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Pre-soaking treatment and foliar application of KNO_3 on growth and flower production of gladiolus (*Gladiolus hortulanus*)

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Abstract A field trial was conducted to investigate the effect of presoaking treatment and foliar application of KNO_3 on the seed germination, growth and flower production of Gladiolus. Two gladiolus cultivar (White Friendship and Oscare) were experimented against pre-soaking and foliar application of KNO_3 at four concentrations (0, 1, 3, 5%). The Experiment was conducted in a four replicated randomized complete block design (RCBD) having net plot size of 1.5m x 1.5m ($2.25m^2$) with plant and row spacing of 30cm and 30cm, respectively. The results revealed a highly significant ($P<0.1$) effect of presoaking treatment and foliar application of KNO_3 (at various concentrations) on the seed germination, growth and flower production of gladiolus cvs. White Friendship and Oscare. White Friendship responded better to presoaking of corms with KNO_3 concentrations of 61.43, 92.50 and 96.25% germination at wk 2, 3 and 4, respectively; 9.02 leaves $plant^{-1}$, 61.10 cm length of leaves, 6.02 days to open 1^{st} floret, 19.27 days life of spike, 13.33 florets $spike^{-1}$, 2.80 corms $plant^{-1}$, 40.83 cormlets $plant^{-1}$, 18.15g corm weight and 0.40g cormlet weight.

Keyword: Pre-soaking, Foliar Application, KNO_3, Growth, Flower, Gladiolus

Introduction

Gladiolus (*Gladiolus hortulanus*), is grown primarily for cut flowers and to a limited extent for landscaping and exhibition purposes. Gladiolus is a genus of perennial bulbous flowering plants (Manning and Peter, 2008).

From commercial point of view, it is rated as the most popular flower in the world (Cohot, 1993). Gladiolus occupies 4th place in International cut flower trade after rose, carnation and chrysanthemum (Farhat, 2004).

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Traditionally flowers are grown for aesthetic, social function and extraction of essential oils and manufacturing of perfumes (Byczynski, 1997). But now, floriculture has been identified as a potential business due to divergence of farmers towards high value floral crops and utilization of flowers in social and industrial level in Punjab, Pakistan. Hence commercial floriculture has emerged inside the country. The most important floricultural crops in the Pakistan cut flower trade are roses, *Gladiolus*, tuberoses, Iris, Carnation, Narcissus, Lilies, Freesia, Statice and Gerbera etc. The production and consumption of cut flowers has also increased over the past decade and this increase is expected to continue due to number of indefinite factors in Pakistan. It is a popular bulbous plant that is grown for both as potted and aesthetic cut flower in the country. Agriculture in Punjab is dominated by the wheat-paddy cropping cycle. Recently, many growers have switched to floriculture from conventional cropping system; because decrease in cultivated land due town planning; soil deterioration and small holdings are promising limitations in the province. Moreover, non-conventional crops provide more per rupee return than routine crops. The total area under flower in Punjab Province is estimated around 9000 acres, under flower farming such as Roses, *Gladiolus,* tuberoses and jasmine. Over 450 acres are under the cultivation of *Gladiolus* in Punjab (Anonymous, 2003).

Production of quality flowers as well as plants depends on vigorous pre-flowering (vegetative) growth. Pre-flowering growth depends on the amount and availability of macro and micronutrients in the soil. Potassium is one of the most important macronutrients that affect growth of gladiolus (Salisbury and Ross, 1992).

In gladiolus both the spikes and corms/cormels are important. Therefore, early and quick vegetative growth is necessary to obtain long and healthy spikes with more number of buds and to obtain more yields of corms in terms of size and number (Amir, 2006). Potassium is known by its influences many enzymatic reactions and is associated with almost every major plant functions. It improves the efficiency of plant water and sugar use for maintenance and normal growth functions. Potassium encourages plants to develop robust, healthy root systems. KNO_3 greatly influenced the plant height as nitrogen supplied. KNO_3 is an indispensable elementary constituent of numerous organic compounds such as amino acid, protein and nucleic acids. It was observed that *Gladiolus* seedling length increased by the effect of KNO_3. Moreover, it plays important role for plant elongation, formation of protoplasm, as well as new cells. The seedling length increased with increase in concentration from 1% to 3% KNO_3 solution, as well as maximum bulb weight and bulb diameter were

obtained in 3% KNO_3 (Ramazan *et al*., 2010). El-Bassiony (2006) examined the influence potassium fertilization on the growth and physiology of gladiolus and reported that gladiolus plant of primed seed attained more length than the plants of non primed seeds. Seedling length increased with increase in concentration from 1% to 3% KNO_3 solution. Tallest plants (14 cm) were observed in under 3% KNO_3 followed by 13.48 cm, 12.45 cm and 12.77 cm in 2% KNO_3, 1% KNO_3 and 4 % KNO_3, respectively. Minimum achievement of 7 cm and 9 cm was noted in Control and distilled water treatments. There was a slight difference in seedling length due to concentration of KNO_3 and increase in seedling length was observed up to 3% KNO_3 concentration then after that there was a declining trend. It may be due to availability of nitrogen and potassium from priming solution. The enhanced seedling length in primed seed may be due to the improved and faster plants seedling emergence and plant length may be due to the efficiency of the plant for utilization of nitrogen which is essential for plant growth and as well as other processes related to nitrogen metabolism. The present study was carried out to investigate the effect of Pre-Soaking treatment and foliar application of KNO_3 on germination, growth and flower production of Gladiolus.

