Research Article

Managing the Growth and Flower Production of Zinnia (*Zinnia elegans*) through Benzyle Amino Purine (BAP) Application and Pinching

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Abstract | Benzyl amino purine (BAP-$C_{12}H_{11}N_5$) generally act as a plant metabolite and growth retardant. It encourages the growth and cell division of dormant buds and bushiness of plant by reducing its height. Similarly, pinching of terminal branches increase the cytokinins and decrease auxin concentrations flourishing the axillary buds. A research study on the growth and production of zinnia flowers through application of BAP (25, 50, 75 and 100 mg L^{-1}) and pinching (2, 4 and 6 leaf stages), was carried out at The University of Agriculture Peshawar, Pakistan. Research analysis showed that zinnia plants treated with 100mg.L^{-1} and pinched at 6 leaves stage recorded maximum days to flowering, flower persistency, branches, leaves and flowers $plant^{-1}$ and stem thickness. While in case of untreated and un-pinched plants maximum flower diameter, fresh and dry flower weight, and height of plant were reported. Hence, it is concluded form the research study that BAP application (@100 mg.L^{-1}) reduced height of plant, enhanced number of flowers per plant and also lateral branching in zinnia plants. Moreover, the plants pinched at the stage of 6 leaves performed well in height reduction and flower quality enhancement.

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Introduction

Zinnia (*Zinnia elegans*) belongs to family *Asteraceae* is originated from Mexico. The leaves are opposite and stalk less. The flowers may have a single row of petals or attain the shape of a dome with purple, lilac and red color. The plants are mostly raised from seeds. Zinnia is used as a cut flower, bedding or pot plant. The reasons of its commercial importance are long shelf life, vast marketing as a cut flower and availability in various shapes and colors (Dole, 1999). Zinnia can withstand arid and hot climatic conditions thus making it appropriate for growing in all conditions with the exception of poorly aerated soils, which may cause root diseases (Reilly, 1978). Zinnia can also be grown as an intercrop in most of the vegetables for the control of nematodes (Yassin and Ismail, 1994). Zinnia is native flower of America which was originated from Central America and Mexico. In Pakistan, zinnia is a flower of summer season, which produce flowering during May-October. Continous flowering with a good quality is depending upon sowing of seeds on time, development and growth of plants, and the flowering behavior of different

cultivars (Javid *et al*., 2005).

Growth inhibitor have great effect in the development and physiology of plants. They almost stunted the stem and also affect the reproductive habit of plants. Stunting growth chemicals depends on method use for treatment of plants may be (foliar application or soil application). It also depends on the type of species and cultivar (Pobudkiewicz, 2008). It enhances branching in floricultural crops in broad. Although having great impact on plants branching at the time of the application. Efficient response of BAP has a short-term response and has no harmful effects in the plant. Therefore, multiple applications of BAP have positive effect on crops. Through coverage of BAP is required so it is well translocated in the plant (Latimer, 1991). Cytokinins applied exogenously have the same effect as pinching in plants. Most of the studies showed auxins and cytokinins might control the apical dominance antagonistically. Effective use of growth regulators of plants is a way to control height of plant (Krug, 2004). BAP belongs to group of cytokinin and is an aromatic compound that stimulates plants to produce lateral branching providing a bushy appearance to the plant. Due to its antagonistic effect to auxin BAP counter the epical dominance while reducing height of plant (Pobudkiewicz, 2008). Applying BAP directly may cause stimulation of growth and cell division in dormant buds while improving the bushiness of plant (Taiz and Zeiger, 2010). Cytokinins like BAP are capable of enhancing branching with the exception of any disadvantages, predominantly stunted growth (Carpenter and Rodriguez, 1971).

Auxins perform a significant role in epical dominance induction by inhibiting lateral bud growth. In auxiliary buds, auxins levels primarily increase later when plant pinching is done and then becomes stable (Gocel *et al*., 1991). Fresh weight of the buds increases even though auxins alone cannot control auxiliary bud improvement. Furthermore, due to pinching the cytokinins content also improve (Mader *et al*., 2003a). During pinching, the apical buds are detached from the plants, while the auxiliary buds are left only to support and improve branching laterally. The apical portions of seedlings are removed in order to support lateral branching and keeping them small and rigid (Bashir and Bantel, 1994). Indirect inhibition of axillary bud growth is indirectly enhanced by a relation in between auxin concentration in epical buds and the epical dominance. After pinching, auxins and cytokinins concentrations in axillary buds increase (Gocal *et al*., 1991). Pinching of terminal buds (containing hormones) allow lateral buds to develop and grow like compact flourishing plants with a better flowering yield (Mader *et al*., 2003b). Keeping in view the importance of BAP application and pinching at different leaf stage the present research work was designed to check their effect on the growth and quality flower production.

