INFLUENCE OF SALICYLIC ACID ON GROWTH AND FLOWERING OF ZINNIA CULTIVARS

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ABSTRACT: *Salicylic acid is an important plant growth regulator. To study the influence of salicylic acid on the growth and flowering of zinnia cultivars, a field experiment was carried out. Four salicylic acid levels (control, 50, 100, 200 mg L^{-1}) and three zinnia cultivars (Dreamland, Lilliput and Zinnia Dahlia Flower) were studied using randomized complete block design with three replications. Most of the studied parameters were significantly affected by salicylic acid foliar application on zinnia cultivars. Salicylic acid (SA) @ 100 mg L^{-1} increased the number of leaves $plant^{-1}$ (516.00), leaf area (15.20 cm^2), plant height (65.70 cm), number of branches $plant^{-1}$(26.00), number of flowers $plant^{-1}$(22.00), flower persistency (38 days), flower stalk length (13.50 cm) and flower diameter (8.70 cm) of zinnia cultivars. Days to flowering (33) were lowest in the plots treated with SA @ 200 mg L^{-1}. In cultivars "Zinnia Dahlia Flower" showed more number of leaves (511), leaf area (15.50 cm^2), plant height (76.50 cm), number of branches $plant^{-1}$ (27.00) and number of flowers $plant^{-1}$ (20.00). "Lilliput and Zinnia Dahlia Flower" gave minimum flowering days of 36. Maximum flower diameter (8.20 cm) and flower persistency (38 days) were recorded in Lilliput, whereas flower stalk length was significantly increased up to 13.5 cm in Dreamland. Interaction of Zinnia Dahlia Flower and 100 mg L^{-1} salicylic acid application improved the studied parameters. It can be concluded from the study that increase in SA levels improved majority of studied parameters, which in turn improved growth and flowering of Zinnia cultivars significantly.*

Key Words: Salicylic acid (SA)**,** Cultivar (Cv.), Cultivars (Cv.'s), Number of leaves plant-1, Leaf area (cm2), Plant height (cm), Number of branches, Days to flowering, Number of flowers plant-1, Flower persistency, Flower stalk length, Flower diameter (cm)

1. INTRODUCTION

Zinnia (*Zinnia elegans*) is gone into dominating in garden flowers, owing its bulky, colorful winsomeness and prevails against hot in sunny season. It is a factual native of America that ascertained from Mexico and Central America [1]. Zinnia bloom once a year and comprised of rigid stem from >15 to <100 cm tall in height, with ovate egg shape leaves belongs to family "Asteraceae" flower size reaches to 10 cm beyond clinging heads. Flowering habit usually repeat disk like shape ranges from brown, purple or orange yellow; the beautiful florets have every color bloom, excluding blue and a choice of shapes such as single or multiple loop. In Pakistan, zinnia is a summer season flowers. Nowadays Zinnias are breed of in double, semi-double and "pompon" shape like Dahlia flower. Conventionally, taller zinnias are uses on multi places in beds, borders and dwarf zinnia granted as cut flowers but the dwarf is particularly grow in containers and window boxes. Zinnia begins flowers from May to October. Outstanding quality and continues flow of flowers rely upon their time of seed availability, sowing, growth, development and eventually flowering habits of each cultivar. Zinnia plant can be grown well in hot weather, if they are irrigated on timely basis [2]. Zinnia is a subsist and diverse genus griped 20-30 species, *Zinnia elegans* and *Zinnia haagaena*, all over the world used and adored [3]. The major fraction of showy cultivars is gained from *Zinnia elegans*. Having extensive collection or groups and many cultivars, which are intensively grown for their fascinating look and beautification purposes because this flowering plant have sturdy physiology, that can tolerate all kind of soil condition in beds, pots, window boxes and rock gardens [4]. Largely cultivated varieties of zinnia "Blue Point" and "Oklahoma" are found irresistible by the mean of their unparalleled accomplishment and distinct blooms. Zinnia flowers display are vivid, uniform colors, strapping stems with strong against diseases and an extended post life [5]. The introduction of salicylic acid (SA), as a natural phenolic secondary metabolite, in various aspects of vital processes like ethylene biosynthesis, stomata conductance, respiration, senescence and the activation of defense systems against different pathogens is well documented [6]. Applying salicylic acid to various species has been shown considerable change in flowering components, increased number of flowering parts in the plants [7]. Its exogenously application may bring some positive plant reactions for example, transpiration, respiration and senescence [8]. It has been stated that acetyl salicylic acid may have potentially alleviating chilling injury, sustained superiority and perk up the nutritive facts of pomegranate fruit for consumption by advancing their antioxidant behavior [9]. One of the prominent involvements of SA on stomata function effectiveness, regulate chlorophyll filling in leaves, transpiration amendment and respiratory tuned pathways, cleared that SA and such type related acid character compounds solemnly concerned in directive of numerous light reactions. The way of reactions of SA on plant physiological processes were found different gamble on species, adorning stage, its volume and particularly environmental conditions [10]. Foliar application of this compound was noted to calibrate chlorophyll volume [11]. Further, with the optimum supply of SA advanced the quality of water use efficiency, rate of transpiration and internal cycle of carbon dioxide in organic compound composition [12]. SA had brought an auspicious function in heat stress environment and perk up seed germination in Arabidopsis thaliana under salt stress conditions [13]. Foliar applications

