number of male flowers (36.12 and 29.44) followed by MH (36.65 and 35.88) as compared to control in both the varieties. Among different concentrations, Ethephon @ 150ppm was found most effective in reducing the number of male flowers (31.00 and 24.66), showing a decrease of –35.76% and –43.51% followed by TIBA @ 25 ppm (32.20) in variety SH-BG-1and Ethephon @ 300ppm (28.33) in Local. Highest number of male flowers were recorded in case of TIBA @ 75 ppm (52.99 and 45.00) in both the varieties. As the concentration of Ethephon, MH and TIBA was increased, there was increase in the number of male flowers per plant in both the varieties.

5. Number of female flowers per plant

In Table-4 the data on number of female flowers per plant for both the varieties SH-BG-1 and Local is given. The perusal of the data revealed significant effect of growth regulator application on the number of female flowers per plant (7.32 and 5.76) in comparison to control (6.01 and 4.03) in both the varieties respectively. Among growth regulators irrespective of concentrations, Ethephon significantly increased the number of female flowers (7.62 and 5.99) as compared to control followed by TIBA (7.19 and 5.67) in both the varieties. When different treatments were analysed, Ethephon @ 150 ppm reported maximum number of female flowers (8.06) in variety SH-BG-1, an increase of 34.22% while TIBA @ 25 ppm reported maximum number of female flowers (6.20) in Local showing an increase of 53.84% over control. Minimum number of female flowers were recorded by MH @ 400 ppm (6.60) in variety SH-BG-1 and TIBA @ 75 ppm (4.90) in Local variety. However, all the treatments recorded higher number of female flowers as compared to control in both the varieties. Number of female flowers per plant in general showed decrease with the increase in concentration of Ethephon, MH and TIBA.

6. Sex ratio

The data on sex ratio for both the varieties SH-BG-1 and Local is presented in Table-4. The comparison of growth regulators application versus control revealed significant effect of growth regulators on sex-ratio in favour of female flowers in both the varieties (1:5.35 and 1: 6.9) in comparison to control (1: 8.02 and 1: 10.83), respectively. Irrespective of concentrations among growth regulators, Ethephon significantly increased the female: male flower ratio (1: 4.81 and 1: 4.95) as compared to control followed by MH (1: 5.16 and

Table 4: Mean values for number of male and female flowers per plant; and sex ratio of bottle gourd cvs. SH-BG-1 and Local as affected by growth regulator treatments

Treatment	No. of male flowers per plant				No. of female flowers per plant				Sex ratio (F:M)			
	SH-BG-1	**Per cent change over control**	**Local**	**Per cent change over control**	**SH-BG-1**	**Per cent change over control**	**Local**	**Per cent change over control**	**SH-BG-1**	**Per cent change over control**	**Local**	**Per cent change over control**
Ethephon	31.00	-35.76	24.66	-43.51	8.06	34.22	6.17	52.18	1:3.85	-51.35	1:3.99	-63.15
150 ppm	34.25	-29.03	28.33	-35.11	8.03	33.66	6.13	52.15	1:4.27	-46.84	1:4.62	-57.84
Ethephon 300 ppm	43.12	-10.65	35.33	-19.07	6.76	12.59	5.67	40.86	1:6.38	-20.53	1:6.23	-42.42
Ethephon 450 ppm												
Mean	**36.12**	**-**	**29.44**	**-**	**7.62**	**-**	**5.99**	**-**	**1:4.81**	**-**	**1 :4.95**	**-**
MH 200 ppm	33.00	-31.62	29.33	-32.82	7.46	24.22	5.83	44.73	1:4.42	-44.88	1:5.03	-53.55
MH 300ppm	35.57	-26.29	38.00	-12.96	7.40	23.12	5.70	41.73	1:4.81	-40.02	1:6.67	-38.41
MH 400ppm	41.40	-14.21	40.33	-8.38	6.60	9.81	5.30	31.51	1:6.27	-21.82	1:7.61	-27.79
Mean	**36.65**	**-**	**35.88**	**-**	**7.15**	**-**	**5.61**	**-**	**1:5.16**	**-**	**1:6.44**	**-**
TIBA 25ppm	32.20	-33.27	31.00	-28.90	7.40	23.12	6.20	53.84	1:4.35	-45.74	1:5.00	-53.50
TIBA 50ppm	47.47	-1.64	38.66	-11.45	7.26	20.89	5.93	47.22	1:6.54	-18.45	1:6.52	-39.37
TIBA 75ppm	52.99	9.80	45.00	3.07	6.93	15.35	4.90	21.58	1:7.65	-4.61	1:9.18	-15.23

