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Review article

Gerbera performance and planting time

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ABSTRACT

Earning livelihood in response to climate change is the biggest threat to mankind. Emerging energy crisis coupled with unprecedented recent hike in fertilizer prices has further warranted towards finding alternative means to improve quality production of Gerbera (*Gerbera jamesonii* Bolus ex. Hook) through modulation in plant requirement agroclimatically. Soil-climate norms are, therefore, considered key to success of Gerbera (*Gerbera jamesonii* Bolus ex Hook) in response to planting time. Studies carried out on Alfisols of humid tropical India under open field conditions suggested the optimum agropedological criteria as: nutrient regime (122.1-152.6 $KMnO_4$-N, 6.1-7.2 Bray-P and 97.6-114.3 NH_4OAc-K mg/kg) and climatic features (182.3-201.0 g/kg soil moisture, rain fall 96.2-223.5 mm/month, 5-8-6.8^{0}C hrs diurnal variation) in order to exploit upon the correct time of planting and harvesting maximum flowers yield of Gerbera grown on Alfisol. Exploiting rhizosphere microbial dynamics vis-à-vis differential changes in soil carbon pool and soil microbial community structure and diversity within the rhizosphere, thereby, paving the way towards usage of microbial consortium to safeguard against any possible nutrient mining within rhizosphere. Developments in soil-climate analogues-based nutrient dynamics vis-à-vis meteorological conditions, facilitating expansion of floriculture industry on sound scientific footing; tailoring fertilization through partitioning nutrients across physiological growth stages; arriving at dynamic nutrient diagnostics enabling identification of nutrient constraints at any growth stage of the crop coupled with biochemical marker aided diagnostics, have collectively added now look to the entire gamut of Gerbera nutrition in particular, and floriculture industry in general. These breakthroughs have eased out the complexities associated with various issues of Gerbera nutrition.

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1. Introduction

Floriculture is increasingly regarded as one of the viable options towards diversification from the traditional field crops due to higher returns per unit area, and fast developing habit of "saying it with flowers". From a symbol of love, flowers have transformed into an industry, which is characterized by constant change, activities and excellence, unique in its character and function. Although the floriculture industry is growing at a faster rate compared to other horticultural based industries. Still there is vast scope to bridge the gap of demand and supply in domestic as well as world market in the field of floriculture (Kundu et al., 1997). Floriculture industry of India (Bijay Kumar et al., 2010) amount to 167 thousand ha and 9.88 thousand tons (loose flowers) in terms of area and production, respectively. While cut flowers figure to 47942 lakhs (as number) with West Bengal (44.3%), Karnataka (12.2%), Maharashtra (11.9%), Gujarat (10.6%) etc. as major partners in cut flowers production, trade and economics.

Gerbera is the latest sensation to Indian Floriculture, commercially grown throughout the world in a wide range of climatic conditions. According to the global trends in floriculture, Gerbera occupies the 4th place among cut flowers (Sujatha et al., 2002). Gerbera at present comprises 45 species, native to tropical Asia and Africa. As many as seven species were recorded in India distributed in temperate Himalayas from Kashmir to Nepal at an altitude of 1,300 to 3,200 meters. Gerbera species of Indian origin are : Gerbera andria, G.kunzeana, G. languinosa, G. macrophylla, G. nivea, G. ovalifolia and G.poiloselloides. The cultivated species in this genus are Gerbera asplenifolia, G. aurantica, G. kunzeana and G. viridifolia.

Botanically known as Gerbera jamesonii Bolus ex Hook, it belongs to the family Asteraceae, and is commonly called as Transvaal daisy, Barbeton daisy or African daisy. The genus Gerbera is named in honour of German naturalist Traugott Gerber, while the species jamesonii was named for Dr.L.S.Jameson, a British colonial statesman. Gerbera is a herbaceous perennial, native to South Africa only (Brickell and Zuk, 1997). Tourjee et al. (1994) revealed that the early development of Gerbera jamesonii as a floricultural crop was traced from its collection as a novelty in South Africa to its establishment as a commercial crop in the 1930's. Loser (1986) grouped Gerbera into single, semi-double and double cultivars based on flower heads. The single types have one or two rows of ray florets on the periphery of the disc and the rest are disc florets while in the double types, more than two rows of ray florets are present in the flowers which enhances its attractiveness. They are further divided into 'Standard', `Spider' and `Mini' depending on the shape and size of the flowers.

In order to get maximum production of quality flowers, crop phenology vis-à-vis plant nutrition holds a paramount importance. While doing so plants need to be exposed to optimum climatic conditions and nourished with appropriate nutrients during the entire growing period. However, the prime constraint in the fact that still the Gerbera flowers are available in the market for a limited period, without any genuine effort to extend its availability throughout the year. Studies on planting time to extend number of harvesting by understanding the crop phenology are one such very promising option. A difference in planting dates often brings about variation in growth, flowering, yield and quality of Gerbera. In a 3- year- trial on Gerbera conducted by Parthasarathy and Nagaraju (2003), it was observed and opined 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 – November. Similarly, studies conducted at Dharwad to evaluate the best planting time for Gerbera cv. Sath Bata showed a profound influence of staggered planting on vegetative as well as reproductive attributes, with July planting resulted in maximum flower size (Singh, 2001).

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. 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; Gurav 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.

