ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau, www.banglajol.info/index.php/JBAU

Efficacy of irrigation methods with varying levels of water in gerbera (*Gerbera jamesonii* L.) production

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ARTICLE INFO

Article history:
Received: 26 September 2019
Accepted: 01 January 2020
Published: 31 March 2020

Keywords:
Gerbera jamesonii L., drip irrigation, plant growth, flower production

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ABSTRACT

Gerbera (*Gerbera jamesonii* L.) requires frequent fresh irrigation water in order to minimize water stress and accomplish maximum production and high quality flower. Salinity is the major constraint for gerbera cultivation in the southern part of Bangladesh. Rainwater preservation and its judicial use could have been an active area of research for gerbera cultivation in saline stressed areas. Drip system is a progressive method to irrigate larger area with minimum loss of water. Thus, an experiment was conducted following RCBD to investigate the efficacy of drip irrigation with stored rainwater and to optimize the water level for gerbera with 400, 500 and 600 ml water day^{-1} plant^{-1}. Application of 500 ml water day^{-1} plant^{-1} by flood irrigation system was considered as control. The highest number of leaves plant^{-1} (56.20), leaf length (25.18 cm), leaf width (7.01 cm), number of flowers plant^{-1} (11.20) and flower diameter (5.25 cm) were recorded in plants irrigated by drip method with 500 ml water day^{-1} plant^{-1} but longest stalked flowers (23.58 cm) was produced by plants irrigated with same quantity of water (500 ml day^{-1}) by conventional (flood) method. No significant differences between drip and flood method with equal quantity of water was observed for number of leaves plant^{-1}, flower stalk length and flower diameter at 60 days after planting but significant variation was recorded for flowers plant^{-1}. Drip irrigation method may be more suitable for irrigating gerbera field and application of 500 ml water day^{-1} plant^{-1} in drip method may be optimum for maximum flowering.

Introduction

Flowers always play an important role in terms of aesthetic value in human life. However, in the recent time flowers and other ornamentals carry importance not only by their aesthetic and social values but by their economic contribution as well. Floriculture has emerged as a profitable agribusiness venture in the world particularly in the developing world including Bangladesh. Among the various cut flower species, the *Gerbera jamesonii* (family Asteraceae), commonly known as gerbera, stands out for its commercial importance and high aggregated product value. The gerbera presents a variety of attractive colours and shapes, achieving the best prices in the market. There are about 40 varieties of gerbera growing all over the country of which *Gerbera jamesonii* is most popular. Gerbera flowers can be grown in both tropical and sub-tropical climatic conditions (Prodhan *et al.,* 2017). These flowers can be cultivated in open fields under tropical climatic conditions. Gerbera is one of the most sought-after flowers in the country after tuberose, various types of roses, gladiolus and marigold (Reza, 2013). In Bangladesh, gerbera cultivation started about two decades ago. Although demand of this lucrative flower is increasing day by day, but still its cultivation is confined to Jashore and to some extent in Savar, Chuadanga, Mymensingh and Gazipur. Even there is an opportunity to export this flower to Arabian and European countries. Most of the non-problematic soils in Bangladesh are over saturated with food crops. In south-western Bangladesh, a huge area of land is available as well as suitable to bring under multiple cropping system. These soils are suffering from salinity stress and are usually used as monocropped with *T. Aman* rice. Gerbera cultivation can be extended in this region as it is highly profitable. In south-western Bangladesh, scarcity of irrigation water during dry season is a major constraint for crop cultivation (Haque, 2006). Possible solution can be preservation of rainwater into ponds and judicious use of this water. In conventional irrigation system, water loss is higher and needs more water to irrigate but this has to be minimized to some extent, especially for southern agriculture.

Inside the shade house, crops require frequent irrigation in order to minimize water stress and accomplish maximum production and high quality (Sezen *et al.,* 2010). For the efficient use of water from renewable but limited natural resources in agricultural production, the yield and quality parameters of plants under different irrigation schedules should be determined. One of the recent strategies used to control growth in plants is the application of water deficit to plants (Cerny *et al.,* 2003;

Cite this article

Mamun, A.A., Remme, R.N., Islam, M.M., Xulian, R.I. 2020. Efficacy of irrigation methods with varying levels of water in gerbera (*Gerbera jamesonii* L.) production. *Journal of Bangladesh Agricultural University*, 18(1): 6–11. https://doi.org/10.5455/JBAU.94715

Montgomery *et al.,* 2004; Cameron *et al.,* 2006). Reductions in leaf area, flower number, size and/or quality are observed in those plants which are exposed to water deficit (Cameron *et al.,* 1999; Sanchez-Blanco *et al.,* 2002).