Mean	**44.22**	**-**	**38.22**	**-**	**7.19**	**-**	**5.67**	**-**	**1:6.18**	**-**	**1: 6.90**	**-**
Control	**48.26**	**-**	**43.66**	**-**	**6.01**	**-**	**4.03**	**-**	**1:8.02**	**-**	**1:10.83**	**-**
G.R. (Mean)	**38.99**	**-**	**34.51**	**-**	**7.32**	**-**	**5.76**	**-**	**1: 5.38**	**-**	**1:6.09**	**-**
C. D. (Treatment)	**2.57**	**-**	**2.17**	**-**	**0.79**	**-**	**0.55**	**-**	**0.93**	**-**	**0.78**	**-**
C. D. (G. R.)	**2.27**	**-**	**3.64**	**-**	**0.44**	**-**	**0.56**	**-**	**0.67**	**-**	**1.21**	**-**

G.R = Growth Regulators

1:6.44) in both the varieties SH-BG-1 and Local. When different treatments were analysed, Ethephon @ 150 ppm was found most effective in narrowing the female: male flower ratio (1: 3.85 and 1: 3.99) showing a decrease of –51.35% and –63.15% over control whereas TIBA @ 75 ppm recorded widest sex ratio (1: 7.65 and 1: 9.18) showing a decrease of –4.61% and –15.23% in both the varieties respectively. As compared to control, however, all the treatments resulted in narrowing down the sex-ratio in both the varieties. There was decrease in female: male flower ratio in both the varieties when the concentrations of Ethephon, MH and TIBA was increased.

7. Fruit length

The Table-5 the data on fruit length for both the varieties SH-BG-1 and Local has been presented. The comparison of growth regulators application versus control revealed non-significant increase in fruit length (51.62 cm) in variety SH-BG-1 but significant increase (47.37cm) in variety Local as compared to control (50.02 cm and 42.97 cm). Among different growth regulators MH significantly increased fruit length (54.49 cm and 49.94 cm). However, Ethephon and TIBA were at par with each other in both the varieties but Ethephon and TIBA decreased fruit length (48.12 cm and 48.96 cm) in variety SH-BG-1 while they increased fruit length (46.32 cm and 45.86 cm) in variety Local as compared to control, respectively. Among different concentrations, MH @ 200 ppm showed maximum fruit length (58.74 cm and 56.03 cm), an increase of 17.43% and 6.67% over control in both the varieties followed by MH @ 300 ppm (55.36 cm) in variety SH-BG-1 and TIBA @ 25 ppm (52.80 cm) in Local. Lowest fruit length was recorded in case of TIBA @ 75 ppm (44.27 cm and 41.69 cm) showing a decrease of 11.49% and –2.97% in both the varieties. There was increase in fruit length with the increase in concentration of Ethephon, while the fruit length decreased with the increase in concentration of MH and TIBA in both the varieties.

8. Fruit girth

The data on fruit girth for both the varieties SH-BG-1 and Local has been presented in Table-5. The perusal of data revealed non-significant decrease in the fruit girth due to the application of growth regulators (6.94 cm and 6.58 cm) in comparison to control (7.10 cm and 6.58 cm) in both the varieties, respectively.

Irrespective of concentrations of different growth regulators, Ethephon recorded maximum fruit girth (7.02 cm and 6.56 cm) followed by MH (7.01 cm and 6.34 cm) in both the varieties. Assessment of individual treatments revealed that Ethephon @ 150 ppm showed maximum fruit girth (7.50 cm and 7.39 cm.) showing an increase of 5.64% and 12.40% followed by MH @ 400 ppm (7.25 cm. and 6.99 cm) showing an increase of 2.11% to 6.27% in both the varieties respectively. Minimum fruit diameter (6.67 cm.) was recorded by MH @ 200 ppm in variety SH-BG-1 and by TIBA @ 25 ppm (5.54 cm) in Local. As the

Table 5: Mean values for fruit length, fruit girth and fruit weight of bottle gourd cvs. SH-BG-1 and Local as affected by growth regulator treatments

