

Optimization of Spacing, doses of Vermi-compost and Foliar Application of Salicylic Acid on Growth, Flowering and Soil Health of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. “Guldasta”

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ABSTRACT

A field experiment was conducted during the year 2018-2019 to study the effect of spacing (50×50, 50×60 and 50×75), dose of vermi-compost (0, 5.0 and 10.0 ton/ha) and foliar application of salicylic acid (0, 100 and 200 ppm) on the growth, flowering and soil health of chrysanthemum. The experiment was laid out in a factorial randomized block design with twenty seven treatments and three replications. Significant improvement in growth and flowering characters was recorded with closer spacing (50×50 cm) except plant spread, number of flowers/plant, weight of individual flower, diameter of flower, shelf life and stalk length while, plants grown at wider spacing had maximum available NPK in post harvested soil. Gradual increases doses of vermicompost for 0 to 10.0 ton/ha significantly improved plant growth, flowering and yield attributing traits alongwith higher availability of NPK in post harvested soil. Among the foliar spray of salicylic acid, salicylic acid (100 ppm) significantly produced good plant growth and flower yield except induced early flowering and 50% flowering however, control showed maximum availability of NPK in post-harvested soil. Among the combined combinations, maximum flower yield/plant was recorded with treatment combination T₂₆(S₃+VC₂+SA₁) and treatment combination T₈(S₁+VC₂+SA₁) resulted in maximum flower yield/plot and flower yield/ha during course of study.

Highlights

- ① The closer spacing showed (50×50 cm) gave maximum plant height and flowering yield/ha while wider spacing (50×75 cm) resulted in maximum plant spread, number of flowers/plant, weight of individual flower, diameter of flower, shelf-life and stalk length.
- ① Gradual increases doses of vermicopost had maximum plant growth, flower yield and higher availability of NPK in post-harvested soil.
- ① An application of salicylic acid @ (100 ppm) significantly produced good plant growth and higher flower yield except induced early flowering and 50% flowering however, control showed maximum availability of NPK in post-harvested soil.
- ① Combined effect of different treatments, maximum flower yield/plant (162.39 g) was recorded with treatment combination T₂₆(S₃+VC₂+SA₁). However, treatment combination T₈(S₁+VC₂+SA₁) resulted in maximum flower yield/plot (4.87 kg) and flower yield (3.79 ton/ha).

Keywords: chrysanthemum, spacing, vermicompost, salicylic acid, growth and flowering



Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is a leading commercial crop grown for cut loose flowers and also as a pot plant (Navale *et al.* 2010). Chrysanthemum is one of the more popular flowers grown in our country for its diversified beauty of colours, shapes, shades and keeping quality. Flowers of standard varieties are produced on long, sturdy stems and have a good keeping quality. These characters make it highly suitable for flower arrangements. Flower of spray varieties are highly suitable as loose flower for making Garland, Veni and Gajara. It is highly suitable for beds, pots and floral arrangement. Its bloom last over a short period of 1 to 2 months. Hence, they command and give remunerative price in the market. On account of its good keeping quality, chrysanthemum flowers can be transported to a distant market easily.

Optimum spacing plays a significant role to increase the higher production of flower and flower yield (Critto *et al.* 1980). Besides spacing, doses of vermi-compost have been recognized as an effecting means for improving soil aggregation structure, fertility and enhancing microbial diversity, moisture holding capacity of soil and crop yield (Zink and Allen 1998; Barakan *et al.* 1995). Vermicomposting, through earthworm, is an important and eco-friendly process that transform energy rich and complex organic substances in to stabilized vermi-compost (Bentize *et al.* 2000). The use of vermi-compost improved soil structure, texture and enhanced soil fertility (Follet *et al.* 1981).

There are few chemical substances capable of inducing flowering in individual plants. Gibberellins, ethylene and cytokinins are all known to induce flowering in one or more plants (Charles and Tanaka 1979). The plant growth regulators like salicylic acid also play an effective role in the regulation of certain events in flowering of plants (Raskin 1992). It may help to regulate several plant functions, including systemic acquire resistance to pathogens and the formation of flowers. It has also been reported that salicylic acid induce flowering in several species of Lemnaceae (Cleland *et al.* 1974; Cleland *et al.* 1982). There are few reports on effect of salicylic acid on plant growth and flowering (Martinez *et al.* 2004; Jabbarzadeh *et al.* 2009). This investigation was carried out to evaluate the effect of spacing, doses of vermi-compost and foliar application of salicylic acid on growth, flowering and soil health of

Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Guldasta.

