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ORIGINAL PAPER

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IMPROVED CUT FLOWER AND CORM PRODUCTION BY EXOGENOUS MORINGA LEAF EXTRACT APPLICATION ON GLADIOLUS CULTIVARS

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ABSTRACT

Bio-stimulants are in excessive demand for the sustainable production of floriculture crops. The current investigation was designed to find out the effect of naturally occurring growth stimulant moringa leaf extract (MLE) on the growth, flowering, post-harvest life and corm production of two gladiolus cultivars (cvs.) 'Rose Supreme' and 'White Prosperity'. The research trial was laid out in the factorial arrangement under randomized complete block design. Corms were grown in the open field under local climatic conditions of Faisalabad, Pakistan. Potential of exogenously applied (MLE; 30 times diluted) was evaluated. Treatments including spraying MLE at 3 leaves, 5 leaves, floral bud stage, one combination of these three stages relative to control with no foliar application. Application of natural bio-stimulant produced maximum height in both cvs. against T_4. Both cvs. gave maximum stalk length in response to T_4. The number of florets spike^{-1} found the maximum (13) in T_1 compared to control T_0 which yield (9) florets. Maximum vase life in sucrose solution (13.33 days) was exhibited by T_1 for both cvs. while minimum (10 days) in T_0. In cultivar comparison earlier spike emergence was observed in 'White Prosperity'. In 'Rose Supreme' maximum corm weight was attained in response to T_3 (43.43 g) while minimum (30.33 g) in T_0.'White Prosperity' produced maximum weight (40.33 g) against T_4 whereas minimum by control. The cultivar mean comparison showed the superiority of cormel diameter in 'Rose Supreme' (10.93 mm) than 'White Prosperity' (9.13 mm). In treatment comparison, T_4 produced maximum diameter (12.04 mm) in 'Rose Supreme' moreover, T_2 induced maximum (9.57 mm) diameter in 'White Prosperity'.

Key words: gladiolus, spike length, moringa leaf extract, vase life, corm size, number of florets spike^{-1}

INTRODUCTION

Pakistan has a range of climatic conditions that favours container and cut flower production. Growing these crops provide comparatively better profit opportunities to small landholders than agronomic crops [Sajid et al. 2015, Younis et al. 2016]. Cut flower as a floriculture subdivision has

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the largest share with respect to production and export [Akpinar and Bulut 2011]. Gladiolus, carnation, tuberoses, freesia, gerbera, roses, iris, statice, narcissus and lilies are usually grown for cut flower production in Pakistan [Riaz et al. 2007, Jameel 2011]. *Gladiolus grandiflorus* L. (sword lily) is most demanded and appealing cut flower all around the world and known as queen of bulbous flowers [Sajid et al. 2015]. It belongs to family Iridaceae, subfamily Ixidaceae having 180 species and 10000 cultivars [Sajid et al. 2015]. At the world level, it ranked the eighth position in cut flower export, while second in Pakistan followed by roses. Good keeping quality, the variety of dazzling colours, big florets and appealing spike shape are some unique features that provide it an opportunity to be used as cut flower in the local and foreign market [Kumar and Gupta 2014]. In Punjab province, as total area under floriculture is 9000 acres, of which 450 acres is under gladiolus cultivation [Riaz et al. 2007].

Despite ample gladiolus production in Pakistan, still its quality not fulfilling the international standards for export purposes [Usman et al. 2015]. There is an immense need for production technology improvement to achieve desirable quantity with appreciable quality of this profitable crop. Flower crops required much nutrition for their growth. Non-judicious use of chemical fertilizers seldom ensures product quality and creates environmental issues as well [Mattner et al. 2013]. Growers are mindful now regarding organic fertilizer for increasing yield and quality [Biswas et al. 2016]. Bio-stimulants reduce fertilizers requirement consequently less environment degradation. They also offer plant resistance against various stresses subsequently improved product quality [Bulgari et al. 2015]. In various studies, plant growth regulators (PGRs) application increased growth and yield [Peanav et al. 2005, Singh et al. 2008].

Moringa oleifera Lam. belongs to family Moringaceae is a miracle tree in agriculture [Moyo et al. 2011, Biswas et al. 2016]. The plant is native to sub-Himalayan tracts of Pakistan, Afghanistan, Bangladesh and India [Fahey 2005]. Leaves are a rich source of vitamin A and C, calcium, β-carotene, riboflavin, iron, phenolics and antioxidants [Nambiar et al. 2005]. Moringa leaf extract is a rich source of growth regulators e.g, zeatin, phenolics, ascorbate and mineral nutrients [Anwar et al. 2007, Basra et al. 2011, Hussain et al. 2013]. To date MLE effect on cut flower production and vase life is unknown. If the application of MLE enhance yield and quality of gladiolus cut flower and corms, then it would be very beneficial from following perspectives: 1) increase export of cut flowers, 2) minimal chemical fertilizers expenditure, 3) ultimately less environmental degradation. Therefore, the aim of this investigation was to check the effect of MLE on vegetative, reproductive, vase life and corm characteristics of gladiolus.

MATERIAL AND METHODS

The research trial was carried out at Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan (latitude 31°30'N, longitude 73°10'E and altitude 213 m) during 2012–2013 under open field conditions. Two imported gladiolus cvs. 'Rose Supreme' and 'White Prosperity' were studied in this trial. The experimental land was set thoroughly by ploughing and levelling. All weeds, crop residues and stubbles were collected and removed manually. For assessing the physiochemical properties (pH, EC, organic matter, texture) soil samples were collected randomly from the trial area.

