Project ID 668

Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Development of Protective Cultivation Techniques of Gladiolus and Gerbera in Bangladesh

Project Duration

May 2017 to September 2018

Floriculture Division, Horticulture Research Centre
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701

Submitted to
Director
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Bangladesh

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Acronyms

BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
CRD	:	Completely Randomized Design
CRG	:	Competitive Research Grant
DMRT	:	Duncan's Multiple Range Test
dS/m	:	DeciSiemens per metre
EC	:	Electrical Conductivity
GA_3	:	Gibberellic acid
HRC	:	Horticulture Research Centre
NARS	:	National Agricultural Research System
NATP	:	National Agricultural Technology Program
pH	:	Hydrogen ion concentration
RCBD	:	Randomized completely block design
RH	:	Relative Humidity

Table of Contents

Executive Summary

Flowers always remain Centre of attraction in human life. They play a cardinal role in human behavior and culture, bringing tranquility and peace of mind. Among various cut flowers, gladiolus and gerbera are commercially more important with high demand in Bangladesh. Almost all the flowers are being produced (>96 percent) under open field conditions in Bangladesh which deteriorates the quality of the flowers. Protected conditions provide favorable environment for the growth of the plants by protecting the crop from heavy rainfall, winds, pests, diseases and other climatic conditions. The yield under protective cultivation can be achieved to the level of 5-8 times as compared to the open crop cultivation. Gerbera don't perform well in open field condition. In protected conditions, it grows faster and produces larger and greener leaves with high dry matter content as well as the yield of flowers increases and more side shoots form. Though gladiolus is cultivated in Bangladesh under open condition but for year round cultivation it needs protection. The market requirement for gladiolus and gerbera is very specific and it can be met consistently, only when the crop is grown under protected conditions. Moreover, for obtaining good growth, yield and quality of flowers depend on some other factors such as genotype, use of growth regulators, optimum substrate, hydroponics culture etc. Keeping this view in mind this project has been designed on cultivation of gladiolus and gerbera under protection also using some other techniques to produce quality flower year round.

Under the activities of the project six experiments titled "Performance of gladiolus varieties in off-season under protected condition", "Effect of gibberellic acid on growth and yield of gladiolus under polytunnel'', "Performance of gerbera varieties under protected condition", "Effect of gibberellic acid on growth, yield and quality of gerbera under polytunnel'', "Performance study on different varieties of gerbera grown in Cooper's Hydroponic solution'' and "Effect of substrates on yield and quality of gerbera in soilless culture" were carried out. The variety BARI Gladiolus-4 under polytunnel recorded best performance owing to improved growth, quality, higher yield and less disease incidence. Corm treated with GA_3 @ 200 ppm was found best result in plant growth, flowering and yield characteristics of gladiolus in Off-season under polytunnel condition. The promising line of Gerbera (GJ-023) performed better with regard to vegetative growth, flower characteristics, yield and quality under polyhouse condition. Gibberellic acid (GA_3) @ 100 ppm accelerated vegetative, flowering, yield and quality characteristics of gerbera. Gerbera varieties successfully grown through hydroponic culture.Perlite + cocodust (1:1 ratio) was the suitable potting substrate followed by cocodust (100%) for gerbera cultivation in pot.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
   Development of Protective Cultivation Techniques of Gladiolus and Gerbera in Bangladesh

2. Implementing organization:
   Floriculture Division, Horticultural Research Centre, BARI, Joydebpur, Gazipur-1701

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**
   Name of PI :Dr. Kabita Anzu-Man-Ara
   Chief Scientific Officer
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   Mobile: 01787111444, E-mail: dr.kabita_2009@yahoo.com

   Name of Co-PI : Dr. S. M. Sharifuzzaman
   Chief Scientific Officer
   RARS, Akbarpur, Maulvi Bazar
   Mobile: 01765295162, Email: dr.sharif_2011@yahoo.com

4. **Sub-project budget (Tk):**
   4.1 Total: 25,00,000.00 **(Twenty five lakh Taka only)**
   4.2 Revised (if any): **2377549.00 (Twenty three lakh seventy seven thousand five hundred forty nine Taka only)**

5. **Duration of the sub-project:**
   5.1 Start date (based on LoA signed): 09th May, 2017
   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

   Flowers always remain centre of attraction in human life. They play a cardinal role in human behavior and culture, bringing tranquility and peace of mind. Evidence from all civilization shows that flowers are used for various purposes in our daily life like worshipping, religious and social functions. But in the present world, flowers became important not only for their aesthetic, medicinal and social values but also for their economic contribution (Ara, 2010). Production and trade with these crops are now very much specialized in developed countries with a significant contribution to their national economy. Todays in Bangladesh, floriculture has also emerged as a lucrative profession with much higher potential to returns than most field and some horticultural crops (Khan and Janakiran, 2016). Bangladesh has advantage due to its favourable climate, topography, less labour cost and relatively low production cost for growing many flowers which can help the development of flower industry (Dadlani, 2013). Among various cut flowers, gladiolus and gerbera are commercially more important with high demand in Bangladesh.

   Almost all the flowers are being produced (>96 percent) under open field conditions (Momin, 2006) in Bangladesh which deteriorates the quality of the flowers. Protected conditions provide favorable environment for the growth of the plants by protecting the crop from heavy rainfall, winds, pests,

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
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2. Implementing organization:
   Floriculture Division, Horticultural Research Centre, BARI, Joydebpur, Gazipur-1701

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

   Name of PI : Dr. Kabita Anzu-Man-Ara
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   Almost all the flowers are being produced (>96 percent) under open field conditions (Momin, 2006) in Bangladesh which deteriorates the quality of the flowers. Protected conditions provide favorable environment for the growth of the plants by protecting the crop from heavy rainfall, winds, pests, diseases and other climatic conditions (Chauhan, 2005). The yield under protective cultivation can be achieved to the level of 5-8 times as compared to the open crop cultivation (Reddy *et al.,* 2013). Gerbera don't perform well in open field condition. In protected conditions, it grows faster and produces larger and greener leaves with high dry matter content as well as the yield of flowers increases and more side shoots form (Mahmood *et al.,* 2013). Though gladiolus is cultivated in Bangladesh under open condition but for year round cultivation it needs protection. Off season quality gladiolus production will help to expand the business of flower growers. The market requirement for gladiolus and gerbera is very specific and it can be met consistently, only when the crop is grown under protected conditions. Moreover, for obtaining good growth, yield and quality of flowers depend on some other factors such as genotype, use of growth regulators, optimum substrate, hydroponics culture etc. (Swarup, 2006). Therefore, it is an urgent need to start cultivation of gladiolus and gerbera under protection using some other techniques to produce quality flower year round.

7. **Sub-project goal:**To available quality flowers round the year.

8. **Sub-project objective (s):**
   i) To develop suitable protective culture technique for gladiolus and gerbera
   ii) To standardize optimum substrate for soilless culture of gerbera
   iii) To establish technology for off-season gladiolus production

9. **Implementing location (s):**Floriculture Division, Horticultural Research Centre, BARI, Joydebpur, Gazipur-1701.

10. **Methodology in brief:**

- Bangladesh Agricultural Research Institute (BARI) acted as lead agency, and provided technological back up, experimental field, laboratory service (such as soil analysis, nutrient analysis etc.), data analysis, report preparation etc.

- The activity of the project were carried on different varieties and promising lines of gerbera and gladiolus during May 2017 to September 2018 by Floriculture Division of Horticulture Research Centre, BARI, Gazipur.

- To conducting the project, necessary infrastructure and solution viz. polystucture, hydroponic solution, GA_3 solution etc. were prepared as when necessary.

- For full fill the objective of the project, six experiments were conducted.

- ANOVA and means were separated using Duncan's Multiple Range Test (DMRT) using MSTAT-C programme.

11. **Results and discussion:**

EXPT. 1 :PERFORMANCE OF GLADIOLUS VARIETIES IN OFF-SEASON UNDER PROTECTED CONDITION

K. A. Ara and S. M. Sharifuzzaman

Abstract

The study on performance of gladiolus varieties under protected conditions were undertaken at Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, *Gazipur during August 2017 to January 2018. Three varieties of gladiolus (BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-5) were included in this study with protective structures (Polytunnel and polyhouse) including control (open field). Uniform sized corms (4.0 cm dia.) of all the varieties were planted at 7.0 cm depth, with a spacing of 20 × 20 cm. The two factorial experiment was laid out in split plot design with three replications. Maximum growth, flowering, yield and quality of BARI Gladiolus-4 was recorded in polytunnel condition followed by polyhouse condition. Early spike initiation was observed in BARI Gladiolus-3 under polytunnel condition. Overall performance of BARI Gladiolus-4 was also found best in polytunnel condition followed by polyhouse condition against disease incidence and quality.*

Introduction

Gladiolus (*Gladiolus spp.)* is an important bulbous crop belongs to family Iridaceae, which is originated from South Africa. It is attributed as Queen of bulbous ornamentals due to its popularity among the bulbous ornamental cultivated in the world. Magnificent inflorescence with variety of colours, made it attractive for use in herbaceous borders, beddings, rockeries, pot and for cut-flowers (Ramzan *et al.,* 2012). In Bangladesh, the agro ecological conditions are very conducive for the survival and culture of gladiolus. It has great economic value as a cut flower and its cultivation is relatively easy. Studies have established by Momin (2006) that income from gladiolus flower production is six times returns from rice. Its elegant spikes, varieties of colour with long vase life are the reason for its ever increasing demand.

Gladiolus occupies 4^{th} place in international cut-flower trade after rose, carnation and chrysanthemum (Saaie *et al.,* 2011). In Bangladesh, it is rated as the most important and popular cut-flower from commercial point of view. However, the constraint of small area under gladiolus cultivation can be overcomedby increasing yield per hectare. This can be achieved by bringing highly reproductive (fruitful) cultivars/varieties in the field. In Bangladesh, gladiolus is commonly cultivated in open field condition. It's cultivation under polytunnel or polyhouse is still in a stage of infancy. Availability of gladiolus in the field and market is mostly concentrated during the winter season that is called on-season. Production and supply of gladiolus flower in summer or rainy season (off-season) is very limited due to adverse weather condition, absence of suitable variety and technology. But, there is a good scope of producing gladiolus round the year as was reported by Ara *et al.* (2003). Keeping this in view, the present investigation was undertaken to assess the performance of gladiolus varieties under protected condition to produce quality bloom in off-season.

Materials and Method

The present investigation was conducted at Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during August 2017 to January 2018. Three varieties of gladiolus (BARI Gladiolus-3, BARI Gladiolus-4 and BARI Gladiolus-5) were included in this study with protective structures (Polytunnel and polyhouse) including control (open field). Uniform sized corms (4.0 cm dia.) of all the varieties were planted at 7.0 cm depth, with a spacing of 20 × 20 cm. The two factorial experiment was laid out in split plot design with three replications. The experimental field was manured and fertilized by adding 10 t cowdung and @ 200.0 Kg N, 50.0 Kg P, 150.0 Kg K, 20.0 Kg S, 2.0 kg B and 3 kg Zn/ha. Cowdung, P, K, B, S and Zn were applied as basal and N was top-dressed in two equal splits at 4 leaf stage and spike initiation stage. Intercultural operations like weeding, watering, spraying, etc. were done as and when necessary. The spikes were cut when lower 2-3 florets showed their blushes of colour. Corms and cormels were lifted two months after cutting flower and treated with Autostin (0.2%) for 30 minutes to prevent incidence of leaf blight disease. Various growth attributes viz., plant height, leave number/hill, leaf size, plant number/hill, sprouting of corms, floral attributes viz., days to spike initiation, spike length, rachis length, number of florets per spike, vase life, flowering duration, flower yield and corm attributes viz., corm number, cormel number, corm weight, cormel weight etc. were recorded. The collected data were analysed statistically by performing analysis of variance and means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Steel *et al.,* 1997).

Results and Discussion

Table 1 reveals that varieties of gladiolus have significant effect on different aspects of plant development process. The tallest plant was recorded (55.0 cm) with V_3 (BARI Gladiolus-5) whereas the shortest plant (50.0 cm) was observed in V_1 (BARI Gladiolus-3) (Table 1). Maximum leaves per hill (12.0), leaf size (62.0 cm) and plants per hill (2.4) was observed in V_2 (BARI Gladiolus-4). Early sprouting of corm (8.0 days) was observed in V_1 (BARI Gladiolus-3) which is statistically at per with V_3 (BARI Gladiolus-5) (8.2 days). The growth characteristics like plant height, leave number, leaf size, sprouting etc. of corm being genetically factored, it is expected to vary among the varieties. The findings are in accordance with the result reported by Islam and Haque (2011) in gladiolus.

Table 1. Performance of different varieties on vegetative growth parameter of gladiolus

Treatments	Plant height (cm)	Leaves/hill	Leaf size (cm^2)	Plants/hill	Sprouting of corm (days)
V_1	50.0 b	9.0 b	56.0 b	1.1 b	8.0 b
V_2	53.5 ab	12.0 a	62.0 a	2.4 a	12.0 a
V_3	55.0 a	10.9 ab	58.4 ab	1.2 b	8.2 b
Level of Sig.	*	*	*	*	*
CV (%)	**7.4**	**8.0**	**9.0**	**7.2**	**8.4**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5

Significant variation was found for vegetative growth in case of T_0 (open field condition) and different protected conditions in T_1 and T_2 (polytunnel and polyhouse conditions respectively). The treatment T_2 (polyhouse condition) produced highest plant height (58.0 cm), maximum number of leaves per hill (13.3), maximum leaf size (63.8 cm^2) and maximum plants per hill (2.7) which is statistically at par with T_1 (polytunnel condition). Similar result was reported by John and Khan (2003) in tulip. Earliest sprouting of corms (8.5 and 8.4 days respectively) were occurred from both protected conditions (polytunnel and polyhouse) and sprouting was delayed (12.0 days) in open field condition (T_0) (Table 2). The earliness in sprouting of corm was recorded in T_1 (polytunnel) and T_2 (polyhouse) might be due to rise in soil temperature inside the protected condition as compared to open field condition which favours the crop to sprout. Similar earliness in protected conditions was noted by Shiva and Dadlani (2002) in gladiolus.

Table 2. Performance of different protected conditions on vegetative growth parameter of gladiolus

Treatments	Plant height (cm)	Leaves/hill	Leaf size (cm^2)	Plants/hill	Sprouting of corm (days)
T_0	53.0 b	10.0 b	57.0 b	1.3 b	12.0 b
T_1	57.5 a	13.0 a	63.5 a	2.6 a	8.5 a
T_2	58.0 a	13.3 a	63.8 a	2.7 a	8.4 a
Level of Sig.	*	*	*	*	*
CV (%)	**7.4**	**8.0**	**9.0**	**7.2**	**8.4**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The interaction effect of varieties and protected conditions on growth parameter of gladiolus was found significant (Table 3). The variety BARI Gladiolus-5 (V_3) recorded maximum plant height (29.0 cm) under polyhouse condition. Highest number of leaves (14.0) and plants/hill (3.2) were obtained by V_2 (BARI Gladiolus-4) under polytunnel condition followed by polyhouse condition. Maximum leaf size (64.0 cm^2) was observed in V_2 (BARI Gladiolus-4) under polytunnel (T_1) condition closely followed by polyhouse (T_2) condition. Early sprouting of corm (8.2 and 8.3 days) was observed in V_1 (BARI Gladiolus-3) under both protected (T_1 and T_2) conditions. All the varieties performed poor condition under open field condition in respect of all growth parameter in gladiolus. Similar variation in growth attributes of gladiolus due to varieties and protected conditions were reported by Al-Humaid (2004) in gladiolus.