MATERIALS AND METHODS

The present investigation was carried out at Horticultural Research Centre (HRC), Sardar Vallabhbhai Patel University of Agriculture of technology, Meerut (U.P.) during 2018-19 to assess the effect of spacing, doses of vermi-compost and foliar feeding of salicylic acid on optimization of growth and flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Guldasta. The experiment was laid out in a factorial randomized block design with twenty seven treatments and three replications. Fully rooted cutting were planted at various spacing i.e. 50×50, 50×60 and 50×75 cm, doses of vermi-compost (0, 5 and 10 ton/ha) was applied before transplanting of crop and salicylic acid spray was applied in the range of 0, 100 and 200 ppm after 20 and 40 days after transplanting of rooted cutting. The basic recommended doses of inorganic fertilizers i.e. 120 kg N (half dose at the time of transplanting and half doses after 25 and 40 days after transplanting) and full dose of 80 kg P₂O₅ and 80 kg K₂O applied uniformly for all the treatments at the time of planting. The cultural practices like irrigation, hoeing, weeding and plant protection measures were done as required by the crop. The vegetative and flowering parameters were recorded during the period of crop while soil parameters were analyzed before and after harvesting the crops. The data was analyzed at 5% level of significance using OPSTAT statistical software. The experiment field soil and compost were tested in laboratory for their different physico-chemical parameters (Table 1 & 2).

Table 1: General soil properties (0–20 cm) before the experiment started in 2017

Parameter	Mean	C.V. ^b (%)
TOC (g kg ⁻¹)	7.44	6.02
Total N (g kg ⁻¹)	0.93	3.02
Olsen-P (mg kg ⁻¹)	9.57	15.66
Available K ^a (mg kg ⁻¹)	191	3.30
Total porosity (%)	49.6	5.8
Bulk density (g cm ⁻³)	1.35	3.70
Parameter	Mean	C.V. ^b (%)

Note: mean values of parameters in the table were calculated from data for all experimental plots.

^a Available K was extracted with 1 M NH₄AC; ^bC.V. is coefficient of variation.



Preparation of vermicompost

The vermicompost (with earthworm *E. eugeniae*) produced by a mixture of different individual organic wastes i.e. wastes of vegetables and fruits with cattle manure in the ratio of 10:1 on dry weight basis. All experimental sets were maintained with moisture content of about 70- 80% by daily sprinkling of water and terminated after 16 weeks by removing earthworms manually in vermicompost sets. The nutrients of vermicompost are presented in (Table 2).

Table 2: Physio-chemical properties of Vermicompost

Parameters	Vermicompost
pH	7.86
Organic carbon	290.00 g/kg
Nitrogen %	1.38
Phosphorus %	0.80
Potash %	1.20
Ext. Cu (mg/kg)	0.88
Ext. Zn (mg/kg)	275.00
Ext. Fe (mg/kg)	9.20
Ext. Mn (mg/kg)	12.80
Exch. Na (g/kg)	6.80
Exch. Ca (g/kg)	18.80
Exch. Mg (g/kg)	5.8

Ext. – Extractable, Exch. - Exchangeable.

Estimation of physio-chemical analysis of soil and vermicompost: A set of five soil (0–20 cm depth) samples were taken from each plot and pooled together. The samples were stored at 4 °C for further physio-chemical analysis. Soil porosity was measured using tension table method as per the procedure explained by (Vomocil 1965). Bulk density of soil was measured by core sampler method developed by (Blake 1965)]. Vermicompost were collected in polythene bags and analyzed for physico-chemical parameters to know the nutrient status. The pH was measured in 1/10 (w/v) aqueous solution (deionized water) using digital pH meter (Systronic made. The organic carbon was determined by the partially-oxidation method (Walkley and Black 1934). Total N was analyzed using a Kjeldahl digestion method (Jackson 1967) while total P and K were determined using a wet digestion (Di-acid digestion) method as described earlier (Prasad *et al.* 2006). Exchangeable Na, Ca and Mg were determined

after extracting the sample using ammonium acetate (Simard, 1993) and analyzed by using atomic absorption spectrophotometry (AAS, Perkin-Elmer A Analyst 100). Metals were determined by DTPA (diethylenetriaminepentaacetic acid) extraction method. 10gm of air-dried soil was taken in a 50 ml conical flask and 20 ml of the DTPA extracting solutions was added to it. The solution was extracted on a horizontal shaker for two hours. After exactly two hours of shaking, suspension was filtered by gravity through Whatmann No.42 filter paper. The filtrate was analyzed for Cu, Zn, Fe and Mn subjected for using AAS.