Blocks were formed according to a factorial arrangement under randomized complete block design and the plot size was 4.0 m × 4.0 m. Five treatments with three replications (10 plants in each replication) including control were studied. The treatments illustration is given in table 1. Healthy corms of Gladiolus cvs. ('Rose Supreme' and 'White Prosperity') were purchased from Greenworks Pvt. Limited, Lahore, an importer of "Stoop Flower Bulb, Holland" in Pakistan. These corms were washed and treated with fungicide (Topsin-M®) prior to planting in last week of October, 2012. Total 150 corms cultivar^{-1} were planted on ridges at (40 cm row × row and 15 cm plant × plant) at a depth of 7–8 cm.

Table 1. Treatment plan for the experiment

Treatments	Plant stage	No. of applications
T_0	no application	—
T_1	three leaves	1
T_2	five leaves stage	1
T_3	floral bud stage	1
T_4	three + five leaves + floral bud stage	3

For MLE preparation, mature moringa leaves were collected from Experimental Nursery Area, Department of Forestry, Range and Wildlife Management, University of Agriculture, Faisalabad, Pakistan. These leaves were stored overnight in freezer after washing thoroughly and next day used for extraction in fabricated machine [Foidle et al. 2001, Yasmeen et al. 2012]. The MLE was filtered through the cheese cloth and further by Whatman filter paper. The extract was then diluted at a ratio of 1 : 30 (v/v) with distilled water [Fuglie 2000]. At each application of MLE, fresh leaves were used for extraction purpose. The foliar spray of extract was done using hand sprayer.

Cultural practices like irrigation, fertilization, weeding, hoeing, plant protection measures, earthing-up etc. were according to the recommendations. Plants were allowed to grow and data were collected using standard procedures for following parameters: sprouting percentage, plant height (cm), number of leaves plant^{-1}, days to spike emergence, number of florets spike^{-1}, stalk length (cm), stem diameter (mm), spike length (cm), floret diameter (cm). For measuring vase life, flowers were harvested at loose bud stage using sharp secateurs. Two lower leaves were allowed to be intact for corm development. Harvested flowers were immediately inserted in cold water bucket and transported to the lab. The flower stalks were defoliated. To prevent air embolism, basal portion of the stalk was recut from the earlier cut at 2 cm and placed in vase life solution. Two vase solutions were used including simple distilled water and sucrose 2%. Glass bottle containing flower stalk were filled with 200 ml solution. The solution was replaced after every two days and stalk was recut 1 inch above the earlier cut using secateurs. Three stalks were selected from each treatment. Days were recorded till flowers lost their freshness and at 50% wilting stage, these considered dead. For quality evaluation, fresh flowers were arranged in bottles containing distilled water. Those were tagged according to treatments and cvs. Visual quality was assessed by faculty members and grading was done out of 10 points. Average was carried out from arranged data. Corm indices including the number of cormels, their diameter (cm), corm and cormel weight were measured manually.

Statistical analysis

Data analysis was performed using Fisher's analysis of variance ANOVA technique [Steel et al. 1997]. Furthermore, treatment means were compared at 5% level of probability by Duncan's Multiple Range.

RESULTS AND DISCUSSION

Soil analysis. Soil analysis of the experimental site are illustrated in table 2.

Sprouting percentage (%). Statistical analysis of collected data revealed non-significant results regarding treatments. For 50% sprouting 'Rose Supreme', corms sprouted maximum (6.917 days) against T_2 while it was minimum (8.273 days) under the effect of T_4. In case of 50% sprouting in 'White Prosperity', T_4 showed earlier sprouting (7.607 days) while in

response to T_1 it showed late sprouting (8.217 days). The cvs. comparison with respect to sprouting % age presented non-significant results. Usually the climatic conditions of the specific area and cultivar type sought to affect sprouting time. Dilta et al. [2004] and Kumar and Yadav [2005] reported genetic variation and climatic conditions the responsible factors for sprouting duration in gladiolus. The cvs were also compared for the response of MLE application. In 'Rose Supreme', 100% sprouting was observed against T_0, T_2, T_3 and T_4 while T_1 exhibited 96.67 sprouting percentage. In 'White Prosperity', only T_2 showed 96.67 sprouting percentage except for the others treatments that exhibited 100% sprouting. Both cvs. exhibited 99.33% sprouting which showed cvs. compatibility for commercial cultivation in Faisalabad. The present results were supported by Dilta et al. [2004], Khan et al. [2008], they reported variation in gladiolus sprouting and flower quality under different planting time.

Table 2. Soil properties

Soil properties	Soil depth (15–30 cm)	Adequate ranges
Organic matter (%)	0.659	>1.29
pH	7.79	7
EC (dS m^{-1})	2.47	3
Nitrogen (%)	11.57	>20
Available phosphorus (mg kg^{-1})	9.6	>15
Exchangable potassium (mg kg^{-1})	204	>150

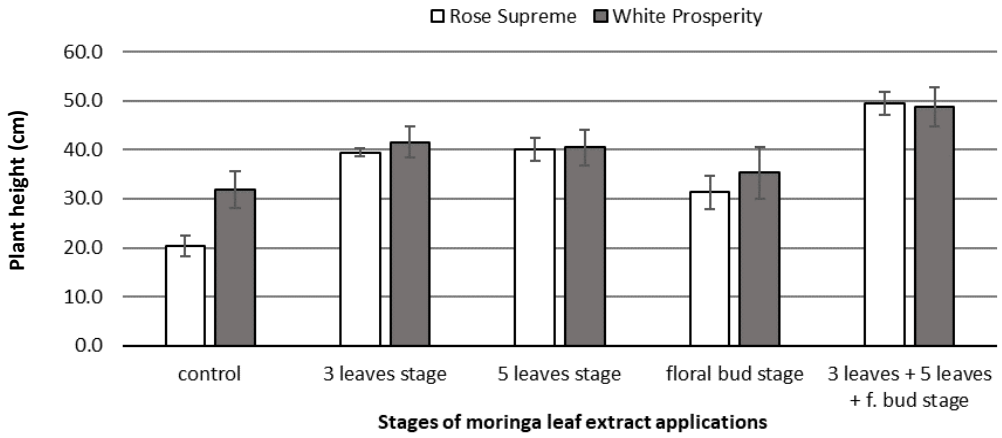

Fig. 1. Effect of MLE applications on plant height at 3 leaves stage of gladiolus 'Rose Supreme' and 'White Prosperity'

