Pak. J. Bot., 50(6): 2159-2165, 2018.

COMPARISON OF IMPACT INDUCED BY DIFFERENT PRIMING TECHNIQUES ON GERMINATION AND PLANT DEVELOPMENT IN LISIANTHUS (*EUSTOMA GRANDIFLORUM*)

MAILA AL SABA SHAH, USMAN SHOUKAT QURESHI*, SAMAN CHUGHTAI, KHALID MEHMOOD QURESHI*, ABDUL AHAD QURESHI AND ISHFAQ AHMAD HAFIZ

[1]Department of Horticulture, PMAS Arid Agriculture University, Rawalpindi, Pakistan
Corresponding author's email: us_qureshi@yahoo.com

Abstract

Lisianthus (*Eustoma grandiflorum*) belongs to family Gentianaceae is becoming one of the most highly ranked cut flowers in international market. Lisianthus seeds exhibited cold-related dormancy and slow germination rate. Seed priming techniques have been utilized to increase germination attributes and improve germination uniformity. The present study was conducted to enhance germination uniformity and plant development in Lisianthus by using different priming techniques. The effect of different concentrations of gibberellic acid (250, 500 and 1000 ppm GA_3), potassium nitrate (0.1, 0.2 and 0.3% KNO_3), hydro priming (DW, CDW, WDW) and control was examined on germination and other physiological parameters. Complete Randomized Design (CRD) was used for nine treatments with five replications. Plants treated with GA_3 of concenteration 1000 ppm had a positive impact on all parameters (mean germination time, germination index, plant height, number of leaves, stem length, number of flowers, size of flower fresh and dry plant weight). It seems that GA_3 and KNO_3 can be replaced partly to improve seed germination of lisianthus seeds. Therefore, it is concluded that for best germination and plant growth parameters of Lisianthus seeds, harmonal (GA_3) and halo priming (KNO_3) can be used.

Key words: Priming, Dormancy, Germination, Potassium nitrate, Gibberellic acid.

Introduction

Eustoma grandiflorum commonly known as Lisiasnthus belongs to Gentianaceae family (Reid, 2009). Emanated from North America currently inhabitant of the southern parts of the United States, encompassing moist meadows from Nebraska to Colorado and Texas (Ohkawa *et al.,* 1991). Lisianthus is the floral crop that has attained importance all over the world as an ornamental plant and cut flower. Lisianthus normally attains the height of 50 to70 cm with 20 to 40 flowers, blossoming mostly in summer season (Cantor *et al.,* 2013). It is herbaceous plant bluish green foliage, sometimes erect and single stem or branched stem. The flower can grow up to two inches in diameter and can be found in variety of colors. Flowers and plant extract are also used in traditional medicines. Lisianthus plants are digestive, anti-inflammatory, anti-fungal, to reduce fever and malaria. They are also used in cosmetics and also include in fragrances, weight loss products, for air purification and various homeopathic medicines (Sreelatha *et al.,* 2006). Lisianthus seeds exhibited cold-related dormancy (Ecker *et al.,* 1994). They are also tolerant to soil acidity, different pathogen attack and high temperature stresses. Size of seed is very small (19,000 seed /gm or 545,000 seeds/oz) due to this reason it is difficult to handle such small seed in field plantings (Rezaee *et al.,* 2012). Lisianthus repeatedly show evidence of a slow germination rate, with as less as zero germination percentages, under normal favorable condition (Ecker *et al.,* 1994).

Seed priming treatments are effective method for enhancing germination characters i.e. seed vigor, germination uniformity and development of seedlings of several plant species under extreme environmental conditions.(Bajehbaj, 2010; Ansari & Sharif-Zadeh, 2012). Priming techniques used on seeds have been generally applied to diminish the time interval from sowing to sprouting and to harmonize emergence of the seedlings (Parera & Cantliffe, 1994). Priming increase germination percentage and seed reserve are used as compared to non-primed seeds (Tabatabaei, 2014). Gibberellic acid (GA_3) is endogenous plant hormone, belongs to gibberellins group and takes part in various metabolic processes (Eason, 2002). GA_3 is mostly known to enhance the production of hydrolyses (α-amylase) in the endosperm of cereals (Kolumbina *et al.,* 2006). Potassium nitrate (KNO_3) is commonly applied chemical for enhancing seed germination (Millaku *et al.,* 2012). Similarly, KNO_3 is also used in osmo priming as osmotica which helps to provide nitrogenous compounds and additional nutrients which are vital for production of protein in early stage of seed germination (Lee, 2004). Keeping in view the importance of Lisianthus plant present study was designed to determine effective priming technique and their best concentrations to be used for early growth and flowering behavior.

Materials and Methods

The present study was carried out in the research area of Department of Horticulture, PMAS Arid Agriculture University Rawalpindi, during 2016-2017. The experiment was conducted in Experimental Area, Department of Horticulture, PMAS-Arid Agricultural Rawalpindi (lat. 33° 38'51"; long. 73°4'57.72"). Seeds of Lisianthus F1 double var. "Echo" were imported from Skata seed cooperation Japan and dusted with thiram. Hydro priming was done with distilled water, cold distilled water and hot distilled water. In case of hydro priming, normal distilled water (DW) used of temperature 15°C, for cold water treatment (CW) distilled water at temperature 5°C and for warm water treatment (WW) water was heated hot plate at the temperature of 40°C for 15 min. regarding halo priming, potassium nitrate was applied at rate of 0.1%, 0.2% and 0.3%. For hormonal priming, gibberellic acid was used at conc. of 250, 500 and 1000 ppm. Dry seed was used as control.