Materials and Methods

Experimental site and design

The present research study was conducted at Ornamental Nursery, Department of Horticulture, The University of Agriculture Peshawar Pakistan. The research site is located at 340m altitude above the sea level with a latitude of 34.01° N and longitude of 71.52° E which is considered as a subtropical region on the basis of its climate. Peshawar is well known by both its prolonged hot summers (max temp 45-47°C) and severe cool winters with a fall in temperature up to 4°C. Both the summer and winter are extreme. March is counted for highest rainfall of approximately 78mm while the lowest rainfall occurs during the month of June (8mm) with an approximate location of 1600km from north of Indian Ocean (Ahmad *et al*., 2019; Basit *et al*., 2019; Sajid *et al*., 2020).

Randomized complete block design with three replications and factor factorial arrangement was used in the experiment. Treatments combination consisted factor A (B_0= control, B_1= 25 mgl^{-1}, B_2= 50 mgl^{-1}, B_3=75 mgl^{-1}, B_4=100 mgl^{-1}) and factor B (P_0 = No pinching (control), P_1= 2 leaf stage, P_2= 4 leaf stage, P_3= 6 leaf stage.

Experimental procedure

Zinnia seeds of a local cultivar were sown in module trays in the Ornamental Nursery under semi shade lath house. Sprinkler irrigation was done on daily basis to get better germination and healthy seedlings. The seedlings developed were transplanted after 17 days and all the basic cultural practices i.e. weeding and irrigation were carried out on regular basis. A total of 10 plants were kept in each treatment. The data collection was started from first day as flowering initiated. Normally cultural practices i.e. fertilizer application, irrigation, weeding and hoeing were done on regular basis.

Parameters studied

Data regarding all parameters were taken and their averages were calculated. The attributes studied included plant height that was measured from the base of plant soil up to plant tip through a measuring tape. Diameter (mm) of stem was calculated at the base or plant while using Vernier caliper as reported by (Basit *et al.*, 2019b; Kamkari *et al.*, 2016). Number of branches were counted at flowering stage and the number of leaves were taken as well. Days to flowering were taken by counting the total days from the day of transplantation to initiation of first flower. Number of flowers were counted and their diameter (cm) were taken with the help of Vernier caliper at both opposite sides of the flowers. Flowers' persistency were taken on the base of initial flower opening up to their senescence. Flowers' fresh weight was taken through a digital weight balance (Model AY220, Shimadzu, Japan) (Basit *et al.*, 2020). Whereas, dry weight of flowers was determined initially by drying the flowers at 40°C for 24 hrs with circulated air until a constant weight was achieved.

Statistical analysis

Data for different attributes were analyzed by using a statistical package, Statistix 8.1, Inc, Tallahassee FL, USA) as suggested by Basit *et al.* (2018). Further, mean values were subjected to Analysis of Variance (ANOVA) suitable for Randomized Complete Block Design (Gilani *et al.*, 2018) and assessed through least significant difference (LSD) test (Jan *et al.*, 2009).

Results and Discussion

Plant height (cm)

Data analysis of showed that maximum plant height (54.3) was attained by plants in control treatment (un-pinched) that was statistically similar to the height of zinnia plants pinched at 2 leaf stage (48.0 cm) (Table 1). Plants that were pinched at 6 leaf stage, attained the lowest (36.3 cm) height (Figure 1A). Regarding BAP application, zinnia plants showed a decrease in plant height when sprayed with BAP in increasing order. Zinnia plants reached to maximum height (49.6 cm) when they were left untreated (control). Statistically similar heights i.e. 48.0, 45.4 and 44.4 cm were also observed when the plants were treated with BAP at the rates of 25, 50 and 75 mg L^{-1} respectively. The lowest plant height (40.8 cm) was recorded in plants that were sprayed with 100 mg L^{-1} BAP (Figure 1B).

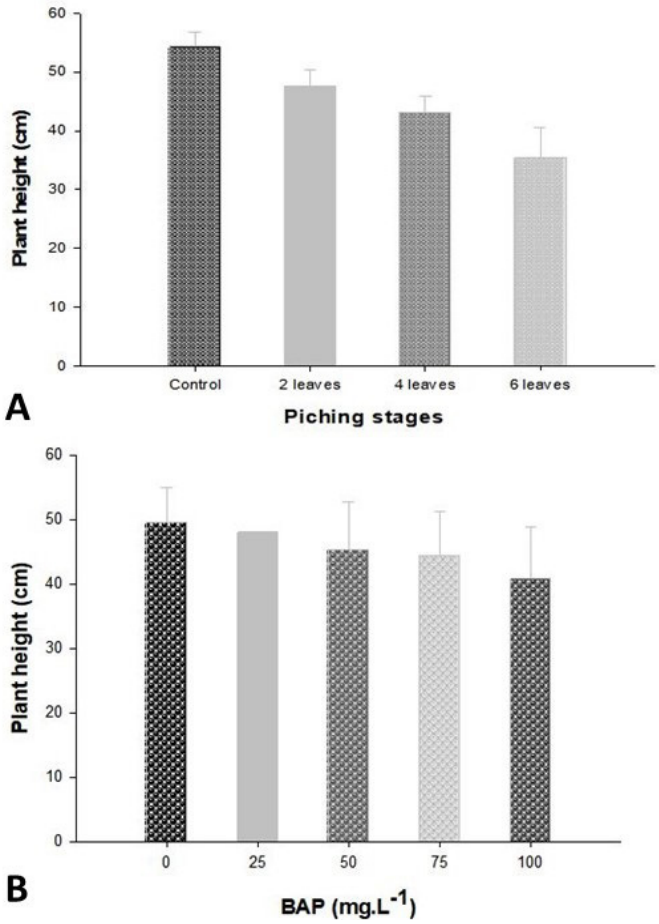

Figure 1: *Zinnia Plant height as affected by (a) pinching stages (b) BAP concentration.*