Table 3. Combined effect of varieties and protected conditions on growth parameter of gladiolus

Treatments	Plant height (cm)	Leaves/hill	Leaf size (cm^2)	Plants/hill	Sprouting of corm (days)
V_1T_0	51.0 c	9.8 b	58.5 b	1.6 b	10.5 ab
V_1T_1	53.0 bc	10.5 ab	58.9 ab	2.2 ab	8.2 b
V_1T_2	54.0 bc	11.0 ab	59.4 ab	2.4 ab	8.3 b
V_2T_0	55.0 bc	11.2 ab	60.8 ab	2.5 ab	10.4 ab
V_2T_1	56.0 b	14.0 a	64.0 a	3.2 a	9.2 ab
V_2T_2	56.9 ab	13.0 ab	62.8 a	2.8 ab	9.3 ab
V_3T_0	57.2 ab	12.0 ab	59.2 ab	2.4 ab	12.0 a
V_3T_1	57.8 ab	12.3 ab	60.5 ab	2.5 ab	9.6 ab
V_3T_2	59.0 a	12.2 ab	61.0 ab	2.6 ab	9.5 ab
Level of Sig.	*	*	*	*	*
CV (%)	**7.4**	**8.0**	**9.0**	**7.2**	**8.4**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The results of different varieties of gladiolus regarding flower characters were found significant (Table 4). The variety BARI Gladiolus-3 (V_1) required minimum days (66.0 days) for flowering, whereas variety BARI Gladiolus-4 (V_2) required maximum days (72.0 days). The longest stalk (70.0 cm) and rachis (48.0 cm) were found from BARI Gladiolus-4 (V_2). The stalk length is a genetic factor therefore, it is expected to vary among the varieties observed by Shiva and Dadlani (2012). Maximum number of floret (12.0) per spike and highest flower yield (2,08,000) per hectare were recorded in BARI Gladiolus-4 (V_2). The same variety also attained maximum vase life (11.3 days) and flowering duration (22.0 days).

Sipke length and rachis length plays an important role in the post-harvest vase life of cutflowers as well as extending flowering duration. It has been found that as the length of the spike and rachis increases the carbohydrates content which helps in increasing the stability of vase life of cutflowers thereby extending flowering duration and prolonging the vase life of cutflowers. These results are in accordance with findings of Shilo and Halevey (2005) in gladiolus.

Table 4. Performance of different varieties on flower parameter of gladiolus

Treatments	Flower colour	Spike initiation (days)	Spike length (cm)	Rachis length (cm)	Floret no./spike	Vase life (days)	Flowering duration (days)	Flower yield (no./ ha) ('000)
V_1	White	66.0 b	64.8 b	43.2 b	10.0 b	9.0 b	18.0 b	204.0 b
V_2	Pink	72.0 a	70.0 a	48.0 a	12.0 a	11.3 a	22.0 a	208.0 a
V_3	Yellow	69.0 ab	66.0 ab	44.7 ab	10.2 b	9.2 b	20.5 ab	206.0 ab
Level of Sig.	*	*	*	*	*	*	*	*
CV (%)	-	**9.3**	**7.5**	**8.4**	**8.0**	**7.2**	**7.9**	**9.8**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5

Significant variation was found for flower parameter of gladiolus in case of different protected conditions (polytunnel and polyhouse) and open field condition (Table 5). Maximum spike length (75.0 cm) and rachis length (52.2 cm) were recorded in polytunnel (T_1) condition followed by polyhouse (T_2) condition. Early spike initiation (66.0 days) was observed in BARI Gladiolus-3 under polytunnel (T_1) followed by polyhouse (T_2) condition. The earliness in spike initiation was recorded in T_1 (polytunnel) and T_2 (polyhouse) might be due to rise in soil temperature inside the protected condition as compared to open field condition which favours the crop to sprout early and complete the vegetative phase earlier. Highest number of floret (12.5) and maximum flower yield (212000 spikes) were observed in polytunnel (T_1) followed by polyhouse (T_2) condition. This could be attributed more favourable environment under polytunnel (T_1) and polyhouse (T_2) condition as compared to open field (T_0) condition. Improved quality i.e. maximum vase life (12.0 days) and longest flowering duration (24.0 days) under protected condition was obtained as compared to the open field culture of gladiolus as observed by Sarkar and Sharma (2016).

Table 5. Performance of different protected conditions on flower parameter of gladiolus

Treatments	Spike initiation (days)	Spike length (cm)	Rachis length (cm)	Floret no./spike	Vase life (days)	Flowering duration (days)	Flower yield (no./ha) ('000)
T_0	75.0 a	70.0 b	47.5 b	10.2 b	9.1 b	18.8 b	206.0 b
T_1	70.0 b	75.0 a	52.2 a	12.5 a	12.0 a	24.0 a	212.0 a
T_2	72.0 ab	68.5 ab	50.0 ab	10.4 b	10.0 ab	22.2 ab	209.0 ab
Level of Sig.	*	*	*	*	*	*	*
CV (%)	**9.3**	**7.5**	**8.4**	**8.0**	**7.2**	**7.9**	**9.8**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

Under open field condition, late flower initiation, minimum spike and rachis length, lowest floret number per spike, lowest flower yield and minimum vase life, shortest flowering duration were recorded as compared to polytunnel (T_1) and polyhouse (T_2) condition. The longer vase life under polytunnel (T_1) and polyhouse (T_2) condition may be due to improved spike length, rachis length free from dew fall and high CO_2 concentration inside polytunnel (T_1) and polyhouse (T_2). The quality of flower was better under polytunnel (T_1) and polyhouse (T_2) as compared to open field (T_0) condition as more disease incidence and flower deterioration was observed. In polytunnel (T_1) and polyhouse (T_2) greater plants/hill, maximum leaf size and more number of leaves/plant were produced which would have resulted in production and accumulation of more photosynthesis, resulting in production of more number of flowers. Polytunnel (T_1) and polyhouse (T_2) also protected the plants from heavy shower. This is in line with the findings of Islam and Haque (2011) in gladiolus.

The interaction between varieties and protected condition was also significant which indicate that the influence of protected condition on flower parameter of different gladiolus varieties (Table 6). Comparison of varieties revealed that the variety BARI Gladiolus-3 (V_1) produced earliest spike initiation (69.0 days) and BARI Gladiolus-4 (V_2) produced longest spike (77.0 cm), longest rachis (53.0 cm), maximum floret number (13.0), maximum flower yield (2,15,000/ha), prolonged vase life (11.8 days) and flowering duration (21.5 days) under polytunnel (T_1) condition followed by polyhouse (T_2) condition. Increase in spike and rachis length of gladiolus inside the polytunnel (T_1) and polyhouse (T_2) might be due to the varieties and availability of more fertilizers and suitability of environmental factors mainly light and temperature in protected condition. The results of the present investigation are in conforming with results of Saeif *et al.* (2011) in gladiolus.

Table 6. Combined effect of varieties and protected conditions on flower parameter of gladiolus

Treatments	Spike initiation (days)	Spike length (cm)	Rachis length (cm)	Floret no./spike	Vase life (days)	Flowering duration (days)	Flower yield (no./ ha) ('000)
V_1T_0	74.0 bc	65.0 c	42.3 c	10.3 b	9.0 b	18.5 b	202.0 d
V_1T_1	69.0 c	72.0 b	45.0 bc	11.0 ab	9.1 b	19.6 ab	204.0 cd
V_1T_2	71.0 bc	70.0 bc	43.8 bc	10.8 ab	10.0 ab	20.0 ab	205.0 cd
V_2T_0	79.0 a	71.2 bc	47.0 b	11.2 ab	10.2 ab	19.0 ab	206.0 c
V_2T_1	75.0 b	77.0 a	53.0 a	13.0 a	11.8 a	21.5 a	215.0 a
V_2T_2	77.0 ab	75.0 ab	50.0 ab	12.0 ab	11.0 ab	20.5 ab	213.0 ab
V_3T_0	78.0 ab	69.0 bc	42.5 c	11.0 ab	9.1 b	19.5 ab	208.0 bc
V_3T_1	75.0 b	72.0 b	46.9 b	11.3 ab	9.8 ab	20.0 ab	211.0 b
V_3T_2	77.0 ab	71.5 bc	44.0 bc	11.4 ab	10.5 ab	20.3 ab	211.8 b
Level of Sig.	*	*	*	*	*	*	*
CV (%)	**9.3**	**7.5**	**8.4**	**8.0**	**7.2**	**7.9**	**7.8**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

With respect to varieties, maximum number of corms (1.8), cormels (10.0), corm weight (60.0 g) and cormel weight (5.0 g) were recorded in BARI Gladiolus-4 (V_2), while it was minimum in BARI Gladiolus-3 (V_1) followed by BARI Gladiolus-5 (V_3). Variation in these characters in different varieties might be due to inherent genetic factors. Such variability in corm parameters might be attributed to influence of genetic makeup of varieties. These results are in close conformity with the findings of Balaram and Janakiram (2009). Superiority of some varieties over the other for corm and cormel traits was also recorded by Kishan *et al.* (2005) in gladiolus.

Table 7. Performance of different varieties on corm parameter of gladiolus

Treatments	No. of corm/plant	No. of cormels/ plant	Corm weight/ plant (g)	10-cormel weight/plant (g)
V_1	1.0 b	6.5 b	50.0 c	2.5 b
V_2	1.8 a	10.0 a	60.0 a	5.0 a
V_3	1.4 ab	8.2 ab	55.4 b	3.5 ab
Level of Sig.	*	*	*	*
CV (%)	**6.9**	**7.4**	**8.3**	**7.1**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5

The data presented in Table 8 indicate that significant variations were recorded among the protected conditions for corm and cormel characters. Corm (2.5) and cormel (12.5) production was found highest in open field condition. The reduction in the corm and cormel production under protected condition (polytunnel and polyhouse) might be due to shorter crop duration where developmental places up to flowering was not affected utilizing majority of the produced and stored foods and produced larger spikes with higher number and size of florets but lower duration between the harvesting of flowers and corm and cormels as compared to open culture might cause imbalance in distribution and supply of food for development of underground modified storage organs and hence larger spikes, rachis and florets were produced at the cost of reduction in number of corms and cormels/plant. On the other hand, the quality of corm and cormel like weight of corm (61.9 g) and cormels (5.5 g) was found best in polytunnel (T_1) followed by polyhouse (T_2) condition.

Table 8. Performance of different protected condition on corm parameter of gladiolus

Treatments	No. of corm/plant	No. of cormels/ plant	Corm weight/ plant (g)	10-cormel weight/plant (g)
T_0	2.5 a	12.5 a	50.0 c	3.1 b
T_1	2.0 b	9.5 ab	61.9 a	5.5 a
T_2	1.9 b	6.9 b	56.0 b	4.0 ab
Level of Sig.	*	*	*	*
CV (%)	**6.9**	**7.4**	**8.3**	**7.1**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The results of different varieties of gladiolus and protected conditions were found significant (Table 9). Polytunnel and polyhouse condition of all gladiolus varieties reduced the production of corms and cormel per plant, but the quality of corm and cormel like weight of corm and cormel was found better under such situation. The increase in corm and cormel weight in polytunnel and polyhouse as compared to open cultivation revealed this act. Varieties differed in the propensity of corm and cormel production which was found highest with BARI Gladiolus-4.

The interaction effect between variety and protected condition showed that BARI Gladiolus-4 (V_2) under open culture produced the highest number of corms (2.8) and cormels (11.0) per plant whereas BARI Gladiolus-3 (V_1) under protected situation produced the lowest number of corms/plant (1.1). Quality of corms like the heaviest corm (65.0 g) and cormel (7.0 g) was recorded with BARI Gladiolus-4 under protected condition. These results indicate the difference in the characters due to the varieties and the congenial conditions obtained in the polytunnel and polyhouse conditions. These results are similar to the findings of Saeif *et al.* (2011) in gladiolus.

Table 9. Combined effect of varieties and protected conditions on corm parameter of gladiolus

Treatments	No. of corm/plant	No. of cormels/ plant	Corm weight/ plant (g)	10-cormel weight/plant (g)
V_1T_0	1.7 b	9.8 ab	44.0 e	2.0 b
V_1T_1	2.0 ab	8.0 ab	48.0 d	3.4 ab
V_1T_2	2.0 ab	7.0 b	52.0 cd	4.3 ab
V_2T_0	2.3 ab	11.0 a	54.0 c	3.5 ab
V_2T_1	2.8 a	9.9 ab	65.0 a	6.5 a
V_2T_2	2.7 a	9.0 ab	59.0 b	5.0 ab
V_3T_0	1.6 b	8.4 ab	52.0 bc	3.5 ab
V_3T_1	2.2 ab	8.0 ab	50.0 cd	4.8 ab
V_3T_2	2.1 ab	7.8 ab	56.0 bc	3.7 ab
Level of Sig.	*	*	*	*
CV (%)	**6.9**	**7.4**	**8.3**	**7.1**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

Disease and insect infestation

Gladiolus is susceptible to several insect and disease which adversely affect the quality and quantity of the crop. Only leaf spot disease found in the present study. However, less disease incidence occurred in polytunnel (T_1) and Polyhouse (T_2) conditions. The gladiolus crop is mostly infested by aphid and thrips (Ramzan *et al.,* 2012). Aphid and thrips infestation found in the present study under open field (T_0)

condition. No pest infestation was occurred under polytunnel and polyhouse condition (Table 10). This finding was supported by Sarkar and Sharma (2016) in gladiolus. Through eye estimation flower quality was found excellent in BARI Gladiolus-4 under polytunnel followed by polyhouse condition.

Table 10. Disease incidence and insect infestation of gladiolus varieties under protected condition

Treatments	Flower quality	Disease incidence	Insect infestation	
		Leaf spot	Aphid	Thrips
V_1T_0	Satisfactory	++	2	+
V_1T_1	Excellent	+	1	-
V_1T_2	Excellent	+	1	-
V_2T_0	Satisfactory	++	2	+
V_2T_1	Excellent	+	1	-
V_2T_2	Excellent	+	1	-
V_3T_0	Satisfactory	++	2	+
V_3T_1	Excellent	+	1	-
V_3T_2	Excellent	+	1	-

V_1= BARI Gladiolus-3, V_2= BARI Gladiolus-4 and BARI Gladiolus-5
T_0 = Open field or control treatment, T_1 = Polytunnel condition and T_2= Polyhouse condition
0 = No population; 1 = a small colony of 10-20 aphid/plant; 2 = a colony with > 20 aphid/plant; 3 = > one colony;
4 = Severe infestation of maximum plantsand, - = Nil; + = Less; ++ = Medium; +++ = High

Conclusion

The variety BARI Gladiolus-4 performed better with regard to attractive flower colour vegetative growth, flower and corm characteristics, yield and quality. Among protected conditions, gladiolus cultivation under polytunnel recorded best performance owing to improved growth, quality, higher yield and less disease incidence. Based on the results emphasis needs to be paid towards cultivation of gladiolus under polytunnel followed by polyhouse during off-season for better quality cut flower production.