Treatment	Fruit length (cm)				Fruit girth (cm)				Fruit weight (kg)			
	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control
Ethephon	46.04	-7.99	42.17	-1.85	7.50	5.64	7.39	12.4	1.56	4.00	1.41	3.67
150 ppm	46.35	-7.33	47.05	9.51	6.82	-3.94	6.65	1.06	1.49	0.66	1.35	-0.74
Ethephon 300 ppm	51.99	3.93	49.75	15.77	6.75	-4.92	5.69	13.48	1.40	-5.41	1.33	-2.20
Ethephon 450 ppm												
Mean	**48.12**		**46.32**		**7.02**		**6.56**		**1.48**		**1.36**	
MH 200 ppm	58.74	17.43	56.03	30.39	6.67	-6.05	5.99	-8.96	1.53	2.00	1.43	5.15
MH 300ppm	55.36	10.67	50.62	17.80	7.11	0.18	6.05	-7.96	1.48	0.00	1.38	1.47
MH 400ppm	49.39	-1.23	43.19	0.51	7.25	2.11	6.99	6.27	1.47	-0.67	1.34	-1.47
Mean	**54.49**		**49.94**		**7.01**		**6.34**		**1.49**		**1.38**	
TIBA 25ppm	53.78	7.52	52.80	22.88	6.74	-5.07	5.54	-15.86	1.53	3.37	1.40	2.94
TIBA 50ppm	48.84	-2.36	43.10	0.30	6.76	-4.79	6.39	-2.94	1.45	-2.03	1.33	-2.20
TIBA 75ppm	44.27	-11.49	41.69	- 2.97	6.87	-3.19	6.61	0.46s	1.42	-4.05	1.32	-2.94

Mean	**48.96**	**-**	**45.86**	**-**	**6.79**	**-**	**6.17**	**-**	**1.46**	**-**	**1.35**	**-**
Control	**50.02**	**-**	**42.97**	**-**	**7.10**	**-**	**6.58**	**-**	**1.48**	**-**	**1.36**	**-**
G.R. (Mean)	**51.62**	**-**	**47.37**	**-**	**6.94**	**-**	**6.36**	**-**	**1.50**	**-**	**1.37**	**-**
C. D. (Treatment)	**4.08**	**-**	**3.30**	**-**	**0.81**	**-**	**0.82**	**-**	**0.11**	**-**	**0.07**	**-**
C. D. (G. R.)	**3.02**	**-**	**2.63**	**-**	**0.27**	**-**	**0.59**	**-**	**0.04**	**-**	**0.06**	**-**

G. R = Growth Regulators

concentration of Ethephon was increased the fruit girth decreased whereas, the fruit girth increased with the increase in concentration of MH and TIBA.

9. Fruit weight

In Table-5 the data on average fruit weight for both the varieties of bottle gourd has been presented. Application of growth regulators irrespective of concentrations and the chemicals used, non-significantly increased the fruit weight (1.50 kg and 1.37 kg) as compared to control (1.48 kg and 1.36 kg) in both the varieties SH-BG-1 and Local, respectively. Individual growth regulators irrespective of concentrations showed significant effect on fruit weight with MH showing maximum fruit weight (1.49 kg and 1.38 kg) while as TIBA recorded minimum fruit weight (1.46 kg and 1.35 kg) in comparison to control in both the varieties. Among different concentrations, maximum fruit weight was shown by Ethephon @ 150 ppm (1.56 kg) *i.e.* an increase of 4.00% in variety SH-BG-1 and in variety Local by MH @ 200 ppm (1.43 kg) showing an increase of 5.15 % over control. Maximum fruit weight was shown by Ethephon @ 450 ppm (1.40 kg) in variety SH-BG-1 and TIBA @ 75 ppm (1.32 kg) in Local. Fruit weight decreased in both the varieties with the increase in concentration of Ethephon, MH and TIBA.

10. Number of fruits per plant

The data related to number of fruits per plant for both the varieties SH-BG-1 and Local is given in Table-6. Significant increase in the number of fruits per plant was recorded due to application of growth regulators irrespective of chemicals and concentrations (4.06 and 3.02) in comparison to control (3.01 and 2.10) in both the varieties, respectively. All individual growth regulators significantly increased the number of fruits per plant with maximum number of fruits shown by ethephon (4.26 and 3.25) followed by TIBA in both the varieties. The results further revealed that TIBA @ 25 ppm showed highest fruit number per plant (4.43) showing an increase of 47.28% followed by Ethephon @ 150 ppm (4.40), an increase of 46.17% in variety SH-BG-1, though both differed non-significantly. Ethephon @ 150 ppm showed highest fruit number (3.49) followed by TIBA @ 25 ppm (3.40) showing an increase of 66.19% and 61.90%, respectively in variety Local. Lowest fruit number was recorded by MH @ 400 ppm (3.37 and 2.20) in both the varieties respectively. There was decrease in number of fruits per plant as the concentration of Ethephon, MH and TIBA was increased in both the varieties.