Vegetative characteristics. Data regarding the number of leaves were collected at three different stages 30, 60, 100 days after planting. After 30 days of planting, results revealed the non-significant difference in treatments and their interaction with cvs. because of no treatment application at this stage. In 'Rose Supreme', under T_1 maximum leaves (3.33) were observed that was followed by T_4 (3.06). Similarly, T_2 and T_3 produced 2.96 and 2.93 leaves respectively while T_0 produce minimum (2.82) number of leaves. In the case of 'White Prosperity', T_4 produced maximum leaves (3.19) that were followed by T_1 (3.18), T_3 (3.180), T_0 (3.17) but minimum leaves (3.10) were observed in T_2. Both cvs. produced almost same results regarding number of leaves. It is possibly due to cultivar, planting time, climatic condition or soil fertility. These results are in agreement with Zubair et al. [2006] who reported healthy gladiolus plants in response to proper planting time. Data analysis revealed significant variation in treatments while non-significant regarding the interaction of treatments and cvs. In both cvs. T_1 and T_4 produced maximum leaves (5.11) while minimum leaves (4.82) were recorded in T_0. Increase number of leaves may be due to growth potential under the influence of MLE application at 3 leaves stage. This statement is supported by Kumar and Arora [2000] who observed increase number of leaves in gladiolus subsequent to growth regulator application.

The present finding also showed similarity with Sudhakar and Kumar [2012] in which PGRs application increased the growth, height and number of leaves in gladiolus. After 100 days of planting, data regarding number of leaves was collected and analysed. Means comparison regarding the number of leaves showed a somewhat better performance of 'White Prosperity' (8.08) than 'Rose Supreme' (7.14). Among all MLE applications on 'Rose Supreme', T_1 produced maximum leaves (7.66) followed by T_4 (7.53), T_2 (7.267), T_3 (7.13 leaves) while non-treated plants exhibited a minimum number of leaves (6.133). Cultivar 'White Prosperity' presented better results in response to T_1 by producing maximum leaves (8.6) that were followed by T_4 (8.133), T_2 (8.06) and T_3 (7.86). The least number of leaves (7.73) were produced in control (T_0). Results of the present study are in accordance with Halder et al. [2007] who reported increase number of leaves in *Gladiolus grandiflorus* as a result of nutrient and growth regulators application. MLE contain nutritional components and cytokinin [Fuglie 2001, Manzoor et al. 2007]. Various findings supported the argument of plant growth and development affected under the influence of bio fertilizer that possesses hormonal effect for nutrient uptake and increases in photosynthesis, thus directly affect plant height and the number of leaves [Cacco and Dell'Agnola 1984; Russo and Berlyn 1991]. Data regarding plant height was collected at 3 stages: 3 leaves stage, 5 leaves stage and floral bud stage. Analysis revealed significant variation regarding plant height (cm) between treatments and cvs. while non-significant results regarding their interaction (treatment × cultivar). Cultivar 'Rose Supreme' showed maximum plant height in T_4 (49.44 cm) at 3 leaves stage followed by T_2 (39.99 cm) and other treatments as illustrated in fig 1. Minimum plant height (20.38 cm) was attained in T_0. Cultivar 'White Prosperity' produced maximum plant height (48.76 cm) against T_4, followed by other treatments in an order of: $T_1 > T_2 > T_3$. Minimum plant height (31.835 cm) was also showed by T_0 in 'White Prosperity'. In the cvs., 'White Prosperity' performed better than 'Rose Supreme' and among treatments, T_4 performed best regarding this parameter in both cvs. The difference in height is concerned with the genetic potential of gladiolus varieties [Kumar and Yadav 2005]. Similarly, longer stems were produced by early planting [Ko et al. 1994]. Results exposed significant variation regarding plant height in treatments, cvs. and their Interaction at 5 leaves phase. This variation was illustrated in fig 2. Maximum height was produced by T_4 in both cvs. at 5 leaves phase. Other treatments showed $T_1 > T_2$ while T_3 produced 66.29 cm but minimum height was observed in T_0 (64.29 cm). In 'Rose Supreme', following order was observed regarding plant height: $T_4 > T_2 > T_1 > T_3 > T_0$. Possible cause for this increase in size was sought to be increased photosynthesis due to excessive chlorophyll production in response to MLE as Mehboob [2011] reported that MLE increased chlorophyll contents subsequently increased photosynthetic rate. At 100 days stage, collected data re-

garding stalk length was analysed which showed significant difference for treatments, cvs. and their interaction. Variation was illustrated in fig 3. 'White Prosperity' performance order was T_4 (130.08 cm) > T_1 (122.36 cm) > T_2 (113.55 cm) > T_3 (110.18 cm) and T_0 (107.69 cm). In 'Rose Supreme': T_4 (122.86 cm) > T_2 (119.58 cm) > T_1 (113.79 cm) > T_3 (99.37 cm) and T_0 (94.94 cm). 'White Prosperity' performance was comparatively better. Foliar application of PGRs on two stages after planting proved good spike quality and length [Sudhakar and Kumar 2012].