Materials and methods

The study was carried out to investigate the effect of presoaking treatment and foliar application of KNO_3 on the seed germination, growth and flower production of Gladiolus. Corms were brought from Lahore (New Pak Seed Company). The Experiment was conducted in a four replicated randomized complete block design having net plot size of 1.5m x 1.5m ($2.25m^2$) with plant to plant distance of 30cm and row to row 30cm at the experimental fields in Orchard, Department of Horticulture, Sindh Agriculture University Tando Jam. After selection of experimental site, the soil was analysed for various physico-chemical characteristics and soil texture was determined as well. The soil samples were obtained at 15 cm depth.

The experimental soil was initially plowed up by means of disc plow to remove the hard pan and disc harrow was operated. When the land was ploughed up, the clods were crushed, and leveling was done to eradicate the weeds and to make the soil surface leveled for uniform distribution of irrigation water. After soaking dose, when the soil came in condition, cultivator was operated and beds were prepared.

Before starting preparation of experimental soil for gladiolus, well rotten farmyard manure was applied.

The beds were slightly raised and completed a week or two prior to planting time to allow for them to firm up. This firmness aided in giving the

plants favorable environment to germinate and a good stand obtained. The different concentrations of KNO_3 i.e. 0, 1, 3 and 5% were used for soaking and as foliar application. A total of three foliar spray of KNO_3 were done. The first spray was done after 25 days and remaining two spray at 20 days interval.

The corms were dipped in KNO_3 solutions at different concentrations (0, 1, 3 and 5%) in a beaker for duration of 48 hours. The soaked corms were dried in room temperature for 48 hours. The dried corms were sown. Fertilizers were applied in the form of urea, single super phosphate and muriate of potash. Farmyard manure at 10 kg/m^2 was applied initially. Half dose of nitrogen and full doses of phosphorus and potash were applied at the time of final land preparation. Remaining half dose of nitrogen was applied (top-dressed) at fourth leaf stage. Weekly irrigation was given to overcome the moisture stress. Weeding and hoeing was done at 20, 40, 60 and 80 days after planting. Earthing up was done 90 days after planting to prevent lodging. Spikes were harvested (when the first floret blushed) with two broad leaves for taking observations related to spike characteristics. After 45 days of spike harvesting, the corms and cormels were harvested and observations on different parameters were recorded by random samplings of five corms of each plot and the weight and number of cormels per plant also recorded for each mother corm. At the time of harvest, 6 leaves were left for corm development. When the leaves attained pale or cream color, the corm was ready for harvest. The corms were harvested after 45 days of spike harvest, i.e. 155 days of planting. The following observations were recorded. (1) Germination percentage (Week 2, 3, 4), (2) Number of leaves $plant^{-1}$, (3) Length of Leaves (cm), (4) Opening of first floret (days), (5) Number of florets per spike, (6) Life of spike (days), (7) Corms $plant^{-1}$, (8) Cormlets $plant^{-1}$, (9) Corm weight, (10) Cormlet weight.

The data so collected were tabulated replication-wise on basis of 10 randomly selected plants, and then averages were worked out. Statistical analysis of the data was done to discriminate the superiority of treatment means, using L.S.D (Least Significant Differences) test, as per the statistical methods developed by Gomez and Gomez (1984). All the statistical tests were performed by using Mstat-C Computer Software.

Results

Germination percentage (Week-1)

According to 1^{st} week the effect of KNO_3 on the cultivars of the gladiolus the germination was not occurred.

Germination percentage (Week-2)

Corm germination is the basic requirement for desired production level of gladiolus flowers. The results in relation to corm germination of gladiolus as influenced by cultivars, pre-soaking of corms and foliar spray of KNO_3 is presented in Table-1. The analysis of variance suggested that the effect of cultivar on corm germination during second week was significant ($P<0.01$) and non-significant ($P>0.05$) due to KNO_3 concentrations and interaction of cultivars x KNO_3 treatment.