11. Fruit yield per plant

In Table-6 the data on fruit yield per plant for both the varieties has been

presented. The comparison of growth regulators application irrespective of concentrations and the chemicals used versus control revealed significant increase in fruit yield per plant (6.07 kg and 4.14 kg) in comparison to control (4.51 kg and 2.87 kg) in both the varieties SH-BG-1 and Local, respectively. The perusal of data further revealed that Ethephon recorded highest fruit yield

Table 6: Mean values for number of fruits per plant, fruit yield per plant and number of seeds per fruit of bottle gourd cvs. SH-BG-1 and Local as affected by growth regulator treatments

Treatment	No. of fruits per plant				Fruit yield per plant (kg)				No. of seeds per fruit			
	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control
Ethephon	4.40	46.17	3.49	66.19	6.86	52.11	4.92	71.42	153.00	26.44	195.67	15.78
150 ppm	4.30	42.85	3.20	52.38	6.41	42.12	4.32	50.52	98.00	-19.00	147.00	-13.01
Ethephon 300 ppm	4.01	33.22	3.06	45.71	5.54	22.84	4.07	41.81	85.33	-29.47	126.44	-25.18
Ethephon 450 ppm												
Mean	**4.26**	-	**3.25**	-	**6.27**	-	**4.45**	-	**112.11**	-	**156.44**	-
MH 200 ppm	4.30	42.85	3.30	57.14	6.54	45.01	4.72	64.45	83.33	-31.13	158.67	-6.11
MH 300ppm	3.87	28.46	3.10	47.61	5.72	26.82	4.27	49.02	107.00	-11.57	178.33	5.52
MH 400ppm	3.37	11.96	2.20	4.76	4.95	9.76	2.95	2.78	189.67	56.75	254.00	50.29
Mean	**3.84**	-	**2.86**	-	**5.73**	-	**3.97**	-	**126.78**	-	**197.00**	-
TIBA 25ppm	4.43	47.28	3.40	61.90	6.78	50.33	4.76	65.10	168.00	38.84	191.33	13.21
TIBA 50ppm	3.96	31.78	3.10	47.62	5.74	27.27	4.12	43.55	151.00	24.79	189.67	12.23
TIBA 75ppm	3.96	31.78	2.40	14.29	5.62	24.61	3.16	10.10	105.00	-13.22	167.33	-0.98

Mean	**4.01**	-	**2.97**	-	**6.05**	-	**4.01**	-	**141.33**	-	**182.77**	-
Control	**3.01**	-	**2.10**	-	**4.51**	-	**2.87**	-	**121.00**	-	**169.00**	-
G.R. (Mean)	**4.06**	-	**3.02**	-	**6.07**	-	**4.14**	-	**126.73**	-	**178.73**	-
C. D. (Treatment)	**0.78**	-	**0.23**	-	**0.91**	-	**0.63**	-	**7.78**	-	**10.02**	-
C. D. (G. R.)	**0.22**	-	**0.73**	-	**0.56**	-	**0.72**	-	**16.89**	-	**15.48**	-

G. R. = Growth Regulators

(6.27 kg and 4.45 kg) followed by TIBA (6.05 kg and 4.01 kg) in both the varieties. When different concentrations were assessed, it was found that Ethephon @ 150 ppm recorded highest fruit yield (6.86 kg and 4.92 kg) showing an increase of 52.11 % and 71.42% over control in both the varieties. Lowest fruit yield was recorded in MH @ 400 ppm (4.95 kg and 2.95 kg) in both the varieties SH-BG-1 and Local, respectively but was still higher than the control. Fruit yield per plant was found to decrease in both the varieties when the concentration of Ethephon, MH and TIBA was increased.

12. Number of seeds per fruit

The data related to the number of seeds per fruit for both the varieties has been presented in Table-6. The perusal of data revealed non-significant increase in the number of seeds per fruit due to the application of growth regulators irrespective of chemicals and concentrations used (126.73 and 178.73) as compared to control (121.00 and 169.00) in both the varieties SH-BG-1 and Local, respectively. Results in the Table-6 further revealed that Ethephon showed lowest number of seeds per fruit (112.11 and 156.44) in both the varieties as compared to control, while as TIBA showed highest number of seeds (141.33) in variety SH-BG-1 and MH showed highest seed number (197.00) in Local. Among different concentrations Ethephon @ 450 ppm recorded lowest number of seeds per fruit (85.33 and 12644) showing a decrease of –29.47% and –25.18%, respectively in both the varieties. MH @ 400 ppm showed highest number of seeds per fruit (189.67 and 254.00) with an increase of 56.75% and 50.29% in both the varieties, respectively as compared to control. As the concentration of Ethephon and TIBA was increased, there was decreased in the number of seeds per fruit. While as the number of seeds per fruit increased with the increase in concentration of MH in both the varieties.