Germination assay: Seeds were inoculated on top of double layer filter papers (ISTA, 1996) with 5 ml water in 10 cm Petri dishes then placed in germination chamber. These petri dishes were sealed with cello tape to avoid moisture loss. Incubation was done in germinator for 30 days with required photoperiod of 12 h maintained with help of fluorescent light 40 µmol $m^{-2}s^{-1}$ and temperature was kept at 25±1°C. Treated seeds were counted up after every 48 h for almost 20 days (Millaku *et al.,* 2012). Seeds were considered sprouted upon appearance of radicals (≥ 2 mm). (Sharma. & Sharma, 2010). Primed seeds were sown in trays filled with Coir (coconut fiber) on surface of substrate because they were photo-sensitive. Green house temperature was maintained 20-22°C and relative humidity maintained at the level of 70-85% of the substrate. Seedlings after attaining proper vigor then transplanted in the 8-10" pots filled with media composed of sand, soil and well rotten farm yard manure (FYM) in ratio of 1:1:1.

Mean Germination Time **(**MGT) was computed conferring to the equation given below. (Moradi *et al.,* 2008). MGT = ΣDn / Σn according to above equation D was the number of days counted from start of germination and n, is the no. of seeds, which germinated on day D. Final germination percentage (FGP) was calculated as it is an assessment of viability of population of seeds (Dewir *et al.,* 2011) in accord to the following formula:

$$\text{FGP} = \frac{\text{No. of ger. seed}}{t\text{otal seeds}} \times 100$$

Germination Index (GI) was determined as illustrated in the Association of Official. Seed. Analysts (AOSA, 1983) by using formula:

$$\text{GI} = \frac{\text{No. of ger. seed}}{\text{Day of first count}} + \ldots\ldots\ldots + \frac{\text{No. of ger. seed}}{\text{Day of final count}}$$

Where, ger. was denoted as germinated.

Measurement of growth attributes: Height of plant and stem length was measured by measuring scale in centimeters; five plants per treatment was analyzed. The numbers of leaves of individual plant was counted and average was worked out for five plants. The stem thickness (cm) and flower diameter (cm) was measured by using Vernier's caliper and average was calculated. Time taken from planting to emergence of flower bud and flower opening was counted in terms of number of days. Freshly harvested shoots from unit area was weighted on analytical balance (grams) and their mean value was calculated. Harvested shoots was dried in sun light for 24 hours and then placed in oven at 65°C for 48 hours and weighted on electronic analytical balance (grams) and means was calculated.

Statistical Analysis

Data was collected (for physiological, visual parameters) and trial was designed according to Complete Block Design (CRD). Data analyzed by Statistix 8.0. LSD test (5% probability level of significance) was applied to check the significance of result (Chase & Bown, 1997). This study eventually display impact of hydro, halo and hormonal priming on germination and growth of Lisianthus *(Eustoma grandiflorum).* Data regarding vegetative and reproductive growth were taken from randomly selected five plants from each treatment per replication on week basis during the entire period of research study.

Results and Discussion

Effect of priming techniques on mean germination time (MGT): The findings of mean germination time (MGT) revealed that Lisianthus primed seeds resulted in significantly enhancing germination time compared to unprimed seeds (Fig. 1). The best performance in terms of mean germination time was of gibberellic acid (GA_3) treatment (T_6) having mean value of 2.04. Whereas the lowest impact of mean 0.6 on germination was shown by hydro primed seeds with warm water (WW) (T_4). All other treatments showed no considerable difference in their mean values.

The enhanced germination by gibberellic acid priming could have initiated quantitative alterations in biochemical components of the seeds, it also resulted in increasing metabolism, protein synthesis (globulins and cruciferin) and membrane integrity of seeds (Varier *et al.,* 2010). The recent results are also in line with the study of Erken and Kaleci (2010), resulted indicated that primed seeds of yellow gentian with GA_3 (600 ppm) provided higher values of germination seeds. In a Millaku *et al.,* (2012) on yellow gentian (*Gentiana lutea* L.) also found that the priming with gibberellic acid and potassium nitrate separately and in combined applications enhanced mean germination time (MGT). Similarly, Ghaleh-Shahi *et al.,* (2017) priming of cocks comb (*Celosia cristata*) seeds with potassium nitrate at rate of 0.2% considerably reduced germination time.

Effect of priming techniques on final germination percentage: The total seeds germinated depicted (Fig. 2) that all priming treatments significantly enhanced final germination percentage except warm water (WW). Those seeds that were treated with gibberellic acid showed better results than other priming techniques used and highest FGP was reported by treatment with 1000 ppm (T_6) having mean value of 83%. Followed by GA_3 the second best effective technique to break dormancy was halo priming with KNO_3. The treatment of KNO_3 (0.3%) gave highest mean 54.33% among all treatments containing potassium nitrate. Lowest impact of priming on final germination percentage was found in case of hydro priming. Hydro priming of Lisianthus seeds with warm water (WW) (T_4) resulted in least emergence percentage (21.33%) as compared to control (T_0) (26.67%).

Resembling our results Petrova *et al.,* (2006) also reported that *G. lutea* seeds treated with GA_3 of conc. 50 mg/L gave higher percentage of germination. Erken and Kaleci (2010) also revealed that the yellow gentian seeds primed with GA_3 (600 ppm) improved germination. Similarly, Millaku *et al.,* (2012) also discovered that GA_3 priming at rate of 1000 ppm resulted in highest mean final germination percentage. The achieved results are also in accordance with preceding researches (Moussa *et al.,* 1998; Rouhi *et al.,* 2010; Zare *et al.,* 2011).