RESULTS AND DISCUSSION

Impact of spacing doses of vermicompost and foliar application of salicylic acid on growth and flowering of chrysanthemum

It is clear from (Table 3) that all the vegetative and flowering characters were significantly influenced by various spacing, doses of vermicompost and foliar application of salicylic acid. The data showed that the maximum plant height (62.26 cm) was recorded under the treatment S₁ (50 × 50 cm) while minimum height of the plant (60.55 cm) exhibited by wider spacing (50 × 75) cm. At closer spacing more plant height might be due to heavy competition between plants for light resulted in elongation of main stem and also might be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another. These results were in accordance with the findings of Karavadia and Dhaduk (2002) in annual chrysanthemum and Shivakumar (2000) in marigold. Maximum plant spread plant (35.05cm), number of primary branches (21.35) and number of secondary branches (26.92cm) were recorded at wider spacing (50×75) whereas, minimum plant spread (33.03 cm), number of primary branches (19.77) and number of secondary branches (24.45) were recorded with closer spacing (50×50 cm). The favorable effect of wider spacing in promoting plant growth might be due to that the wider spacing seems to have helped to the individual plant to utilize more soil, water, nutrition, air and light to help to put up better growth than those having closer spacing, where the plant population per unit area has increased. Similar results have been

**Table 3:** Impact of spacing, doses of vermi-compost and foliar application of salicylic acid on growth and flowering of chrysanthemum

Treatment	Plant height (cm)	Plant spread (cm)	Number of branches/plant		Days to first bud initiation	Days to 50% flowering	Shelf-life (hrs)	Stalk length (cm)
			Primary branches	Secondary branches				
Spacing (cm)								
S ₁ (50×50)	62.26	33.03	19.77	24.45	68.84	100.58	47.70	5.06
S ₂ (50×60)	61.35	33.64	20.40	26.03	67.05	98.86	48.32	5.20
S ₃ (50×75)	60.55	35.05	21.35	26.92	65.41	97.23	49.00	5.36
Vermi-compost (ton/ha)								
VC ₀ (0)	59.54	32.71	19.42	24.04	70.30	101.43	47.10	4.93
VC ₁ (5)	61.68	34.14	20.62	26.46	66.16	98.18	48.55	5.27
VC ₂ (10)	62.93	34.86	21.48	26.91	64.84	97.07	49.38	5.41
Salicylic acid (ppm)								
SA ₀ (0)	58.20	32.29	18.94	23.45	72.88	104.16	44.92	4.54
SA ₁ (100)	63.32	34.90	21.55	27.29	64.44	96.48	50.14	5.56
SA ₂ (200)	62.64	34.53	21.03	26.67	63.97	96.04	49.97	5.51
CD at 5%	0.07	0.016	0.032	0.032	0.051	0.044	0.064	0.008

reported by Vinayak *et al.* (2017) in salvia. Minimum days required for first bud initiation (65.41 days) and days 50% flowering (97.23 days) were recorded at wider spacing (50×75) while, closer spacing (50×50 cm) induced later bud initiation (68.84 days) and 50% flowering (100.58 days) respectively. The favorable effect of wider spacing inducing early flowering might be due to more space available to the plants to absorb more nutrients from soil for better growth and development of plants. The other apparent reason may be due to less competition to plants at wider spacing as results reduced shading effect and increased open area for better light exposure. The same feature holds good for soil moisture availability at wider spacing. Similar results were also reported by Kour (2009) in chrysanthemum and Pal *et al.* (2015) in gladiolus. Maximum shelf life (49hrs) and stalk length (5.36 cm) was recorded with wider spacing (50×75) on the other hand closer spacing (50×50 cm) resulted in minimum shelf-life (47.70 hrs) and stalk length (5.06 cm). The beneficial effect of wider spacing on the shelf life and stalk length may be due to reduced shading effect and increased open area for better light exposure and extraction of more nutrients under wider spacing of plants (Khalaj *et al.* 2012; Dorajeero and Mokashi 2013; Bhande *et al.* 2015). Various doses of vermi-compost (0 – 10 ton/ha) had significant effect on growth and flowering