In plants, the apical bud produces auxins that are responsible for apical dominance. Removal of apical buds also stimulates cytokinins to trigger the lateral buds to start growth and ultimately it suppresses apical dominance that control plant height (Sunitha *et al.*, 2007). Pathania *et al.* (2000) reported reduction in plant height with pinching in carnation plants. Munir and Naz (2006) also reported maximum plant height in snapdragon plants that were left un-pinched as compared with the plants that were pinched. BAP reduces plant height due to its control of auxins action of apical growth. The current findings are supported by Nermeen and Amira (2011), who observed minimum plant height with the application of BAP on plants. Carey *et al.* (2008) also concluded that BAP enhance the quality of *Salvia nemorosa* by stunting the plant height resulting in more compact plants.

Stem thickness (mm)

Table 1 indicated that stem thickness of zinnia plants increased with the progression in pinching stage. The plants pinched at 6 leaf stage attained maximum (7.7 mm) stem thickness. Zinnia plants pinched at

4 and 2 leaf stage produced stem thickness of 7.4 and 7.2 mm respectively. However, the lowest (7.0 mm) stem thickness was recorded in plants which were not pinched (Figure 2a). In case of BAP foliar application, stem thickness increased with the increase in BAP concentration as well. The thickest stems (7.8 mm) were observed when BAP was sprayed on the plants at the rate of 100 mg L^{-1}, closely followed by the plants that received 75 and 50 mg L^{-1} BAP application attaining stem thickness of 7.6 and 7.4 mm respectively. Minimum stem thickness (6.8 mm) was recorded in control treatment (no BAP), but it was statistically at par with 7.0 mm thickness of the stem obtained, when 25 mg L^{-1} BAP were sprayed to the plants (Figure 2b).

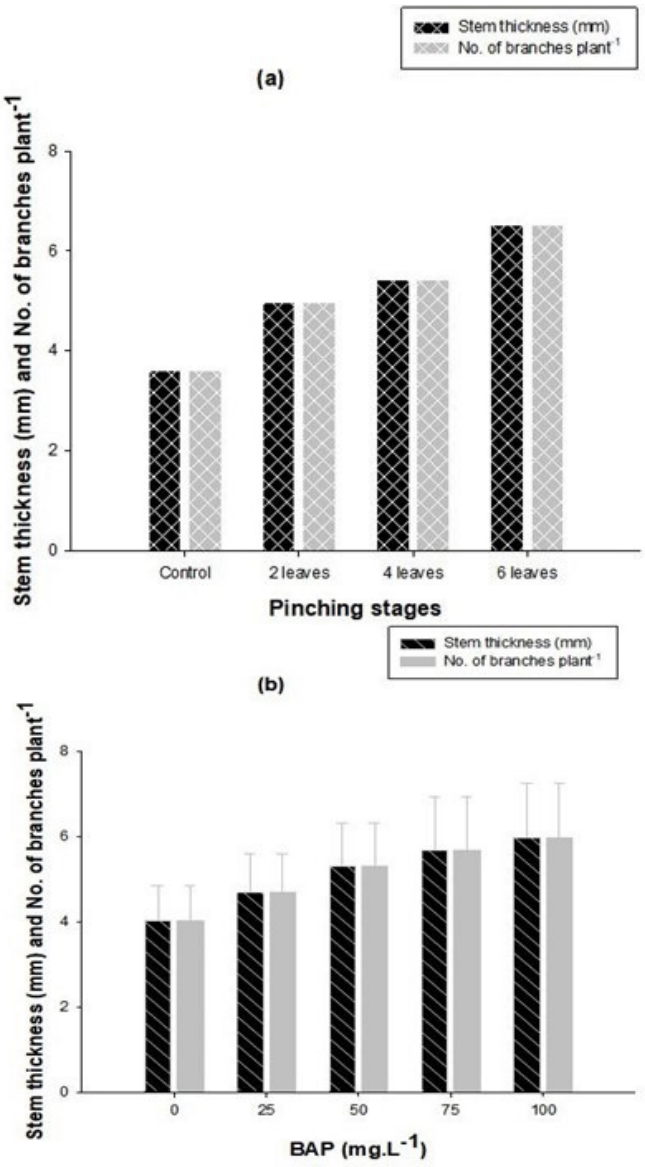

Figure 2: *Stem thickness and No. of branches plant of zinna as affected by (a) Pinching stages and (b) BAP concentrations.*

Increase in thickness of stem due to pinching may be with the reason of cell division and enlargement, and lateral growth improvement in plant (Yadav *et al.*, 2004). Contrarily, Whipker *et al.* (2000) suggested a 13.2% reduction in canopy diameter with pinching of plants. Agboola *et al.* (2004) and Fadimue *et al.* (2012) reported that plant hormone application increased stem diameter of *Spondias mombin* significantly. The current research is also in line with the results of Sardoei *et al.* (2014), who concluded that foliar application of BAP increase in stem diameter of *Schefflera arboricola*.