Effect of priming techniques on germination index (GI): Results pertaining to germination index (GI) in Lisianthus plants represented that all priming treatments positively impacted GI (Fig. 3). The highest recorded mean 5.64 illustrated by GA_3 (1000 ppm) treatment (T_6) and the lowest recorded mean 0.93 was in case of control treatment (T_0) and warm water (WW) treatment (T_3). Afterward, seed primed with KNO_3 of dose 0.1% (T_7) accounted the highest mean GI 4 in all treatments containing KNO_3. Remaining treatments demonstrated no substantial difference in their mean values.

Similar results were observed by Demir Kaya *et al.,* (2006) in case of sunflower seeds primed with KNO_3 enhanced germination rate. Farooq *et al.,* (2007) also reported that seeds treated with potassium chloride and calcium chloride increased germination in both rice cultivars. The results attained by Millaku *et al.,* (2012) also revealed that germination index was considerably improved by yellow gentian seeds primed with GA_3 of conc. 1000 ppm and KNO_3 of dose 0.1%. Wheat seeds primed by halo and hydro priming also displayed increasing germination rates (Tabatabaei, 2014).

Effect of priming techniques on plant height (cm): The statistical analysis of variance showed that seed priming showed significant impact on the height of Lisianthus plants (Fig. 4). The highest mean value 70.20 cm of the data was recorded as by the application of Gibberellic acid (GA_3) of concentration 1000 ppm (T_6). There was an immense reduction in plant height (24.20 cm) in case of plant produced from hydro primed seeds with warm water (WW). Among all treatments comprising water as primer, the highest mean height (64.60 cm) was achieved by Cold water treatment (T_2). Among three doses of GA_3, treatment of 1000 ppm (T_6) showed the best result (70.20 cm) while means of other concentrations were not significant to each other. In case of potassium nitrate applications, highest mean (58.50 cm) by pre-sown seed treated with KNO_3 of concentration 0.3% (T_9) while other two application depicted that their means were not substantially differ from each other. Non-primed seeds (T_0) gave mean height of about 28 cm followed by Warm water treatment (T_3) 24.2 cm.

The pre-sowing treatment of seeds with gibberellic acid (GA) might highly modify the vegetative development pathways, plant physiological and metabolism related cycles resulting institution of biological production of vital cellular metabolites (Mazid, 2014). These results are also in agreement with Naeem and Muhammad (2006), who also reported that seed priming with high concentrations of gibberellic acid (GA) significantly enhanced germination and growth of cereal crops. Mazid, (2014) also acknowledged that seed primed with GA considerably enhanced plant height in chick pea plants Similar results were achieved by, Shariatmadari *et al.,* (2017) who also stated that GA priming of chick pea seed considerably improved plant height under drought stress.

Effect of priming techniques on number of leaves per plant: All priming techniques used in experiment indicated significant impact on the number of leaves (Fig. 5). Data showed that the performance of Lisianthus plants was significantly improved as compared to control (T_0). Highest mean number of leaves 36 were observed in GA_3 applied at the rate of 1000 ppm (T_6) and second highest mean 33.6 was obtained by application of KNO_3 (0.1%). Lowest effect on number of leaves was found by control treatment (T_0) having mean of 18.4. The other two treatments of GA_3 enhanced number of leaves but their mean values (31 and 31.8) depicted no significant difference among them. Treatments containing KNO_3, two treatments T_7 and T_8 showed means (33.6 and 33 respectively) with no considerable difference with each other.

Like our results the study conducted by Qureshi *et al.,* (2016) also revealed that the priming of Bismarkia palm seed with gibberellic acid of concentration 750 mg/L enhanced number of leaves but more leaves were produced by seed treated with imidacloprid. Similarly, Sajid *et al.,* (2016) also reported that the application of gibberellic acid at rate of 250 mg/L gave maximum number of leaves (55.05) in *Chrysanthemum morifolium*.

Effect of priming techniques on stem length (cm): the use of different priming techniques had significant impact on stem length of Lisianthus plant (Fig. 6). Three priming methods were used by evolving three treatments for each technique and a single for control. It was observed that highest mean (65.4 cm) was obtained at application of GA_3 of dose 1000 ppm (T_6) and hydro priming with warm water (T_3) gave lowest mean (20.2 cm). Best results were gained with gibberellic acid and later KNO_3 treatments has displayed relatively better results but the mean values exhibited non-significant difference among them. Conversely, the treatments with dosage of gibberellic acid indicated that mean value increased with increasing concentration.

These findings are in accord with Naeem and Muhammad (2006) who also reported the priming of seeds with low doses of gibberellic acid improved shoot lengths but increased concentrations had more impact on growth and development of cereals. Similar results are indicated by Qureshi *et al.,* (2016) that primed seeds of bismarkia palm with GA_3 of concentration 1250 mg/L enhanced plant height as compared to control.

Effect of priming techniques on stem thickness (cm): The statistical analysis of the data (Fig. 7) observed from effect of priming on Lisianthus plant revealed that the GA_3 treatment of conc. 1000 ppm (T_6) gave the highest mean value of 3.79 cm and second highest mean 3.45 cm was obtained from treatment KNO_3 (0.3%) (T_9). Further, the remaining treatments (T_4, T_5, T_7 and T_8) enhanced diameter but did not show significant difference among their mean values. Results achieved by different priming techniques indicated that the group of treatments containing gibberellic acid, application of gave GA_3 treatment (T_6) the maximum diameter (3.79 cm). On contrary, for all the treatments of KNO_3, application of KNO_3 at rate of 0.3% gave maximum diameter. All hydro priming treatments enhanced stem diameter in comparison to control in Lisianthus plants but their means show no considerable difference with each other.

These results were in correlation with those of Naeem & Muhammad (2006) that seed primed with different concentration of gibberellic acid showed a significant difference in improving shoot lengths and growth of cereals. Similar results were also found by Nouman *et al.,* (2012b) that the hydro priming enhanced shoot length and diameter of Moringa plant.