Reproductive characteristics. Result regarding days for spike emergence revealed significant variation in treatments and cvs. while non-significant for their interaction. Spike emergence was earlier in 'White Prosperity' than 'Rose Supreme'. While in response to all treatments spike emergence was earlier relative to control (T_0). Days for spike emergence possibly due to increase in stored food, providing potential for early spike emergence. Increased photosynthesis rate under the influence of GA_3 application shortened the days for spike emergence [Sudhakar and Kumar 2012]. Our results showed contradiction with the Sajid et al. [2015] who reported no variation in gladiolus spike emergence behaviour under PGRs application. Treatments effect regarding number of florets was significant. Varieties and their interaction showed non-significant results in this regard as illustrated in Figure 4. T_1 showed good performance in 'White Prosperity' (13) and in 'Rose Supreme' (12.33) florets. 'White Prosperity' depicted maximum florets in T_1 (13 florets). Treatment T_4 and T_2 produced almost same number of florets (12.33) followed by T_3 (11.08 florets). T_0 registered minimum number of florets (9.41 florets). In 'Rose Supreme' cultivar T_1 again produced maximum number of florets (12.33) followed by T_4 and T_2 (11.33 florets). T_3 produced (10.33) as compared to control T_0 (9.83 florets) which was minimum among all treatments. These results are supported by Sudhakar and Kumar (2012) as they reported enhancement in photosynthesis, increased the number of florets in gladiolus.

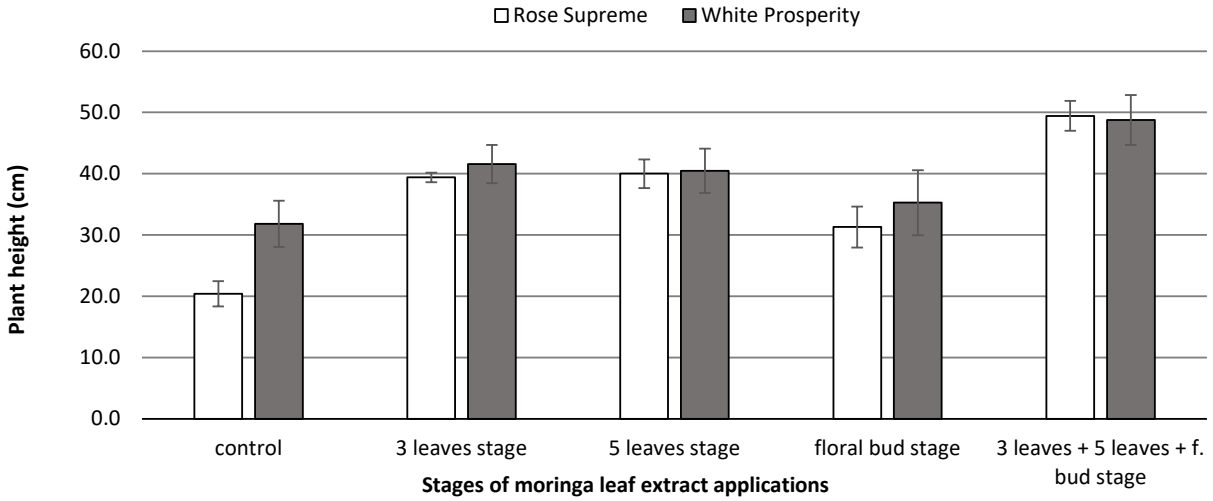

Fig. 2. Effect of MLE applications on plant height at 5 leaves stage of gladiolus 'Rose Supreme' and 'White Prosperity'

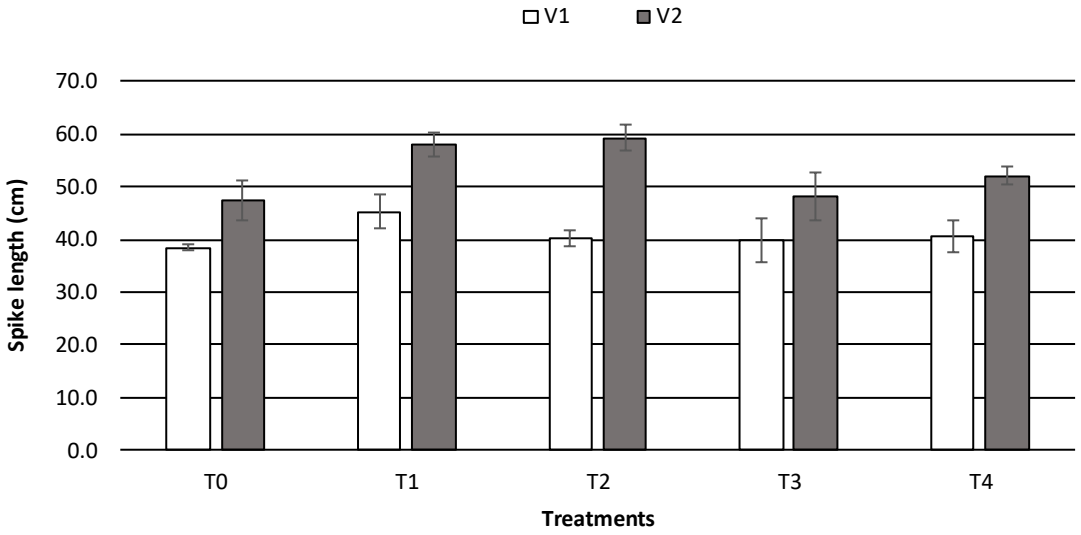

Fig. 3. Effect of MLE applications stalk length (cm) of gladiolus 'Rose Supreme' and 'White Prosperity'

