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Effect of planting geometry and growing conditions on vegetative, flowering and quality parameters of gypsophila (*Gypsophila paniculata* L.)

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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 vegetative and quality parameters with different plant geometry (40 cm × 30 cm, 40 cm × 40 cm, 50 cm × 30 cm and 50 cm × 50 cm) and growing conditions (Shade house and polyhouse). The results revealed that, plants grown under polyhouse with the spacing of 50 cm × 50 cm maximum plant height, plant spread (E-W, N-S), Number of primary and secondary branches, flower stalk length and girth at different growth stages. Early bud initiation and flowering was recorded in plants grown under polyhouse condition with the spacing of 40 cm × 30 cm. Whereas, minimum was recorded under shadehouse condition with the spacing of 40 cm × 30 cm.

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

Introduction
Gypsophila is termed a long day plant, requiring a day length between 12 to 18 hours to initiate flowering, depending on the clone (Halevy, 2003) [1]. Gypsophila or Baby's breath (*Gypsophila paniculata* L.) is a native of Eastern Europe and a member of the 'Caryophyllaceae' family, gypsophila is one of the 2000 species of flowering plants. In some areas, growing is done outdoors while in others it is in controlled greenhouses. Now it is grown commercially on a large scale in Holland, Israel and elsewhere in the world on a smaller scale (Fascella *et al.*, 2008) [2].

It has been grown for many years both for fresh and dried cut flowers. It is valued as a cut flower in floristry to add as a filler to flower bouquets as grown in the past few years. The performance of any crop may be enhanced when it is grown under protected conditions. The growing environmental conditions *viz.*, temperature, humidity, light and photoperiod will play an important role on growth, yield and quality of gypsophila (Alams *et al.*, 2014) [3].

However, among the producing farms, some have been forced to stop production because of the major quality and productivity issues related to fresh weight of the flowers, planting density and cultivar selection. Thus, finding out appropriate planting density brings better quality and yield in Indian condition would be necessary to support growers to be competitive in the global market. Therefore, there is need to understand the relationship between plant density and yield so as to identify the optimum population (Khenizy *et al.*, 2014) [4]. Considering the importance of this crop, there is a prime need for its improvement in cultivation practices adaptable for cut flower production.

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 important cut flower and is being grown on a commercial scale under different environmental condition to meet the quality standards. Commercial cultivation of gypsophila crop started in India only recently. The salient findings of the investigation are discussed in this chapter.

I. Vegetative parameters

Data on plant height, plant spread (E-W and N-S direction), number of primary and secondary branches are recorded during different crop growth period as influenced by growing conditions, planting geometry and their interaction effects at 30, 60, 90, 120 and 150 days after planting (DAP) is presented in Table 1, 2 and 3. The interaction effect between different growing condition and varying spacing was found to be significant for plant height recorded at 30, 60, 90, 120 and 150 days after planting. The higher plant height (20.79, 28.59, 44.61, 82.66 and 96.00 cm respectively) was recorded in plants grown under polyouse (G_1) with (50 cm × 50 cm) (S_4) spaced plants followed by (17.47, 26.07, 38.39, 73.24 and 85.20 cm respectively) under polyouse (G_1) with (50 cm × 30 cm) (S_3) spacing. Whereas, it was less (11.45, 13.73, 25.25, 49.36 and 55.08 cm respectively) under shade house (G_2) with (40 cm × 30 cm) (S_1) spaced plants. 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) [5] in rose, Shwetha (2013) in gerbera and Naik and Kumar (2014) [6] in *Dendrobium* orchids.

Maximum plant spread towards East-West was recorded in interaction of $G_1 \times S_4$: (polyhouse × (50 cm × 50 cm) (25.87, 36.51, 46.16, 66.33 and 67.42 cm respectively) followed by ($G_1 \times S_3$): (polyhouse × (50 cm × 30 cm) (22.86, 32.29, 41.41, 62.82 and 63.13 cm respectively). The interaction effect between different growing condition and varying spacing was found significant on plant spread towards North-South at 30, 60 90, 120 and 150 days after planting. Maximum plant spread (North-South) was recorded in ($G_1 \times S_4$) combination (26.52, 38.55, 46.87, 66.63 and 66.76 cm respectively) followed by ($G_1 \times S_3$): polyhouse × (50 cm × 30 cm) (23.55, 33.49, 42.22, 61.91 and 62.53 cm respectively). Whereas, it was minimum (12.64, 21.62, 29.87, 42.41 and 46.57 cm respectively) recorded in ($G_2 \times S_1$) combination. This variation might be due to microclimate inside the polyhouse and inter-plant competition for space, light and nutrients. Similar explanation was recorded Mohanthy *et al.* (2011) [5] in rose, Shwetha (2013) in gerbera.

