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# FOLIAR APPLICATION OF SALICYLIC ACID ENHANCED THE PRODUCTION OF TUBEROSE (*POLIANTHES TUBEROSA* L).

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**Abstract**

*The present study was designed to investigate the "Effect of foliar applied salicylic acid at different times on the growth and production of tuberose" at ornamental nursery, department of horticulture, The University of Agriculture Peshawar during spring 2015. Experiment was carried out in randomized complete block design (RCBD) with split plot arrangements consisting of two factors; Salicylic acid concentrations (0, 1.0, 1.5, 2.0, and 2.5 mM) and time of foliar application (35, 45 and 55 days after sowing). Treatments were repeated three times .The results showed that foliar application of Salicylic acid , its time of application and their interaction significantly affected the growth parameters such as number of leaves plant$^{-1}$ , chlorophyll contents , days to first floret opening , spike length, leaf area, number of florets spike$^{-1}$, vase life and bulb weight plant$^{-1}$. It is concluded that Salicylic acid at concentration of 2 mM in plant sprayed 35 days after sowing was most effective for better growth and production of tuberose flowers and bulbs.*

**Key words:** Salicylic acid, foliar application, growth, production, tuberose.

## INTRODUCTION

Tuberose (*Polianthes tuberosa L.*) is an important ornamental perennial bulbous plant from the commercial and aesthetic point of view. It belongs to the family Amaryllidaceae and is native to Mexico. Its potential for cut flower trade, sweet fragrance, long vase life and essential oil makes it one of the most important commercially grown cut flowers (Singh, 1995). It is most commonly used in artistic garland, interior decoration, bouquets, wedding and birth ceremonies and in cosmetic industry (Das, 1988). The flowers are waxy white color; about 25 mm long and cone shaped. It has great demand in the markets (Dahiya *et al.,* 2001). It can be grown in flower beds and pots as well as for its cut flowers successfully. The cultivation of tuberose on large scale mostly occurs in USA, Italy, France, North Carolina and South Africa and in several subtropical and tropical areas (Bose, 2002). The tuberose need full light and sandy loam soils with pH ranges between 6.6-7.6 (Sharga and Sharma, 1994). Tuberose is generally planted in March-April in the plains. Tuberose is mostly propagated vegetatively through bulbs (Mahanta *et al*., 1999). Proper planting depth for bulbous plants is very important factor in getting best quality of flowers (Hagiladi *et al*., 1992). Bulbs are planted at a spacing of 20x30 cm or 20x20 cm and planting depth varies from 4-7 cm depend upon the size of blub and environmental condition as well as growing media (De Hertogh *et al*., 1998). The bulbs of 30-40 g are considered better for good flower production (Singh, 1995).The cut flower production is of significant importance in agriculture world. The cut flowers are important from trade perspective and contribute about 45% of the world trade in floriculture sector. It was estimated to be 5.5 billion US $ growing at the rate of 10% per annum (Woodson *et al*., 1992). However, Pakistan's share in the floriculture industry is not considerable because of fewer facilities for cut flower production and also lack of knowledge. However, proper research and utilization of updated technology as well as training of commercial growers on production and marketing of cut flowers at both grower and professional's level can help in strengthening the floriculture industry in the country.

Salicylic acid (SA) is the natural chemical found in the bark of White willow tree (*Salix Alba*) and is beneficial to other plants. Since ancient times, plant salicylates have been used in medicine. The SA has the potential to play important role in plant's growth and development (Raskin, 1992). SA regulates several processes in plants such as ethylene production, germination of seed, disease resistance, sex polarization and heat stress, membrane permeability, uptake and transport of ions, stomata opening and closing as well as growth and photosynthesis (Raskin, 1992; Senaratna *et al*., 2000). SA application has diverse effect on plant tolerance against abiotic and biotic stresses such as extreme temperature, drought stress, heavy metal, salinity and pathogens (Bosch *et al.,* 2007). The large number of flowers and leaves and earlier appearance of flowers are the indications of the positive response of plants to SA (Hosseini, 2009).The SA has positive impact on fresh and dry weight of petal, moisture content and cell membrane stability of petals of Calendula flower (Bayat *et al*., 2012), Persian cyclamen (Farjadi-Shakib*et al.*,2012) and violet flower (Ghorbani *et al.* 2013).The SA also increases the postharvest vase life of Chrysanthemum (Zamani *et al*., 2011a), Gladiolus ( Hatamzadeh *et al*.,2012) and narcissus ( Sardoei *et al*., 2013). The foliar spray of SA on alstroemeria plants increases water absorption and chlorophyll content (Soleimany-Fard *et al*., 2013). SA also increases the vase life of rose cut flowers by decreasing reactive oxygen species and ethylene (Zamani *et al*., 2011b). SA positively influences the plant height, number of leaves, length of floral stalk, the number of florets per spike as well as vase life of tuberose (Anwar *et al*., 2014, Khodakhah *et al*.,2014) and carnation (Qureshi *et al.*,2015).

