The Pharma Innovation Journal 2023; 12(2): 2615-2617

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(2): 2615-2617

www.thepharmajournal.com
Received: 15-12-2022
Accepted: 24-01-2023

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Response of chrysanthemum to different planting densities under hot and humid climatic conditions

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Abstract
An investigation entitled "Response of chrysanthemum to different planting densities under hot and humid conditions" was undertaken at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during 2020 to 2022. Result of the study revealed that among three different spacings *viz*., 30 cm x 30 cm (S_1), 45 cm x 30 cm (S_2) and 60 cm x 30 cm (S_3) tried, wider spacing S_3 (60 cm x 30 cm) was found superior with respect to number of branches per plant (14.89), leaves per plant (60.16), average plant spread (22.81 cm), stem diameter (5.86 mm), flowering duration (51.16 days) and number of flowers (33.49) and per plant while maximum plant height (23.07 cm), minimum days for flower bud initiation (41.90 days) and 50 percent flowering (58.26 days) were recorded in closer spacing S_1 (30 cm x 30 cm).

Keywords: Chrysanthemum, spacing, flowering

Introduction
Chrysanthemum is commonly known as Guldaudi, Autumn Queen or Queen of the East (Koley and Sarkar, 2013) [19]. It belongs to family Asteraceae and is native to Northern Hemisphere chiefly Europe and Asia. The word chrysanthemum is derived from the Greek words 'chrysos' (gold) and 'anthemon' or 'anthos' (flower). It has diverse and beautiful range of colour shades, shapes and size. It is grown as cut flower, loose flower, potted plant, bedding plant and also for exhibitions and garden display purpose. It is mostly used in our country for making garlands, venis, bracelets, flower decoration and religious offerings (Bohra and Kumar, 2014) [5].
Chrysanthemum is grown both for its aesthetic and commercial value. It covers about 20090 ha area with production of 185240 MT of loose flower and 14930 MT of cut flower in India during 2015-2016 (Anon, 2018) [3]. Wide variation in its growth habit, vase life and its amenability to various growth regulatory practices has made chrysanthemum flower popular among flower growers. Also, ease of its cultivation, high returns, and increasing market demand are the main reasons for the popularity of this crop.
Since, ultimate aim of any crop is the productivity and good quality produce different agro-techniques are followed. Also among different crop management practices, planting density influences the plant growth to a major extent. Mainly it affects flower number by modifying the microclimate of the plants, exerting a considerable influence on the performance of the crop by creating competition between plants for nutrients, water and light. This makes it necessary to study optimum spacing for maximization of production of quality flowers.

Material and Methods
The present investigation was carried out at Hi-Tech unit, College of Horticulture, Dapoli, Dr. Balasaheb Sawant Krishi Vidyapeeth, Dapoli, Dist-Ratnagiri (M.S) during the period 2020-21 and 2021-22.The experiment was laid out in a randomized block design with three treatments comprising 30 cm x 30 cm (S_1), 45 cm x 30 cm (S_2) and 60 cm x 30 cm (S_3) and seven replications. The field was thoroughly prepared and healthy and uniform seedlings of cv. Zhizhino yellow were transplanted on raised beds following different spacing levels as per treatments. A regular watering, weeding and plant protection measures were carried out as and when required. Five plants were selected randomly from each plot for recording data on various growth and flowering attributes. The observations were recorded during the course of investigation and subjected to statistical analysis as per Panse and Sukhatme (1995) [12]. The appropriate standard error of mean S.E. (m) and the critical difference (C.D.) were calculated at 5% level of probability.

Results and Discussion

The standardization of important agro technique like spacing is of paramount importance which decides the performance of the produce. During present investigation three different spacing's were tested for two years.

Significantly highest plant height (23.07 cm) was observed in closer spacing S_1 (30 cm x 30 cm) and lowest (19.85 cm) in wider spacing S_3 (60 cm x 30 cm). Increase in plant height at closer spacing might be due to heavy competition between plants for light, moisture, space and aeration which increases the stem elongation by increasing the cell size and cell number (Singh *et al*., 2018) [16]. It can also be the indication of a classical shade avoidance response, where plant height tends to increase with higher planting densities (Smith, 1982) [17]. On the contrary, Sanwal (2005) [13] and Singh *et al.* (2015) [14] reported maximum height in wider spaced chrysanthemum plants.

The wider spacing S_3 (60 cm x 30 cm) was superior among all the treatments with respect to number of branches per plant (14.89) and number of leaves per plant (60.16) while closer spacing S_1 (30 cm x 30 cm) marked the least branches (11.36) and leaves (56.89) per plant.

According to Harper (1977) [7] at higher planting density, per plant light interception is less which results in per plant lower carbon fixation that reduces the plant's ability in carbon assimilation and translocation towards new branch production and thus potentially reduces the number of branches per plant. However, increase in number of branches and leaves per plant at lower planting density, might be attributed to sufficient amount of light, air and nutrients producing more photosynthates and hence more number of branches and leaves utilizing proper carbohydrates. Similar results were also reported by Aashutosh *et al*. (2019) [1] in chrysanthemum. On the contrary, Beniwal (2001) [4] reported maximum branches per plant in chrysanthemum when planted at closer spacing.