2. Phenology of flowering

A comprehensive description of flower development in Asteraceae can be found in Harris (1995). In the Gerbera capitulum, three types of flowers (or florets) can be distinguished: central disk, trans- and marginal ray florets. Floret initiation in Gerbera, as in most species of Asteraceae tribe Mutisieae (Harris, 1995), takes place in an acropetal or centripetal manner on the capitulum disk. Peripheral ray floret primordia are the first to appear, and their organogenesis precedes that of trans and disc floret primordial. At early stages, all of the flowers primordial are morphologically indistinguishable; the differentiation of ray, trans and disc florets occurs at mid-developmental stages. The basic organ composition of the three types of florets is similar. Positionally orthologous to sepals, whorl 1 is occupied by bristly pappus structures. Whorl 2 is composed of a bilabiate corolla with elongate, fused petals and two opposite petal rudiments, whorl 3 of five fused stamens or five separate staminodes, and whorl 4 of two fused carpels with one ovary and a single ovule. During flower development, anthers arrest at intermediate stages of development, anthers arrest at intermediate stages of development, resulting in the formation of non-functional staminodes in the highly zygomorphic ray and intermediate trans florets. The central disc florets are sexually perfect and less zygomorphic. In other Asteraceae species, disc florets may be completely actinomorphic while others may be homomorphic, having only ray or disc florets (Bremer, 1994).

During flowering in Gerbera, specialized features are found at the level of inflorescence development, indicated by the presence of different flower types, and at the level of organ differentiation, manifested by the special anatomy of pappus, bristals (sepals) corolla and the fused anthers. At early stages of flower primordial development, at flower types are indistinguishable, and the differentiation between marginal ray/trans flowers and central disc florets takes place later. There are three types of flowers that exist in Gerbera composite blooms. The dark central disc contains disc florets. Around this disc is a ring containing intermediate transflorets. Finally, the outer petals constitute a final ring of ray florets. Thus, Gerbera is today a powerful system for functional analysis of the general regulation of various aspects of flower development, organ differentiation and metabolism (Keditsu, 2013e).

The phenology of flowering behaviour is characterized on the basis of : i. time taken in terms of days consumed to bud emergence, ii. time taken to reach bud burst stage from planting time, iii. time taken from bud emergence stage to bud burst, and iv. time taken for full bloom from planting time. These four parameters were most favourable with June date of planting under humid tropical climate of northeast India because of the most suitable agropedological settings achieved during this month of planting. These could be characterized as : i. better soil moisture nearer to field capacity soil moisture content, ii. nearby 12-15% of total rainfall taking place and ensuring the necessary moisture level within soil, iii. triggered nutrient flow, and iv. sunshine hours of 6-8 hours/day plus minimum variation in air temperature as diurnal variation (only 4.80C) with relative humidity of 88.6%. These were the optimum conditions for achieving good floral response in Gerbera if a sound foundation for better flower yield coupled with flower quality is to be laid exploiting the other co-factors very effectively and efficiently. These growing conditions could be easily transformed into agropedological analogues for exploiting upon the growing conditions with much costlier inputs(Keditsu, 2012a; 2012b).

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 (7.90C). On the other hand, growing conditions of March, the soil moisture has depleted to maximum without much appreciable water and nutrient movement under highly limited sap flow movement coupled highly varying diurnal temperature (11.70C). This is the maximum variation in diurnal temperature, and Gerbera plants had to exert lot more energy for both nutrient and water acquisition despite an extended day length (sunshine 8.5 hours/day). It is suggested that two different pathways for water uptake: a direct one thro ugh 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 observation; they constructed a practical model to assess the efficiency of indirect selection for cut flower yield using flowering time as a market trait.

3. Planting time and crop performance

Planting time in cut flowers is considered to be the most important factor in the pretext of phenology. In a given soil and climatic conditions, the optimum planting time needs to be standardized so that the quality production should be improved in addition to maintaining the soil fertility. Performance of each Gerbera variety varied with respect to number of flowers per plant, stalk length and flower diameter due to several factors like genomic constitution, environmental factors, growing conditions, soil and inputs (Horn et al., 1974). The influence of planting time on the performance of Gerbera vis-à-vis crop phenology should be seen from the angles of the changes that are brought into the physico-chemical properties (pH of the growing medium, oxygen supply and flooding, microbial conditions, nutrient supply level and the soil temperature) of the growing medium, the meteorological conditions, physiological conditions and other interrelated factors. All of them either individually or collectively influence the performance of Gerbera versus crop phenology in relation to planting time. These factors have been thoroughly reviewed

3.1. Effect of substrate properties

The performance of Gerbera is largely dependent upon substrate properties. Gerbera cultivars, Amber and Queen Rebecca were grown rockwool slabs in hydroponic system with nutrient solution pH set at 5.0, 6.0 or 7.0. Total flower production/m2 was greatest at pH 6.0 in cv Amber in 1990-91, but was not significantly affected by pH in Amber in 1991-92 or in Queen Rebecca in either year. Nutrient solution pH had no significant effect on stem length or flower weight (Guba, 1994). The Gerberas grown in polystyrene showed high rates of gas exchange and plant growth at the beginning of the cultivation period, but low flower production and quality (Papadopoulou et al.,1996). In another study, application of B. subtilis (0.5 – 1.0 x 106 cfu/ml) alone reduced flower yield/plant in cv.I. by 9%, compared with controls, but the other treatments increased flower yield, with VAM + B. subtilis (post planting) giving the highest yield (15% more than controls). For cv.II, all treatments increased yield, with VAM + B. subtilis (post planting) being most effective (29% increase). It was concluded that application of B. subtilis and VAM can be beneficial for plant health and yield, but that in Gerbera the effects are cultivar dependent (Jacob, 1997). In another study, the periods from October to November and February to April appeared to be highly favourable for the production of flowers in the regions where minimum and maximum temperatures were around 100 C and 260 C, respectively (Kiranjeet et al., 1997).