Gerbera is very sensitive to moisture and it needs very precise water supply (Rogers and Tjia, 1990). In drip irrigation system, water falls drop by drop just at the position of roots and it is more effective and less expensive if a large amount of soil can be wetted with each emitter without losing water or nutrients below the root zone (Skaggs *et al*., 2010). The drip system can be the most water efficient irrigation method as the field water efficiency is typically in the range of 80 to 90% when managed correctly and evaporation and runoff are minimized. This system can be designed for uniformity and offers a great potential to improve water management by improving crop yield and quality. It can be helpful to cope with negative effect of climate change (Bates *et al*., 2008). Localising fertiliser and water applications, known as fertigation, can be done easily by this method, which helps to reduce pollution risk (Provenzano, 2007; Fernandez-Galvez and Simmonds, 2006). Efficiency of drip irrigation in gerbera cultivation has been reported by many researchers (Al-Omran *et al.*, 2005; Tiwari *et al*., 2003).

Gerbera cannot tolerate salinity and it reduces flower yield and quality. In the southern part of Bangladesh, water from most of the sources has salinity problems. Rainwater may be the best source to irrigate gerbera. An efficient method to irrigate gerbera is needed to find out for efficient flower production as it requires water throughout its growing period. Therefore, a research was conducted to investigate the efficacy of drip irrigation and to determine water requirement for proper growth and flowering of gerbera.

Materials and Methods

Plant materials

An investigation was carried out at 'Gerbera Research Center' of Agrotechnology Discipline in Khulna University (latitude 22°79′88″ E, longitude 89°53′44″ N and elevation: 18 m), Khulna, Bangladesh to find out the suitability of drip irrigation method on gerbera production and to determine the optimum amount of water for efficient flower production. Alabanda genotype of gerbera saplings were collected from Godkhali under Jhikorgacha Upazila of Jashore district and used as experimental material.

Experimental design

The experiment was laid out under a plastic covered shade with lateral net screen according to Randomized Completely Block Design (RCBD) with five replications.

Irrigation treatments

Different levels of irrigation water were considered as treatments. The water was applied by following schedule-

Treatment	Quantity of water applied			Method of application
	plant^{-1} day^{-1} (ml)	plot^{-1} day^{-1} (ml)	cm day^{-1} (cm)	
I_1	500	42,000	0.5	Flood
I_2	400	33,600	0.4	Drip
I_3	500	42,000	0.5	Drip
I_4	600	50,400	0.6	Drip

Preparation of bed for planting

Application of 500 ml water plant^{-1} day^{-1} by conventional (flood) method was considered as control. The soil of the experimental field was well-drained, rich, light, slightly alkaline (pH 7.5 to 8.0). The soil was made highly porous and well drained by ploughing 4 times followed by laddering and breaking the clods for growth and better penetration of roots of gerbera. All the weeds and stubbles were removed. The beds were prepared manually with spade. The experimental plots size were 8.4 m^2 (14 m × 0.6 m), plant spacing was 0.1m^2 (0.4 m × 0.25 m) and the number of plants for each treatment plot were 84 (8.4÷0.1). Vermicompost and coconut coir dust (1:2) was applied and mixed well with the soil to make it porous and well drained, and were kept fallow for a week prior to planting gerbera plantlets.

Intercultural operations

After one week of bed preparation, 30 days old gerbera saplings were planted in beds (Fig. 1) maintaining a distance of 40 cm between rows and of 25 cm between two plants within the row. At the time of planting, the crown of gerbera plants were kept 1.5-2.0 cm above soil level. Saplings were watered immediately after planting. Fertigation with Urea, TSP and MoP in the ratio of 10:15:20 g/m^2/month was applied throughout the experimental period (Palanisamy *et al.,* 2015). Necessary weeding was done time to time to reduce competition of weeds with crop plants, allelopathic effect of weeds and to increase the efficiency of irrigation water. Soil and growing media were loosened several times with hand harrow to increase aeration and to provide better condition for plant growth.

Data collection

At ten days interval after three weeks of planting, data on leaves plant^{-1}, leaf length, leaf diameter, flowers plant^{-1}, flower stalk length and flower diameter were collected for four months.

Statistical analysis

The collected data were analyzed according to the statistical procedure described by Gomez and Gomez (1984) by using the computer package program MSTAT-C. Differences among treatment means were separated by using Duncan's Multiple Range Test (DMRT).

