INFLUENCE OF GA_3 ON GROWTH AND YIELD OF FRENCH MARIGOLD

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INFLUENCE OF GA_3 ON GROWTH AND YIELD OF FRENCH MARIGOLD

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF GA_3 ON GROWTH AND YIELD OF FRENCH MARIGOLD"** submitted to the **Department of Horticulture**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (MS)** in **HORTICULTURE** embodies the result of a piece of bona fide research work carried out by **SANJIDA JAHAN**, Registration No.**13-05263** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

June, 2020

Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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The Author

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ABSTRACT

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2018 to January 2019. Five French marigold cultivars *viz*. V_1 (Royal yellow fire), V_2 (Royal red), V_3 (Royal orange), V_4 (Royal bolero) and V_5 (Royal yellow) and four levels of GA_3 application *viz*. G_0 (control; 0 ppm GA_3), G_1 (50 ppm GA_3), G_2 (100 ppm GA_3) and G_3 (150 ppm GA_3) were considered for the study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of the combination of cultivars and GA_3, all the parameters were affected significantly. The maximum plant height (34.67 cm) and number of leaves plant^{-1} (25.40) were achieved from V_4G_3. The lowest days to 1st visible flower bud (14.67), days to 1st flower (14.67), days to 50% flowering (25.33) and days to 80% flowering (31.67) were recorded from V_4G_2 which also gave highest number of branches plant^{-1} (9.87), floral diameter (6.53 cm), single flower weight (5.33 g), total number of flowers plant^{-1} (24.62) and number of flowers ha^{-1} (6154 thousand). Again, the minimum plant height (24.93 cm) and number of branches plant^{-1} (4.67) were recorded from V_5G_0 which also contributed to the lowest floral diameter (5.03 cm), single flower weight (2.00 g), total number of flowers plant^{-1} (15.05) and number of flowers ha^{-1} (3763 thousand). Concerning economic study, the highest gross return (Tk. 615400), net return (Tk. 397992) and BCR (2.83) were obtained from V_4G_2 whereas the lowest gross return (Tk. 376300), net return (Tk. 162162) and BCR (1.75) were obtained from V_5G_0. From the above results, it can be concluded that the treatment combination of V_4G_2 (Royal bolero with 100 ppm GA_3) showed highest yield advantage regarding flower yield of marigold and this treatment combination can be considered as the best treatment combination.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
LSD	=	Least Significant Difference
MS	=	Master of Science
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
NaOH	=	Sodium hydroxide
GA_3	=	Gibberellic Acid
MOP	=	Murate of Potash
TSP	=	Triple Super Phosphate
UNDP	=	United Nations Development Program
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Marigold (*Tagetes spp.* L.) belonging to family Asteraceae is one of the major important commercial flower crop and widely grown for loose flower production. In general, the commercially cultivated marigold is of two types *i.e.* African marigold (*Tagetes erecta*)) and French marigold (*Tagetes patula*). Marigold is popular throughout the world because of wide spectrum of attractive colors, shape and good keeping quality. Marigold has gained popularity on account of its easy cultivation, wide adaptability and production throughout the year (Singh *et al*., 2019).

Marigold becomes one of the most popular flowers in our country on account of its easy culture wider adaptability and lucrative returns. Its habit of free flowering, short duration to product marketable flowers, and wide range of colors, shape, size and keeping quality attracted the attention of flower growers (Kumar *et al*., 2010). It is in great demand as loose flower throughout year and commonly used for decoration, making garlands for religious and social functions. Globular shaped flower with long stalks are used for cut-flower purposes. In gardens marigold provides beautification of beds and borders. An orange pigment extracted from petals is in great demand for poultry feed (Kumar *et al*., 2010).

Since climatic conditions of our country are highly variable, hence introduced varieties vary in performance. Therefore, it is essential to develop varieties suited to specific climatic condition, which can be utilized for further improvement. The extent of improvement depends on the variability in different genotypes (Kumar *et al*., 2015). Marigold can be produced throughout the year *viz*. in summer, rainy and winter season. However, low productivity of marigold is one of the major constraints in its commercial production. With diverse genotypes of indigenously available marigold, there is a lot of potential to explore and identify marigold genotypes with higher yield. For this, different genotypes of marigold available in production area need to be evaluated for growth, flowering, yield attributes and yield (Naik *et al*., 2019).

Moreover, susceptibility of existing varieties to different biotic stresses augments the need of promising genotypes. The ultimate yield and production of quality flowers, pigment contents in flower and resistance to biotic factors depend upon the selection of

suitable cultivars for a particular locality (Naik *et al*., 2019). However, the growers are unaware of varieties suitable for their location and selecting the varieties based on the fellow farmers recommendation and relies completely on seed shops. Under given agro-climatic conditions, it is important to study the performance of existing varieties available in market and also to identify the best genotype with desirable characteristics and yield which will fetch remunerative profit to farmers (Mahantesh *et al*., 2018).

In recent year, use of plant growth regulators is being increased to manipulate the growth, flowering and yield of many ornamental plants (Markam *et al*., 2016). Application of plant growth regulator in floriculture played important role in vegetative propagation, inhibition of abscission, prevention of bud dormancy, growth control, and promotion of flowering, prolonging the vase life of flowers and retarding senescence (Kumar *et al*., 2010).

Use of growth regulators play an important role by increasing, reducing or modifying the physiological process within plant and which ultimately affect the growth, flowering and yield. Gibberellins fall in growth promote group of plant hormones. Gibberellic acid plays a vital role in improving the vegetative growth characters of the plants as it enhances the elongation and cell division by promoting the DNA synthesis in the cell (Meshram *et al*., 2015). Gibberellic acid plays important role in elongation of shoot, flower induction, flower and seed development and mobilization of storage reserves (Kumar *et al*., 2010). It reduced the juvenile phase due to increase in photosynthesis and respiration with enhanced CO_2 fixation in the plant. Gibberellic acid helps to produce the good quality flower and increased flower yield in marigold (Meshram *et al*., 2015).

Keeping these views in concern, the present investigation was carried out with the following objectives:

1. To identify the suitable French marigold cultivar for commercial production.
2. To find out the optimum level of GA_3 on growth and yield of French marigold.
3. To determine the best combination of variety and GA_3 levels on growth and yield of French marigold cultivar.

CHAPTER II

REVIEW OF LITERATURE

A brief review of research work done on the "Influence of GA_3 on growth and yield of French marigold" is being discussed in this chapter. It includes brief results of the research work done in Bangladesh and elsewhere which is similar to or closely related with the present investigation. In this chapter, the updated literature pertaining to different aspects of the present research work done on the evaluation of marigold cultivars and/or GA_3 for growth and flower yield of marigold and other floricultural crops have been summarized under following heads:

2.1 Effect of cultivars

Naik *et al*. (2019) carried out a study to evaluate and commercialize the marigold (*Tagetus spp.* L.) genotypes for UKP command area in Karnataka" for two seasons during Kharif (2015-16) and Summer (2016-17). The results reveals that, among the different genotypes, mean plant height was significantly varied among the varieties in season-I and season-II. The maximum plant height was recorded in cv. Maxima yellow (66.14 cm and 52.26 cm) and it was followed by cv. Arka Bangara-2 (58.17cm and 50.21cm), and least was recorded in cv. Raichur local (46.97 cm) and cv. Arka Bangara (37.85 cm), maximum mean plant spread was recorded in cv. Maxima yellow (2452.80 cm^2 and 1670.33 cm^2 respectively) followed by cv. Arka Bangara-2 (2280.90 cm^2 and 1670.23 cm^2 respectively), Whereas, the least plant spread recorded was in cv. Raichur local (1593.53 cm^2 and 1021.67 cm^2 respectively) and maximum number of secondary branches per plant was noticed in Arka Bangara-2 (22.69 and 19.00) followed by Arka Agni (17.62 and 14.41) and least number of secondary branches found in Bhuvan Orange (11.81) and Arka Bangara (10.48) in karif and summer the season respectively. Netam *et al*. (2019) conducted an investigation entitled "The growth performance of marigold (*Tagetes spp*. L.)" with fifteen genotypes and three cultivars. Studies showed significant effect on plant height CGSG-2 at 30 DAT and CGR-2 at 60 DAT whereas, at 90 DAT, genotype CGJS-4 recorded maximum plant height. Maximum plant spread was recorded in genotype CGR-2 at 60 DAT and CGRJ-1 at 90 DAT. Maximum primary branches $plant^{-1}$ was recorded in genotype CGSG-2 at 30 DAT whereas, CGR-

3 at 60 and 90 DAT. Maximum secondary branches plant^{-1} was recorded in genotype PNG at 60 and 90 DAT. Maximum number of leaves plant^{-1} was recorded in genotype CGJS-3 at 30, 60 and 90 DAT.

Mahantesh *et al*. (2018) conducted a study to evaluate different African marigold (*Tagetes species* Linn.) genotypes for vegetative, floral and yield attributes on performance of 8 genotypes under semi-arid climatic conditions of Hyderabad, Telangana condition under the college of Horticulture Mojerla. Experiment was laid out in Randomised block design (RBD) with three replications, at College of Horticulture Mojerla, Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Mojerla during winter season of 2016 – 2017. All the genotypes showed significant variations for growth, flowering and yield parameters. The genotypes T5-Double Orange (81.79 cm) recorded the maximum plant height. Plant spread shows that maximum (N-S) was recorded T1-Arka Agni (48.83 cm). The maximum plant spread in (E-W) was recorded in genotype T1-Arka Agni (52.80 cm). The cultivar recorded the maximum stem girth T4-Erecta Naana Moon Light (5.17 cm). The maximum stem diameter (1.23 cm) was observed in T1-Arka Agni. Numbers of primary branches were maximum T1-Arka Agni (12.40). Secondary branches maximum in T1-Arka Agni (24.13). The genotypes T4-Erecta Naana Moon Light (46.63 days), recorded the least number of days to first flower bud appearance. The genotype T3-Arka Bangara-2 (48.40 days) was earliest in first flower opening. The maximum diameter of flower was recorded in T4-Erecta Naana Moon Light (6.13 cm).

Deepa and Patil (2016) conducted an investigation with the objective to find out the suitable marigold hybrids for cultivation under Dharwad condition. There were significant differences among the hybrids with respect to vegetative and floral characters. Among the hybrids, Double Orange, Garland Orange and Sarpan-11 were found to be superior with respect to vegetative growth and flower yield of marigold. They also observed that marigold is a hardy annual commercial and ornamental flower crop grown for its flowers. Flowers are commercially used for making garlands, wreaths, religious offerings, social functions, floral rangolies, decoration and as cut flower in one or other forms.

Kumar *et al*. (2015) carried out an investigation to study the performance of 10 genotypes of French marigold (*Tagetes patula* L.). Vegetative and flower characters varied significantly among the genotypes. The results revealed that the genotype hero red recorded maximum plant height (31.20 cm), stem diameter (2.00 cm), plant spread (30.10 cm), number of secondary branches (39.41) and number of flowers per plant (134.30 cm). Maximum number of primary branches was recorded for genotype red brocade (12.32) and duration of flowering (40.00 days) and maximum flower diameter (3.54 cm). Also, genotype red brocade took minimum days to flower bud initiation (25.68 days). Minimum days to opening of first flower were recorded for genotype yellow gate (8.76 days). Maximum flower weight was recorded for genotype honey comb (2.17 g) followed by red brocade (1.96 g). Maximum flower yield was recorded for honey comb (228.52 g/plant) followed by red brocade (219.64 g/plant).

Kumar *et al.* (2015) evaluated varieties of chrysanthemum for loose flower production and reported that the Decorative White recorded maximum plant height (60.9 cm), plant spread (40 cm), number of branches per plant (16) and number of leaves per branches (44). Significantly earlier appearance of bud (43), maximum average flower weight (8.6g), average 100 flower weight (320g), size of flower (8.5 cm) recorded under T_2 (Pompon Rosy Pink). Maximum flower diameter (7.60 cm) and floret size (2.1cm) recorded under T_9 (Suneel) whereas, maximum number of florets per flower (860) recorded under T_4 (Decorative Reddish Yellow). In treatment T_3 maximum number of flower per plant (42) was observed in impressive condition. Highest yield was observed under treatment T_3 (18.90 kg).

Singh *et al.* (2014) evaluated twenty-one genotypes of African marigold *(Tagetes erecta* L.) for growth and flowering. Analysis of variance for all the traits showed significant differences among genotypes for all the growth and flowering related traits. The result showed variation in plant height (64.00-106.67 cm), plant spread (49.33-72.00 cm), flower diameter (3.77-6.17 cm), days required for flowering (78.67-99.33 days), number of secondary branches (22.13-37.47) and flower duration (26.00-44.83 days).

Khobragade *et al.* (2014) evaluated four African marigold varieties *viz*. African Double Orange, Pusa Basanti Gainda, Pusa Narangi Gainda, and African Marigold Local-1 and reported that among all the varieties, Pusa Basanti Gainda attained maximum number of branches, number of flowers per plant and yield of flowers per plot and per hectare.

Choudhary *et al.* (2014) conducted a study on the performance of thirty genotypes of marigold. All the genotypes showed significant variations for growth, flowering and yield parameters. The genotype Hisar Jaffri-2 exhibited best performance in terms plant spread (77.72 cm), numbers of secondary branches plant^{-1} (150.97), number of bud's plant^{-1} (217.10), duration of flowering (76.53 days) and flower yield plot^{-1} (20.99 kg). The genotype MGH-148-3-3 recorded maximum stem diameter (2.14 cm) and dry weight of plant (130.72 g), whereas it was minimum (0.61 cm and 9.91 g, respectively) in Hisar Beauty. Maximum diameter of flower (8.21cm) was recorded in MGH-09-276, while it was minimum (4.01 cm) in Hisar Jaffri-2. The maximum dry weight of flower (2.04 g) was recorded in MGH-09-271.

Bharathi and Jawaharlal (2014) conducted an investigation to evaluate twenty-eight genotypes of African marigold *(Tagetes erecta.* L) for growth and flowering traits. The marigold germplasm exhibited significant variation for various growth and flowering traits. The highest plant height was recorded in Dharmapuri local (113.27 cm) and the highest number of primary and secondary branches plant^{-1} was observed in Bidhan-1 (22.40 and 41.47, respectively). The highest flower yield plant^{-1} was recorded in Coimbatore Local Orange (1.48kg) followed by Coimbatore local orange (1.12 kg).

Munikrishnappa *et al.* (2013) conducted an investigation to evaluate suitable varieties on growth and flower yield of China aster. The maximum flower yield (37.91 t ha^{-1}) was recorded in Phule Ganesh White and it was lowest Mixed Variety Local (9.97 ton). Number of cut flower production was maximum (55.43) in variety Phule Ganesh Violet and the lowest number of cut flower plant^{-1} was produced in Shashank (40.92). The maximum number of cut flowers (40.76 lakh ha^{-1}) was recorded in Phule Ganesh Violet and minimum number of cut flower (31.64 lakh ha^{-1}) was recorded in variety Kamini.

Krol (2012) evaluated five genotypes of pot marigold which differed in colour and in size of inflorescences *viz.*, 'Orange King', 'Persimmom Beauty' 'Promyk', 'Radio' and 'Santana'. For, morphological features 'Orange King' performed best. It produced the most numerous and shapeliest inflorescences, with the biggest number of ligulate flowers. Raw material yield of compared cultivars oscillated from 849 to 1661 kg ha^{-1} of flower heads, and the ligulate flowers themselves from 449 to 1141 kg ha^{-1}. In both cases the highest yield was obtained by 'Orange King', and the lowest by 'Promyk'.
Anuja and Jahnavi (2012) studied genetic variability and heritability involving thirty genotypes of French marigold and indicated that there were highly significant differences between the genotypes for flower yield and other growth and flower attributes.

Raghuvanshi and Sharma (2011) evaluated fourteen diverse genotypes of French marigold and found that the genotypes, differs significantly in for all characters. The mean performance of characters showed that the cultivar Safari has maximum duration of flowering (39.67 days) which at par with the Bonanza Bolero.

Narsude *et al.* (2010a) studied the different genotypes of marigold for growth and yield attributes. The genotype Pakharsangavi Local had significantly maximum plant height (114.64 cm) as compared to other genotypes, whereas, African Giant Double Mixed had the lowest (87.98 cm). Maximum spread of plant (64.48 cm) was observed in genotype Tuljapur Local-2, whereas, minimum (51.98 cm) was observed in genotype Marigold Orange Bunch. Maximum number of branches (21.46) were recorded in genotype Tuljapur Local-1, whereas, it was minimum (14.26) in genotype Latur Local. As regards to yield characters like number of flowers per plant, yield per plant and yield per hectare, the genotype Tuljapur Local-1 showed significantly superior performance and produced maximum number of flowers (71.00), yield $plant^{-1}$ (630.48 g) and maximum yield (24.67 MT ha^{-1}), followed by genotypes Pakharsangavi Local and Tuljapur Local-2.