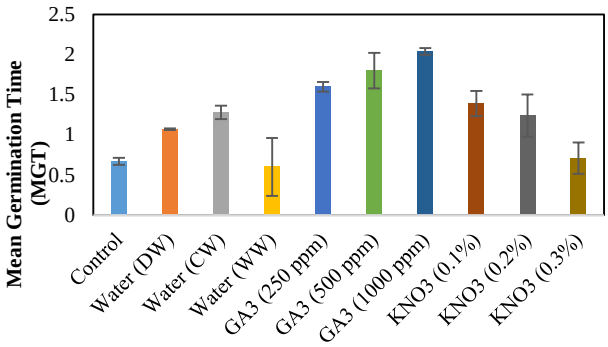

Fig. 1. Impact of priming techniques on mean germination time of Lisianthus plant.

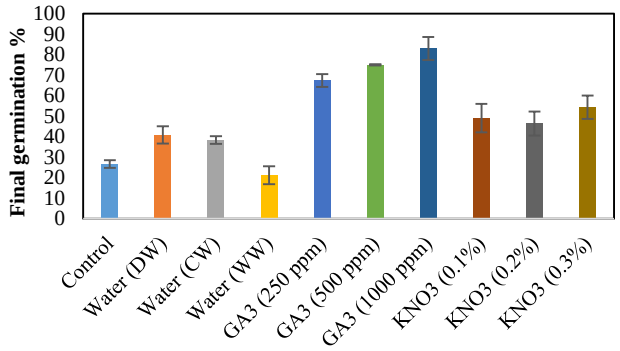

Fig. 2. Impact of priming techniques on final germination percentage (%) of Lisianthus plant.

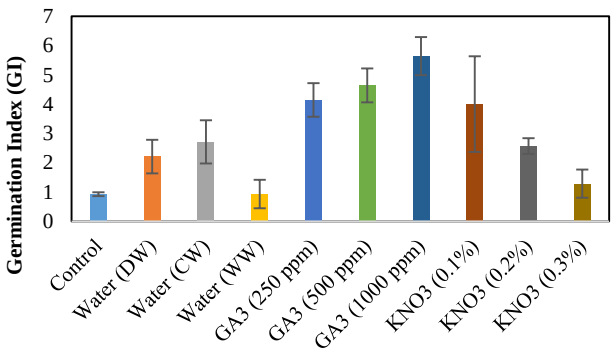

Fig. 3. Impact of priming techniques on Germination Index (GI) of Lisianthus plant.

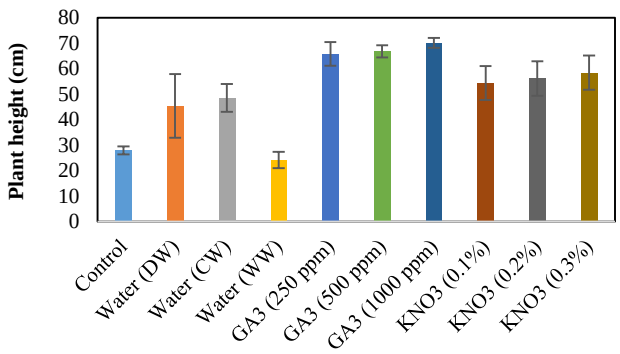

Fig. 4. Impact of priming techniques on plant height (cm) of Lisianthus plant.

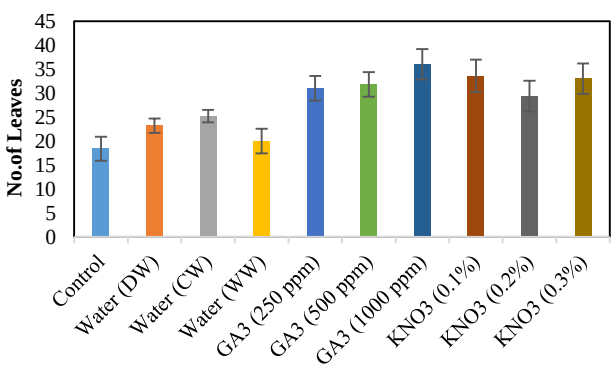

Fig. 5. Impact of priming techniques on number of leaves of Lisianthus plant.

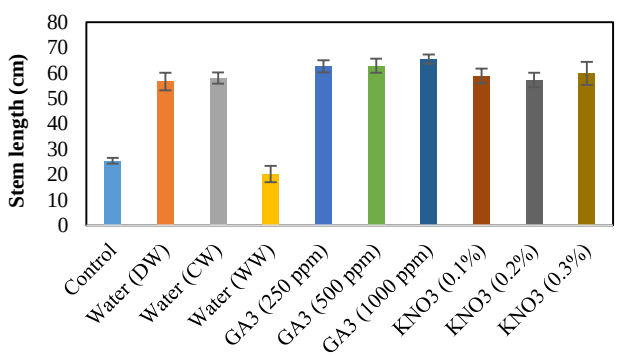

Fig. 6. Impact of priming techniques on stem length (cm) of Lisianthus plant.

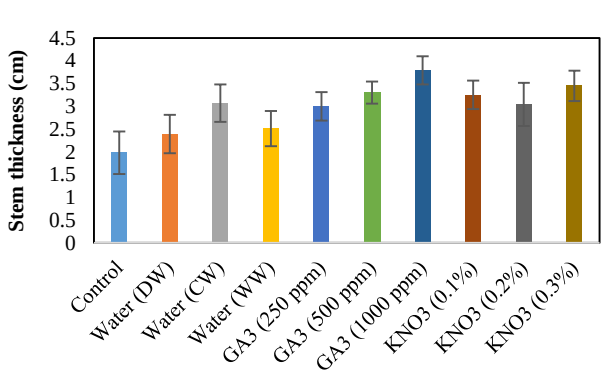

Fig. 7. Impact of different priming techniques on stem thickness (cm) of Lisianthus plant.