Number of primary branches showed significant results for interaction between growing conditions and different spacing at 60 and 90 days after planting. Highest number of primary branches was recorded in ($G_1 \times S_4$) treatment combination (15.62 and 16.15 respectively) followed by ($G_1 \times S_3$) (14.43 and 14.69 respectively). Number of secondary branches showed significant results for interaction between growing conditions and different spacing at 60 and 90 days after planting. Maximum number of secondary branches was recorded in ($G_1 \times S_4$): polyhouse × (50 cm × 50 cm) (23.37 and 30.55 respectively) followed by ($G_1 \times S_3$): polyhouse × (50 cm × 30 cm) (20.50 and 28.30 respectively). The increased number of branches at the wider plant spacing could also be attributed to more interception of sunlight for photosynthesis and at high density there might also be comparatively low light interception through crop canopy as compared to wider spacing that might have resulted in lesser axillary buds leading to lower number of branches per plant. More interception of sunlight for photosynthesis, which may have resulted in production of more assimilate for partitioning towards the development of more branches. These findings are in accordance with the findings of Agrawal and Dorajeerao (2016) [8] in golden rod; Lee *et al.* (2008) [9] in chrysanthemum and Suma (2010) [10] in gypsophila.

Table 1: Plant height (cm) in gypsophila as influenced by growing conditions, plant geometry and interaction effect

Treatments	Plant height (cm)				
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
Growing conditions					
G_1 -Polyhouse	16.34	25.27	37.92	72.59	84.19
G_2-Shade house	13.82	18.13	29.57	61.63	67.23
S.Em±	0.15	0.08	0.21	0.50	0.61
CD $_{0.05}$	0.44	0.23	0.63	1.52	1.85
Spacing (cm)					
S_1 - 40 × 30	12.12	17.60	29.24	56.87	65.10
S_2 - 40 × 40	14.01	21.21	31.76	64.82	70.96
S_3 - 50 × 30	15.25	22.91	34.43	69.41	76.99
S_4 - 50 × 50	18.94	25.09	39.56	77.34	89.79
S.Em±	0.21	0.11	0.29	0.71	0.87
CD $_{0.05}$	0.63	0.34	0.89	2.15	2.63
Interaction					
$G_1 S_1$	12.79	21.46	33.22	64.38	75.13
$G_1 S_2$	15.32	24.96	35.45	70.08	80.43
$G_1 S_3$	17.47	26.07	38.39	73.24	85.20
$G_1 S_4$	20.79	28.59	44.61	82.66	96.00

G_2 S_1	11.45	13.73	25.25	49.36	55.08
G_2 S_2	12.70	17.46	28.07	59.56	61.49
G_2 S_3	14.03	19.74	30.46	65.57	68.77
G_2 S_4	17.10	21.59	34.51	72.01	83.57
S.Em±	0.29	0.16	0.42	1.00	1.23
CD $_{0.05}$	0.88	0.47	1.26	3.04	3.71

Table 2: Plant spread: East-West (cm) and North-South (cm) in gypsophila as influenced by growing conditions, spacing and interaction effect