Keeping in view the importance and multipurpose uses of tuberose and potential positive effects of SA on it, the research was designed to study the impact of foliar spray of SA on the growth, production and vase life of tuberose.

## MATERIAL AND METHODS

A field experiment was conducted at ornamental nursery, Department of Horticulture, The University of Agriculture Peshawar during spring 2015, to evaluate the effect of SA concentrations and time of application on the growth and production of tuberose. The soil of the experimental field was sandy loam having pH 7.72, Electric conductivity 0.165 $dSm^{-1}$, organic matter 0.3%, lime 8.36%, Nitrogen 0.04%, Phosphorus 3.5 $mg.kg^{-1}$ and Potassium 90 $mg.kg^{-1}$. The experiment was carried out in Randomized Complete Block Design (RCBD) with split-plot arrangements and had 15 treatments replicated thrice. Bulbs were planted at a distance of 20 cm while row to row distance was kept 30 cm. The Foliar application of SA with five different concentrations (0, 1.0, 1.5, 2.0 and 2.5 mM) was kept in sub plot and time of application (35, 45 and 55 days after sowing) was assigned to main plot. All cultural practices such as hoeing, weeding, irrigation and fertilizer application were carried out uniformly.

**Statistical Methods:** The statistical analysis was performed by using the statistical package version 8.1 Comparisons among the treatments were evaluated by using the least significant difference (LSD) test. Differences between the treatments were considered significant at $P \leq 0.05$ level (Jan *et al.,* 2009).

## RESUT AND DISCUSSION

**Number of leaves plant$^{-1}$:** Number of leaves plant$^{-1}$ of tuberose was significantly affected by salicylic acid (SA) concentrations, application timing and their interaction. SA application resulted in higher leaf area in comparison to the control treatment which received no salicylic acid (Fig. 1a). Among the different SA application rates, the maximum number of leaves was produced in the plants treated with 2 mM SA. The worst overall performance in the SA applied treatments was in the plants supplied with no SA (distilled water treated plants). Regarding application time, application of SA (1.5 and 2 mM) resulted in higher leaf area at 35 days after sowing, however; the application of SA (1 and 2.5mM) at 45 days after sowing appeared to promote leaf area of tuberose as compared to control (distilled water). Overall, number of leaves was increased to the maximum in plants treated with foliar application of 2 mM of SA 35 days after sowing. SA as plant growth regulator helps in synthesis of kinase proteins which help in the regulation of biochemical and physiological processes thus improved plant growth and development (Hayat *et al.,* 2010). SA enhanced the uptake of nutrients and also promoted the photosynthetic activity in plant that lead to the synthesis of carbohydrate which enhanced the number of leaves. The results are in line with Yildirim *et al.* (2008), who reported an increase in the number of leaves of cucumber with the application of SA. Anwar *et al.* (2014) also found that the exogenous application of SA had positive effect on number of leaves in tuberose. More number of leaves was also found with foliar application of SA in calendula officinalis, tuberose and zinnia by Pacheco *et al.* (2013), Khodakhah *et al*. (2014) and Al-Abbasi *et al.* (2015) respectively.

