Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 418–422

P- ISSN: 0976-1675 | **E-** ISSN: 2249-4538

www.rjas.org

Research Paper

Effect of Gypsum and Foliar Application of Micronutrients on Spike and Corm Yield Maximization in Gladiolus (*G. grandiflorus* L.) Cv. Sarala

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Received: 23 Dec 2020 | Revised accepted: 21 Feb 2021 | Published online: 09 Mar 2021

ABSTRACT

Application of gypsum is vital for corm development in gladiolus as it acts as source of calcium and soil loosening factor. Hence, a field experiment on gladiolus was conducted in Randomized Block Design with three replications in Department of Horticulture, Annamalai University, during 2019 to maximize the yield and quality of spikes and corms. The gladiolus cv. Sarala was tested with ten treatments comprised different combinations of recommended dose of fertilizers (NPK @ 120:150:150 kg ha^{-1}), Gypsum at three levels (100 kg ha^{-1}, 200 kg ha^{-1}, and 300 kg ha^{1}), and foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ and H_3BO_3 @5% each at single spray (at 30 Days) and double spray (at 30 and 45 Days). The growth, flowering, and corm yield parameters were periodically assessed. The results revealed that application of gypsum and micronutrients significantly increased the vegetative growth, flowering, spike yield, and corm yield. Among the ten treatments, application of NPK @ 120:150:150 kg ha^{-1} + Gypsum 300 kg ha^{-1} + foliar application of micronutrients at 30 and 45 DAP was found most effective with highest plant height, leaf area, spike length, floret diameter, spike yield, corm yield, corm weight, number of daughter corms per plant and weight of daughter corms.

***Key words*:** Corm yield, Foliar application, Gladiolus, Gypsum, Micronutrients, Spike yield

Floriculture has become a profitable venture as the value of flower crops are enhanced due to raising demand for social and industrial use. Gladiolus occupies eighth position in the world among cut flowers in global trade. Gladiolus is the second most important cut flower which is propagated by its underground storage organ i.e., Corms. Corms of gladiolus are rich in stored food which is sufficient to sustain for its growth in initial few days. As the cost of planting material accounts for 50 percent of its production economics, the successful cultivation of gladiolus is not only depending on its marketable spike yield but also on the corm yield and quality. Nutrient management is of prime importance to obtain good quality flowers and corms. Development of corms and cormels require fertile and loose soil. Gypsum a Calcium sulfate dehydrated ($CaSO_4$, $2H_2O$) mineral form of the evaporate family [1] is an excellent source of sulfur for plant nutrition and improving crop yield and it acts as source of calcium and soil loosening factor. Gypsum can enhance water movement into the soil and allow the crop to have deeper rooting those results in better nutrient absorption. Gypsum effectively changes the structure and fertility of heavy clay soils. Gypsum is also sodic by removing sodium from the soil and replacing it with calcium. Gypsum would also improve drainage, decrease acidity and eliminate soil salts [2]. Beneficial effect of gypsum in enhancing flowering and underground storage organs has been recorded in flower crops like *Polianthes tuberose* [3].

Micronutrients play a vital role in the growth and development of plants, due to their stimulatory and catalytic effects on metabolic processes and ultimately on flower yield [4] and quality [5]. To determinate the commercial value on corm production parameters, the micronutrients contribute most important role on various metabolism and synthesis process in plants. The deficiencies of micronutrients create different abnormalities like chlorosis, rosetting and scorching etc. [6]. Being involved in the physiology of plants, micronutrients well contribute to the growth and yield of the plants [7]. Though the micronutrients are present in soil, their availability to plants is restricted when soil salinity and soil pH are at high levels [8]. Foliar application of nutrients is useful to meet the plant's specific needs for one or more micro or macro nutrients especially trace minerals and enable to correct deficiencies, strengthen weak or damaged crops, speed growth, and grow better [9]. The yield and quality of flowers and corms can be improved by integrating all kinds of nutrient management practices which include the judicious and combined use of gypsum with inorganic fertilizers and micronutrients. Though, cormels require fairly good amount of fertilizers due to their small size, the micronutrients are needed in large quantity. Hence, there is a need to develop sustainable nutrient management package by considering the beneficial effects of major nutrients through inorganic fertilizers, gypsum and foliar application of micro nutrients.

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Therefore, the present study has been carried out to study the effect of gypsum and foliar application of micronutrients on spike and corm yield maximization in gladiolus (*G. grandiflorus* L.) cv. Sarala under coastal region of Tamil Nadu.