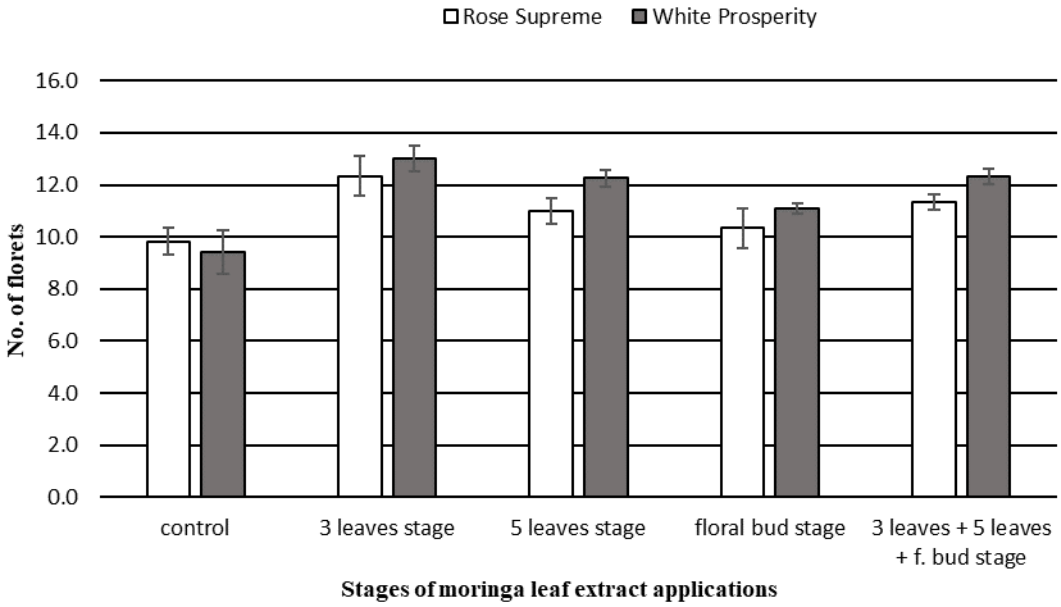

Fig. 4. Effect of MLE applications on number of florets of Gladiolus 'Rose Supreme' and 'White Prosperity'

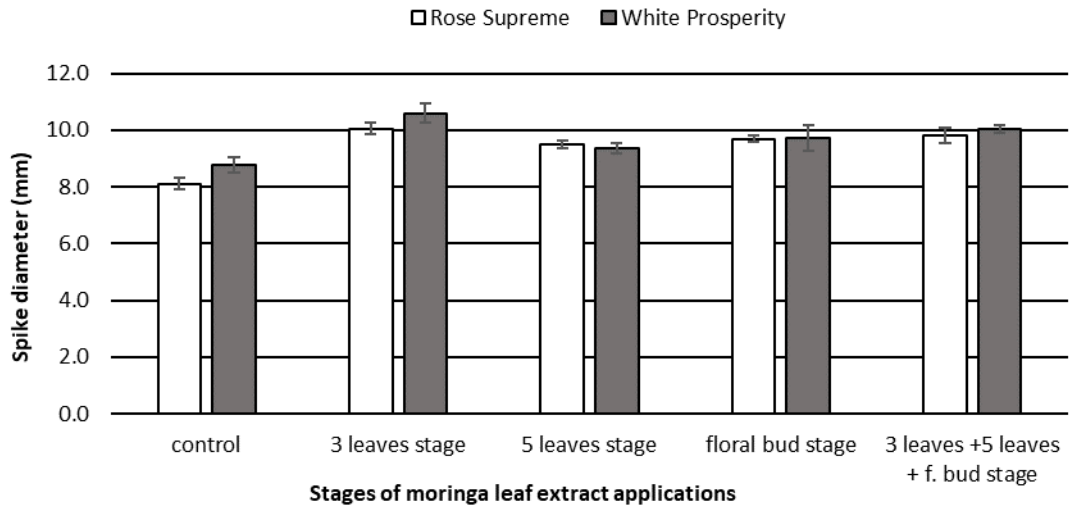

Fig. 5. Effect of MLE applications on stem diameter of Gladiolus 'Rose Supreme' and 'White Prosperity'

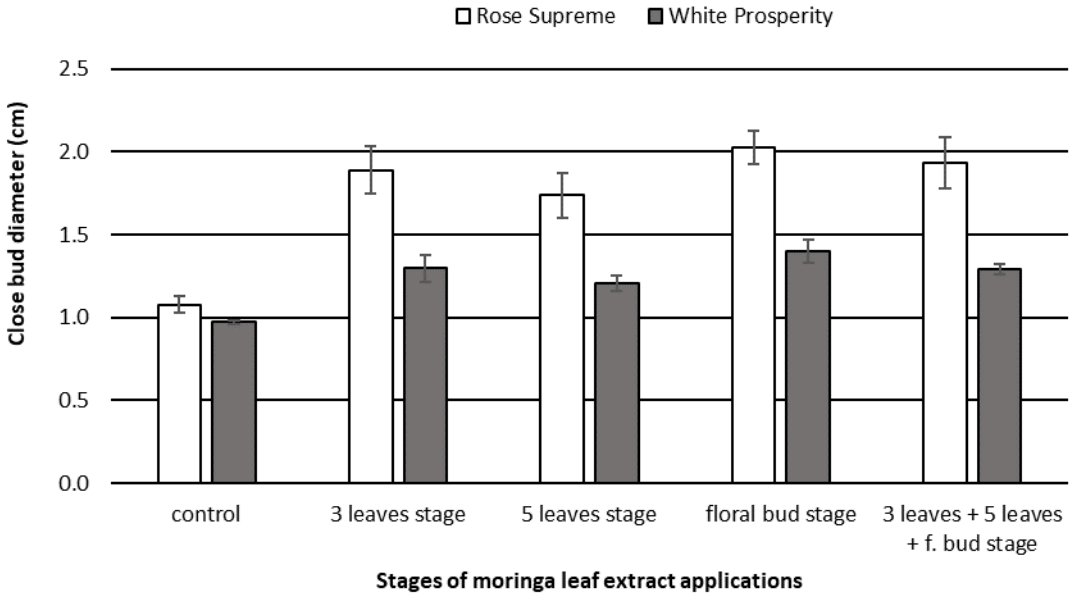

Fig. 6. Effect of MLE applications on close bud diameter of Gladiolus 'Rose Supreme' and 'White Prosperity'