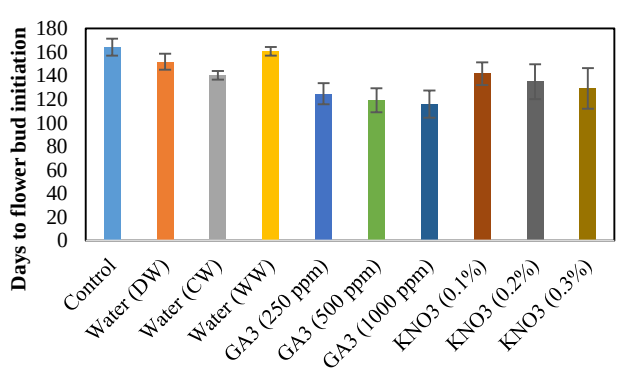

Fig. 8. Impact of priming techniques on days to flower bud initiation of Lisianthus plant.

Effect of priming techniques on days to flower bud initiation (Days): The means acquired from analysis of data clearly denoted that all applications significantly reduced number of days to flower bud initiation in Lisianthus plant (Fig. 8). Highest mean days 164.20 was recorded for control plant (T_0) followed by seed priming with warm water (WW) (T_3) having the mean of 160.60 days. The best performance was shown by gibberellic acid treatment (T_6) which was 115.80 lowest mean days to initiate flower. Thus far, all KNO_3 containing treatments reduced number of days to flower bud initiation with increasing concentration and the priming with 0.3% dose (T_9) gave the lowest mean of days to flower bud initiation (129.2 days). All other treatments showed significant influence by decreasing number of days required for flower initiation as compared to control (T_0).

Priming techniques resulted in enhancing early flower induction in several plant species (Harris *et al.,* 2000). These results were also in agreement with that of Harris *et al.,* (1999) who also found that the hydro priming resulted in early flower initiation in rice, chickpea and maize. Similarly, Murungu and Madanzi (2010) also revealed that wheat on field seed priming positively impacted time to flower induction and flower maturity. Foliar application of GA_3 of dose 150 ppm also imitated early bud induction and reduced days to full bloom and full flowering in china aster (Vijayakumar *et al.,* 2017).

Effect of priming techniques on days to flower opening: The statistical analysis of data showed (Fig. 9) that all treatments significantly impacted flowering days. Among the treatments applied minimum time for flower opening 135.80 days was taken by GA_3 (gibberellic acid) at conc. 1000 ppm (T_6) while other concentrations of GA_3 500 ppm (139 days) and 250 ppm (144 days) also showed remarkable effect on days to flower opening in Lisianthus plants. Treatment with KNO_3 (0.3%) (T_9) reduced number of days to flower opening having mean of 151.20 days. Hydro priming showed that they were not as successful for reducing maximum days for flower opening for Lisianthus as GA_3 and KNO_3. Priming with warm water (WW) (T_3) had days to flower opening value of 182.0 $\pm$ 1.66, Distilled water (DW) primed seeds (T_1) grown plants had 180.6 days and plant produced from cold water (CW) primed seeds (T_2) had 171.8 days. Control plants (T_0) attained maximum days for flower opening (186.20 days).

Recent findings were in line with Harris *et al.,* (1999) who also found reduction in number of days to bloom by the seed treatment of rice, maize and chickpea with hydro priming technique. Murungu *et al.,* (2010) also found that seed priming influence the flowering period of maize seeds in field. Similarly, Vijayakumar *et al*., (2017) also reported that application of gibberellic acid (150 ppm) on china aster reduced days to flower opening and full bloom as compared to control.

Effect of priming techniques on number of flowers: The statistical analysis of data (Fig. 10) revealed that 1000 ppm (T_6) of GA_3 had highest number of flowers (9), followed by GA_3 of conc. 500 ppm (T_5) (8) and KNO_3 applied at 0.3% (T_9) (5.6) correspondingly. GA_3 is followed by KNO_3 (0.3%) and cold water treatment (T_2). All concentrations of KNO_3 had no comparable difference between them while mean values for 0.2% and 0.1% of KNO_3 were 4 and 3.4 respectively. Hydro priming had shown no positive response to number of flowers of Lisianthus. The performance of Halo priming with KNO_3 salt is better than hydro priming. There was no significant difference between all treatments of water and for cold water (CW) (T_2) mean was 4.4, warm water (WW) (T_3) gave low mean value of 2.2 and distilled water (DW) (T_1) had mean number of flowers 3 while control had statistical value of 2.

These findings were in agreement with Vijayakumar *et al.,* (2017), who reported that application of gibberellic acid of conc. 150 ppm enhanced number of flowers per plant in china aster. Similar results were also obtained by Sajid *et al.,* (2016) that application of GA_3 250 mg/L considerably increased number of flowers in chrysanthemum.

Effect of priming techniques on diameter of flower (cm): Analysis of data displayed that priming of Lisianthus seeds significantly improved flower diameter (Fig. 11). The highest value of flower diameter 4.3 cm were recorded with of gibberellic acid (GA_3) treatment (T_6) and second highest mean value 3.94 cm was achieved from priming with KNO_3 at rate of 0.3% (T_9). Subsequently, lowest flower diameter mean 2.04 cm were found in control treatment (T_0). In GA_3 treatments the best performance showed by GA_3 of conc. 1000 ppm (T_6) (4.3 cm). As for KNO_3, all treatments enhanced flower diameter with increasing concentrations in order $T_9 > T_8 > T_7$. Other treatments containing water (T_1, T_2 and T_3) showed no substantial difference among each other.

