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Effect of fertigation levels on flower production of Gladiolus (*Gladiolus grandiflorus* L.)

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ABSTRACT

The present study was undertaken to determine NPK dose of gladiolus through fertigation and standardize fertigation method through drip irrigation for better flower yield and flower quality in gladiolus. The experiment was laid out in randomized block design using 7 different treatments with 3 replications with300 kg N + 200kg P + 200 kg K ha-1in F1 with33.3% each of NPKat 3 leaf stage , 6 leaf stage and spike emergence and F2 @ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPKat 3 leaf stage , 6 leaf stage and spike emergence respectively.225 kg N + 150kg P + 150 kg K ha-1 in F3with 33.3% each of NPKat 3 leaf stage , 6 leaf stage and spike emergence and F4@ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPKat 3 leaf stage , 6 leaf stage and spike emergence respectively.150 kg N + 100kg P + 100 kg K ha-1 in F5 with33.3% each of NPKat 3 leaf stage , 6 leaf stage and spike emergence and F6@ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPKat 3 leaf stage , 6 leaf stage and spike emergence respectively and F7(control) i.e. 300 kg N + 200kg P + 200 kg K ha-1. Among the treatments, F1 resulted in maximum sprouting percentage (90.66%) and took minimum time from sprouting to spike emergence (81.66 days) and total days to flowering (111.26 days). Maximum plant height (103.90 cm), spike length (83.46 cm) and rachis length (51.29 cm) with maximum florets (12.26) and vase life (10.66 days) was recorded in F1. The highest corm and cormel production were observed under treatment F1.

Keywords: Gladiolus, drip irrigation, fertigation, corm

INTRODUCTION

Gladiolus grandiflorus L. is an important bulbous cut flower and belongs to family Iridaceae. This crop is widely grown in various countries and considered as potential cut flower in domestic and international market (Jat 2017). Amongst the cut flowers, gladiolus holds 3rd rank in terms of both area (11.55 thousand hectare), production (176.07 thousand metric tonnes) and productivity 15.24 per hectare in India (Anonymous 2021-2022). The spikes of gladiolus bear attractive and delicate florets with wide range of colours varying from white to dark crimson which open in sequence for longer duration. The gladiolus spikes are used for flower arrangements and for floral bouquets. Gladiolus prefers open sunny conditions and sandy soils with good drainage. Neutral soil with pH range of 6–7 is best suitable for gladiolus cultivation (Woltz 1976, Boodley 1981). The optimum range of temperature is 25-30°C and 10-12 hours photo-period for better flower production. Gladiolus is commercially propagated from corms and cormels. Adequate level of fertilization helps in obtaining maximum flower yield and best flower quality of the crop. Drip irrigation system utilized for fertigation allows the applied fertilizer to be placed in the plant's active root zone and as per nutrient requirement of the plant (Neilsen 2004). Fertigation has the advantages of supply of adequate amount of nutrients at right time and right place. Flower crops are highly responsive to fertilizer and capable of absorbing nutrients from the soil. Hence the maximum flower production is ensured by application of increased dose of chemical fertilizer with balanced proportion. Like other crops, fertilizer requirements of gladiolus play an important role in growth, quality, corm and cormel production. Keeping the importance of gladiolus as a cut flower and its response to fertigation, the study was planned to improve the production for better returns with low inputs.