As a result of PGRs application; florets, spike length and height increased. MLE due to presence of Zeatin and cytokinin increased photosynthesis [Foidle et al. 2001]. Further, it was reported Menary and Staden [1997] that cytokinin positive influenced the number of flowers and their development. Applications of PGRs such as GA_3 improved flower quantity as well as quality in gladiolus [Patel et al. 2010, Chopde et al. 2012b]. Results depicted significant variation between treatments while non-significant in cvs. and their interaction with treatments. In 'White Prosperity', T_1 performed the best (9.66) while in 'Rose Supreme', T_4 produce similar results. All treatment performed better than control. MLE contain Zeatin and cytokinin and nutritional components [Foidle et al. 2001, Basra et al. 2009]. Application of GA_3 increased number of florets and stalk length in various studies [Barma and Rajni 2004, Chopde et al. 2012a]. Results regarding spike length showed non-significant variations in treatments and their interaction with cvs. In case of cvs. significant variation was observed. Treatments comparison in 'White Prosperity' revealed maximum spike size in T_2 (59.26 cm) followed by T_1 (57.99 cm), T_4 (52.07 cm), T_2 (57.99 cm) and T_3 (48.26 cm). Shortest spike length was measured in control T_0 (47.417 cm) where no application of MLE was applied. In 'Rose Supreme' again T_1 produced longest spike (45.29 cm) followed by T_4 (40.66 cm), T_2 (40.20 cm) and T_3 (39.79 cm) while shortest spike was produced by T_0 (38.52 cm). These results are supported by Barma and Rajni [2004] they reported increased spike length under the influence of growth regulators. Data analysis revealed significant variations regarding stem diameter in response to treatments while non-significant variations were recorded in cvs. and their interaction with treatment. In cvs., similar response was observed regarding stem diameter. In 'Rose Supreme' treatments showed maximum stem diameter in T_1 (10.67 mm) followed by other treatments while T_0 registered minimum diameter (8.74 mm) as illustrated in fig 5. In 'White Prosperity' T_1 showed again maximum diameter (11.183 70 mm) followed by T_4 (10.40 mm) > T_3 (10.08 mm). T_2 produce (9.757 mm) while minimum diameter was measured in T_0 (9.07 mm). Similar observations have been demonstrated by Mehboob [2011] who reported improve permeability and chlorophyll contents by MLE applications. Gladiolus leaf and stem growth improved subsequent to growth regulators application [Sudhakar and Kumar 2012]. Analysis depicted significant differences between cvs. and treatments while non-significant for the interaction between treatments × cvs. In the comparison of cvs., 'Rose Supreme' showed superiority (1.73 cm) regarding close bud diameter over 'White Prosperity' (1.23 cm) by MLE application. In the case of treatment comparison, T_3 performed well in both cvs. In 'Rose Supreme' treatments maximum close bud diameter was measured in T_3 (2.02 cm) followed by T_4 (1.93 cm), T_1 (1.89 cm) and T_2 (1.07 cm) while minimum diameter was produced by T_0 (1.07 cm) as illustrated in Figure 6. Same results were obtained in 'White Prosperity' in which T_3 produced maximum diameter followed by other treatments. T_0 (control) exhibited minimum close bud diameter (0.97 cm). These findings are in line with the Foidle et al. [2001] and Culver et al. [2012], they reported improved vegetative growth in rape and cabbage by the application of MLE. Results for treatments and cvs. showed significant variations while it remained non-significant in the interaction of treatment and cultivar. Bud diameter of 'White Prosperity' was in order: T_4 (10.57 cm), T_3 and T_1 (10.25 and 10.09 cm) and T_2 (9.88 cm) as compared to control T_0 which exhibited minimum diameter (7.06 cm). In 'Rose Supreme' bud diameter produced in a decreasing trend by different treatments: T_4 (11.05 cm) followed by T_3 (10.89 cm), T_1, T_2 (10.18 cm) while minimum in T_0 (7.06 cm). Foidle et al. [2001] and Culver et al. [2012] also reported same results about increases vegetative growth by application of MLE in cabbage and rape. These results are in line with the findings of [Awasthi et al. 2012, Chopde et al. 2012a] for improved flowering in gladiolus as a result of PGRs. Thus, the results of the present finding are in agreement with the previous findings.

Vase life characteristics. Results revealed that vase life significantly affected in treatments response while cvs. And their interaction remained non-significant.