Our results were correlated with those of Vijayakumar *et al*., (2017) that the application of gibberellic acid showed a significant increase in flower diameter of china aster (*Callistephus chinensis* l. Nees.) *cv.* Local.

Effect of priming techniques on fresh weight of plant (g): All the treatments differ potentially for fresh weight of plant. The statistical measure of fresh weight is presented in figure no. 12 and tabulated in appendices. The data showed that the maximum weight (32.9 g) attained by Lisianthus plant was observed in treatment T_6: (GA_3 1000 ppm), while the lowest weight (21 g) was attained from T_0 controlled. The best result in GA_3 treatments (32.9 g) was shown by T_6 while best result (32.57 g) in case of KNO_3 treatments at rate of by T_9 (@ 0.3%).

The higher plant biomass is caused by application of hormones. Gibberellic acid as an endogenous growth regulator controls a vast range of physiological processes (Eason, 2002). Harris *et al.*, (1999) also reported that hydro priming enhanced crop fresh weight in case of on field seed priming of rice, maize and chickpea. A study conducted by Murungu *et al*., (2004) showed that the on field seed priming of maize in semi-arid region also enhanced plant biomass. Similarly, Sajid *et al.,* (2016) also found that the application of gibberellic acid of conc. 250 mg/L on *Chrysanthemum morifolium* improved plant biomass and flower fresh weight.

Effect of priming techniques on dry weight of plant (g): All the treatments differ significantly for dry weight of plant (Fig. 13). The data indicated that the maximum weight (10.03 g) attained by Lisianthus plant was observed in GA_3 treatment of conc. 1000 ppm (T_6), while the least

weight observed was (7.01 g) from seed priming with warm water (WW) (T_3). The best result in GA_3 containing treatments (10.03 g) was shown by T_6 (1000 ppm) while best result in KNO_3 treatments (8.76 g) was depicted by T_8 (KNO_3 at the rate of 0.2%).

Crops cultivated with primed seeds have more dry matter accretion than unprimed ones (Harris *et al*., 2001). Like our results the study conducted by Soltani *et al.,* (2006) also revealed that the seed priming enhanced seedling dry matter content in wheat. Ansari *et al.,* (2012) also found that priming methods increased seedling dry weight in case of mountain rye. Similarly, Tabatabaei (2014) also proved that halo and hydro priming of wheat seeds significantly improved dry weight.

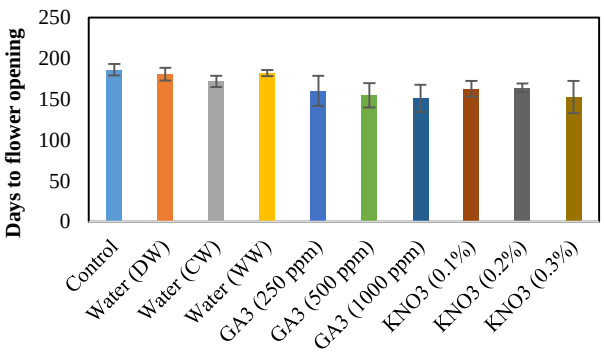

Fig. 9. Impact of priming techniques on days to flower opening of Lisianthus plant.

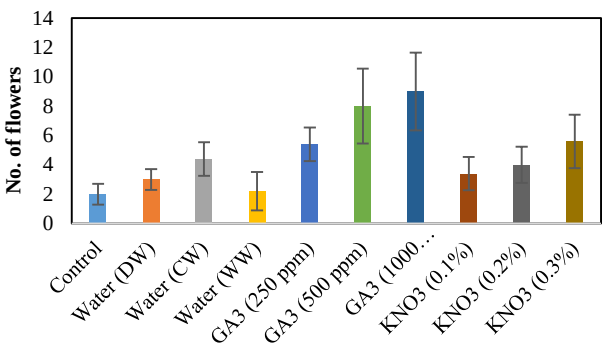

Fig. 10. Impact of priming techniques on number of flower of Lisianthus plant.

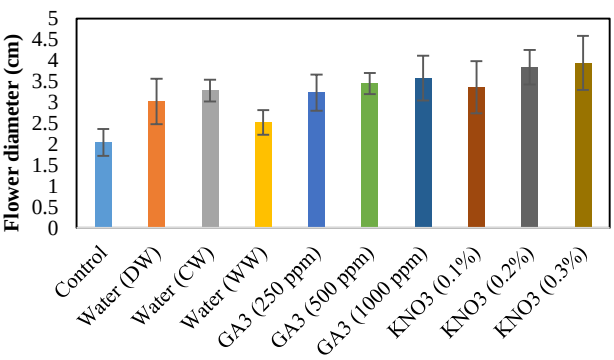

Fig 11. Impact of priming techniques on flower diameter (cm) of Lisianthus plant.

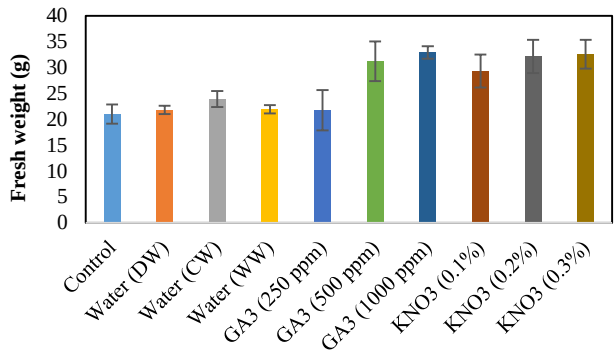

Fig. 12. Impact of priming techniques on fresh weight (g) of Lisianthus plant.