Karuppaiah and Kumar (2010) carried out an investigation with thirty-four genotypes of African marigold to asses association of yield components and their direct and

indirect effects on flower yield. Results of correlation analysis indicated that the flower yield plant^{-1} was found to be significantly and positively correlated with number of branches plant^{-1}, flower size, flower weight, number of flowers plant^{-1} and xanthophylls content. The study indicated that flower diameter, number of flowers plant^{-1} and xanthophylls content are important characters in deciding the flower yield plant^{-1}.

Singh and Singh (2010) carried an experiment consisting forty-four genotypes of marigold. The genotypes TEG28 was found to have maximum days to flowering (87.00 days) and TEG7 showed earliest days to flowering (46.67 days).

Narsude *et al.* (2010) carried an investigation for performance of four improved and two Local genotypes of African marigold. The study showed that significantly maximum plant height in Pakharsangvi Local (114.64 cm) and minimum in African Joint Double Mix (87.98 cm.). They also reported that the significant differences in genotypes in respect of number of flowers per plant and yield of flowers per hectare was significantly more in genotype Tuljapur-1 (71.00 lakh) and minimum Akiolner Local (36.47 lakh).

Singh *et al.* (2008) studied twenty-nine lines of African marigold *(Tagetes erecta)* to assess the diversity present in the population for various growth and flowering attributes. Germplasm TEG 26 recorded maxmum plant height, flower diameter and number of petals plant^{-1}. Germplasm TEG 26 also attained second earliest value for days taken to flowering. Maximum number of secondary branches plant^{-1} was observed in germplasm TEG 17, whereas TEG 19 attained maximum flower yield plant^{-1} among all the twenty-nine accessions.

Singh and Mishra (2008) conducted an experiment to assess the diversity of forty-five genotypes of marigold *(Tagetes* spp.) under plain condition of UP. Marigold germplasm exhibited significant variation for various growth parameters. Cross 'Sutton Orange' × 'Crackerjack Mix' recorded maximum plant height (127.80 cm), whereas parent 'French Dwarf' attained maximum plant spread and maximum secondary branches plant^{-1} (76.61 cm and 107.40). 'Pusa Narangi Gainda' × 'Late Summer' attained the

maximum flower diameter (13.00), flower yield ha^{-1} (182.13). Cross 'Seraceul' x 'Late Summer' exhibited the maximum duration for flowering (134.00 days) in the first year and cross ‘Pusa Narangi Gainda’ × ‘French Dwarf’ attained the longest flowering duration (132.33 days) in the second year.

Namita *et al.* (2008) evaluated eleven selections of French marigold *(Tagetes patula)* and was found high heritability values for plant height ranging 31.40- 62.50 cm.

Verma and Beniwal (2006) evaluated thirty-two marigold genotypes for their resistance to the root knot nematode. No susceptible or highly susceptible reaction was observed in any of the genotypes, including the local control (*Pusa Narangi*). Eight genotypes (MGH-126, MGH-127, MGH-131, MGH-138, MGH- 141, MGH-154, MGH-159 and MGH-160) exhibited moderate resistance. Only one genotype (MGH-136) was highly resistant to the root knot nematode.

Singh and Singh (2006) evaluated performance of twenty-nine genotypes of African marigold *(Tagetes erecta* Unn.) and reported significant variation in germplasm for all the growth and flowering parameters. The germplasm TEG16 exhibited best performance on number of primary branches/plant, number of flowers/plant and dry weight of leaf. However, germplasm TEG17 resulted in maximum flower longevity and dry weight of flower, whereas maximum duration of flowering was recorded with TEG13. Germplasm TEG23 exerted poorest performance on various growth and flowering attributes.

Suma and Patil (2006) carried out an investigation to evaluate the performance of eight daisy genotypes with respect to various morphological characters and yield. The genotypes Purple Monarch, Dark Milka, Blue Moon and White Prestige, showed good performance for growth attributes as well as yield attributes viz., plant height and total dry matter production and these genotypes produced more number of flowers plant^{-1} and flower spikes plant^{-1}. The genotypes Milka Star and Pink Milka showed minimum plant height and the genotypes Painted Lady, Peter’s White and Pink Milka, produced less number of flower spikes plant^{-1}. Size of flower, length of flower spike and vase life

was more in the genotypes Purple Monarch, Dark Milka and Blue Moon.

Singh and Singh (2005) conducted an experiment to evaluate thirteen germplasm of *Tagetes patula* (TP1 to TP13) and two of *Tagetes minuta* (TMI and TM2). Among these germplasm, TP7 germplasm of *Tagetes patula* exhibited better performance in terms of diameter of flower and yield of flowers plant^{-1}. Both the germplasm of *Tagetes minuta i.e.,* TMI and TM2 resulted in maximum vegetative growth in terms of number of leaves and number of secondary branches plant^{-1}.

Naik *et al.* (2005) conducted an experiment to find a suitable and stable genotype for higher flower production in African marigold across the environments. The results of the stability analysis over three environments (*viz.* Kharif 2001-02 (E1), Rabi 2001-02 (E2) and Kharif 2002-03 (E3) revealed that the genotype, African Marigold Orange (AMO) recorded significantly higher flower yield (16.47 t ha^{-1}) ha^{-1} with a B: C ratio of 3.28 as compared to the local check (Orange Double).

Rao *et al.* (2005) conducted an experiment comprising the treatment of ten open pollinated African marigold cultivars. They observed that better plant growth was found in cultivar Orange Double with the highest plant height (84.00 cm) and minimum in Hyd. Local Sel.-4 (46.00cm) whereas, the maximum number of branches in Hyd. Local Se.-1 (20) followed by Orange double (18). The Pusa Narangi Gainda, Hyd.Local Sel.-2 and Lemon Yellow genotypes produced the same number of branches with an average of 12 branches per plant. They also reported the longest duration of flowering in Orange Double followed by Pusa Basanti Gainda and the cv. Orange Double recorded highest flower yield among other nine cultivars.

Verma *et al.* (2004) collected twelve genotypes of *T. patula* and twenty genotypes of *T. erecta* from Uttaranchal, India and evaluated for 9 character traits *viz.*, plant height, number of leaves plant^{-1}, leaf length, leaf width, peduncle length, number of branches plant^{-1}, stem diameter, plant canopy and flower diameter. The tallest plants (208.01 cm) were observed in the genotype NIC-14859, while the shortest plant was observed in NIC-14839. The highest number of branches plant^{-1} (25.80) was obtained from NIC-

14841. The highest stem diameter was obtained from NIC-14847 (1.81 cm). The plant canopy spread was highest (6855.11 cm) in NIC-14848, while the lowest was in NIC-14834. The flower diameter (7.67 cm) was maximum in NIC-14865.

Kelly and Harbaugh (2002) evaluated eighty-four cultivars of African marigold *(Tagetes erecta)* and French marigold *(T. patula).* Cultivars *viz.*, 'Inca Gold' and 'Royal Gold' (African marigold), 'Disco Granada' (French marigold) and 'Golden Boy' and 'Hero Gold' (French dwarf-double gold class) were observed to perform well with similar heat and cold hardiness zones.

2.2 Effect of GA_3

Sarkar *et al.*, (2018) reported that the application of GA_3 at 200 ppm recorded significantly higher plant height (85.36 cm), number of branches plant^{-1} (39.72 branches plant^{-1}), total leaf number (183.43), number of flowers (63.80) and flower yield per hectare (10.19 t).

Markam *et al*. (2016) conducted a field experiment to investigate the effect of different levels of growth promoters and retardants on growth and flower yield of different cultivars of African marigold. The experiment was laid out in factorial RBD comprising treatment combination of two PGR (GA_3 and Cycocel) and two marigold verities (Pusa Narangi and Pusa Basanti Gainda) The result indicated that the growth and flower yield were significantly influenced by different plant growth regulators and cultivars. The maximum plant height was recorded with *cv.* Pusa Basanti Gainda as compared to *cv.* Pusa Narangi Gainda. While, maximum number of primary and secondary branches was recorded with *cv.* Pusa Narangi Gainda. Among the growth regulators treatments, GA_3 300 ppm (25 DAT) + GA_3 300 ppm (45 DAT) recorded maximum plant height. However, maximum number of primary and secondary branches, number of flowers, fresh weight of flowers per plant and flower yield ha^{-1} was noticed with treatment GA_3 300 ppm (25 DAT) + CCC 1500 ppm (45 DAT).

Kumar *et al.* (2015) reported that the effect of GA_3at concentrations of 100, 200 and 300 ppm, on growth and flowering behavior of African marigold *(Tagetes erecta* L.)

cv. Pusa Narangi Gainda. Among the concentrations of GA_3 at 300 ppm, recorded maximum plant height (75.93 cm), plant spread (50.07 cm) and early flower bud initiation (48 days), opening of first flower, duration of flowering (50.47 days), flower stalk length, flowers plant^{-1} (60.33), closely followed by GA_3, 200 ppm over other treatments.

Badge *et al.* (2015) observed that the foliar application of gibberellic acid, minimum days to first flower bud initiation (32.34 days) and days to first harvesting (52.62 days) with maximum flowering duration (58.37 days), fresh weight of flower (7.32g), number of flower plant^{-1} (32.49), flower yield plant^{-1} (237.55g) and hectare^{-1} (17.79 t), diameter of flower (8.17cm), length of pedicel flower (8.85cm), and shelf life of flower (6.70 days) were recorded maximum with treatment GA_3 300 ppm.

Meshram *et al*. (2015) conducted a field experiment to study the effect of different concentrations of GA_3 (100, 200, 300 and 400 ppm) and NAA (50, 100, 150 and 200 ppm) on growth, quality and flower yield in African marigold. The result revealed that, vegetative growth *viz*., height of plant (43.56 cm), number of branches (10.83), spread of plant at 50% flowering stage E-W (24.77) and N-S (24.92) was recorded significantly maximum with treatment of GA_3 at 400 ppm, whereas, stem diameter (1.27 cm) of plant were found maximum with the treatment NAA 50 ppm. In respect of quality parameters, viz., length of pedicel (7.05 cm), length of flower along with pedicel (10.69), shelf life (4.68 days) was found maximum with the treatment of GA_3 400 ppm whereas, treatment NAA 50 ppm had produced significantly maximum weight (6.10 g) and diameter of fully opened flower (6.51 cm). Regarding yield contributing characters viz., number of flowers plant^{-1} (48.66), flower yield plant^{-1} (254.00 g) and ha^{-1} (187.96 q) were recorded maximum at GA_3 400 ppm.

Rajhansa *et al.* (2015) reported that the influence of GA_3 at concentrations of 100 and 200 ppmon flowering and yield attributes of African marigold *(Tagetes erecta* L.) cv. Pusa Narangi Gainda. They found that the days to first flowering and 50 percent flowering were significantly reduced by the application of GA_3 at 200 ppm. Period of

bloom, flower diameter, fresh weight of flower per plant and flower yield was also improved with the application of 200 ppm GA_3.

Kanwar *et al.* (2013) revealed that single spray of GA_3 at 150 ppm recorded significantly higher plant height (83.30 cm), leaf area (1188.58 cm^2), number of flowers per plant (78.49), average weight of flower (4.85 g) and yield of flowers per plant (365.23 g) as well as per hectare (132.27 q/ha) in African marigold.

Kumar *et al.* (2012) found that GA_3 at higher concentration of 100 ppm as a pre-harvest spray exerted a significant influence on crop growth and recorded highest mean values for plant height (76.18 cm), stalk length (60.98 cm), stem girth (1.66 cm) and total chlorophyll content (1.826 mg g^{-1}) of rose. Similarly, the application of GA_3 at 100 ppm level drastically increased the quality traits viz., mean flower diameter (6.89 cm), anthocyanin content (0.1970 OD value) and vase life (2.6 days). The earliest flowering (40 days) was also obtained from pre-harvest spray of GA_3 at 100 ppm.

Kumar *et al.* (2012) found that GA_3 application at 350 ppm was most effective as it gave highest flower yield per plant, maximum fresh weight per flower and highest number of flowers per plant and earlier flower bud initiation and flowering and also increased number of leaves as well as recorded maximum plant height in African marigold.

Kumar *et al.* (2012) reported that GA_3 at 200 ppm registered significantly maximum flower yield per plant (639.18 gm) with longest duration of flowering (87.18 days) as compared to control in African marigold.

Shivaprakash *et al.* (2011) reported that plant height, maximum stem girth, more dry matter production of stem, leaf and flower were recorded maximum with 200 ppm GA_3 in African marigold *(Tagetes erecta* L.) cv. Orange Double. The same treatment also recorded significantly more diameter of flower, number of flowers per plant, yield per plot (6.45 kg) and yield per ha (9.83 t) than control.

Kumar *et al.* (2011) reported that GA_3 application at 350 ppm were showed maximum plant height, highest flower yield per plant, maximum fresh weight per flower, highest number of flowers per plant, maximum number of leaves, earlier flower bud initiation and flowering in African marigold.

Shinde *et al.* (2010) reported that the significantly maximum number of branches, plant spread, number of suckers per plant, number of flowers per plant, yield of flowers per plant and yield of flowers per hectare were recorded with the spraying of GA_3 at 200 ppm in chrysanthemum *(Chrysanthemum morifolium* R.) cv. IIHR-6.However, minimum number of days for initiation of flowering maximum duration of flowering, flower diameter, fresh flower weight, shelf and vase life of flowers were obtained with 150 ppm GA_3.

Himabindu (2010) working with an experiment on African marigold and revealed that, GA_3 at 300 ppm recorded maximum plant height (94.52 cm), more plant spread, maximum number of laterals, minimum number of days (39.39 days) to first flower bud initiation and days to 50% flowering (56.66 days), maximum flower diameter (6.97 cm), flower weight (6.08 g) and flower yield per plant (299.45 g) over other treatments in African marigold cv. Pusa Narangi Gainda.

Ramdevputra *et al.* (2009) observed that all the vegetative growth characters of African marigold were highly influenced by GA_3 at 300 ppm. Maximum number of flowers per plant (86.43), weight of flowers (248.67 g) per plant and flower yield (79.56 q/ha) was obtained by spraying of GA_3 at 300 ppm.

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Bihari and Narayan (2009) revealed that spraying of 100 ppm GA_3 at 15 days after transplanting proved significantly effective for a floriferous crop of African marigold cv. African Orange.

Mayoli *et al.*, (2009) observed early flowering, highest quality flower, maximum stem diameter, early flower bud initiation, maximum flower head diameter and maximum tuberous root fresh weight in ranunculus cut flower when tuberous roots were soaked in 100 mg/l GA_3 before planting.

Dalal *et al.* (2009) found that maximum vegetative growth, flower yield and quality was with the treatment of GA_3at 150 ppm in gerbera under polyhouse conditions while, early flowering was noticed with 50 ppm GA_3application.
Pandey and Chandra (2008) reported that the GA_3 450 ppm was significantly increased plant height, number of branches, diameter of main stem, number of leaves, number of flowers and total yield of flowers in French marigold as compared to other treatments.

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Swaroop *et al.* (2007) conducted field experiments to study the effect of GA_3 on vegetative growth and flower characters of African marigold cv. Pusa Narangi Gainda during mild off seasons and reported that, the maximum plant height (94.52 cm), number of primary branches per plant (8.75), number of flowers per plant, fresh weight of single flower (6.92 g) and flower yield per plant (433.00 g) was recorded with GA_3 at 300 ppm (23.75) compared to other concentrations and control.

Parmar *et al.*, (2007) reported in spider lily that spraying of 200 ppm GA_3 twice i.e. 45 and 60 days after planting had shown superiority in all vegetative, floral and yield characters *viz*., plant height (79.92 cm), number of leaves per plant (60.33), leaf width (7.23 cm), leaf area (377.92 cm^2), dry weight of plant (0.97 kg), flower diameter (4.26 cm), days taken for first spike emergence (53.38 days), days taken for first flower emergence (61.14 days), spike length (89.62 cm), number of flowers per spike (17.32), fresh flower weight (2.85 g), dry flower weight (0.38g), yield (50812 flower bud bundles/hectare).

Sunitha *et al.,* (2007) found that spraying of GA_3 200 ppm recorded significantly higher plant height (101.2 cm) and number of primary branches (14.4) in marigold.