parameters of chrysanthemum. Treatment VC₂ (10 ton/ha) resulted in maximum height of the plant (62.93cm), plant spread (34.86 cm), number of primary branches (21.48) and number of secondary branches (26.91) while minimum plant height (59.54 cm), plant spread (32.71 cm), number of primary branches (19.42) and number of secondary branches (24.04) were noted with control. The favorable effect of vermi-compost to increased vegetative growth in chrysanthemum plants might be due to soil built-up organic carbon, improve nutrient status, and enhance cation exchange capacity, microbial activities, microbial biomass carbon and enzymatic activities. The earthworms' castings also have pest repellent attributes. Beside that vermicompost also improves soil structure, soil aggregation and improve water retention capacity (Kumar *et al.* 2018). Neilsan (1985) reported that the presence of plant growth promoting compound elaborated by earthworm promote a significantly increase in plant growth and N uptake. Sainz *et al.* (1998) reported that the beneficial effect of vermi-compost on plants might be due to the addition of vermi-compost to soil resulted in increase mineral content in substrate and higher concentration of P, Ca, Mg, Cu, Mn and Zn. Another favorable effect of vermi-compost may be due to after application into soil, the plant growth bacteria (PGB) directly stimulate



growth through nitrogen fixation and plant growth stimulates (Han *et al.* 2005). The results are close conformity with the findings of Maniram *et al.* (2012) in gladiolus. The plant receiving VC₂ (10 ton/ha) emerged earlier flower bud initiation (64.84 days) and 50% flowering (97.07 days) while control took maximum days to flower bud initiation (70.30 days) and 50% flowering (101.43 days) respectively. It may also be due to increase in absorptive surface area of the roots might have led to enhanced uptake and translocation of available water and nutrients like P, Zn, Fe, Mg and Cl, ultimately resulting in better sink for faster mobilization of photosynthesis and early transformation of plant parts from vegetative to reproductive phase. Similar results were also reported by Singh *et al.* (2012) in marigold, Singh *et al.* (2010) in chilli, Singh *et al.* (2013) in gladiolus; Kumar (2014) in gladiolus; Kumar, (2014) in tuberose; Tiwari *et al.* (2018 b) in marigold. The treatment VC₂ (10 ton/ha) had maximum shelf life (49.38 hrs) and stalk length (5.41cm) while minimum shelf life (47.10 hrs) and stalk length (4.93 cm) was registered with control. The best effect of vermicompost had been registered for increasement of number of florets and these florets indirectly increase shelf life of flowers. Increase shelf life and stalk length might be due to increased more uptake of nutrient by plant and greater development of water conducting tissues. Similar results were also reported by Bhalla *et al.* (2007) in carnation and Maniram *et al.* (2012) in gladiolus.

As far as concentrations of salicylic acid, maximum height of the plant (63.32 cm), plant spread (34.90 cm), number of primary branches (21.55) and number of secondary branches (27.29) were recorded with salicylic acid @ 100ppm, which continuously decreased with @ 200 ppm and control respectively. It is due to that application of salicylic acid on plant decreased ethylene production and stimulated plant growth (Sarek 1992). Similar findings have been reported by Kamkari *et al.* (2016) in marigold. Flowering character like minimum days required for first bud initiation (63.97 days) and days for 50% flowering (96.04 days) were recorded with 200 ppm of salicylic acid while control took more days for flower bud initiation (72.88) and 50% flowering (104.16). Earlier floral bud initiation has also been induced by salicylic acid concentrations because this stimulating agent accelerates biosynthesis of

secondary metabolites. SA as a manager of blooming time, interacts with both photoperiod-dependent and self-governing pathways. The favorable effect of salicylic acid deficient plant displayed a late flowering due to high based expression of FLC gene Martinez *et al.* (2004) and decreasing the duration of first flower opening might be due to the given emergence of floral bud Khurama and Cililand (1992). These results were in conformity with Hayat and Ahmad (2007); Hayat *et al.* (2010) who had reported similar results. The findings are in line with Martin *et al.* (2005) in African violates. The maximum shelf life of flower (50.14 days) was found under the treatment SA₁ (100 ppm), which decreased (49.97 days) with SA₂ (200 ppm) and control attained minimum shelf life (44.92 days). Salicylic acid has great impact on sustaining shelf life in flowering plants particularly equitable interrupted in flowering anatomy. Adding together of small quantity of compound salicylic acid postponed time of senescence, while large amount brought prompt changes by mean of abscission as well as induced senescence in lupine cut flower (Mackay *et al.* 2000). Similar results were also reported by Al-hasnawi *et al.* (2019) in gladiolus, Rahmania *et al.* (2015) in gladiolus and Roodbaraky *et al.* (2012) in carnation. Maximum length of stalk (5.56 cm.) was recorded with application of salicylic acid @ 100 ppm and control produced minimum stalk length (4.54 cm). Salicylic acid plays an important role in flower stalk length, due increasing stem elongation. The stalk length increased as level précised of salicylic acid, since cell elongation and cell expansion occurred (Raskin 1992). Khandaker *et al.* (2011) also observed significant increasement in stalk length of Red Amaranthus by foliar application of SA as compared to control plants.