During second week, 61.43 percent corms of gladiolus cv. White Friendship were germinated, while corms of cv. Oscare did not germinate during first and second week. The average corm germination was highest (40.37 %) when corms were pre-soaked and foliar spray with 3% KNO_3 concentration. Increasing KNO_3 upto 5 % concentration adversely impacted corm germination (32.50%), while corm germination reduced to 27.50 percent with decreasing KNO_3 concentration upto 1%, while the lowest corm germination of 22.50 % was recorded under control, where only distilled water was used and no KNO_3. The interaction of cv. x White Friendship 3% KNO_3 concentration showed highest germination of 80.75 %, while interaction between cv x . Oscare KNO_3 at all concentrations did not succeed to produce germination. It was observed that gladiolus cv. White Friendship showed earliness in corm germination over cv. Oscare germinates, while 3% KNO_3 concentration produced higher corm germination than rest of the concentrations and control.

Table 1. Mean corm germination (%) of gladiolus cultivars during second, third and forth week as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

Second week			
KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	45.00	0.00	22.50
1.00% KNO_3 concentration	55.00	0.00	27.50
3.00% KNO_3	80.75	0.00	40.37
5.00% KNO_3	65.00	0.00	32.50
Mean for Cultivars	61.43 a	0.00 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	4.6682	6.6018	9.3364
LSD 0.05	13.729	-	-
LSD 0.01	18.692	-	-
CV%	60.79		

Mean values with same letters do not differ significantly at 0.05 probability level

Germination percentage (Week-3)

The data pertaining to corm germination of gladiolus during week-3 of corm sowing as influenced by cultivars, pre-soaking of corms and foliar spray of KNO_3 are shown in Table-2. The analysis of variance illustrated that the corm germination during third week was significantly ($P<0.01$) affected by cultivars, while the effect on corm germination due to KNO_3 concentrations as well as interaction of cultivars and KNO_3 concentrations was and non-significant ($P>0.05$).

The results (Tabe-2) indicated that during third week, cv. White Friendship displayed higher corm germination (92.50%) as compared to cv. Oscare (69.37%). The effect of KNO_3 on gladiolus corm germination during third week indicated that KNO_3 at 5% concentration caused maximum corm germination of 90.00 percent, followed by 88.75 and 80.00 percent corm germination during third week under 3% and 1% KNO_3 concentrations, respectively. However, the lowest corm germination of during third week of 65.00 percent was noted in control, where the pre-soaking treatment and foliar spray was done only by distilled water. The interaction of cv. White Friendship x 1%, 3% and 5% KNO_3 concentrations showed equally highest corm germination of 100%, while interaction between cv. Oscare x 0 and 1% KNO_3 concentrations produce equally lowest corm germination of 60.00 percent. It was noted that regardless of KNO_3 concentrations, gladiolus corms given pre-soaking treatment resulted higher corm germination than the control, while cv White Friendship showed earliness in corm germination over cv. Oscare germinates. Moreover, corm germination in cv. Oscare started in the third week.

Table 2. Mean corm germination (%) of gladiolus cultivars during third week as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

	Third week		
KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	70.00	60.00	65.00
1.00% KNO_3 concentration	100.00	60.00	80.00
3.00% KNO_3	100.00	77.50	88.75
5.00% KNO_3	100.00	80.00	90.00
Mean for cultivars	92.50 a	69.37 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	5.2584	7.4365	10.517
LSD 0.05	15.465	-	-
LSD 0.01	21.055	-	-
CV%	25.99		

Mean values with same letters do not differ significantly at 0.05 probability level

Germination percentage (Week-4)

The results regarding gladiolus corm germination during week-4 of corm sowing as influenced by cultivars, pre-soaking of corms and foliar spray of KNO_3 are presented in Table-3. The analysis of variance indicated that the corm germination during fourth week was significantly ($P<0.01$) influenced by KNO_3 concentrations, while non-significant ($P>0.05$) effect was noted on corm germination was noted due cultivars and interaction of cultivars x KNO_3 concentrations.

Table 3. Mean corm germination (%) of gladiolus cultivars during fourth week as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

	FORTH WEEK		
	Cultivars		**Mean for KNO_3 concentrations**
KNO_3 concentrations	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	85.00	85.00	85.00
1.00% KNO_3 concentration	100.00	100.00	100.00
3.00% KNO_3	100.00	95.00	97.50
5.00% KNO_3	100.00	100.00	100.00
Mean for cultivars	96.25	95.00	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	1.4042	1.9858	2.8084
LSD 0.05	-	4.1297	-
LSD 0.01	-	7.9517	-
CV%	5.87		

Mean values with same letters do not differ significantly at 0.05 probability level

It is obvious from the data (Tabe-3) that during fourth week, cv. White Friendship exhibited maximum corm germination of 96.25% and minimum (95.00%) by cv. Oscare. The effect of KNO_3 on corm germination showed that at 1% and 5% concentrations equally maximum corm germination of 100.00 percent was recorded, followed by 97.00 percent germination under 3% KNO_3 concentrations; while the lowest corm germination of 85.00 percent was observed in control, where only distilled water was used for corm soaking and foliar spray. The interaction of cv. White Friendship x 1%, 3% and 5% KNO_3 concentrations and cv. Oscare x 1% and 5% KNO_3 concentrations displayed equally 100% corn germination; while interaction of both the cultivars x control displayed equally minimum (85.00%) corm germination. It was noted that after completion of four weeks, almost 100 percent corm germination was received

when corms given pre-soaking treatment, while in case of control, the germination remained up to 85.00 percent.

