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Effect of spacing and growing conditions on growth and quality of Gypsophila (*Gypsophila paniculata* L.) cut flower

Poornima S, Munikrishnappa PM, Seetharamu GK, Rajiv Kumar, Amreen Taj, Anil Kumar and Mohan Kumar

Poornima S
Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Munikrishnappa PM
Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Seetharamu GK
Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Rajiv Kumar
Principal Scientist, Division of Floriculture and Medicinal crops, Hesaraghatta lake post, IIHR, Bengaluru, Karnataka, India

Amreen Taj
Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Anil Kumar
Scientist, KVK Tamaka Kolar, Karnataka, India

Mohan Kumar
Department of Crop Physiology, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Corresponding Author:
Poornima S
Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka, India

Abstract
An experiment was carried out at College of Horticulture, UHS campus, Bengaluru during 2018-20. The experiment was laid out in a Factorial Randomized Complete Block Design (FRCBD) comprising of two factors. The present investigation was carried out to study the response of gypsophila to growth and quality with different spacing and growing condition. Results revealed that among growth parameters, plant height, plant spread (East-West and North- South), number of primary and secondary branches, leaf area and flower stalk length and girth were highest in plants grown under polyhouse condition (G_1). Among the different spacing, maximum growth parameters were recorded in S_4 (50 cm × 50 cm) spaced plants. In G × S interaction, plants grown under polyhouse with wider spacing were taller (96.00 cm) compared to shade house. Significant increase in plant spread: East-West (67.42 cm), plant spread: North-South (66.76 cm), number of primary branches (16.15), number of secondary branches (30.55) and leaf area (24.05 cm^2) after planting while, shade grown pants with narrow spacing recorded the least growth.

Keywords: Gypsophila, growing condition, spacing, growth and quality

Introduction
Gypsophila (*Gypsophila paniculata*) is a native of Eastern Europe and is now grown everywhere in the world; in fields and greenhouses. It is valued as a cut flower in floristry to add as a filler to flower bouquets. It is commonly used in flower arrangements for new babies or in bouquets of roses. The light airy masses of small white or pink flowers make a good contrast to larger flowers in the bouquets. New trends in floristry favoured by celebrity and designer florists; incorporate Gypsophila into trendy table arrangements and wedding bouquets consisting of nothing more than *Gypsophila* and a little foliage.

Gypsophila belongs to family 'Caryophyllaceae'. It is an extremely hardy perennial plant with a very deep tap root system. The stems are slender, erect to spreading, swollen at the nodes. The leaves are opposite, small, narrowly lanceolate, often falcate (sickle-shaped) with bluish green colour. Flowers are numerous produced in large inflorescences, usually in profusely branched panicles. Each flower in small; 3-10 mm diameter with white and pink petals (Suma *et al.*, 2010) [15].

It is widely grown commercially on a large scale in Holland and Israel, and elsewhere in the world on a smaller scale. It can be grown in a wide range of soils from a high sandy to clay loam, well drained, friable soil rich in organic matter and nutrients available. For best results it requires slightly acidic soil of about pH 5.8-6.5, where most of the nutrients are available to the plants. For successful cultivation of this plant, mild climate is while very hot and too cool atmospheric conditions are detrimental. The day temperature should range between 15 ^{0}C to 20 ^{0}C. As a plant able to withstand relatively severe drought conditions has hermaphrodite flowers and is pollinated by insects.

Plant density is another important affecting the yield and yield contributing characters, which can be manipulated to maximize the yield. Dry matter production of crop depends on the amount of incident solar radiation and its conversion to chemical energy. The efficiency of crop in intercepting and converting solar energy is dependent on the distribution and posture of the leaves in the canopy (Singh *et al.*, 2015) [14]. Population density modifies the canopy structure and influence light interception, dry matter production and yield of the crop. The plant density and spatial arrangements greatly affect the growth and yield of crop plants. Optimum density and row spacing are essential for attaining desired yield (Khenizy *et al.*, 2014) [4].

Flowers are highly perishable in postharvest chain from growers to consumers. Floral organs continue to flourish actively. They have high rate of respiration, which continue after harvest. As a result, maintenance of keeping quality and enhancement of vase life of cut flowers occupy the crucial part in horticultural research. Since gypsophila has many florets which open sequentially, extension of shelf life or vase life of this flower will help to more economic utilization of flower. Domestic gypsophila are mainly produced and distributed for business demands and special attention is not paid for vase life at consumer's level. Especially, at the growing areas, basic processing technique of cutting gypsophila came from overseas and not introduced to the growers. It is necessary to improve vase life at the consumer's level by employing international standard techniques.

Although India enjoys favourable climatic condition that enable of producing a wide array of cut flowers and foliage plants. Presently, the production mainly concentrated in only few states at local entrepreneurs and non-government organization levels. But although there is a great scope of growing gypsophila throughout the country, it has got very little research attention. There is no or scanty information available on spacing, growing condition and preservation technology of gypsophila. This supports the importance of conducting studies on ornamental filler plant gypsophila to meet the ever growing demands for cut foliage in domestic and international markets. Therefore, the present investigations are undertaken to standardize the growing condition and spacing for growth and quality.