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Plate 1.Planting of Corm

Plate 2.Vegetative stage of gladiolus varieties under polyhouse condition

Plate 3.Flowering stage of gladiolus varieties under polytunnel condition

EXPT. 2 :EFFECT OF GIBBERELLIC ACID ON GROWTH AND YIELD OF GLADIOLUS UNDER POLYTUNNEL

K. A. Ara and S. M. Sharifuzzaman

Abstract

An attempt has been made to study the effect of GA_3 *pretreated corm on growth and yield of Gladiolus laid on randomized block design under polytunnel during August-January, 2017-18. For this purpose, corms of BARI Gladiolus-4 were dipped in six different concentrations of gibberellic acid (*GA_3*) (0, 50, 100, 150, 200 and 250 ppm), each with 3 replicates. Results indicated that the pretreated corm with* GA_3 *had significantly improved various growth, flowering and corm parameters. Maximum vegetative growth in terms of plant height, leave number/hill, plant number/hill, leaf size and early sprouting of corm was observed in 200 ppm* GA_3*. In addition, the results also showed that the pretreated corms at a higher concentration of* GA_3 *@200 ppm hadsignificantly increased spike length, rachis length and florets number/spike. Early appearance of initial spike, maximum durability and vase life of spike and maximum production of corm-cormels were also recorded with* GA_3 *200 ppm.*GA_3 *pretreatment @200 ppm also increased yield of flower. Therefore, it was concluded that* GA_3 *at 200 ppm proved to be best concentration in enhancing all the vegetative (plant height, leave number/hill, plant number/hill, leaf size and sprouting of corms), floral (spike initiation, spike length, rachis length, florets number/spikes, flower yield, vase life and flower durability) and corm production (number of corm-cormels and weight of corm-cormels) characteristics in gladiolus.*

Introduction

Gladiolus (*Gladiolus grandiflorus*) is a flower of glamour and perfection which is known as the queen of bulbous flowers belongs to family Iridaceae. The gladiolus gained popularity in Bangladesh and different parts of the world due to its unsurpassed beauty and economic value. Now the flower is in high demand due to attractive spikes, big florets, dazzling colors and long vase life (Khan *et al*., 2011). With the progress in development of floriculture business in Bangladesh, the farmers are diverting to high values floral crops due to increase in utilization of flowers in various social events. The most important floral crops in Bangladesh include gladiolus, rose, tuberose, marigold, gerbera and jasmine (Ara *et al*., 2010). However, local fresh flower market is flooded with mostly gladiolus and tuberose. The gladiolus has the potential not only to fulfill the local requirements but also to earn foreign exchange as the crop is of short duration, wide varietal wealth, better economic returns than conventional crops and wide range of available climatic conditions in the country have contributed to its growth potentials. Gladiolus is a winter flower but it can be grown in summer under polytunnel because the climatic conditions are favorable for its cultivation and can be grown as off season crop and more chances to get better economic return. Gladiolus is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquets (Pal and Chowdhary, 1998). To enhance yield and quality of any flower crop, various cultural management practices like good planting material, spacing, irrigation, nutrition, plant protection, use of growth regulators, protective culture etc. are required. With the expectation to all above, use of plant growth regulator and protected condition for producing better quality crop is gaining much more importance which is highly beneficial not only for the producers and sellers but also for the consumers.

The application of gibberellins has brought a sort of revolution for the floriculture industry. Gibberellins are the plant growth regulators that are known to stimulate physiological responses in plants and alter the source-sink metabolism through their effect on photosynthesis and sink formation (Iqbal *et al.,* 2011). Gibberellic acid treatments are known to play important role in promoting diverse processes throughout the development of plant; induced early flowering, increased length or height of plant, number of leaves, chlorophyll content, yield and quality in different flowering crops (Kumar *et al*., 2012, Dalal *et al*., 2009, Panwar *et al*., 2006 and Rana *et al*., 2005). Therefore, the present investigation was conducted to find out the optimum concentration of GA_3 on yield and quality of gladiolus in off-season under polytunnel.

Materials and Method

The experiment was carried out at the Floriculture field of Horticulture Research Centre, BARI, Gazipur during August 2017 to January 2018. The experimental land was prepared with deep ploughing. Manure and fertilizers were applied @ 10 ton, 200.0 kg, 225.0 kg, 190.0 kg, 20.0 kg, 2.0 kg, 3.0 kg per hectare of cowdung, Urea, TSP, MoP, S, B and Zn respectively. Cowdung, TSP, MoP, S, B and Zn were applied as basal and urea was top-dressed in two equal splits at 4 leaf stage and spike initiation stage. Healthy corms of BARI Galdiolus-4 having a diameter of about 5.0 cm were used as material. Treatments were comprised of corm dipping at six different GA_3 concentrations viz. T_1: 0 ppm, T_2: 50 ppm, T_3: 100 ppm, T_4: 50 ppm, T_5: 200 ppm and T_6: 250 ppm was conducted for 24 hours before planting. The unit plot size was 2.5 m $\times$ 2.0 m. The experiment was laid out in RCB design with 3 replications. Management practices like irrigation, weeding, mulching etc. were same for all treatments during entire period of study. The spikes were cut when lower 2-3 florets showed their blushes of colour. Corms and cormels were lifted three months after cutting flower and treated with Autostin (0.2%) for 30 minutes to prevent incidence of leaf blight disease. Various growth attributes viz., plant height, leave number/hill, leaf size, plant number/hill, sprouting of corms, floral attributes viz., days to spike initiation, spike length, rachis length, number of florets per spike, floret size, vase life, flowering duration, flower yield and corm attributes viz., corm number, cormel number, corm weight, cormel weight etc. were recorded. The collected data were analysed statistically by performing analysis of variance and means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Steel and Torrie, 1997).

Result and Discussion

The results revealed that GA_3-treated corm significantly influenced all the growth attributes. In general, pretreated corms showed significant increase in all the growth parameters as compared to control. Significant maximum plant height (58.0 cm) was observed with GA_3-treated corm at 200 ppm (Table 1). Similarly, treatment of GA_3 at 200 ppm gave the highest number of leaves per hill (16.5) and control plants were observed to have the lowest number of leaves/hill (8.4). The leaf size also showed a significant increase with the application of GA_3 at an increasing concentration upto 200 ppm (66.0 cm) as compared to control (54.5 cm) plants. Chopde *et al*. (2012) also observed significant increase in size of leaf when corm dipped with GA_3 at 200 ppm in gladiolus cv. Friendship. Favorable effect of GA_3 might be due to the fact that it improves the sink strength of actively growing plant parts like immature leaves which are the metabolic sinks to support growth and development of the plant throughout the life cycle. An application of GA_3 enhanced plant height, number of leaves and leaf size due to increase in level of auxin causing increased cell division and cell elongation (Rana *et al*., 2005). The mechanism involves the hydrolysis of starch resulting from the production of GA_3 induced-amylase which might increase the concentration of sugars, thereby raising the osmotic pressure of the cell sap. As a result of which, water enters into the cell and tends to stretch cell wall (Panwar *et al*., 2006), consequently contributes to cell elongation and promotes growth. Earlier studies have also reported maximum plant growth with respect to plant height, number of leaves, number of plants and leaf size with GA_3 (Chopde *et al.*, 2012) in gladiolus and Sharifuzzaman *et al.* (2011) in Chrysanthemum. Singh and Shanker (2011) also found the best result at concentration of 200 ppm GA_3 in case of gladiolus. The influence of GA_3-treated corm was also found to be significant on number of plants per hill amongst all the concentrations. Table 1 clearly showed enhancement in number of plants per hill (4.0) with application of GA_3 at 200 ppm whereas the lowest number of plants per hill (2.0) was found in control plants. Data pertaining to sprouting of corms revealed that application of GA_3 at 200 ppm took minimum (8.0) days among all the concentrations and control plant took maximum (14.0) days for sprouting. Kumar and Singh (2005) also found lower number of days taken for germination of corm in gladiolus at 200 ppm GA_3. This might be due to rapid rate of hydrolysis of stored starch by higher activity of α-amylase and decrease in level of abscisic acid formed during dormant state which makes the corms unable to germinate.

Table 1. Effect of GA_3 on growth parameter of gladiolus

Treatments	Plant height (cm)	Leaves/hill	Leave size (cm)	Plants/hill	Sprouting of corm (days)
T_1	48.0 c	8.4 c	54.5 c	2.0 b	14.0 a
T_2	50.8 bc	9.6 bc	55.7 bc	2.9 ab	13.0 ab
T_3	52.1 b	10. 2 bc	57.2 bc	3.5 ab	12.0 ab
T_4	55.6 ab	14.3 ab	60.8 b	3.7 ab	10.0 ab
T_5	58.0 a	16.5 a	66.0 a	4.0 a	8.0 b
T_6	53.3 ab	12.0 b	58.4 ab	3.2 ab	12.0 ab
LSD (0.05)	**2.4**	**2.2**	**2.7**	**1.1**	**1.6**
CV (%)	**10.1**	**8.5**	**9.0**	**7.8**	**9.5**

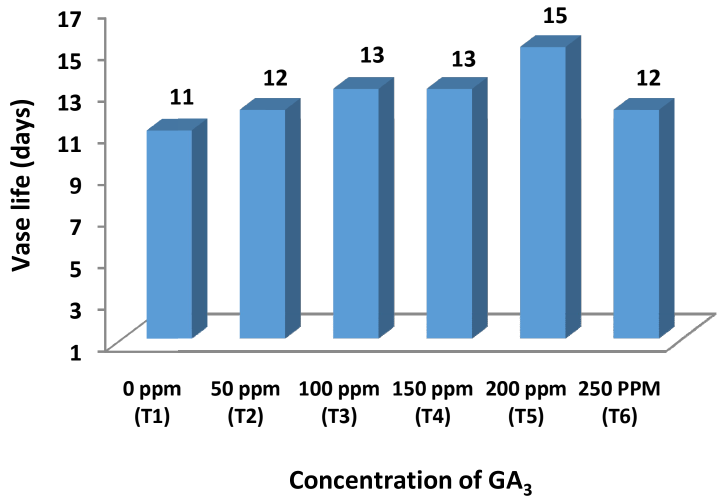
T_1= GA_3 0 ppm, T_2= GA_3 50 ppm, T_3=GA_3 100 ppm, T_4=150 ppm, T_5=200 ppm and T_6= 250 ppm

Table 2 clearly indicated that all concentrations of GA_3 under study succeeded in respect of first spike initiation, spike length, rachis length, floret number/spike, flowering duration, flower yield and vase life as compared to control except floret size. When comparing early appearance of initial spike, it was found that GA_3-treated corm at 200 ppm caused early initiation of spike (66.0 days) whereas control plant took maximum days for spike emergence (75.0 days) which might be due to early flower primordial development, cell differentiation and early utilization of nutrients. GA_3 at 200 ppm concentration might have reduced the vegetative period, resulting in induction of early flower development. Likewise, GA_3 treatments @ 150-200 ppm significantly shortened the time taken from planting to flowering in gladiolus (Panwar *et al*., 2006). Spike length increased with application of GA_3 and maximum was found in 200 ppm treated plants (78.0 cm). Similar variations have also been found previously by Chopde *et al*. (2012) and Dogra *et al.* (2012) in gladiolus at 200 ppm GA_3. Rachis length (52.8 cm) was markedly influenced with the concentration of 200 ppm GA_3 over control (42.5 cm). Kumar *et al*. (2012) also found the similar results in tuberose when soaked in concentration of GA_3 at 150-200 ppm. The possible reason for increasing spike length and rachis length might be due to increase in the cell division and cell elongation of intercalary meristem resulting in rapid internode elongation (Shanker *et al*., 2011).

Table 2. Effect of GA_3 on floral parameters of gladiolus

Treatments	Spike initiation (days)	Spike length (cm)	Rachis length (cm)	Floret no./spike	Floret size (cm)	Flowering duration (days)	Flower yield (no./ha)'000
T_1	75.0 a	68.2 c	42.5 c	10.2 b	9.5	19.0 c	200 d
T_2	73.0 ab	71.7 bc	44.6 bc	11.4 ab	9.6	21.0 bc	210 cd
T_3	71.4 ab	73.0 b	46.3 bc	13.3 ab	9.8	22.4 b	212 b
T_4	69.5 b	75.8 ab	50.0 ab	13.9 ab	9.9	25.0 ab	218 ab
T_5	66.0 c	78.0 a	52.8 a	14.5 a	10.0	28.0 a	220 a
T_6	72.8 ab	74.2 ab	48.0 b	13.0 ab	9.6	21.3 bc	207 c
LSD (0.05)	**1.4**	**2.2**	**2.4**	**2.1**	**NS**	**2.5**	**2.7**
CV (%)	**9.0**	**10.3**	**9.8**	**9.0**	**5.5**	**10.1**	**9.4**

T_1= GA_3 0 ppm, T_2= GA_3 50 ppm, T_3=GA_3 100 ppm, T_4=150 ppm, T_5=200 ppm and T_6= 250 ppm



T_1= GA_3 0 ppm, T_2= GA_3 50 ppm, T_3=GA_3 100 ppm, T_4=150 ppm, T_5=200 ppm and T_6= 250 ppm

Fig. 1. Effect of GA_3 on vase life of gladiolus

Data presented in Table 2 and Fig. 1 with respect to floret number, flowering duration, flower yield and vase life also recorded significant results with GA_3-treated corm except floret size. Variation in number of florets per spike among all the concentrations had also been observed as compared to control. GA_3 at 200 ppm gave the largest number of florets per spike (14.5). Panwar *et al*. (2006) also observed striking influence with the concentration of GA_3 at 200 ppm on number of florets per spike in gladiolus over control. A dose of 200 ppm GA_3 was found effective for maximum flowering duration (28.0 days), vase life (15.0 days) and flower yield (2,20,000 no./ha) as compared to control plant which showed a minimum flowering duration (19.0 days), vase life (11.0 days) and yield (2,00,000 no./ha). These results are in consonance with findings of Umrao *et al*. (2007) and Rana *et al*. (2005) in gladiolus. Favorable effect of application of gibberellins on number of florets, vase life, flower yield and flowering duration might be due to improved physiological efficiency, selective ion uptake, sufficient water uptake causing high rate of accumulate deposition.

Table 3. Effect of GA_3 on corm production of gladiolus

Treatments	No. of corm/plant	No. of cormels/plant	Corm weight/ plant (g)	10-cormel weight/plant (g)
T_1	1.5 b	6.4 c	59.0 c	4.0 b
T_2	2.0 ab	8.5 bc	64.4 bc	5.5 ab
T_3	2.1 ab	10.6 b	66.0 b	6.0 ab
T_4	2.2 ab	12.5 ab	67.8 ab	6.4 ab
T_5	2.8 a	15.0 a	70.0 a	8.0 a
T_6	2.0 ab	9.4 bc	67.0 ab	5.8 ab
LSD (0.05)	**1.2**	**2.0**	**2.4**	**1.5**
CV (%)	**7.3**	**8.9**	**9.5**	**7.5**

T_1= GA_3 0 ppm, T_2= GA_3 50 ppm, T_3=GA_3 100 ppm, T_4=150 ppm, T_5=200 ppm and T_6= 250 ppm

The highest number of corms (2.8) and cormels (15.0) per plant was noticed when corms were treated with GA_3 at 200 ppm. This number decreased with reduction in concentration of GA_3 (Table 3).