Number of leaves plant^{-1}

The data in relation to number of leaves plant^{-1} of gladiolus as influenced by cultivars, pre-soaking of corms and foliar spray of KNO_3 are shown in Table-4. The analysis of variance indicated that the number of leaves plant^{-1} was significantly ($P<0.01$) influenced by cultivars and KNO_3 concentrations, while non-significant ($P>0.05$) effect was noted on number of leaves plant^{-1} due to interaction of cultivars x KNO_3 concentrations.

Table 4. Mean number of leaves plant^{-1} of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= Control (Distilled water)	8.58	7.00	7.79 b
1.00% KNO_3 concentration	9.00	6.83	7.91 b
3.00% KNO_3	9.83	7.75	8.79 a
5.00% KNO_3	8.66	6.83	7.75 c
Mean for cultivars	9.02a	7.10 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.1826	0.2583	0.3653
LSD 0.05	0.5371	0.7596	-
LSD 0.01	0.7313	1.0342	-
CV%	9.06		

Mean values with same letters do not differ significantly at 0.05 probability level.

The results showed that the cv. White Friendship had markedly higher number of leaves plant^{-1} (9.02) than cv. Oscare (7.10). In case of KNO_3 treatment effect, the pre-soaking treatment at 3% KNO_3 concentration resulted in highest number of leaves (8.79) plant^{-1}, followed by 7.91 and 7.79 leaves plant^{-1} recorded under 1% KNO_3 concentration and control (0 KNO_3), respectively. However, the lowest number of leaves (7.75) plant^{-1} was recorded under higher KNO_3 concentration of 5%. The interaction of cv. White Friendship x 3% KNO_3 concentration resulted in maximum number of leaves (9.83) plant^{-1}, while the minimum number of leaves (6.83) plant^{-1} equally under interaction of cv. Oscare x 1% and 5% KNO_3 concentrations. The results showed that with increasing KNO_3 concentrations upto 3% for pre-soaking treatment and foliar spray, the number of leaves plant^{-1} increased significantly.

However, further increase in KNO_3 (5% concentration) displayed adverse effects on the number of leaves plant^{-1}. Hence, it is suggestible that for pre-soaking treatment and foliar spray, KNO_3 may be applied at the concentration of 3%.

Length of leaves (cm)

The results pertaining to length of leaves of gladiolus as affected by cultivars, pre-soaking treatment and foliar spray of KNO_3 are presented in Table-5. The analysis of variance demonstrated that the effect of KNO_3 concentrations on the length of leaves was significant ($P<0.01$), while non-significant ($P>0.05$) due to cultivars and interaction of cultivars x KNO_3 concentrations.

Table 5. Mean length of leaves (cm) of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	59.54	56.75	58.14 b
1.00% KNO_3 concentration	60.79	58.21	59.50 b
3.00% KNO_3	64.54	64.33	64.43 a
5.00% KNO_3	59.54	56.95	58.25 b
Mean for cultivars	61.10	59.95	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.6032	0.8531	1.2064
LSD 0.05	-	2.5089	-
LSD 0.01	-	3.4159	-
CV%	4.02		

Mean values with same letters do not differ significantly at 0.05 probability level

It is apparent from the results (Table-5) that cv. White Friendship produced leaves with relatively greater length (61.10 cm) than cv Oscare. (59.06 cm). In case of KNO_3 treatment effect, the pre-soaking treatment at 3% KNO_3 concentration resulted in highest length of leaves (64.43 cm), followed by 59.50 cm and 58.25 cm length of leaves recorded under 1% and 5% KNO_3 concentrations, respectively. However, the lowest length of leaves (58.14 cm) was recorded in control, where KNO_3 was not applied and pre-soaking treatment and foliar spray was done by distilled water. The interaction of cv. White Friendship x 3% KNO_3 concentration resulted in maximum length of leaves (64.54 cm), while the minimum length of leaves (56.75 cm) under

interaction of cv. Oscare x control. The response of both the cultivars to KNO_3 for length of leaves was positive and similar; and with increasing KNO_3 concentrations upto 3% for pre-soaking treatment and foliar spray, the length of leaves increased significantly. However, further increase in KNO_3 (5% concentration) resulted negative effects and length of leaves reduced. Thus, 3% KNO_3 may be considered as an optimum concentration.

Days taken to open first floret

The data in relation to number of days taken to open first floret of gladiolus as influenced by cultivars and KNO_3 concentrations are reported in Table-6. The results of analysis of variance suggested that the effect of cultivar KNO_3 concentrations as well as treatment interaction of cultivars x KNO_3 concentrations was significant ($P<0.01$) on the days taken to open first floret.