MATERIALS AND METHODS

The experiment was carried out in Floriculture yard, Department of Horticulture, Annamalai University, Tamil Nadu during the year 2019. The experiment was conducted in randomized block design with three replications. Corms of Sarala were collected from commercial floriculture units in Kalimpong. These corms were planted in ridges and furrows made at a spacing of 45 cm x 15 cm in a plot size of 2m x 2m dimension. The soil of the experiment site is sandy-clayey loam having the pH range of 7.5 – 7.8. During land preparation, 25 t/ha of vermicompost was applied to the soil. Standard package of practices were adopted throughout the experiment to grow a healthy crop. Ten treatment combinations comprised of different combinations of recommended dose of fertilizers (RDF-NPK @ 120:150:150 kg ha^{-1}), Gypsum (100 kg ha^{-1}, 200 kg ha^{-1}, and 300 kg ha^{1}), and foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ and H_3BO_3 @ 5% each at single spray at 30 days after planting (DAP) and double spray at 30 and 45DAP were applied. The treatments include T_1- RDF (control), T_2- RDF + Gypsum 100 kg ha^{-1}, T_3- RDF + Gypsum 200 kg ha^{-1}, T_4- RDF + Gypsum 300 kg ha^{-1}, T_5- RDF + Gypsum 100 kg ha^{-1} + Foliar application of micronutrients at 30 DAP, T_6- RDF + Gypsum 200 kg ha^{-1} + Foliar application of micronutrients at 30 DAP, T_7- RDF + Gypsum 300 kg ha^{-1} + Foliar application of micronutrients at 30 DAP, T_8- RDF + Gypsum 100 kg ha^{-1} + Foliar application of micronutrients at 30 and 45 DAP, T_9- RDF + Gypsum 200 kg ha^{-1} + Foliar application of micronutrients at 30 and 45DAP, and T_{10}- RDF + Gypsum 300 kg ha^{-1} + Foliar application of micronutrients at 30 and 45 DAP.

For treatments with recommended dose (NPK @ 120:150:150 kg/ha) of inorganic fertilizers, entire P and K were applied as basal and 50% of N was given as basal and remaining was given as two split doses, one at three leaf stage and second at bud stage. For foliar application of micronutrients, $FeSO_4$, H_3BO_3, $ZnSO_4$. $7H_2O$ and $MnSO_4$ were dissolved in water at 0.5% concentration each and sprayed during at 3^{rd} and 6^{th} leaf stage (30 and 45 DAP respectively) as per treatment schedule. Observations on various morphological parameters including plant height, number of leaves per plant, leaf length, leaf width, days to spike emergence, spike length, number of florets per spike, flower length, flower diameter, diameter of corm and number of cormels were recorded periodically. The data were analyzed as per the procedure given by the [10]. Mean and critical difference for each character was computed to derive meaningful conclusion.

RESULTS AND DISCUSSION

Growth characters

Results revealed that the growth characters were significantly varied due to the application gypsum and foliar nutrients (Table 1). Application of RDF (NPK @ 120:150:150 kg ha^{-1}) + gypsum 300 kg ha^{-1} + foliar spray of $FeSO_4$, $MnSO_4$, $ZnSO_4$ and H_3BO_3 (0.5% each) on 30DAP and 45DAP has resulted significantly higher growth when compared to all other treatments.

Table 1 Effect of gypsum and foliar application of micronutrients on growth parameters of gladiolus (*G. grandiflorus* L.) cv. Sarala

Treatments	Plant height	Leaf length (cm)	Leaf area (cm^2)	DMP (g/plant)	Days taken for spike emergence
T_1- RDF (control)	104.71	66.11	119.32	33.66	76.53
T_2- RDF + Gypsum 100 kg ha^{-1}	105.20	68.62	119.66	36.52	73.96
T_3- RDF + Gypsum 200 kg ha^{-1}	108.46	70.75	123.36	37.65	73.23
T_4- RDF + Gypsum 300 kg ha^{-1}	109.42	71.93	124.40	38.67	72.38
T_5- RDF + Gypsum 100 kg ha^{-1} + Foliar application of micronutrients at 30 DAP	110.39	73.13	125.44	39.70	71.53
T_6- RDF + Gypsum 200 kg ha^{-1} + Foliar application of micronutrients at 30 DAP	111.33	74.30	126.47	40.71	70.69
T_7- RDF + Gypsum 300 kg ha^{-1} + Foliar application of micronutrients at 30 DAP	112.30	75.50	127.51	41.74	69.84
T_8- RDF + Gypsum 100 kg ha^{-1} + Foliar application of micronutrients at 30 & 45 DAP	112.31	75.51	127.52	41.75	69.83
T_9- RDF + Gypsum 200 kg ha^{-1} + Foliar application of micronutrients at 30 and 45DAP	113.25	76.68	128.54	42.75	69.01
T_{10}- RDF + Gypsum 300 kg ha^{-1} + Foliar application of micronutrients at 30 and 45 DAP	114.20	77.85	129.56	43.76	68.17
SED	0.42	0.52	0.45	0.45	0.37
CD (p=0.05)	0.94	1.16	1.01	1.00	0.83