Tyagi and Kumar (2006) reported that the GA_3 at 200 ppm were gave maximum plant height (22.25 cm), plant spread (25.88 cm), stem diameter (1.03 cm), number of primary branches per plant (15.49), number of flowers per plant (14.00), flower diameter (5.62 cm), stalk length (2.47 cm), fresh weight per flower (6.17 g), weight of flowers per plant (86.31 g) and yield of flowers (71.92 q/ha) in African marigold cv. Cupid.

Gautam *et al.* (2006) observed the effect of GA_3 on growth and flowering of *Chrysanthemum morifolium* cv. Nilima and revealed that GA_3 at all levels promoted the growth and GA3 at 200 ppm recorded maximum plant height (72.24 cm), number of branches (23.67), number of flowers per plant (44.94) and flower yield (14.23 tons per ha) than control in *Chrysanthemum morifolium* cv. Nilima.

Varma and Arha (2004) reported that the GA_3 at 200 ppm registered maximum flower yield per plant (82.62 g) and yield per hectare (9617.48 kg) in African marigold as compared to control (59.46 g and 7018.37 kg, respectively).
Singh (2004) reported that the greatest fresh (14.55 g) and dry weights (2.57 g) of 30 leaves per plant in French marigold were observed with GA_3 at 100 ppm and the greatest plant height (59.77 cm) was recorded with GA_3 at 200 ppm. GA_3 at 200 ppm increased the number of seeds per flower (96.43) and seed yield per plant (63.41 g).

Verma and Parmar (2003) reported that the maximum plant height (65.94 cm), number of flowers per plant (7.25) and stem length (58.25 cm) were in GA_3 at 100 ppm which applied twice whereas GA_3 at 50 ppm was produced buds of maximum size (1.83 cm) and maximum flower diameter (6.96 cm) in carnation.

Tripathi *et al.,* (2003) observed that GA_3at 400 ppm recorded the highest flower yield per plant (127.71 g) and number of flowers per plant (78.83) in French marigold.

Kumar *et al.* (2003) reported that the maximum height (62.00 cm), number of branches (20.27) per plant, number of flowers (67.33) per plant, flower weight (2.86 g) and flower yield (192.59 g) were recorded with GA_3 at 200 ppm as compared to GA_3 100 ppm in China aster cv. Kamini.

Khan and Tewari (2003) observed thatGA_3 at 90 ppm significantly increased the plant height (69.00 cm), produced more number of branches (6.60) and flowers (15.80) per plant compared to control in Dahlia.

Sujatha *et al.* (2002) found that spraying of GA_3 at 100 ppm recorded maximum plant spread (31.10 cm), number of leaves (15.19), more number of flowers (18.63) per pot and diameter of flower head (7.53 cm) as compared to control in Gerbera.

Maurya and Nagda (2002) noticed the maximum height (104.50 cm) in the plant treated with 100 ppm GA_3as compared to control (95.10 cm) in gladiolus cv. Friendship. Spraying of GA_3at 100 ppm increased the number of corms per plant (1.87), weight of corms per plant (78.70 g) and weight of corms per bed (1.60 kg) compared to control (1.20, 53.30 g and 0.95 kg/bed, respectively).

Sharma *et al.* (2001) studied the effect of GA_3 on four cultivars of *Chrysanthemum morifolium* and reported that GA_3 increased plant height and number of branches in all the cultivars. They further stated that, this effect was more pronounced in dwarf varieties and maximum plant height was observed with GA_3 at 50 ppm (96 cm) with cv. Ajina purple and maximum number of branches was observed with GA_3 50 ppm (13.50) with cv. Premier.

Dutta *et al.* (1993) reported that GA_3 at 50 ppm increased the duration of flowering, which was longest (212.67 and 219 days) compared with (83.67 and 87.33 days) the untreated controls. The highest flower yields (0.682 and 0.685 kg) per plant were obtained with GA_3 at 150 ppm and this treatment also showed the longest cut flowers and shelf life when compared to control.

Singh *et al.* (1991) observed that induction of early flowering (85.36 days) and increased number of flowers, flower yield (574.55 g) per plant and test weight of seed (3.31 g) were noticed with the application of GA_3 at 500 ppm compared to control (91.45 days, 27.67, 274.84 g per plant and 2.12 g, respectively) in African marigold.

Syamal *et al.* (1990) reported that when the African marigold and China aster were treated with GA_3through foliar spray at 100 and 200 ppm after 15 days of transplanting and twice more at 10 days' intervals, the best results with regard to the number of flowers per plant and seed yield were obtained with GA3 at 200 ppm in both the species.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in execution of the experiment.

3.1 Experimental site

The experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October, 2018 to January, 2019. The location of the site in 23.774° N latitude and 90.335° E longitudes with an elevation of 8.2 m from sea level presented in Appendix I. The experimental field was medium high land belonging to the Chhiata series of Grey Terrace Soil (AEZ-28, Madhupur Tract).

3.2 Climate

The experimental field is under subtropical climate characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The monthly means of daily maximum, Minimum and average temperature, relative humidity, total rainfall and sunshine hours received at the experimental site during the period from October 2018 to January 2019 are presented in (Appendix II).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix III.

3.4 Planting materials

Seeds of French marigold were used for the present study and collected from Savar, Dhaka (Plate 1).

Plate 1: Collected seeds of French marigold

3.5 Seed bed preparation and raising of seedlings

The land selected for nursery beds were well drained and were sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cow dung at the rate of 5 kg/bed. The size of each seed bed was 3 m × 1m raised above the ground level maintaining a spacing of 50 cm between the beds. Two seed beds were prepared for raising the seedlings (Plate 2). Five (5) grams of seeds were sown in each seed bed on 20 October, 2018. After sowing, the seeds were covered with light soil. Miral 3-GN was applied in each seed bed as precautionary measure against ants and woms. Complete germination of the seeds took place with 5 days after seed sowing. Seedlings were raised with gentle care (Plate 3). Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

Plate 2: Seed bed preparation

Plate 3: Raising of seedlings

3.6 Land preparation

The land was first open by ploughing on 25th October with the help of a power tiller and then it kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth. The basal dose of manures and fertilizers were mixed into the soil during final land preparation.

3.7 Manures, fertilizers and their application methods

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as source of nitrogen, phosphorus and potassium respectively. Full dose of cow dung (5 t ha^{-1}), MoP and TSP were incorporated during final land preparation. The total urea was applied in three equal installments.

The following doses of fertilizer were used for French marigold cultivation:

Nutrients	Manures/fertilizers	Doses ha^{-1}
-	Cow dung	5ton
N	Urea	450 kg ha^{-1}
P	TSP	200 kg ha^{-1}
K	MoP	160 kg ha^{-1}

Source: Fertilizer recommendation guide, 2016

3.8 Treatments of the experiment

The experiment consisted of two factors, which are as follows:

3.8.1 Factor A: Cultivars

1. V_1 = Royal yellow fire
2. V_2 = Royal red
3. V_3 = Royal orange
4. V_4 = Royal bolero
5. V_5 = Royal yellow

3.8.2 Factor B: GA_3 application

1. G_0 = Control (0 ppm GA_3)
2. G_1 = 50 ppm GA_3
3. G_2 = 100 ppm GA_3
4. G_3 = 150 ppm GA_3

3.8.3 Interaction effect of cultivar and GA_3

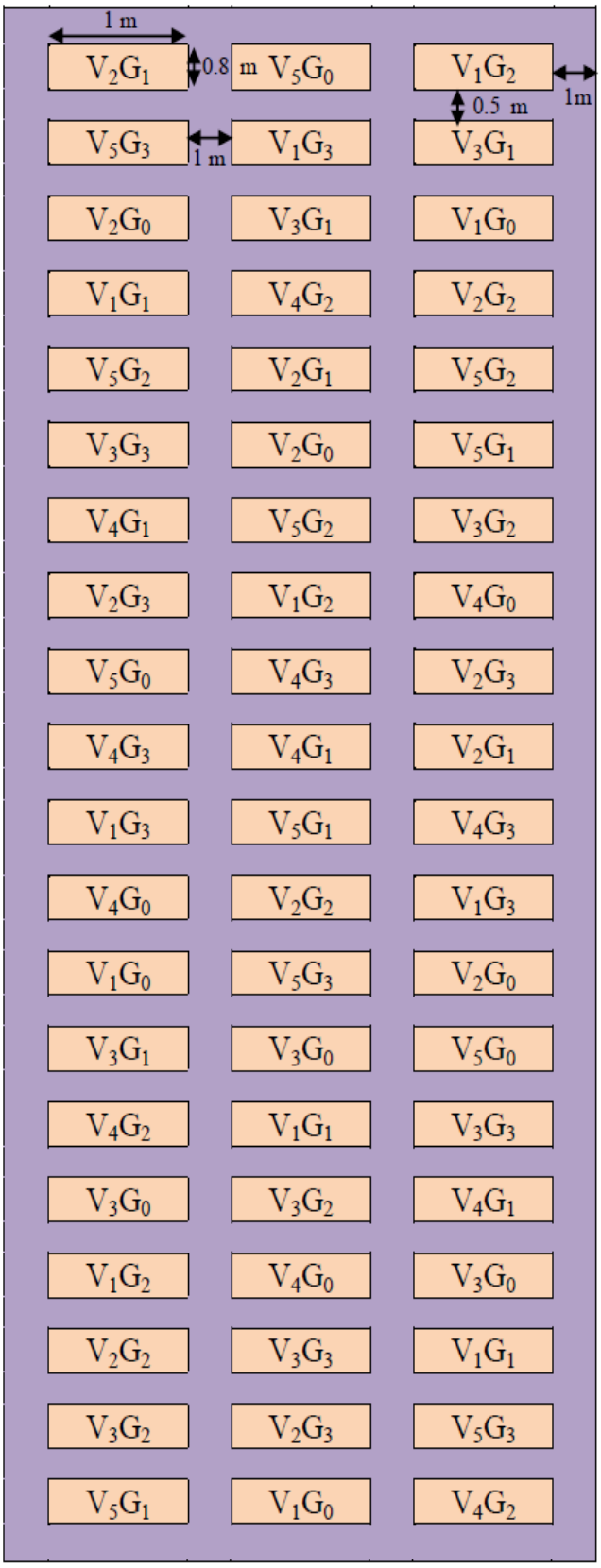
V_1G_0, V_1G_1, V_1G_2, V_1G_3, V_2G_0, V_2G_1, V_2G_2, V_2G_3, V_3G_0, V_3G_1, V_3G_2, V_3G_3, V_4G_0, V_4G_1, V_4G_2, V_4G_3, V_5G_0, V_5G_1, V_5G_2, V_5G_3.

3.9 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. Each block was divided into 20 plots, where treatments were allotted at random. Thus, there were 60 unit plots in the experiment. The size of each plot was 1 m × 0.8 m. The distance between blocks was 1 m and 0.5 m wide drains were made between the plots. The detailed lay-out is present in (Figure 1).

3.10 Transplanting of seedlings and GA_3 application

Healthy and uniform sized 15 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 5th November, 2018 maintaining a spacing of 20 cm × 20 cm (Plate 4). This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect. GA_3 were applied two times 1st 7 days after transplanting and 2nd 14 days after transplanting (Plate 5).



Legend

N

W E

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Treatments

Factor A: Cultivars

1. V_1 = Royal yellow fire
2. V_2 = Royal red
3. V_3 = Royal orange
4. V_4 = Royal bolero
5. V_5 = Royal yellow

Factor B: GA_3 application

1. G_0 = Control (0 ppm GA_3)
2. G_1 = 50 ppm GA_3
3. G_2 = 100 ppm GA_3
4. G_3 = 150 ppm GA_3

Plot size = 1 m × 0.8 m

Plant spacing = 20 cm × 20 cm

Block to block distances = 1 m

Plot to plot distances = 0.5 m

Figure 1: Layout of experimental field

Plate 4: Transplanting of seedlings

3.11 Intercultural operations

3.11.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy plants from the border whenever it required.

3.11.2 Weeding and mulching

The plots were kept weed free by regular weeding. The soil was mulched frequently after irrigation by breaking the crust for easy aeration and to conserve soil moisture (Plate 6).

3.11.3 Irrigation

The experimental plots were irrigated as and when necessary during the crop period.

3.11.4 Selection and tagging of plants

Five plants from each of the plots were selected randomly for recording data for different characters.

3.11.5 Pest management

Mole cricket, field cricket and cutworm attacks were a problem during seedling stage for marigold cultivation. As a preventive measure against the insect pest, Dursban 20 EC was applied @ 0.2% at 15 days' interval for three times starting from 20 days after emergence of bulb.

3.11.6 Disease management

Dithane M-45 @ 0.2% was sprayed to check the fungal infection.

3.12 Harvesting

The flowers of Fresh marigold were harvested when it was bloomed completely. First harvesting was done at 50 DAT and continued up to 75 DAT.

3.13 Collection of data

Data were collected on the following parameters

3.13.1 Growth parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}

3.13.2 Yield contributing parameters

1. Days to 1st visible flower bud
2. Days to 1st flower
3. Days to 50% flowering
4. Days to 80% flowering
5. Floret number flower^{-1}
6. Flower diameter (cm)
7. Single flower weight (g)

3.13.3 Yield parameters

1. Number of flowers plant^{-1} at 50 DAT
2. Total number of flower plant^{-1} at harvest
3. Number of flowers plot^{-1}
4. No. of flowers ha^{-1} (000)

3.13.4 Economic analysis

1. Total cost of production
2. Gross return (Tk. ha^{-1})
3. Net return (Tk. ha^{-1})
4. BCR

3.14 Procedure of recording data

3. 14.1 Growth parameters

3. 14.1.1 Plant height (cm)

Plant height was measured from five plants in centimeter (cm) from the ground level to the tip of the longest leaf of the sample plants at 30, 50 and 70 days after transplanting (DAT). The mean was also calculated and expressed in centimeter (cm).

3. 14.1.2 Number of leaves $plant^{-1}$

The number of leaves produced by mother plant was referred to the number of leaves per plant. All the leaves of five randomly selected plants were counted and their mean was calculated. The data recorded three times at an interval of 20 days starting from 30 DAT to 70 days after transplanting (DAT).

3. 14.1.3 Number of branches $plant^{-1}$

Number of branch per plant was counted at different DAT of crop. Branches number per plant was recorded from five randomly selected plants and their mean was calculated. Data was taken at 30, 50 and 70 days after transplanting (DAT).

3. 14.2 Yield contributing parameters

3. 14.2.1 Days to 1^{st} visible flower bud

Days to first (1^{st}) visible flower bud was recorded from the date of transplanting to when 1^{st} flower bud was visible in the plant.

3. 14.2.2 Days to 1st flower

Days to first (1st) flower was recorded from the date of transplanting to when 1st flower is appeared in the plant.

3. 14.2.3 Days to 50% flowering

Days to 50% flowering was recorded from the date of transplanting when 50% of the plants in a plot opened flowers fully.

3. 14.2.4 Days to 80% flowering

Days to 80% flowering was recorded from the date of transplanting when 80% of the plants in a plot opened flowers fully.

3. 14.2.5 Floret number flower^{-1}

Total floret number was counted from five flower randomly and average number of floret was expressed as number of floret per flower.

3. 14.2.6 Flower diameter (cm)

Ten flowers were collected from randomly selected five plants from each unit plot and the diameter of flowers was taken with the help of measuring scale and their mean was calculated and expressed in centimeter (cm).

3. 14.2.7 Single flower weight (g)

Single flower weight was measured from 20 flowers collected from randomly selected five plants from each unit plot and the weight of flowers was taken with the help of electric balance and their mean was calculated and expressed in gram (g).

3. 14.3 Yield parameters

3. 14.3.1 Number of flowers plant^{-1} at 50 DAT

Number of flowers at 50 DAT was recorded from five randomly selected plants and average number of flowers was expressed as number of flowers per plant at 50 DAT.

3. 14.3.2 Total number of flower plant^{-1} at harvest

Total number of flowers was counted from five randomly selected plants and average number of flowers was expressed as total number of flowers per plant.

3. 14.3.3 Number of flowers plot^{-1}

Total number of flowers was calculated from each plot of 1 m^2 area and was converted to plot area.

3. 14.3.4 Number of flowers ha^{-1} (000)

Total number of flowers was calculated from each plot of 1 m^2 area and was converted to ha.