13. Vine length (cm)

In Table-7 the data on vine length for both the varieties SH-BG-1 and Local is presented. The perusal of data revealed non significant increase in vine length due to the application of growth regulators irrespective of chemical and concentrations used (299.70 cm and 275.30 cm) as compared to control (296.70 cm and 274.00 cm) in both the varieties SH-BG-1 and Local, respectively. Among individual growth regulators, Ethephon showed maximum increase in vine length (299.55 cm and 283.78 cm) while MH recorded minimum vine length (290.11 cm and 264.67 cm) in comparison to control in both the varieties. Assessment of the individual treatment revealed that Ethephon @ 150 ppm recorded maximum vine length (327.33) in variety SH-BG-1 and TIBA @ 75 ppm recorded maximum vine length (304.00 cm) in variety Local, showing an increase of 10.33% and 10.94% over control, respectively. MH @ 400 ppm recorded minimum vine length (279-.67 cm and 246.67 cm) in both the varieties showing a decrease of –5.72% and –9.97%. In case of Ethephon

and MH, there was decrease in vine length with an increase in concentration but in case of TIBA, vine length increased with an increase in concentration.

14. Number of nodes per plant

The data on the number of nodes per plant for both the varieties SH-BG-1 and Local is presented in Table-7. Growth regulator application irrespective of concentrations or the chemical, lead to significant increase in number of nodes per plant (21.84) in variety SH-BG-1 but non-significant increase (19.81) in variety Local in comparison to control (18.66 and 18.00). Results in Table-7 further revealed that among different growth regulators, TIBA recorded maximum number of nodes (21.65) in variety SH-BG-1 and Ethephon recorded maximum number of nodes (20.40) in Local. When individual concentration of growth regulators was assessed, it was observed that Ethephon @ 150 ppm recorded maximum number of nodes (23.97 and 22.68) showing an increase of 28.16% and 26% over control while as MH @ 400 ppm recorded minimum number of nodes (19.29 and 17.49) in both the varieties.

15. Internodal distance

In Table-7 the data on internodal distance for both the varieties has been presented. Internodal distance was significantly reduced by growth regulators application (13.88 cm and 13.65 cm) as compared to control (15.89 cm and 15.22 cm) in both the varieties SH-BG-1 and Local, respectively. The results further revealed that among different growth regulators irrespective of

Table-7: Mean values for vine length, number of nodes per plant and internodal distance of bottle gourd cvs. SH-BG-1 and Local as affected by growth regulator treatments

Treatment	Vine length (cm)				No. of nodes per plant				Internodal distance(cm)			
	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control	SH-BG-1	Per cent change over control	Local	Per cent change over control
Ethephon	327.33	10.33	300.67	9.73	23.97	28.16	22.68	26.00	14.13	-11.07	13.26	-12.87
150 ppm	290.00	-2.15	297.00	8.39	20.00	7.18	21.36	18.66	14.50	-8.75	13.90	-8.67
Ethephon 300 ppm	281.33	-5.16	253.67	-7.41	19.88	6.53	18.20	1.11	15.46	-2.70	13.90	-8.67
Ethephon												
450 ppm												
Mean	**299.55**	**--**	**283.78**	**-**	**20.75**	**-**	**20.40**	**-**	**14.70**	**-**	**13.69**	**-**
MH 200 ppm	309.00	4.15	298.33	8.87	23.27	24.70	21.36	18.66	13.28	-16.42	12.95	-14.91
MH 300ppm	281.67	-5.05	249.00	-9.12	20.63	10.55	19.23	6.83	13.65	-14.09	13.97	-8.21
MH 400ppm	279.67	-5.72	246.67	-9.97	19.29	3.37	17.49	-2.83	14.46	-8.99	14.10	-7.35
Mean	**290.11**		**264.67**	**-**	**21.06**	**-**	**19.36**	**-**	**13.79**	**-**	**13.67**	**-**
TIBA 25ppm	284.33	-4.15	250.00	-8.75	21.34	14.36	18.54	3.00	14.07	-11.45	15.01	-1.37
TIBA 50ppm	293.33	-1.12	278.33	1.58	21.21	13.66	18.97	5.38	13.83	-12.58	14.67	-3.61
TIBA 75ppm	300.33	1.23	304.00	10.94	22.41	20.09	22.51	25.05	12.68	-20.20	11.11	27.00