Number of branches plant^{-1}

Number of branches plant^{-1} were improved significantly by both pinching stages and BAP concentrations (Table 1). The plants produced more number of branches as pinching was delayed up to 6 leaf stage. Maximum branches plant^{-1} (6.5) were produced by the plants pinched at 6 leaf stage, followed by the plants pinched at 4 and 2 leaf stages producing 5.4 and 5.0 branches respectively. However, minimum branches plant^{-1} (3.6) were produced by unpinched plants (Figure 2a). In case of BAP application, branches in plants increased with increase in BAP concentration. Maximum branches (6.0 plant^{-1}) were produced by the plants that were sprayed with BAP at the rate of 100 mg L^{-1}, closely followed by 75 and 50 mg L^{-1} BAP concentrations that produced 5.7 and 5.3 branches plant^{-1} respectively. Minimum branches plant^{-1} (4.0) were recorded in plants left untreated. However, it was also at par with 25 mg L^{-1} BAP application that resulted in 4.7 branches (Figure 2b).

Terminal buds producing natural auxin were removed which enhanced number of branches plant^{-1} in chrysanthemum flower. With removing the terminal buds reduces auxins concentration that hampers upward plant growth and the lateral buds starts to sprout as a result number of branches increases (Habiba *et al.*, 2012). Eraki (1994) also found increased branches plant^{-1}with foliar application of BAP on Hibiscus. Abd El-Aziz (2007) also reported that BAP showed positive effect on number of branches of croton plants. The effect of BAP could be attributed to its role in stimulating vascular strand development and xylem differentiation. It also increases water and nutrient uptake that increases plant biomass. This increment in branches is attributed to negative impact of BAP on apical dominance (Saadawy and Abdel-Moniem, 2015). The number of branches increase in petunia was observed by the foliar application of BAP (Carey *et al.*, 2008).

Table 1: *Means Square value of growth and quality production of zinnia plant as affected by pinching stages and BAP concentrations.*

SOV	Df	Mean square (MS)									
		PH	ST	NOBPP	NOLPP	DTF	NOFPP	FD	NOFP	FFW	FDW
Blocks	2	16.143^{ns}	0.043^{ns}	1.838^{ns}	366.446^{ns}	16.143^{ns}	2.188^{ns}	0.518^{ns}	2.883ns	0.45^{ns}	0.061^{ns}
Pinching	3	856.073**	1.394**	20.9**	2475.72**	856.073**	16.626**	6.46**	13.416**	6.634**	4.944**
BAP	4	138,63**	1.819**	7.566**	1496.6**	138.63**	7.828**	3.784**	15.203**	3.784**	2.403**
Pin * BAP	12	8.51^{ns}	0.139^{ns}	0.245^{ns}	105.245^{ns}	8.51^{ns}	0.472^{ns}	0.228^{ns}	0.52^{ns}	0.217^{ns}	0.153^{ns}
Error	38	35.128	0.073	0.578	130.464	35.128	0.873	0.336	1.254	0.322	0.142
Total	59										

***: LSD≤0.01; ns: Non-significant; PH: Plant height; ST: Stem thickness, NOBPP: Number of branches plant^{-1}; NOLP: Number of leaves plant^{-1}; DTF: Days to flowering; NOFPP: Number of flowers plant^{-1}; FD: Flower diameter; NOFP: Number of flowers plan^{t-1}; FFW: Flower fresh weight; FDW: Flower dry weight.*

Number of leaves plant^{-1}

Increased stage of pinching caused an increase in leaves number plant^{-1} (Table 1). Pinching of epical buds at the stage of 6 leaves produced more leaves (84.8) while the plants pinched at 4 and 2 leaf stages produced average of 77.2 and 70.9 leaves per plant respectively. Whereas, controlled (un-pinched) plants produced less number of leaves (53.3) plant^{-1} (Figure 3a). Higher concentration of BAP application caused production of more number of leaves in zinnia plants (Figure 2b). Number of leaves plant^{-1} in zinnia were maximum (86.4) in plants sprayed with 100 mg L^{-1} BAP closely followed by the plants treated with 75 and 50 mg L^{-1} BAP which produced 80.0 and 72.1 leaves in each treatment respectively. In case of controlled (un-treated) plants produced less number of leaves (54.8) plant^{-1}.

Habiba *et al.* (2012) observed more leaves plant^{-1} after pinching *Chrysanthemum indicum*. Naresh and Singh (2012) reported that plants (African marigold) that were pinched produced maximum leaves plant^{-1}. The current results are also in line with those of Sehrawat *et al.* (2003), who reported that pinching increased the number of leaves in several ornamental plants. Ona *et al.* (2015) also noticed more leaves plant^{-1} in pinched plants of snowball chrysanthemum. Saadawy and Abdel-Moniem (2015) observed more leaves plant^{-1}in *Euphorbia milii* after foliar application of BAP at 100 mg L^{-1}. The current findings similar to those reported Mutunga (1998), who reported that *Matricaria chamomilla* applied with high concentration of BAP had higher number of leaves plant^{-1} as compared to control. Findings of our current study are in line with the findings of Eid and Leila (2006) who studied highest number of leaves in cotton plants treated with BAP foliar application.