Effect of spacing, doses of vermicompost and foliar application of salicylic acid on qualitative characters of chrysanthemum

The data revealed (Table 4) that different spacing showed significant differences among the qualitative traits of chrysanthemum. Wider spacing (50×75 cm) resulted in maximum number of flowers/plant (47.61) while closer spacing (50×50 cm) showed minimum number of flowers/plant (46.16). The beneficial effect of wider spacing on more production of flowers may be due to reduced

Table 4: Impact of spacing, doses of vermi-compost and foliar application of salicylic acid on qualitative traits of chrysanthemum

Treatment	Number of flowers		Diameter of flower (cm)	Weight of individual flower (g)	Flower yield/plant(g)	Flower yield/plot(kg)	Total flower yield(ton/h)
Spacing (cm)	Number of flowers/plant	Number of flowers/plot					
S ₁ (50×50)	46.16	1,661.40	5.24	2.12	107.27	3.86	2.99
S ₂ (50×60)	46.95	1,408.64	5.41	2.21	117.16	3.51	2.73
S ₃ (50×75)	47.61	1,142.66	5.58	2.29	126.17	3.03	2.35
Vermi-compost (ton/ha)							
VC ₀ (0)	45.11	1,350.46	5.06	1.85	98.62	2.93	2.27
VC ₁ (5)	47.54	1,423.11	5.51	2.28	122.85	3.64	2.83
VC ₂ (10)	48.07	1,439.13	5.64	2.49	129.12	3.83	2.98
Salicylic acid (ppm)							
SA ₀ (0)	43.40	1,300.60	4.76	1.46	83.36	2.49	1.93
SA ₁ (100)	48.74	1458.13	5.76	2.75	135.03	4.00	3.11
SA ₂ (200)	48.59	1,453.87	5.70	2.41	132.20	3.92	3.04
CD at 5%	0.028	1.083	0.009	0.007	0.386	0.011	0.009

shading effect and increased open area for better light exposure and more extraction of nutrient for plants (Khalaj *et al.* 2012; Dorajeerao and Mokashi, 2013; Bhande *et al.* 2015). This may also be due to less competition among the plants for proper space, light and nutrition. Similar findings have been reported by Baboo *et al.* (2005) in marigold, Dorajeerao and Mokashi (2013) in chrysanthemum. Closer spacing (50×50 cm) had the maximum number of flowers/ plot (1661.40) and wider spacing gave minimum number of flowers/plot (1142.66). It could be attributed to accommodation of more number of plants per unit area. Similar results have also been reported by Barman and Pal, (1999) in chrysanthemum. Maximum flower diameter (5.58 cm) was noted with wider spacing (50×75 cm) whereas, plant spaced at closer spacing (50×50 cm) exhibited minimum diameter of flower (5.24 cm). The increase in flower diameter at wider spacing could be attributed to availability of greater space and light for photosynthesis with higher availability and uptake of nutrients by plants which could have enhanced cell division, cell elongation as well as protein synthesis and greater accumulation of dry matter in larger sized sink (flower). The results are close conformity with Pal and Pandey, (2007) and Maniram *et al.* (2012, a and b) in gladiolus and Singh *et al.* (2015 a and b) in marigold. Flower yield parameters showed significant differences among

the spacing. Maximum weight of individual flower (2.29 gm) was recorded with wider spacing (50×75 cm) and minimum weight of individual flower (2.12 g) was registered with control. The significant increase in weight of individual flower under the wider spacing may be due to less competition among the plants for soil, water, nitrogen, air and light. The increase in weight of individual flower at a wider spacing is in complete agreement with the work done by Kour (2009) in chrysanthemum. Srivastava *et al.* (2002) also found reduced weight of individual flower in marigold at the closer spacing as compared to wider spacing. Maximum flower yield/plant (126.17g) gave by wider spacing (50×75 cm) while the plants spaced at closer spacing had minimum flower yield/plant (107.27g) respectively. The increase in flower yield/plant at wider spacing could be attributed to availability of greater space and light for photosynthesis with higher availability and uptake of nutrients by plants which could have enhanced cell division, cell elongation as well as protein synthesis and greater accumulation of dry matter in larger sized sink (flower). The increase of the yield of flower per plant at wider spacing is in complete agreement with the work done by Beniwal *et al.* (2005) in chrysanthemum. The plants spaced at closer spacing S₁ (50×50 cm) gave maximum flower yield per plot (3.86 kg) whereas, wider