Gerbera cultivars Lily, Blorosa, Rosabella, Goldspot and Lilabella were studied for flower production from April 1997 to May 1998 under open conditions at Ludhiana. The best cultivar was Goldspot, producing a monthly mean of 23.56 flowers per unit area (3.78 flowers per plant), and the best season was April 1998, when the highest number of flowers were obtained in all cultivars (Deepak Kumar and Ramesh Kumar, 2000). The effects of regulating growing medium temperature on the growth and flowering of Gerbera hybrida cv. Nini plants grown at 19-230C in rockwool were investigated in relation to leaf water potential, photosynthesis and dry matter distribution. The number of inflorescences per crown was 1.8-2.0 and was almost constant in all temperature regimes. Water stress during the day was reduced by cooling the medium in summer, the consequent increase in stomatal conductance resulting in increased photosynthesis and dry matter accumulation in the crown, while heating the medium reduced dry matter accumulation in roots. The combination of cooling the medium in summer and heating it in winter did not have any additive effect on cut flower yield (Katsukawa et al., 2000). The results of the studies by Olivella et al. (2000) suggest that abscissic acid and cytokinin may act as signals of flooding stress. Also, the marked intolerance of Gerbera to flooding could be a serious barrier to its culture under anaerobic conditions, and hence careful irrigation management is required. These results could well apply in interpreting the influence of planting time on the performance of Gerbera, on account of differential soil moisture levels maintained.

Plantlets of Gerbera jamesonii cultivars Ensophy, Estel, Suset, Rita, Tamara and Beauty produced in vitro were transferred to a greenhouse and grown for one year. The plants were grown with two different culture methods: substrate culture (closed system) and soil culture. In substrate culture, the plants were transferred to the culture beds filled with four kinds of growing medium: rockwool, cocopeat, perlite, and vermiculite. Number of flowers/plant, flower height, flower weight, and flower diameter were far better in substrate culture than in soil culture in both cultivars. Rockwool gave better results in number of flowers/plant; plant height, plant weight, and flower diameter in 'Ensophy', while no significant differences were observed among growing media in 'Estel'. Relatively smaller numbers of flowers/plant were produced in cocopeat in both 'Ensophy' and 'Estel'. Ensophy showed black spots on the petals under high air temperatures in summer time, while other cultivars showed no such symptoms (Hahn et al., 2001). Effects of rhizosphere heating at 7-11, 15 and 200C on flower yields and quality of 7 Gerbera cultivars (Terra Cerris, Terra Queen, Clementine, Terra Sun, Terra Mor, Terra Visa and Terra Fame) grown in soilless cultures were investigated during the winter season. Flower yield and quality significantly increased due to rhizosphere heating. The increments of flower yield and stem length were 71.34 and 19.14%, respectively, after rhizosphere heating at 200C. The highest increments of flower yield and stem length were 90.98 and 28.32%, respectively (Wang et al., 2001).

Results showed that longer stems had a longer vase life compared with shorter stems. Lyonella recorded the longest vase life (5.06-9.13 days), followed by Tiramisu (4.96-8.76 days), while Thalassa had the shortest (3.93-7.03 days) (Singh and Sangama, 2002). The total porosity of the growing media decreased during the initial growth period of the plants and increased at the latter stages of plant growth. River waste could be a potential substitute for sphagnum peat (Benedetto et al., 2003). The highest yield was obtained from plants grown under 20 h lighting period as a total of the whole experimental period. In the first part of the experimental period, when the natural light conditions were poor, plants grown under 20 h lighting period produced the highest yield. However, when the natural light conditions improved in the spring, the plants grown under 10 h lighting period, partly or continuously, produced the highest yield (Pettersen and Gislerod, 2003).

3.2. Water relations

Exploiting conditions towards crop performance is the translation of using water relations keeping in mind the phenology of crop (Keditsu 2013c; 2013d). Rogers (1973) reported that turgidity in plants and florets depends on the balance between the rate of water loss, utilization and water supply. The termination of vase life of many cut flower is characterized by wilting and therefore, many studies have been made for evaluation of events leading to the phenomenon of wilting (Halvey and Mayak, 1981).Shelf life of cut flowers depends on genetic makeup and water quality. In a study conducted by Jong (1985) where the Gerbera cut flowers were held in contaminated water could be kept for only six days as compared to 14 days in fresh clean water. Although the bacterial population present in the vase water can cause plugging of xylem vessels, the population of bacteria were low at growers level but became increasingly higher at auction centers. The number of bacteria present in the retail levels was enough to reduce the longevity of Gerbera (Hoogerwerf and Van Doorn, 1992). The planting time affects the complete phenology of crop as evident from the response of different planting time on vegetative growth, floral characteristics and yield characteristic of open field Gerbera (Table 1).

