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Full Length Research Paper

The Performance of open field Gerbera in response to planting time

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Adjustment in planting time is one of the effective means of improving cut flower output under open field conditions. A field experiment was carried out on Gerbera with eight different dates of planting (15th March - 15th October) on Alfisol during 2006 to 2009. Difference in planting time induced a significant difference in performance of Gerbera, due to variation in soil moisture content (153.2 g/kg in May planting to 301.6 g/kg in August planting, coinciding linearly with rainfall received). However, the treatment with June planting produced the best response in terms of number of leaves/plant (15.96), leaf area (138.78 cm^2), plant height (27.09 cm), flower size (9.12 cm), stalk length (35.77 cm), number of flowers (220.1/m^2) and flower yield (2.95 kg/m^2) compared to rest of the other dates of planting. The study, hence, suggested that an effective benchmark of optimum soil moisture (201.0 g/kg, that is, 82.8% of 33 KPa soil moisture) is necessary to harness upon the benefits of suitable planting time under rainfed open field conditions.

Key words: Soil moisture, planting time, vegetative growth, flower yield, Alfisol, Gerbera.

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus ex Hook) is the latest sensation to Indian Floriculture, commercially grown throughout the world in a wide range of climatic conditions (Lhoste, 2002) According to the global trends in floriculture, Gerbera occupies the 4th place among cut flowers (Sujatha et al., 2002). Studies in the past showed that variation in planting time poses the most profound effect on both vegetative as well as reproductive features of the crop evident from evaluation of different gerbera varieties at West Bengal (Sarkar and Ghimiray, 2004), Bay Islands (Nair et al., 2002), Tarai conditions of Uttarakhand (Khandpal et al., 2003), Jorhat, Assam (Barooah and Talukdar, 2009), Goa (Thangam et al., 2009), Poona (Wankhede and Gajbhiye, 2013) and Aurangabad (Chobe et al., 2010) areas of Maharashtra. In a 3- year- trial on Gerbera conducted by Parthasarathy and Nagaraju (2003), it was observed that the flower bud initiation, growth, development and flowering were faster during warmer period (April – May and June – July),while the longevity of flower was more during October to November. Similarly, studies conducted at Dharwad to evaluate the best planting time for Gerbera cv. Sath Bata showed a strong influence of staggered planting on vegetative as well as reproductive attributes, with July planting resulted in maximum flower size (Singh, 2001).

The northeastern region (NER) has been identified as the potential belt for the development of floriculture, as the region has distinct climatic variations, the rapid changes in the topography within a short distance, making it one of the most ideal climates for the commercial cultivation of floriculture crop (Longchar and Keditsu, 2013). Such agropedological conditions extensively exist in most of the tropical countries having acidic soils taxonomically belonging predominantly to Alfisols and Ultisols. The major constraint lies in the extended trade of Gerbera is on account of limited availability of flower in the market throughout the year. Good plant growth, maximum number of flowers coupled with good stalk length and flower size are some of the global criteria for cut flower trade (Nair et al., 2002; Gaurav et al., 2005).

Seasonal influence on growth and flower yield of Gerbera provides a greater flexibility in modulating the growing conditions to harness towards better vegetative growth and flower yield. Open field Gerbera in this regard becomes highly sensitive to climatic conditions (Aderson et al., 2011). While evaluating the response of planting time, other associated co-factors, especially the meteorological conditions also aid in raising the flower yield as well as the floral characteristics. Jamaludin et al. (2012) observed the significant influence of different light intensities (full sunlight equivalent to 10,000 lux or more, 60% reduced sunlight as 2400-4000 lux and 40% reduced sunlight as 6000-6500 lux) on the growth and flower characteristics of Gerbera.

The study further concluded that photosynthetically active radiation is the major factor regulating photosynthesis, dry matter production and flower yield. In this background, the present study was carried out with this sole objective since the desired information is extremely lacking in the context of humid tropical conditions of Nagaland, a province of NER of India, so that such concepts can be replicated elsewhere with similar agropedological analogues.