spacing gave minimum flower yield/ plot (3.03 kg). Similarly, total flower yield (q/ha) differed each other among spacing and closer spacing S_1 (50x50 cm) had maximum flower yield (2.99 ton/ha) while plants spaced at wider spacing S_3 (50x75 cm) gave minimum total flower yield (2.35 ton/ha). It could be attributed to accommodation of more number of plants per unit area ultimately increased the flower yield/plot as well as total flower yield/ha. Similar results have also been reported by Barman and Pal (1999) in chrysanthemum.

Different doses of vermicompost showed significant differences among the qualitative traits of chrysanthemum. Maximum number of flowers per plant (48.07) and number of flower per plot (1439.13) were recorded with 10 ton/ha of vermi-compost while, control (VC_0) resulted in minimum number of flowers/plant (45.11) and number of flowers/plot (1350.46). The increase in number of flower with increase doses of vermi-compost might be due to that after incorporated of vermi-compost produce good plant growth which enhances the process of more photosynthesis in plants (Tomati *et al.* 1988). These finding were conformity with Padaganur *et al.* (2005) in tuberose, Kumar (2015) in gladiolus.

The treatment VC_2 (10 ton/ha) produced larger size flower (5.64 cm) while control (VC_0) gave smaller size flower (5.06 cm). Treatment VC_2 was registered with in maximum weight of individual flower (2.49 g), flower yield per plant (129.12 g), flower yield per plot (3.83kg) and total flower yield (2.98 ton/ha) whereas, the plants grown without any vermicompost (control) had smaller flower (5.06 cm), minimum weight of individual flower (1.85 g), flower yield per plant (98.62 g), flower yield per plot (2.93 kg) and total flower yield (2.27 ton/ha) respectively. It might be due to increase the vegetative growth of plants that produced more photosynthesis which in turn might have increased the flower diameter. The highest number of flowers per plant and more production of flowers/plot as well as yield/ha might be due to the fact that the application of vermicompost increases good physical and biological conditions of soils which might have improved the physiology of plant to shift from vegetative to reproductive stage. Moreover, vermicompost enhances photosynthesis efficacy which may have enhanced food accumulation resulting in better plant growth and subsequently

higher number of flowers per plant as well as yield (Sunitha *et al.* 2007). The increased production of flower in response to vermi-compost was attributed to a greater availability of mineral nutrient (Edward and Burrovs 1988). Similar results were also reported by Maniram *et al.* (2012 b) in gladiolus.

Application of salicylic acid showed significant differences among the treatments in terms of flowering parameters. Maximum number of flowers per plant (48.74) and number of flower per plot (1458.13) were recorded with foliar application of salicylic acid @ 100 ppm while minimum number of flowers/ plant (43.40) and number of flowers/ plot (1300.60) were noted in control. It might be due to that foliar spray of salicylic acid increased protein synthesis and appearance of new isozyme bands (Kumar and Nanda 1981). Chen *et al.* (1993) reported that salicylic acid inhibited the synthesis of catalase and accumulated of H_2O_2 . Similar results were also reported by Handro *et al.* (1997) in *Streptocarpus nobilis*; Jabbarzadeh *et al.* (2009) in African violet. Application of SA_1 @100 ppm produced larger size of flower (5.76 cm) whereas, control (SA_0) gave smaller size of flower (4.76 cm). Salicylic acid has positive effect on photosynthesis and carbohydrate in leaves and stem due to this reason flower size increased. The increase in flower diameter could be due to the synergism between salicylic acid and auxin. Similar results were obtained by Maniram *et al.* (2012) who recorded increase in flower diameter with application of salicylic acid in gladiolus. Flower yield attributing characters were significantly influenced by various concentrations of salicylic acid and differed each other. Maximum weight of individual flower (2.75 g) was recorded with SA_1 @100 ppm followed by, (2.41 g) with SA_2 @200 ppm and minimum weight of individual flower (1.46 g) was recorded under control. Application of SA significantly increased the weight of flower by improving photosynthetic efficiency (Hayat and Ahmad 2007), stabilization of chlorophyll and assimilates translocation from source to sink which ultimately enhanced weight of flower (Choudhary *et al.* 2016). The results are in agreement with the work done by Naglaa *et al.* (2018) in Zinnia and Basit *et al.* (2018) in marigold. Maximum flower yield/ plant (135.03 g), flower yield/ plot (4.00 kg) and total flower yield/ha (3.11 ton/ha) had been observed with 100 ppm while, SA_0