Fig. 1. A view of the experimental set up. A. plastic covered experimental shade, B. preparation of bed, C. Alabanda genotype of gerbera, D. collected saplings of Alabanda, and E. transplanting of the saplings.

Results and Discussion

Plant growth parameters

Drip irrigation system with various levels of water *viz.* 400, 500 and 600 ml plant^{-1} day^{-1} was applied in gerbera beds and compared with conventional flood watering method (500 ml plant^{-1} day^{-1}). Plant growth and flower yield parameters were studied under these irrigation systems and water levels. Different water levels as well as application methods had variable effects on number of leaves plant^{-1} (Table 1). At 60 DAP (days after planting), no significant variation on leaves plant^{-1} was noticed among the treatments. At 90 and 120 DAP, plants irrigated with 500 ml water by drip method produced significantly more leaves plant^{-1} (45.60 and 56.20, respectively) than under other treatments which were statistically identical with 600, drip at 90 & 120 DAP and 500, flood at 120 DAP while plants that were supplied with 400 ml water daily by drip method produced lowest number of leaves plant^{-1} (27.40 and 35.80 at 90 and 120 DAP, respectively). Evolution of number of leaves per plant during the period of measurements had shown in Fig. 2.

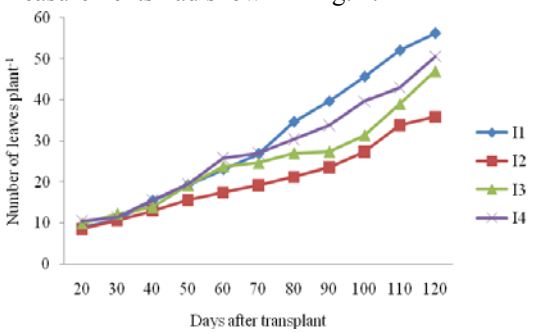

Fig. 2. Evolution of leaf number by irrigation treatments (day mean)

Significant variation on leaf length of gerbera was recorded for different methods and levels of irrigation water. Throughout the growing period, plants irrigated by drip method with 500 ml water produced the longest leaves that were significantly similar for the plants irrigated by conventional method with 500 ml water. The shortest leaves were produced by plants irrigated with 400 ml water followed by plants irrigated with 600 ml by drip method. Plants supplied with 500 ml of water per day may be the favourable condition for long leaf production in gerbera. Similar results have been also found by Katsoulas *et al.* (2006) who studied the effect of two irrigation frequencies on leaf area of a rose crop grown on rockwool slabs in a closed hydroponic system. Irrigation levels and methods had variable effects on leaf width of gerbera. Widest leaves were recoded in the plants which watered with 500 ml day^{-1}by drip method followed by plants watered with flood irrigation method at 60, 90 and 120 DAP. On the other hand, plants supplied with 400 ml water day^{-1} by drip method produced comperatively narrow leaves. The quantity of water as well as the method of irrigation influencd the leaf area of gerbera plants. Fluctuations in leaf length and leaf area during the period of measurements were observed and this may due to continuous removal of damaged and/or old leaves and emergence of new leaves (Rogers and Tjia, 1990). Tsirogiannis *et al.* (2010) who studied on effect of irrigation scheduling on gerbera flower yield and quality had also found similar results.

Cut flower yield and quality

Flowering started in gerbera field after 50 days of planting. Variable results were recorded for flower characteristics of gerbera irrigated with different water levels.

Table 1. Effect of different water levels on leaf characteristics of gerbera at different stages

Irrigation	No. of leaves plant^{-1} at (DAP)			Length(cm) of leaves at (DAP)			Width (cm) of leaves at (DAP)		
	60	90	120	60	90	120	60	90	120
I_1	24.60	31.40bc	47.00ab	18.56ab	21.34ab	22.56a	5.14ab	6.02ab	6.46ab
I_2	19.20	27.40c	35.80b	13.64c	15.93c	17.21b	4.24c	4.77b	5.39b
I_3	26.80	45.60a	56.20a	21.19a	24.49a	25.18a	5.84a	6.32a	7.01a
I_4	27.00	39.60ab	50.60ab	16.03bc	19.50bc	21.10ab	4.98bc	5.51ab	6.43ab
LS	NS	**	**	**	**	**	**	**	*
CV (%)	17.98	16.19	16.22	13.94	10.75	10.81	8.28	11.41	11.60