MATERIALS AND METHODS

Experimental set-up

A field experiment under humid tropical climate (33.9 - 22.5°C as maximum temperature and 10.9 - 27.4°C as minimum temperature, 1100 mm rainfall and 80.6 to 91.7% relative humidity) was conducted during 2006-09 at Government Nursery (25°45´43´´N latitude; 93°53´44´´E longitude at an elevation of 210 m in above mean sea level at Dimapur, Nagaland. The experiment soil belonged to Alfisol (sand 594.0 g/kg, silt 241.5 g/kg, clay 164.5 g/kg, 33 KPa 242.6 g/kg, 1500 KPa 104.3 g/kg, soil pH 5.2, $KMnO_4$-N 148.6 mg/kg, Bray's-P 4.2 mg/kg and neutral NH_4OAc-K 98.9 mg/kg).

The experimental plot was ploughed deeply and thoroughly harrowed to a fine tilth. Individual beds of 1·2 m × 1·2 m size, raised to a height of 15 cm were prepared. At the time of planting 7 tons FYM/ha alongwith recommended dose of fertilizer consisting of 60 kg N (urea) – 40 kg P_2O_5 (single superphosphate) and 60 kg K_2O/ha (muriat of potash) were applied uniformly. Healthy suckers of Gerbera cv. Red Gem were collected from experimental farm of Assam Agricultural University, Jorhat, Assam which was used as the planting material for carrying out the research. The individual healthy suckers were separated from the clump, the leaves and roots were trimmed off. Thereafter, the suckers were planted with utmost care not to cover the crown with soil. The suckers were planted at a spacing of 30 × 30 cm, accommodating around 16 plants in each plot. Planting was done in the evening hours, immediately followed by applying irrigation water. The plots were kept free from weeds throughout the growing period by manual weeding. For proper growth and development of the plants, various intercultural operations such as irrigation, earthing up, removal of dried leaves and flowers etc. were done at regular intervals.

Eight treatments consisting of M_1 (15^{th} March date of planting), M_2 (15^{th} April date of planting), M_3 (15^{th} May date of planting), M_4 (15^{th} June date of planting), M_5 (15^{th} July date of planting), M_6 (15^{th} August date of planting), M_7 (15^{th} September date of planting) and M_8 (15^{th} October date of planting) replicated three times were tested in a randomized complete block design.

Plant observations

The number of leaves per plant was recorded from each sample plant and the average was taken. The observation was taken at the time of first flowering. Five numbers of leaves of various sizes were collected from each sample plant and were measured with the help of leaf area meter and the average was recorded in cm^2. The plant height was measured with the help of linear scale and expressed in centimeter. The observation was taken at the time of first flowering from the base of the plant to the tip of the longest leaf.

Days taken from planting to the visibility of the flower bud (pea size) at the ground level, days taken from planting to the date when the bud first begins to open, number of days taken from bud emergence to bud burst stage, days taken from the date of planting to the full opening of disc floret, diameter of the flower (measured with the help of linear scale at full bloom stage and expressed in centimetre), length of flower stalk (measured in centimeter with the help of linear scale from the base of the stalk to the point where the head is joined to the tip of stalk), girth of flower stalk (measured at the mid portion of the stalk with the help of vernier caliper and expressed in centimetre), The flowers were harvested when the outer rows of the disc floret were perpendicular to the stalk. Harvesting was done in the morning hours by giving a sideward pull at the base of the flower stalk. Immediately after harvesting, the stem end is immersed into a container half filled with clean water.

Soil moisture analysis

Soil samples (0 to 15 cm depth) collected at flowering stage were subjected to thermo-gravimetric analysis (Chopra and Kanwar, 1986).

Statistical analysis

Critical difference (CD) was calculated using as per the standard procedure. Linear coefficient of correlation ($r = \sigma xy/\sigma x \cdot \sigma y$, where σx and σy are the standard deviations of x and y, respectively, and σxy the covariance) and regression analyses ($y = a + bx$, where y, a, b and x stand for dependent variable, intercept, regression coefficient and independent variable) were used to screen the soil properties significantly affecting the fruit yield and quality (Rangaswamy, 1995).

RESULTS AND DISCUSSION

Variation in soil moisture

Crop response to planting time under rainfed open field conditions was primarily governed by differential soil moisture in addition to other meteorological conditions.

Table 1. Effect of planting time on the vegetative growth parameters of Gerbera cv. Red Gem.