of SA (2 mg L^{-1}) increased chlorophyll concentration in canola plant (*Brassica napus L.*) [14]. Steadily increased in various levels prompted enzyme activities, it can control plant growth &development, help in enhancing of cell membrane permeability, induction and maintenance of flowering, photosynthesis and various plant physiological and biochemical responses [15]. Application of various concentrations of salicylic acid on the Tagetes sp. plants improved their flower density also their root and fresh weight and root length. Foliar supplements of SA reduced the vulnerable effects of water on seedling growth, salinity and restored of all the growth activities in wheat [16]. The best result was at the lowest concentration of salicylic acid at 6-10 mM [17]. Foliar Spraying of SA on wild chamomile (*Matricaria recutita* L.) increased the chlorophyll content. SA foliar application improves production of leaf chlorophyll content [18]. Keeping in view the importance of salicylic acid for flowering of zinnia cultivars the current experiment was designed under agro ecological conditions of Peshawar.

2. MATERIALS AND METHODS

Plant materials and cultural practices

Nursery was raised in 8-10 inches pots; seedlings was transplanted after 22 days with 2-3 true leaf stage on well prepared soil in field. Plot size was kept 2.5m x 2.1m with row to row and plant to plant distance of 60 cm and 45 cm, respectively. All other cultural practices were carried out as per plant requirement and previously recommended by various researchers.

Preparation and application of salicylic acid

Different solution of salicylic acid was prepared by placing on stirring machine for 48 hours. Salicylic acid was applied foliar spray in two split doses; in randomized complete block deigns (RCBD) which was replicated three times. Salicylic acid half dose was sprayed just after transplantation and half dose right before bud formation.

The factors and their levels were as follows:

Factor A: SA levels (mg L^{-1})	**Factor B: Zinnia Cv.s**
SA_1 = 0	CV1 = Dreamland
SA_2 = 50	CV2 = Lilliput
SA_3 = 100	CV3 = Zinnia Dahlia Flower
SA_4 = 200	

Data was recorded on the following parameters:

Number of leaves plant^{-1}

Total number of leaves plant^{-1} in each replication was added and mean was calculated for each treatment.

Leaf area (cm^2)

Leaf length from base to tip and leaf width plant^{-1}was determined with the help of measuring tape and average was computed for each treatment.

Plant height (cm)

Height of the plant from the soil surface to the top of the plant was metered and average was calculated for each treatment.