3.3. Effect of plant population

Optimum plant population and crop performance are inter-related. In 2-year greenhouse trials with the cultivars Brigitte and Sylvia, the in vitro-raised plants were either transplanted to benches on 2, 4 and 12 June at 6 x 6 or 8 x 8 cm, or they were potted individually in 6- or 8-cm diameter pots filled with a 1:1 high peat [sphagnum]: sand mixture supplemented with a compound fertilizer, Azofoska, at 2 g/litre. The potted plants were then transferred to 22-cm tall pots filled with a 3:1 high peat:bark mixture and grown for a further 6 months. Generally the best results were obtained in 8-cm pots or by bench planting at 8 x 8 cm (Pytlewski, 1989). Later, Shamasundaran et al. (2002) showed that a plot size of 1.08 square meters corresponding to a plant stand of 16, arranged in a rectangular or square shape, was ideal for cv. Diablo under greenhouse conditions. The spacing of 30 x 30 cm significantly produced the most number of flowers/plant/year (25.50), number of flowers/m^2/season (102.40) and number 'A' grade flowers/m2/season (83.31). The spacing of 30x40 cm, however, produced flowers with longer stalk (52.50 cm) and larger diameter (11.60 cm). The plant spacing of 30 x 30 cm, therefore, can be recommended as the most optimum spacing for quality production in Gerbera (Gurav et al., 2005). The four-row planting technique and the 30 x 30 cm spacing recorded the highest number of days to flowering (46.50 and 46.33 days, respectively), while the rest of the treatments recorded 45.00 days to flowering. The four-row planting technique and 30 x 20 spacing resulted in the greatest stem length (53.35 and 52.30 cm, respectively), while the three-row planting technique and 30x20 cm spacing recorded the maximum flower diameter of 10.05 and 9.73 cm, respectively (Gurav et al., 2002).

Studies carried out on the pigmentation regulated by light in ray floret of Gerbera hybrids demonstrated that light is an important factor for pigmentation of ray floret petal in Gerbera and the petal itself acts as a light sensor site to perceive the light signal. From the different light qualities evaluated, blue light promoted gene expression of chalcone synthetase and dihydroflavonol-4-reductase, and red light enhanced the gene expression of chalcone synthetase, indicating the photoreceptors responding to blue and red light involved in the photoregulation of flower pigmentation in Gerbera (Meng et al., 2004).

Table 1

Response of different planting time on the crop phenology of open field Gerbera (Pooled data).

Treatments	Vegetative growth			Floral characteristics			Flower yield	
	Number of leaves/ plant	Leaf area (cm^2)	Plant height (cm)	Full bloom from planting time (No. of days)	Flower size(cm)	Stalk length (cm)	Fresh weight of flower (g)	Flower yield (kg/m^2)
M_1(March)	9.17	89.31	19.88	128.20	8.25	26.46	8.74	1.59
M_2(April)	10.99	111.97	23.10	130.44	8.09	26.35	9.60	1.83
M_3(May)	10.78	103.87	25.09	121.63	9.05	31.99	11.41	2.25
M_4(June)	15.96	138.78	27.09	116.56	9.12	35.77	13.42	2.95
M_5(July)	11.76	120.61	24.08	120.10	8.75	36.17	11.08	2.14
M_6(Aug.)	10.08	66.59	20.86	129.96	8.61	29.89	9.07	1.70
M_7(Sept.)	9.80	87.71	19.56	130.53	8.15	27.72	8.11	1.45
M_8(Oct.)	9.94	74.97	19.71	133.56	7.82	27.65	8.08	1.46
CD (p=0.05)	3.36	11.54	1.67	2.20	0.30	2.42	0.38	0.20

Source : Keditsu (2012a; 2012b; 2013e).

3.4. Effect of photoperiod

Photoperiod and crop phenology operate in tandem for better crop performance. Plants of 3 greenhouse Gerbera cultivars were grown at day/night temperatures of 21/14, 18/18 and 14/210C. The average number of damaged flowers/m2 in cultivars Fleur, Terrafame and Joyce were 14.6, 12.4 and 15.6 at 21/140 C and 12.6, 9.6 and 12.8 at 14/210C; similarly flower weights were 16.8, 22.8 and 18.6, and 17.0, 24.5 and 19.5 under the 2 treatments. Under cold day treatments (14/210) the flowers were slightly smaller than under the other treatments but their colour was more intense. There were few differences in stem length between treatments (Os et al., 1989).

Studies were carried out on Gerbera cv. Happipot during autumn/winter 1987 and on Gerbera cv. Tempo during winter/spring. Both cultivars were grown under 30, 50 or 90 micro mol/m2s with a 16-h photoperiod or 60 micro mol/m^{2}s with a 20-h photoperiod. Light treatments were provided by 400-W HPS lamps with control plants kept under ambient light conditions. The growth, development and flowering of Gerbera cv. Happipot were significantly increased under all light treatments compared with the control. Highest plant width, height, shoot dry weight and number of buds and flowers and lowest number of days to flowering were obtained under the 90 micro mol/m^{2}s for 16 h treatment. The 60 micro mol/m2s for 16 h light treatment resulted in significantly higher flower number in cv. Tempo than in the control. The 90 micro mol/m^{2}s for 16 h light treatment reduced the number of days to flowering (production time) by 23 d and 11 d for cv. Happipot and Tempo, respectively. The various light treatments had more effect on plant growth, development and flowering in the autumn-winter study than in the winter-spring study and this was probably due to increased ambient light conditions during the winter-spring study (Gagnon and Dansereau, 1990). Farina et al. (1993) later observed that the split night temperature regime increased flower yields between 1 Jan. and 28 Feb. compared with control. This regime did not increase flower yields in the other 2 seasons. The split night temperature regime reduced heating time by 30-40% compared with the control. The pulsing night temperature regime reduced heating time by 30% compared with the control and increased flower yield by 16%.