Table 6. Mean days taken to open first floret of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	Cultivars		Mean for KNO_3 concentrations
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	6.41	5.58	6.00 a
1.00% KNO_3 concentration	5.50	4.90	5.20b
3.00% KNO_3	5.34	4.66	5.0 b
5.00% KNO_3	6.83	5.33	6.08 a
Mean for cultivars	6.02 a	5.12 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.1582	0.2238	0.3165
LSD 0.05	0.4654	0.6582	0.9308
LSD 0.01	0.6337	0.8961	1.2673
CV%	4.02		

Mean values with same letters do not differ significantly at 0.05 probability level.

The results showed that cv White Friendship took greater number of days (6.02) to open first floret than cv. Oscare. (5.12 days). In case of KNO_3 treatments, the gladiolus plants treated with 3% KNO_3 concentration took minimum number of days (5.0) to open first floret, followed by 5.2 days taken by the gladiolus to open first floret under 1% KNO_3 concentrations respectively. However, the maximum days taken to open first floret (6.08) were recorded in T4 (5% KNO_3). The interaction of cv Oscare 3% KNO_3 concentration resulted in minimum days taken to open first floret (4.66), while the maximum days taken to open first floret (6.83) under interaction of cv. White Friendship x 5%

KNO_3 concentration. The response cultivars was relatively different to days taken to open first floret and cv. White Friendship took more time than cv. Oscare to open first floret. The increase in KNO_3 concentration upto 3% resulted in decreased time to open first floret.

Life of spike (days)

The life of spike is one of the most important quality characters in gladiolus flower; the data regarding the life of spike as influenced by cultivars and KNO_3 concentrations are presented in Table-7. The analysis of variance indicated that the effect of cultivars and KNO_3 concentrations on the life of spike was significant ($P<0.01$), while non-significant ($P>0.05$) for interaction between cultivars x KNO_3 concentrations.

Table 7. Mean life of spike (days) of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	Cultivars		Mean for KNO_3 concentrations
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	19.08	12.91	16.00 b
1.00% KNO_3 concentration	20.08	14.41	17.25 a
3.00% KNO_3	20.25	14.25	17.25 a
5.00% KNO_3	17.66	13.00	15.33 b
Mean for cultivars	19.27 a	13.64 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.2707	0.3828	0.5414
LSD 0.05	0.7961	1.1258	-
LSD 0.01	1.0839	1.5328	-
CV%	6.58		

Mean values with same letters do not differ significantly at 0.05 probability level.

It can be seen from the results that cv. White Friendship had remarkably higher spike life (19.27 days) than cv. Oscare (13.64 days). In case of KNO_3 treatments, the gladiolus plants treated with 1% and 3% KNO_3 concentrations resulted in equally maximum spike life of 17.25 days, followed by 16.00 days spike life in control (0 KNO_3). However, the lowest life of spike (15.33 days) was recorded under highest KNO_3 concentration of 5%. The interaction of cv. White Friendship x 3% KNO_3 concentration resulted in maximum life of spike (20.25 days), while the minimum life of spike (12.91 days) was noted under interaction of cv. Oscare x control (0 KNO_3). This higher life of spike in cv White Friendship was a splendid quality of this cultivar, while cv. . Oscare was relatively late in this quality. The increase in KNO_3 concentration upto 3%

resulted in increased life of spike; but further increase in KNO_3 (5% concentration) showed adverse impact on life of spike.

Number of florets spike^{-1}

Number of florets spike^{-1} is also a quality characteristic in gladiolus flower plant. The data regarding the number of florets spike^{-1} as affected by cultivars and KNO_3 concentrations are shown in Table-8. The analysis of variance described that the effect of cultivars and KNO_3 concentrations on the number of florets spike^{-1} was significant ($P<0.01$), while non-significant ($P>0.05$) for interaction between cultivars x KNO_3 concentrations.

Table 8. Mean number of florets spike^{-1} of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	Cultivars		Mean for KNO_3 concentrations
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	12.25	10.16	11.46 c
1.00% KNO_3 concentration	13.83	11.58	12.71 b
3.00% KNO_3	14.25	13.00	13.62 a
5.00% KNO_3	12.50	11.42	11.60 c
Mean for cultivars	13.33 a	11.54 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.1900	0.2688	0.3801
LSD 0.05	0.5589	0.7904	-
LSD 0.01	0.7609	1.0761	-
CV%	6.11		

Mean values with same letters do not differ significantly at 0.05 probability level.