**Chlorophyll contents (mg cm$^{-2}$):** Data regarding Chlorophyll contents are shown in Figure 1b. Chlorophyll content was found highest in plants treated with 2 mM of SA sprayed 35 days after sowing, followed by 1.5 mM sprayed 35 days after sowing while least chlorophyll content were observed in plants sprayed with distilled water 45 days after sowing. The SA plays an important role in regulating of stomatal opening and closing, enzyme activity, biosynthesis of pigmented compounds including chlorophyll, rate of transpiration and respiration as well as photosynthesis which might be the reasons of increased chlorophyll content. Furthermore, SA decreases the synthesis of ethylene precursor (1-aminocyclopropane-1-carboxylic acid) which causes the loss of chlorophyll in plants (Soleimany-Fard *et al*. 2013). The results are in line with that of Hossein zadeh *et al.*, (2013) who found an increase in chlorophyll content of artichoke with the foliar application of SA. Bayat *et al.* (2012) also reported maximum chlorophyll contents in the leaves of calendula when treated with SA at concentration of 2 mM. Similar results were reported by Karlidag *et al.*

(2009), Sajjad *et al.* (2014), Jahanbazi *et al.* (2014), Kazemi (2014) in strawberry, gladiolus, roses and tomato respectively.

**Days to first floret opening:** SA concentrations, time of foliar application and their interaction significantly affected days to first floret opening (Figure 1c). Results showed that early flowering was noticed in plants treated with foliar application of SA (1.5mM), 45 days after sowing while flowering was delayed in control treatment. It may be due to synergist effect of SA with Auxin which helps to induce flowering (Hayat *et al.,* 2007). SA also enhances the photosynthesis process and carbohydrate in leaves that promote leaves maturity. The flower emergence mostly started when leaves achieves maximum size (Arfan *et al.,* 2007). Similar results were noticed by Anwar *et al*. (2014) who reported that the foliar application of SA enhanced early flowering in tuberose. Padmapriya and Chezhiyan (2002) also stated that the SA application induced early flowering in chrysanthemum. Pal *et al.* (2015) found that the foliar application of SA minimized days to flower emergence in gladiolus.

**Spike Length (cm):** SA concentrations, its time of application and their interaction significantly influenced the spike length of tuberose (Figure 1d). Spikes with maximum length were produced in plants sprayed 35 days after sowing and minimum spike length was found in plants treated 55 days after sowing. Among various concentrations of SA, spike length was enhanced when plants were treated with 2 mM of SA while spike length was reduced in plants sprayed with distilled water (Control treatment). SA as plant hormone has synergistic effect on auxin due to which cell division and enlargement takes place. SA had a positive role on enhanced photosynthate assimilation and chlorophyll content as well as improved mineral uptake by plants (Karlidag *et al* ., 2009). An increase in spike length with the application of SA was also reported by Anwar *et al.,* (2014), Jahanbazi *et al*., (2014), Pal *et al.,* (2015) in tuberose, rose cv. Angelina and gladiolus respectively.

**Leaf Area:** Leaf area of tuberose was significantly affected by the application timing (days after sowing), concentration of salicylic acid and their interaction. Generally, SA application resulted in higher leaf area in comparison to the control treatment which received no salicylic acid ( Fig. 2a). Among different SA application rates, the higher leaf area was produced in the plants treated with 2 mM SA which was at par with application of SA at rate of 1.5 mM. The worst overall performance in the SA applied treatments was in the plants supplied with no SA (distilled water treated plants). Regarding application time, application of SA (1.5 and 2 mM) resulted in higher leaf area sprayed 35 days after sowing, however; the application of SA (1 and 2.5mM) at 45 days after sowing appeared to promote leaf area of tuberose as compared to control. Overall, maximum leaf area was measured in plants treated with foliar application of SA at the rate of 2mM sprayed 35 days after sowing. SA improved the process of photosynthesis and biosynthesis of organic substances that enhanced the leaf area. Bayat *et al.* (2012) , Pacheco *et al.* (2013), Pal *et al.,* (2015) reported an increase in leaf area with the application of SA in calendula, marigold and gladiolus. The results are in line with Zarghami *et al*.( 2014) who found maximum leaf area with foliar application of SA (2 mM) in *petunia hybrida*.