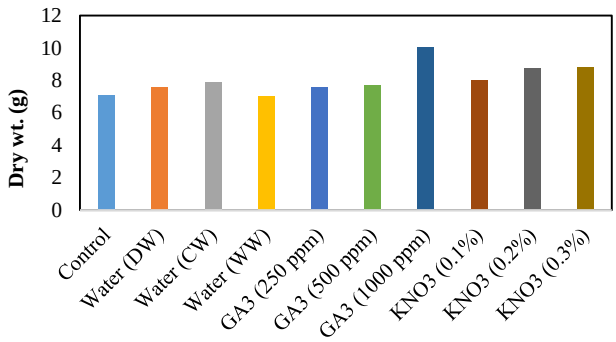

Fig. 13. Impact of priming techniques on dry weight (g) of Lisianthus plant.

Conclusion

Priming of Lisianthus seeds was effective in improving its morpho-physiological characteristics and flowering attributes. Plants showed improvement in germination, plant height, number of leaves, early flowering, flower size and number of flowers. Application of gibberellic acid at relatively higher concentration (1000 ppm) was proved more effective in breaking dormancy than lower doses and enhanced plant growth. The KNO_3 treatments were found to be second best technique in improving seedling stand and development. While in case of hydro priming only cold water provided best results regarding germination and plant development. So, it can be concluded that harmonal priming is most effective to enhance germination and plant development in Lisianthus plant.

References

Ansari, O. and F. Sharif-Zadeh. 2012. Osmo and hydro priming improvement germination characteristics and enzyme activity of Mountain Rye (*Secale montanum*) seeds under drought stress. *J. Stress Phy. & Biochem.,* 8(4): 253-261.

AOSA. 1983. Seed vigor testing handbook: Contribution no. 32 to handbook on seed testing. Association of Official Seed Analysis, Springfield, IL., USA., pp: 1-93.

Bajehbaj, A.A. 2010. The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. *African J. Biotech.,* 9: 1764-1770.

Cantor, M., R. Pop, I.E. Csete, B. Erzsebet and A. Husti. 2013. Researches concerning the multiplication *In Vivo* of Lisianthus for promoting in Romanian green houses. *Sci. Papers. Series B, Horti.,* 57: 303-307.

Chase, W. and F. Bown. 1997. General Statistics. 3rd Ed John Willey and Sons. Inc. NY. p. 491-523.

Demir Kaya M., Okcu Gamze., M. Atak, Y. Cikili and O. Kolsarici. 2006. Seed treatment to overcome salt and drought stress during germination in sunflower (Helianthus annuus L.). *Eur. J. Agronomy.* 24: 291-295.

Dewir, Y.H., M.E. El-Mahrouk and Y. Naidoo. 2011. Effects of some mechanical and chemical treatments on seed germination of Sabal palmetto and Thrinax morrisii palms. *Aus. J. Crop Sci.,* 5(3): 248-253.

Eason, J.R. 2002. *Sandersonia aurantiaca*: an evaluation of postharvest pulsing solutions to maximize cut flower quality. New Zealand *J. Crop Hort. Sci.,* 30: 273-279.

Ecker, R., A. Barzilay and E. Osherenko. 1994. Inheritance of Seed Dormancy in Lisianthus *(Eustoma grandiflorum). Plant Breeding,* 113: 335-338.

Erken, S. and N. Kaleci. 2010. Determination of germination characteristics of yellow genetian (*Gentiana lutea* subsp. *symphyandra*) seeds under controlled conditions. *J. Bahce.,* 39(2): 17-26.

Farooq, M., S.M.A. Barsa and M.B. Khan. 2007. Seed priming improves growth of nursery seedlings and yield of transplanted rice. *Arch. Agron. Soil Sci.,* 53: 315-326.

Farooq, M., S.M.A. Basra and N. Ahmad. 2007. Improving the performance of transplanted rice by seed priming. *Plant Growth Regulation,* 51(2): 129-137.

Ghaleh-Shahi, Z.G., H. Zarei, M. Babarabie, A. Danyaei, M. Ahmadi and S. Badeli. 2017. The effect of different levels of salinity and potassium nitrate on the germination of cocks comb (*Celosia cristata*). *Open J. of Eco.,* 7(4): 289.

Harris, D., A. Joshi, A.P. Khan, P. Gothkar and S.P. Sodhi. 1999. On-farm seed priming in semiarid agriculture: development and evaluation in maize, rice and chickpea in India using participatory methods. *Exp. Agric.,* 35: 15-29.

Harris, D., B.S. Raghuwanshi, J.S. Ganwar, S.C. Singh, K.D. Joshi, A. Rashid and P.A. Hollington. 2001. Participatory evolution by farmers of on farm seed priming in wheat in India, Nepal, and Pakistan. *Exp. Agric.,* 37: 403-415.

Harris, D., R.S. Tripathi and A. Joshi. 2000. On-farm seed priming to improve crop establishment and yield in direct-seeded rice. IRRI: Inter. Workshop on Dry-seeded Rice Tech., 2000.

Kolumbina, M., M. Blesing and D.J. Mares. 2006. α-Amylase and programmed cell death in aleurone of ripening wheat grains. *J. Exp. Bot.,* 57(4): 877-885.

Lee, J.M. 2004. Seed enhancement for healthy seedlings. APSA technical report no. 40 presented at Asian seed, Seoul Korea.

Mazid, M. 2014. Seed priming application of gibberellic acid on growth, biochemical, yield attributes and protein status of chickpea (*Cicer arietinum* L. cv. DCP 92-3). *Int. J. Genetic Enginee & Biotech, 5*(1): 17-22.