resulted in minimum flower yield/plant (83.36 g), flower yield /plot (2.49 kg) and total flower yield (1.93 ton/ha) respectively. SA enhances transcription and translation of mRNA and protein (Singh *et al.* 2002), that help in developing new groups of isozymes which enhance the number of flower buds (Bayat *et al.* 2012). These increases of flower buds/plant ultimately increased number of flowers/plot as well as total flower yield/ha. Similar results were also reported by Gad *et al.* (2016) in *Ixora* plant.

Combined effect of spacing, doses of vermicompost and foliar application of salicylic acid on flower yield of chrysanthemum

The combined/interactions effect generated by planting spacing, doses of vermi-compost and foliar application of salicylic acid showed significant

effect on flower yield attributes (Table 5). Maximum flower yield/plant (162.39 g) was recorded with treatment combination T₂₆ (S₃+VC₂+SA₁). The increasing number of flower/plant might be due more plant space along with vermi-compost which provides more nutrients to the plant similarly, foliar application of salicylic acid increased protein synthesis and appearance of new isozyme bands resulted more number of flower/plant. However, treatment combination T₈ (S₁+VC₂+SA₁) resulted in maximum flower yield/plot (4.87 kg) and flower yield (3.79 ton/ha). It might be due to more number of plants at particular area and higher doses of vermi-compost attributed to a greater availability of mineral nutrients to the plants while 100 ppm foliar application of salicylic acid increased protein synthesis and appearance of new isozyme bands resulted more flower yield/ha.

Table 5: Combined impact of spacing, doses of vermi-compost and foliar application of salicylic acid on yield of chrysanthemum

Treatment	Yield of flower			
	Spacing (cm)	Flower yield/plant(g)	Flower yield/plot(kg)	Total flower yield (ton/h)
T ₁ [S ₁ +VC ₀ +SA ₀ (50×50+0+0)]		69.18	2.49	1.93
T ₂ [S ₁ +VC ₀ +SA ₁ (50×50+0+100)]		101.32	3.64	2.83
T ₃ [S ₁ +VC ₀ +SA ₂ (50×50+0+200)]		99.33	3.58	2.78
T ₄ [S ₁ +VC ₁ +SA ₀ (50×50+5+0)]		81.54	2.94	2.28
T ₅ [S ₁ +VC ₁ +SA ₁ (50×50+5+100)]		129.70	4.67	3.63
T ₆ [S ₁ +VC ₁ +SA ₂ (50×50+5+200)]		127.62	4.59	3.57
T ₇ [S ₁ +VC ₂ +SA ₀ (50×50+10+0)]		89.09	3.21	2.49
T ₈ [S ₁ +VC ₂ +SA ₁ (50×50+10+100)]		135.36	4.87	3.79
T ₉ [S ₁ +VC ₂ +SA ₂ (50×50+10+200)]		132.31	4.76	3.70
T ₁₀ [S ₂ +VC ₀ +SA ₀ (50×60+0+0)]		74.95	2.25	1.75
T ₁₁ [S ₂ +VC ₀ +SA ₁ (50×60+0+100)]		115.72	3.47	2.70
T ₁₂ [S ₂ +VC ₀ +SA ₂ (50×60+0+200)]		109.40	3.28	2.55
T ₁₃ [S ₂ +VC ₁ +SA ₀ (50×60+5+0)]		83.56	2.51	1.95
T ₁₄ [S ₂ +VC ₁ +SA ₁ (50×60+5+100)]		142.80	4.28	3.33
T ₁₅ [S ₂ +VC ₁ +SA ₂ (50×60+5+200)]		140.09	4.20	3.27
T ₁₆ [S ₂ +VC ₂ +SA ₀ (50×60+10+0)]		91.64	2.75	2.14
T ₁₇ [S ₂ +VC ₂ +SA ₁ (50×60+10+100)]		149.06	4.47	3.48
T ₁₈ [S ₂ +VC ₂ +SA ₂ (50×60+10+200)]		147.19	4.42	3.43
T ₁₉ [S ₃ +VC ₀ +SA ₀ (50×75+0+0)]		78.93	1.90	1.47
T ₂₀ [S ₃ +VC ₀ +SA ₁ (50×75+0+100)]		120.50	2.89	2.25
T ₂₁ [S ₃ +VC ₀ +SA ₂ (50×75+0+200)]		118.28	2.84	2.21
T ₂₂ [S ₃ +VC ₁ +SA ₀ (50×75+5+0)]		86.59	2.08	1.62
T ₂₃ [S ₃ +VC ₁ +SA ₁ (50×75+5+100)]		158.44	3.80	2.95
T ₂₄ [S ₃ +VC ₁ +SA ₂ (50×75+5+200)]		155.36	3.73	2.90
T ₂₅ [S ₃ +VC ₂ +SA ₀ (50×75+10+0)]		94.78	2.27	1.77
T ₂₆ [S ₃ +VC ₂ +SA ₁ (50×75+10+100)]		162.39	3.90	3.02
T ₂₇ [S ₃ +VC ₂ +SA ₂ (50×75+10+200)]		160.25	3.84	2.99
CD at 5%		1.157	0.034	0.027