Material and Methods

The experiment entitled "Growth and quality response of gypsophila (*Gypsophila paniculata* L.) cut flower in different growing conditions" was undertaken at the Dept. of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot. Studies were conducted in three types of growing conditions *viz.,* polyhouse - (G_1), gypsophila was raised in a naturally ventilated polyhouse (NVP) which was oriented in East-West direction with a size of 22 m length, 6 m width (132 m^2) with central height of 6 m and shade house condition - (G_2), plants were grown under 50 per cent green colour shade net and oriented towards East-West direction, the frame of the shade house was constructed with GI pipes. Drip irrigation system was installed for the complete cropped area with four different spacing *viz.,* S_1 – 40 cm × 30 cm, S_2 – 40 cm × 40 cm, S_3 – 50 cm × 30 cm and S_4 – 50 cm × 50 cm.

The experimental design adopted was Factorial Completely Randomized Block Design (FRCBD) with three replications. The treatments in each replication were allotted randomly. Healthy tissue cultured plants of six months old (3-4 leaf stage) were obtained from Florence Flora, Bengaluru and were planted on 7th April 2019. All the vegetative parameters *viz.,* plant height, spread, number of primary and secondary branches and leaf area were recorded at monthly intervals from five tagged plants at 30, 60, 90, 120 and 150 days after planting and pruning.

Results and Discussion

Gypsophila is one of the most important cash crop which requires less maintenance than the other floricultural crops. Planting density plays an important role in success of a crop. In general the planting density should be such that it provides a congenial root environment and results in healthy growth of plants. Gypsophila cultivation under polyhouse is quite popular in the world, but very meagre work related with the systematic study regarding the planting density has been reported. Planting density plays a vital role in influencing the quality of flowers as well as the incidence of diseases and pests. Keeping in view the importance of planting density on growth and quality of flowers the experiment was undertaken.

I. Growth parameters

Vegetative growth in gypsophila is measured in better way in terms of plant height, plant spread (East-West and North-South), number of primary and secondary branches and leaf area are very much important as they play a key role in deciding the ultimate crop yield.

Plant height, Plant spread (North-South and East-West), Number of primary branches, secondary branches and leaf area were significantly influenced by growing conditions, spacing and interactions at grand growth stage of the plant. Gypsophila plants grown under polyhouse recorded maximum plant height (84.19 cm). Greater plant height achieved could be due to stimulation of cellular expansion and cell division ultimately resulting the luxurious growth of plant under polyhouse condition might be due to prevalence of optimum temperature, humidity, light and CO2 concentration helps in larger biosynthesis of photo assimilates. Similar findings were also reported reported by Shwetha (2013) in gerbera, While maximum plant spread (East-West) (61.87 cm) and (North-South) (58.98 cm) was recorded in plants grown under polyhouse condition. The reason might be due to lack of capture of solar radiant energy by the plants and lack of light could be attributed to the vigorous, horizontal growth put forth of plants as the only option. Similar variations in growing conditions for plant spread were also observed in gerbera by Kumar and Sooch (2003) [6] and Shwetha *et al.* (2014) [12] in gerbera. Number of primary branches (14.23) and number of secondary branches (27.45) were highest under polyhouse grown plants, this might be due to enhanced metabolic activities like photosynthesis, respiration and transpiration due to favourable microclimatic conditions that prevailed inside the polyhouse condition. These observations were in conformity with the results of Negi (2012) [10] in *Phalaenopsis*; Kaveriamma (2012) in *Phalaenopsis* and. Maximum leaf area (22.25 cm^2) was found in polyhouse, these results are in conformity with Shwetha (2013) in gerbera. Whereas, all the vegetative parameters recorded minimum under shade house condition compare to polyhouse condition.

Significant variation in plant height as influenced by different spacing at grand growth stage after planting was registered in gypsophila. Plants grown with spacing (S_4) 50 cm × 50 cm recorded the highest plant height (89.79 cm), plant spread towards East-West (64.19 cm), towards North-South (61.56 cm), number of primary branches (13.93), secondary branches (28.47) and leaf area (21.50 cm^2). This increase in plant vegetative parameters might be due to the greater competition for space and light, thereby forcing the plants to grow taller. Increase in the number of plants per unit area coupled with high plant to plant competition. Due to this, lower amount of light intercepted by a single plant resulting into increased inter nodal length and also under higher plant density there might be comparatively low solar interception through crop canopy and under increased inter and intra row spacing probably the reduced interplant competition for light might have resulted in such variation in plant height. Similar observations were also reported by Agrawal and Dorajeerao (2016) [1] in golden rod, Lee *et al.* (2008) in chrysanthemum and Suma (2010) [15] in gypsophila.

