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Manimaran P
Department of Horticulture, Nammazhvar College of Agriculture and Technology, Peraiyur, Kamudi, Tamil Nadu, India

Ganga M
Department of Floriculture and Landscaping, Horticultural College and Research Institute Tamil Nadu Agricultural University, Coimbatore. Tamil Nadu, India

Corresponding Author:
Manimaran P
Department of Horticulture, Nammazhvar College of Agriculture and Technology, Peraiyur, Kamudi, Tamil Nadu, India

Effect of different plant spacing on growth, flower yield and quality of Jasmine spp. (*Jasminum nitidum*)

Manimaran P and Ganga M

Abstract
A study was conducted to standardize the plant spacing for a clonal selection (Acc.Jn-1) of the underutilized jasmine, *Jasminum nitidum* evolved at TNAU. The experiment was laid out in RBD with 7 treatments and 4 replications. Among the seven levels of plant spacing, (S_7) 2.00 x 1.50 m spacing accommodating 3330 plants/ha proved its superiority with respect to most of the parameters. The growth parameters recorded the highest values in this treatment which included plant height (46.40 and 69.31 cm), plant spread in N-S and E-W directions (29.13 and 57.13 cm and 31.43 and 61.43 cm respectively), number of primary branches plant^{-1} (5.58 and 9.74) and secondary branches plant^{-1} (17.16 and 29.41) at180 and 360 days after planting when compared to the other treatments. This treatment also recorded the highest values for the yield parameters *viz.*, weight of hundred flower buds (17.897 g), single bud weight (0.1789 g) and maximum annual flower yield plant^{-1} (1319.69 g) respectively. This treatment proved superior also for flower quality parameters with the maximum values for flower bud length (without corolla tube) (2.057 cm), total flower bud length (3.962 cm), corolla tube length (1.905 cm) and flower bud width (0.519 cm). This treatment also proved superior for physiological parameters *viz.*, maximum leaf area (2040.96 and 6783.52 cm^2), leaf area index (2.229 and 1.933), total chlorophyll content (1.3868 and 1.4957 mg/g) and total phenol content (6.007 and 8.995 mg/g) recorded at180 and 360 days after planting. When compared to the wider spacing the highest estimated annual flower yield/ha (5.29t) was recorded in the closer spacing (S_1) 1.25 x 1.25 m and this is due to the higher plant population (6400 plants/ha) accommodated by this spacing. Hence closest spacing of 1.25 x 1.25 m is recommended since *J. nitidum* plants can be maintained with compact canopy with regular pruning.

Keywords: Growth and development, *Jasminum nitidum*, physiological parameters, quality and yield, spacing

Introduction

Commercial floriculture in India comprises of both the modern and the traditional groups of flowers. Among the traditional flowers, jasmine occupies a very significant place. The term jasmine is derived from an Arabic word "Jessamine" and in Persian language it is called as "Yasmin" or "Yasmyn" which means fragrance Bailey, 1951. There are more than 200 species of *Jasminum* of which 40 species have been identified in India, and 20 species are cultivated in South India Bhattacharjee, 1982. Therapeutically, jasmine oil is used as an antidepressant, antiseptic, antispasmodic and sedative (Kang & Kim, 2002) [19]; (Maxia *et al.*, 2009) [23].

Among the large number of species existing, only three species (*J. sambac, J. grandiflorum, J. auriculatum*) have attained importance in commercial cultivation (Rimando, 2003) [39]; (Green & Miller, 2009) [15]. However, these three species do not produce flowers during the off-season from December to March. Preliminary research taken up at TNAU has indicated that besides the above species, few more species namely, *J. calophyllum, J. nitidum, J. rigidum, J. flexile* and *J. multiflorum* (Syn: *J. pubescens*) possess economic importance since they produce flowers which are suitable for use as loose flower and the plants of these species are suitable for use as fragrant flowering garden plants. The above species have the added merit of flowering throughout the year Ganga *et al*., 2015, unlike the three popular commercial species namely, *J. sambac, J. grandiflorum and J. auriculatum*, besides being relatively free from major pests and diseases.