It is evident from the Data (Table-8) that significantly maximum number of florets (13.33) spike^{-1} was recorded in cv. White Friendship, while the minimum number of florets (11.54) spike^{-1} was observed in cv.. Oscare In case of KNO_3 treatments, the gladiolus plants treated with 3% and 1% KNO_3 concentrations resulted in maximum number of florets (13.62) spike^{-1}, followed by 12.71 and 11.60 florets spike^{-1} recorded in gladiolus flowers treated with 1% and 5% KNO_3 concentrations, respectively. However, the minimum number of florets (11.46) spike^{-1} was recorded under control, where distilled water was used for soaking and foliar spraying. The interaction of cv White Friendship x 3% KNO_3 concentration resulted in maximum number of florets (14.25) spike^{-1}, while the minimum number of florets (10.16) spike^{-1} was observed in interaction of cv. Oscare x control (0 KNO_3). This higher number of florets spike^{-1} in cv White Friendship was a special quality that made this cultivar

superior from. Oscare. However, increase in KNO_3 concentration upto 3% showed positive impact on this characteristic; because further increase in KNO_3 (5% concentration) showed negative effect on the number of florets spike^{-1}.

Number of corms plant^{-1}

The data in relation to number of corms plant^{-1} of gladiolus cultivars as affected by application of KNO_3 at various concentrations are presented in Table-9. The analysis of variance suggested that number of corms plant^{-1} was significantly ($P<0.05$) influenced by cultivars as well as by KNO_3 concentrations, while the interactive effect of cultivars and KNO_3 concentrations was non-significant ($P>0.05$).

Table 9. Mean number of corms plant^{-1} of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	2.66	2.00	2.33 b
1.00% KNO_3 concentration	2.91	2.00	2.45 a
3.00% KNO_3	3.45	2.08	2.77 a
5.00% KNO_3	2.16	1.91	2.04 b
Mean for cultivars	2.80 a	2.00 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.1713	0.2423	0.3427
LSD 0.05	0.3563	0.5139	-
LSD 0.01	0.4851	-	-
CV%	20.18		

Mean values with same letters do not differ significantly at 0.05 probability level.

The results in Table-9 indicated that the number of corms plant^{-1} was higher (2.80) in gladiolus cv. White Friendship as compared to Oscare (2.00). The gladiolus sown in media with 3% KNO_3 resulted in maximum number of corms (2.77) plant^{-1}, while the number of corms slightly decreased to 2.45 plant^{-1} under 1% KNO_3 concentration. The number of corms plant^{-1} of gladiolus was 2.33 plant^{-1} when gladiolus was sown in media with 0% KNO_3 concentrations. However, the lowest number of corms (2.04) plant^{-1} was recorded under 5% KNO_3 concentration. The interaction of cv. White Friendship x 3% KNO_3 concentration resulted in maximum number of corms (3.45) plant^{-1}, while the minimum number of corms (2.00) plant^{-1} was observed in interactions of cv. Oscare x control and 1% KNO_3 concentration. The results

suggested that cv White Friendship seems to be superior over. Oscare for this trait; while 3% KNO_3 concentration optimally provided better results for this trait as compared to rest of the KNO_3 and control.

Number of cormlets plant^{-1}

The results pertaining to number of cormlets plant^{-1} of gladiolus cultivars as affected by application of KNO_3 at various concentrations are shown in Table-10. The analysis of variance demonstrated that number of cormlets plant^{-1} was significantly ($P<0.05$) affected by cultivars, KNO_3 concentrations as well as by their interaction.

Table 10. Mean number of cormlets plant^{-1} of gladiolus cultivars affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	Cultivars		Mean for KNO_3 concentrations
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	27.83	5.58	16.71 b
1.00% KNO_3 concentration	49.00	6.25	27.62 a
3.00% KNO_3	30.08	12.66	36.37 a
5.00% KNO_3	26.41	7.33	16.87 b
Mean for cultivars	40.83 a	7.95 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	3.6810	5.2027	7.3619
LSD 0.05	7.6550	10.826	15.310
LSD 0.01	10.422	14.739	-
CV%	42.60		

Mean values with same letters do not differ significantly at 0.05 probability level.

The number of cormlets plant^{-1} was remarkably higher (40.83) in gladiolus cv. White Friendship as compared to Oscare (7.95). The pre-soaking gladiolus treatment with 3% KNO_3 caused to have maximum number of cormlets (36.37) plant^{-1}, while the number of cormlets slightly decreased to 27.62 plant^{-1} under 1% KNO_3 concentration. The number of cormlets plant^{-1} of gladiolus was 16.87 plant^{-1} when gladiolus was sown in media with 5% KNO_3 concentrations. However, the lowest number of cormlets (16.71) plant^{-1} was recorded in control (distilled water only). The interaction of cv White Friendship x 3% KNO_3 concentration resulted in maximum number of cormlets (60.08) plant^{-1}, while the minimum number of cormlets (5.58) plant^{-1} was observed in interactions of cv. Oscare x control. It is evident from the results that cv. White Friendship is remarkably superior than Oscare for number of

cormlets plant^{-1}; while 3% KNO_3 concentration proved to be better than all rest of the treatments and control for this trait.