Gibberellic acid is known to increase the plant height, number of leaves and leaf size that might have led to enhance the rate of photosynthesis. As a result of this, availability of metabolites to the developing corms and cormels might be increased, thereby led to increase in the number of corm and cormel count. The present results are in agreement with findings of Jinesh *et al.* (2010) and Khan *et al.* (2011) in gladiolus who also observed the best result at concentration of GA_3 at 200 ppm. The data inferred the significant reduction of corm numbers with declining concentrations of GA_3 upto 200 ppm (Table 3). However, GA_3 at 200 ppm resulted in maximum corm number (2.8). The maximum number of cormel (15.0) was also obtained under GA_3 200 ppm, which was significantly higher than the other treatments. A perusal of data depicted in Table 3 revealed that the weight of corm and cormels per plant significantly increased with GA_3 treatments over control. However, the maximum weight of corm (70.0 g) and 10-cormel weight (8.0 g) were recorded with GA_3 200 ppm. Increasing concentration of GA_3 upto 200 ppm resulted in a linear increase in number, size and weight of corm and cormels per plant. GA_3 is known to induce cell elongation, thus leading to increase in number of leaves per plant, leaf size and plant height which might have led to overall improved rate of photosynthesis and nutrient and water uptake. As a result of this, increased availability of the metabolites to the developing corm and cormels led to the improved number, size and weight of corm and cormels. These findings are in accordance with Devi *et al.* (2007) that GA_3 treated corm at 200 ppm enhanced number of corms in gladiolus cv. Sylvia.

Conclusion

Corm treated with GA_3 @ 200 ppm was found best result in plant growth, flowering and yield characteristics of gladiolus in Off-season under polytunnel condition.

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Plate 1. Plants /hill in gladiolus using GA_3@ 200 ppm

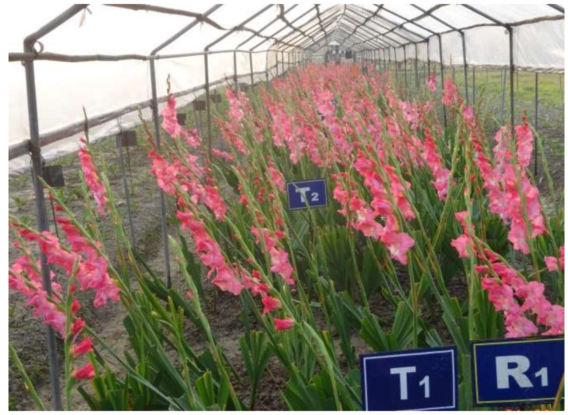

Plate 2. Effect of GA_3 treatments on flowering of gladiolus

Plate 3. Maximum Rachis length of gladiolus using GA_3 @ 200 ppm

Plate 4. Maximum vase life of gladiolus using GA @ 200 ppm

EXPT. 3 :PERFORMANCE OF GERBERA VARIETIES UNDER PROTECTED CONDITION

S. M. Sharifuzzaman and K. A. Ara

Abstract

The study of protective condition on different gerbera varieties were undertaken at Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during Rabi season 2017-2018. One month age of tissue cultured plantlets of BARI Gerbera-1, BARI Gerbera-2 and promising line GJ-023 were included in this study with protective structures (poly tunnel and polyhouse) including control (open field). The two factorial experiment was laid out in split plot design with three replications. Spacing was maintained at 50 cm from row to row and 40 cm from plant to plant. Maximum growth, flowering, yield and quality of promising gerbera line GJ-023 was recorded in polyhouse condition. Overall performance of GJ-023 was also found best in polyhouse condition against disease incidence and insect infestation.

Introduction

Gerbera (*Gerbera jamesonii*) is a popular commercial flower grown throughout the world (Ambad *et al.,* 2001). It is a perennial herb native to South Africa and belongs to the family Asteraceae. Gerbera produces very attractive flowers in various colours and occupying fourth place among top ten cut flowers (Dadlani, 2003). It is suitable for wide range of floral arrangements and also used for beds, borders and pot culture. In recent years, the popularity of Gerbera has increased due to demand from florest shops and consumers throughout the country. Since it is comparatively a new cut flower for Bangladesh, many private companies, farmers and farmers Co-operatives are importing the planting material from abroad. At present, the importing planting material has not performed well in our country. There is an urgent need to provide them with suitable production techniques under partially modified structure to produce the quality blooms (Choudhury and Prasad, 2000) in order to be competitive in the flower trade. According to Prokash *et al.* (2013), gerbera have to be cultivated in a protective atmosphere to get quality flowers. Reddy *et al.* (2003) grew gerbera under protected conditions and observed better growth, yield and quality. Considering the above facts, an attempt was made to evaluate the performance of different gerbera varieties under protected conditions.

Materials and Method

The study was undertaken at Floriculture Division, HRC, BARI, Gazipur during Rabi season 2017-2018. One month age of tissue cultured plantlets of BARI Gerbera-1, BARI Gerbera-2 and promising line GJ-023 were included in this study with protective structures (poly tunnel and polyhouse) including control (open field).The two factorial experiment was laid out in split plot design with three replications. Spacing was maintained at 50 cm from row to row and 40 cm from plant to plant. Cowdung, N, P, K, S, B, Zn and Cocodust at the rate of 5 ton, 150 kg, 75 kg, 150 kg,30 kg,2kg, 3 kg and 500 kg per hectare were applied according to Dufaulot *et al.* (1990). The entire quantity of cowdung, cocodust, P, K, S, B and Zn were applied during final land preparation. N was applied in two equal installments at 35 and 65 days after planting the sucker. Data on plant height, leave number, leave size, plant spread, sucker number, days to flowering, flower number, flower colour, number of ray florets, stalk diameter, stalk length, stalk weight, vase life and flowering duration were recorded. Recorded different plant and floral parameters were statistically analyzed through analysis of variance with the help of MSTAT software. Difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1997). Monthly meterological data is shown in Appendix1, 2 and 3.

Results and Discussion

Vegetative growth is best measured in terms of plant height, plant spread, number of leaves, leaf size and number of sucker in gerbera flower. The growth character displayed a wide range of variation and showed significant differences among varieties (Table 1). The maximum plant height (25.0 cm) was recorded in promising line GJ-023 followed by BARI Gerbera-2 (23.0 cm) whereas the minimum plant height was recorded in BARI Gerbera-1 (20.5 cm) (Table 1). The plant height being genetically factored, it is expected to vary among the varieties (Bhayani *et al.,* 2005). There was significant difference among the different varieties of gerbera regarding other vegetative growth like plant spread, number of leaves, leaf size and number of sucker production also. Maximum plant spread (31.0 cm^2), number of leaves (12.0), leaf size (12.9 cm^2) and number of sucker (3.2) was observed from GJ-023 and minimum from BARI Gerbera-1. This variation may be due to the response of varieties of varying genetic makeup of gerbera. Similar variations were also reported by Kumar and Yadav (2001) and Ahlawat *et al.* (2012) in gerbera.

Table 1. Performance of different varieties on vegetative growth parameter of gerbera

Treatments	Plant height (cm)	Plant spread (cm^2)	Number of leaves/plant	Leaf size (cm^2)	Number of sucker/plant
V_1	20.5 b	25.0 b	8.0b	10.0 b	2.0 b
V_2	23.0 ab	29.0 ab	10.7 ab	11.8 ab	2.5 ab
V_3	25.0 a	31.0 a	12.0 a	12.9 a	3.2 a
Level of Sig.	*	*	*	*	*
CV (%)	**7.49**	**8.42**	**6.94**	**7.25**	**6.05**

Means with the same letter (s) are not significantly different at 5% by DMRT

* = Significant at 5% level of probability

V_1= BARI Gerbera-1, V_2= BARI Gerbera-2 and V_3= GJ-023

Significant variation was found for vegetative growth in case of open field condition (T_0) and different protected conditions (Polytunnel and polyhouse: T_1 and T_2 respectively). Maximum plant height (25.0 cm), plant spread (32.5 cm^2) were observed in polyhouse condition. Highest number of leaves (14.0), maximum leaf size (13.5 cm^2) and highest number of suckers (3.5) were observed in polyhouse condition followed by polytunnel condition (Table 2). While it was minimum in open field condition. Improved vegetative growth like plant spread, leaf size, leave number, plant height etc. in polyhouse followed by polytunnel due to favourable microclimate and high photosynthetic rate which might have enhanced the growth and development of gerbera plants. The similar variations have been reported by Kamar and Yadav (2005) in gerbera.

Table 2. Performance of different protected conditions on vegetative growth parameter of gerbera

Treatments	Plant height (cm)	Plant spread (cm^2)	Number of leaves/plant	Leaf size (cm^2)	Number of sucker/plant
T_0	22.0 b	26.8 b	9.5 b	11.0 b	2.0 b
T_1	25.5 b	30.7 ab	12.5 ab	13.3 ab	3.0 ab
T_2	25.0 a	32.5 a	14.0 a	15.0 a	3.5 a
Level of Sig.	*	*	*	*	*
CV (%)	**7.49**	**8.42**	**6.94**	**7.25**	**6.05**

Means with the same letter (s) are not significantly different at 5% by DMRT

* = Significant at 5% level of probability

T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The interaction effect of varieties and protected conditions on growth parameter of gerbera was found significant (Table 3). The promising line GJ-023 recorded maximum plant height (29.0 cm), plant spread (34.5 cm^2) and leaf size (14.5cm^2) in polyhouse condition. Highest number of leaves (15.0 cm) and suckers (3.5) were also produced under polyhouse condition followed by polytunnel condition. All the varieties performed poor condition under open field condition in respect of all growth parameter in gerbera. Similar result were obtained by Hedau *et al.* (2012) in gerbera varieties.

Table 3. Combined effect of varieties and protected conditions on vegetative growth parameter of gerbera

Treatments	Plant height (cm)	Plant spread (cm^2)	Number of leaves/plant	Leaf size (cm^2)	Number of sucker/plant
V_1T_0	25.6 ab	30.0 b	10.0 b	11.0 b	2.0 b
V_1T_1	27.5 ab	31.0 ab	10.7 ab	11.2 b	2.1 b
V_1T_2	26.4 ab	31.8 ab	11.5 ab	11.8 ab	2.4 ab
V_2T_0	25.0 ab	31.2 ab	11.0 ab	12.0 ab	2.5 ab
V_2T_1	26.0 ab	32.0 ab	12.8 ab	12.5 ab	2.8 ab
V_2T_2	27.3 ab	32.4 ab	13.0 ab	13.0 ab	3.0 ab
V_3T_0	23.8 b	31.8 ab	12.7 ab	12.6 ab	3.2 ab
V_3T_1	27.0 ab	33.0 ab	13.5 ab	13.4 ab	3.5 ab
V_3T_2	29.0 a	34.5 a	15.0 a	14.5 a	4.0 a
Level of Sig.	*	*	*	*	*
CV (%)	**7.49**	**8.42**	**6.94**	**7.25**	**6.05**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gerbera-1, V_2= BARI Gerbera-2 and V_3= GJ-023
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The results of different varieties of gerbera regarding flower characters were found significant (Table 4). The promising line GJ-023 required minimum days (66.0 days) for flowering, whereas variety BARI Gerbera-1 required maximum days (71.0 days). The longest stalk (15.0 cm), maximum stalk diameter (1.30 cm), stalk weight (20.0 g) were found from GJ-023. The stalk length is a genetic factor therefore, it is expected to vary among the varieties observed by Parneetha (2005). Stalk length is a very important factor for gerbera cut flower. It decides the quality of cut flowers. As there will be more stalk length more reserved food will be stored in the stalk which will later be available to the flower for longer time period of vase life. The findings are in accordance with the result reported by Ahlawat *et al.* (2012) in gerbera.

Table 4. Performance of different varieties on flower parameter of gerbera

Treatments	Days to flowering (days)	Stalk length (cm)	Stalk diameter (cm)	Stalk weight (g)	Flower no/plant	Ray floret no/plant	Vase life (days)	Flowering duration (days)
V_1	71.0 a	12.0 b	0.70 b	16.0 b	13.0 b	40.0 b	9.0 b	14.5 b
V_2	68.0 ab	13.5 ab	0.75 b	18.2 ab	14.5 ab	43.0 ab	10.0 ab	15.0 b
V_3	66.0 b	15.0 a	1.30 a	20.0 a	16.0 a	45.0 a	11.0 a	17.0 a
Level of Sig.	*	*	*	*	*	*	*	*
CV (%)	**9.4**	**8.2**	**6.9**	**7.5**	**7.0**	**7.2**	**8.1**	**7.3**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gerbera-1, V_2= BARI Gerbera-2 and V_3= GJ-023

Maximum number of flower (16.0) and ray floret number (45.0) was recorded in GJ-023, whereas BARI Gerbera-1 recorded minimum number of flower (13.0) and ray floret (40.0). The increased flower yield in GJ-023 might be attributed to the more number of leaves per plant as well as greater leaf size development would have resulted in production and accumulation of maximum photosynthates resulted in production of more number of flowers. The results are in accordance with the findings of Bhayani *et al.* (2005) in gerbera. Maximum vase life (11.0 days) and flowering duration (17.0 days) were also observed in GJ-023, whereas minimum was recorded from BARI Gerbera-1. The above mentioned findings indicated that considering the important characteristics, promising line GJ-023 is the best line having longest stalk length containing more number of flowers with maximum vase life and flowering duration.

Significant variation was found for flower parameter of gerbera in case of different protected conditions (polytunnel and polyhouse) and open field condition (Table 5). Early flowering (67.0 days), maximum stalk length (15.4 cm), stalk diameter (1.40 cm) and stalk weight (20.5 g) were recorded in polyhouse condition. This could be attributed to the more favorable environment under polyhouse as compared to open field condition. Because it retained about + 4^0C high temperature than the control treatment (open field). Highest number (17.0) of flower, maximum vase life (11.5 days) and flowering duration (19.0 days) were also recorded in polyhouse condition followed by polytunnel condition. The quality parameter, which greatly influence the quality of cut flower is density of the ray floret or the number of ray florets. Maximum number of ray florets (47.0) was noticed in polyhouse as compared to polytunnel and open field condition. Under open field condition, late flower initiation, minimum stalk length, lowest flower number, minimum vase life and flowering duration were recorded as compared to polyhouse and polytunnel condition.

Table 5. Performance of different protected conditions on flower parameter of gerbera

Treatments	Days to flowering (days)	Stalk length (cm)	Stalk diameter (cm)	Stalk weight (cm)	Flower no/plant	Ray floret no/plant	Vase life (days)	Flowering duration (days)
T_0	72.0 a	12.2 b	0.80 b	16.4 b	13.4 b	42.2 b	9.5 b	14.9 b
T_1	69.0 ab	13.8 ab	1.00 ab	18.6 ab	15.0 ab	45.3 ab	10.8 ab	17.0 ab
T_2	67.0 b	15.4 a	1.40 a	20.5 a	17.0 a	47.0 a	11.5 a	19.0 a
Level of Sig.	*	*	*	*	*	*	*	*
CV (%)	**9.4**	**8.2**	**6.9**	**7.5**	**7.0**	**7.2**	**8.1**	**7.3**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The longer vase life under polyhouse condition may be due to improved stalk length, stalk diameter free from dew fall and high CO_2 concentration inside polyhouse. The quality of flower was better under polyhouse as compared to open field condition as more bending incidence and flower deterioration was observed. In polyhouse greater plant spread and more number of leaves/plant were produced which would have resulted in production and accumulation of more photosynthesis, resulting in production of more number of flowers. This is in line with the findings of Biradar (1996) in gerbera.