The increased productivity of flower crop can appreciably be achieved through adoption of improved cultural practices. It has been established that spacing and pruning play an important part in overall improvement of growth and yield of many flower crops. The optimum plant spacing not only helps in obtaining increased production of better quality produce, but also in proper utilization of land and other inputs. Hence, due attention has to be paid to determine optimum spacing. Plant density plays an important role in determining the yield per unit area.

For appropriation of maximized yield, plant density is an important management requirement for the efficient utilization of applied inputs. It has been established that spacing and pruning play an important part in overall improvement of growth and yield of many flower crops (Patel, Parmar, & Parmar, 2006) [30, 31] and (R. Kumar, Gobind, & Yadav, 2003) [21].

Materials and Methods

The experiment was conducted to determine the effect of different plant spacing on growth, flower yield and quality of Jasmine spp. (*Jasminum nitidum*) at the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Experiments were laid out in RBD with 7 treatments and 4 replications corresponding to different populations *viz.*, S_1 - 1.25 m x 1.25 m (6,400 plants/ha), S_2 - 1.50 m x 1.25 m (5,330 plants/ha), S_3 - 2.00 m x 1.00 m (5,000 plants/ha), S_4 - 1.75 m x 1.25 m (4,570 plants/ha), S_5 - 1.50 m x 1.50 m (4,440 plants/ha), S_6 - 2.00 m x 1.25 m (4,000 plants/ha), S_7 - 2.00 m x 1.50 m (3,330 plants/ha). The observations are recorded on the selected five plants for a treatment in each replication and the mean data is statistically analyzed by the ANOVA technique as described by Panse and Sukhatme (1967) [29].

Results and Discussion

Plant growth parameters

Data pertaining to the plant growth parameters recorded in the present study. Different stages of plant growth as influenced by different plant spacing are presented in Table 1. Among the seven plant spacing treatments imposed, (2.00 x 1.50 m) S_7 which was the widest among the spacing treatments recorded the maximum plant height (46.40 and 69.31 cm). This was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (43.62 and 64.32 cm) at 180 and 360 DAP respectively. The lowest plant height (29.47 and 45.27 cm) 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing). The maximum plant spread N-S and E-W (29.13 and 57.13 cm) and (31.43 and 61.43 cm) was observed in the treatment S_7 (2.00 x 1.50 m) spacing during the stages of (180 and 360 DAP) and this was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (27.14 and 54.84 cm) and (28.07 and 56.77 cm) at 180 and 360 DAP respectively. The lowest plant spread N-S and E-W (17.07 and 37.09 cm) and (17.89 and 36.93 cm) was recorded in the treatment S_1 (1.25 x 1.25 m) spacing at 180 and 360 DAP). Plant density influences the growth of branches by light interception. With increase in plant spacing, light interception and solar energy conversion efficiency is more, which might be the reason for variation in plant height and plant spread at different spacing. Moreover, wider spacing provides more free space for crop growth with no competition for nutrients between plants, thereby increasing the plant height as suggested by (Ramesh, Farooqi, & Subbaiah, 1989) [34] in *Andrographi spaniculata*. It has also been well documented that the plant height and plant spread increases with an increase in plant density by several researchers like (Ilangovan, Subbaiah, & Natarajan, 1990) [18] in *Cassia angustifolia*, (Subbi Reddy & Krishnan, 1991) [49] and (Gangadharappa, 2000) [10, 11] in *Solanum khasianum*, (Gurav *et al.*, 2005) [16, 17] in *Polianthes tuberosa*, (Sreekanth, Padma, Chandrasekhar, & T.Y. Madhulety, 2008) [46] in *Tagetus erecta* and (Monirul Islam, Satyaranjan Saha, MD. Hasanuzzaman Akand and Md. Abdur Rahim, 2011) in Sweet pepper.