3. 14.4 Economic analysis

The cost of production was analyzed in order to find out the most economic combination on different level of GA_3 application to different marigold cultivars. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 8% in simple rate. The market price of marigold flower was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

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

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different level of GA_3 application for different marigold cultivars on growth and flower yield of marigold. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The data recorded on various characters during the course of investigation entitled "Influence of GA_3 on growth and yield of French marigold" have been presented in this chapter along with appropriate tables and figures under the following heads:

4.1 Growth parameters

4.1.1 Plant height

Effect of cultivars

Data recorded on the plant height shown in (Figure 2) reveals non-significant difference (Appendix IV) in plant height of different cultivars of marigold plant at all the stages of crop growth *viz.*, 30, 50 and 70 DAT. However, results revealed that the maximum plant height at 30 DAT (16.34 cm) was recorded from V_4 (Royal bolero) cultivar and minimum plant height (15.13 cm) was observed in V_5 (Royal yellow) cultivar. Similar trend was observed at 50 and 70 DAT and V_4 (Royal bolero) cultivar showed maximum plant height (26.80 and 29.90 cm, respectively) whereas the minimum plant height (24.67 and 27.67 cm at 50 and 70 DAT, respectively) was achieved from V_5 (Royal yellow) cultivar.

The variation in plant height among French marigold varieties might be due to congenial environment to express the dominant genes in the genotypes and different genetic makeup of the varieties. The observations are in conformity with the findings of Sreekala *et al.* (2002), Rao *et al.* (2005), Narsude *et al.* (2010) in African marigold and Namita *et al.* (2008) in French marigold. Naik *et al*. (2019) and Netam *et al*. (2019) also found similar result with the present study.

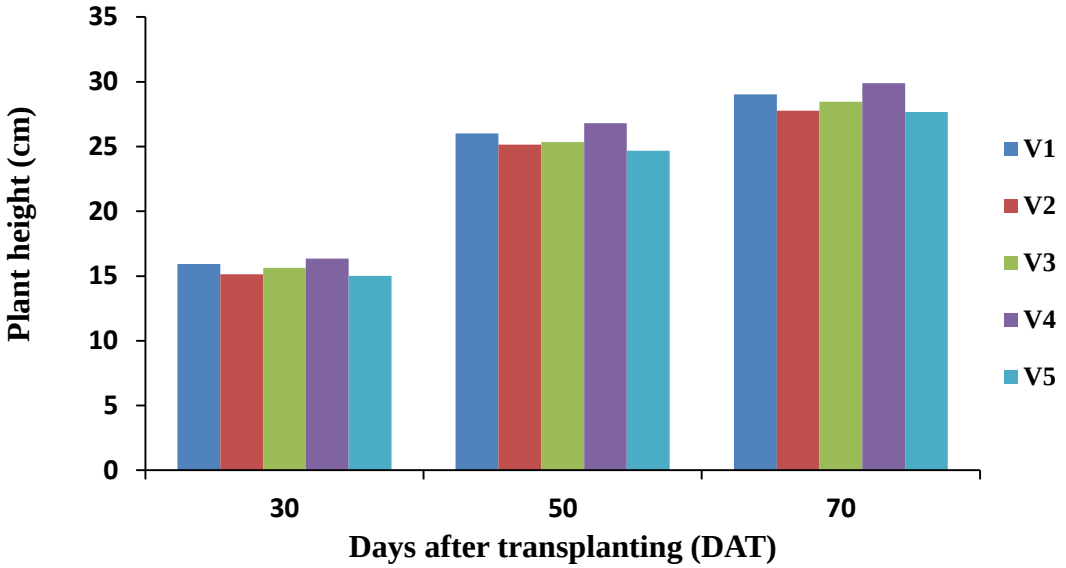
Effect of GA_3

Plant height of marigold affected by different levels of GA_3 application presented through (Figure 3) reveals significant variation (Appendix IV) at all the stages of crop growth *viz.*, 30, 50 and 70 DAT. Results revealed that at 30 DAT, the maximum plant height (17.18 cm) was achieved from G_3 (150 ppm GA_3) which was statistically similar with G_2 (100 ppm GA_3) whereas the minimum plant height (14.03 cm) was recorded from control treatment G_0 (0 ppm GA_3). At 50 DAT, the maximum plant height (27.95 cm) was achieved from G_3 (150 ppm GA_3) which was significantly different from all other treatments but the minimum plant height (23.03 cm) was recorded from control treatment G_0 (0 ppm GA_3) which was statistically identical with G_1 (50 ppm GA_3). Again, at 70 DAT, the maximum plant height (32.41 cm) was achieved from G_3 (150 ppm GA_3) which was statistically identical with G_2 (100 ppm GA_3) while the minimum plant height (25.36 cm) was recorded from control treatment G_0 (0 ppm GA_3).

All the treatments recorded more height with higher doses of GA_3 as compared to the control because GA_3 may be attributed to the action of gibberellins which promote vegetative growth by way of cell division and cell elongation and this may have resulted in the increase of plant height. GA_3 helps to increase the photosynthetic activity in plants. Thus, it might have increased osmotic uptake of water and nutrients, by maintaining constant swelling force against the softening of cell walls. These results are in close conformity with the findings of Sunitha *et al.* (2007), Pandey and Chandra (2008), Ramdevputra *et al.* (2009), Shivaprakash *et al.* (2011), Kanwar *et al.* (2013) Kumar *et al.* (2015) and Sarkar *et al.*, (2018) in marigold.

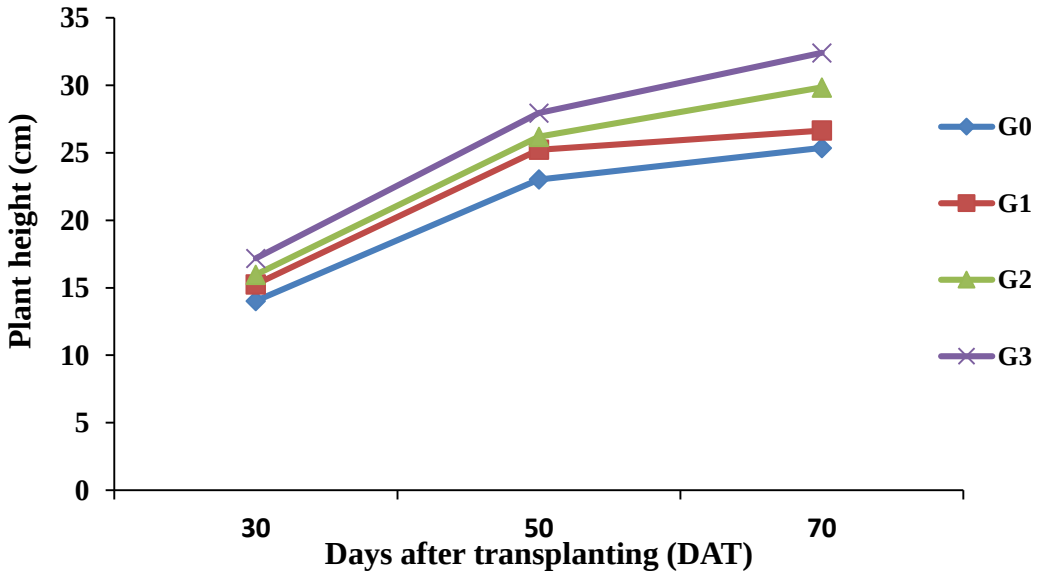
Combined effect of cultivar and GA_3

The treatment interactions between cultivars and GA_3 were found significant (Appendix IV) on plant height of marigold presented in Table 1 at different growth stages *viz.*, 30, 50 and 70 DAT. Results revealed that at 30 DAT, the



V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

Figure 2. Plant height of French marigold at different days after transplanting as influenced by different cultivars



G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

Figure 3. Plant height of French marigold at different days after transplanting as influenced by different doses of GA_3

maximum plant height (18.40 cm) was achieved from the treatment combination of V_4G_3 and was found to be at par with the treatments combination of V_1G_3 whereas the

minimum plant height (13.00 cm) was observed from control treatment G_0 (0 ppm GA_3) which was at par with the treatments combination of V_2G_0. Likewise, at 50 and 70 DAT, the maximum plant height (30.13 and 34.67cm, respectively) was achieved from the treatment combination of V_4G_3 followed by V_1G_3 whereas the minimum plant height (21.00 and 24.93 cm at 50 and 70 DAT, respectively) was observed from the treatment combination of V_5G_0 followed by V_2G_0, V_3G_0 and V_4G_0 (Table 1).

Table 1. Plant height of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Treatment	Plant height (cm)		
	30 DAT	**50 DAT**	**70 DAT**
V_1G_0	14.67 j	23.87 h	25.73 hij
V_1G_1	15.33 hi	25.47 efg	26.80 g
V_1G_2	16.03 ef	26.20 de	29.93 de
V_1G_3	17.70 b	28.53 b	33.67 b
V_2G_0	13.63 l	22.93 i	25.07 j
V_2G_1	14.93 ij	24.67 gh	26.13 ghi
V_2G_2	15.63 fgh	25.87 ef	29.07 ef
V_2G_3	16.33 de	27.13 c	30.87 d
V_3G_0	14.07 k	23.07 i	25.33 ij
V_3G_1	15.27 hi	25.20 fg	26.67 gh
V_3G_2	15.90 efg	25.93 def	29.67 e
V_3G_3	17.23 c	27.20 c	32.20 c
V_4G_0	14.77 j	24.27 h	25.73 hij
V_4G_1	15.50 gh	25.60 ef	27.07 g
V_4G_2	16.70 d	27.20 c	32.13 c
V_4G_3	18.40 a	30.13 a	34.67 a
V_5G_0	13.00 m	21.00 j	24.93 j
V_5G_1	15.27 hi	25.20 fg	26.60 gh
V_5G_2	15.57 gh	25.73 ef	28.47 f
V_5G_3	16.23 e	26.73 cd	30.67 d
$LSD_{0.05}$	**0.415**	**0.7893**	**0.8886**
CV(%)	**6.59**	**7.84**	**5.30**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.1.2 Number of leaves plant^{-1}

Effect of cultivars

A significant difference in number of leaves plant^{-1} was recorded among the different cultivars of marigold at 50 and 70 DAT shown in (Figure 4) but at 30 DAT non-significant variation was found among the cultivars on number of leaves plant^{-1} (Appendix V). Results revealed that at 30 DAT, non-significant variation was found, however, the maximum number of leaves plant^{-1} (8.77) was found in V_4 (Royal bolero) cultivar whereas the minimum number of leaves plant^{-1} (8.23) was observed from V_3 (Royal orange). At 50 DAT, significant variation was found and the maximum number of leaves plant^{-1} (14.77) was found in V_4 (Royal bolero) cultivar which was statistically identical with V_1 (Royal yellow fire) and V_2 (Royal red) followed by V_5 (Royal yellow) whereas the minimum number of leaves plant^{-1} (12.83) was observed from V_3 (Royal orange). Likewise, at 70 DAT, significant variation was found and the maximum number of leaves plant^{-1} (22.88) was found in V_4 (Royal bolero) cultivar which was statistically identical with V_1 (Royal yellow fire) whereas the minimum number of leaves plant^{-1} (20.51) was observed from V_3 (Royal orange) followed by V_5 (Royal yellow).

Maximum leaves of plant might be due to the congenial environment to express the dominant genes in the genotypes and different genetic makeup of the variety. The present research work confirms the findings Sreekala *et al.* (2002) and Narsude *et al.* (2010).

Effect of GA_3

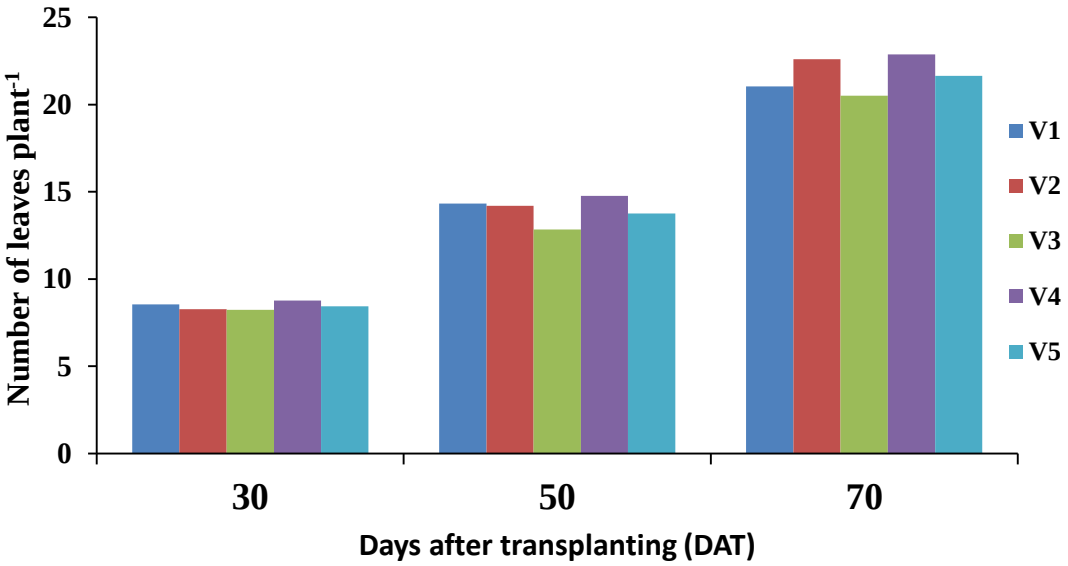
Number of leaves plant^{-1} of marigold affected by different levels of GA_3 application presented in (Fig. 5) reveals significant variation (Appendix V) at all the stages of crop growth *viz.*, 30, 50 and 70 DAT. Results indicated that at 30 DAT, the maximum number of leaves plant^{-1} (9.05) was recorded from G_3 (150 ppm GA_3) which was statistically similar with G_2 (100 ppm GA_3) whereas the minimum number of leaves plant^{-1} (7.73) was recorded from control treatment G_0 (0 ppm GA_3). At 50 DAT, the maximum number of leaves plant^{-1} (14.93) was recorded from G_3 (150 ppm GA_3) which was statistically different from other treatments whereas the minimum number of leaves

plant^{-1} (13.27) was observed from control treatment G_0 (0 ppm GA_3). At 70 DAT, the maximum number of leaves plant^{-1} (23.28) was recorded from G_3 (150 ppm GA_3) which was statistically identical with G_2 (100 ppm GA_3) whereas the minimum number of leaves plant^{-1} (19.89) was recorded from control treatment G_0 (0 ppm GA_3).

These findings may be due to appropriate concentration of GA_3 which increased the height of plant when applied in early stage. Therefore, energy diverted and promoted more foliage and this phenomenon increased with increasing levels of growth promoter. However, in later stage (70 DAT) G_2 also performed well and it may be due to satisfactory gain in number of leaves plant^{-1} and then after that the energy diverted for initiation of satisfactory foliage because of appropriate concentration of GA_3. Similar result was also observed by Sarkar *et al.,* (2018).

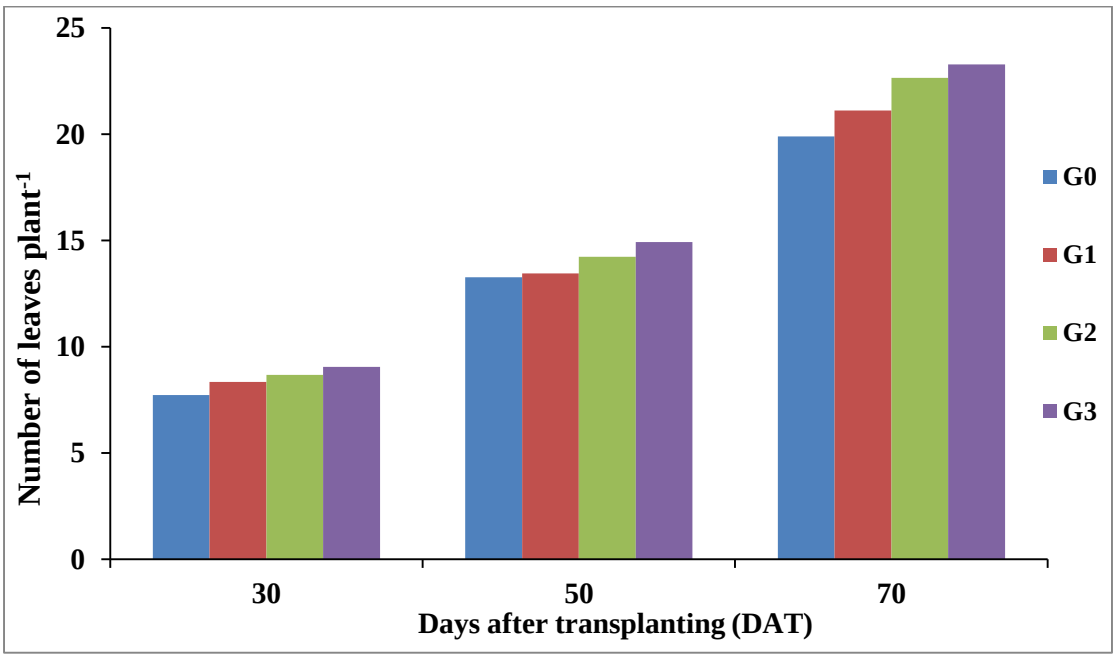
Combined effect of cultivar and GA_3

Treatment combination of cultivars and GA_3 showed significant variation on number of leaves plant^{-1} of marigold (Appendix V) presented in (Table 2) at different growth stages *viz.*, 50 and 70 DAT. but at 30 DAT non-significant variation was found among the treatment combinations (Appendix V). Results exhibited that at 30 DAT, non-significant variation was found, however, the maximum number of leaves plant^{-1} (9.47) was found in the treatment combination of V_4G_3 whereas the minimum number of leaves plant^{-1} (7.53) was observed from the treatment combination of V_3G_0. Again, at 50 DAT,



V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

Figure 4. Number of leaves plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars



G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

Figure 5. Number of leaves plant^{-1} of French marigold at different days after transplanting as influenced by different doses of GA_3

Significant variation was observed and the maximum number of leaves plant^{-1} (16.73) was found in the treatment combination of V_4G_3 which was statistically different from others whereas the minimum number of leaves plant^{-1} (11.53) was observed from the treatment combination of V_3G_0 which was statistically identical with V_1G_0. Similarly, at 70 DAT, significant variation was observed and the maximum number of leaves plant^{-1} (25.40) was found in the treatment combination of V_4G_3 which was statistically similar with V_2G_2 whereas the minimum number of leaves plant^{-1} (16.73) was observed from the treatment combination of V_3G_0 which was statistically different from others followed by V_1G_0 and V_5G_0.