Martinez et al. (1993) reported that night and day short-term (5h) substrate flooding decreased carnation assimilation rates in cultivars Orion and Diamonetta. The decrease in photosynthetic rates was greater in plants in which half the root system was flooded than in those in which the full root system was flooded. This decline was not linked to a decrease in stomatal conductance indicating that it was due to photosynthetic capacity. Flooding slightly lowered shoot water potential; this decrease was higher in treatments affecting full root systems. This suggests that water potential is not a factor causing the observed decline in photosynthesis. Noordwijk and Brouwer (1993) observed that Gerbera jamesonii cv Fleur roots had a higher gas-filled root porosity (Ep (% v/v)) when grown permanently in a non-aerated than aerated solution. The Ep of roots increased during 2 weeks when half the root system of a young plant was transferred to a non-aerated solution; in older plants this response was not seen. These observations suggested that Gerbera is a sensitive cut flower crop to low oxygen level in the growing medium. In another study by Shin et al. (1994) the number of stems > 40 cm was highest in cv Gomarchi (94%) and lowest in Appelbloesm (20%). Abnormal flowers occurred under the high-temperature and short-day conditions at the end of the year, the incidence varying between cultivars; Queen Rebecca had the most abnormalities (20.6%) while Terravisa had none. Vase life was > 20 days for some cultivars in spring but only averaged 7-9 days in summer.

The highest number of flowers (32/plant) was produced by the plants maintained under complete cover but the difference in flower yield and flower quality was only numerically significant (Kaur et al.,1996). While another study suggested that Gerberas can be planted in unheated tunnels after 15 May, when the average 24-h temperature will be 150 C. The choice of cultivars is also very important (Lisiecka, 1996). Syros et al. (2000) observed that differences in photosynthetic parameters within the irrigation treatments and between cultivars were related to the increase of specific peroxidase activity and the appearance of new cationic peroxidase isoforms. In all experiments, the 12-h photoperiod produced the highest number of inflorescences if the same daily supplementary light integral was used. Doubling the daily light integral by extending the photoperiod to 24 h did not increase the flower yield except in the case of Estelle in one experiment. On the other hand, an increase in the daily light integral by increased supplementary light intensity strongly affected the number of inflorescences in the 12-h photoperiod. As the quantity of Gerbera flower yield was strongly affected by supplementary lighting regimes, the grower must be aware of different distributions of the same light energy over one day, which may lead to a change of about 45% in number of inflorescences. If only the number of inflorescences is considered, a combination of short photoperiod and high light intensity can be recommended (Autio, 2000).

The simultaneous, long-term effects of three substrates (zeolite, perlite and their 1:1 mixture) and of two heating systems (lower and upper) upon the diurnal changes in photosynthesis of Gerbera (Gerbera jamesonii) cultivars Cyprus and Heart Breaker were investigated. The results revealed the higher net CO_2 assimilation rate and stomatal conductance than Heart Breaker, while transpiration rate was almost the same. Based on both stomatal conductance and transpiration rate, the zeolite-perlite mixture substrate exerted a more beneficial effect on the soil-plant water system. No change in chlorophyll levels, either timewise or between Gerbera cultivars, was observed in response to different substrates and heating systems. Diurnal net CO_2 assimilation rate, followed only for Cyprus, was reduced significantly from morning to late afternoon, possibly as a result of stomatal conductance reduction (Issa, 2001).

The performance of Gerbera in terms of flower yield (an index of productivity) which takes into account all the growing conditions at their optimum use. The flower yield related parameters such as fresh weight of flowers, number of flowers/m^2 and flower yield/m^2, all three were registered to have maximum response with the planting done 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 – 31.70C (4.80C 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 – 31.40C) 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 hours/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 harvest maximally (Table 2).

Table 2

Soil and climatic analogue for optimum production of open field Gerbera.

Analogues for Soil				
Optimum available nutrients (mg/kg)		152.6 N – 7.2 P_2O_5 – 114.3 K_2O		
Suboptimum available nutrients		< 122.1 N - 6.1 P_2O_5 – 97.6 K_2O		
Analogues for climatic conditions				
	Soil moisture(g/kg)	Rainfall(mm)	Sunshine(hrs)	Diurnal air temperature (^{0}C)
Optimum	201.0	223.5	6.8	4.81 (26.9 – 31.7^{0}C)
Suboptimum	< 182.3	< 96.2	< 5.8	7.9 (23.5 – 31.4^{0}C)

Note: Relative humidity showed no distinct difference since it varied from 82.1 to 89.9% considering March to October dates of planting.

Source: Keditsu (2012a; 2012b).