Table 6. Combined effect of varieties and protected conditions on flower parameter of gerbera

Treatments	Days to flowering (days)	Stalk length (cm)	Stalk diameter (cm)	Stalk weight (g)	Flower no/plant	Ray floret no/plant	Vase life (days)	Flowering duration (days)
V_1T_0	72.0 a	13.0 b	0.75 b	15.5 b	14.0 b	40.0 c	9.5 b	15.0 b
V_1T_1	70.9 ab	14.0 ab	0.80 b	15.8 ab	15.3 ab	42.0 bc	10.4 ab	15.5 b
V_1T_2	70.6 ab	14.8 ab	0.90 ab	16.0 ab	15.5 ab	45.0 b	10.5 ab	16.0 ab
V_2T_0	70.5 ab	15.2ab	0.99 ab	16.5 ab	15.8 ab	43.0 bc	10.2 ab	16.5 ab
V_2T_1	70.0 ab	15.0 ab	1.10 ab	17.0 ab	16.0 ab	45.0 b	10.8 ab	17.5 ab
V_2T_2	69.0 ab	16.0 ab	1.25 ab	18.0 ab	16.5 ab	47.0 ab	11.3 ab	18.0 ab
V_3T_0	68.0 ab	15.0 ab	1.20 ab	18.2 ab	16.3 ab	46.0 ab	11.0 ab	18.0 ab
V_3T_1	67.0 ab	16.5 ab	1.35 ab	20.0 ab	17.0 ab	48.0 ab	11.5 ab	19.0 ab
V_3T_2	65.0 b	17.0 a	1.50 a	22.0 a	18.0 a	50.0 a	12.0 a	21.0 a
Level of Sig.	*	*	*	*	*	*	*	*
CV (%)	**9.4**	**8.2**	**6.9**	**7.5**	**7.0**	**7.2**	**8.1**	**7.3**

Means with the same letter (s) are not significantly different at 5% by DMRT
* = Significant at 5% level of probability
V_1= BARI Gerbera-1, V_2= BARI Gerbera-2 and V_3= GJ-023
T_0 = Open field, T_1 = Polytunnel condition and T_2= Polyhouse condition

The interaction between varieties and protected condition was also significant (Table 6) which indicate that the influence of protected condition on flowering parameter of different gerbera varieties. Comparison of varieties revealed that the promising line GJ-023 produced earliest flowering (18.0), longest stalk length (17.0 cm), maximum stalk diameter (1.50 cm) and stalk weight (22.0 cm), maximum number of flower production (18.0), ray floret production (18.0), prolonged vase life (12.0 days) and flowering duration (21.0 days) under polyhouse condition followed by polytunnel condition.

Gerbera is susceptible to several diseases and insect which adversely affect the quality and quantity of gerbera flower. Reddy *et al.* (2013) reported very few diseases (powdery mildew, leaf spot, crown rot etc.) occurred in gerbera during winter. During study period, powdery mildew and leaf spot diseases occurred. No crown rot disease appeared. The gerbera crop is mostly infested by aphid, thrips and mite (Prokash *et al.,* 2013). Mite and aphid infestation found in the present study. No thrips infestation was occurred. Disease incidence and pest infestation was low in polyhouse condition (Table 7). This finding was supported by Reddy *et al.* (2013) in gerbera. Through eye estimation flower quality was found excellent in promising line GJ-023 under polyhouse followed by polytunnel condition.

Table 7. Disease incidence and insect infestation of gerbera varieties under protected condition

Treatments	Flower quality	Disease incidence			Insect infestation		
		Powdery mildew	Leaf spot	Crown rot	Aphid	Mite	Thrips
V_1T_0	Good	++	++	-	3	++	-
V_1T_1	Satisfactory	+	+	-	2	+	-
V_1T_2	Excellent	-	-	-	1	+	-
V_2T_0	Good	++	++	-	3	++	-
V_2T_1	Satisfactory	+	+	-	2	+	-
V_2T_2	Excellent	-	-	-	1	+	-
V_3T_0	Satisfactory	+	+	-	2	++	-
V_3T_1	Excellent	-	-	-	1	+	-
V_3T_2	Excellent	-	-	-	1	+	-

V_1= BARI Gerbera-1, V_2= BARI Gerbera-2 and V_3= GJ-023
T_0 = Open field or control treatment, T_1 = Polytunnel condition and T_2= Polyhouse condition
0 = No population; 1 = a small colony of 10-20 aphid/plant; 2 = a colony with > 20 aphid/plant; 3 = > one colony;
4 = Severe infestation of maximum plantsand, - = Nil; + = Less; ++ = Medium; +++ = High

Conclusion

The promising line GJ-023 performed better with regard to vegetative growth, flower characteristics, yield and quality. Among protected conditions, gerbera cultivation under polyhouse recorded best performance owing to improved growth, quality, higher yield and less disease incidence and insect infestations. Based on the results emphasis needs to be paid towards cultivation of gerbera under polyhouse for better quality cut flower production. So, adaptive trial may be taken with in some flower this promising technology growing areas in Bangladesh.

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Plate 1.Establishment of Polyhouse

Plate 2. Vegetative stage of gerbera varieties under Polyhouse

Plate 3.Flowering stage of gerbera (GJ-023) under polyhouse

EXPT. 4 : EFFECT OF GIBBERELLIC ACID ON GROWTH, YIELD AND QUALITY OF GERBERA UNDER POLYTUNNEL

S. M. Sharifuzzaman and K. A. Ara

Abstract

The experiment was conducted at Floriculture Division of Horticulture Research Centre, BARI at Joydebpur, Gazipur during Rabi period 2017-2018 to study growth, yield and quality of gerbera under polytunnel condition by gibberellic acid treatments. Five weeks old tissue cultured plantets of gerbera (GJ-023) with 4-5 leaves were planted in beds and experiment was designed in a Completely Randomized Block Design with three replications. The details of the gibberellic acid treatments are as follows. T_1*:* GA_3 *@ 0 ppm (control),* T_2*:* GA_3 *@ 50 ppm,* T_3*:* GA_3 *@ 100 ppm,* T_4*:* GA_3 *@ 150 ppm,* T_5*:* GA_3 *@ 200 ppm and* T_6*:* GA_3 *@ 250 ppm. Among all the treatments, application of* GA_3 *@ 100 ppm was found best resulting in more number of leaves/plant, maximum plant spread, early appearance of flowering and that too in more number of sucker/plant. Length of flower stalk and number of flower/ plant were found maximum in this treatment. Flowering duration and vase life were also maximum in this treatment.*

Introduction

Gerbera (*Gerbera jamesonii* Bolus) is a popular commercial flower, occupying fourth place among the cut flowers (Bose *et al.*,2003). It has wide ranges of form, size and color. Gerberas are cultivated for dramatic garden display, home decoration, cut flowers, bedding, floral arrangement and other useful purposes. In Bangladesh, it is grown commercially in more than 500 ha of land. Due to the changes in social and cultural life-style of the people, cut-flowers have now found an important place in various social functions. The agro-ecological conditions of the country are also favorable for the culture and survival of gerbera. For this, the flower growers of Bangladesh are very much interested in cultivating gerbera instead of the traditional flower crops that usually do not give much return to them. As a result, recently introduced gerbera is becoming attractive to the growers as well as users, as it has great potential for local and export market.

Gibberellic acid is a simple gibberellin, application of gibberellic acid (GA_3) to plants results in a variety of responses like cell division (Nair *et al.,* 2002) cell elongation (Dalal *et al.,* 2009) or both (Brian, 1957). Gibberellic acid treated plants exhibited a change in leaf shape or size and a retardation of root growth (Brian, 1957). Prominent phytohormone, gibberellic acid (GA_3) has the potential control on growth and flowering process. In addition, GA_3 application increased petiole length, leaf area and delayed petal abscission and color fading (senescence) by the hydrolysis of starch and sucrose into fructose and glucose (Matsumoto, 2006). In case of gerbera, maximum vegetative growth, flower yield and quality were observed with the application of 100-150 ppm GA_3 (Dalal *et al.,* 2009; Uddin *et al.,* 2014). Thus, keeping in view the potentialities of gibberellic acid, the study was undertaken to find out the suitable concentration of GA_3 for better growth, yield and quality of gerbera under polytunnel.

Materials and Method

The experiment was conducted at Floriculture Division of Horticulture Research Centre, BARI at Joydebpur, Gazipur during Rabi period 2017-2018 to study growth, yield and quality of gerbera under polytunnel condition by gibberellic acid treatments. Five weeks old tissue cultured plantlets of gerbera (GJ-023) with 4-5 leaves were planted in beds and experiment was designed in a Completely Randomized Block Design with three replications. The details of the gibberellic acid treatments are as follows. T_1: GA_3 @ 0 ppm (control), T_2: GA_3 @ 50 ppm, T_3: GA_3 @ 100 ppm, T_4: GA_3 @ 150 ppm, T_5: GA_3 @ 200 ppm and T_6: GA_3 @ 250 ppm. The growth regulator GA_3 was given through spraying. They are soluble in alcohol and then diluted in water. The growth regulator GA_3 was sprayed on plant in the morning started after one month of planting and repeated two times at 3 weeks intervals. All the cultural operations were done as per need of the crop. Plants was sprayed with fungicides (Autostin) and miticide (Vertimac) at doses 2 g/L for each 2 times at weekly intervals. The data were recorded on plant spread, number of leaves, number of suckers, leave size, days to flowering, number of flowers, diameter of flower stalk, length of flower stalk, vase life and flowering duration. The recorded data were statistically analyzed and treatment means were separated by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1997).

Results and Discussion

The Table 1 showed that the different growth characteristics exhibited differences among the six treatments of GA_3 under study. The tallest plant (27.0 cm) was found from the treatment T_3 (GA_3 100 ppm) which was statistically identical (26.6 cm) with T_4 (GA_3 150 ppm) treatment and the shortest plant (22.0 cm) in T_1 (GA_3 0 ppm) treatment. The maximum spreading of plant (36.0 cm^2) was observed when plants were sprayed with GA_3 @ 100 ppm (T_3) which was closely followed by application of GA_3 @ 150 ppm (T_4) (35.8 cm^2). The minimum plant spread (29.0 cm^2) was recorded in plants without sprayed with GA_3 (T_1). In case of gerbera plant spread was measured as a major vegetative growth due to its rosette type of growth habit instead of plant height. Another growth character such as number of leaves per plant was found maximum (16.5) with GA_3 100 ppm throughout the observation periods. Significant variation was observed as to the leave size among the treatments (Table 1). The longest leave size 15.0 cm^2 was produced by treatment T_3 (GA_3 100 ppm) followed by T_4 (GA_3 150 ppm). On the contrary, the treatment T_1 produced shortest leave size of 10.0 cm^2. The results are also in accordance with the findings of Dalal *et al.* (2009) and Singh *et al.* (2009) in gerbera. The highest number of suckers (4.7) per plant was produced when plants treated with GA_3 100 ppm followed by GA_3 150 ppm (4.2). Without use of gibberllic acid (T_1) (control) produced the lowest number of suckers (2.0). This is in agreement with the findings of Reddy *et al.* (1997). The higher number of sucker production by using GA_3 100 ppm (T_3) might be due to increase the number and size of leaves as a results of higher translocation of the photosynthates and eventually that would have been used for the production of propagules (suckers).

Table 1. Effect of gibberellic acid on growth parameter of gerbera

Treatments	Plant height (cm)	Plant spread (cm^2)	Number of leaves/plant	Leaf size (cm^2)	Number of sucker/plant
T_1 (0 ppm)	22.0 b	29.0 b	8.0 c	10.0 b	2.5 b
T_2 (50 ppm)	24.0 ab	34.0 ab	11.9 bc	13.3 ab	3.7 ab
T_3 (100 ppm)	27.0 a	36.0 a	16.5 a	15.0 a	4.7 a
T_4 (150 ppm)	26.6 a	35.8 a	13.8 ab	14.2 ab	4.2 ab
T_5 (200 ppm)	23.8 ab	33.0 ab	12.4 b	13.5 ab	3.6 ab
T_6 (250 ppm)	23.0 ab	31.4 ab	10.8 bc	12.0 ab	3.2 ab
Level of Sig.	**	**	**	**	**
CV (%)	**6.07**	**7.45**	**8.30**	**9.40**	**9.01**

T_1 (0 ppm), T_2 (50 ppm), T_3 (100 ppm), T_4 (150 ppm), T_5 (200 ppm) and T_6 (250 ppm)

The data on flowering parameters presented in Table 2 show that, the gibberellic acid at 100 ppm (T_3) showed significantly higher results in flowering parameters i.e. length of flower stalk (15.0 cm), flower stalk diameter (0.95 mm) and number of ray florets per flower (170.0). In case of GA_3 at 100 ppm (T_3) showed lowest number of days to the appearance of first flower bud and opening the first flower (54.0 and 62.5 days, respectively. In case of gibberellic acid at 0 ppm (T_1) showed poorest result in all flowering parameters. It is fact that GA_3 increased the cell elongation and cell division influencing flowering. It also accumulates more carbohydrate in plant body which leads to early flower bud initiation as well as bud opening. The plants receiving required gibberellic acid in an optimum proportion could have results in flowering quality by increasing number of cells. The result is also in conformity with those of Dalal *et al.* (2009) who stated that GA_3 at 100 ppm gave the best results in flower stalk length in gerbera. Similar results were obtained by Nair *et al.* (2002). Singh *et al.* (2009) recorded maximum flower stalk length when sprayed GA_3 at 150 ppm in chrysanthemum.

Table 2. Effect of gibberellic acid on flowering parameters of gerbera

Treatments	Days to appearance of first flower bud (days)	Days to open first flower (days)	Length of flower stalk (cm)	Flower stalk diameter (cm)	No. of ray florets per flower	Flowering duration (days)
T_1 (0 ppm)	62.0 a	67.0 a	9.0 b	0.40 b	155.0 c	12.0 c
T_2 (50 ppm)	59.4 ab	65.0 ab	12.5 ab	0.60 ab	161.0 bc	15.0 bc
T_3 (100 ppm)	54.0 c	62.5 b	15.0 a	0.95 a	170.0 a	21.0 a
T_4 (150 ppm)	58.0 b	64.0 ab	13.6 ab	0.67 ab	165.0 ab	18.0 ab
T_5 (200 ppm)	59.8 ab	64.7 ab	13.0 ab	0.65 ab	163.0 b	16.0 b
T_6 (250 ppm)	60.0 ab	65.4 ab	12.4 ab	0.58 ab	160.5 bc	14.0 bc
Level of Sig.	**	**	**	**	**	**
CV (%)	**8.70**	**7.45**	**8.70**	**7.96**	**9.40**	**8.66**

T_1 (0 ppm), T_2 (50 ppm), T_3 (100 ppm), T_4 (150 ppm), T_5 (200 ppm) and T_6 (250 ppm)

Data on flower number have been presented in Figure 1. Gibberellic acid at 100 ppm (T_3) was found better for number of cut flowers per plant (9.0) (Plate 1) followed by GA_3 @ 150 ppm (T_4) (8.0) and minimum flower (4.5) were found in GA_3 @ 0 ppm (T_1). Maximum flower stalk diameter (0.95 cm) and highest number of ray florets (170) were observed in GA_3 100 ppm (T3) treatment. GA_3 through alphaamylase activity, auxin stimulating effect and cell wall loosing, increased cell elongation along with cell enlargement. All these causes effect to increase leaf size, resulted in more photosynthetic area. Thus, increase in carbohydrate food material enhanced the good vegetative growth like more number of suckers per plant, green biomass turned to higher number of flowers per plant. Increased flower yield through foliar application of gibberellic acid @ 100 ppm was also reported by Dalal *et al*. (2009) in gerbera, the foliar application of 100 ppm GA_3 at monthly intervals gave better results in maximum number of cut flowers.