Table 2. Number of leaves plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Treatment	Number of leaves plant^{-1}		
	30 DAT	**50 DAT**	**70 DAT**
V_1G_0	7.93	11.93 j	18.92 j
V_1G_1	8.40	16.27 b	21.33 fg
V_1G_2	8.67	14.67 e	23.92 cd
V_1G_3	9.20	13.93 fg	21.53 fg
V_2G_0	7.67	13.27 h	20.00 i
V_2G_1	8.27	15.60 c	23.13 e
V_2G_2	8.53	15.27 cd	25.07 ab
V_2G_3	8.73	12.67 i	20.67 h
V_3G_0	7.53	11.53 j	16.73 k
V_3G_1	8.33	13.47 gh	24.47 bc
V_3G_2	8.60	13.67 gh	21.60 fg
V_3G_3	9.13	13.67 gh	21.93 f
V_4G_0	8.07	12.73 i	20.53 hi
V_4G_1	8.47	14.67 e	24.09 c
V_4G_2	9.07	13.67 gh	19.93 i
V_4G_3	9.47	16.73 a	25.40 a
V_5G_0	7.47	12.67 i	18.93 j
V_5G_1	8.27	14.20 f	23.40 de
V_5G_2	8.47	14.93 de	21.13 gh
V_5G_3	8.73	13.93 fg	22.00 f
$LSD_{0.05}$	**NS**	**0.437**	**0.621**
CV(%)	**9.14**	**11.43**	**9.24**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.1.3 Number of branches plant^{-1}

Effect of cultivars

The examining of data on number of branches plant^{-1} presented in (Fig. 6) showed a significant difference among the different genotypes at 50 and 70 DAT but at 30 DAT non-significant variations was found among the cultivars on number of branches plant^{-1} (Appendix VI). At 30 DAT, non-significant variation was found, however, the maximum number of branches plant^{-1} (3.70) was found in V_4 (Royal bolero) cultivar whereas the minimum number of branches plant^{-1} (3.23) was observed from V_5 (Royal yellow). Again, at 50 DAT, significant variation was found and the maximum number of branches plant^{-1} (5.23) was found in V_4 (Royal bolero) cultivar which was statistically identical with V_1 (Royal yellow fire) and V_3 (Royal orange) followed by V_2 (Royal red) whereas the minimum number of branches plant^{-1} (4.53) was recorded from V_5 (Royal yellow). But at 70 DAT, significant variation was found and the maximum number of branches plant^{-1} (7.80 was found in V_4 (Royal bolero) cultivar which was statistically different from others followed by V_1 (Royal yellow fire) and V_3 (Royal orange) whereas the minimum number of branches plant^{-1} (6.62) was observed from V_5 (Royal yellow) which was statistically identical with V_2 (Royal red).

From the above findings, significantly maximum number of branches was observed in V_4 (Royal bolero) at all the growth stages and it might be due to the congenial environment to express the dominant genes in the genotypes and different genetic makeup of the variety. The present research work corroborates with the findings of Rao *et al.* (2005) and Narsude *et al.* (2010).

Effect of GA_3

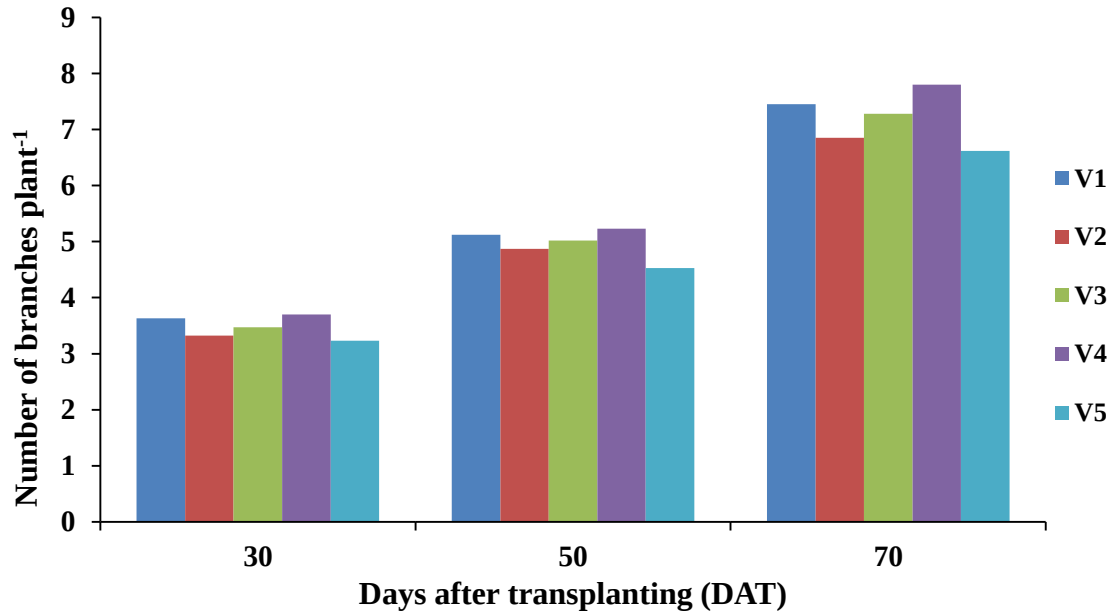
Data recorded on number of branches plant^{-1} of marigold showed in (Fig. 7) affected by GA_3 application reveals significant variation (Appendix VI) at all the stages of crop growth *viz.*, 50 and 70 DAT except 30 DAT. Non-significant variations was found at 30 DAT, however, the maximum number of branches plant^{-1} (3.83) was found from G_2 (100 ppm GA_3) whereas the minimum number of branches plant^{-1} (3.11) was observed from control treatment G_0 (0 ppm GA_3). Again, at 50 DAT, the maximum number of branches plant^{-1} (3.65) was found from G_2 (100 ppm GA_3) which was at par with G_1 (50

ppm GA_3) whereas the minimum number of branches plant^{-1} (4.13) was observed from control treatment G_0 (0 ppm GA_3). Similarly, at 70 DAT, the maximum number of branches plant^{-1} (8.57) was found from G_2 (100 ppm GA_3) which was significantly different from other treatments whereas the minimum number of branches plant^{-1} (5.77) was observed from control treatment G_0 (0 ppm GA_3) which was also significantly different from other treatments.

The increase in number of branches may be due to appropriate dose of GA_3 compared to higher and lower doses. Higher dose of GA_3 may be contributed to higher shoot growth and resulted lower number of branches. Similar results were obtained by Sarkar *et al.,* (2018), Meshram *et al*. (2015), Shinde *et al.* (2010) and Pandey and Chandra (2008).

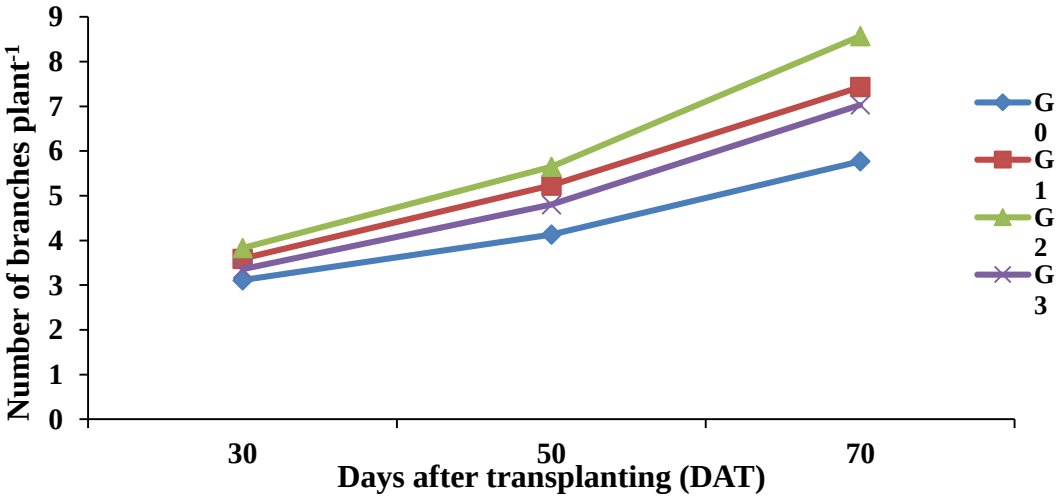
Combined effect of cultivar and GA_3

Number of branches plant^{-1} of marigold presented in (Table 3) was significantly varied due to the treatment combination of cultivars and GA_3 at different growth stages *viz.*, 30, 50 and 70 DAT (Appendix VI). At 30 DAT, the highest number of branches plant^{-1} (4.40) was recorded from the treatment combination of V_4G_2 which was statistically identical with V_1G_2 and V_3G_2 whereas the lowest number of branches plant^{-1} (2.20) was observed from the treatment combination of V_5G_0 followed by V_1G_0 and V_3G_0. At 50 DAT, the highest number of branches plant^{-1} (5.87) was recorded from the treatment combination of V_4G_2 which was statistically identical with V_1G_2, V_3G_2 and V_4G_1 whereas the lowest number of branches plant^{-1} (3.27) was observed from the treatment combination of V_5G_0 followed by V_2G_0 and V_3G_0. At 70 DAT.



V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

Figure 6. Number of branches plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars



G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

Figure 7. Number of branches plant^{-1} of French marigold at different days after transplanting as influenced by different doses of GA_3

the highest number of branches plant^{-1} (9.87) was recorded from the treatment combination of V_4G_2 which was significantly different from other treatment

combinations whereas the lowest number of branches plant^{-1} (4.67) was observed from the treatment combination of V_5G_0 which was also significantly different from other treatment combinations.

Table 3. Number of branches plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Treatment	Number of branches plant^{-1}		
	30 DAT	**50 DAT**	**70 DAT**
V_1G_0	2.73 gh	4.47 ef	6.27 g
V_1G_1	3.80 bc	5.27 bc	7.40 e
V_1G_2	4.33 a	5.87 a	8.93 b
V_1G_3	3.13 ef	4.87 d	7.20 e
V_2G_0	3.47 cde	4.20 f	5.40 h
V_2G_1	3.47 cde	5.00 cd	7.33 e
V_2G_2	3.60 bcd	5.53 ab	7.80 d
V_2G_3	3.33 de	4.73 de	6.87 f
V_3G_0	2.53 h	4.27 f	6.20 g
V_3G_1	3.73 bc	5.27 bc	7.33 e
V_3G_2	4.27 a	5.73 a	8.53 c
V_3G_3	3.47 cde	4.80 de	7.07 ef
V_4G_0	3.33 de	4.47 ef	6.33 g
V_4G_1	3.93 b	5.67 a	7.80 d
V_4G_2	4.40 a	5.87 a	9.87 a
V_4G_3	3.20 ef	4.93 cd	7.20 e
V_5G_0	2.20 i	3.27 g	4.67 i
V_5G_1	2.93 fg	4.93 cd	7.27 e
V_5G_2	3.73 bc	5.27 bc	7.73 d
V_5G_3	3.80 bc	4.67 de	6.80 f
$LSD_{0.05}$	**0.296**	**0.314**	**0.303**
CV(%)	**6.64**	**7.08**	**9.02**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.2 Yield contributing parameters

4.2.1 Days to 1st visible flower bud

Effect of cultivars

The observing of data on days to 1st visible flower bud presented in (Table 4) shows a non-significant difference among the different cultivars (Appendix VII). However, the highest days to 1st flower emergence (16.42) was recorded from V_5 (Royal yellow) whereas the lowest days to 1st visible flower bud (16.17) was observed from V_4 (Royal bolero).

The genetic control of the characters and modification in their expression due to environmental conditions might be the possible cause of observed variation in duration of 1st visible flower bud.

Effect of GA_3

Data recorded on days to 1st visible flower bud of marigold showed in (Table 4) affected by GA_3 application expose significant variation (Appendix V). Results indicated that the highest days to 1st visible flower bud (17.13) was recorded from control treatment G_0 (0 ppm GA_3) whereas the lowest days to 1st visible flower bud (15.53) was observed from G_2 (100 ppm GA_3) which was statistically identical with G_1 (50 ppm GA_3) and G_3 (150 ppm GA_3).

From the above findings, different concentrations of GA_3 have significantly affected the number of days taken for first visible flower bud. The early enhancement in first flower bud formation in GA_3 treatments may be due to increase in the endogenous level of gibberellins which by virtue of its flower inducing characteristics might have also promoted the first visible flower bud. Similar results have also been reported by Sunitha *et al.* (2007) and Ramdevputra *et al.* (2009), Similar result was also observed by the findings of Kumar *et al.* (2012) and Kumar *et al.* (2012) in marigold.

Combined effect of cultivar and GA_3

Days to 1st visible flower bud of marigold presented in (Table 5) was significantly varied due to the treatment combination of cultivars and GA_3 (Appendix VII). It was found that the highest days to 1st visible flower bud (17.67) was recorded from the treatment combination of V_5G_0 which was at par with the treatment combination of V_2G_0 and V_3G_0. The lowest days to 1st visible flower bud (14.67) was observed from the treatment combination of V_4G_2 which was statistically identical with the treatment combination of V_1G_1 and V_5G_2.

4.2.2 Days to 1st flower

Effect of cultivars

Significant variation was found among the different cultivars of marigold on days to 1st flower (Appendix VII) presented in (Table 4). Results revealed that the highest days to 1st flowering (27.17) was recorded from V_5 (Royal yellow) which was statistically identical with V_2 (Royal red) whereas the lowest days to 1st flowering (24.25) was observed from V_4 (Royal bolero) followed by the cultivar V_1 (Royal yellow fire).

Variation in days to 1st flower among different genotypes of marigold might be influenced by the genetic makeup of different genotypes. Similar findings have been also reported by Mahantesh *et al*. (2018), Rao *et al.* (2005) and Raghuvanshi and Sharma (2011) in African marigold.

Effect of GA_3

Significant influence was observed on days to 1st flower of marigold affected by GA_3 application (Appendix VII) showed in (Table 4). It was observed that the highest days to 1st flower (31.53) was recorded from control treatment G_0 (0 ppm GA_3) which was statistically different from other treatments. The lowest days to 1st flowering (21.60) was observed from G_2 (100 ppm GA_3) followed by G_1 (50 ppm GA_3).

All the treatments of GA_3 in recorded minimum days taken for first flower as compared to control. This advancement in anthesis with GA_3 treated plants might have led to the increase in endogenous levels of gibberellins which by virtue of its characteristics may have hastened the flowering. Although gibberellin is not a flowering hormone, but

when these are present in proper concentrations, florigen (flowering hormone) may be synthesized. GA_3 might also activate genes, which control the synthesis of florigen and thus induce the early flowering. Besides this the earlier anthesis with the application of GA_3 may be the ability of gibberellins to modify the photoperiodic requirements of plants which is essential for flower anthesis. Similar results have also been reported by Sunitha *et al*. (2007), Ramdevputra *et al*. (2009), Rajhansa *et al.* (2015), Badge *et al.* (2015) and Kumar *et al.* (2012) in marigold.