A decrease in number of leaves with increase in plant height was also ascertained to typical plant response towards the changing densities and neighbor detection. The plants in closer spacing develop a strategy to grow taller in order to capture more photosynthetic radiation at the expense of leaves being smaller and lesser (Smith, 1982) [17]. It also cause etiolation of leaves due to shading effect, which lead to decrease in the number of leaves (Ameri *et al*., 2008) [2] with the plant height.

The average spread of the plant (22.81 cm) was found maximum under wider spacing S_3 (60 cm x 30 cm) which was at par (21.86 cm) with medium spacing S_2 (45 cm x 30 cm) and minimum (20.14 cm) under closer spacing S_1 (30 cm x 30 cm). Singh *et al.* (2005) [15] observed less radiation interception when plants were closely spaced which might be due to the somewhat vertical orientation of auxiliary shoot and leaves causing less absorption of solar radiations.

However, plants at wider spacing were found to intercept highest radiations thereby increasing the temperature and reducing the relative humidity owing to higher foliage and more horizontal orientation of shoots and leaves. This increase in plant spread also might be due to increased lateral growth at the expense of apical growth. (Mohammed *et al*., 1984) [10].

Table 1: Effect of planting density on growth and flowering parameters of chrysanthemum cv. Zhizhino yellow

Spacing	Plant height (cm)	Number of branches	Number of leaves	Average plant spread (cm)	Stem diameter (mm)	Flower bud initiation (days)	Days to 50% flowering	Duration of flowering (days)	Number of flowers per plant
S_1	23.07	11.36	56.89	20.14	4.68	41.90	58.26	47.26	6.83
S_2	21.03	13.15	58.86	21.86	5.27	43.07	60.85	49.40	6.27
S_3	19.85	14.89	60.16	22.81	5.86	44.84	63.16	51.16	6.03
Mean	21.32	13.13	58.64	21.60	5.27	43.27	60.76	49.27	6.38
F Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.16	0.30	0.28	0.21	0.12	0.29	0.38	0.31	0.15
CD at 5%	0.48	0.91	0.87	0.65	0.38	0.89	1.16	0.94	0.45

The basal stem diameter (5.86 mm) was also recorded maximum in wider spacing S_3 (60 cm x 30 cm) and minimum (4.68 mm) in closer spacing S_1 (30 cm x 30 cm).The decrease in plant height is generally associated with increase in stem diameter, because shorter the height thicker is the stem and vice versa (Zuo *et al.*, 2021) [18]. Smith, 1982 [17] also observed a significant decrease in stem diameter with the increase in plant height. He explained it with a plant strategy to grow taller in order to capture more photosynthetic radiation at the expense of stems being thinner.

Maximum days for flower bud initiation (44.84 days) and 50 per cent flowering (63.16 days).were recorded in wider spacing S_3 (60 cm x 30 cm) while minimum days for flower bud initiation (41.90 days) and 50 per cent flowering (58.26 days) were observed in closer spacing S_1 (30 cm x 30 cm). Earliness in flower bud initiation might be ascribed to the fact that individual plant grown at the closer spacing might have entered its reproductive phase earlier due to more competition among the plants for nutrient, moisture, sunlight, etc. Similar findings were reported by Kour (2009) [9] in chrysanthemum cv. Flirt. On the contrary, Joshi *et al*. (2016) [8] in annual chrysanthemum recorded earliness in flower bud initiation at wider spacing.

Maximum flowering duration (51.16 days) was recorded in wider spacing S_3 (60 cm x 30 cm) while minimum flowering duration (47.26 days) was recorded in closer spacing S_1 (30 cm x 30 cm). Plants spaced widely, remained in vegetative phase for longer duration on account of lesser competition for space and light. This increased the duration of flowering which was also reported by Kour (2009) [9] in chrysanthemum.

The number of flowers per plant (33.49) were found maximum under wider spacing S_3 (60 cm x 30 cm) and minimum (22.55) under closer spacing S_1 (30 cm x 30 cm). Plants grew more luxuriantly under wider spacing due to more availability of nutrients and space and results in production of more vegetative growth which is responsible for mobilization of biomass from source to sink i.e. flowers. (Dorajeerao *et al*., 2012) [6]. As a result of this the widely spaced plants had comparatively higher levels of organic

reserves, conductive for better floral development which there by increased the number of flowers per plant. (Nagdeve *et al*., 2021) [11].

Conclusion

The chrysanthemum cv. Zhizhino yellow at wider spacing shows better vegetative growth and maximum number of flowers per plant whereas when planted at closer spacing experiences early flowering.

Acknowledgment

The authors are highly grateful to the Associate dean, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for providing all the facilities during the period of research work.

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