I_1: 500 ml (flood), I_2: 400 ml (drip), I_3: 500 ml (drip), I_4: 600 ml (drip) water plant^{-1} day^{-1}.
NS= Not Significant, *= Significant at 5% level, **= Significant at 1% level, LS= Level of Significance

Flowers produced by plants differed significantly with different water levels throughout the research period whereas no significant differences was found on flower stalk length and flower diameter in the plants among the treatments at 60 DAP but significant variations was recorded at 90 and 120 DAP (Table 2). Flower production was the highest in the plants irrigated with 500 ml water day^{-1} by drip method followed by plants irrigated with 600 ml of water day^{-1} applied by same method. The lowest flower was produced by plants irrigated with 400 ml day^{-1} water by drip method. Yield and quality of cut flowers are influenced by many pre-harvest and postharvest treatments. The factors influencing pre-harvest yield and quality may include environmental conditions such as light, temperature, season, relative humidity and growing media as well as cultural practices such as irrigation, fertilization, cultivar, supporting, reduction of the buds, and disease and pest management (Taylor *et al.,* 2004). Irrigation, one of the significant cultural practices in gerbera cultivation, like in other cut flowers, has significant effects on yield and quality.

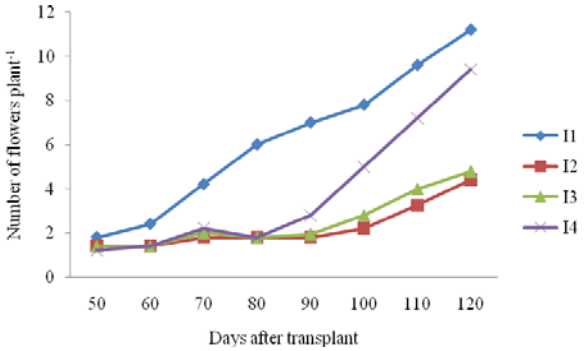

Fig. 3. Evolution of the number of harvested flower by irrigation treatments (day mean)

Evolution of the number of harvested flowers during the period of measurements had shown in Fig. 3. At 90 and 120 DAP, plants irrigated by flooding method (control) produced significantly longest flower stalk (17.98 and 23.58 cm, respectively) which were statistically identical with that irrigated at 500 ml water day^{-1} by drip method. The shortest stalked flowers were produced in plants supplied with 400 ml irrigation water day^{-1} by drip method.

Table 2. Effect of different water levels on floral characteristics of gerbera at different stages

Irrigation	Number of flower plant^{-1}at (DAP)			Flower stalk length (cm) at (DAP)			Flower diameter (cm) at (DAP)		
	60	90	120	60	90	120	60	90	120
I_1	2.00b	2.80bc	4.80b	12.86	17.98a	23.58a	1.94	3.54ab	4.80a
I_2	1.80b	2.20c	4.40b	5.46	5.56b	10.41b	2.18	1.45c	2.94b
I_3	4.20a	7.80a	11.20a	11.98	17.66a	19.04ab	3.45	4.69a	5.25a
I_4	2.20ab	5.00b	9.40a	13.50	10.26b	15.14ab	2.60	1.80bc	3.30b
LS	**	*	*	NS	**	*	NS	**	*
CV(%)	19.54	19.51	18.90	13.21	12.23	17.58	15.00	10.63	12.17

I_1: 500 ml (flood), I_2: 400 ml (drip), I_3: 500 ml (drip), I_4: 600 ml (drip) water plant^{-1} day^{-1}.
NS= Not Significant, *= Significant at 5% level, **= Significant at 1% level, LS= Level of Significance

Flower diameter and stalk length are important factor for the market value of cut-flowers like gerbera. Plants that were irrigated by drip method with 500 ml water day^{-1} treatment produced flowers with maximum diameter (4.69 and 5.25 cm at 90 and 120 DAP, respectively). At 90 and 120 DAP, no significant variation on flower diameter was observed among plants supplied with 500 ml water by conventional method. On the other hand, flowers with minimum diameter were produced in plants supplied daily with 400 ml irrigation water by drip method. The saturation of all soil pores with water under high irrigation intervals leads to a reduction in oxygen availability in the root zone. This prevents well aeration of the medium and causes reductions in yield. There had always a linear and positive relationship among leaf number per plant with flower per plant and flower diameter. The higher value of R^2 (R^2>0.50) suggests that more than 50% of the variations in number of flowers plant^{-1} and flower diameter could be explained by the variations in number of leaves plant^{-1}. Leaf length showed positive association with flower stalk length and the leaf length had also a positively impact on flower production in gerbera treated with different irrigations (Fig. 4).