Days to flowering

Table 1 indicated that Zinnia flowering significantly delayed with progression in pinching stage. The un-pinched (control) plants produced the earliest flowers (in 30.3 days). This was closely followed by the plants pinched at 2 leaf stage taking 37.9 days to flowering. Pinching the plants at 4 leaf stage resulted in 42.0 days to flowering, while maximum days to flowering (48.3) were taken by plants pinched at 6 leaf stage (Figure 3a). Regarding BAP application, flowering delayed with the increase in BAP concentration as well. Minimum days (34.8) to flowering were taken by plants in control treatment. However, it was also at par with the plants that received 25 and 50 mg L^{-1} BAP application which took 38.4 and 39.4 days to flowering respectively. Maximum days (43.6) to flowering were found in plants sprayed with 100 mg L^{-1} BAP but the effect was similar to 75 mg L^{-1} BAP dose, which took 42.0 days to flowering (Figure 3b). The interactive effect of pinching and BAP regarding days o flowering was found non-significant.

Pinching in plants delays the flowering process, as the pinched plants produced flowers later than the control plants. This delay seems to push the plant back into juvenile stage. Plants pinched later will flower later and vice versa. Delay in flowering process of the plant is due to the vegetative growth initiation of auxiliary buds being the apical meristems removed. Findings of our study are in similarity to those of Wainwright and Irwin (1987) reported in winter (Coronette scarlet and yellow) and summer (Chime white) of snapdragon flowers. Another possible reason for late flowering in pinched plants could be signal transduction from leaves to apical meristems which have genes to change the meristems from vegetative to reproductive stage (Munir, 2003). Different plant growth regulators

including BAP enhance vegetative growth (Keever and Morrison, 2003). Application of BAP at higher concentration was observed with excessive vegetative growth in young trees, i.e. Sophora (Carswell *et al*., 1996), roses (Chu and Lai, 1997) and poplar tree (Cline and Dong, 2002). Matsumoto (2006) recorded that foliar application of BAP from 25 to 50 mM enhanced vegetative shoots in *Miltoniopsis orchids* and delayed flowering. Richards and Wilkinson (1984) recorded that BAP at lower concentration was effective for early flowering as compared to higher concentration ranging from 10-150 mg l^{-1} in *Boronia heterophylla*. Foley and Keever (1991) reported that benzyladenine at 200 mg/l delayed flowering in *Dianthus caryophyllus*.

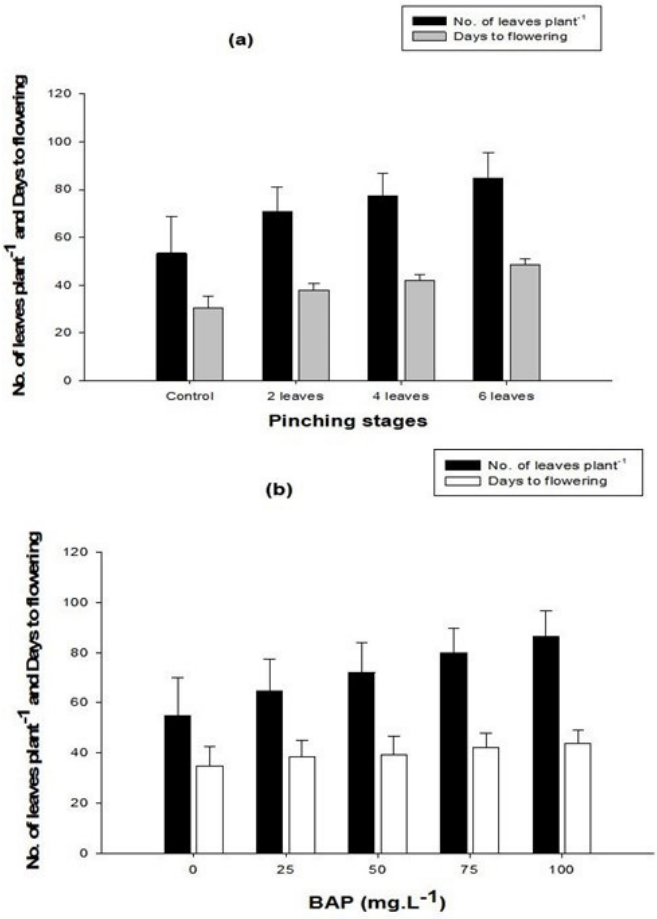

Figure 3: *No. of leaves plant-1 and Days to flowering of zinnia as affected by (a) Pinching stages and (b) BAP concentrations.*