RDF-NPK@120:150:150 kg/ha
Foliar application-$FeSO_4$, $MnSO_4$ and $ZnSO_4$ and H_3BO_3 @ 0.5% each

The highest plant height (114.2 cm), leaf length (77.85 cm), leaf area (129.56 cm^2) and DMP (43.76 g $plant^{-1}$) were observed in T_{10} (RDF + Gypsum 300 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30^{th} and 45^{th} DAP) was followed by the T_9 (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30^{th} and 45^{th} DAP). The treatments T_8 and T_7 were on par with each other in all the growth parameters. The control treatment T_1 (RDF- NPK @ 120:150:150 kg ha^{-1}) has recorded the least growth parameters viz. plant height (104.71 cm), leaf length

(66.11 cm), leaf area (119.32cm^2) and DMP (33.66 g plant^{-1}). Application of inorganic nutrients with micronutrients might have attributed to the translocation of nutrients from soil and enhanced supply of macro and micronutrients during entire growing season and microbial decomposition. Thereby, it might have favoured for stimulation of all growth parameters [11-14]. Foliar spray of micronutrients, containing Zn, B, Fe and Mn, also significantly increased growth characters of gladiolus [4-5]. Application of Gypsum has favoured all the growth parameter of gladiolus. The effect was linear in trend with the increasing dose of Gypsum. The positive effects of gypsum in plants might be due to its ability to change the structure and fertility of clay soils [15].

The spike emergence is an indicator for the plant to attain its maximum growth. The earliest spike emergence on 68.17 days was observed in treatment T_{10} (RDF + Gypsum 300 kg ha^{-1}+ foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) was followed by T_9 (69.01) (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP). The spike emergence was significantly late in control treatment T_1 (76.53 days). The early emergence of spike observed in these treatments might be attributed to the fact the accumulation of photosynthates are more and faster in these treatments due to increased nutrient up take and its cascading effects on physiological processes that augment growth rate.

Flowering and spike yield characters

The flowering and spike yield parameters were significantly influenced by the treatments when compared to control (Table 2). The maximum spike length of 99.75 cm was observed in T_{10} (RDF + Gypsum 300 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) was followed by T_9 (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) (98.75cm). The least spike length of 89.75cm was recorded in control. The maximum spike weight of 106.38 g was observed in treatment T_{10} was followed by T_9 (105.42g). Application of higher level of micro nutrients along with gypsum might have resulted availability of more micro and macro nutrients needed for growth and regulatory processes leading to production of maximum spike length, more number of florets per spike that contribute to increased spike weight [16].

Table 2 Effect of gypsum and foliar application of micronutrients on flowering and spike yield of gladiolus (*G. grandiflorus* L.) cv. Sarala

Treatments	Spike length (cm)	Spike weight (g)	Rachis length (cm)	Floret diameter (cm)	Days taken for first floret open	Spike yield per plant	Marketable spikes per plant
T_1	89.75	96.76	59.32	3.21	89.11	0.41	0.31
T_2	90.89	97.54	61.55	5.55	86.97	0.65	0.58
T_3	93.70	100.56	63.45	5.72	85.27	0.67	0.60
T_4	94.71	101.53	64.51	6.36	84.28	0.74	0.68
T_5	95.73	102.51	65.58	7.01	83.29	0.81	0.75
T_6	96.73	103.47	66.62	7.64	82.32	0.88	0.83
T_7	97.75	104.46	67.69	8.29	81.33	0.95	0.90
T_8	97.76	104.47	67.70	8.30	81.32	0.95	0.90
T_9	98.75	105.42	68.73	8.93	80.35	1.01	0.98
T_{10}	99.75	106.38	69.78	9.56	79.38	1.08	1.05
SED	0.44	0.43	0.46	0.28	0.43	0.03	0.03
CD (p=0.05)	0.99	0.95	1.04	0.63	0.96	0.07	0.07

RDF-NPK@120:150:150 kg/ha
Foliar application-$FeSO_4$, $MnSO_4$ and $ZnSO_4$ and H_3BO_3 @ 0.5% each