Number of branches

The number of branches was counted for each treatment in each replication of five randomly selected plants and then the means was calculated for each treatment.

Days to flowering

Days to flowering for each treatment were counted from date of planting to the date of first flower appearance five randomly selected plants in each plots and average was calculated.

Number of flowers plant^{-1}

Total number of flowers plant^{-1} for each treatment was counted and average was calculated.

Flower persistency

Floret persistency for each treatment was calculated by counting days from the date of flower opening to the date of flower senescence and average was calculated.

Flower stalk length

Flower stalk length pant^{-1} in each treatment was measured by meter rod and then average was calculated for each treatment.

Flower diameter (cm)

Flower size plant^{-1} in each treatment was measured and mean was computed. Three plants were taken as a sample from each treatment.

Statistical analysis

The data was analyzed statistically using analysis of variance techniques appropriate for randomized complete block deign (RCBD). Significant differences among treatments was determined using least significant difference (LSD) test for main as well as interaction effects [19].

3. RESULTS AND DISCUSSIONS

Number of leaves plant^{-1}

The statistical analysis indicated that cultivars and salicylic acid levels significantly affected flower number of leaves plant^{-1}, while their interaction (SA x CV) was found non-significant. Highest number of leaves plant^{-1}(516) was noted in plots sprayed with 100 mg L^{-1} SA, while lowest number of leaves plant^{-1} (438) was seen in control plot. Among the cultivars, "Zinnia Dahlia Flower" produced maximum number of leaves plant^{-1} (511) followed by dreamland (494 number of leaves plant^{-1}), whereas Lilliput produced minimum number leaves plant^{-1} (391) (Table 1). Salicylic acid due to its defensive feature induced a protective mechanism under unfavorable environmental conditions in plant physiology, precise functions of certain directly enzyme directly or accelerate related genes responsible for defensive control induces specific changes in leaf number and chloroplast structure has vital contribute in the energy status of plants, subsequently plant use two photosystems in series to generate ATP and reduce NADPH enough energy are used to form organic molecules, translocation and storage of this assimilates enable plant caused in beneficial increased of leaf numbers. Using various concentrations produced prominent increased in leaves of soybean [20]. It is phenolic nature compound produced profound increased of leaves number in cucumber plant by spraying [21].Involved in regulation of growth processes, such as in ornamental plants young shoots stimulate leaves [22].

Leaf area (cm^2)

Plots applied 100 mg L^{-1} SA had the largest leaf area (15.2 cm^2), which was statistically similar to the leaf area where 200 mg L^{-1} SA was applied, while small leaf area (12 cm^2) was obtained for control. Maximum leaf area (15.5 cm^2) was noted in zinnia dahlia cultivar, followed by dreamland (13.1

cm^2), whereas lower leaf area (12.7 cm^2) was in Lilliput (Table 1). Interaction between SA and Cultivar showed that leaf area was increased for all cultivars with all levels of SA, however maximum leaf was recorded for zinnia with the application of 200 mg L^{-1} SA. Increase or decrease in levels of photosynthetic pigments after salicylic acid applications it is determined that various methods of applications caused rise in plants productivity associated largely in cell expansion and division. Due to the progressive growth and development leaf length and width was increased [23]. Application of different levels were credited to the expand of photosynthetic integrant, since there was a positive association between photosynthesis and leaf area on wheat plants served couple with SA, both under trauma and normal growth state were investigated to be promised on the species and cultivar [24]. In the plants cell division and expansion is driven by this type compounds, ages of popularity of PGR's such as salicylic acid, evidently built a balance between establishment and growth of crops [25].