Mean	**292.66**	**-**	**277.44**	**-**	**21.65**	**-**	**19.34**	**-**	**13.53**	**-**	**13.59**	**-**
Control	**296.70**	**-**	**274.00**	**-**	**18.66**	**-**	**18.00**	**-**	**15.89**	**-**	**15.22**	**-**
G.R. (Mean)	**299.70**	**-**	**275.30**	**-**	**21.84**	**-**	**19.81**	**-**	**13.88**	**-**	**13.65**	**-**
C. D. (Treatment)	**11.33**	**-**	**17.17**	**-**	**1.92**	**-**	**1.40**	**-**	**0.96**	**-**	**0.16**	**-**
C. D. (G. R.)	**6.55**	**-**	**8.29**	**-**	**1.61**	**-**	**1.98**	**-**	**0.95**	**-**	**1.11**	**-**

G.R = Growth Regulators

concentrations, TIBA recorded shortest internodal distance (13.53 cm and 13.59 cm) followed by Ethephon (13.79 cm and 13.67 cm) in both the varieties. Among different concentrations, TIBA @ 75 ppm recorded shortest internodal distance (12.88 cm and 11.11 cm) showing a decrease of –20.20% and –27.00% in both the varieties. Ethephon @ 450 ppm recorded largest internodal distance (15.46cm) in variety SH-BG-1 while TIBA @ 25 ppm recorded largest internodal distance (15.10 cm) in variety Local. Internodal distances increased with an increase in concentration of Ethephon and MH but decreased with an increase in concentration of TIBA in both the varieties .

Chapter-V

DISCUSSION

Cucurbits exhibit a wide array of sex forms which are known to be governed by genetical as well as environmental factors (Singh and Choudhary, 1989). A high correlation between the number of pistillate flowers and total yield has invited attention of research workers towards the aspect of sex expression in cucurbits.

Since last three decades it has been demonstrated that sex expression and yield in cucurbits could be effectively modified by application of various growth regulators. However, responses vary with the species of plant, the type of chemical and its concentration used. These growth regulators induce various physiological effects which could be used to regulate various phases of plants metabolism, growth and development (Sims and Gledhill, 1969).

Bottle gourd is a monoecious crop in which staminate flowers are borne at lower nodes than pistillate flowers and the number of male flowers is normally more than the female flowers with a sex ratio ranging from resulting in the production of fewer fruits per plant and hence lower yields. However, several plant growth regulators have been successfully exploited not only to increase the number of female flowers but also fruit set and ultimate yield (Singh *et al.*, 1975; Shannon and Robinson, 1978; Krishnamoorthy and

Sandooja, 1982; and Arora *et al.*, 1985). Under temperate conditions of Kashmir valley the information regarding effects of various growth regulators on sex expression and yield in cucurbits in general and in bottle gourd in particular, is very scanty. Hence, the present investigation was carried out to study the effect of various growth regulators viz., Ethephon, MH and TIBA on female: male flower ratio and also to ascertain their effect on early yield and yield attributing characters in bottle gourd. The results of the experiment conducted are discussed here under:

Growth regulator application not only delayed the appearance of first staminate flower but also induced earlier appearance of first pistillate flower in both the varieties of bottle gourd. However, response varied with the chemical and the concentration used. Staminate flower appeared on highest node in case of TIBA in both the varieties. Among various treatments Ethephon @ 150 ppm was most effective in shifting first staminate flower to higher node and first pistillate flower to lower node in both the varieties. The reduced level of gibberllins after Ethephon treatment may be responsible for delayed appearance of staminate flower in bottle gourd as reported by Singh (1980) and Arora *et al.* (1985). Similar effects have also been reported by Saimbhi (1984) and Krishnanmoorthy and Sandooja (1982) in bottle gourd.