Corm weight (g)

The results regarding the corm weight of gladiolus cultivars as influenced by application of KNO_3 at various concentrations are shown in Table-11. The analysis of variance described that corm weight was significantly ($P<0.05$) affected by cultivars as well as by KNO_3 concentrations, while the interactive effect of cultivars and KNO_3 concentrations was non-significant ($P>0.05$).

Table 11. Mean corm weight (g) of gladiolus cultivars as affected by pre-soaking corm treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= C (Distilled water)	11.99	8.80	10.39 c
1.00% KNO_3 concentration	20.30	10.90	15.60 b
3.00% KNO_3	27.37	13.16	20.27 a
5.00% KNO_3	12.95	10.52	11.73 c
Mean for cultivars	18.15 a	10.84 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	1.8798	2.0584	3.7595
LSD 0.05	3.9092	5.5285	-
LSD 0.01	5.3223	7.5259	-
CV%	36.68		

Mean values with same letters do not differ significantly at 0.05 probability level.

The corm weight was significantly higher (18.15 g) for gladiolus cv. White Friendship as compared to cv. Oscare (10.84 g). The pre-soaking treatment with 3% KNO_3 resulted in maximum corm weight (20.27 g), followed by pre-soaking treatment with 1% KNO_3 concentration resulted 15.60 g corm weight. The corm weight was reduced to 11.73 g under 5% KNO_3 concentrations; while the lowest corm weight (10.39 g) was recorded in control (0% KNO_3). The interaction of cv White Friendship x 3% KNO_3 concentration resulted in maximum corm weight (27.37 g), while the minimum corm weight (8.80 g) was observed in interactions of cv. . Oscare x control. It can be clearly assumed from the results that cv White Friendship is superior in corm weight than (cv). Oscare; while 3% KNO_3 showed its appropriateness as pre-soaking corm treatment in gladiolus.

Cormlet weight (g)

The data pertaining to cormlet weight of gladiolus cultivars as affected by pre-soaking corm treatment with KNO_3 at various concentrations are presented in Table-12. The analysis of variance suggested that cormlet weight was significantly ($P<0.05$) affected by cultivars, KNO_3 concentrations as well as by their interaction.

Table 12. Mean cormlet weight (g) of gladiolus cultivars as affected by pre-soaking cormlet treatment and foliar spray with various KNO_3 concentrations

KNO_3 concentrations	**Cultivars**		**Mean for KNO_3 concentrations**
	White Friendship	Oscare	
0% KNO_3= Control (Distilled water)	0.38	0.24	0.31 b
1.00% KNO_3 concentration	0.44	0.22	0.33 b
3.00% KNO_3	0.49	0.32	0.41 a
5.00% KNO_3	0.30	0.24	0.27 c
Mean for cultivars	0.40 a	0.25 b	-
	Cultivars (V)	KNO_3 conc. (C)	V x C
S.E.±	0.0190	0.0197	0.0297
LSD 0.05	0.0290	0.0410	0.0580
LSD 0.01	0.0395	0.0559	0.0790
CV%	36.68		

Mean values with same letters do not differ significantly at 0.05 probability level.

It is apparent from the results (Table-12) that the cormlet weight was significantly higher (0.40 g) for gladiolus cv White Friendship. as compared to cv. Oscare (0.25 g). The pre-soaking treatment with 3% KNO_3 resulted in maximum cormlet weight (0.41 g), followed by pre-soaking treatment with 1% KNO_3 concentration that resulted 0.33 g cormlet weight. The cormlet weight followed a decreasing trend (0.27 g) under 5% KNO_3 concentrations; while the cormlet weight in control was 0.31 g. The interaction of cv. Oscare x 3% KNO_3 concentration resulted in maximum cormlet weight (0.49 g), while the minimum cormlet weight (0.22 g) was noted in interactions of cv. White Friendship x 1% KNO_3 concentration. The results suggested that cv White Friendship was better in cormlet weight than cv. . Oscare and 3% KNO_3 concentration proved to be an appropriate concentration for maximizing cormlet weight.

Discussion

Among ornamental plants, Gladiolus is considered of prime importance and are used for cut flowers, landscaping, exhibition purposes (Manning and Peter, 2008). There are hundreds of gladiolus species and they vary from very small to the spectacular giant flower spikes (Wikipedia, 2010 a,b). Gladiolus occupies 4th place in International cut flower trade after rose, carnation and chrysanthemum (Farhat, 2004). Potassium plays significant role in regulating the opening and closing of stomata and water retention of plants and promotes the growth of meristematic tissue, activates some enzymatic reactions, aids in nitrogen metabolism, and the synthesis of proteins, catalyzes activities of some mineral elements, and aids in carbohydrate metabolism and translocation; and corms soaked with 2% KNO_3 showed better germination than untreated corms (Singh *et al*., 1997). In order to examine effect of Pre-Soaking treatment and foliar application of KNO_3 on germination, growth and flower production of Gladiolus, the response of gladiolus varieties Oscare and White Friendship against pre-soaking and foliar application of KNO_3 at various concentrations (0, 1, 3, 5%) was investigated under field conditions.