Treatments	Soil moisture (g/kg)	Number of leaves/plant	Leaf area (cm^2)	Plant height (cm)
M_1(March)	182.3	9.17	89.31	19.88
M_2(April)	164.6	10.99	111.97	23.10
M_3(May)	153.2	10.78	103.87	25.09
M_4(June)	201.0	15.96	138.78	27.09
M_5(July)	284.3	11.76	120.61	24.08
M_6(August)	301.6	10.08	66.59	20.86
M_7(Sept.)	284.3	9.80	87.71	19.56
M_8(Oct.)	204.1	9.94	74.97	19.71
CD (*P=0.05*)	9.3	3.36	11.54	1.67

Source: Pooled data of 2006-2009.

Different dates of planting from March (M_1) to October (M_8) displayed a significant variation in soil moisture from 153.2 g/kg during May date of planting (M_3) to 301.6 g/kg during August date of planting (M_6). Considering the field capacity (33 KPa) soil moisture, the August (M_6) and September (M_7) dates of planting maintained significantly higher soil moisture, while March (M_1), April (M_2) and May (M_3) registered the soil moisture level with nearer to 1500 KPa.

Correlation matrix developed for soil moisture variation versus all the vegetative growth and flower yield parameters suggested strong influence of soil moisture on the performance of Gerbera as evident from statistically significant correlations of soil moisture with number of leaves (r = 0.512, $p = 0.01$) , leaf area (r = 0.632, $p = 0.01$), plant height (r = 0.714, $p = 0.01$), flower size (r = 0.489, $p = 0.01$), stalk length (r = 0.382, $p = 0.05$), number of flowers (r = 0.716, $p = 0.01$) and flower yield (r = 0.743, $p = 0.01$). Correlation studies earlier carried out by Kannan and Ramdas (1990) showed that flower yield/ plant had significant and positive correlation with a period of flower retention on the plant whereas number of leaves had significantly positive correlation with number of sucker production/plant and flower stalk girth.

Number of leaves/plant, leaf area and plant height

The time of planting inflicted a significant response on number of leaves/plant (Table 1). The number of leaves/plant was maximum (15.96 leaves/plant) when planting was undertaken in the month of June (M_4) followed by July (M_5) month of planting (11.76 leaves/plant), but statistically on par with April to May (M_2-M_3) months of planting (10.99-10.78 leaves/plant). While, minimum number of leaves (9.17 leaves/plant) was observed in March planting (M_1) which was statistically on par with rest of the other months of planting ranging from August (M_6) to October (M_8) recording 10.08 to 9.94 leaves/plant. Hence, most effective and least effective treatments were observed as M_4 (15.96 leaves/plant) and M_1 (9.17 leaves/plant), respectively.

The leaf area was observed as 138.78 cm^2 with treatment M_4 when planting was done in June. While, minimum leaf area of 74.97 cm^2 was observed with treatment M_8 when planting was done in October. The other dates of planting such as March (M_1), August (M_6) and September (M_7) were not so effective in developing leaf area. Rest of the other treatments having planting date of July (M_5) and April (M_2) were ,although responsive, but on par to each other, and proved as second order effective treatments to June date of planting (M_4) or July date of planting (M_5) as first order effective treatments.

Height of the plant is another effective index of measuring the magnitude of vegetative growth. Pooled data on plant height for both the seasons were analyzed and results obtained were almost of the same magnitude compared to data when analyzed season wise. The treatment M_4 (27.09 cm with June date of planting) continued its supremacy over rest of the other treatments. While M_7 and M_8 were observed as least effective treatment. June to July (M_4-M_5) date of planting produced the best response on plant height followed by April to May (M_2 – M_3) (and September - October (M_7 – M_8) date of planting.

Time of bud emergence, bud burst and bud emergence to bud burst

Change in planting time influenced the parameters like time of bud emergence, bud burst and bud emergence to bud burst. The treatment M_4 (June date of planting) and M_2 (April date of planting) took 101.82 and 113.45 days, respectively, for bud emergence from planting time. Incidentally, these treatments suggested the most effective and least effective treatment, respectively. The same treatment M_4 (June date of planting) and M_2 (April date of planting) demonstrating as most effective and

Table 2. Days taken to flowering in response to different planting time and flowering characteristics in Gerbera.