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MATERIALS AND METHODS

The present study was conducted at Research Farm, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, Punjab during the year 2019-20.The soil was sandy loam with good water holding capacity and soil pH 8.5. The experiment was laid out in randomized block design using seven treatments with 3 replications of 300 kg N + 200kg P + 200 kg K ha-1 in F1 with 33.3% each of NPKat 3 leaf stage, 6 leaf stage and spike emergence and F2 @ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPK at 3 leaf stage, 6 leaf stage and spike emergence respectively. 225 kg N + 150kg P + 150 kg K ha^{-1} in F3 with 33.3% each of NPKat 3 leaf stage, 6 leaf stage and spike emergence and F4 @ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPK at 3 leaf stage, 6 leaf stage and spike emergence respectively. 150 kg N + 100kg P + 100 kg K ha^{-1} in F5 with 33.3% each of NPKat 3 leaf stage, 6 leaf stage and spike emergence and F6 @ 40:20:20% NPK, 30:40:40% NPK and 30:40:40% NPK at 3 leaf stage, 6 leaf stage and spike emergence respectively. In this experiment F7 was taken as control with application of300 kg N + 200kg P + 200 kg K ha^{-1} which was applied as 50% N, 100% P and 100% K applied at time of planting and remaining 50%Nwas applied after 45 days of planting. After thorough preparation of field and application of well decomposed farmyard manure @25 t/ha. The uniform sized corms were planted in second week of November with a spacing of 30 × 20 cm. The plot of 5×0.6 m^2per treatment per replication was prepared. Drip irrigation consisting of main, sub-main and laterals was laid out in the experiment plot. The laterals of 16 mm diameter were laid 1m apart with the spacing of 40 cm distance two inline emitters. The emitter discharge was 2.2 l/hr and the end plugs were fixed to all control taps on laterals to facilitate in controlling the system. In all treatments (F1-F6) 25% of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details using water soluble fertilizers through drip irrigation. The observations recorded were days taken to sprouting, corms sprouting percentage, days taken from sprouting to spike emergence, days taken to flowering, total days taken to flowering, plant height (cm), spike length (cm), rachis length (cm), number of florets per spike, chlorophyll index (SPAD value), vase life (days), number of corms per plant, number of cormels per plant, diameter of corm (cm) and weight of cormels per plant (g). Available soil NPK (kg/ha) at initial and final after harvesting was determined (Table 5). Ten plants per replication in each treatment were randomly selected for observation on these parameters and average was worked out. The experimental data were analyzed using Analysis of Variance (ANOVA) with Statistical Product and Service Solution, USA (SPSS 21). Mean comparisons for different vegetative, floral and corm characters of gladiolus were performed based on Tukey HSD[a] at 5% probability level of test differences between treatments means.

RESULTS AND DISCUSSION

Corms sprouting, days to spike emergence and flowering

Data presented in Table 1 indicate the maximum sprouting percentage was recorded under F1 (90.66%) followed by F3 (90.33%) and F2 (88%). Minimum sprouting (85.33%) was recorded under F6. It was observed that under drip fertigation, even distribution of the nutrients at appropriate stage in the root zone with higher moisture availability might have enhanced better nutrient uptake ensuing higher synthesis of metabolites and further translocation resulting in high sprouting percentage. These results are in line with the findings of Baladha *et al.* (2020) and Jat (2017) in gladiolus. Minimum duration (13.06 days) taken to sprouting was recorded under F7 (control) followed by F1 (13.16 days) and maximum time (13.96 days) was taken to sprouting by F3. Application of recommended dose of fertilizer (RDF) could not have any significant effect on time taken to sprouting of gladiolus corms as F1 was at par with F2 and F7 (control). Earliest time (81.66 days) taken from sprouting to spike emergence was recorded under F1 followed by F2 (83.36 days). The maximum time (86.26 days) taken from sprouting to spike emergence was recorded under F5. It can be assumed that fertigation with higher NPK dose is responsible for developing faster and early internal food reserves which resulted in early spike emergence. Thus, the variation in days to sprouting and spike emergence could be due to different fertigation levels applied in each treatment. These results are in conformity with Shiraj and Maurya (2005) in gladiolus. Minimum time (16.43 days) taken from spike emergence to flowering was recorded under F1 followed by F3 (16.50 days) and maximum time (17.30 days) was taken by F6. This could be accounted as fertigation treatments receiving higher rates of NPK dose resulted in early opening of first floret due to accumulation of carbohydrates required by plant for early opening of first floret.Maximum time taken to flowering from spike emergence was under F6 treatment receiving 50% recommended dose of fertilizer. Treatment F1 took minimum time (111.26 days) from planting to flowering followed by F2 (113.14 days). The maximum time (117.10 days) to flowering from planting was recorded under F6. It might be due to water-soluble fertilizer which was readily translocated by higher moisture regimes. The nutrients are constituent of proteins, amino acids, nucleic acid, various enzymes and coenzymes which enhance the process of photosynthesis in plants and further transfer of manufactured food from leaf to spike. These results confirm the findings of Jat 2017 and Shiraj and Maurya 2005.