The findings of the study showed that cv. White Friendship responded better to presoaking of corms with KNO_3 concentrations of 61.43, 92.50 and 96.25% germination at wk 2, 3 and 4, respectively; 9.02 leaves plant^{-1}, 61.10 cm length of leaves, 6.02 days to open 1st floret, 19.27 days life of spike, 13.33 florets spike^{-1}, 2.80 comrs plant^{-1}, 40.83 cormlets plant^{-1}, 18.15g corm weight and 0.40g cormlet weight. Similarly, in KNO_3 concentrations, all the growth and flower production characters studied were optimally better under 3% concentration with 40.37, 88.75 and 97.50% germination at wk 2, 3 and 4, respectively; 8.79 leaves plant^{-1}, 64.43 cm length of leaves, 5.0 days to open 1st floret, 17.25 days life of spike and 13.62 florets spike^{-1}, 2.77 corms plant^{-1}, 36.37 cormlets plant^{-1}, 20.27g corm weight and 0.41g cormlet weight; while in control (0% KNO_3) poor germination of gladiolus corms was recorded i.e. 22.50, 65.00 and 85.00% germination at wk 2, 3 and 4, respectively; 7.79 leaves plant^{-1}, 58.14 cm length of leaves, 6.00 days to open 1st floret, 16 days life of spike, 11.46 florets spike^{-1}, 2.33 corms plant^{-1}, 16.71 cormlets plant^{-1}, 10.39g corm weight and 0.39g cormlet weight.

It was observed that cv. White Friendship proved to be superior in response to pre-soaking treatment and foliar application of KNO_3 over cv. Oscare; while upto 3% KNO_3 concentration positively influenced almost all the characters studied and there were adverse effects when KNO_3 was increased upto 5% concentration. These results are further supported by

Karagüzel and Doran (2000) who applied 25 g/m^2 KNO_3 (5 times) and significant differences in leaf nutrient content were observed between gladiolus cultivars due to KNO_3 fertilization were observed. Abbasi *et al.* (2005) found that priming with KNO_3 greatly influenced the germination, plant height, length of leaves and florets per spike of gladiolus. Roychowdhury and Roychowdhury (2006) reported that application of KNO_3 and K_2SO_4 at medium level gave the maximum number of flowers opening at one time; while field application of KNO_3 at maximum application gave maximum period of prime beauty in gladiolus. Ghoname *et al*. (2007) reported that potassium nitrate had a more significant effect in both vegetative growth and bulb quality compared with potassium sulfate. Sathiyamoorthy and Vivekanandan (2008) reported that pre-sowing soaking treatment of corms with KNO_3 resulted in better development of the root and shoot system of gladiolus than the control. Ramzan *et al.* (2010) studied KNO_3 concentrations (1, 2, 3, 4, 5 and 0 %) on germination percentage of gladiolus corms and reported that the bulb gained maximum weight (0.6467 g) and diameter (9.49 mm) in 3% KNO_3.

Concluding the proceedings of the study, it is suggested that cv. White Friendship may preferably be grown at 3% KNO_3 concentration as pre-soaking corm treatment and foliar application. These results are further supported by many research workers in the past. Amir (2006) reported that both the spikes and corms/cormels were improved when presoaking treatment with KNO_3 was given.

Early and quick vegetative growth is necessary to obtain long and healthy spikes with more number of buds and to obtain more yields of corms in terms of size and number. KNO_3 improved the seed germination in several ornamental plants including gladiolus (Ramazan *et al*., 2010); potassium encourages plants to develop robust with healthy root systems. It was also observed that KNO_3 greatly influenced the plant height; and KNO_3 causes amino acid, protein and nucleic acids; Gladiolus seedling length increased by the effect of KNO_3. The seedling length increased with increase in concentration from 1% to 3% KNO_3 solution, as well as maximum bulb weight and bulb diameter were obtained in 3% KNO_3 (Ramazan *et al*., 2010) and El-Bassiony (2006) also attained more length in primed corms than the plants of non-primed corms in gladiolus.

The comparative analysis of findings of the present research and work on the similar aspects done by past researchers coincides and suggested that presoaking treatment and foliar application of KNO_3 may be disseminated among the gladiolus growers, so that quality flower production may be ensured.

Conclusion

It was concluded that cv. White Friendship proved to be superior in response to pre-soaking treatment and foliar application of KNO_3 over cv. Oscare; while upto 3% KNO_3 concentration positively influenced almost all the characters studied and there were adverse effects when KNO_3 was increased upto 5% concentration. Hence, it is suggested that cv. White Friendship may preferably be grown at 3% KNO_3 concentration as pre-soaking corm treatment and foliar application.

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