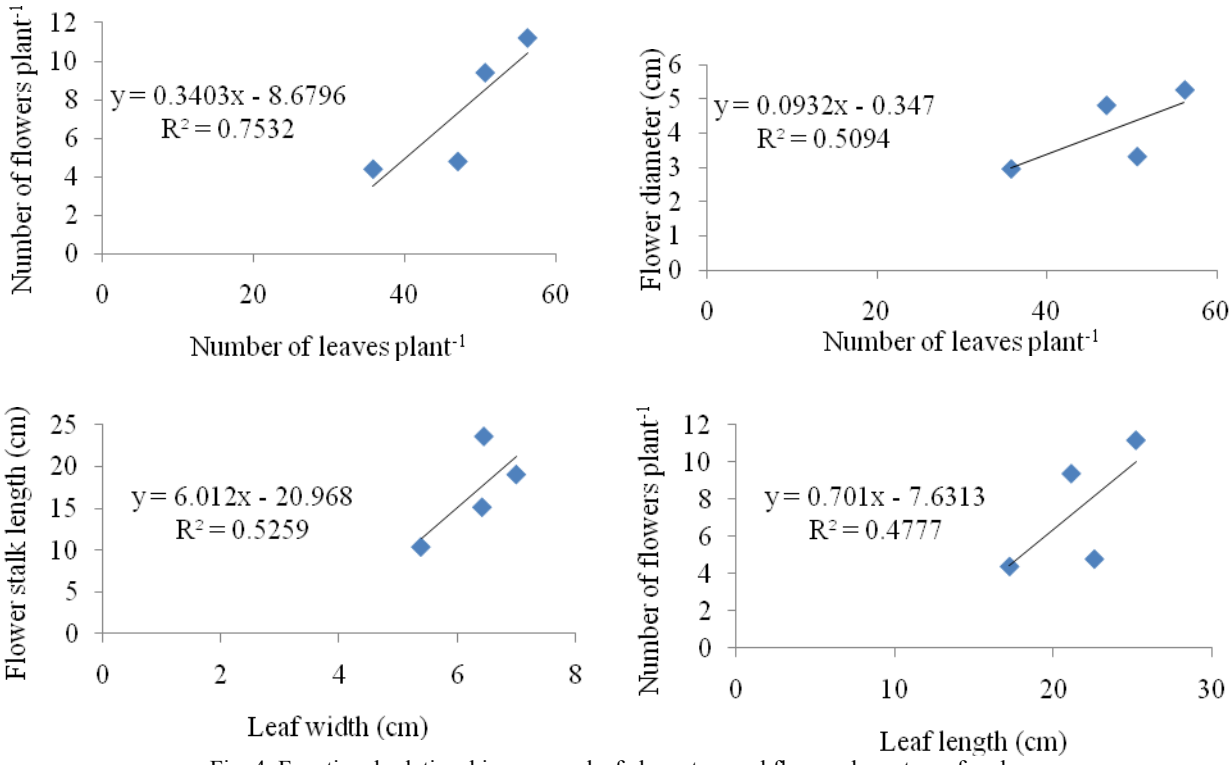

Fig. 4. Functional relationships among leaf characters and flower characters of gerbera

Katsoulas *et al*. (2006) concluded that the yield in cut flowers increased with increased frequency of irrigation. Significant variations in flower diameter of gerbera with different irrigation was also reported by Velázquez *et al.* (2017) who investigated the effect of different irrigation on gerbera production in substrate. Water deficiency in the plant root zone affects not only the vegetative growth of the plant but also yield (Pugnaire *et al.*, 1994).

Fig. 5. Different growth stages of gerbera from planting to flowering in the experiment

Conclusion

In the present investigation, different irrigation treatments were evaluated on growth and yield of gerbera. Plant growth and yield were influenced by irrigation treatments. In case of both leaf and floral characteristics studied, plants supplied with 500 ml irrigation water day^{-1} by drip method produced maximum values except flower stalk length. A gerbera plant with longer and wider leaves producing maximum flowers with wide diameter and short stalk might be a good plant suitable for commercial flower cultivation. So, irrigation with 500 ml water plant^{-1} day^{-1} by drip method might be a suitable irrigation method for flower production in gerbera.

Acknowledgement

The authors are grateful to 'Khulna University Research Cell', Khulna University for financial assistance under Research Grants Program (RGP) to facilitate research in this area.

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