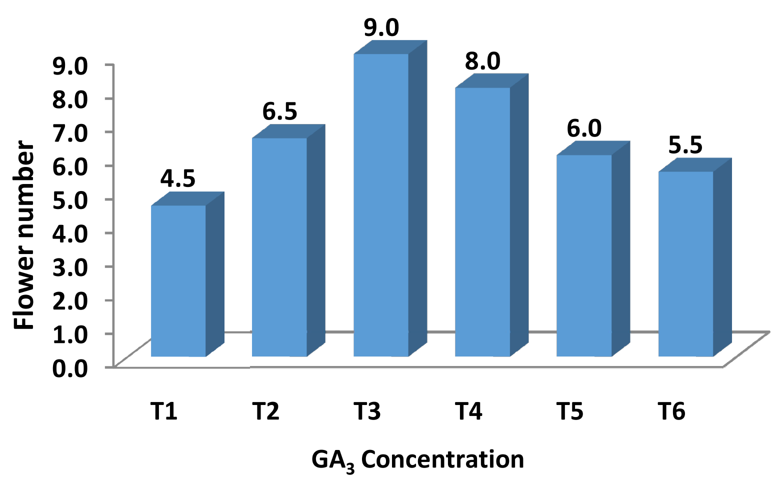

Figure 1. Effect of gibberellic acid on flower number of gerbera

T_1 (0 ppm), T_2 (50 ppm), T_3 (100 ppm), T_4 (150 ppm), T_5 (200 ppm) and T_6 (250 ppm)

Significant variation in respect of flowering duration was observed among the gibberllic acid treatment. Maximum duration of flowering of 21 days was observed in gibberellic acid at 100 ppm. Nair *et al.* (2002) observed similar results in gerbera where higher duration from full bloom to flower deterioration was observed in plant when foliar sprayed with GA_3 100 ppm.

Vase life of flowers was also found significant in gibberellic acid at 100 ppm (13.0 days) (Plate 2) whereas GA_3 at 150 ppm was at par with respect to vase life of flower (12.0 days). GA_3@ 0 ppm found poor results. GA_3 @ 100 ppm reduced the water loss and decreased anti-senescence activities leading to enhanced vase life of cut flowers. The plants receiving optimum gibberellic acid could have resulted in increased vase life of flowers. Similar results were obtained by Nair *et al.* (2002) in gerbera.

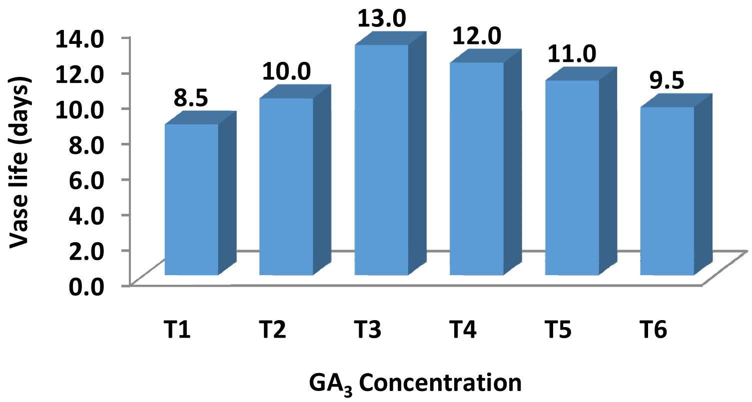

Figure 2. Effect of gibberellic acid on vase life of gerbera

T_1 (0 ppm), T_2 (50 ppm), T_3 (100 ppm), T_4 (150 ppm), T_5 (200 ppm) and T_6 (250 ppm)

Conclusion

A study was carried out to find out the effect of gibberellic acid on growth, yield and quality of gerbera plants under polytunnel. The findings of the investigation revealed that GA_3 @ 100 ppm accelerated vegetative, flowering, yield and quality characteristics of gerbera.

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Plate 1. Application of gibberellic acid @ 100 ppm on vase life of gerbera

EXPT. 5 :PERFORMANCE STUDY ON DIFFERENT VARIETIES OF GERBERA THROUGH HYDROPONIC CULTURE

K. A. Ara and S. M. Sharifuzzaman

Abstract

A trial was conducted on performance study on three varieties (BARI Gerbera-1, BARI Gerbera-2 and promising line GJ-023) of gerbera which were grown on steel tray and plastic bucket containing Cooper's hydroponic solution maintaining EC1.5 dS/m and pH 6.0. The performance of vegetative growth, flowering and yield quality in all varieties were satisfactory. The results revealed that the promising line GJ-023 recorded maximum leave number (8.3), flower number (6.0), highest stalk length (34.4 cm) and stalk weight (28.0 g). Maximum flowering duration (15 days) was also observed in promising line GJ-023. No insect and disease incidence was appeared during the study. Appearance of flower quality was very good in all the varieties. It is indicated that all gerbera varieties successfully grown in steel tray and plastic bucket through hydroponic culture. However, GJ-023 performed best in respect to growth and flower characteristics comparison to other varieties in hydroponic culture.

Introduction

Hydroponic or soil-less culture is a technology for growing plants in nutrient solution that supply all nutrient elements needed for optimum plant growth with or without the use of inert medium such as gravel, saw dust, coir dust, coconut fiber etc. to provide mechanical support. The soil less medium must provide oxygen, water, nutrients and support for plant root just as soil does. There is not much physiological difference between plants grown hydroponically and those grown in soil. Plants grown in soil take nutrient from soil medium but in hydroponic nutrients are supplied artificially in the form of nutrient solution. The benefits of hydroponic culture are year round crop production where no suitable land exists. The crop cultivation regardless of seasonality, more efficient use of water and fertilizers and minimal use of land area are the principal advantages of soil-less culture. Another major benefit is the possibility of obtaining pesticide free products, which fetch higher prices. Bangladesh is densely populated country with ever increasing population. On the contrary, the cultivable land is decreasing. In this situation hydroponic culture would be useful for growing gerbera in open space, window box and roof of the building. In Bangladesh, gerbera usually grown in soil having less quality and yield. In soil culture this lower yield is caused by several factors like presence of soil born disease and pests, soil fertility problem and also changing climatic condition. Hydroponic production of gerbera under protective condition increases crop quality and productivity, which result in higher competitiveness and economic incomes (Manins *et al.,* 1995). Therefore, the present study was under taken on performance study of gerbera varieties through hydroponic culture.

Materials and Method

The experiment was conducted at the shade house of Floriculture Division, Horticulture Research Centre, BARI, Joydebpur, Gazipur, during Rabi season 2017-2018. Four weeks old hardened tissue cultured plantlets of BARI Gerbera-1, BARI Gerbera-2 and GJ-023 were placed in plastic bucket and steel tray (1.0 × 3.0 × 0.20 m) at a spacing of 40 × 40 cm keeping 5-10 cm vacuum space. When the plantlets were transplanted, 2/3rd of the roots were in the nutrient solution in non-circulating system and 1/3rd of roots were kept in the vacuum space. Some, extra holes were made for air movement. The pH and EC were measured twice in a month. Coopers hydroponic nutrient solution (Table 1) was added in the bucket and steel tray maintaining EC 1.5 dS/m and pH 6.0.

Table 1. Chemicals needed to prepare 1000 liters of nutrient solution

Nutrient chemicals	Weight (g)
Potassium hydrogen phosphate	263.00
Potassium Nitrate	583.00
Calcium Nitrate	1003.00
Magnesium sulphate	513.00
EDTA iron	79.00
Manganese sulphate	6.10
Boric acid	1.70
Copper sulphate	0.39
Ammonium molybdate	0.37
Zinc sulphate	0.44

Source : Mallik *et al.* (2016)

At first calcium nitrate and EDTA iron was dissolved in 10 literes of water and was labelled them as “Nutrient Solution-A” and the rest of the nutrient in another 10 liters of water was labelled as “Nutrient Solution-B”. These are called stock solution. When feeding this solution to the plants, solution A and B should be diluted 100 times in equal volumes. First, solution A is added in tank and stirred well and next solution B was added. The exact volume to be added will depend on the final volume of nutrient solution required for the hydroponics system.

Result

The present investigation was carried out to study the performance of gerbera varieties growing in non-circulating system of hydroponic culture are presented in Table 2. Plant growth parameters and flower characteristics were evaluated. The results revealed that the promising line GJ-023 recorded maximum leave number (8.3), flower number (6.0), highest stalk length (34.4 cm) and stalk weight (28.0 g) (Table 2). The tallest plant (24.0 cm) was observed in BARI Gerbera-1. GJ-023 recorded minimum days (50 days) to flowering followed by BARI Gerbera-2 (52.5 days). Maximum flowering duration (15 days) was also observed in promising line GJ-023. No insect and disease incidence was appeared during the study. Appearance of flower quality was very good in all the varieties. It is indicated that all gerbera varieties successfully grown in steel tray and plastic bucket through hydroponic culture. However, GJ-023 performed best in respect of growth and flower characteristics comparison to other varieties in hydroponic culture.

Table 2: Growth and yield of Gerbera varieties through hydroponic culture

Varieties	Plant height (cm)	Leave number /plant	Days to flowering	Flower number / plant	Flower stalk length (cm)	Flower stalk wt. (g)	Flowering duration (days)	Flower quality	Insect & disease reaction
BARI Gerbera-1	24.0 a	5.0 b	55.0 a	3.5 b	39.0 a	22.0 b	12.5 b	Very good	-
BARI Gerbera-2	20.0 b	6.5 ab	52.5 ab	4.9 ab	36.8 ab	25.0 ab	13.8 ab	Very good	-
GJ-023	22.0 ab	8.3 a	50.0 b	6.0 a	34.4 b	28.0 a	15.0 a	Very good	-
CV (%)	**5.6**	**6.5**	**6.2**	**7.4**	**6.8**	**5.8**	**6.9**	Very good	-

Conclusion

Gerbera varieties successfully grown through hydroponic culture. This is the 1st report on hydroponic culture of gerbera in Bangladesh. For more confirmation of results the experiment should be repeated next year.

Reference

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Plate 1. Vetative stage of gerbera under hydroponic culture

Plate 2. Flowering stage of gerbera under hydroponic culture

EXPT. 6 :EFFECT OF SUBSTRATES ON YIELD AND QUALITY OF GERBERA IN SOILLESS CULTURE

K. A. Ara and S. M. Sharifuzzaman

Abstract

An experiment was conducted at the Floriculture Division of Bangladesh Agricultural Research Institute, Gazipur during winter season of 2017-18 to study the effect of different substrate on growth, flowering, yield and quality of gerbera. Four different potting substrates like soil, cocodust, perlite and sawdust were used in seven combinations. The treatment combinations were T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1), T_6: Cocodust + soil (1:1) and T_7: Cocodust + sawdust (1:1). Data on plant growth and flower character like plant height, leave number, plant spread, sucker number, days to flowering, flower number, stalk length, stalk weight, stalk diameter, vase life and flowering duration were recorded. Among the various substrates, cocodust and perlite (T_5) (1:1) as well as cocodust (T_2) singly performed best followed by in respect of growth, floral and quality characteristics of gerbera. Contrasting to this, gerbera grown on soil (T_1) alone performed poor result.

Introduction

Gerbera (*Gerbera jamesonii* L.) belongs to Asteraceae familyis considered a promising and valuable cut flower crop next to rose, ranks fifth among top ten cut flowers of world market (Bose *et al.,*2000). Recently, gerbera has been introduced in Bangladesh and gaining its demand. It has wide ranges of form, size and colour. Gerberas are now cultivated for dramatic garden display, home decoration, cut-flowers, bedding, floral arrangement and other useful purposes. The major production of gerbera has been promoted in and around Jashore, Gazipur, Savar, Sylhet, Manikgonj, Rajshahi and certain pockets of Narayangonj on commercial scale. Recently, its production has picked up and being grown under semi controlled growing conditions. In city area, there is little or no longer space for flower garden therefore, demand for pot plants and flowers for house decoration as well as roof gardening has immensely increased in recent years. Soil alone as a growing medium does not fulfill all requirements for its higher yield and quality. The introduction of the soilless medium has brought radical change in its protected cultivation and is gaining importance day by day. Gerbera grows well in substrates such as coco peat, peat, sawdust, cocodust, vermicompost, perlite etc. Growing in artificial substrates has many advantages over soil as mixes contain the same composition, diseases and weed free, light in weight and porus (Bala and Singh, 2013) with low salt content, good water-holding capacity, ion exchange capacity and near neutral pH. So keeping in view, an attempt has been made to study the performance of growth and flowering of gerbera affected by different substrates.

Materials and Method

A pot experiment was conducted in the Floriculture Division of Bangladesh Agricultural Research Institute, Gazipur during winter season of 2017-18 with four different substrates. The materials were soil, cocodust, perlite and sawdust. Perlite has been widely used in gerbera pot culture (Sindhu *et al.,* 2010). Sawdust has been identified as an agricultural by product which can be a suitable substrate component (Buck and Evans, 2010) in flower crops. Six weeks old of hardened tissue cultured gerbera plantlets of promising line GJ-023 were used as planting material. The experiment was laid out following Completely Randomized Design (CRD) with three replications consisting of 15 treatments each. Ten inches earthen pots were taken for the experiment. Before setting up the experiment the chemical composition of potting substrates were analyzed and are presented in Table 1. Well- decomposed saw dust, perlite and coco dust were used singly and combindly before 20 days of seedling transplanting. The gerbera plants were nourished with Cooper's nutrient solution having EC of 1.5 dS/m throughout the growing period. Data on survivability %, plant height, leave number, plant spread, sucker number, days to flowering, flower number, stalk length, flower weight, vase life and flowering duration were recorded. Recorded different plant and floral parameters were statistically analyzed through analysis variance with the help of MSTAT software. Difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1997). Chemical properties of post-harvest substrates were and are presented in Table 2.