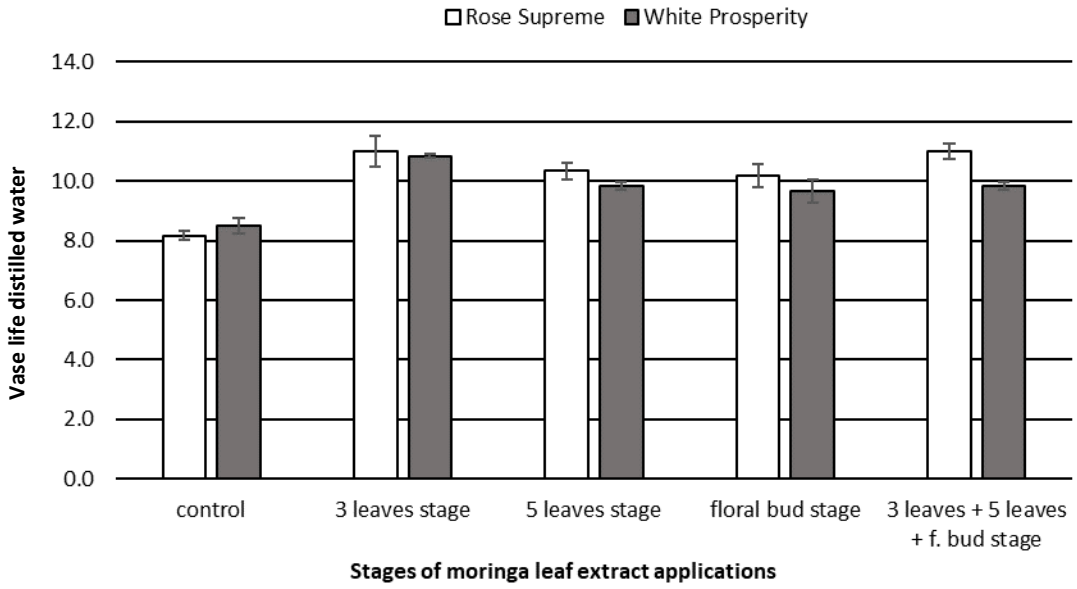

Fig. 7. Effect of MLE applications on vase life of Gladiolus 'Rose Supreme' and 'White Prosperity' in distilled water

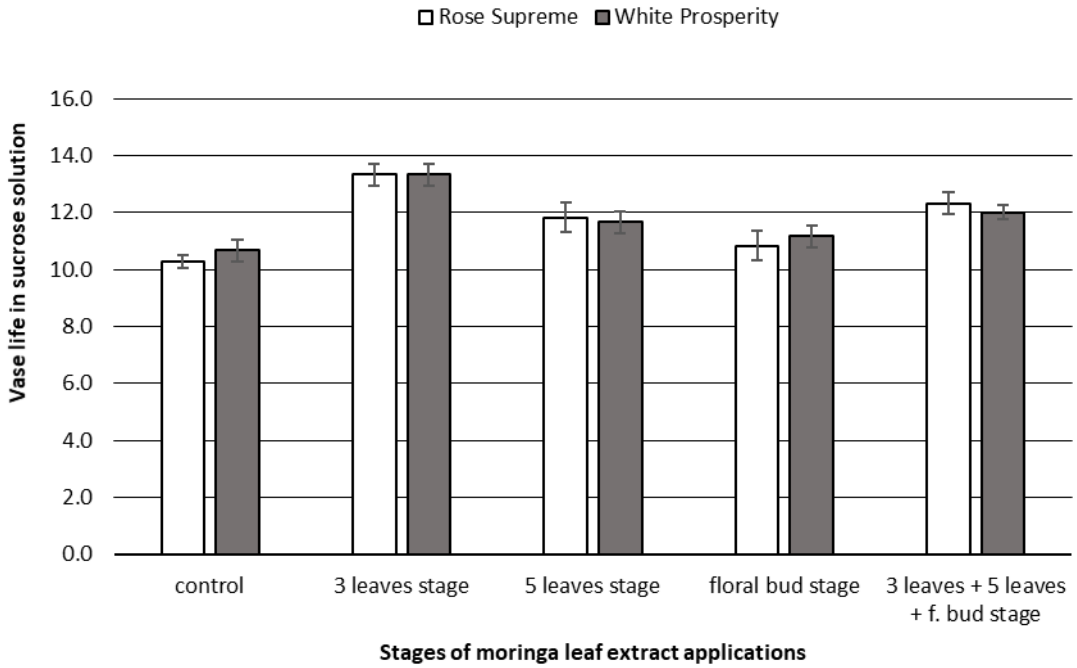

Fig. 8. Effect of MLE applications on vase life of Gladiolus 'Rose Supreme' and 'White Prosperity' in Sucrose solution

Cultivars exposed different response to MLE applications in days mean value regarding this parameter ('Rose Supreme' 10.133; 'White Prosperity' 9.73). Variation among treatment on 'White Prosperity' was as: $T_1 > T_4 > T_2 > T_3 > T_0$ while in 'Rose Supreme' it was in an order of: T_1 and T_4 remained same by showing vase life for 11 days followed by T_2 (10.33 days) and T_3 (10.16 days) while observed minimum in T_0 (8.167 days) as illustrated in fig 7. Nutritional components and anti-aging possessions in MLE produced better results regarding vase life [Basra et al. 2009]. At anthesis, in response to application of cytokinin sugar level increased that has the positive affect on vase life [Mataa et al. 1997]. Results regarding vase life in sucrose solution showed the significant difference in treatments while depicted non-significant variation between cvs. and their interaction with treatments. Treatment response was almost same as 'Rose Supreme' and 'White Prosperity' showed vase life for 11.72 and 11.76 days respectively. In 'White Prosperity' maximum vase life was observed in T_1 (13.33 days) that was followed by T_4 and T_2 then T_3 while in control shortest vase life (10.667 days) was observed as illustrated in Figure 8. In 'Rose Supreme', again T_1 performed better by showing longest shelf life for 13.333 days followed by 12.33 (T_4), 11.83 (T_2), 10.83 days (T_3) while 10.267 days in T_0. Increase in vase life possibly due to nutritional components and PGRs present in MLE. Our results coincided by Basra et al. [2009] who reported long vase life in gladiolus cut-flower under the influence MLE application.