Table 1: Effect of plant spacing on plant growth parameters of *Jasminum nitidum* at different stages

Treatment			Plant height (cm)		Plant spread (cm)				Primary branches plant^{-1}		Secondary branches plant^{-1}	
Code	Spacing (m)	No. of plants/ha	180 DAP	360 DAP	180 DAP		360 DAP		180 DAP	360 DAP	180 DAP	360 DAP
					N-S	E-W						
S_1	1.25 x 1.25	6400	29.47	45.27	17.07	17.89	37.09	36.93	3.08	7.03	12.31	21.14
S_2	1.50 x 1.25	5330	32.74	50.17	18.63	20.54	41.71	41.63	3.47	7.56	13.05	23.76
S_3	2.00 x 1.00	5000	35.22	54.32	20.17	22.27	44.37	44.47	3.97	7.91	13.85	25.31
S_4	1.75 x 1.25	4570	37.62	58.48	21.85	24.97	48.94	49.45	4.16	8.35	14.75	26.83
S_5	1.50 x 1.50	4440	40.12	60.24	24.24	26.18	51.24	51.97	4.45	8.83	15.86	28.21
S_6	2.00 x 1.25	4000	43.62	64.327	27.14	28.07	54.84	56.77	4.75	9.25	16.66	29.04
S_7	2.00 x 1.50	3330	46.40	69.31	29.13	31.43	57.13	61.43	5.58	9.74	17.16	29.41
Mean			37.88	57.45	22.60	24.48	47.90	48.95	4.20	8.38	14.80	26.24
S.Ed			0.91	1.02	0.26	0.52	0.92	1.19	0.11	0.16	0.45	0.57
CD (p=0.05)			1.98	2.22	0.56	1.13	1.99	2.59	0.24	0.36	0.98	1.25

Among the different plant spacing treatments imposed, the highest number of primary branches plant^{-1} (5.58 and 9.74) was recorded in the treatment S_7 (2.00 x 1.50 m) spacing and it was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (4.75 and 9.25) at 180 and 360 DAP respectively. The lowest number of primary branches plant^{-1} (3.08 and 7.03) was observed in S_1 (1.25 x 1.25 m) spacing at 180 and 360 DAP. The more number of secondary branches plant^{-1} (17.16 and 29.41) was observed in the treatment S_7 (2.00 x 1.50 m) spacing during 180 and 360 DAP respectively and this was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (16.66 and 29.04). The least number of secondary branches plant^{-1} (12.31 and 21.14) at 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing. The increase in number of primary and secondary branches at wider spacing could be attributed to the greater interception of light due to higher surface area, while there was shading effect particularly on the lower leaves in the closer spacing. Similar results were obtained by (Ilangovan *et al.*, 1990) [18] in *Cassia angustifolia* and (Selvaraj & Natarajan, 2002) [41] in *Solanumm uricatum*, (H. P. Sumangala, V. S. Patil, & M. M. Rao, 2003) [51, 52] in *Jasminum sambac*,(Srivastava, Singh, & Srivastava, 2005) [47, 48] in *Tagetus erecta* and (Dixit, 2004) [5] in *Dendranthema grandiflora*.

The increase in growth parameters of *J. nitidum* plant can be obtained by wider spacing which is in conformity with the results of (Mohanty, Ravindran, Rao, & Reddy, 1986) [24] and (Natarajan & Vijayakumar, 2002) [26, 27, 28] in *Tagetus erecta*, (Bhande, Neha, Sushma, & Parinita, 2015) [2] in *Gladiolus spp*, (Poonam, Kumar, & Dubey, 2002) [32] in *Zinnia elegans* and (Sushma, Reddy, Kulkarni, & Patil, 2013) [53] in *Heliconia spp*.

Flower yield and quality parameters

Data pertinent to the flower yield and quality parameters are presented in Table 2, Figure 1. Among the different plant spacing treatments imposed, the highest hundred bud weight (17.897 g) was recorded in the treatment S_7 (2.00 x 1.50 m) spacing and it was on par with S_6 (2.00 x 1.25 m) spacing which recorded the values of (17.884 g) respectively. The lowest weight of hundred flower buds (16.417 g) was recorded in S_1 (1.25 x 1.25 m) spacing. The highest single bud weight (0.1789 g) was recorded in the treatment S_7 (2.00 x 1.50 m) spacing and it was on par with S_6 (2.00 x 1.25 m) spacing which recorded the value of (0.1784 g) respectively. The lowest weight of single flower buds (0.1641 g) was recorded in S_1 (1.25 x 1.25 m) spacing. The maximum flower yield plant^{-1} annual^{-1} (1319.69 g) (fig.1) was found in the treatment S_7 (2.00 x 1.50 m) spacing and it was followed by S_6 (2.00 x 1.25 m) spacing which recorded the value of (1173.01 g) respectively. The minimum flower yield plant^{-1} annual^{-1} (827.63 g) was observed in S_1 (1.25 x 1.25 m) spacing. Increased flower bud yield plant^{-1}at wider spacing could be attributed to the superiority of wider spacing on the vegetative parameters and yield attributing components. The cumulative superiority in vegetative parameters *viz*., number of branches, number of leaves and leaf area must have contributed to higher production of flowers plant^{-1} in wider spacing as compared to closer spacing. Increased flower production under wider spacing was also reported by (G. Reddy & Krishnan, 1991) [38] in *Solanum viarum*. The present results are also in conformity with the findings of (Rao, Hedge, Selvaraj, Subhash Chandra, & Randhawa, 1981) [37] and (Saxena & Dutta, 1985) [40] in *Dioscorea floribunda*, (Natarajan & Vijyakumar, 2002) [26, 27, 28] in *Tagetus erecta*, (AK Singh, Kumar, & Kumar, 2015) in *Tagetes erecta* and (Dorajeerao & Mokashi, 2012a) [6] in *Dendranthema grandiflora*.