Plant height (cm)

The data regarding plant height is given in Table 1. Comparing different cultivars, Zinnia Dahlia Flower gave maximum plant height (76.5 cm), which was followed by dreamland (68.5 cm), whereas the minimum plant height (26.8 cm) was recorded for Lilliput. While applying different levels of salicylic acid, 200 mg L^{-1} level had given the highest plant height (65.7 cm) followed by 100 mg L^{-1} (56.5 cm), as compared to the control plots which was minimum (53.1 cm). As far as concerned with interaction between SA x CV, various salicylic acid levels increased plant height significantly in all the chosen cultivars of zinnia as shown in Table3. Salicylic acid is a simple phenolic compound enable plant to withstand various soil and environmental condition and can be applied on many ways, which plays an important role in regulation of plant growth and development and physiological processes as whole. Various treatments increased almost all contents of nutrients and hormonal regulation in plants [26, 27]. SA increased plant height by increased Rubisco activity and photosynthetic rate [28]. Average increased in plant height of < 24 % and >21 % was noticed under greenhouse conditions as well as field environment, respectively [29]. However, shoot growth was increased with the concentration of salicylic acid used [30].

Number of branches plant^{-1}

Data analysis opened that, considerable effects of various salicylic acid levels on selected flower cultivars and interaction occurred between the factors. Zinnia dahlia flower produced more (27) number of branches plant^{-1}, followed by Dreamland (23), while Lilliput zinnia produced less (22) number of branches plant^{-1}. Salicylic acid foliar application @ 100 mg L^{-1} produced more branches plant^{-1} (26) same as level 200 mg L^{-1}, while less (21) branches plant^{-1}was noted in control plot (Table 1). As for as concerned with interaction between salicylic acid levels and cultivars of zinnia, highest number of branches plant^{-1} (32) was recorded in plots where 200 mg L^{-1} SA were applied and Zinnia dahlia was used. Salicylic acid increased immunity endorsed plant through continuous supply of nutrients and well-acted responses to environmental stresses, an important signal molecules altered physiological regulation. Eventually it was documented that potentially that plant regulator engendered extensive range of metabolic responses in plants and finally photosynthetic factors of plants was affected. These responses could be mal-physiological responses. Application on number of shoots was significant [31]. Number of leaves linearly increased with salicylic acid levels in marigold plants [25]. Treatments responses under ambient condition increased shoots growth similarly [29].

Days to flowering

Table 1 indicated that salicylic acid and different cultivars significantly affected days to flowering. The interaction between SA x CV was also significant. Mean values for salicylic acid levels indicated that fewer days to flowering (33) were recorded in plots where increased level 200 mg L^{-1} of SA was applied, followed by (37), (40), at 100 mg L^{-1}, 50 mg L^{-1}, respectively and delay in days to flowering (41) was noted in control plot. In case of cultivars there was significant difference for days to flowering. Lilliput zinnia and zinnia dahlia had taken fewer (36) days to flowering, while late (37 days) flowering was noticed in dreamland cultivar. Significant interaction occurred between salicylic acid and zinnia cultivars. Statistical values showed that dreamland at salicylic acid level of 200 mg L^{-1} had brought earlier flowering (after 31 days). But on the other hand flowering delayed in all cultivars where no salicylic acid was applied. Early flowering and floral bud sprouts have 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 [32]. Salicylic acid stimulated initiation of flowers subsequently involved in the physiological processes [33]. The molecular mechanisms of salicylic acid engaged in the bud- stimulating behaviors just like phenolic nature substances because of this harmonic behavior could act as natural regulators or act together with growth substances, by the reason metabolism of indole-3-acetic acid can be shifted in presence of phenolic chemicals [34]. SA applied as spray form promote formation of pods and flowers in the treated plant [35].