4. Conclusion and perspectives

Gerbera cultivation gradually is experiencing paradigm changes, especially with respect to greater intervention of production driven technologies. This has induced a distinct change in per capita consumption of flowers. Thumping success of Gerbera under protected conditions has extensively discouraged growers to raise this crop under open field conditions, with the result, most of the studies have accrued out under protected conditions. The cut flowers like Gerbera is intensively cultivated, and substantial amounts of nutrients are anticipated to be removed with every harvest. The definitive role of soil-climate specific agro-techniques is being increasingly explored to sustain the flower production coupled with quality as an important flower trade attribute. Improvisation in of flower yield alongwith quality makes this maiden but important task, all the more challenging, especially in the context of vagaries associated with open field conditions. Exploiting the prevailing growing conditions (e.g. planting time) and maintaining water-nutrient synergy through an integrated nutrient supply system across crop phenophases are considered as the two most important aspects of Gerbera cultivation, and if addressed to their potential, are supposed to bring some discernible changes in the overall scenario of Gerbera cultivation, especially under open field conditions.

Occurrence of nutrient constraint at any phonological growth stage on multi-nutrient deficient soils could jeopardize the incentives accruing through otherwise balanced fertilization in highly diversified nutrient demanding flower varieties (Keditsu, 2012a). The current state of knowledge on the subject, especially under open field conditions is very limited, although, technology for protected cultivation using hydroponics is very well established (Keditsu, 2012b; 2013b). The subject relating open field Floriculture becomes still very complex in the absence of knowledge on kinetics and co-kinetics of different nutrients being partitioned across different growth stages so that the growth stage wise nutrient demand is precisely determined, and accordingly type and source of nutrients are fed synchronising the physiological nutrient demand. Development of microbial consortium (microbial reactor) exploiting the native and natural microbial synergisms (with twin role as growth promoter and antagonistic to soil borne pathogens) is one of the popular methods of providing the desired dynamism to nutrient dynamics within the rhizosphere. Such rhizosphere specific consortia could further engineer rhizosphere's nutrient demand and supply through loading with organic manures in much value added form (Longchar and Keditsu, 2013). The efforts such as these could only meet their objectivity unless duly supported by an efficient nutrient diagnostics applicable under varying field conditions.

Development of cultivar specific norms nutrient norms (e.g., optimum level of leaf N, P and K were determined as 2.22 - 2.56%, 0.18 - 0.25 % and 1.80 – 2.20 %, respectively, for open field Gerbera) and soil test rating besides microbially loaded substrate for crop like mushroom need a thorough revisit and to be field validated in order to provide their application at regional level (Keditu, 2013b). A good success on these aspects has been achieved in grape, mango, citrus, papaya, banana, guava, sapota, pomegranate. However, the major point of discontent still remains to be warded off with respect to whether nor not different nutrient norms are required as per cultivar within the same variety. The biggest constraint on the other hand in making soil test ratings more purposeful is the non-redressal of spatial variation in soil fertility. Conjoint use of geoinformatics (Geographical Information System, Global Positioning System, Hyperspectral Remote Sensing) and site specific nutrient management strategy exploiting spatial variability in soil fertility have offered an easier method of combating the such pivotal factors driving to reduced fertilizer use efficiency. Sensor-based technology has further added a new dimension in providing the nutrient supply as per canopy size in time domain manner using programmable multi-channel fertigation. Application of open field hydroponics is the starting point to adopt such improvised production technologies. However, it remains to be seen in different flower crops, do we need a different nutrient levels vis-à-vis critical growth stages so that a complete cropwise nutrient logging studies ease out the so called complexity in understanding the nutrient dynamics in flower crops which remained an under-focussed issue for a quite long time (Keditsu, 2013a; 2013b). Extending vase life through nutrient-water synergy has to be viewed afresh through desired changes in scavenging impact on reactive oxygen species vis-à-vis antioxidant profiling.

References

Aderson, S., De Andrade Jr., Lisânea, M.O., Damasceno Ildo, Da S. Dias, Hans R. Gheyi, Guiselini Cristiane, 2011. Climate variations in greenhouse cultivated with Gerbera and relationship with external conditions. J. Braz. Asso. Agric. Engg., 31(5), 857-867.

Autio, J., 2000. Supplementary lighting regimes strongly affect the quantity of Gerbera flower yield. Acta Hort., 515, 91-98.

Barooah, L. Talukdar M.C., 2009. Evaluation of different Gerbera (Gerbera jamsonii Bolus ex Hooker F.) cultivars under agroclimatic conditions of Jorhat. Assam. J. Orn. Hort., 12(2), 106-110.

Benedetto, A.di., Boschi C., Klasman R., Molinari, J., 2003. Ornamental bedding plant growth in different growing media. J. Orn. Hort., 9(2), 171-177.

Bijay Kumar, Mistry, N.C., Brajendra Singh, Chander P. Gandhi, 2010. Indian Horticulture Database 2009, pp. 14-15.

Bremer, K., 1994. Asteraceae: Cladistics and Classification. Portland: Timber Press.

Brickell, C., Zuk J.D., 1997. A-Z Encyclopedia of Garden Plants. The American Horticultural Society, D.K. Publishing Inc. New York.

Chobe, R.R., Pachankar, P.B., Warade, S.D., 2010. Performance of different cultivars of Gerbera under polyhouse conditions. Asian J. Hort., 5(2), 333-335.