When compared to the wider spacing the highest estimated annual flower yield/ha (5.29 t) (fig.1) was recorded in the closer spacing (S_1) 1.25 x 1.25 m and this is due to the higher plant population (6400 plants/ha) accommodated by this spacing and it was followed by S_2 (1.50 x 1.25 m) spacing with (4.85 t). The minimum flower yield ha^{-1} was in S_7 (2.00 x 1.50 m) spacing with (4.39 t). Hence closest spacing of 1.25 x 1.25 m is recommended since *J. nitidum* plants can be maintained with compact canopy with regular pruning. It may be due to the higher plant population per unit area accommodated with closer spacing as suggested by (Patel *et al*., 2006) in *Polianthes tuberosa*. Similar results were reported by (K. P. Singh, 2003) in *Polianthes tuberosa*, (R. M. Yadav, Dubey, & Asati, 2004) [56] in *Tageteserecta*, (Gurav *et al*., 2005) [16, 17] in *Gerbera jamesonii*, (Girish, Raddy, Balaji, & Kulkarni, 2008) [12, 13] in *Heliconia spp*, (Ranveet, 2009) [35, 36] in *Dendranthema grandiflora*, (Tingare, Patil, Ranshur, Todmal, & Musale, 2007) [54], (Natarajan & Vijyakumar, 2002) [26, 27, 28], (Srivastava *et al*., 2005) [47, 48], and (Lakshmi *et al*., 2014) [22] in *Tagetes erecta*, (Dorajeerao & Mokashi, 2012a) [6] in *Dendranthema grandiflora* and (Subhendu Jena and CR Mohanty, 2021) [50] in Annual Chrysanthemum.

Table 2: Effect of plant spacing on Flower Yield and Quality parameters of *Jasminum nitidum*

Treatment			Weight of hundred flower buds (g)	Weight of single flower bud (g)	Annual flower yield plant^{-1} (g)	Estimated annual flower yield ha^{-1} (t)	Flower bud length (cm)	Corolla tube length (cm)	Total Length of flower bud (cm)	Flower bud width (cm)
Code	Spacing (m)	No. of plants/ha								
S 1	1.25 x 1.25	6400	16.417	0.1641	827.63	5.29	1.893	1.784	3.677	0.491
S 2	1.50 x 1.25	5330	16.841	0.1684	909.67	4.85	1.921	1.802	3.723	0.499
S 3	2.00 x 1.00	5000	17.097	0.1709	966.61	4.83	1.947	1.822	3.769	0.502
S 4	1.75 x 1.25	4570	17.213	0.1721	1041.31	4.76	1.981	1.849	3.830	0.506
S 5	1.50 x 1.50	4440	17.530	0.1753	1070.41	4.75	2.010	1.872	3.882	0.511
S 6	2.00 x 1.25	4000	17.884	0.1784	1173.01	4.69	2.041	1.897	3.938	0.516
S 7	2.00 x 1.50	3330	17.897	0.1789	1319.69	4.39	2.057	1.905	3.962	0.519
Mean			17.268	0.1726	1044.05	4.79	1.978	1.847	3.826	0.506
S.Ed			0.448	0.0032	14.81	0.09	0.042	0.040	0.065	0.011
CD (p=0.05)			0.976	0.0069	32.27	0.19	0.092	(NS)	0.142	(NS)