Number of flowers plant^{-1}

The effects of salicylic acid levels, different cultivars and their interaction (SA x CV) on number of flowers plant^{-1} were found significant. Zinnia dahlia flower performed best and gave 20 number of flowers plant^{-1}, followed by dreamland (19), whereas Lilliput performed poor (18) number of flowers plant^{-1}. Salicylic acid levels affected significantly number of flowers plant^{-1}. SA level 100 mg L^{-1} produced maximum No. of flowers plant^{-1} (22), whereas least number of flower plant^{-1} (17) was recorded in control plot. Interaction (SA x CV) also affected number of flowers plant^{-1}.SA at level of 100 mg $L^{-1}$and highest number of flowers plant^{-1} (24) produced in zinnia dahlia, while no application of SA produced lowest number of flowers plant^{-1} on the same cultivar (Table 2). Salicylic acid has also been used for its effects on distinct morphological progressions concerned to enlargement and desirable maturity of plants under ordinary circumstances defends up their concentrations. In a group with these effects the succession of flowering in herbaceous species was noticed [36]. It is an exogenous regulator of flowering was

demonstrating in all species belonging to different families, it is also concluded that the use of this compound increased number of inflorescence in plants [15]. Exogenous application stimulated large number of floral buds per plant [37]. The use of like as salicylic acid substitutes a creditable crop management technique to improve the number of inflorescences in marigold plants, in reserve to the exceptional effect on inflorescence production, the incorporation increased content of flavonoids in the inflorescences [38]. Induced flowering in tomato plants [39].

Flower persistency

Among the SA levels, higher flower persistency (38 days) was resulted in the plots which were treated with 100 mg L^{-1}, followed by (35 days)at @ 200 mg L^{-1},which was (33 days) statistically similar to @ 50 mg L^{-1},while lower flower persistency (25 days) was obtained with no application of SA. As about cultivars concerned, "Lilliput" zinnia produced more persistent flowers (36 days), while "zinnia dahlia" flower produced less (32 days) persistent flowers (Table 2). Salicylic acid has great impact on sustaining shelf life of 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 [40]. The inhibitory action of dinitro phenol was similar to salicylic acid, a well-known inhibitor which alter enzyme to produce ethylene in the plant [41]. Salicylic acid also enhanced appearance of the flower [42]. It has positive effect on flowering agenda in the plant which may be caused of perseverance in flowers [43].

Flowers stalk length (cm)

The data regarding flower stalk length is presented in Table 2. Mean data showed that highest flower stalk length (13.5 cm) was recorded in dreamland which was statically similar to zinnia dahlia flower, while minimum flower stalk (7.1 cm) was recorded for CV "Lilliput". Using various salicylic acid levels, highest flower stalk length (12.0 cm) was noted at level of 100 mg L^{-1}, which was found statistically similar to 200 mg L^{-1} (11.4 cm), whereas lowest flower stalk length (10.6 cm) was noted in control. Salicylic acid plays an imperative role in flower stem length, while gave best result in increasing stem elongation in different ornamental plants. The length of flower stem increased as level précised of salicylic acid, since cell elongation and cell expansion occurred [44]. This hormone plays contribution in the synthesis specific proteins that named kinase protein, played key role in the regulation of cell division, differentiation and cell structural formation [45].

Flowers diameter (cm)

Data in association with flower diameter in Table 2 revealed that there was significant variation for salicylic acid and cultivars (CV) shown. No interaction between SA x CV occurred for flower diameter. Using various levels of salicylic acid, mean values revealed that application of 100 mg L^{-1} SA produced large size of flowers(8.7 cm) followed by (7.9 cm flower diameter) 200 mg L^{-1}, whereas in control plot, small size of flowers (7.1 cm) were recorded. In case of different cultivars, Lilliput zinnia produced large size of flowers (8.2 cm) followed by Zinnia dahlia flower (7.8 cm) while small size of flower (7.4 cm) was produced by dreamland. Like other plant hormones salicylic acid is a plant-produced compound, further of this set can act as plant growth regulators. Beyond vegetative behavior also has outstanding correlation size of flower, in addition, increase flavonoids contents in the inflorescence consequently enhanced flower length and width as a result used of different levels of SA, influenced positively flowering size and plant growth [46]. Various concentrations on violet flower diameter of this hormone like substance produced high hormonal activities by secondary metabolites production [47].