**Number of florets spike$^{-1}$:** SA concentration, its time of application and their interaction significantly enhanced the number of florets spike$^{-1}$ of tuberose (Fig. 2b). Foliar spray of SA 35 days after sowing at the concentration of 2 mM produced highest number of florets spike$^{-1}$ which is statistically at par with the application of SA @ 1.5 mM sprayed 35 days after sowing while minimum number of floret spike$^{-1}$ was recorded in plants sprayed with distilled water, 55 days after sowing. SA increased the leaf area, chlorophyll contents hence enhanced photosynthetic activity resulted in long healthy spikes with more number of florets. SA helps in assimilation of carbohydrates and increases mineral uptake which affect the induction of flower and increases the number of flowers (Khurama, 1992 and Fariduddin *et al*., 2003). An increase in the number of florets spike$^{-1}$ with the application of SA was also reported by Jabbarzadeh *et al.* (2009), Sardoei *et al.* (2014), Pal *et al.* (2015) and Qureshi *et al.* (2015) in African violet, Petunia, gladiolus and carnation respectively. The results are in line with Zarghami *et al.* (2015) who found that SA concentration @ 2 mM enhanced number of florets per plant in petunia.

**Vase Life (days):** SA concentrations, its time of foliar application and their interaction significantly influenced the vase life of tuberose (Fig. 2c). Maximum vase life was observed in spikes of plants treated with 2 mM of SA sprayed 35 days after sowing followed by 1.5 mM of SA, whereas spikes treated with distilled water sprayed 35 and 45 days after sowing had shortest vase life. SA has been reported to decline the ethylene production, it reduces the bacteria augmentation and prohibits vascular blockage (Williamson *et al.,* 2002) and hence resulted in an increase in vase life. SA might reduced the rate of transpiration and evaporation from tissues and regulated the uptake of water. The results are in line with that of Anwar *et al.,* 2014 who reported a delay in senescence process and an enhanced post harvest vase life in spike of tuberose plants sprayed with SA. Soleimany-Fard *et al.* (2013) observed that SA application retained the vase life in Alstroemeria. Hatamzadeh *et al.* (2012) observed delayed petal senescence in cut spikes of gladiolus treated with SA as compared to control. Khodakhah *et al.,* (2014) and Al-Abbasi *et al.,* (2015) also reported that treatment of SA resulted in enhanced post harvest life of tuberose and zinnia respectively.