Combined effect of cultivar and GA_3

Combination of cultivars and GA_3 presented in (Table 5) showed significant variation on days to 1st flower of marigold (Appendix VII). Results showed that the highest days to 1st flower (17.67) was recorded from the treatment combination of V_5G_0 which was statistically identical with the treatment combination of V_2G_0 and V_3G_0. The lowest days to 1st flower (14.67) was observed from the treatment combination of V_4G_2 which was statistically similar with the treatment combination of V_1G_2 and V_3G_2.

4.2.3 Days to 50% flowering

Effect of cultivars

Significant variation was found on days to 50% flowering as influenced by different cultivars of marigold (Appendix VII) presented in (Table 4). It was found that the highest days to 50% flowering (32.33) was recorded from V_5 (Royal yellow) which was significantly different from other treatments. Again, the lowest days to 50% flowering (29.83) was observed from V_4 (Royal bolero) which was statistically similar with V_1 (Royal yellow fire).

The differences in flowering might be due to the different time period taken by the different genotypes based on their genetic makeup. The findings also corroborate with the findings of Palai *et al.* (2008) in chrysanthemum and Kumar *et al*. (2015) in French marigold.

Effect of GA_3

Different levels of GA_3 application revealed the significant variation on days to 50% flowering (Appendix VII) which is shown in (Table 4). It was observed that the highest

days to 50% flowering (36.53) was recorded from control treatment G_0 (0 ppm GA_3) which was statistically different from other treatments. Similarly, the lowest days to 50% flowering (27.60) was observed from G_2 (100 ppm GA_3) which was statistically identical with G_1 (50 ppm GA_3).

In general, the early 50% of flowering were observed which might be due to increase in the endogenous gibberellin levels in the plants, as gibberellins are well-known for inducing early flowering in several crop plants. Similar findings were reported by Sunitha *et al.* (2007), Meshram *et al*. (2015) and Rajhansa *et al.* (2015) in marigold, Shinde *et al*. (2010) in chrysanthemum.

Combined effect of cultivar and GA_3

Variation on days to 50% flowering of marigold presented in (Table 5) was significant influenced by the treatment combination of cultivars and GA_3 (Appendix VII). It was indicated that the highest days to 50% flowering (37.67) was recorded from the treatment combination of V_5G_0 which was at par with the treatment combination of V_2G_0 and V_4G_0. Again, the lowest days to 50% flowering (25.33) was observed from the treatment combination of V_4G_2 which was statistically similar with the treatment combination of V_1G_2, V_3G_1 and V_3G_2.

4.2.4 Days to 80% flowering

Effect of cultivars

Significant variation was found on days to 80% flowering as influenced by different cultivars of marigold (Appendix VII) presented in (Table 4).It was found that the highest days to 80% flowering (38.00) was recorded from V_5 (Royal yellow) which was statistically identical with V_2 (Royal red). Again, the lowest days to 80% flowering (35.75) was observed from V_4 (Royal bolero) which was statistically identical with V_1 (Royal yellow fire) and V_3 (Royal orange).

The result obtained from the present study was similar with the findings of Kumar *et al*. (2015) in French marigold.

Effect of GA_3

Different levels of GA_3 application revealed the significant variation on days to 80% flowering (Appendix VII) which is shown in (Table 4). Results showed that the highest days to 80% flowering (42.07) was recorded from control treatment G_0 (0 ppm GA_3) which was statistically different from other treatments whereas the lowest days to 80% flowering (32.87) was observed from G_2 (100 ppm GA_3). Similar result was also observed by the findings of Sunitha *et al.* (2007) and Rajhansa *et al.* (2015).

Combined effect of cultivar and GA_3

Variation on days to 80% flowering of marigold presented in (Table 4) was noted as significant influenced by the treatment combination of cultivars and GA_3 (Appendix VII). Results indicated that the highest days to 80% flowering (43.33) was recorded from the treatment combination of V_5G_0 which was statistically similar with the treatment combination of V_2G_0 whereas the lowest days to 80% flowering (31.67) was observed from the treatment combination of V_4G_2 which was at par with the treatment combination of V_1G_2 and V_3G_2.

Table 4. Yield contributing parameters of French marigold as influenced by different cultivars and different doses of GA_3

Treatment	Yield contributing parameters						
	Days to 1st visible flower bud	**Days to 1st flower**	**Days to 50% flowering**	**Days to 80% flowering**	**Floret number flower^{-1}**	**Flower diameter (cm)**	**Single flower weight (g)**
Effect of cultivar							
V_1	16.17	25.17 c	30.33 cd	36.33 b	44.70ab	5.76	4.00 a
V_2	16.25	26.75 a	31.42 b	37.83 a	41.33 c	5.58	3.83 ab
V_3	16.25	26.08 b	30.50 c	36.58 b	43.78 b	5.67	4.00 a
V_4	15.83	24.25 d	29.83 d	35.75 b	46.10 a	5.90	4.33 a
V_5	16.42	27.17 a	32.33 a	38.00 a	39.88 c	5.49	3.50 b
$LSD_{0.05}$	**NS**	**0.5061**	**0.5074**	**1.069**	**1.620**	**NS**	**0.462**
CV(%)	**6.70**	**8.75**	**9.75**	**5.19**	**10.87**	**7.41**	**6.10**
Effect of GA_3							
G_0	17.1 a	31.53 a	36.53 a	42.07 a	34.97 d	5.18 d	3.07 c
G_1	16.0 b	23.47 c	27.67 c	35.13 c	46.24 b	5.83 b	4.27 b
G_2	15.5 b	21.60 d	27.60 c	32.87 d	51.36 a	6.21 a	4.93 a
G_3	16.1 b	26.93 b	31.73 b	37.53 b	40.06 c	5.51 c	3.73 b
$LSD_{0.05}$	**0.807**	**1.139**	**1.358**	**1.417**	**1.787**	**0.311**	**0.624**
CV(%)	**6.70**	**8.75**	**9.75**	**5.19**	**10.87**	**7.41**	**6.10**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.2.5 Floret number flower^{-1}

Effect of cultivars

The checking of data on floret number flower^{-1} presented in (Table 4) showed significant difference among the different cultivars (Appendix VII). Results revealed that the highest floret number flower^{-1} (46.10) was recorded from V_4 (Royal bolero) which was statistically similar with V_1 (Royal yellow fire) whereas the lowest floret number flower^{-1} (39.88) was recorded from V_5 (Royal yellow) which was statistically identical with V_2 (Royal red).

Similar result was also observed by Kumar *et al.* (2015) in chrysanthmum varieties and by Mahantesh *et al*. (2018) in marigold.

Effect of GA_3

Data recorded on floret number flower^{-1} of marigold showed in (Table 4) affected by GA_3 application exposed significant variation (Appendix VII). Results indicated that the highest floret number flower^{-1} (51.36) was recorded from G_2 (100 ppm GA_3) which was statistically different from other treatments followed by G_1 (50 ppm GA_3). Similarly, the lowest floret number flower^{-1} (34.97) was observed from control treatment G_0 (0 ppm GA_3) followed by G_3 (150 ppm GA_3).

Combined effect of cultivar and GA_3

Floret number flower^{-1} of marigold presented in (Table 5) was varied significantly due to the treatment combination of cultivars and GA_3 (Appendix VII). Results showed that the highest floret number flower^{-1} (54.60) was recorded from the treatment combination of V_4G_2 which was statistically similar with the treatment combination of V_1G_2 and V_3G_2. Again, the lowest floret number flower^{-1} (31.13) was observed from the treatment combination of V_5G_0 which was statistically similar with the treatment combination of V_2G_0.

4.2.6 Flower diameter (cm)

Effect of cultivars

Different cultivars of marigold showed non-significant variation on flower diameter of marigold (Appendix VII) presented in (Table 4). However, results showed that the highest flower diameter (5.90 cm) was recorded from V_4 (Royal bolero) whereas the lowest floral diameter (5.49 cm) was observed from V_5 (Royal yellow).

Variation in flower diameter among different genotypes of marigold might be influenced by the genetic makeup of different genotypes. The results are in agreement with the findings of Pkanwar *et al.* (2013) and Narsude *et al.* (2010a) in African marigold.

Effect of GA_3

Significant influence was observed on flower diameter of marigold affected by GA_3 application (Appendix VII) showed in (Table 4). It was observed that the highest flower diameter (6.21 cm) was recorded from G_2 (100 ppm GA_3) which was statistically

different from other treatments whereas the lowest flower diameter (5.18 cm) was observed from control treatment G_0 (0 ppm GA_3).

The role of GA_3 in improving the bud size may be ascribed to the translocation of metabolites at the site of bud development. Increase in flower diameter might be due to cell elongation in the flower. Gibberellins are also known to increase the sink strength of actively growing parts. The similar findings were also noted by Meshram *et al*. (2015), Badge *et al.* (2015), Rajhansa *et al.* (2015) and Shivaprakash *et al.* (2011) in marigold.

Combined effect of cultivar and GA_3

Combination of cultivars and GA_3 presented in (Table 5) showed significant variation on flower diameter of marigold (Appendix VII). It was found that the highest flower diameter (6.53 cm) was recorded from the treatment combination of V_4G_2 which was statistically different from all other treatment combinations followed by V_1G_2 and V_4G_1. Similarly, the lowest flower diameter (5.03 cm) was observed from the treatment combination of V_5G_0 which was statistically similar with the treatment combination of V_2G_0.

Table 5. Yield contributing parameters of French marigold as influenced by combination of different cultivars and different doses of GA_3

Treatment	Yield contributing parameters						
	Days to 1st visible flower bud	**Days to 1st flower**	**Days to 50% flowering**	**Days to 80% flowering**	**Floret number flower^{-1}**	**Flower diameter (cm)**	**Single flower weight (g)**
V_1G_0	17.00 bc	30.67 b	35.00 cd	41.67bc	37.47 fg	5.28 h	3.33 c
V_1G_1	15.00 g	23.00 gh	27.33 jk	34.33 f	47.27 c	5.87 de	4.67 ab
V_1G_2	15.67 f	21.33 jk	26.33 kl	32.00 h	53.47 ab	6.31 b	5.00 a
V_1G_3	16.00 ef	25.67 e	30.67 gh	37.33de	40.60 def	5.60 fg	4.00 bc
V_2G_0	17.33 ab	32.33 a	37.00 ab	43.00ab	32.87 hi	5.11 ij	3.33 c
V_2G_1	16.00 ef	24.00 fg	30.00 h	36.33 e	43.80 d	5.71 f	4.00 bc
V_2G_2	15.67 f	22.33 hij	28.00 ijk	34.00 fg	48.47 c	6.00 d	4.67 ab
V_2G_3	16.00 ef	28.33 c	33.67 de	38.00 d	40.17 def	5.50 g	3.33 c
V_3G_0	17.33 ab	32.00 a	35.67 bc	41.67bc	34.93 gh	5.19 hi	3.33 c
V_3G_1	16.00 ef	24.00 fg	26.67 kl	34.67 f	47.20 c	5.75 ef	4.00 bc
V_3G_2	16.67 cd	21.33 jk	26.33 kl	32.67gh	52.80 ab	6.23 bc	4.67 ab
V_3G_3	17.00 bc	27.00 d	33.33 ef	37.33de	40.20 ef	5.52 g	4.00 bc
V_4G_0	17.00 bc	30.00 b	37.33 a	40.67 c	38.47 f	5.30 h	3.33 c
V_4G_1	16.00 ef	21.67 ij	29.67 hi	33.67fg	50.60 bc	6.16 c	4.67 ab
V_4G_2	14.67 g	20.33 k	25.33 l	31.67 h	54.60 a	6.53 a	5.33 a
V_4G_3	16.00 ef	25.00 ef	29.00 hij	37.00de	40.73 def	5.62 fg	4.00 bc
V_5G_0	17.67 a	32.67 a	37.67 a	43.33 a	31.13 i	5.03 j	2.00 d
V_5G_1	16.00 ef	24.67 ef	29.00 hij	36.67de	42.33 de	5.63 fg	4.00 bc
V_5G_2	15.00 g	22.67 hi	27.67 jk	34.00fg	47.47 c	5.98 d	4.67 ab
V_5G_3	16.33 de	28.67 c	32.00 fg	38.00 d	38.60 f	5.32 h	3.33 c
$LSD_{0.05}$	**0.473**	**1.012**	**1.570**	**1.356**	**3.240**	**0.138**	**1.061**
CV(%)	**6.70**	**8.75**	**9.75**	**5.19**	**10.87**	**7.41**	**6.10**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.2.7 Single flower weight (g)

Effect of cultivars

Significant variation was remarked on single flower weight as influenced by different cultivars of marigold (Appendix VII) presented in (Table 4). It was exposed that the highest single flower weight (4.33 g) was recorded from V_4 (Royal bolero) which was at par with the cultivar V_1 (Royal yellow fire), V_2 (Royal red) and V_3 (Royal orange) whereas the lowest single flower weight (3.50 g) was observed from V_5 (Royal yellow). Differences in single flower weight might be due to the effect of parameters *viz.*, flower diameter and flower size, resulting in flower weight. Similar findings were also reported by Kumar *et al.* (2014) in marigold.

Effect of GA_3

Different levels of GA_3 application revealed the significant variation on days single flower weight (Appendix VII) which is shown in (Table 4). Results revealed that the highest single flower weight (4.93 g) was recorded from G_2 (100 ppm GA_3) which was statistically different from other treatments followed by G_1 (50 ppm GA_3) and G_3 (150 ppm GA_3) whereas the lowest single flower weight (3.07 g) was observed from control treatment G_0 (0 ppm GA_3).

Increase in fresh weight of flowers with the application of GA_3 100 ppm might be due to higher floral diameter resulting in increased weight of fresh flower weight. According to Meshram *et al*. (2015), Badge *et al.* (2015) and Rajhansa *et al.* (2015) in marigold, increased floral diameter was found with GA_3 application. These results are in close agreement with the findings of Yadav (1997), Dani *etal.* (2010) and Kanwar *etal.* (2013) in marigold.

Combined effect of cultivar and GA_3

Variation on single flower weight of marigold presented in (Table 5) was noted as significant influenced by the treatment combination of cultivars and GA_3 (Appendix VII). Results revealed that the highest single flower weight (5.33 g) was recorded from the treatment combination of V_4G_2 which was statistically similar with the treatment combination of V_1G_1, V_1G_2, V_2G_2, V_3G_2, V_4G_1 and V_5G_2. Similarly, the lowest single flower weight (2.00 g) was observed from the treatment combination of V_5G_0 which

was statistically different from all other treatment combinations.

4.3 Yield parameters

4.3.1 Number of flowers plant^{-1} at 50 DAT

Effect of cultivars

The checking of data on number of flowers plant^{-1} at 50 DAT presented in (Table 6) showed non-significant difference among the different cultivars (Appendix VIII). However, it was found that the highest number of flowers plant^{-1} at 50 DAT (10.05) was recorded from V_4 (Royal bolero) whereas the lowest number of flowers plant^{-1} at 50 DAT (9.53) was observed from V_5 (Royal yellow).

These results are in accordance with the findings obtained by Singh and Misra (2008), Rao *etal*. (2005), and Beniwal and Dahiya (2012) in marigold.

Effect of GA_3

Data recorded on number of flowers plant^{-1} of marigold at 50 DAT presented in (Table 6) affected by GA_3 application gave significant variation (Appendix VIII). Results indicated that the highest number of flowers plant^{-1} at 50 DAT (10.39) was recorded from G_2 (100 ppm GA_3) which was statistically similar with G_1 (50 ppm GA_3) whereas the lowest number of flowers plant^{-1} at 50 DAT (9.09) was observed from control treatment G_0 (0 ppm GA_3) followed byG_3 (150 ppm GA_3).

Combined effect of cultivar and GA_3

Number of flowers plant^{-1} of marigold at 50 DAT presented in (Table 7) was varied significantly due to the treatment combination of cultivars and GA_3 (Appendix VIII). It was observed that the highest number of flowers plant^{-1} at 50 DAT (10.80) was recorded from the treatment combination of V_4G_2 which was statistically different from all other treatment combinations. Again, the lowest number of flowers plant^{-1} at 50 DAT (8.73) was observed from the treatment combination of V_5G_0 which was statistically identical with V_2G_0.