Table 1: Effect of fertigation on corm sprouting and time taken to spike emergence and flowering in gladiolus

Treatments	Sprouting percentage	Days taken to sprouting	Days taken from sprouting to spike emergence	Days taken from spike to flowering	Total days taken to flowering
F1	90.66[a]	13.16[b]	81.66[b]	16.43[b]	111.26[c]
F2	88.00[a]	13.20[b]	83.36[ab]	16.56[b]	113.14[bc]
F3	90.33[a]	13.96[a]	83.46[ab]	16.50[b]	113.94[abc]
F4	86.66[a]	13.66[ab]	85.73[ab]	16.63[b]	115.43[ab]
F5	86.66[a]	13.23[ab]	86.20[a]	16.73[ab]	116.16[ab]
F6	85.33[a]	13.53[ab]	86.26[a]	17.30[a]	117.10[a]
F7(control)	87.33[a]	13.06[b]	84.83[ab]	16.93[ab]	114.84[abc]
Mean	87.85	13.40	84.50	16.72	114.55
SEM (±)	0.92	0.05	0.34	0.04	0.29
Max	90.66	13.96	86.26	17.30	117.10
Min	85.33	13.06	81.66	16.43	111.26

**F1 and F2 @300 kg N + 200kg P + 200 kg K ha^{-1} (100% RDF) through drip irrigation, F3and F4@225 kg N + 150kg P + 150 kg K ha^{-1} (75% RDF) through drip irrigation, F5 and F6 @150 kg N + 100kg P + 100 kg K ha^{-1} (50% RDF) through drip irrigation, F7 @ 300 kg N + 200kg P + 200 kg K ha^{-1} (control)*

Plant height and chlorophyll index (SPAD value)

Table 2 represented the plant height and chlorophyll index (SPAD value) in gladiolus. The maximum plant height was observed under F1 (103.90 cm) followed by F3 (102.65 cm). The minimum plant height was observed under F6 (84.41 cm) providing 50% of RDF. The variation in plant height under different fertigation levels could be assumed as NPK are the major nutrients responsible for growth and development of the plant. The increase in the plant height might be due to optimum nitrogen level because it is an important constituent of chlorophyll, amino acids, proteins and nucleic acids which promotes cell division and cell elongation, thus resulting in the longer stem. Nitrogen is the chief constituent of protoplasm so adequate amount of nitrogen in each cell is needed for proper growth and development (Baboo and Singh 2006).

Phosphorus is one of the constituents of chlorophyll which is associated with various physiological processes like cell division, development of merismatic tissues, photosynthesis, metabolism of carbohydrates, fats, protein, etc. Potassium is involved in formation of carbohydrates and proteins, synthesis of nucleic acid and chlorophyll, photosynthesis, action of enzyme, translocation of solutes etc. (Marschner 1995). Potassium is also reported in the synthesis of peptide bond, carbohydrate and protein metabolism resulting in rapid cell division and differentiation (Belorkar *et al.*1992). It has also been observed that the enhanced food formation during initial stages of plant might have resulted in better growth and increased plant height. Sharma and Singh (2007) reported that the plant height increased significantly with increased level of nitrogen, phosphorus and potassium in gladiolus. The performance of the plant is improved with increased levels of N and K concentration (Azeezahmed *et al.* 2016). The treatment F1 resulted in maximum SPAD value (54.18) and was found to be at par with F2 (52.70). The minimum SPAD value (46.42) was recorded in F7 (control). There was significant variation for chlorophyll index (SPAD value) with different treatments. Nitrogen and magnesium are essential nutrients which are main components of chlorophyll and due to this chlorophyll value increases by nitrogen fertigation.