Among the interactions effect, The higher plant height (96.00 cm), plant spread towards East-West (67.42 cm), towards North-South (66.76 cm), number of primary branches (16.15) and secondary branches (30.55) was recorded in plants grown under G_1S_4 treatment combination. This might be due to prevalence of congenial growing conditions and increase in the space between the plants that prevailed during experimental period. Similar variation of plant height was also observed by Mohanthy *et al.* (2011) [8] in rose, Shwetha (2013) in gerbera and Naik and Kumar (2014) [9] in *Dendrobium* orchids.

II. Quality parameters

Flower stalk length is a very important quality trait which is considered while grading the flower stalks. It also plays a vital role in the vase life by extending their post harvest life of cut spikes. Flower stalk length as influenced by the growing conditions, spacing and their interaction effects are illustrated in Table 2.

Longest flower stalk (60.22 cm) and stalk girth (6.31 mm) were recorded in plants grown under polyhouse (G_1) condition. Plants grown with the spacing of 50 cm × 50 cm (S_4) recorded significantly the longest flower stalk length (57.62 cm) and stalk girth (6.07 mm). The interaction effect between different growing condition and spacing, longest flower stalk (63.29 cm) and stalk girth (6.77 mm) was recorded in plants grown under G_1S_4 treatment combination. This may be due to the plants of wider spacing could receive more light, nutrients and other resources than the plants of closer spacing which leads to increase in stalk length and girth under polyhouse with wider spacing. These findings have been reported by Jain *et al.* (2018) [2] in statice; Siddappa *et al.* (2018) [13] in daisy and Shashank *et al.* (2016) [11] in carnation.

Table 1: Vegetative parameters in gypsophila as influenced by growing conditions, spacing and interaction effect after planting

Treatments	Vegetative parameters at grand growth stage					
	Plant height (cm)	Plant spread (North-South) (cm)	Plant spread (East-West) (cm)	No. of primary branches	No. of secondary branches	Leaf area (cm^2)
Growing conditions						
G_1 -Polyhouse	84.19	58.98	61.87	14.23	27.45	22.25
G_2-Shade house	67.23	48.93	55.76	10.30	22.87	17.05
S.E.m±	0.61	0.27	0.23	0.09	0.20	0.09
CD $_{0.05}$	1.85	0.83	0.69	0.26	0.60	0.26
Spacing (cm)						
S_1 - 40 × 30	65.10	47.37	55.15	10.88	21.37	18.13
S_2 - 40 × 40	70.96	50.45	56.97	11.60	24.54	19.03
S_3 - 50 × 30	76.99	56.44	58.95	12.64	26.25	19.94
S_4 - 50 × 50	89.79	61.56	64.19	13.93	28.47	21.50
S.E.m±	0.87	0.39	0.32	0.12	0.28	0.12
CD $_{0.05}$	2.63	1.18	0.98	0.37	0.86	0.37
Interaction						
G_1 S_1	75.13	52.17	58.38	12.42	24.45	20.60
G_1 S_2	80.43	55.17	60.56	13.64	26.48	21.45
G_1 S_3	85.20	62.53	63.13	14.69	28.30	22.61
G_1 S_4	96.00	66.76	67.42	16.15	30.55	24.05
G_2 S_1	55.08	46.57	51.93	9.33	18.29	15.80
G_2 S_2	61.49	45.73	53.38	9.56	22.59	16.05
G_2 S_3	68.77	50.35	56.76	10.58	24.20	17.52
G_2 S_4	83.57	57.07	60.96	11.71	26.40	18.55
S.Em±	1.23	0.55	0.46	0.17	0.40	0.28
CD $_{0.05}$	3.71	1.66	1.38	0.52	1.21	NS

Table 2: Quality parameters in gypsophila as influenced by growing conditions, spacing and interaction effect after planting

Treatments	Quality parameters	
	Flower stalk length (cm)	Flower stalk girth (mm)
Growing conditions		
G_1 -Polyhouse	60.22	6.31
G_2-Shade house	46.45	4.91
S.Em±	0.16	0.02
CD $_{0.05}$	0.47	0.06
Spacing (cm)		
S_1 - 40 × 30	49.56	5.17
S_2 - 40 × 40	52.01	5.42
S_3 - 50 × 30	54.16	5.78
S_4 - 50 × 50	57.62	6.07
S.Em±	0.22	0.03
CD $_{0.05}$	0.68	0.09
Interaction		
G_1 S_1	56.63	5.78
G_1 S_2	59.43	6.21

$G_1 S_3$	61.51	6.49
$G_1 S_4$	63.29	6.77
$G_2 S_1$	42.49	4.56
$G_2 S_2$	44.59	4.64
$G_2 S_3$	46.80	5.07
$G_2 S_4$	51.94	5.37
S.Em±	0.32	0.04
CD $_{0.05}$	0.95	0.12

Conclusion

The present investigation reveals that there was an improvement in the growth and quality parameters of gypsophila with different growing condition, spacing and their combination. Based on the results, it concluded that, polyhouse grown plants with wider spacing *i.e.*, S_4 (50 cm × 50 cm) had significant increase in plant height, plant spread, number of primary and secondary branches and quality parameters like flower stalk length and girth.

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