Table 6. Yield parameters of French marigold as influenced by different cultivars and different doses of GA_3

Treatment	Yield parameters			
	Number of flowers plant^{-1} at 50 DAT	**Total number of flower plant^{-1} at harvest**	**Number of flowers plot^{-1}**	**No. of flowers ha^{-1} (000)**
Effect of cultivar				
V_1	9.87	19.58 b	391.70 b	4896.00 b
V_2	9.60	19.08 bc	381.70 c	4771.00 d
V_3	9.73	19.22 bc	384.40 c	4805.00 c
V_4	10.05	20.77 a	415.40 a	5193.00 a
V_5	9.53	18.70 c	373.90 d	4674.00 e
$LSD_{0.05}$	**1.239**	**0.5914**	**3.786**	**18.07**
CV(%)	**7.37**	**8.68**	**8.68**	**8.68**
Effect of GA_3				
G_0	9.087 c	15.79 d	315.80 d	3948.00 d
G_1	9.960 ab	20.10 b	402.00 b	5025.00 b
G_2	10.39 a	23.85 a	477.10 a	5963.00 a
G_3	9.587 b	18.14 c	362.80 c	4535.00 c
$LSD_{0.05}$	**0.4942**	**0.5284**	**3.695**	**22.96**
CV(%)	**7.37**	**8.68**	**8.68**	**8.68**

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.3.2 Total number of flowers plant^{-1} at harvest

Effect of cultivars

Recorded data on total number of flowers plant^{-1} at harvest presented in (Table 6) showed significant difference among the different cultivars (Appendix VIII). Results revealed that the highest number of flowers plant^{-1} (20.77) at harvest was observed from V_4 (Royal bolero) followed by the cultivar V_1 (Royal yellow fire) whereas the lowest number of flowers plant^{-1} (18.70) at harvest was observed from V_5 (Royal yellow) which was statistically similar with V_2 (Royal red) and V_3 (Royal orange).

The number of flowers plant^{-1} at harvest significantly depended on vigor of plant, branches produced by an individual plant during crop period. Genotypes having more numbers of branches resulting in more number of flowers in that plant. The variation in number of flower plant^{-1} at harvest might be due to hereditary traits of the genotypes. Number of flowers plant^{-1} at harvest may have increased with the increase in number of branches plant^{-1} (Laishram *et al.,* 2013). Moreover, different photosynthesis efficacy of genotypes may have enhanced food accumulation resulting in better plant growth and subsequently higher number of flowers per plant (Sunitha *et al.,* 2007). These results are in accordance with the findings obtained by Singh and Sangama (2000) in China aster and by Singh and Misra (2008), Rao *etal*. (2005), Narsude *et al.* (2010), Beniwal and Dahiya (2012) and Bharathi and Jawaharlal (2014) in marigold.

Effect of GA_3

Recorded data on total number of flowers plant^{-1} at harvest showed in (Table 6) affected by GA_3 application gave significant variation (Appendix VIII). It was observed that the highest total number of flowers plant^{-1} at harvest (23.85) was recorded from G_2 (100 ppm GA_3) which was statistically different from other treatments followed by G_1 (50 ppm GA_3) whereas the lowest total number of flowers plant^{-1} at harvest (15.79) was observed from control treatment G_0 (0 ppm GA_3)

Maximum number of flowers plant^{-} with the application of GA_3 might be due to more number of branches. Higher number of branches with GA_3 allowed the higher number of lateral branches or auxiliary shoots with flowers located terminally resulting in increased number of flowers plant^{-1}. These results are in close agreement with findings of Kumar *et al.* (2015), Badge *et al.* (2015), Meshram *et al*. (2015) and Kanwar *etal.* (2013) in marigold.

Combined effect of cultivar and GA_3

Total number of flowers plant^{-1} at harvest presented in (Table 7) was varied significantly due to the treatment combination of cultivars and GA_3 (Appendix VIII). Results indicated that the highest total number of flowers plant^{-1} at harvest (24.62) was recorded from the treatment combination of V_4G_2 which was statistically similar with the treatment combination of V_1G_2, V_2G_2, V_3G_2 and V_4G_1. Similarly, the lowest total

number of flowers plant^{-1} at harvest (15.05) was observed from the treatment combination of V_5G_0 which was statistically identical with the treatment combination of V_1G_0, V_2G_0, V_3G_0 and V_4G_0.

4.3.3 Number of flowers plot^{-1}

Effect of cultivars

Different cultivars of marigold showed significant variation on number of flowers plot^{-1} of marigold (Appendix VIII) presented in (Table 6). It was found that the highest number of flowers plot^{-1} (415.40) was recorded from V_4 (Royal bolero) which was significantly different from other cultivars followed by V_1 (Royal yellow fire). Again, the lowest number of flowers plot^{-1} (373.90) was observed from V_5 (Royal yellow) followed by V_2 (Royal red) and V_3 (Royal orange).

Effect of GA_3

Significant influence was observed on number of flowers plot^{-1} of marigold affected by GA_3 application (Appendix VIII) showed in (Table 6). The highest number of flowers plot^{-1} (477.140) was recorded from G_2 (100 ppm GA_3) which was statistically different from other treatments followed by G_1 (50 ppm GA_3) whereas the lowest number of flowers plot^{-1} (315.80) was observed from control treatment G_0 (0 ppm GA_3).

Combined effect of cultivar and GA_3

Combination of marigold cultivars and GA_3 presented in (Table 7) showed significant variation on number of flowers plot^{-1} (Appendix VIII). Results showed that the highest number of flowers plot^{-1} (492.30) was recorded from the treatment combination of V_4G_2 which was significantly different from all other treatment combinations followed by V_1G_2. Similarly, the lowest number of flowers plot^{-1} (301.00) was observed from the treatment combination of V_5G_0 which was also significantly different from all other treatment combinations followed by V_2G_0 and V_3G_0.

4.3.4 Number of flowers ha^{-1} ('000')

Effect of cultivars

Significant variation was remarked on number of flowers ha^{-1} ('000') as influenced by different cultivars of marigold (Appendix VIII) presented in (Table 6). The highest number of flowers ha^{-1} (5193 thousand) was recorded from V_4 (Royal bolero) which was statistically different from other cultivars but the second highest number of flowers ha^{-1} (4896 thousand) was achieved from V_1 (Royal yellow fire) cultivar. Similarly, the lowest number of flowers ha^{-1} (4674 thousand) was observed from V_5 (Royal yellow) followed by V_2 (Royal red).

The increase in flower yield ha^{-1} may be due to increased flower weight and number of flowers plant^{-1} of specific genotypes. Variation in flower yield of varieties was also observed in China aster by Munikrishnappa *et al.* (2013) and by Kumar *et al*. (2015), Khobragade *et al.* (2014) and Krol (2012) in marigold.

Effect of GA_3

Different levels of GA_3 application exposed significant variation on number of flowers ha^{-1} (Appendix VIII) which is shown in (Table 6). The highest number of flowers ha^{-1} (5963 thousand) was recorded from G_2 (100 ppm GA_3) whereas the second highest number of flowers ha^{-1} (5025 thousand) was found from G_1 (50 ppm GA_3). Again, the lowest number of flowers ha^{-1} (3948 thousand) was observed from control treatment G_0 (0 ppm GA_3).

In general, findings indicated that the concentration of GA_3 initiated more number of flowers. The GA_3 is growth promoter which increases early growth resulting in more number of flowers. Maximum flower yield per hectare in French marigold with the application of GA_3 might be due to increase in number of branches and leaves per plant which might have produced more number of flowers per plant and also increasing weight of flowers ultimately increasing the flower yield per plant and per hectare. Similar results were also reported by Kumar *et al.* (2015), Badge *et al.* (2015), Meshram *et al*. (2015), Kanwar *etal.* (2013), Khan *etal*. (2012) and Kumar *etal*. (2011).

Table 7. Yield parameters of French marigold as influenced by different cultivars and different doses of GA_3

Treatment	Yield parameters			
	Number of flowers plant^{-1} at 50 DAT	**Total number of flower plant^{-1} at harvest**	**Number of flowers plot^{-1}**	**No. of flowers ha^{-1} (000)**
V_1G_0	9.27 hi	16.22 f	324.30 j	4054.00 l
V_1G_1	10.07 c	19.78 c	395.70 e	4946.00 f
V_1G_2	10.53 b	24.10 ab	482.00 b	6025.00 b
V_1G_3	9.60 efg	18.23 de	364.70 h	4558.00 j
V_2G_0	8.87 j	15.72 f	314.30 k	3929.00 m
V_2G_1	9.80 de	19.08 cde	381.70 f	4771.00 h
V_2G_2	10.20 c	23.50 ab	470.00 cd	5875.00 d
V_2G_3	9.53 fg	18.03 de	360.70 hi	4508.00 j
V_3G_0	9.17 i	15.72 f	314.30 k	3929.00 m
V_3G_1	9.87 d	19.33 cd	386.70 f	4833.00 g
V_3G_2	10.27 c	23.77 ab	475.30 bc	5942.00 c
V_3G_3	9.60 efg	18.07 de	361.30 hi	4517.00 j
V_4G_0	9.40 gh	16.25 f	325.00 j	4063.00 l
V_4G_1	10.27 c	23.60 ab	472.00 cd	5900.00 cd
V_4G_2	10.80 a	24.62 a	492.30 a	6154.00 a
V_4G_3	9.73 def	18.62 cde	372.30 g	4654.00 i
V_5G_0	8.73 j	15.05 f	301.00 l	3763.00 n
V_5G_1	9.80 de	18.70 cde	374.00 g	4675.00 i
V_5G_2	10.13 c	23.28 b	465.70 d	5821.00 e
V_5G_3	9.47 gh	17.75 e	355.00 i	4438.00 k
$LSD_{0.05}$	0.196	1.171	7.573	50.38
CV(%)	7.37	8.68	8.68	8.68

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

Combined effect of cultivar and GA_3

Variation on number of flowers ha^{-1} of marigold presented in (Table 7) was noted as significant influenced by the treatment combination of cultivars and GA_3 (Appendix VIII). The highest number of flowers ha^{-1} (6154 thousand) was recorded from the treatment combination of V_4G_2 which was statistically different from all other treatment combinations but the second highest number of flowers ha^{-1} (6025 thousand) was

achieved from the treatment combination of V_1G_2. The lowest number of flowers ha^{-1} (3763 thousand) was observed from the treatment combination of V_5G_0 which was statistically different from all other treatment combinations followed by the treatment combination of V_2G_0 and V_3G_0.

4.4 Economic analysis

All the material and non-material input cost like land preparation, seed cost, manure and fertilizers, irrigation and manpower required for all the operation, interest on fixed capital of land (leased land by bank loan basis) and miscellaneous cost were considered for calculating the total cost of production from planting of seed to harvesting of marigold flower and these items were recorded for unit plot and converted into cost per hectare (Table 8 and Appendix IX). Price of marigold flower was considered at market rate. The economic analysis is presented under the following headlines:

4.4.1 Gross income

The combination of different marigold cultivars and GA_3 levels showed variations on gross return (Table 8). Gross income was calculated on the basis of sale of marigold flowers. The highest gross return (Tk. 615400) obtained from V_4G_2 (Royal bolero with 100 ppm GA_3) treatment combination and lowest gross return (Tk. 376300) obtained from the treatment combination of V_5G_0 (Royal yellow with 0 ppm GA_3).

4.4.2 Net return

Treatment combinations of different marigold cultivars and GA_3 levels showed net returns variations (Table 8). The highest net return (Tk. 397992) obtained from the treatment combination of V_4G_2 (Royal bolero with 100 ppm GA_3) and lowest net return (Tk. 162162) obtained from the treatment combination of V_5G_0 (Royal yellow with 0 ppm GA_3).

Table 8. Economic analysis of French marigold production as influenced by different cultivars and different doses of GA_3

Treatments	Economic analysis				
	Flower yield ha^{-1} (No. in thousands)	**Total cost of production**	**Gross return (Tk. ha^{-1})**	**Net return (Tk. ha^{-1})**	**BCR**
V_1G_0	4054	214138	405400	191262	1.89
V_1G_1	4946	215773	494600	278827	2.29
V_1G_2	6025	217408	602500	385092	2.77
V_1G_3	4558	219043	455800	236757	2.08
V_2G_0	3929	214138	392900	178762	1.83
V_2G_1	4771	215773	477100	261327	2.21
V_2G_2	5875	217408	587500	370092	2.70
V_2G_3	4508	219043	450800	231757	2.05
V_3G_0	3929	214138	392900	178762	1.83
V_3G_1	4833	215773	483300	267527	2.24
V_3G_2	5942	217408	594200	376792	2.75
V_3G_3	4517	219043	451700	232657	2.06
V_4G_0	4063	214138	406300	192162	1.90
V_4G_1	5900	215773	590000	374227	2.73
V_4G_2	6154	217408	615400	397992	2.83
V_4G_3	4654	219043	465400	246375	2.12
V_5G_0	3763	214138	376300	162162	1.75
V_5G_1	4675	215773	467500	251727	2.16
V_5G_2	5821	217408	582100	364692	2.68
V_5G_3	4438	219043	443800	224757	2.03

* Selling cost of marigold = 0.10 Tk/piece

V_1 = Royal yellow fire, V_2 = Royal red, V_3 = Royal orange, V_4 = Royal bolero, V_5 = Royal yellow

G_0 = Control (0 ppm GA_3), G_1 = 50 ppm GA_3, G_2 = 100 ppm GA_3, G_3 = 150 ppm GA_3

4.4.3 Benefit cost ratio (BCR)

Among different treatment combinations of marigold cultivars and GA_3 levels, variation on BCR was observed among the treatment combinations (Table 8). The highest Benefit cost ratio (BCR); 2.83 was obtained from the treatment combination of V_4G_2 (Royal bolero with 100 ppm GA_3) and lowest BCR (1.75) was obtained from V_5G_0 (Royal yellow with 0 ppm GA_3) treatment combination. From economic point of view, it was noticeable from the above results that the treatment combination of V_4G_2 (Royal bolero with 100 ppm GA_3) was more profitable than rest of the treatment combinations.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2018 to January 2019. to study the influence of GA_3 on growth and yield of French marigold. The experiment considered of two factors; (i) Factor A - five French marigold cultivars*viz*. V_1 (Royal yellow fire), V_2 (Royal red), V_3 (Royal orange), V_4 (Royal bolero) and V_5 (Royal yellow) and (ii) Factor B - four levels of GA_3 application *viz*. G_0 (control; 0 ppm GA_3), G_1 (50 ppm GA_3), G_2 (100 ppm GA_3) and G_3 (150 ppm GA_3). The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield components and yield parameters were recorded.

In terms of cultivars performance, considering growth parameters, plant height showed non-significant difference among the cultivars at all growth stages, but the maximum plant height (16.34, 26.80 and 29.90 cm at 30 50 and 70 DAT, respectively) was recorded from V_4 (Royal bolero) and this cultivar also showed highest number of leaves plant^{-1} (8.77, 14.77 and 22.88 at 30, 50 and 70 DAT, respectively) and number of branches plant^{-1} (3.70, 5.23 and 7.80 at 30, 50 and 70 DAT, respectively) which were significant at 50 and 70 DAT. Similarly, the minimum plant height (15.02, 24.67 and 27.67 cm at 30 50 and 70 DAT, respectively) and number of branches plant^{-1} (3.23, 4.53 and 6.62 at 30, 50 and 70 DAT, respectively) were recorded from V_5 (Royal yellow) but the lowest number of leaves plant^{-1} (8.23, 12.83 and 20.51 at 30, 50 and 70 DAT, respectively) was observed from V_3 (Royal orange).

In case of yield contributing parameters and yield regarding the performance of different marigold cultivars, the lowest days to 1st flower emergence (16.17), days to 1st flowering (24.25), days to 50% flowering (29.83) and days to 80% flowering (35.75) was observed from V_4 (Royal bolero) but this cultivar (Royal bolero) showed highest floret number plant^{-1} (46.10), floral diameter (5.90 cm), single flower weight (4.33 g), number of flowers plant^{-1} at 50 DAT (10.05), total number of flowers plant^{-1} (20.77), number of flowers plot^{-1} (415.40) and number of flowers ha^{-1} (5193 thousand). Similarly, the highest days to 1st visible flower bud (16.42), days to 1st flower (27.17), days to 50% flowering (32.33) and days to 80% flowering (38.00) were recorded from

V_5 (Royal yellow) but the lowest floret number plant^{-1} (39.88), floral diameter (5.49 cm), single flower weight (3.50 g), number of flowers plant^{-1} at 50 DAT (9.53), total number of flowers plant^{-1} (18.70), number of flowers plot^{-1} (373.90) and number of flowers ha^{-1} (4674 thousand) were also observed from V_5 (Royal yellow).

Regarding GA_3 application, all growth parameters were significant at all growth stages except number of branches plant^{-1} at 30 DAT. However, the maximum plant height (17.18, 27.95 and 32.41 cm at 30, 50 and 70 DAT, respectively) and number of leaves plant^{-1} (9.05, 14.93 and 23.8 at 30, 50 and 70 DAT, respectively) were recorded from G_3 (150 ppm GA_3) but the maximum number of branches plant^{-1} (3.83, 5.65 and 8.57 at 30, 50 and 70 DAT, respectively) was recorded from G_2 (100 ppm GA_3). Similarly, minimum plant height (14.03, 23.03 and 25.36 cm at 30, 50 and 70 DAT, respectively), number of leaves plant^{-1} (7.73, 13.27 and 19.89 at 30, 50 and 70 DAT, respectively) and number of branches plant^{-1} (3.11, 4.13 and 5.77 at 30, 50 and 70 DAT, respectively) were observed from control treatment G_0 (0 ppm GA_3).