Table 2: Effect of fertigation on plant height and chlorophyll index (SPAD value) in gladiolus

Treatments	Plant height (cm)	Chlorophyll index (SPAD value)
F1	103.90[a]	54.18[a]
F2	103.00[a]	52.70[a]
F3	102.65[a]	52.58[a]
F4	100.00[ab]	48.12[b]
F5	88.52[bc]	47.95[b]
F6	84.41[c]	47.82[b]
F7(control)	92.05[abc]	46.42[b]
Mean	96.36	49.97
SEM (±)	0.97	0.30
Max	103.90	54.18
Min	84.41	46.42

Spike length and rachis length

Data in Table 3 indicated the spike length, rachis length, number of florets per spike and vase life in gladiolus. The maximum spike length (83.46 cm) was recorded under F1 followed by F3 with spike length (81.50 cm).The minimum spike length (63.64 cm) was recorded in F5.The maximum rachis length (51.29 cm) was recorded in F1 followed by F3 with rachis length (49.30 cm). The minimum rachis length (33.58 cm) was recorded in F5.Number of florets per spike is an important character in gladiolus and the varieties are also graded as fancy, special, standard and utility grades on the basis of number of florets per spike.The significant variation was noted for spike length and rachis length under different fertigation treatments. The longest spike and rachis length in gladiolus is dependent on the plant height. These positive effects might have been influenced by the proper supply which in turn resulted in production of longer spikes and rachis. These findings are in conformity with the findings of Jat (2017) and Bashir *et al.* (2016) in gladiolus.

Florets per spike and vase life

Table 3 indicated the maximum number of florets per spike (12.26) was counted in F1 which was significantly at par with F2 (12.18). Minimum number of florets per spike (10.74) was counted in F6. The variation in number of florets per spike may be due to accumulation of carbohydrates as increased amount of carbohydrates in plant resulted in increased number of florets per spike (Lehri *et al.*2011 and Singh and Bijimol 2003).The maximum vase life of 10.66 days was recorded under F1. It was followed by 10.33 days in F3 and 10.00 days in F2. The minimum vase life of 9.00 days was recorded under both F5 and F6 treatments. The longest vase life of 10.66 days in F1 might be due to longer spikes under that treatment. The optimum level maintained C: N ratio, hormonal and water balance in the floral parts of plant. Thus, the spikes maintained turgidity resulting in increased vase life and delayed the wilting of basal floret. Nitrogen is the chief constituent of proteins that is involved in various metabolic activities and might enhance the vase life of the spikes of gladiolus (Singh and Bijimol 2003 and Jat 2017).

Table 3: Effect of fertigation on spike length, rachis length, number of florets per spike and vase life in gladiolus

Treatments	Spike length (cm)	Rachis length (cm)	Number of florets per spike	Vase life (days)
F1	83.46[a]	51.29[a]	12.26[a]	10.66[a]
F2	81.79[ab]	49.72[a]	12.18[a]	10.00[abc]
F3	81.50[ab]	49.30[a]	11.98[ab]	10.33[ab]
F4	78.69[abc]	44.74[ab]	11.71[abc]	9.66[abc]
F5	63.64[d]	33.58[c]	10.87[bc]	9.00[c]
F6	68.14[cd]	39.41[bc]	10.74[c]	9.00[c]
F7(control)	71.35[bcd]	45.37[ab]	11.58[abc]	9.33[bc]
Mean	75.51	44.77	11.61	9.71
SEM (±)	0.94	0.59	0.17	0.09
Max	83.46	51.29	12.26	10.66
Min	63.64	33.58	10.74	9.00

Corms and cormels production

Table 4 showed the corms and cormels production in gladiolus. The number of corms per plant was maximum in F1 (1.26) and the minimum was recorded in F5 and F6 (1.00). Maximum number of cormels per plant was recorded in F1 (45.96) whereas minimum number of cormels per plant was recorded in F6 (34.86). The maximum and minimum diameter of corm was recorded in F1 (4.93 cm) and F7 (control) (3.80 cm) respectively. As per weight of cormels per plant is concerned, the maximum weight was recorded in F1 (33.09 g) and minimum weight of cormels per plant was recorded in F6 (24.96).

Overall, F1 recorded maximum number of corm and cormel per plant, diameter of corm and weight of cormels among seven treatments. The significant difference was observed for number of corms per plant and number of cormels per plant in fertigation treatments. Thus, diameter of corm and weight of cormels per plant also increased significantly due to optimum dose of NPK fetigation. These results matched with the findings of Barman *et al.*(2005) and Baboo and Singh (2006) in gladiolus. Nitrogen is responsible for protein synthesis that promotes rapid growth and development of plant by increasing photosynthetic rate and mobilization of photosynthates to the sink resulting in higher yield. Phosphorus is a constituent of energy rich compounds which promotes entire root growth and helps in easy uptake of other nutrients resulting in increased growth and yield. Potassium increases the photosynthetic rate and easy mobilization of sucrose to the growing plant parts for their proper growth and development. Potassium is involved in protein synthesis and also provides resistance against stress that might help the plant for attaining higher yields (Barman *et al.* 2005).