Millaku, F., B. Gashi, K. Abdullai, S. Aliu, M. Osmani, E. Krasniqi, V. Mata and A. Rysha. 2012. Effects of cold-stratification, gibberellic acid and potassium nitrate on seed germination of yellow gentian (*Gentiana lutea* L.). *Afr. J. Biotechnol.,* 11(68): 13173-13178.

Moradi D.P., F. Sharif-zadeh and M. Janmohammadi. 2008. Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays* L.). *ARPN J. Agricul and Biol. Sci.,* 3(3): 22-25.

Moussa, H., H.A. Margolis, P. Dube and J. Odongo. 1998. Factors effecting the germination of doum palm (*Hyphaene thebaica* Mart.) seeds from the semi-arid zone of Niger, West Africa. *For Ecol. Manage*., 104: 27-41.

Murungu, F.S. and T. Madanzi. 2010. Seed priming, genotype and sowing date effects on emergence, growth and yield of wheat in a tropical low altitude area of Zimbabwe. African journal of agricultural research, 5(17), 2341-2349.

Murungu, F.S., C. Chiduza, P. Nyamugafata, L.J. Clark, W.R. Whalley and W.E. Finch-Savage. 2004. Effects of 'on-farm seed priming' on consecutive daily sowing occasions on the emergence and growth of maize in semi-arid Zimbabwe. *Field Crops Research,* 89(1): 49-57.

Naeem, M.A. and S. Muhammad. 2006. Effect of seed priming on growth of barley (*Hordeum vulgare*) by using brackish water in salt affected soils. *Pak. J. Bot.,* 38(3): 613.

Nouman, W., M.T. Siddiqui, S.M.A. Basra, I. Afzal and H. Rehman, 2012b. Enhancement of emergence potential and stand establishment of *Moringa oleifera* Lam. by seed priming. Turk. *J. Agric. For.,* 36: 227-235.

Ohkawa, K., A. Kano, K. Kanematsu and M. Korenaga. 1991. Effects of air temperature and time on rosette formation in seedlings of *Eustoma grandiflorum* (Raf.) Shinn. *Scientia Hort.,* 48: 171-176.

Parera, C.A. and D.J. Cantliffe. 1994. Presowing seed treatments to enhance super sweet sweet corn seed and seedling quality. *Hort. Science,* 29(4): 277-278.

Petrova, M., N. Zagorska, K. Tasheva and L. Evstatieva. 2006. In vitro propagation of *Gentiana lutea* L. *Genet. Breed.,* 35(1-2): 63-68.

Qureshi, U.S., M. Shakeel, K.M. Qureshi, S. Chughtai, A. Saleem, A.R. Mir and A.A. Qureshi. 2016. Effect of seed priming through gibberellic acid (GA_3) and imidacloprid on bismarckia palm seed. *Int. J. Biosci.,* 8(4): 18-27.

Reid, M.S. 2009. The commercial storage of fruit, vegetables and florist and nursery stocks, USDA handbook, pp. 66:36.

Rezaee, F., F. Ghanati and B.L. Yusefzadeh. 2012. Micropropagation of Lisianthus (*Eustoma grandiflorum* L.) from different explants to flowering onset. *Iranian J Plant Physiology,* 3(1): 583-587.

Rouhi, H.R, R. Shakarami and T. Afshari. 2010. Seed treatments to overcome dormancy of waterliliy tulip (*Tulipa kaufmanniana* Regel.). *Aust. J. Crop. Sci*., 4(9): 718-721.

Sajid, M.U., N. Amin, H. Ahmad and K. Khan. 2016. Effect of gibberellic acid on enhancing flowering time in Chrysanthemum morifolium. *Pak. J. Bot.,* 48(2): 477-83.

Shariatmadari, M.H., M. Parsa, A. Nezami and M. Kafi. 2017. The effects of hormonal priming on emergence, growth and yield of chickpea under drought stress in glasshouse and field. *Bioscience Research,* 14(1): 34-41.

Sharma, R.K. and S. Sharma. 2010. Effect of storage and cold-stratification on seed physiological aspects of *Bunium persicum*: A threatened medicinal herb of Trans-Himalaya. *Int. J. Bot.,* 6(2): 151-156.

Soltani, A., M. Gholipoor and E. Zeinali. 2006 - Seed reserve utilization and seedling growth of wheat as affected by drought and salinity. *Environmental and Experimental Botany,* 55: 195-200.

Sreelatha, U., T.S. Baburaj, C. Narajanan-kutty, N. Mini-Raj and P.A. Nazeem. 2006. *Exacum bicolor* – An exquisite, endemic flowering herb from the wild. Abstracts, National Symposium on Under Utilized Horticultural Crops held during 8-9th, June at IIHR, Bangalore, pp. 137.

Tabatabaei, S.A. 2014. The effect of priming on germination indexes and seed reserve utilization of maize seeds under salinity stress. *J. Seed Sci. Technol.,* 3(4): 44-51.

Varier, A., A.K. Vari and M. Dadlani. 2010. The sub cellular basis of seed priming. *Cur. Sci.,* 99: 450-456.

Vijayakumar, S., K.R. Rajadurai and P. Pandiyaraj. 2017. Effect of plant growth regulators on flower quality, yield and postharvest shelf life of China aster (*Callistephus chinensis* L. Nees.) cv. Local. *Int. J. Agri. Sci.,* 7(2): 297- 304.

Zare, A.R., M. Solouki, M. Omidi, N. Irvani, A.O. Abasabadi and M.N. Nezad. 2011. Effect of various treatments on seed germination and dormancy breaking *Ferula assa foetida* L. (Asafetida), a threatened Medicinal herb. *Trakia J. Sci*., 9(2): 57-61.

(Received for publication 11 December 2017)