Table 1. Chemical properties of different potting substrates (initial)

Materials	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			(Meq/100g)				(µg per g)						
Cocodust	7.5	28	1.1	0.3	1.5	1.65	1.0	2.0	0.015	0.005	0.80	0.020	0.012
Perlite	7.4	25	0.9	0.3	1.2	1.60	0.8	1.8	0.010	0.004	0.40	0.090	0.010
Sawdust	6.6	20	0.8	0.2	1.1	1.40	0.5	1.6	0.004	0.001	0.20	0.005	0.008
Soil (Sandy loam)	7.2	0.5	13.0	3.0	0.2	0.03	11.0	10.0	0.018	1.100	20.0	17.000	3.900
Critical Level			**2.0**	**0.8**	**0.2**	**-**	**14.0**	**14.0**	**0.020**	**1.000**	**10.0**	**5.000**	**2.000**

Table 2. **Chemical properties of post-harvest pottingsubstrates**

Treatments	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			(Meq/100g)				(µg per g)						
T_1	7.7	0.45	12.0	3.2	0.15	0.024	10.5	12.0	0.015	1.0	19	17	3.7
T_2	7.0	9.75	10.5	2.5	0.38	0.450	14.3	15.0	0.070	1.2	30	12	2.3
T_3	7.6	8.00	10.0	2.3	0.28	0.250	13.0	13.0	0.050	1.8	36	13	2.4
T_4	7.8	5.50	8.5	2.0	0.26	0.035	12.5	12.5	0.023	1.7	40	25	3.0
T_5	7.2	9.80	10.8	2.6	0.35	0.400	14.0	15.2	0.075	1.3	35	14	3.2
T_6	7.5	8.20	9.8	2.4	0.30	0.150	13.5	14.0	0.040	0.6	45	18	2.5
T_7	7.7	6.10	9.0	2.5	0.25	0.010	13.0	13.0	0.030	0.7	48	25	3.2
Critical Level			**20**	**0.8**	**0.20**		**14.0**	**14.0**	**0.20**	**1.0**	**10**	**5.0**	**2.0**

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Results and Discussion

Effects of different potting substrates on morphological and floral characters of gerbera were studied in this experiment. Findings of the experiment have been presented in Table 3, Table 4, Figure 1, Figure 2 and Figure 3. Significant variations were observed on morphological, flowering, yield and yield contributing characters.

The effect of different potting substrate on percent survival of gerbera plantlets are given in Figure 1. Among different treatments, T_5 (cocodust + perlite @ of 1:1) showed 100% survival of plants followed by T_2 (cocodust singly) and T_6 (cocodust + soil @ of 1:1) with 90% survivability. The reason for the best performance of cocodust with the perlite are high organic matter content, which increases the water and nutrient holding capacity of the plant. The lowest survivability percentage (70%) was noted in T_1

when soil alone used as potting substrate. Similar observation was also reported by Sharifuzzaman *et al.* (2010) while working with different potting substrate in house plants.

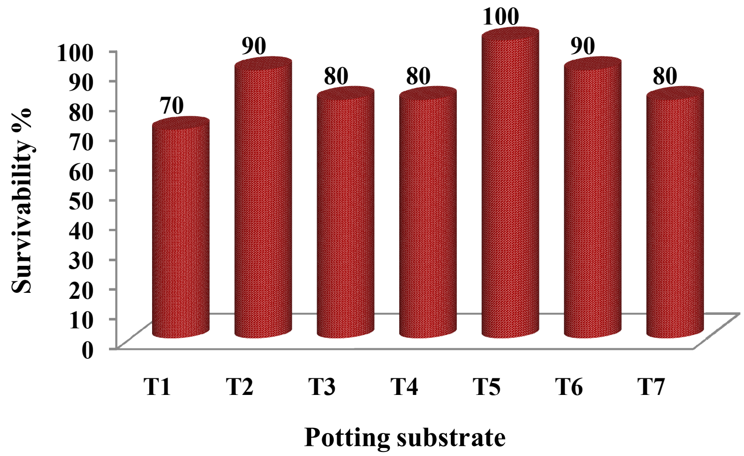

Fig. 1. Effect of potting substrate on survivability % of gerbera

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Table 3. Performance of different potting substrates on growth parameters of gerbera

Treatments	Plant height (cm)	Number of leaves/plant	Plant spread/ (cm^2)	Number of sucker/plant
T_1	20.0 b	8.0 b	27.0 c	2.0 b
T_2	24.5 a	13.0 a	36.5 a	4.4 a
T_3	22.4 ab	10.9 ab	34.0 ab	3.5 ab
T_4	21.8 ab	10.0 ab	31.8 b	3.3 ab
T_5	25.0 a	12.8 ab	36.2 a	4.5 a
T_6	22.8 ab	10.7 ab	36.1 ab	3.5 ab
T_7	22.0 ab	10.0 ab	33.3 ab	3.2 ab
Level of Sig.	**2.0**	**1.9**	**2.2**	**2.2**
CV %	**5.98**	**6.99**	**7.54**	**9.03**

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Data from the Table 3 exhibited that the tallest plant (25.0 cm) was found from the treatment T_5 (cocodust + perlite) which was statistically identical with T_2 (cocodust) treatment and the shortest plant (20.0 cm) in T_1 treatment. Potting substrates of cocodust (T_2) and cocodust + perlite (T_5) contain more organic matter in decomposed form which release more nitrogen that accelerates plant growth than all other treatments. Meyer and Anderson (2003) reported that the highest doses of N enhance cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increased plant height. The total number of leaves produced per plant was found to be significant in different substrate medium. Substrate amended with cocodust (T_2) produced highest number of leave (13.0) followed by T_5 (cocodust + perlite) (12.80). Adequate number of leaves is essential for normal growth and production. An increase in number of leaves causes the accumulation of greater photosynthates leading to better growth parameters. The substrate amended only with soil (T_1) recorded minimum number of leaves per plant (8.0). Similar results were reported by Thangam *et al.* (2009) and Sindhu *et al.* (2010) in gerbera. The result revealed that there was a significant difference in plant spread among the treatments (Table 3). Maximum plant spread was observed in T_2 (36.5 cm^2) which was statistically identical with T_5 (36.2 cm^2). Minimum plant spread (27.0 cm^2) was observed in T_1 (soil). The highest numbers of suckers per plant (4.5) were found from T_5 treatment which was statically similar with T_2 treatment (4.4) and the lowest (2.3) from T_1 treatment. Saha *et al.* (2018) also indicated that perlite and cocodust (1:1) (T_5) and cocodust (100%) (T_2) contain higher amount of plant nutrient and have potential for restoration of soil fertility as well as increase the number of sucker per plant. This finding is in agreement with Thangam *et al.* (2009) that maximum number of sucker in gerbera was obtained, when a potting substrate containing cocodust + perlite was used.

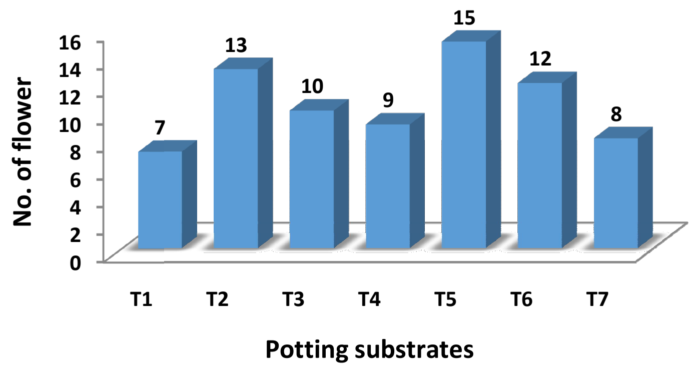

Fig. 2. Flower number of gerbera as influenced by different potting substrate

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Variation was observed regarding number of flowers produced per plant. It varied from 7.0-15.0. Flowering is a complex process in plant's life for which the plants requires optimum growth and nutrients and thus the substrate containing more nutrients produced higher number of flowers. The highest number of flowers per plant was produced by T_5 (15.0) followed by T_2 (13.0). Plants of the treatment T_1 produced the lowest number of flowers (7.0) (Figure 1). Maximum number of flowers was also obtained using cocodust alone along with cocodust + perlite by Pivot (1985) in gerbera. Considering the chemical properties of different potting substrates, T_5 (cocodust + perlite) and T_2 (cocodust) provided higher amount of N, P, K, B and Zn (Table 2). This is in line with the findings of Ahmad *et al*., (2012) in gerbera.

Table 4. Performance of different potting substrates on flower parameters of gerbera

Treatments	Days to flowering	Stalk length (cm)	Stalk weight (g)	Stalk diameter (cm)	Vase life (days)
T_1	68.0 a	8.5 b	16.0 c	0.40 b	8.5 b
T_2	60.0 c	13.7 a	26.0 a	0.88 a	12.3 a
T_3	65.0 bc	12.4 ab	18.8 bc	0.44 ab	10.8 ab
T_4	67.4 ab	11.0 ab	17.5 bc	0.40 ab	9.4 ab
T_5	60.3 c	14.0 a	27.0 a	0.99 a	12.5 a
T_6	64.0 b	11.5 ab	24.0 ab	0.60 ab	10.9 ab
T_7	66.0 ab	8.8 b	22.0 b	0.50 ab	9.5 ab
Level of Sig.	**2.4**	**2.2**	**1.9**	**1.8**	**2.1**
CV %	**8.12**	**6.99**	**7.03**	**6.58**	**5.64**

T_1: Soil (control), T_2: Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Days to flowering were significantly affected by different potting substrate. Plants took more time to flower where the nutrients availability was restricted i.e. T_1 (soil) with 68.0 days to flowering. On the other hand, plants grown in nutrient enriched media took less time to flower i.e. 60.0 and 60.3 days to flowering in T_2 (cocodust) and T_5 (cocodust + perlite), respectively. Present results are in agreement with Ahmad *et al.* (2012) the mixture of cocodust + perlite and cocodust singly resulted in early flowering in gerbera.

Different potting substrates significantly influenced the stalk length of gerbera. The treatment T_5 produced the longest stalk length (14.0 cm) which was identical with T_2 (13.7 cm) treatment and shortest in T_1 and T_7 (8.5 and 8.8 cm respectively). Flower growth and development is mainly influenced by the availability of phosphorus to plant in a growing medium which ultimately resulted in increased flower stalk length. Plants grown in substrates containing cocodust singly and mixture of cocodust with perlite produced longer flower stalks which are in line with the findings of Ahmad *et al.* (2012) who observed longest stalks of roses when grown in combination of perlite with coco fiber. Media which had more phosphorus contents produced thicker stalks as compared to other treatments. These findings confirmed the findings of Meyer and Anderson (2003) who observed thick flower stalks of gladiolus and lily when grown in various nutrient rich media. Differences in substrate composition markedly affected flower quality and substrate rich in nutrients and with favorable physico-chemical properties produced best quality blooms as compared to rest of the treatments. These results confirmed the findings of Nowak and Strojny (2003) who claimed best quality gerbera production in cocodust.

Significant variation in respect of stalk weight was observed among the substrate (Table 4). The highest stalk weight of 27.0 g was produced by treatment T_5 followed by T_2 (26.0 g) while the shortest spike of 16.0 g was produced by T_1. More or less similar results were reported by Wilson (1988) in gerbera.

Data regarding diameter of stalk showed that maximum diameter of stalk (0.99 cm) was noted in T_5 (cocodust + perlite) closely followed by 0.88 cm flower stalk diameter observed in T_2 (cocodust). The minimum flower stalk diameter (0.40 cm) was reported in T_1 (soil). As the soil has lower water holding capacity and is deficient in many nutrients, thus these factors could be responsible for least diameter of flower stalk and vice versa.

This parameter is related to post-harvest handling of cut flowers. This is one of the most important commercial aspects of gerbera production. Significantly longer vase life (12.5 days) was counted for the plants grown in T_5 (cocodust + perlite). Statistically similar results (12.3 days) were reported for T_2 (cocodust). The minimum (8.5 days) vase life was recorded for the plants grown in T_1 (soil). Ahmad *et al.* (2012) also reported similar results by stating that the combination of cocodust + perlite had eventually increased the flower vase life of gerbera.

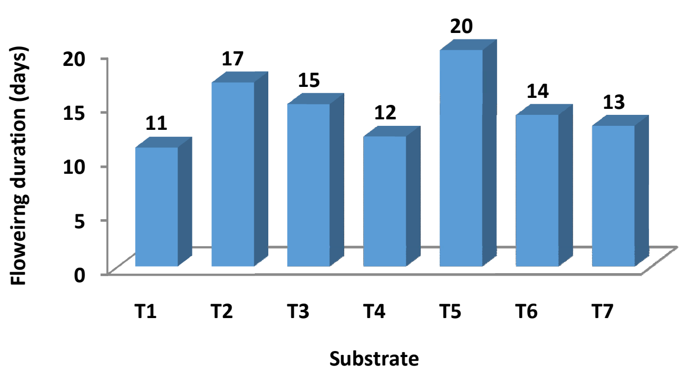

Fig. 3. Effect of substrate on flowering duration of gerbera

T_1: Soil (control), T : Cocodust, T_3: Perlite, T_4: Sawdust, T_5: Cocodust + perlite (1:1, v/v), T_6: Cocodust + soil (1:1, v/v) and T_7: Cocodust + sawdust (1:1, v/v)

Maximum duration of flowering of 20 days was observed in cocodust with perlite media (T_5) followed by 17 days of flowering duration from substrate containing cocodust singly (T_2). Dutta *et al.* (2002) obtained similar results in gerbera where higher duration from full bloom to flower deterioration was observed in plants grown in cocodust substrate. The increased flowering duration could be attributed to conductive conditions in the substrate and higher nutrient uptake and utilization in plants grown in T_2 and T_5 substrate. The minimum flowering duration of 11 days was recorded in T_1 (soil).

Conclusion

From the findings of experimentation, it can be concluded that perlite + cocodust (1:1 ratio) was the suitable potting substrate followed by cocodust (100%) for gerbera cultivation in pot. This finding would be very helpful to urban people for the cultivation of gerbera successfully.