Number of flowers plant-1

It is obvious from Table 1 that the number of flowers plant^{-1} significantly increased as the pinching was delayed up to 6 leaf stage. Maximum flowers plant^{-1} (12.2) were observed when zinnia plants were pinched at 6th leaf stage. The plants produced 11.5 and 11.1 flowers plant^{-1} when pinched at 4 and 2 leaf stages, respectively. Minimum flowers plant^{-1} (9.7) were recorded in plants of control treatment (Figure 4a). Regarding BAP application, increase in zinnia flowers plant^{-1} was observed with the increase in concentration of BAP. Maximum flowers plant^{-1} (12.0) were obtained at 100 mg L^{-1} BAP dose, which was closely followed by 75 mg L^{-1} and 50 mg L^{-1} BAP doses that produced 11.7 and 11.2 flowers plant^{-1} respectively. Minimum flowers plant^{-1} (10.1) were recorded in control treatment, which was at par with those sprayed with 25 mg L^{-1} BAP concentration producing 10.6 flowers plant^{-1} (Figure 4b).

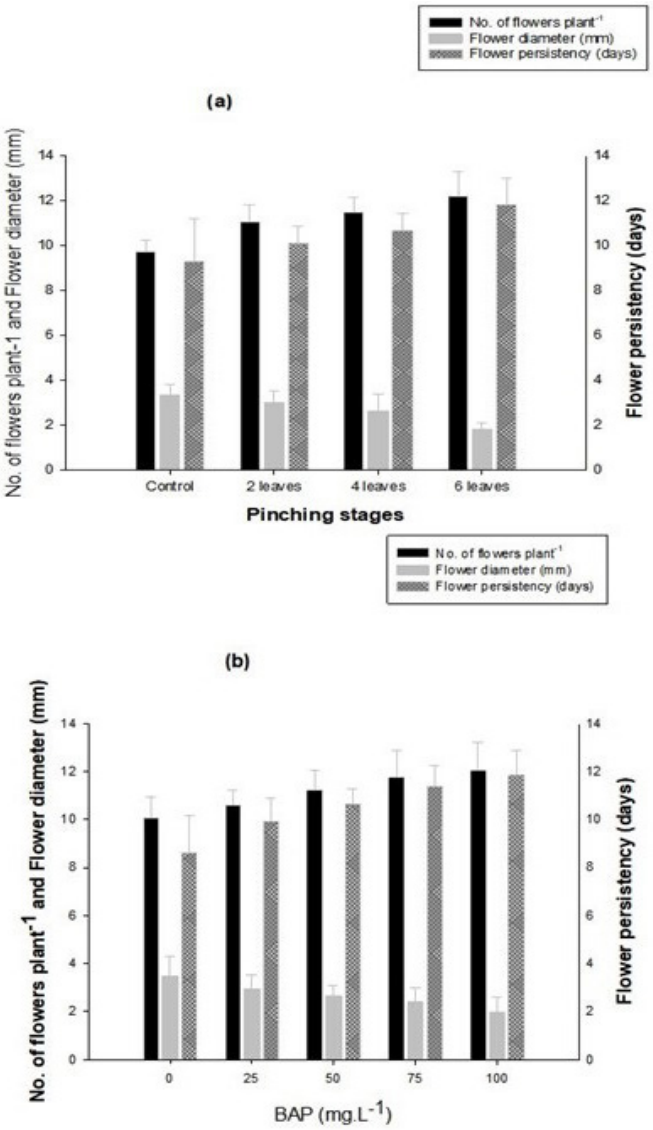

Figure 4: *No. of flowers plant-1, flower diameter and flower persistency of zinnia as affected by (a) Pinching stages and (b) BAP concentration.*

Number of flowers is directly related to number of lateral branches. Pinching suppresses apical dominance and ultimately enhances number of lateral shoots that consequently increases the number of flowers (Ahmad *et al*., 2007). Cytokinins can affect number of flowers depending upon the concentration

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used (Pobudkiewicz, 2008). Hopkins and Huner (2009), reported that cytokinins are the derivatives of nitrogen based adenine that are noted for stimulating cell division in tissue culture. BAP is one of the aromatic cytokinins that stimulate cell division in lateral buds, which encourage flower buds to sprout. The current results are supported by the findings of Dalal *et al*. (2006), who reported that carnation plants pinched twice gave more flowers plant^{-1} as compared to un-pinched. Abd El-Aal and Mohamed (2017), reported that Geranium plants when treated with paclobutrazol gave maximum number of flower as compared to untreated. Foliar application of BAP significantly increase number of flowers in every cluster of *Jatropha curcas* as compared to control (Bang and Xu, 2011).

Flower diameter (cm)

Zinnia flower diameter significantly decreased with the increase in pinching stages (Table 1). The un-pinched plants produced the flowers with maximum (3.3 cm) diameter. This was closely followed by the zinnia plants pinched at 2 and 4 leaf stage having diameter of 3.0 and 2.7 cm respectively, while minimum flower diameter (1.8 cm) was recorded in plants pinched at 6 leaf stage (Figure 4a). The highest flower diameter in zinnia (3.5 cm) was observed in plants that were not sprayed with BAP (control), and it was closely followed by diameter of 3.0 cm in zinnia flower treated with 25 mg L^{-1} BAP. The flower diameter in plants sprayed with100 mg L^{-1} BAP was the lowest (2.0 cm), which was statistically similar with the flower diameter of plants treated with 75 mg L^{-1} and 50 mg L^{-1} (2.7 cm, 2.4 cm flower diameter respectively (Figure 4b).