Table 4: Effect of fertigation on corms and cormels production in gladiolus

Treatments	Number of corms per plant	Number of cormels per plant	Diameter of corm (cm)	Weight of cormels per plant (g)
F1	1.26[a]	45.96[a]	4.93[a]	33.09[a]
F2	1.23[ab]	45.40[a]	4.90[ab]	32.67[a]
F3	1.20[ab]	43.80[b]	4.76[ab]	31.53[b]
F4	1.13[bc]	41.70[c]	4.70[b]	30.31[c]
F5	1.00[d]	35.60[d]	4.18[c]	25.48[de]
F6	1.00[d]	34.86[d]	4.14[c]	24.96[e]
F7(Control)	1.06[cd]	36.10[d]	3.80[d]	25.99[d]
Mean	1.12	40.49	4.90	29.15
SEM (±)	0.01	0.10	0.01	0.07
Max	1.26	45.96	4.93	33.09
Min	1	34.86	3.80	24.96

Soil Nutrients

Data in Table 5 indicated that initial and final value of soil nutrients. Initially available nitrogen recorded was 110.7 kg N ha^{-1}, phosphorous was 22.3 kg P ha^{-1} and potassium was 185.1 kg K ha^{-1} before planting of corms. The maximum nitrogen (132.46 kg N ha^{-1}) and potassium (211.10 kg K ha^{-1}) was recorded in F1. However, the results also indicate that the maximum phosphorus (32.80 kg P ha^{-1}) was recorded under F2 and it was at par with F1 (31.16 kg P ha^{-1}). The minimum nitrogen (117.80 kg N ha^{-1}) and potassium (193.73 kg K ha^{-1}) was recorded in F6 whereas, the minimum available soil phosphorus (25.66 kg P ha^{-1}) was recorded in F5.

Table 5: Effect of fertigation on soil nutrients

Available soil NPK (kg/ha) initial			
	N	P	K
	110.7	22.3	185.1
Available soil NPK (kg/ha) final			
Treatments	N	P	K
F1	132.46[a]	31.16[ab]	211.10[a]
F2	131.70[a]	32.80[a]	207.67[b]
F3	126.50[a]	29.53[bc]	202.80[c]
F4	123.43[a]	28.93[c]	197.83[d]
F5	118.56[a]	25.66[e]	194.73[e]
F6	117.80[a]	26.76[de]	193.76[e]
F7(Control)	124.23[a]	27.86[cd]	198.73[d]
Mean	124.95	28.95	200.94
SEM (±)	0.63	0.48	0.39
Max	132.46	32.80	211.10
Min	117.80	25.66	193.76

The study showed the significant variation for available soil NPK after harvest. These results get scientific support from the Table 5 where maximum potassium in the soil was recorded with F1 (100% RDF). At the same time the corm and cormel production decreased significantly as the RDF was reduced from 100% to 50%. From the present study it was concluded that 100% RDF of potassium is required for best corm and cormel production. As per results of this experiment it has been observed that F1 where 100% of RDF (3000 kg N + 200 kg P + 200 kg K ha^{-1}) resulted in maximum plant height, spike length, rachis length and SPAD value. However, it is interesting to note that these results were statistically at par with F3 where 75% of RDF (225 kg N + 150kg P + 150 kg K ha^{-1}) was used. These results get support from the data on final uptake by the soil at the time of harvesting. In F1 nitrogen was recorded as maximum but at par with F2 and F3. While comparing the data on available phosphorus it has been observed that maximum phosphorus was recorded under F2 but at the same time it was at par with F1 (100% RDF) and F3 (75% RDF).