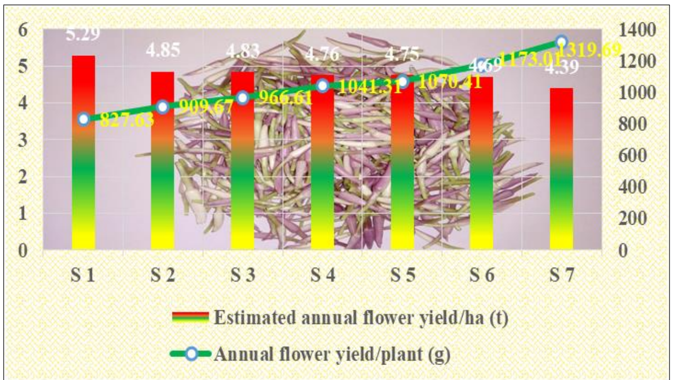

Fig 1: Effect of plant spacing on annual flower yield plant^{-1} (g) and estimated annual flower yield hectare^{-1} (t) of *Jasminum nitidum*

Among the seven plant spacing, the flower bud length (without corolla tube) was maximum in S_7 (2.00 x 1.50 m) spacing with the value of (2.057 cm) and it was on par with S_6 (2.00 x 1.25 m) spacing which recorded the values of (2.041 cm) respectively.

The minimum flower bud length (without corolla tube) (1.893) was recorded in S_1 (1.25 x 1.25 m) spacing. The plant spacing, S_7 (2.00 x 1.50 m) was recorded maximum corolla tube length (1.900 cm) and it was closely followed by S_6 (2.00 x 1.25 m) spacing which recorded the value of (1.891 cm) respectively. The minimum corolla tube length of (1.774 cm) was recorded in S_1 (1.25 x 1.25 m) spacing. The total length of flower bud (cm) was maximum in S_7 (2.00 x 1.50 m) spacing with the values of (3.962 cm) and it was on par with S_6 (2.00 x 1.25 m) spacing which recorded the values of

(3.938 cm) respectively. The minimum total length of flower bud (3.677 cm) was recorded in S_1 (1.25 x 1.25 m) spacing. The flower bud width (cm) was maximum in S_7 (2.00 x 1.50 m) spacing with the values of (0.519 cm) and it was on par with S_6 (2.00 x 1.25 m) spacing which recorded the values of (0.516 cm) respectively. The minimum total length of flower bud (0.491 cm) was recorded in S_1 (1.25 x 1.25 m) spacing. The superior flower quality parameters in wider spacing could be attributed to the overall superiority of wider spacing in enhancing the vegetative parameters which was due to better utilization of light and soil moisture resulting in production of higher photosynthates and ultimately leading to increase in the flower quality parameters.

The decrease in the yield attributing parameters in closer spacing might be due to the higher inter-plant competition which might have limited the availability of nutrients and light. Similar results were reported by (A. K. Singh *et al.*, 2015) in *Tagetes erecta.*

These results are in conformity with the findings of (N. Desai *et al*., 2005) [4, 16, 17] in *Polianthes tuberosa*, (Ramachandrudu & Thangam, 2007) [33] in *Gladiolus spp* and (Ranveet, 2009) [35, 36] in *Dendranthema grandiflora*, (Kołodziej, 2008) [20] and (Osman & Sewedan, 2014) in *Solidago canadensis*.

Physiological parameters

Data pertinent to the Physiological parameters are presented in Table 3. Among the different plant spacing treatments imposed, the highest leaf area of the plant (2040.96 and 6783.52 cm^2) was recorded in the treatment S_7 (2.00 x 1.50 m) spacing and it was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (1655.54 and 5489.77 cm^2) at 180 and 360 DAP respectively. The lowest values of leaf area (446.81 and 1458.98 cm^2) at 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing. The highest leaf area index (2.229 and 1.933) was observed in the treatment S_7 (2.00 x 1.50 m) spacing during 180 and 360 DAP respectively and this was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (2.173 and 1.763). The lowest leaf area index (1.463 and 1.065) at 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing. This may be due to the fact that at wider spacing, plants must have faced less competition for moisture and sunlight which was reflected in the production of higher number of branches, increased leaf production with maximum leaf area as suggested by (Gangadharappa, 2000) [10, 11]. Similar results were reported by (H. Sumangala, V. Patil, & M. Rao, 2003) [51, 52] in *Jasminum sambac* and (B. S. Yadav *et al.*, 2005a) [55] in *Polianthes tuberosa* and (Girish *et al.*, 2008) [12, 13] in *Heliconia spp*.