Plate 1. Preparation of substrates ready for planting of gerbera

Plat

Plate 2. Vegetative stage of gerbera using different substrates

Plate 3. Flowering stage of gerbera using different substrates

12. Research highlight/findings :

- The variety BARI Gladiolus-4 under poly tunnel recorded best performance owing to improved growth, quality, higher yield and less disease incidence
- Corm treated with GA_3 @ 200 ppm was found best result in plant growth, flowering and yield characteristics of BARI Gladiolus-4 in Off-season under poly tunnel condition
- Promising line of gerbera (GJ-023) under poly house recorded best performance owing to improved growth, quality, higher yield and less disease incidence and insect infestations
- A study was carried out to find out the effect of gibberellic acid on growth, yield and quality of gerbera plants under poly tunnel
- The findings of the investigation revealed that GA_3 @ 100 ppm accelerated vegetative, flowering, yield and quality characteristics of gerbera
- Gerbera varieties successfully grown through hydroponic culture. This is the 1st report on hydroponic culture of gerbera in Bangladesh
- From the findings of experimentation, it can be concluded that perlite + cocodust (1:1 ratio) was the suitable potting substrate followed by cocodust (100%) for gerbera cultivation in pot
- This finding would be very helpful to urban people for the cultivation of gerbera successfully

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B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	299000.00	299000.00	100%	100%	
(b) Lab & field equipment	275800.00	275800.00	100%	100%	
(c) Other capital items	15000.00	15000.00	100%	100%	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Others (Shade net, GI pipe structure, Polythene & UV polyfilm roll, Tarpaulin, Trolley, Aluminum ladder, Wire, Milk crate, Vertical plastic Rack with Iron structure, Bamboo, Cement pole, Insect net, Fishing net, Mud tub, plastic pot, wire, watering pipe, Electric goods & Cable etc.)	498200.00	100%	-	-	-

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	-
(b) Workshop	-	-	-	-	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	268669	268669	268669	0	100.00	
B. Field research/lab expenses and supplies	1518625	1471889	1470036	1853	96.80	Delay of fund received
C. Operating expenses	158180	147763	152208	-4445	96.22	
D. Vehicle hire and fuel, oil & maintenance	99400	99400	96400	3000	96.98	
E. Training/workshop/seminar etc.	0	0	0	0	0	
F. Publications and printing	100000	34000	36139	-2139	36.14	
G. Miscellaneous	41126	41828	36751	5077	89.36	
H. Capital expenses	314000	314000	314000	0	100.00	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
To develop suitable protective culture technique for gladiolus and gerbera	▪ Making poly house and poly tunnel structure ▪ Field visit ▪ Monitoring and evaluation report	Developed protected cultivation techniques of gerbera and gladiolus	Increased quality flower production of gerbera and gladiolus
To standardize optimum substrate for soilless culture of gerbera	▪ Collection of different substrates ▪ Placement of substrates under soilless culture	Developed gerbera production technology under soilless culture	Aesthetic people/ farmers have been benefitted using soilless culture to produce disease and insect free quality flower yield of gerbera
To establish technology for off-season gladiolus production	▪ Making shed structure ▪ Collection of BARI varieties of gladiolus ▪ Field visit	Developed techniques for sustainable yield and quality potentials of gladiolus varieties under off-season	Substantial increase of farm family income

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/booklet·/leaflet/flyer etc.	02 (Two) Nos.		
Journal publication	03 (Three) Nos.	-	
Information development	-	-	
Other publications, if any	-	01	March, 2018 (BARI Sangbad Magazine)

F. Technology/Knowledge generation/Policy Support (as applied):

i. **Generation of technology (Commodity & Non-commodity)**

- The variety BARI Gladiolus-4 under poly tunnel recorded best performance owing to improved growth, quality, higher yield and less disease incidence
- Corm treated with GA_3 @ 200 ppm was found best result in plant growth, flowering and yield characteristics of gladiolus in Off-season under poly tunnel condition
- The promising line of Gerbera(GJ-023)performed better with regard to vegetative growth, flower characteristics, yield and quality under poly house condition
- GA_3 @ 100 ppm accelerated vegetative, flowering, yield and quality characteristics of gerbera
- Gerbera varieties successfully grown through hydroponic culture
- Perlite + cocodust (1:1 ratio) was the suitable potting substrate followed by cocodust (100%) for gerbera cultivation in pot

ii. **Generation of new knowledge that help in developing more technology in future**
Suitable potting substrates and soilless production of gerbera would be very helpful to urban people for the cultivation of gerbera successfully.

iii. **Technology transferred that help increased agricultural productivity and farmers' income**
Developed offseason gladiolus production under poly tunnel condition and gerbera under poly house condition may help to increase quality flower production and farmers' income. Dissemination of these developed technologies is needed for gladiolus and gerbera production area.

iv. **Policy Support**

G. Information regarding Desk and Field Monitoring

i) **Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):**

16 January 2018 & 1 time visit by Dr. Md. Abdul Jalil Bhuyan and his associates

ii) **Field Monitoring (time& No. of visit, Team visit and output): 02**
Visited two times at16 January and 22 February 2018 by the following personnel;

- Dr. Md. Dr. Md. Abdul Jalil Bhuyan, Research management specialist, NATP-2, BARC
- Dr. Md. Aziz Zilani Chowdhury, Member Director (Crop) BARC, Dhaka
- Dr. Abdus Salam, CSO (Crop), BARC, Dhaka
- Dr. Md. Kabir Uddin, CSO, BARC, Dhaka
- Md. Monirul Islam NATP-2, BARC, Dhaka
- Mr. Abdul Mamun, NATP-2, BARC, Dhaka

Monitoring team	Date(s) of visit	Total visit date (No.)	Remarks
PIU-BARC, NATP-2	16 January, 2018	1	
Technical Division/ Unit, BARC	22 February, 2018	1	
Internal Monitoring of BARI	29 January, 2018	1	
Others Visitors			
Agriculture Ministry	27 January, 2018 21 February, 2018	2	
University (BAU)	24 February, 2018	1	
DAE Officer's	20 March, 2018	1	
NGO's	11 March, 2018	1	
Farmers	13 March, 2018	2	
Students	4 May, 2018	7	

Output: Monitoring team gave some valuable advices for the betterment of study those were followed as per their suggestions.

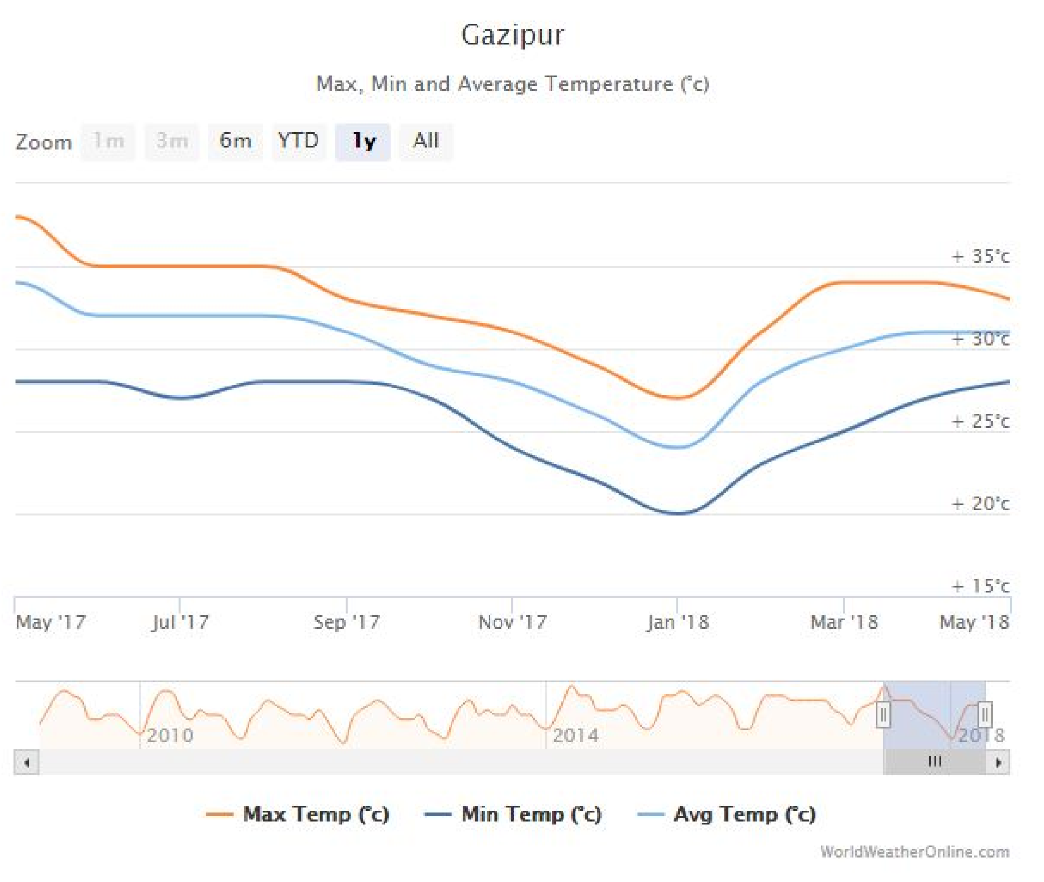
I. Lesson Learned/Challenges (if any):

- High rainfall and hail storm caused partial damage of gladiolus and gerbera crop under open field condition during study period
- Delay of fund received

Signature of the Principal Investigator
Date ………………………….
Seal

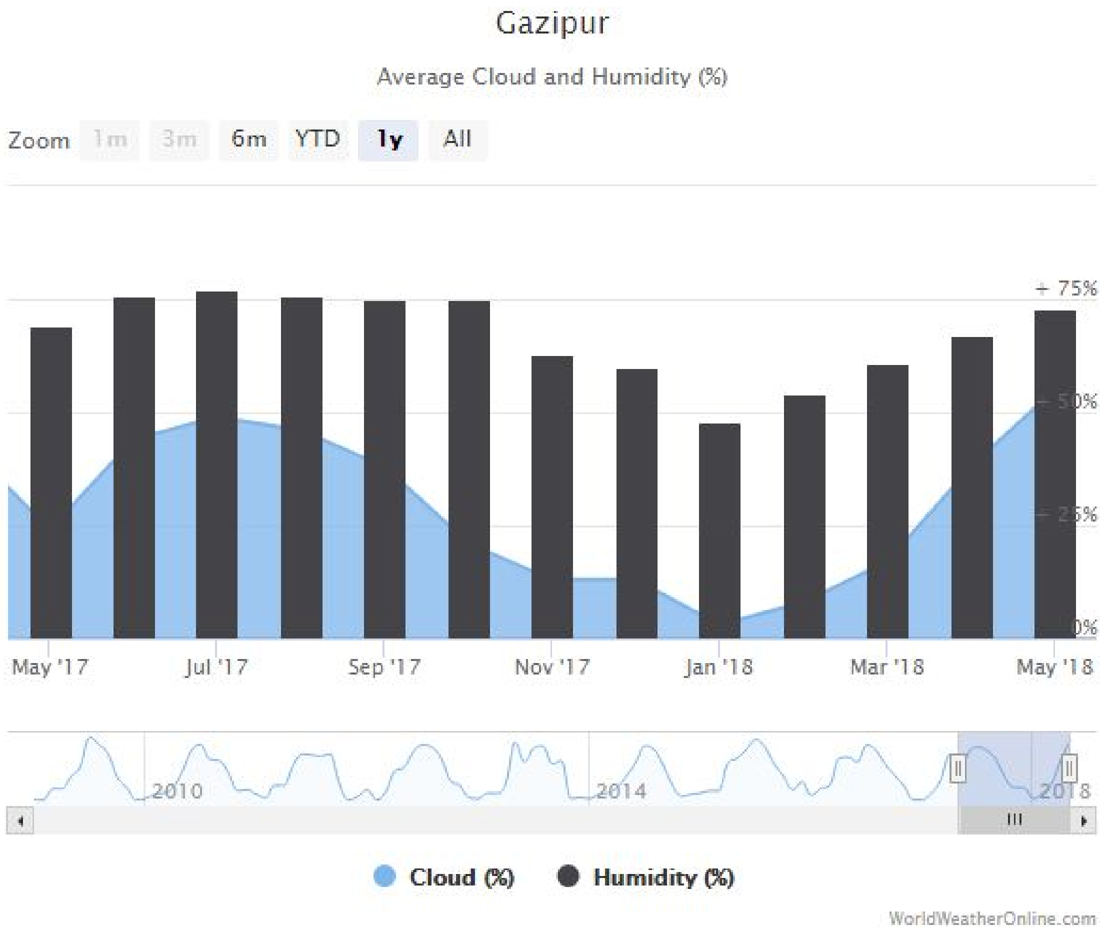
Counter signature of the Head of the organization/authorized representative
Date …………………………..
Seal

Appendix 1



Gazipur
Max, Min and Average Temperature (°c)
Zoom 1m 3m 6m YTD 1y All
+ 35°c
+ 30°c
+ 25°c
+ 20°c
+ 15°c
May '17
Jul '17
Sep '17
Nov '17
Jan '18
Mar '18
May '18
2010
2014
2018
Max Temp (°c)
Min Temp (°c)
Avg Temp (°c)
WorldWeatherOnline.com

Appendix 2



Gazipur
Average Cloud and Humidity (%)
Zoom 1m 3m 6m YTD 1y All
75%
50%
25%
0%
May '17
Jul '17
Sep '17
Nov '17
Jan '18
Mar '18
May '18
2010
2014
2018
Cloud (%)
Humidity (%)
WorldWeatherOnline.com

Appendix 3

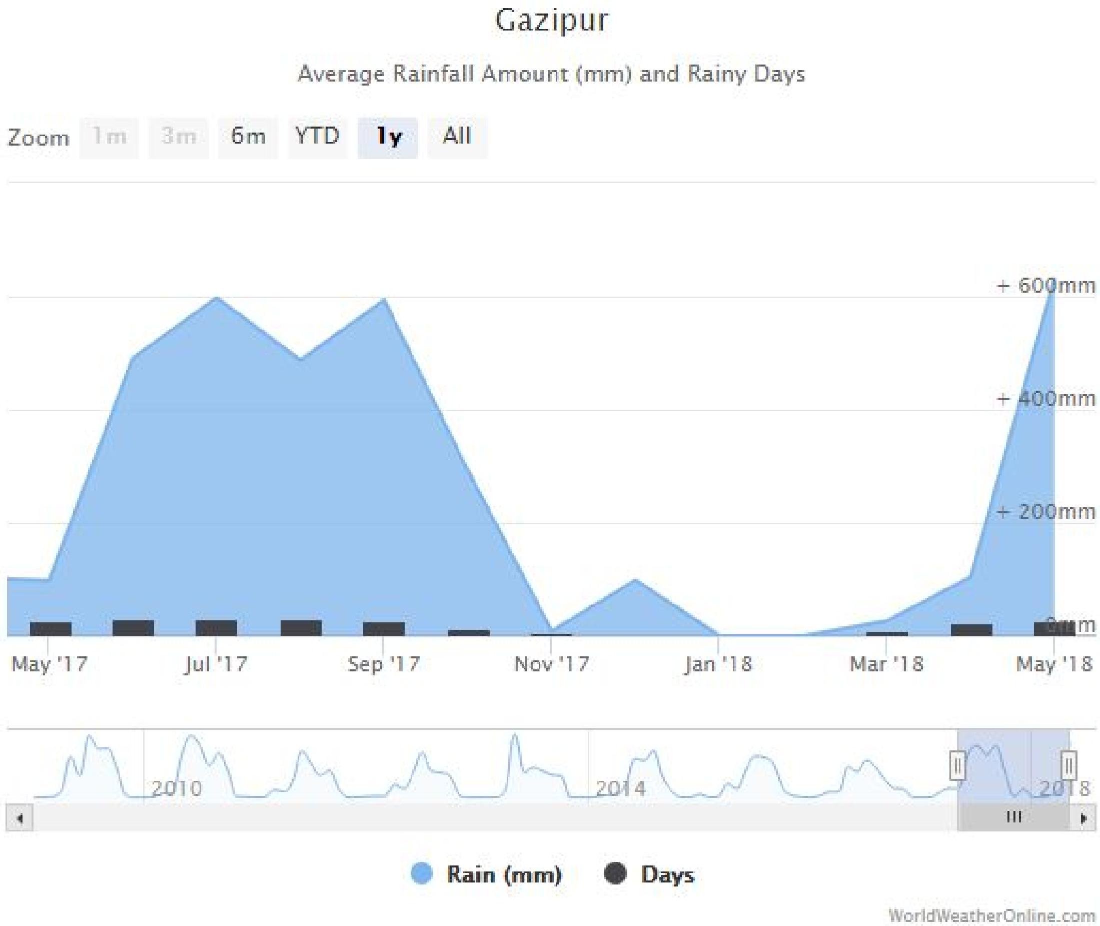

Gazipur
Average Rainfall Amount (mm) and Rainy Days
Zoom
1m
3m
6m
YTD
1y
All
600mm
400mm
200mm
0mm
May '17
Jul '17
Sep '17
Nov '17
Jan '18
Mar '18
May '18
2010
2014
2018
Rain (mm)
Days
WorldWeatherOnline.com

Photo documentation (Res. Work, Monitoring, Training, Field day etc.)

Photo documentation (Res. Work, Monitoring, Training, Field day etc.)