Sharaf-Eldien *et al*. (2017) found a decrease in flower diameter of *Zinnia elegans* after pinching. The present study is in line with the findings of Srivastava *et al*. (2002), who noticed smaller flowers in marigold plants that were left un-pinched and smaller size flowers were also recorded in plants pinched at 20 days after transplanting of carnation (Dalal *et al*., 2006). In case of BAP, the current results are in contrast with the findings of Nishijima *et al*. (2006) who investigated that diameter of Petunia flowers were enhanced after the application of cytokinins. While, the results are in line with the findings of Saadawy and Abdel-Moniem (2015), who reported that BAP applied at high concentrations resulted in small flowers of *Euphorbia milii*. Pobudkiewicz (2005) also observed a decrease in flower size with BAP application on carnation 'Snowmass'. Wu and Chang (2011) further investigated smaller flowers of *Phalaenopsis* orchid after the application of higher concentrations of BAP, which may be due to nutrient competition for subsequent flower development after improving the flower number.

Flower persistency (days)

Ant Table 1 shows a significant effect with the treatment of pinching stages and BAP concentration for flower persistency. Flowers persisted for maximum days (11.8) on the plants pinched at 6 leaf stage, closely followed by the plants pinched at 4 leaf stage with a flower persistence of 10.7 days. The flower persistence was minimum (9.3 days) in un-pinched plants, which was also at par with the plants pinched at 2 leaf stage having a flower persistency of 10.1 days (Figure 4a). The highest persistency of flowers (11.9 days) was recorded in plants treated with 100 mg L^{-1} BAP, which was statistically similar with the persistency recorded in plants treated with 75 and 50 mg L^{-1} BAP (11.4 and 10.6 days, respectively). The persistency of flowers in control plants was the lowest (8.6 days) and it was closely followed by the plants treated with 25 mg L^{-1} BAP (9.9 days) (Figure 4b).

The current findings show that flower persistency enhanced as the plants were pinched at maximum leaf stage (6 leaf stage). These findings are in line with the results of Singh *et al*. (1980), who found increase in the persistency of flowers with pinching and reported that pinching helped to improve the luster and keeping quality of flowers. Cytokinins are considered to decrease sensitivity of flowers to ethylene, which ultimately increases the longevity of individual flower on the plant. Chang *et al*. (2003) reported that when pollinated flowers of petunia were treated with cytokinins. They were more persistent because of slow senescence process Gulzar *et al*. (2005) also reported that cytokinins increase flower persistency in daylilies. The current findings are also in line with the results of Wu and Chang (2011), who observed that increase in concentration of BAP as foliar application increased flower persistency in *Phalaenopsis*.

Flower fresh weight (g)

The fresh weight of the zinnia flowers reduced with the progression in pinching stage (Table 1). The plants which were left un-pinched produced the highest fresh flower weight (6.6 g). This was closely

followed by the plants pinched at 2 leaf stage and 4 leaf stage resulted in 6.2 and 5.9 g fresh weight respectively. While lowest fresh weight (5.1 g) of zinnia flowers was observed in the plants pinched at 6 leaf stage (Figure 5a). Concerning BAP application, flower fresh weight was reduced with the increase in BAP concentration as well. Maximum fresh flower weight (6.7 g) was recorded for plants grown in control treatment. However, it was also statistically similar with the plants that received 25 mg L^{-1} BAP application, which resulted in 6.2 g of fresh flower weight. Plants treated with BAP at the rate of 50 and 75 mg L^{-1} behaved alike and produced the flowers with fresh weights of 5.9 and 5.6 g respectively. Whereas, the lowest flower fresh weight (5.2 g) of zinnia flower was recorded in plants that were treated with 100 mg L^{-1} BAP dose (Figure 5b).