While analyzing the number of corm and cormel production in the experiment it has been noticed that the maximum corm and cormel production was under F1 (100% RDF). The increase in the available N, P and K with 100% RDF might be due to the higher application dose which means that after meeting the plant requirements the left-over quantity contributed to the buildup of the available N, P and K in the soil. Jat (2017) reported that the highest doses of NPK significantly increased the available N, P and K content in the soil after harvest in gladiolus. Also, these results are in line with the findings of Singh *et al.* (2015) in carnation.

CONCLUSION

It is concluded that F1 with 100% RDF resulted in maximum plant height, spike length, rachis length and corm yield. The study also concluded that F3 with 75% RDF presented the same results for vegetative flowering and corm parameters. Therefore, application of 33.3% NPK each at 3 leaf stage, 6 leaf stage and spike emergence @225 kg N + 150kg P + 150 kg K ha^{-1} (75%RDF) can save 25% fertiliser with superior quality spikes and corm yield of gladiolus.

REFERENCES

Anonymous (2021-2022) Horticulture Crops (Final), Department of Agriculture Govt. India. www.agricoop.nic.in.

Azeezahmed, S. K., Dubey, R. K., Kukal, S. S. and Sethi, V. P. (2016) Effect of different nitrogen-potassium concentrations on growth and flowering of chrysanthemum in a drip hydroponic system. *Journal of Plant Nutrition*, ***39***(13), 1891-98.

Baboo, R. and Singh, R.D. (2006) Response of nitrogen, phosphorus and corm size on flowering and corm production in gladiolus. *J OrnaHort* **9** (1): 66-68.

Baladha, R.F., Varu, D.K., Bhuva, S.K., Parsana, J.S. and Pipaliya, H.R. (2020) Effect of drip fertigation schedule and different mulches on vegetative growth of gladiolus cv. Psittacinus Hybrid. *IJCS* **8**(5): 494-98.

Barman, D.,Rajni, K., Pal, R. and Upadhyaya, R.C. (2005) Effect of mulching on cut flower production and corm multiplication in gladiolus. *J OrnaHort* **8** (2): 152-54.

Bashir, M., Khan, I., Qadri, R.W., Tanveer, M., Zain, M. and Ahmad, I. (2016) Growth and corm production of *Gladiolus grandiflorus*L. 'Essential' Under different NPK Regimes. *J Orna Pl* **6**: 11-19.

Belorkar, P.V., Patel, B.N., Golliwar, V.J. and Kothare, A. J. (1992) Effect of nitrogen and spacing on growth, flowering and yield of African marigold. *J Soils Crops* 2: 62–64.

Boodley, J.W. (1981) *The Commercial Greenhouse*.Pp. 568. Delmar Publishers Inc., Albany, New York.

Jat, R.N. (2017) *Effect of Fertigation, Spacing and Mulching on the Performance of Gladiolus (Gladiolus hybridus*L.) *cv. American Beauty (SKNAU) (RARI) (PhD)* (Doctoral dissertation, SKNAU).

Lehri, S. M., Khurd, A.A., Rind, M.A. and Bangulzai, N.A. (2011) The response of *Gladiolus tritis*L.to N and P2O5 fertilizers. *Sarhad J Agric* **27**(2): 185-88.

Marschner, H. (1995).Mineral nutrition of higher plants. 2 ed. New York: Academic Press, pp: 889.

Neilsen, G. H., Neilsen, D.L., Herbert, C. and Hogue, E. J. (2004) Response of apple to fertigation of N and K under conditions susceptible to the K deficiency. *J American Soc Hort Sci* **6**: 129-32.

Sharma, G. and Singh, P. (2007) Response of N, P and K on vegetative growth, flowering and corm production in gladiolus under mango orchard. *J OrnaHort* **10**(1): 52-54.

Shiraj, A. and Maurya, K.R. (2005) Effect of spacing and corm size on growth, flowering and corm production in gladiolus. *Indian J Hort* **62**(1): 95-96.

Singh, A.K. and Bijimol, G. (2003) Effect of spacing and nitrogen on gladiolus. *J OrnaHort* **6**(1): 73-75.

Woltz, S.S. (1976) Fertilization of gladiolus.Gladio Grams. In: Magie R D (ed) *Gladiolus Council*. Pp. 1-5. Bulletin No.: **21**. Commercial Growers Division of the North America.