Treatments	Plant spread: East-West (cm)					Plant spread: North-South (cm)				
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
Growing conditions										
G_1 –Polyhouse	20.70	30.57	40.61	60.43	61.87	21.55	31.66	41.04	61.72	58.98
G_2-Shade house	15.54	24.72	35.73	54.25	55.76	16.45	26.62	36.39	52.17	48.93
S.Em±	0.10	0.18	0.29	0.39	0.23	0.09	0.18	0.35	0.26	0.27
CD $_{0.05}$	0.29	0.56	0.86	1.16	0.69	0.28	0.55	1.04	0.78	0.83
Spacing (cm)										
S_1 - 40 × 30	13.31	22.31	33.32	52.84	55.15	14.68	24.32	33.04	52.07	47.37
S_2 - 40 × 40	15.72	24.29	35.29	54.92	56.97	16.82	25.62	35.66	55.30	50.45
S_3 - 50 × 30	19.99	29.30	38.99	58.15	58.95	20.59	30.35	40.35	57.91	56.44
S_4 - 50 × 50	23.45	34.68	45.08	63.43	64.19	23.92	36.27	45.81	62.51	61.56
S.Em±	0.14	0.26	0.40	0.54	0.32	0.13	0.26	0.49	0.37	0.39
CD $_{0.05}$	0.42	0.79	1.22	1.65	0.98	0.40	0.78	1.48	1.11	1.18
Interaction										
G_1 S_1	16.21	25.64	36.34	55.40	58.38	16.72	27.01	36.21	57.73	52.17
G_1 S_2	17.85	27.83	38.53	57.17	60.56	19.41	27.60	38.84	60.63	55.17
G_1 S_3	22.86	32.29	41.41	62.82	63.13	23.55	33.49	42.22	61.91	62.53
G_1 S_4	25.87	36.51	46.16	66.33	67.42	26.52	38.55	46.87	66.63	66.76
G_2 S_1	10.41	18.98	30.30	50.29	51.93	12.64	21.62	29.87	42.41	46.57
G_2 S_2	13.60	20.75	32.05	52.67	53.38	14.23	23.64	32.48	49.97	45.73
G_2 S_3	17.12	26.30	36.57	53.48	56.76	17.63	27.20	38.47	53.92	50.35
G_2 S_4	21.03	32.85	44.00	60.54	60.96	21.32	34.00	44.74	58.39	57.07
S.Em±	0.20	0.37	0.57	0.77	0.46	0.19	0.37	0.69	0.52	0.55
CD $_{0.05}$	0.59	1.12	1.72	2.33	1.38	0.56	1.10	2.09	1.56	1.66

Table 3: Number of primary and secondary branches in gypsophila as influenced by growing conditions, spacing and interaction effect

Treatments	Number of primary branches			Number of secondary branches		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
Growing conditions						
G_1-Polyhouse	4.65	13.56	14.23	8.09	19.89	27.45
G_2-Shade house	4.20	9.63	10.30	8.06	14.52	22.87
S.Em±	0.26	0.08	0.09	0.16	0.08	0.20
CD $_{0.05}$	NS	0.25	0.26	NS	0.25	0.60
Spacing (cm)						
S_1 - 40 × 30	4.50	9.99	10.88	7.98	14.35	21.37
S_2 - 40 × 40	4.45	11.15	11.60	7.95	15.52	24.54
S_3 - 50 × 30	4.00	12.05	12.64	8.19	18.04	26.25
S_4 - 50 × 50	4.75	13.20	13.93	8.18	20.91	28.47
S.Em±	0.37	0.12	0.12	0.23	0.12	0.28
CD $_{0.05}$	NS	0.36	0.37	NS	0.36	0.86
Interaction						
G_1 S_1	4.33	11.55	12.42	7.73	17.29	24.45
G_1 S_2	4.43	12.65	13.64	8.10	18.40	26.48
G_1 S_3	4.70	14.43	14.69	8.31	20.50	28.30
G_1 S_4	5.13	15.62	16.15	8.23	23.37	30.55
G_2 S_1	4.67	8.42	9.33	8.23	11.40	18.29
G_2 S_2	4.47	9.66	9.56	7.80	12.64	22.59
G_2 S_3	3.29	9.67	10.58	8.07	15.59	24.20
G_2 S_4	4.37	10.78	11.71	8.13	18.45	26.40
S.Em±	0.52	0.17	0.17	0.32	0.17	0.40
CD $_{0.05}$	NS	0.51	0.52	NS	0.50	1.21

II. Flowering parameters

Data pertaining to days taken for bud initiation as influenced by growing conditions, spacing and their interactions are presented in Table 4. Early (69.37 days) bud initiation was recorded in G_1S_1 followed by (71.44 days) were in polyhouse (G_1) + (40 cm × 40 cm) spaced plants. However, it was delayed (80.56 days) under shade house condition (G_2) + (50 cm × 50 cm) spaced plants. Early blooming (88.41 days) was recorded in polyhouse (G_1) + (40 cm × 30 cm) spaced plants followed by (91.56 days) were reported in G_1S_2 combination. Late blooming (97.46 days) was recorded in G_2S_4 treatment combination. Exposing the plants to higher temperature and higher light intensity inside the polyhouse might have helped in quick intiation of bud as compared shade environment with lower plant density. Similar results were obtained by Sudeep *et al.* (2018) [11] in *dendrobium* orchid; Deshpande *et al.* (2001) [12] and Mellesse (2013) [13] in statice.