Table 3: Effect of plant spacing on Physiological parameters of *Jasminum nitidum* at different stages

Treatment			Total leaf area plant^{-1} (cm^2)		Leaf area index		Total chlorophyll (mg/g)		Total phenol content (mg/g)	
Code	Spacing (m)	No. of plants/ha	180 DAP	360 DAP	180 DAP	360 DAP	180 DAP	360 DAP	180 DAP	360 DAP
S_1	1.25 x 1.25	6400	446.81	1458.98	1.463	1.065	0.8161	0.9640	3.776	6.186
S_2	1.50 x 1.25	5330	614.15	2105.87	1.605	1.213	0.8982	1.117	3.964	6.740
S_3	2.00 x 1.00	5000	894.57	2562.92	1.992	1.299	0.9691	1.2195	4.264	7.430
S_4	1.75 x 1.25	4570	1170.93	3462.86	2.146	1.431	1.1679	1.2441	4.704	7.730
S_5	1.50 x 1.50	4440	1365.22	4437.12	2.151	1.666	1.1973	1.2940	5.410	7.973
S_6	2.00 x 1.25	4000	1655.54	5489.77	2.173	1.763	1.2770	1.3180	5.803	8.702
S_7	2.00 x 1.50	3330	2040.96	6783.52	2.229	1.933	1.3868	1.4957	6.007	8.995
Mean			1169.74	3757.29	1.965	1.481	1.1018	1.2360	4.847	7.679
S.Ed			23.24	91.63	0.047	0.033	0.0255	0.0286	0.093	0.206
CD (p=0.05)			50.63	199.65	0.104	0.073	0.0556	0.0623	0.202	0.449

Data pertaining to the impact of different levels of plant spacing on the total chlorophyll content at different stages of plant growth are furnished in Table 3. Among the seven plant spacing, highest total chlorophyll content (1.3868 and 1.4957 mg g^{-1}) was observed in the treatment S_7 (2.00 x 1.50 m) spacing during 180 and 360 DAP respectively and it was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (1.2770 and 1.3180 mg g^{-1}). The lowest total chlorophyll content (0.8161 and 0.9640 mg g^{-1}) at 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing. Wider spacing of 2.00 x 1.50m (S_7) had increased chlorophyll content because its associated characters might have attributed to increased biomass production because of increased chlorophyll contents and photosynthetic efficiency. Similar results were reported by (Sheel, Bhattacharjee, & Vijaykumar, 2006) [42]. The intensity of the greenness in terms of chlorophyll content of the plant had influenced the photosynthetic rate and thereby the efficiency of the plant is improved for increased biomass production. (Sivakumar, Chandrasekhar, & Srividhya, 2014) [45] reported in *J. sambac* a highly significant correlation of chlorophyll content with photosynthetic rate.

Among the seven plant spacing, highest total phenol content of the plant (6.007 and 8.995 mg g^{-1}) was also recorded in the treatment S_7 (2.00 x 1.50 m) spacing and it was followed by S_6 (2.00 x 1.25 m) spacing which recorded the values of (5.803 and 8.702 mg g^{-1}) at 180 and 360 DAP respectively. The lowest total phenol content of the plant (3.776 and 6.186 mg g^{-1}) at 180 and 360 DAP were observed in S_1 (1.25 x 1.25 m) spacing. The accumulation of phenols might be due to the excess production of hydrogen peroxide by increased respiration (Farkas & Kiraaly, 1962) [7] or due to the activation of hexose monophosphate (HMP) shunt pathway, acetate pathway and release of bound phenols by hydrolytic enzymes (Goodman, Király, & Zaitlin, 1967) [14]. The depletion in sugar level is also responsible for the accumulation of phenols since the sugars are utilized for the synthesis of phenols (Fruton & Simmonds, 1960) [8].

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