Corm characteristics. Results with respect to corm weight showed significant variation in treatments, cvs. and their interaction. Response to different treatments by 'Rose Supreme' regarding corm weight was maximum in T_3 (43.43 g). Minimum weight was measured in T_0 (30.33 g) which was statistically different from other treatment and recorded as: $T_4 > T_2 > T_1$. While in 'White Prosperity' T_4 produce maximum weight (40.33 g) followed by other treatments in an order: $T_3 > T_2 > T_1 > T_0$. Mean cultivar comparison showed the maximum corm weight in 'Rose Supreme' (36.36 g) followed by 'White Prosperity' (28.13 g). Lush vegetative growth exhausted the potential for corm formation in 'White Prosperity'

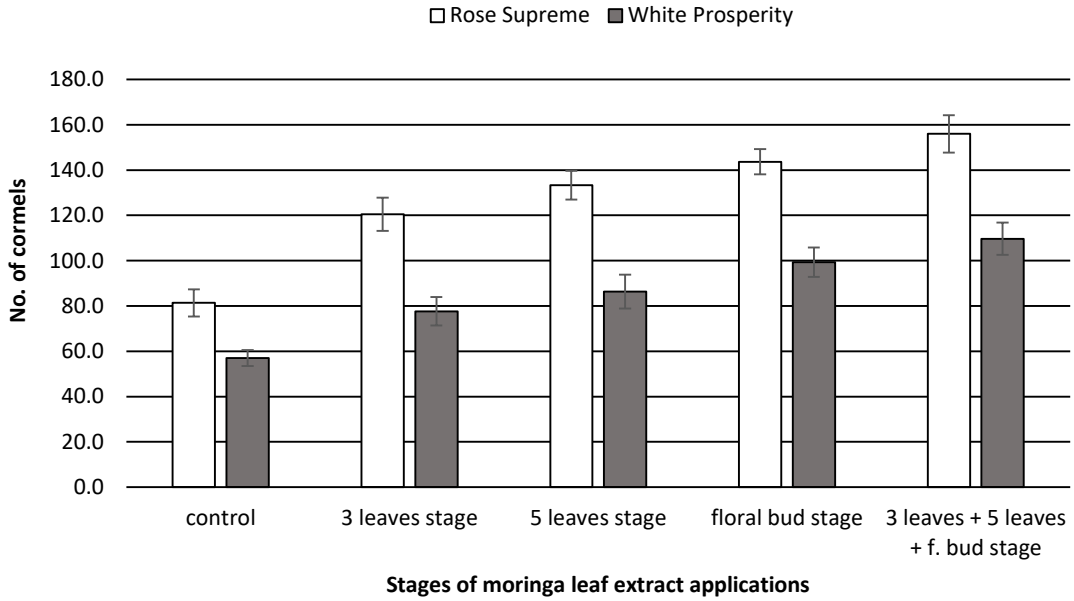

Fig. 9. Effect of MLE applications on number of cormels of Gladiolus 'Rose Supreme' and 'White Prosperity'

while minimum growth promoted corm weight in 'Rose Supreme'. These results are supported by the finding of Foidle et al. [2001] in which increased corm weigh was obtained by MLE foliar application. The cytokinin in MLE was responsible for the enhanced crop production [Fuglie 2000]. Results regarding the number of cormels per plant showed significant variation in cvs. and treatments while their interaction was non-significant. Treatments response in 'Rose Supreme' was recorded as: T_4 (156.03) > T_3 (143.66) > T_2 (133.33) > T_1 (120.5) > T_0 (81.4). While in 'White Prosperity', T_4 (109.67) followed by other treatments while T_0 produce the least cormel number (57) as shown in Figure 9. Mean cultivar comparison indicated that 'Rose Supreme' produce additional cormels number (36.36 g) than 'White Prosperity' (28.11 g) may be due to the more food in lower portions than 'White Prosperity' that had higher vegetative growth. Present results are supported by [Culver et al. 2012] who reported increased yield after PGRs application. Similar results have also been stated in Foidle et al. [2001] and Price, [1985] that MLE foliar application increased the grain yield. Increase yield in gladiolus was reported in response to GA_3 application [Peanav et al. 2005, Umrao et al. 2007]. Results regarding cormels diameter exposed significant change in treatments and cvs. but non-significant in their interaction. Mean cultivar comparison showed 'Rose Supreme' superiority in cormel diameter 10.937 mm than 'White Prosperity' 9.13 mm. In treatments on 'Rose Supreme', T_4 produce maximum diameter (12.04 mm) while T_2 and T_3 remained lower by producing 11.42 mm and 11.21 mm respectively. T_1 produced 10.56 mm while least diameter was measured in T_0 9.44 mm. In 'White Prosperity' maximum diameter was observed in T_2 (9.57 mm) while other remained lower in an order of: T_4 (9.54 mm) > T_3 (9.43 mm) > T_1 (9.04 mm) > T_0 (8.07 mm). These findings are in the congruence with the results of [Hartmann et al. 1990] that subsequent to spike formation, the photosynthetic food was transferred in the underground portion that increased the cormel size. Results regarding cormels weight (g) exposed significant variation in cvs. but non- significant for treatments and their interactions with cvs. 'Rose Supreme' was found to be the most effective regarding cormel weight (13.29 g), followed by 'White Prosperity' (9.06 g). In 'Rose Supreme' maximum cormel weight was measured in T_4 (16.61 g) while other treatments followed a decreasing trend > T_3 > T_0 > T_2. Minimum weight was measured in T_1 (11.17 g). In 'White Prosperity' T_3 produced maximum weight in T_3 (9.43 g), followed by T_2, T_0 and T_4 (8.95 g) while minimum weight was exhibited by T_1 (8.71 g). Sharma et al. [2004] and Kumar et al. [2008] regarding gladiolus reported same results regarding cormel weight.

CONCLUSION

The investigation results revealed that both *Gladiolus grandiflorus* cvs. responded very well to the MLE exogenous application regarding plant height, spike length, floret numbers, shelf life corm weight and size compared to Control. Among all treatments applied, T_4 gave remarkable performance regarding all parameters whereas other treatments had the minor effect in both cvs. For commercial cut-flower production, 'White Prosperity' performed outstandingly. 'Rose Supreme' demonstrated positive results regarding corm production. Therefore, it can be concluded that export quality gladiolus cut-flower and corm production could be successfully attained by the economical plant source growth regulator (MLE) in the climatic conditions of Faisalabad, Pakistan.

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