In terms of yield contributing parameters and yield of marigold, regarding GA_3 application, the lowest days to 1st visible flower bud e (15.53), days to 1st flower (21.60), days to 50% flowering (27.60) and days to 80% flowering (32.87) was observed from G_2 (100 ppm GA_3) but the highest floret number plant^{-1} (51.36), floral diameter (6.21 cm), single flower weight (4.93 g), number of flowers plant^{-1} at 50 DAT (10.39), total number of flowers plant^{-1} (23.85) at harvest, number of flowers plot^{-1} (477.140) and number of flowers ha^{-1} (5963 thousand) were also found from G_2 (100 ppm GA_3). Similarly, the highest days to 1st visible flower bud (17.13), days to 1st flower (31.53), days to 50% flowering (36.53) and days to 80% flowering (42.07) were recorded from control treatment G_0 (0 ppm GA_3) but on the other hand, the lowest floret number plant^{-1} (34.97), floral diameter (5.18 cm), single flower weight (3.07 g), number of flowers plant^{-1} at 50 DAT (9.09), total number of flowers plant^{-1} (15.79) at harvest, number of flowers plot^{-1} (315.80) and number of flowers ha^{-1} (3948 thousand) were also recorded from control treatment G_0 (0 ppm GA_3).

In case of the combination of cultivars and GA_3, all growth parameters were significant at all growth stages except plant height at 30 DAT. However, the maximum plant height (18.40, 30.13 and 34.67 cm at 30, 50 and 70 DAT, respectively) and number of leaves plant^{-1} (9.47, 16.73 and 25.40 at 30, 50 and 70 DAT, respectively) were achieved from

the treatment combination of V_4G_3 but the highest number of branches plant^{-1} (4.40, 5.87 and 9.87 at 30, 50 and 70 DAT, respectively) was recorded from the treatment combination of V_4G_2. Similarly, the minimum plant height (13.00, 21.00 and 24.93 cm at 30, 50 and 70 DAT, respectively) and number of branches plant^{-1} (2.20, 3.27 and 4.67 at 30, 50 and 70 DAT, respectively) were observed from the treatment combination of V_5G_0 whereas the lowest number of leaves plant^{-1} (7.53, 11.53 and 16.73 at 30, 50 and 70 DAT, respectively) was recorded from the treatment combination of V_3G_0.

In terms of yield contributing parameters and yield of marigold, regarding combined effect of cultivars and GA_3 application, the lowest days to 1st flower emergence (14.67), days to 1st flowering (14.67), days to 50% flowering (25.33) and days to 80% flowering (31.67) were observed from the treatment combination of V_4G_2 but this treatment combination (V_4G_2) also showed highest floret number plant^{-1} (54.60), floral diameter (6.53 cm), single flower weight (5.33 g), number of flowers plant^{-1} at 50 DAT (10.80), total number of flowers plant^{-1} (24.62), number of flowers plot^{-1} (492.30) and number of flowers ha^{-1} (6154 thousand). Again, the treatment combination of V_5G_0 gave highest days to 1st flower emergence (17.67), days to 1st flowering (17.67), days to 50% flowering (37.67) and days to 80% flowering (43.33) were recorded from the treatment combination of V_5G_0 while the lowest floret number plant^{-1} (31.13), floral diameter (5.03 cm), single flower weight (2.00 g), number of flowers plant^{-1} at 50 DAT (8.73), total number of flowers plant^{-1} (15.05), number of flowers plot^{-1} (301.00) and number of flowers ha^{-1} (3763 thousand) were also obtained from the treatment combination of V_5G_0.

In terms of economic analysis, the highest gross return (Tk. 615400), net return (Tk. 397992) and BCR (2.83) were obtained from the treatment combination of V_4G_2 whereas the lowest gross return (Tk. 376300), net return (Tk. 162162) and BCR (1.75) was obtained from V_5G_0.

From the above results, it can be concluded that the treatment combination of V_4G_2 (Royal bolero with 100 ppm GA_3) showed highest yield advantage regarding flower yield of marigold. So, this treatment combination can be considered as the best treatment combination considering gross return, net return and BCR. So, V_4G_2 (Royal bolero with 100 ppm GA_3) might be considered as the best treatment combination because of highest economic return

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

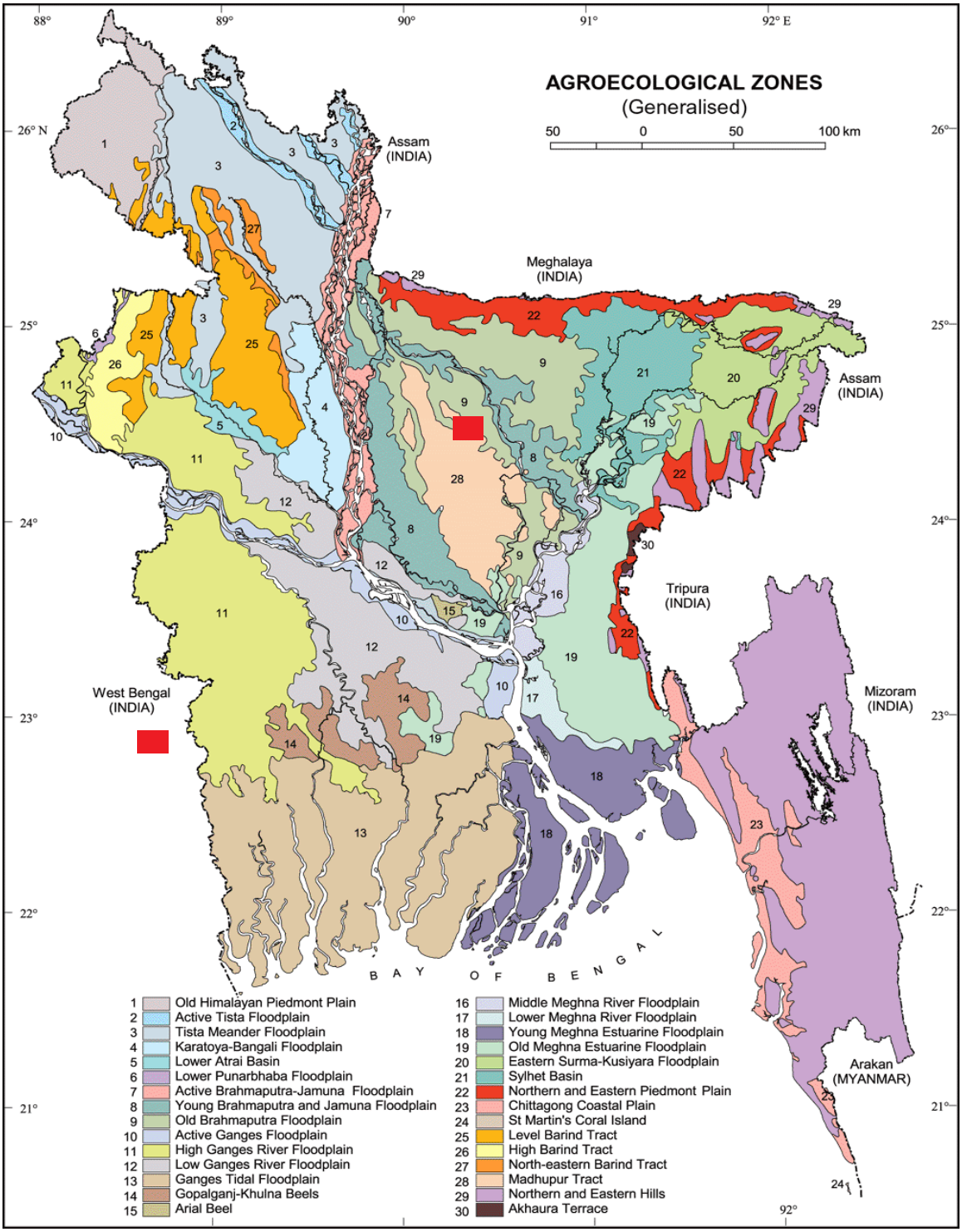

Figure 8. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from October 2018 to January 2019.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	***Min***	***Mean***		
2018	October	30.42	16.24	23.33	68.48	52.60
2018	November	28.60	8.52	18.56	56.75	14.40
2018	December	25.50	6.70	16.10	54.80	0.0
2019	January	23.80	11.70	17.75	46.20	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV: Mean square of plant height of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Sources of variation	Degrees of freedom	Mean square of plant height		
		30 DAT	50 DAT	70 DAT
Replication	2	1.202	2.765	4.538
Factor A	4	8.522^{NS}	38.54*	106.02*
Factor B	3	14.97^{NS}	1.041**	11.160*
AB	12	1.57^{NS}	6.678*	5.104*
Error	38	2.733	4.028	2.289

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V: Mean square of number of leaves plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAT	50 DAT	70 DAT
Replication	2	2.016	0.581	4.172
Factor A	4	2.078^{NS}	10.85*	36.99*
Factor B	3	0.797**	0.364**	11.58*
AB	12	0.508^{NS}	5.102*	9.118*
Error	38	0.596	2.550	4.031

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI: Mean square of number of branches plant^{-1} of French marigold at different days after transplanting as influenced by different cultivars and different doses of GA_3

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}		
		30 DAT	50 DAT	70 DAT
Replication	2	1.422	2.025	4.958
Factor A	4	2.159 ^{NS}	4.177*	8.145*
Factor B	3	0.546 ^{NS}	0.301**	3.207*
AB	12	0.738*	0.517*	2.870**
Error	38	0.792	0.716	1.876

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII: Mean square of yield contributing parameters of French marigold as influenced by different cultivars and different doses of GA_3

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters						
		Days to 1st visible flower bud	Days to 1st flower	Days to 50% flowering	Days to 80% flowering	Floret number flower^{-1}	Flower diameter (cm)	Single flower weight (g)
Replication	2	0.217	6.211	4.200	5.550	12.829	0.159	0.800
Factor A	4	6.192^{NS}	166.35*	75.733*	71.89*	303.83*	2.021^{NS}	2.000**
Factor B	3	0.861**	29.350*	17.111*	0.378**	68.567*	0.197**	6.400*
AB	12	0.958*	14.836**	19.056*	5.003**	104.09*	0.121**	0.844**
Error	38	1.182	6.375	23.902	3.673	35.842	0.177	0.712

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII: Mean square of yield parameters of French marigold as influenced by different cultivars and different doses of GA_3

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Number of flowers plant^{-1} at 50 DAT	Total number of flower plant^{-1} at harvest	Number of flowers plot^{-1}	No. of flowers ha^{-1} (000)
Replication	2	0.831	1.539	61.517	189.422
Factor A	4	1.406^{NS}	21.364*	854.708*	2637.010*
Factor B	3	0.897**	115.14*	4605.86*	14215.15*
AB	12	0.657**	12.343**	493.042**	1523.236**
Error	38	2.247	0.512	20.990	63.920

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX: Cost of production of marigold per hectare

A. Input cost (Tk. ha^{-1})

Treatments	Cultivation with Labor	Marigold seed cost	Insecticide cost (Tk. ha^{-1})	Irrigation	Cowdung	Fertilizer			GA_3 application	Seed bed preparation and seed sowing cost	Transplanting cost	Subtotal (A)
						Urea	TSP	MOP				
V_1G_0	32000	45000	10000	15000	10000	7200	5000	2560	0	3000	30000	159760
V_1G_1	32000	45000	10000	15000	10000	7200	5000	2560	1500	3000	30000	161260
V_1G_2	32000	45000	10000	15000	10000	7200	5000	2560	3000	3000	30000	162760
V_1G_3	32000	45000	10000	15000	10000	7200	5000	2560	4500	3000	30000	164260
V_2G_0	32000	45000	10000	15000	10000	7200	5000	2560	0	3000	30000	159760
V_2G_1	32000	45000	10000	15000	10000	7200	5000	2560	1500	3000	30000	161260
V_2G_2	32000	45000	10000	15000	10000	7200	5000	2560	3000	3000	30000	162760
V_2G_3	32000	45000	10000	15000	10000	7200	5000	2560	4500	3000	30000	164260
V_3G_0	32000	45000	10000	15000	10000	7200	5000	2560	0	3000	30000	159760
V_3G_1	32000	45000	10000	15000	10000	7200	5000	2560	1500	3000	30000	161260
V_3G_2	32000	45000	10000	15000	10000	7200	5000	2560	3000	3000	30000	162760
V_3G_3	32000	45000	10000	15000	10000	7200	5000	2560	4500	3000	30000	164260
V_4G_0	32000	45000	10000	15000	10000	7200	5000	2560	0	3000	30000	159760
V_4G_1	32000	45000	10000	15000	10000	7200	5000	2560	1500	3000	30000	161260
V_4G_2	32000	45000	10000	15000	10000	7200	5000	2560	3000	3000	30000	162760
V_4G_3	32000	45000	10000	15000	10000	7200	5000	2560	4500	3000	30000	164260
V_5G_0	32000	45000	10000	15000	10000	7200	5000	2560	0	3000	30000	159760
V_5G_1	32000	45000	10000	15000	10000	7200	5000	2560	1500	3000	30000	161260
V_5G_2	32000	45000	10000	15000	10000	7200	5000	2560	3000	3000	30000	162760
V_5G_3	32000	45000	10000	15000	10000	7200	5000	2560	4500	3000	30000	164260

B. Overhead cost (Tk. ha^{-1}), Cost of production (Tk. ha^{-1}), Gross return (Tk. ha^{-1}), Net return (Tk. ha^{-1}) and BCR

Treatments	Overhead cost (Tk. ha^{-1})				Subtotal (A)	Total cost of production (A+B)	Yield ha^{-1} (No. in thousands)	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
	Cost of leased land for 6 months (8% of value of land Tk. 10,00,000/-	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (8% of cost year^{-1})	Subtotal (B)						
V_1G_0	40000	7988	6390	54378	159760	21	4054	405400	191262	1.88
V_1G_1	40000	8063	6450	54513	161260	21	4946	494600	278827	2.29
V_1G_2	40000	8138	6510	54648	162760	21	6025	602500	385092	2.77
V_1G_3	40000	8213	6570	54783	164260	21	4558	455800	236757	2.08
V_2G_0	40000	7988	6390	54378	159760	21	3929	392900	178762	1.83
V_2G_1	40000	8063	6450	54513	161260	21	4771	477100	261327	2.21
V_2G_2	40000	8138	6510	54648	162760	21	5875	587500	370092	2.70
V_2G_3	40000	8213	6570	54783	164260	2	4508	450800	231757	2.05
V_3G_0	40000	7988	6390	54378	159760	21	3929	392900	178762	1.83
V_3G_1	40000	8063	6450	54513	161260	21	4833	483300	267527	2.24
V_3G_2	40000	8138	6510	54648	162760	21	5942	594200	376792	2.75
V_3G_3	40000	8213	6570	54783	164260	2	4517	451700	232657	2.06
V_4G_0	40000	7988	6390	54378	159760	2	4063	406300	192162	1.90
V_4G_1	40000	8063	6450	54513	161260	21	5900	590000	374227	2.73
V_4G_2	40000	8138	6510	54648	162760	21	6154	615400	397992	2.83
V_4G_3	40000	8213	6570	54783	164260	2	4654	465400	246375	2.12
V_5G_0	40000	7988	6390	54378	159760	2	3763	376300	162162	1.75
V_5G_1	40000	8063	6450	54513	161260	21	4675	467500	251727	2.16
V_5G_2	40000	8138	6510	54648	162760	2	5821	582100	364692	2.68
V_5G_3	40000	8213	6570	54783	164260	22	4438	443800	224757	2.03

* Selling cost of marigold = 0.10 Tk/piece

Appendix X: Pictorial view of marigold cultivation

Plate 5. GA_3 application

Plate 6: Weeding of the experiment plot

Plate 7: Experiment field showing early flowering stage

Plate 8: Data collection on flower diameter

Plate 9: Data collection of flower weight

Plate 10: Royal yellow fire cultivar of France marigold

Plate 11: Royal orange cultivar of France marigold

Plate 12: Royal red cultivar of France marigold

Plate 13: Royal bolero cultivar of France marigold

Plate 14: Royal yellow cultivar of France marigold

Plate 15: Experiment field showing 50% flowering

Plate 16: Experiment field showing 80% flowering