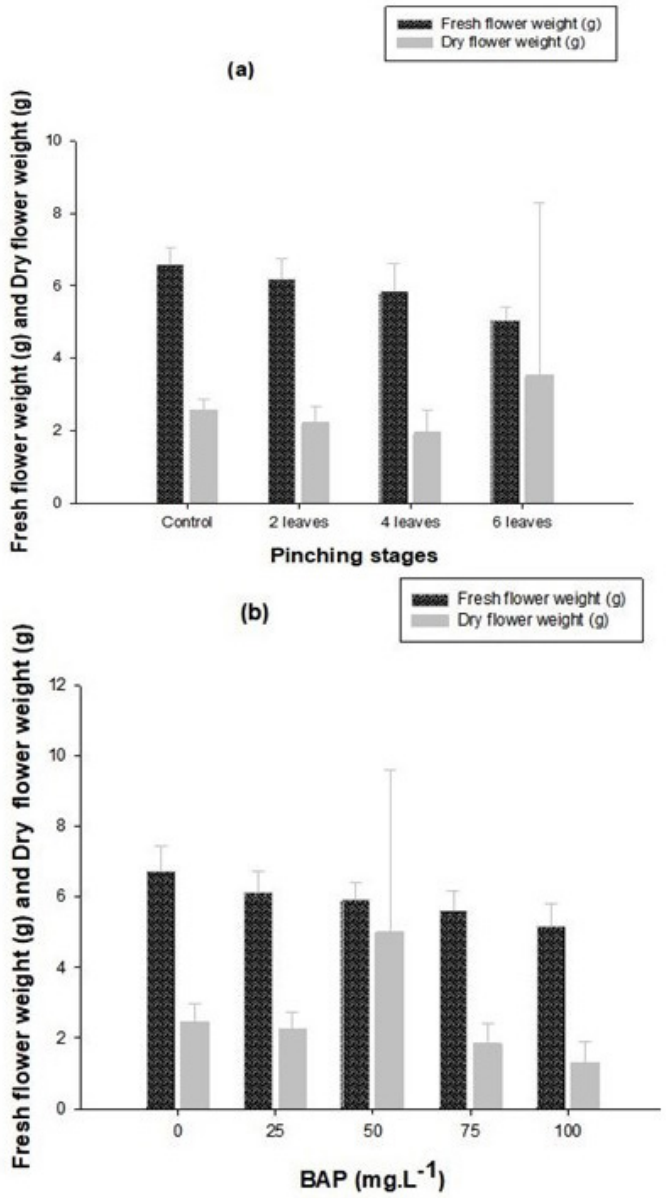

Figure 5: *Fresh flower weight (g) and dry flower weight of zinnia as affected by (a) Pinching stages and (b) BAP concentrations.*

The current results are in line with Dorajeerao and Mokashi (2012), who worked on pinching in chrysanthemum and observed that pinching enhanced number of flowers $plant^{-1}$, but reduced flower fresh weight and size. The present findings are also in line with the results of Nazir and Amin (1990), who worked on carnation pinching. In case of BAP, the results reveal that fresh weight of flowers decreased with the application of BAP and was found the lowest at the highest level of BAP. The present findings are also in line with the results of Gibson and Whiper (2003) and Hojjati *et al.* (2009), who observed that application of BAP to plant, decreased its growth. They observed more branches $plant^{-1}$ having more flowers of smaller sizes and lesser fresh weights.

Flower dry weight (g)

Table 1 shows a significant effect of flower dry weight with the application of pinching stages and BAP concentration. The dry weight of zinnia flowers declined with severity in pinching. The control treatment resulted in maximum dry weight (2.6 g) of zinnia flower. Plants pinched at 2 and 4 leaf stages behaved alike and producing 2.2 and 2.0 g flower dry weight respectively (Figure 5a). The flower dry weight was mini mum at 6 leaf stage having weight of 1.2 g. Regarding BAP application, maximum flower dry weight (2.5 g) was obtained in un-pinched zinnia plants, closely followed by 25 mg L^{-1} BAP application with 2.3 g flower dry weight. BAP sprayed at 50 and 75 mg L^{-1} concentrations produced flowers with 2.1 and 1.9 g dry weight respectively. The application of BAP at 100 mg L^{-1} concentration resulted in minimum (1.3 g) flower dry weight (Figure 5b).

Pinching increases the number of flowers $plant^{-1}$ but reduces flower size and hence its dry weight. The dry weight of the flowers decreased with pinching stages and was the lowest at 6 leaf stage of pinching. The present finding is in accordance with Naresh and Singh (2012), who worked on pinching in African marigold and found a decrease in dry weight of flowers with pinching. The current results are in line with those of Bhatti and Chikara (1987), who found minimum dry weight of flowers in pinched plants as compared to un-pinched. In case of BAP, dry weight of flowers decreased with the application of BAP. The present findings are in accordance with the results of Gibson and Whiper (2003) and Hojjati *et al.* (2009), who observed that application of BAP decreased plant growth. They found more branches $plant^{-1}$ with

more but smaller flowers with lower dry weights.

Conclusions and Recommendations

Zinnia pinched at 6 leaf stage performed better in term of reducing plant height and increasing number of branches and flowers. Foliar spray of BAP at 100 mg L^{-1} resulted in reduction in plant height compared to control and enhanced lateral branching and flower yield. Pinching zinnia at 6 leaf stage is recommended to control plant height and increase flower production. A foliar dose of 100 mg L^{-1} BAP should be applied to reduce plant height and enhance flower production in zinnia.

Novelty Statement

The comparative effect of both BAP and pinching was evaluated for quality flower production and growth of zinnia flower in the agro-climatic zone of Peshawar. Pinched flowers of zinnia at six (6) leaves stage with the application of BAP (@100mg.L-1) recorded an abrupt change in the height of plants and flowers production.

Author's Contribution

S. Ali and A.M. Khattak: Conceived and designed the study.
S. Ali and A. Basit: Performed the experiment.
A. Basit, S.T. Shah and I. Ullah: Analyzed the data.
I. Ahmad, N.A. Khan, K. Rauf, S. Khan, I. Ullah and I. Ahmad: Contributed the chemical/ materials/ analysis tools.
A. Basit: Wrote and reviewed the paper.

Conflict of interest
The authors have declared no conflict of interest.

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