Studies on number of staminate and pistillate flowers revealed that the application of growth regulators significantly reduced the number of staminate flowers coupled with increase in the number of pistillate flowers in both the varieties. Among growth regulators Ethephon was most effective followed by MH in variety SH-BG-1 and TIBA in Local. This modification of sex ratio in favour of female flowers by Ethephon is in conformity with the findings of Singh *et al.* (1975), Krishnamoorthy and Sandooja (1982) and Arora *et al*. (1982). These growth regulators probably produced auxin like effects which resulted in production of more pistillate flowers. MH has also been reported to cause reduction in respiration rate, an effect similar to low temperature which promotes female flower production in cucurbits (Cathey, 1964; and Choudhary and Babel, 1969). Similar trend has been reported by Choudhary and Elkholy(1972) in experiments with watermelon.

The practical utility of increasing the number of pistillate flowers is to obtain increased number of fruits per plant. However, size and weight of such fruits would also be important as these fruit characters are useful for their consumer acceptability. In the present investigation MH recorded maximum fruit length while as MH along with Ethephon recorded highest fruit girth in both the varieties. Similar findings have been also reported by Singh (1985).

Number and weight of fruits per plant were significantly affected by application of growth regulators at various concentrations. Ethephon @ 150 ppm and MH @ 200 ppm recorded highest fruit weight in both the varieties SH-BG-1 and Local, respectively. Increase in the number of fruits per plant with Ethephon and MH has been reported by Arora *et al*. (1982); and Singh and Choudhary (1989) in bottle gourd. Similar results have been also recorded by Pandey and Singh (1973) in bottle gourd.

Fruit yield per plant was significantly increased by application of growth regulators as compared to control. All the three growth regulators (Ethephon, MH and TIBA) recorded increase in the fruit yield in comparison to control which is similar to the findings of Singh *et al.* (1975) and Saimbhi and Gill (1988) in bottle gourd and in bitter gourd by Verma *et al.* (1984). Application of Ethephon @ 150 ppm and TIBA @ 25 ppm recorded highest fruit yield per plant in both the varieties. This increase in fruit yield was due to increase in the number of fruits per plant and average fruit weight. The possible reason for increased number of fruits and yield per plant was that the plants remained physiologically more active to build up sufficient food material for developing more number of flowers and fruits, ultimately leading to higher fruit yield per plant. Higher fruit yields associated with Ethephon application have been reported in squash by Singh *et al.* (1975), in bottle gourd by Singh and Choudhary (1989) and in bitter gourd by Verma *et al.* (1984). The above results have also been reported by Arora *et al.* (1985) who found improvement in fruit yield of bottle gourd, sponge gourd and summer squash with MH @ 50 ppm, Ethrel @ 100 ppm and Ethrel @ 250 ppm, respectively.

Application of growth regulators significantly affected the number of seeds per fruit. Ethephon application recorded lowest number of seeds per fruit in both the varieties while TIBA and MH recorded highest number of seeds per fruit in both the varieties SH-BG-1 and Local respectively.

Apart from increase in yield, application of growth regulators also resulted in the reduction of number of days taken for first fruit picking. TIBA and Ethephon were equally effective in reducing the days to first fruit picking in both the varieties. Such observations have been reported by

Arora *et al.* (1987), Saimbhi and Thakur (1974) and Arora *et al.* (1985), who attributed early fruit maturity as substitution of thermal requirements by these chemicals. But on the other hand the delayed fruit maturity by 1-2 weeks may be useful in giving more vegetative growth and hence more fruit yield per plant.

Growth character like vine length was non-significantly affected by application of growth regulators as compared to control. Though non-significantly, Ethephon recorded highest vine length while MH registered shortest vine length in both the varieties. Arora *et al.* (1985); and Saimbhi and Thakur (1974) also observed similar results in various crops and attributed increased vine length to increased cell elongation whereas MH, on the other hand by inhibiting cell division in the apical meristem probably suppressed the stem growth, resulting in shorter plants.

Application of growth regulators irrespective of chemical and the concentrations used, significantly increased the number of nodes per plant with Ethephon, MH and TIBA being at par with each other in their individual effects. Significant effect was observed on internodal distance as a result of growth regulators application as compared to control. Ethephon @ 450 ppm recorded maximum internodal distance while TIBA @ 75 ppm recorded minimum internodal distance which confirm the findings of Arora and Partap (1988) in pumpkin. Shorter internodal distance resulted in more number of nodes per plant which in turn produced more flowers and fruits.

From the present investigation it can be concluded that all the three growth regulators showed marked improvement in sex ratio and fruit yield over the control. Ethephon was found to be most effective as compared to TIBA and MH in increasing sex ratio and fruit yield per plant. This increase in the fruit yield could be attributed mainly to the reduction in number of male flowers with concomitant increase in the number of female flowers leading to higher number of fruits per plant. Ethephon @ 150 ppm proved to be most effective in bringing improvement in sex ratio and fruit yield and the second best treatment was TIBA @ 25 ppm.