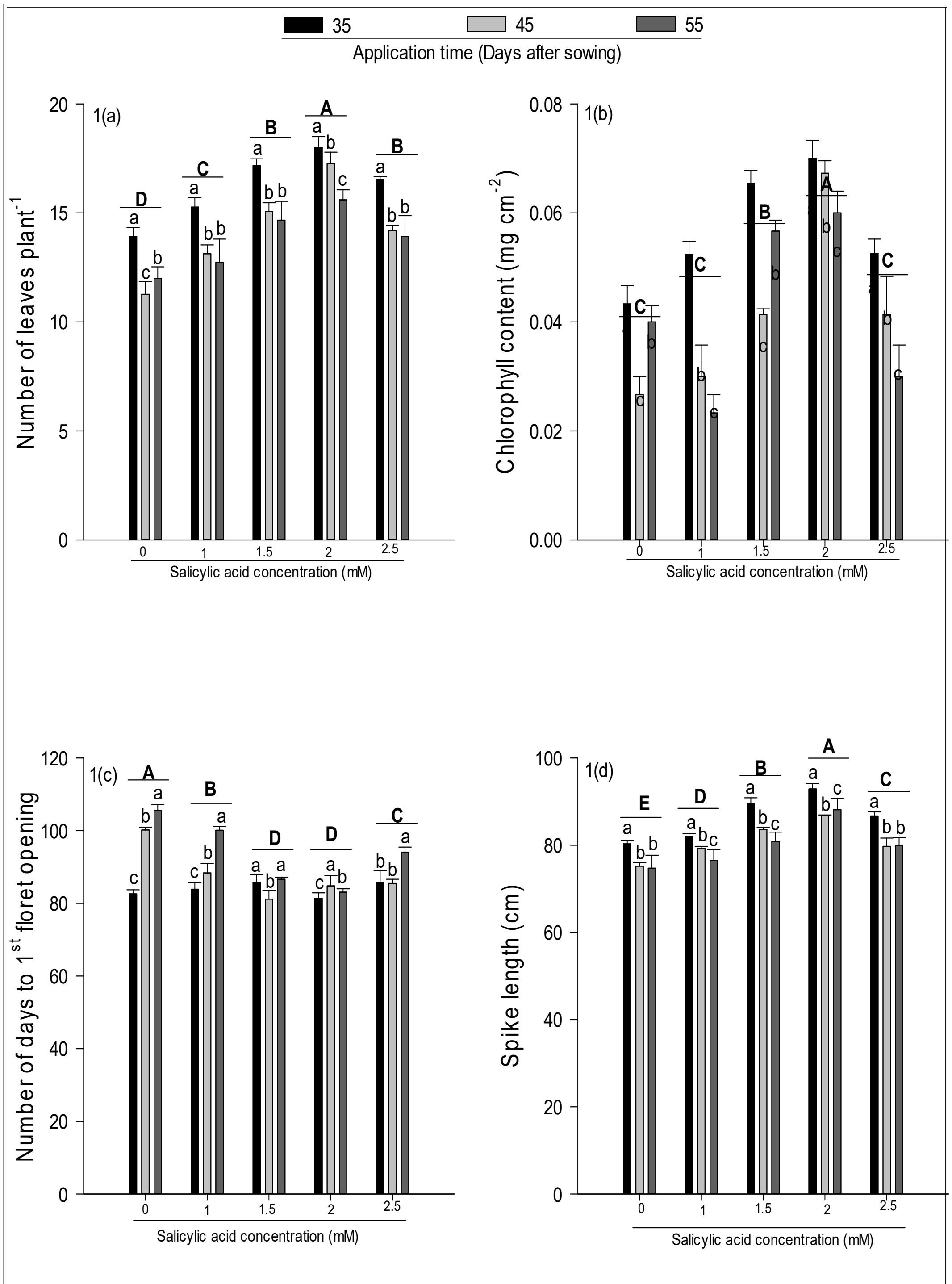


*Figure 1(a); Changes over time in number of leaves plant-$^{1}$; Fig.2(b) changes over time in Chlorphyll contents (mg cm$^{-2}$) ; Fig.2(c) changes over time in Number of days to first floret opening and Fig 2(d) changes over time in spike length (cm) of Tuberose in response to the application rate of salicylic acid (0, 1, 1.5, 2 and 2.5mM) at three different timings/growth stages (35, 45 and 55 days after sowing). Values represent means ± SEM (n = 3). Different capital letters above the represent significant differences between salicylic acid P< 0.05 level, while lowercase letters represent differences within an individual treatment (application time) at the P< 0.05 level.*