Table 1: Number of leaves plant^{-1}, leaf area, plant height, number of branches plant^{-1}, and days to flowering of zinnia cultivars as affected by SA levels

Zinnia Cultivars	Number of leaves plant^{-1}	Leaf area (cm^2)	Plant height (cm)	Number of branches plant^{-1}	Days to flowering
Dreamland	494.00 a	13.10 b	68.5 b	23.00 b	37 a
Lilliput	391.00 b	12.70 b	26.8 c	22.00 c	36 b
Zinnia dahlia	511.00 a	15.50 a	76.5 a	27.00 a	36 b
LSD α 0.5	19.40	0.50	2.60	1.00	0.7
Salicylic acid levels (mg L^{-1})					
0	438.00 c	12.00 c	53.10 c	21.00 c	41 a
50	440.00 c	13.20 b	53.70 bc	23.00 b	40 b
100	516.00 a	15.20 a	56.50 b	26.00 a	37 c
200	467.00 b	14.60 a	65.70 a	26.00 a	33 d
LSD α 0.5	22.00	0.50	2.98	1.00	0.8

Table 2: Number of flowers plant^{-1}, flower persistency, flower stalk length and flower diameter of Zinnia cultivars as affected by SA levels

Zinnia Cultivars	Number of flowers plant^{-1}	Flower persistency	Flower stalk length (cm)	Flower diameter (cm$^{2)}$
Dreamland	19.00 b	33.00 b	13.50 a	7.40 c
Lilliput	18.00 c	36.00 a	7.10 b	8.20 a
Zinnia dahlia	20.00 a	32.00 b	13.20 a	7.80 b
LSD α 0.5	0.62	1.40	0.50	0.25
Salicylic acid levels (mg L^{-1})				
0	17.00 d	26.00 c	10.60 c	7.10 d
50	18.00 c	34.00 b	11.00 bc	7.50 c
100	22.00 a	38.00 a	12.00 a	8.70 a
200	19.00 b	35.00 b	11.40 ab	7.90 b
LSD α 0.5	0.72	1.60	0.50	0.30