Treatments	Bud emergence (Days)	Bud burst stage from planting time (Days)	Bud emergence to bud burst (Days)	Full bloom from planting time(Days)	Flower size (cm)	Stalk length (cm)
M_1(March)	108.96	118.32	9.36	128.20	8.25	26.46
M_2(April)	113.45	122.56	9.11	130.44	8.09	26.35
M_3(May)	58.92	112.56	9.05	121.63	9.05	31.99
M_4(June)	101.82	109.31	7.49	116.56	9.12	35.77
M_5(July)	102.21	110.57	8.36	120.10	8.75	36.17
M_6(August)	109.70	119.07	9.37	129.96	8.61	29.89
M_7(Sept.)	110.60	119.98	9.38	130.53	8.15	27.72
M_8(Oct.)	112.53	122.03	9.5	133.56	7.82	27.65
CD(*P=0.05*)	1.93	1.93	0.69	2.20	0.30	2.42

Source: Pooled data of 2006-2009.

least effective treatment, respectively (Table 2) on bud burst stage from planting time. However, other treatments showed some variation in response when compared between seasons (Table 2). The phenology of flowering behaviour is characterized on the basis of: (1) time taken in terms of days consumed to bud emergence; (2) time taken to reach bud burst stage from planting time; (3) time taken from bud emergence stage to bud burst, and

(4) time taken to full bloom from planting time. These four parameters were most favourable with June date of planting because of the most suitable agropedological settings achieved during this month of planting. These could be characterized as: (1) better soil moisture nearer to field capacity soil moisture content; (2) nearby 12 to 15% of total rainfall taking place and ensuring the necessary moisture level within soil; (3) triggered nutrient flow, and (4) sunshine hours of 6 to 8 h/day plus minimum variation in air temperature as diurnal variation (only 4.8°C) with relative humidity of 88.6%.

Time taken from bud emergence to bud burst holds a strong promise in the context of readiness of flower to full bloom. Number of days taken from bud emergence to bud burst was significantly ($p \leq 0.05$) influenced by different dates of planting (Table 2). The treatment M_4 (June date of planting) took minimum days of 7.49 days when planted in the month of June, closely on par with other treatments such as M_5 (with July date of planting). However, M_8 was significantly superior to other treatments including M_6 (August date of planting), M_7 (September date of planting), M_8 (October date of planting), M_1 (March date of planting), M_2 (April date of planting) and M_3 (May date of planting).

Time on full bloom from planting time

The time taken for full bloom from planting time is considered the most important criterion deciding the time of harvest which triggers a significant influence on vase life of the cut flowers. Influence of change in planting time significantly affected the time taken (number of days) in attaining full bloom from planting time. The time taken for attaining full bloom from planting time varied from minimum of 116.56 days (with June date of planting) to maximum of 133.56 days (with October date of planting) coinciding with most effective and least effective treatment, respectively. Hence, by the changing of date of planting, the flowers can be cut earlier by 17.02 days, keeping all other cultural practices of cultivation the same, simply by virtue of variation in soil moisture variation.

Flower size and stalk length

The time of planting showed a significant response on the size of the flower, which varied from minimum size of 7.82 cm with treatment M_8 (October date of planting) to the maximum flower size of 9.12 cm with treatment M_4 (June date of planting). These two treatments M_8 and M_4 were observed as least effective and most effective treatments, respectively, on the basis of responses obtained during both the seasons. The treatment M_4 displayed its clear cut superiority over rest of the treatments. However, the treatments like M_7 versus M_1, M_2 versus M_3 or M_3 versus M_4 showed no significant difference (Table 2).

In cut flowers, higher stalk length of flowers is a desirable feature. The stalk length was significantly ($p \leq 0.05$) affected by various planting time. During both the seasons, treatments such as M_7, M_8, M_1 and M_2 showed no significant response amongst themselves. The maximum (36.17 cm) and minimum (26.16 cm) stalk length were recorded with treatment M_5 and M_2, respectively. However, M_5 was on par with M_4, suggesting, thereby, the suitability of June-July as most suitable time of planting (Table 2). Correlation studies by Rao and Vasudevan (2009) revealed positive and