Chapter-VI

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of different growth regulators on sex expression and yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] was carried out during kharif 2002 at Vegetable Experimental Farm, Division of Olericulture, SKUAST(K), Shalimar. The experimental material consisted of two varieties of bottle gourd viz. SH-BG-1 and Local. The various concentrations of growth regulators viz. Ethephon (150, 300 and 450 ppm), Maleic Hydrazide (200, 300 and 400 ppm) and Tri-iodobenzoic Acid (25, 50 and 75 ppm) were sprayed on both varieties following randomized block design with three replications. The results obtained during the investigation are summarized as follows.

Growth regulators significantly affected the node number of first male and female flower in both the varieties SH-BG-1 and Local. Among different growth regulators TIBA delayed the appearance of first staminate flower while Ethephon induced early appearance of first female flower in both the varieties.

Days to first fruit picking was significantly affected by growth regulators application in both the varieties. Application of MH was most effective in delaying days to first fruit picking in both the varieties. MH application @ 400 ppm was found most effective in delaying days to first fruit picking in variety SH-BG-1 while TIBA @ 25 ppm showed maximum delay in first fruit picking in variety Local.

Application of growth regulators significantly decreased the number of male flowers and increased the number of female flowers in both the varieties. Ethephon was most effective in decreasing the number of male flowers and increasing the number of female flowers in both the varieties SH-BG-1 and Local. Application of Ethephon @ 150 ppm was found to be most effective among all the growth regulator treatments. Consequently Ethephon was found to be most effective in modifying the sex ratio in favour of female flowers, with the dose of 150 ppm being most effective.

Growth regulators application increased fruit length non- significantly in variety SH-BG-1 and significantly in Local. Among growth regulators MH irrespective of concentrations recorded significant increase in fruit length in both the varieties. Application of growth regulators non-significantly increased the fruit girth in both the varieties. Irrespective of concentrations Ethephon recorded highest fruit girth in both the varieties. Ethephon @ 150 ppm was found to be most effective in increasing fruit girth as compared to control. Fruit weight was not affected significantly by application of growth regulators irrespective of concentrations and chemical used. Among the growth regulators MH recorded highest fruit weight in both the varieties. Ethephon @ 150 ppm and MH @ 200 ppm recorded highest fruit weight in both the varieties SH-BG-1 and Local, respectively.

Number of fruits per plant was significantly affected by application of growth regulators in both the varieties. Among growth regulators Ethephon recorded maximum number of fruits per plant in both the varieties. Ethephon @ 150 ppm was found most effective in increasing the number of fruits per plant in both the varieties. Application of growth regulators resulted in significant increase in fruit yield per plant in both varieties. Among different growth regulators Ethephon recorded highest fruit yield per plant in both the varieties. Ethephon @ 150 ppm proved to be most effective in increasing fruit yield per plant.

Growth regulators application non-significantly increased the number of seeds per fruit in both the varieties. TIBA and MH irrespective of concentrations recorded highest number of seeds per fruit while Ethephon recorded lowest number of seeds per fruit in both the varieties SH-BG-1 and Local, respectively. MH @ 200 ppm, Ethephon @ 450 ppm recorded lowest number of seeds per fruit in variety SH-BG-1 while Ethephon @ 450 ppm recorded lowest seed number in Local.

Application of growth regulators recorded increase in vine length, though non-significantly in both the varieties. Among growth regulators Ethephon recorded highest vine length while MH recorded lowest vine length in both the varieties. Number of nodes per plant registered increase due to growth regulator application irrespective of concentration and chemicals used. Ethephon @ 150 ppm recorded maximum nodes per plant in both the varieties. Growth regulators application significantly affected internodal distance also with TIBA @ 75 ppm showing shortest internodal distance in both the varieties.

From the present study it was concluded that application of growth regulators in general significantly modified sex ratio in favour of female flowers and increased fruit yield per plant in comparison to control. Irrespective of concentrations, Ethephon @ 150 ppm was superior in narrowing down the sex ratio and increasing the yield followed by TIBA @ 25 ppm. Therefore, it is suggested that for the improvement of fruit yield in bottle gourd, the application of Ethephon @ 150 ppm or TIBA @ 25 ppm may be followed under the temperate conditions.

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*Originals not seen