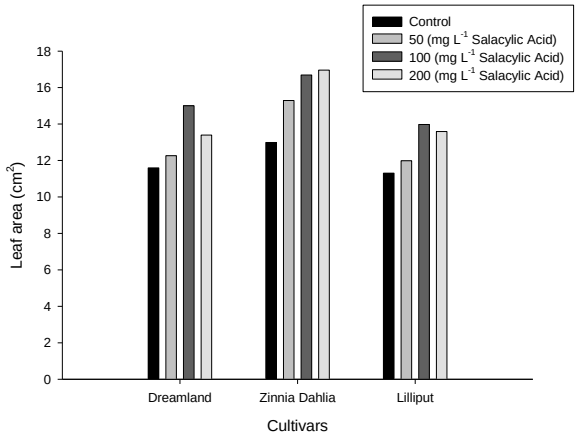

Figure 1: Leaf area as affected by SA x Zinnia cultivars

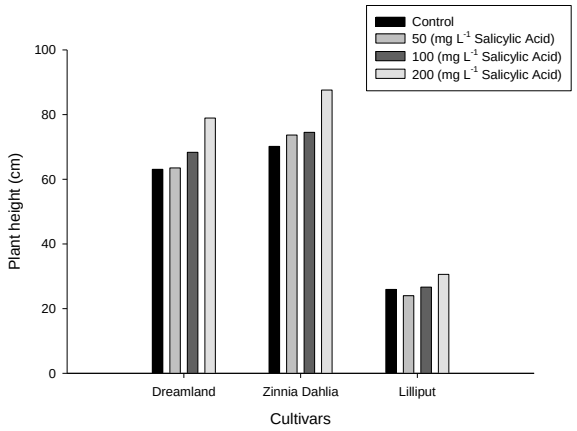

Figure 2: Plant height (cm) as affected by SA x Zinnia cultivars

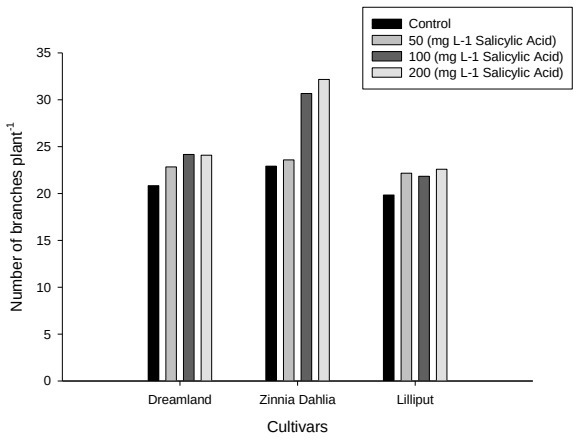

Figure 3: No. branches plant^{-1} as affected by SA x Zinnia cultivars

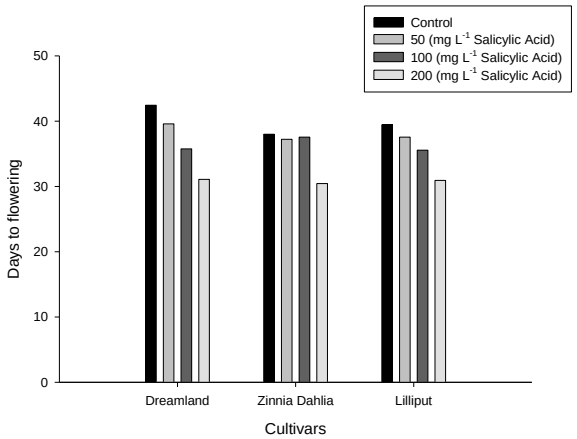

Figure 4: Days to flowering as affected by SA x Zinnia cultivars

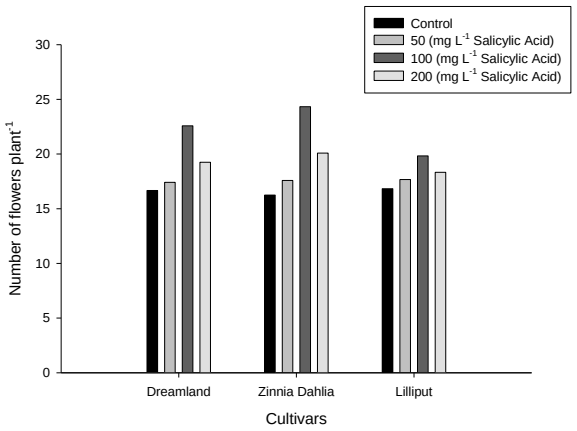

Figure 5: No. of flowers as affected by SA x Zinnia cultivars

4. CONCLUSIONS

It can be concluded from the findings of this experiment that: All salicylic acid levels foliar application and different zinnia cultivars affected significantly growth and flowering of zinnia. Results represented that salicylic acid @ 100 mg L^{-1} application responded well in all studied parameters except days to flowering, which was decreased @ 200 mg L^{-1}. Growth and flowering attributes in "Zinnia Dahlia Flower" gave best results, while flower diameter and flower persistency were found best in "Lilliput". Interaction between Cv.'s and SA foliar application, growing "Zinnia Dahlia Flower" with application of 100 mg L^{-1} salicylic acid improved the studied characteristics. For optimum growth and flower production salicylic acid @ 100 mg L^{-1}, while for early flowering 200 mg L^{-1} should be better. Zinnia Dahlia Flower should be best for overall growth and flower production. For flower persistency and flower diameter Cv. "Lilliput" should be best.

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