Table 4: Days to bud initiation and flowering in gypsophila as influenced by growing conditions, spacing and interaction effect

Treatments	Days to bud initiation	Days to flowering
Growing conditions		
G_1-Polyhouse	73.12	92.17
G_2-Shade house	76.69	95.24
S.Em±	0.07	0.17
CD $_{0.05}$	0.20	0.50
Spacing (cm)		
S_1 - 40 × 30	71.34	90.57
S_2 - 40 × 40	73.43	92.95
S_3 - 50 × 30	75.91	94.90
S_4 - 50 × 50	78.95	96.41
S.Em±	0.10	0.24
CD $_{0.05}$	0.29	0.72
Interaction		
G_1 S_1	69.37	88.41
G_1 S_2	71.44	91.56
G_1 S_3	74.34	93.35
G_1 S_4	77.33	95.36
G_2 S_1	73.30	92.72
G_2 S_2	75.41	94.33
G_2 S_3	77.49	96.44
G_2 S_4	80.56	97.46
S.Em±	0.14	0.34
CD $_{0.05}$	0.41	1.01

II. Quality parameters

Flower stalk length is one of the qualitative characters which determine the prices in the domestic and international market. Flower stalk length as influenced by the growing conditions, spacing and their interaction effects at 60, 90 and 120 days after planting are presented in Table 5. The interaction effect between different growing condition and spacing was also found significant for flower stalk length (cm) recorded. Longest flower stalk (27.36, 50.53 and 63.29 cm respectively) was recorded G_1S_4 treatment combination followed by (25.70, 45.28 and 61.51 cm respectively) under G_1S_3 combination.

Flower stalk girth showed significant interaction between growing conditions and spacing after planting. Maximum flower stalk girth (6.77 mm) was recorded in G_1S_4 treatment combination followed by G_1S_3 combination (6.49 mm). Whereas, it was minimum (4.56 mm) recorded in G_2S_1 combination. The above variation might be due to wider spacing and prevalence of congenial micro climatic condition. Similar variation in spike length was also observed previously by Shashank *et al.* (2016) [14] in carnation; Deshpande *et al.* (2001) [12] and Mellesse (2013) [13] in statice.

Table 5: Flower stalk length (cm) in gypsophila as influenced by growing conditions, spacing and interaction effect after planting

Treatments	Flower stalk length (cm)			Flower stalk girth (mm)
	60 DAP	90 DAP	120 DAP	
Growing conditions				
G_1-Polyhouse	26.38	44.65	60.22	6.31
G_2-Shade house	20.57	36.30	46.45	4.91
S.Em±	0.23	0.22	0.16	0.02
CD $_{0.05}$	0.68	0.67	0.47	0.06
Spacing (cm)				
S_1 - 40 × 30	22.99	36.58	49.56	5.17
S_2 - 40 × 40	23.13	38.73	52.01	5.42
S_3 - 50 × 30	23.33	41.01	54.16	5.78
S_4 - 50 × 50	24.45	45.58	57.62	6.07
S.Em±	0.32	0.31	0.22	0.03
CD $_{0.05}$	0.97	0.95	0.68	0.09
Interaction				
G_1 S_1	25.19	40.33	56.63	5.78
G_1 S_2	27.26	42.45	59.43	6.21
G_1 S_3	25.70	45.28	61.51	6.49
G_1 S_4	27.36	50.53	63.29	6.77
G_2 S_1	19.00	32.83	42.49	4.56
G_2 S_2	20.79	35.02	44.59	4.64
G_2 S_3	21.54	36.75	46.80	5.07
G_2 S_4	20.96	40.63	51.94	5.37

S. Em±	0.45	0.44	0.32	0.04
CD $_{0.05}$	1.37	1.34	0.95	0.12

Conclusion

The present investigation reveals that growing condition and planting geometry have significant effect on improving the vegetative, flowering and quality parameters. 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, flowering parameters like days to bud initiation, flowering and quality parameters like flower stalk length and girth at different stages of plant growth.

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