Deepak, Kumar, Ramesh Kumar, 2000. Seasonal response on Gerbera cultivars. J. Orn. Hort., New Series 3(2), 103-106.

Farina, E., Paterniani T., Cervelli, C., Palagi M. Volpi, L., 1993. Gerbera cultivation using different night temperature regimes. Prot. Crops., 22(7), 69-74.

Gagnon, S., Dansereau, B., 1990. Influence of light and photoperiod on growth and development of Gerbera. Acta Hort., 272, 145-151.

Guba, W., 1994. The effect of pH in the root medium on production and quality of Gerbera grown on rockwool. J. Fruit Orn. Pl. Res., 2(3),123-134.

Gurav, S.B., Patil, S.S.D., Patil, M.T., Katwate, S.M., Singh, B.R., 2002. Studies on planting technique and spacing for Gerbera under low cost polytunnel. In : Proceedings of the National Symposium on Indian Floriculture in the New Millennium, Floriculture Research trend in India, Lal Bagh, Bangalore, 25-27 February, pp. 317-318.

Gurav, S.B., Singh, B.R., Desai, U.T., Katwate, S.M., Kakade, D.S., Dhane, A.V. 2005. Effect of spacing on yield and quality of Gerbera (Gerbera jamesonii Bolus ex Hook) under polyhouse. J. Orn. Hort., New-Series 8(1), 62-64.

Hahn, EunJoo, Jeon, MinWha, Paek KeeYoeup, 2001. Culture method and growing medium affect growth and flower quality of several Gerbera cultivars. Acta Hort., 548, 385-391.

Halvey, A.H., Mayak S., 1981. Sensence and post harvest physiology of cut flowers Part II. Hort. Rev., 3, 59-143.

Harris, E.M., 1995. Inflorescence and floral ontogeny in Asteraceae: a synthesis of historical and current concepts. Bot. Rev., 61, 193-278.

Hoogerwerf, A., Van Doorn, W.G., 1992. Number of bacteria in aqueous solutions used for post harvest handling of cut flowers. Post Harvest Bio. Tech. 1(4), 295-304.

Horn, W., Wricke, G., Weber W.E., 1974. Genotypic and environmental effects on characters expression in Gerbera jamesonii. Gareten Sci., 39(3), 289-300.

Issa, M., Ouzounidou, G., Maloupa, H., Constantinidou, H.I.A., 2001. Seasonal and diurnal photosynthetic responses of two Gerbera cultivars to different substrates and heating systems. Sci. Hort., 88(3), 215-234.

Jacob, M., 1997. Beneficial organisms increase yield and resistance of Gerbera. TASPO Hort. Mag., 6(12), 56-57.

Jamaludin, A.F.M., Das, C., Shammy, F.H., Foysal, M., Islam, M.S., 2012. Growth and flowering performance of potted Gerbera, Gerbera jamsonni L. under different light intensity. J. Bangladesh Acad. Sci., 36(2), 226-226.

Jong, J. De. 1985. Gerbera can be a long lasting cut flower. J. Flori., 40(43), 111.

Katsukawa, K., Aoki, M., Inamoto K., Doi, M., Matsuyama K., Imanishi, H., 2000. Growth and flowering of Gerbera plants grown on temperature-regulated rockwool medium in relation to photosynthesis and water potentials. J. Soc. High Tech. Agri., 12(4), 248-253.

Kaur, K., Gill A.P.S., Ramesh Kumar, 1996. Effect of modified environments on plant growth and flowering production of Gerbera. Madras Agric. J., 83(11), 681-683.

Keditsu, Rokolhuii, 2012a. Response of Gerbera to inorganic fertilization versus organic manuring. Ann. Pl. Soil Res. 14(2), 163-166.

Keditsu, Rokolhuii, 2012b. Agronomic performance and variation of flower characteristics of Gerbera under varying soil condition and open field cultivation. J. Agric. Phy., 12(2), 1-12.

Keditsu, Rokolhuii , 2013a. Gerbera: Soil fertility and plant nutrition. Sci. J. Agric., 2(3), 97-114

Keditsu, Rokolhuii , 2013b. Gerbera Nutrition. Lambert Academic Publishing, Germany, pp. 1-276.

Keditsu, Rokolhuii, 2013c. Nutrient dynamics in open field floriculture : Some thoughts. Agrotechnol. 2,2 http://dx.doi.org/10.4172/2168-9881.1000e105.

Keditsu, Rokolhuii, 2013d. Agropedology on performance of open field Gerbera. Ann. Pl. Soil Res., 15(1),65-69.

Keditsu, Rokolhuii, 2013e. Performance of open field Gerbera in resposne to planting time. African J. Agri. Res., 8(23), 3068-3074 .

Khandpal, K., Kumar, S., Srivastava, R., Ramchandra, 2003. Evaluation of Gerbera (Gerbera jamsonii) cultivars under Tarai conditions. J. Orn. Hort., 6(3), 252-235.

Kiranjeet, Kaur, Gill A.P.S., Ramesh Kumar, 1997. Growth and flowering behaviour of Gerbera (Gerbera jamesonii) in sub-tropical region of north-west plains of India. J. Orn. Hort., 3(1/2), 26-29.

Kundu, K.K., Jaisingh V.K., Suhag K.S., 1997. India's floriculture exports – growth status, constraints and export strategies : An analysis. Indian J. Agri. Mrkting., 11(1&2), 37-40.