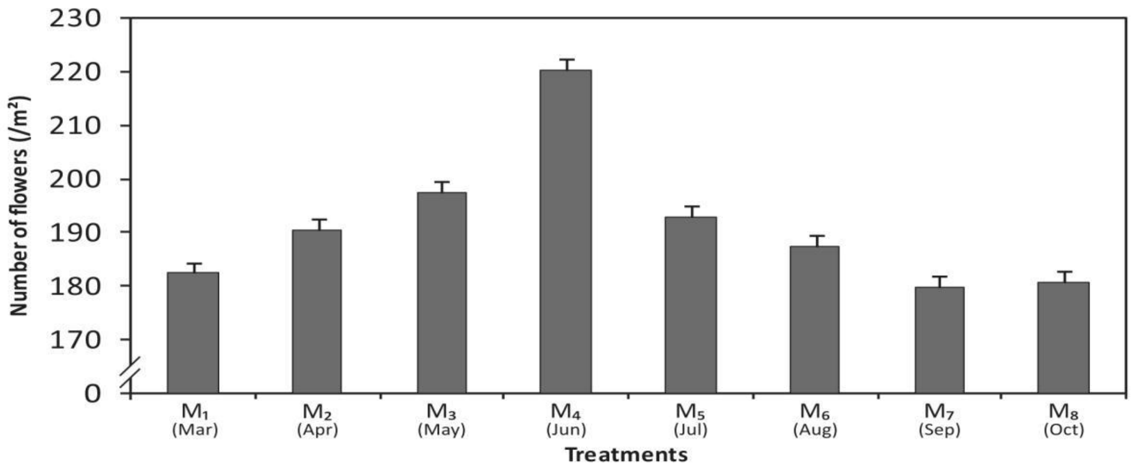

Figure 1. Effect of different planting time on number of flowers in Gerbera (Pooled data of 2006-2009).

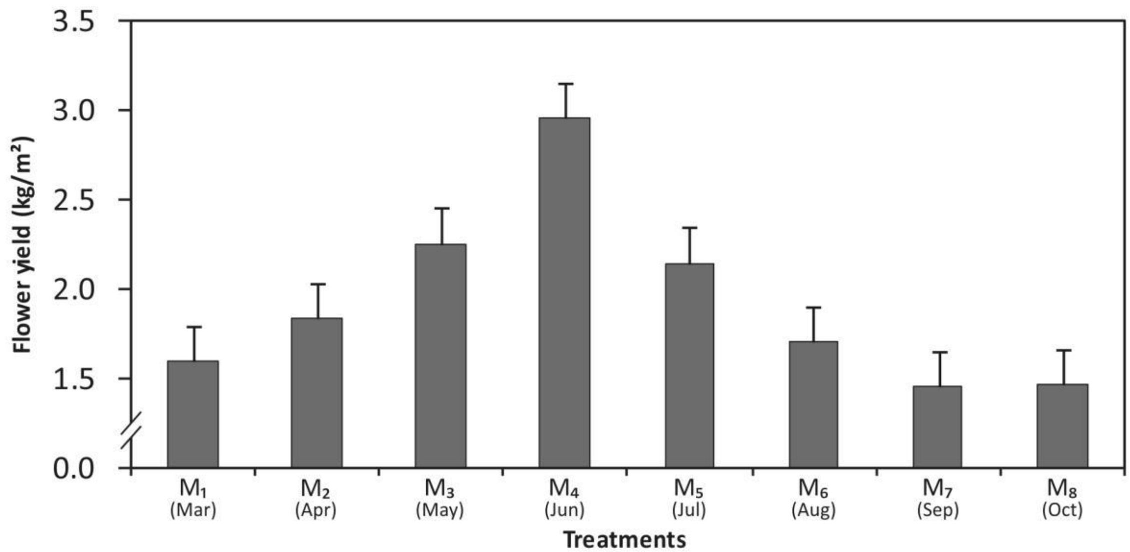

Figure 2. Effect of different planting time on flower yield of Gerbera (Pooled data of 2006-09).

significant correlation between plant height and number of cut flowers/plant (r = 0.506, $p = 0.05$). Similarly, there was highly significant and positive correlation between plant height and plant spread (r = 0.823, p = *0.01*) whereas leaf length had highly significant and positive correlation with leaf width (r = 0.716, $p = 0.01$), leaf area (r = 0.645, $p = 0.05$), stalk length (r = 0.756, $p=0.01$) and diameter of stalk (r = 0.743, p = 0.01). Stalk length was positively correlated with diameter of flower stalk (r = 0.537, $p = 0.05$) and diameter of flower (r = 0.535, $p = 0.05$), whereas, it was negatively correlated with number of cut flowers (r = −0.179, $p = 0.05$).