Effect of spacing, doses of vermicompost and foliar application of salicylic acid on availability of NPK in post-harvested soil of chrysanthemum

Data presented in (Table 6) indicates that various spacing, gradual doses of vermicompost and different concentrations of salicylic acid had significant effect on availability of NPK in post harvested soil. The maximum nitrogen (146.76), phosphorus (24.22) and potassium (126.81) were recorded with wider spacing (50×75) however, closer spacing (50×50) had minimum nitrogen (142.60 kg), phosphorus (20.46 kg) and potassium (123.00 kg/ha). It might be due that under wider spacing had less number of plant which absorbed low quantity of nutrients ultimately increased the availability of NPK in post harvested soil as compared to closer spacing. Similar results were also reported by Ingle *et al.* (2014) in sorghum.

Table 6: Impact of spacing, doses of vermi-compost and foliar application of salicylic acid on NPK of post-harvested soil of chrysanthemum

Treatment	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Spacing (cm)			
S ₁ (50×50)	142.60	20.46	123.00
S ₂ (50×60)	144.65	22.30	124.85
S ₃ (50×75)	146.76	24.22	126.81
Vermi-compost (ton/ha)			
VC ₀ (0)	134.09	17.12	115.13
VC ₁ (5)	146.74	22.85	126.62
VC ₂ (10)	153.17	27.81	132.90
Salicylic acid (ppm)			
SA ₀ (0)	144.28	22.05	124.69
SA ₁ (100)	142.99	20.75	123.09
SA ₂ (200)	143.72	21.17	123.88
CD at 5%	0.102	0.026	0.148

Various doses of vermicompost exhibited significant effect on NPK availability of post harvested soil. The maximum nitrogen (153.17 kg/ha), phosphorus (27.81 kg) and potassium (132.90 kg/ha) was recorded when plants were treated with VC₂ (10 ton/ha) while control VC₀ resulted in minimum nitrogen (134.09 kg/ha), phosphorus (17.12 kg/ha) and potassium (115.13 kg/ha) during course of study. The higher values of NPK in post-harvested soil under the treatment VC₂ may be due to additional

supply of nutrients in the soil by vermi-compost and lower availability of NPK in treatment VC₀ might be due to more absorption of nutrients. Similar findings reported by Tiwari *et al.* (2018 a) in marigold.

Different concentrations of salicylic acid differed each other among the treatments in terms of availability of NPK in post harvested soil. The plants sprayed without any salicylic acid had maximum nitrogen (144.28 kg/ha), phosphorus (22.05 kg/ha) and potassium (124.69 kg/ha) on the other hand minimum available nitrogen (142.99 kg/ha), phosphorus (20.75 kg/ha) and potassium (123.09 kg/ha) were recorded with foliar application of salicylic acid @ 100 ppm. It might be due to that SA in lower quantity stimulated of root formation in young shoots of ornamental plants (Singh 1993). This positive effect could be explained upon the effect of SA on increasing CO₂ assimilation and accordingly photosynthetic rate in addition to the increase in mineral uptake (Karlidage *et al.* 2009).

CONCLUSION

On the basis of results obtained from the present investigation, it can be concluded that closer spacing (50 × 50 cm), 10 ton/ha of vermi-compost and 100 ppm of salicylic acid is optimum cultural activities for better growth and higher flower yield in chrysanthemum.

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