Lisiecka, A., 1996. The yield of Gerberas grown in cold tunnels in relation to the date of planting. Agric. Sci. & Forest., 81, 283-294.

Longchar, A., Keditsu, Rokolhuii, 2013. Flower yield and vase life of Gerbera in response to planting time and organic manures on Alfisol. Sci. J. Agri., 2(3), 124-128

Loser, H. 1986. New Gerbera cultivars at Heidellorgg. Deutscher Gartenbau, 40(32),1461-1464.

Martínez, F.X., Fabregas X., Tapia, L., Caballero, A., 1993. Effects of short term substrates flooding on gaseous exchange of carnation. Acta Hort., 342, 77-84.

Meeteren, U. Van, 1978. Water relations and keeping quality of cut Gerbera flowers. I. The cause of stem break. Sci. Hort., 8(1),68-74.

Meng, Xiang Chun, Xing Tim, XiaoJin Wang, 2004. The role of light in the regulation of anthocyanin accumulation in Gerbera hybrida. Pl. Grwth. Regulat., 44(3), 243-250.

Nair, A., Sujatha, K., Medhi, R.P., 2002. Performance of Gerbera cultivars in Bray Island. Indian J. Hort. 59(8), 322-325.

Noordwijk, M. van, Brouwer, G., 1993. Gas-filled root porosity in response to temporary low oxygen supply in different growth stages. Pl. Soil, 152(2), 187-199.

Olivella, C., Biel C., Vendrell M., Save, R., 2000. Hormonal and physiological responses of Gerbera jamesonii to flooding stress. HortSci., 35(2), 222-225.

Os, P.C.van., Koster,R.de, vander Wurff. A.A.M., 1989. Day/night temperatures affect production and quality of Gerbera. J. Flori., 44(7), 56-57.

Papadopoulou, E., Gerasopoulos D., Maloupa, E., 1996. Effect of the substrate and frequency of irrigation on growth, yield and quality of Gerbera jamesonii Bolus cultivated in pots. Int. J. Agric. Sci., 126(3), 297-302.

Parthasarthy, V.A., Nagaraju. E., 2003. Evaluation of Gerbera under mid-hills of Meghalaya. J. Orn. Hort., 6(4), 376-380.

Pettersen, R.I., Gislerod, H.R., 2003. Effects of lighting period and temperature on growth, yield and keeping quality of Gerbera jamesonii Bolus. Europ. J. Hort. Sci., 68(1), 32-37.

Pytlewski, C.A., 1989. Trials on the growing method and fertilization of young Gerbera plants obtained from in vitro culture. III. Effect of growing method on plant growth and cropping. Orn. Plants, Series B. 14, 49-54.

Rogers, M.N., 1973. A historical and critical review of post harvest physiology research on cut flowers. Hort Sci., 8, 189-194.

Sarkar, I., Ghimiray, T.S., 2004. Performance of Gerbera under protected condition in hilly region of West .Bengal. J. Orn. Hort., 7(3, 4), 230-234.

Shamasundaran, K.S., Singh, K.P., Mandhar, S.C., 2002. Standardization of optimum size and shape of plots for Gerbera under naturally ventilated greenhouse condition. Indian J. Hort., 59(4), 431-434.

Shin, H.K., Kim, J.Y., Shin, R.W., Ko, J.Y., 1994. Seasonal fluctuation of yield and quality of cut flowers in Gerbera hybrids. J. Agri. Sci. Hort., 36(1), 444-452.

Singh, K.P., 2001. Agro-techniques for Gerbera cultivation in India. Flori. Today 5, 9-13.

Singh, K.P., Sangama, 2002. Influence of cultivars and flower stalk length on vase life of Gerbera. In : Proceedings of the National Symposium on Indian Floriculture in the New Millennium", Floriculture Research Trend in India Lal Bagh, Bangalore, 25,27 February, pp. 324-325.

Sujatha, K., Gowda, J.V.N., Khan, M.M., 2002. Effects of different fertigation levels on Gerbera under low cost greenhouse. J. Orn. Hort., New Series 5(1), 54-59.

Syros, T., Yupsanis T., Omirou M., Economou, A., 2000. Photosynthetic response and peroxidases in relation to water and nutrient deficiency in Gerbera. Environ. Exp. Bot., 52(1), 23-31.

Thangam, M., Ladaniya, M.S., Korikanthimath V.S., 2009. Performance of Gerbera varieties in different growing media under coastal humid conditions of Goa. Indian J. Hort. 66(1), 79-82.

Tourjee, K.R., James Harding, Thomas G. Byrne, 1994. Early development of Gerbera as a floriculture crop HortTech., 4, 134-140.

Wang, GouLiang, Wu, ZhuHua., Tang, GengGuo, Wang, YouLiang, Li XuePing, 2001. The effects of rhizosphere heating on flower yields and quality of soilless growing Gerbera during winter. Acta. Hort., Sinica 28(2), 144-148.

Wankhede, S., Gajbhiye, R.P., 2013. Evaluation of Gerbera varieties for growth and flowering under shed net. Int. J. Hort. 3(19), 42-45.

Yu, Y., Harding, J., Byrne T., 1990. Inheritance of flowering time and its application for indirect selection in the Davis population of Gerbera. HortSci. 25(11), 1357-1358.