Number of flowers and flower yield

Changing the time of planting has brought significant changes in both number of flowers and flower yield. The highest number of flowers (220.1 /m^2) and flower yield (2.95 kg/m^2) were observed with treatment M_4 with June date of planting (Figures 1 and 2). This date of planting proved to be highly superior to rest of the other dates of planting. For example, difference of 50.4 flowers/m^2 was observed between least effective treatment M_7 (179.7 flowers/m^2 with September date of planting) and most effective treatment M_4 (220.1 flowers/m^2 with June date of planting).

The optimum conditions for achieving good floral response in Gerbera have to be met through adjustments in plating time only if a sound foundation for better flower yield is to be laid effectively exploiting the other co-factors. Such growing conditions could be easily transformed into agropedological analogues for exploiting upon the growing conditions with much costlier inputs. It is equally interesting to pinpoint the other prevailing conditions as unsuitable for favourable flowering behaviour. For example, October and March dates of planting. In October date of planting, the monsoon rain continues to recede from September onwards, and reaches to almost a complete halt, and soil highly porous in nature, allowing leaching of otherwise stored water causing restricted movement of water and nutrients under continuously growing diurnal variation in temperature (7.9°C). On the other hand, in the March date of planting, the soil moisture has depleted to maximum without much appreciable water and nutrient movement under highly limited sap flow movement coupled with highly varying diurnal temperature (11.7°C). This is the maximum variation in diurnal temperature (12.8°C), and Gerbera plants had to exert lot more energy for both nutrient and water acquisition despite an extended day length (sunshine 8.5 h/day). It is suggested that two different pathways are available for water uptake: A direct one through xylem vessels and an indirect one through the cavity of stem. However, any direct method of water uptake contributes to growth of the plant (Meeteren, 1978). According to Yu et al. (1990), flowering time was negatively correlated with cut flower yield, and based on this, they constructed a practical model to assess the efficiency of indirect selection for cut flower yield using flowering time as a market trait.

Flower yield is an index of productivity which takes into account all the growing conditions at their optimum use. The response of planting time on flower yield was observed more distinctively (Figure 2). The magnitude of response on flower yield was observed maximum with planting undertaken in the month of June on account of suitable soil moisture (201.0 g/kg) conditioned by good rainfall (223.5 mm), air temperature range of 26.9 to 31.7°C (4.8°C in diurnal variation), relative humidity of 88.6% and a maximum nutrient flow (152.6 mg/kg $KMnO_4$-N, 7.2 mg/kg Bray-P and 114.3 mg/kg NH_4OAc-K). These conditions collectively created the optimum desired requisites for the plants to remain metabolically active for an extended period within the growth period. With other dates of planting, these conditions were far from optimum. For example, all the three indices of flower yield viz., fresh weight of flower, number of flowers and the flower yield were minimum due to minimum soil moisture (184.1 g/kg), lowest rainfall (96.2 mm), air temperature with maximum variation (23.52 - 31.40°C) and lowest nutrient regime (131.6 mg/kg $KMnO_4$-N, 6.1 mg/kg Bray-P and 104.3 mg/kg NH_4OAc-K) despite comparatively longer day length (sunshine of 5.8 h/day) and relative humidity of 87.5%. These observations lend a strong support in favour of necessity to have different soil nutrient and climatic analogues in relation to optimum flower yield of Gerbera, if the optimum growing conditions via suitable planting time are to be maintained. Earlier studies established that Gerbera is highly nutrient responsive crop depending upon nutrient supply level of growing medium (Sirin, 2011; Ahmad et al., 2012).

Conclusion

The response of Gerbera to differential planting time is the impact of prevailing soil and meteorological conditions. The observations made through our studies have strongly warranted that, simply changing the time of planting, in a way, using the available soil moisture supply coupled with nutrient flow and meteorological conditions could bring so much of improvements in crop response in flower yield by inducing earliness in bud burst and reducing the time taken for full bloom coupled with other favourable vegetative growth parameters viz., number of leaves/plant, leaf area and plant height. Such studies also lay a solid foundation for developing soil-climate analogues for open field Gerbera as a part of crop modelling.

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