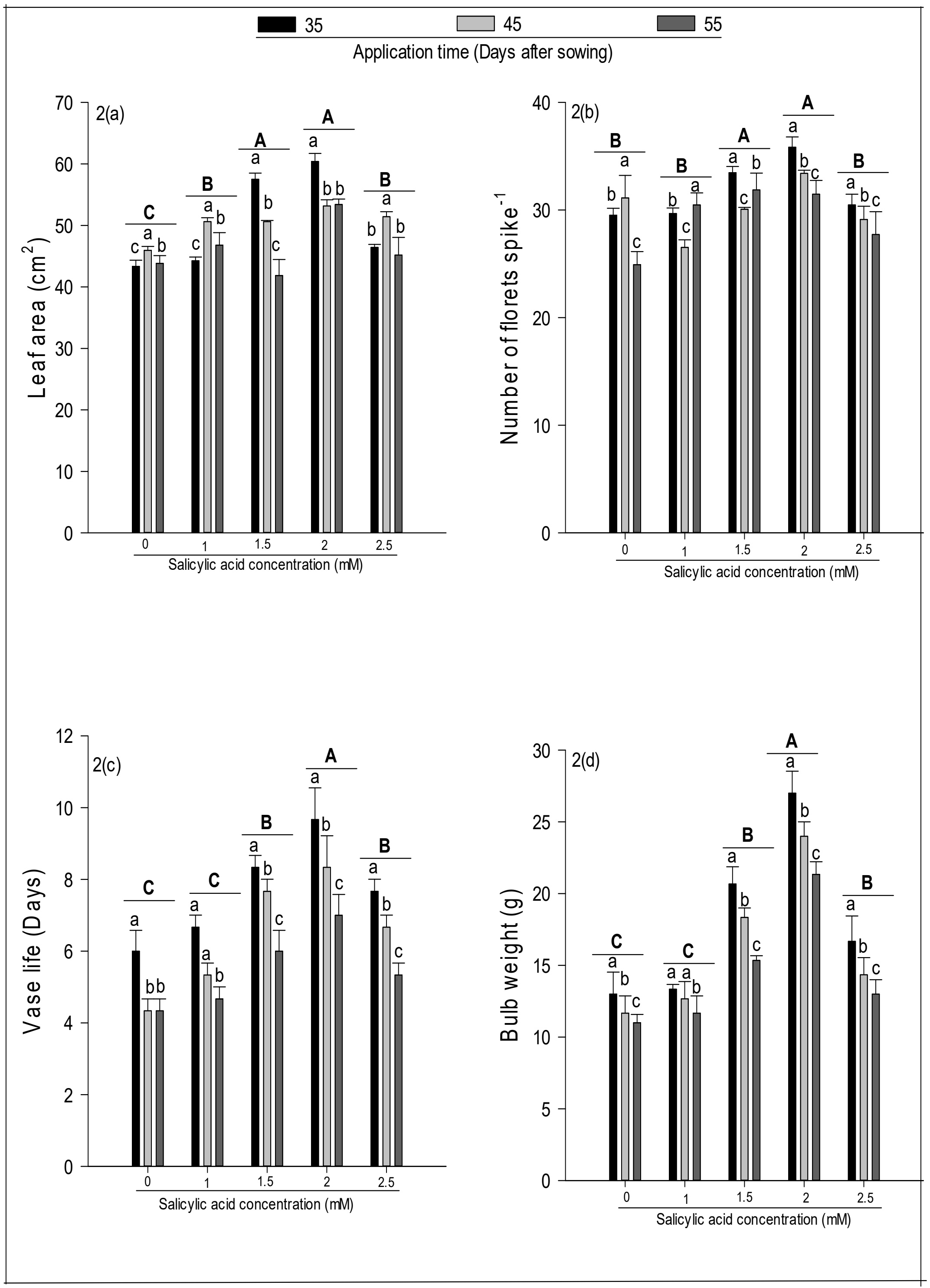


*Figure 2(a); Changes over time in leaf area; Fig.2(b) changes over time in number of florets spike$^{-1}$; Fig.2(c) changes over time in vase life and Fig 2(d) changes over time in bulb weight of tuberose in response to the application rate of salicylic acid (0, 1, 1.5, 2 and 2.5mM) at three different timings/ growth stages (35, 45 and 55 days after sowing). Values represent means ± SEM (n = 3). Different capital letters above represent significant differences between salicylic acid P< 0.05 level, while lowercase letters represent differences within an individual treatment (application time) at the P< 0.05 level.*

**Bulb weight plant$^{-1}$ (g):** The Bulb weight plant$^{-1}$ was significantly affected by SA concentrations, time of application and their interaction (Fig. 2d). Data showed an increase in bulb weight with increase in concentration of SA and it was enhanced to maximum at 2 mM of SA and then there was a decline in bulb weight at the concentration of 2.5 mM of SA. Overall, Maximum bulb weigh plant$^{-1}$ was found when the plants were sprayed with 2 mM of SA, 35 days after sowing , followed by 1.5 mM of SA while minimum bulb weight was found in plants treated with foliar application of distilled water (0 mM of SA) 55 days after sowing. SA application increased the chlorophyll contents in leaves and also enhanced soluble starch, sugar and soluble protein that resulted in an increase in bulb weight of tuberose. SA plays important role in synthesis of kinase proteins which helps in the regulation of biochemical and physiological processes in plants which have significant effect on bulb weight. The present result are in line with Amin *et al*. (2007) who stated that SA enhanced cell division and carbohydrate accumulation which as a result increased the bulb weight in onion. Similarly Bideshki *et al*. (2010) and Hadi & balali (2010) found an increase in the weight of garlic bubls and potato tubers respectively with the application of SA.

## CONCLUSION

Salicylic acid (SA) concentrations and time of its foliar application had significant effects on the yield and yield related traits of tuberose. Among different concentrations of SA, foliar application of 2 mM done 35 days after sowing had more pronounced effect on growth and production of tuberose.To obtain the maximum production and better quality of tuberose (both flowers and bulbs), the foliar application of SA at concentration of 2 mM could be sprayed 35 days after sowing under the agro climatic condition of Peshawar Khyber Pakhtunkhwa. Future research work is recommended to study the role of SA on oil production and biochemical attributes of tuberose oil.

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