The highest length of rachis was observed in treatment combination of T_{10} (RDF + Gypsum 300 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) (69.78 cm) was followed by T_9 (68.73 cm). The least rachis length of 59.3cm was recorded in control treatment T_1. The increased number of florets per spike in these treatments might have contributed for the attributed to elongation of spike growth as well as rachis length. Increase in rachis length might have enabled the plants to produce more photosynthates which was subsequently supplied to spike for their development. This may also be due to increased availability of all essential micronutrients in easily available form [17]. The first floret opening observed in treatment T_{10} (79.38 days) was significantly earliest and it was followed by the treatments T_9 (80.35 days) as this treatment includes RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP. The first floret open was significantly late in control treatment T_1 (89.11 days). Early flowering observed in these treatments might be attributed to the faster translocation of phytohormones to the shoots that lead to early flower initiation [18-19]. The maximum diameter of floret observed in treatment T_{10} (9.56 cm) was followed by T_9 (8.93 cm). Micronutrients like Fe, Zn, Mn and Cu play a vital role in the growth and development of gladiolus plants because of their stimulatory and catalytic effects on flower characters and metabolic processes [20-22].

The highest of 1.08 spikes per plant was observed in treatment T_{10} (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) followed by T_9 (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) with 1.01 spikes per plant. The least number of 0.41spike per plant was recorded in control treatment T_1. Addition of gypsum along with foliar application of micronutrients recorded significantly maximum yield of gladiolus spikes with superior quality. This might be due to increased availability of photosynthates as a result of enhanced growth rate of vegetative plant parts. Further higher amount of photosynthates available might have directly utilized for initiation of more floral sinks and have increased the yield of better-quality spikes in respect of length of spike, rachis length, and their turgidity [23]. The maximum of 1.05 marketable spikes per plant was observed in treatment combination of T_{10}. The least of 0.31 marketable spikes per plant recorded in control treatment T_1. Application of gypsum at higher level might have improved the flower parameters such as spike length, rachis length and also dry matter production. The beneficial effects of Gypsum might be due to its ability to remove sodium from soil and replace it with calcium. It can also improve drainage, decreases acidity and eliminate the soil salts [24].

Corm characters

The treatments that consist of recommended dose of fertilizers (RDF) with gypsum application and foliar spray of micro nutrients performed better when compared to control with only RDF. The highest corm diameter (5.3cm), number of corms per plant (2.14) and corm weight (27.32g) were recorded in T_{10} (RDF + Gypsum 200 kg ha^{-1} + foliar application of $FeSO_4$, $MnSO_4$, $ZnSO_4$ H_3BO_3 at 30th and 45th DAP) followed by T_9. The least corm diameter (2 cm), number of corms per plant (0.66), and corm weight (20.76g) were recorded in control treatment T_1 (RDF). The maximum number of daughter corms per plant (20.41) and weight of daughter corms (21.62g) were recorded in T_{10}. The least number of daughter corms per plant (11.1) and weight of daughter corms (12.17g) were recorded in control treatment [25-30]. Increased corm weight and corm yield may be due to better availability of phosphorous, which is required particularly for corm growth. Better cormels production might be due to added gypsum in soil that would have increased the solubility of nutrients and made them available for intake by plants. The increase in corms weight and number of cormels might be due to the augmented photosynthetic productivity in best treatments that compelled the plants to apportion more carbohydrate towards sink and to increase sink source in the form of corms and cormels. The foliar micronutrients might have enabled speedy translocation of carbohydrates and soluble nitrogen compounds from leaves to corms [31]. The role of zinc in translocation of constituents from one part to other part and maximizing corm yield might be due to its catalytic role in the activation of enzymes needed for nitrogen assimilation and synthesis of protein [32-33]. Apart from the soil loosening effect caused by Gypsum, it might have attributed to the beneficial effects of potassium by increasing the protein content in plants and also improving the accumulation of carbohydrates, ascorbic acid and thereby enhancing corm expansion [34-35.

Table 3 Effect of gypsum and foliar application of micronutrients on corm yield of gladiolus (*G. grandiflorus* L.) cv. Sarala

Treatments	Corm diameter (cm)	No. of corms per plant	Corm weight (g)	Number of daughter corms per plant	Weight of daughter corms (g)
T_1	2.00	0.66	20.76	11.1	12.17
T_2	3.20	1.21	20.84	14.33	15.60
T_3	3.30	1.24	21.48	14.77	16.08
T_4	3.64	1.39	22.46	15.71	16.85
T_5	3.97	1.55	23.44	16.66	17.82
T_6	4.30	1.69	24.41	17.59	18.76
T_7	4.64	1.84	25.39	18.54	19.73
T_8	4.64	1.85	25.40	18.55	19.73
T_9	4.97	1.99	26.36	19.47	20.67
T_{10}	5.30	2.14	27.32	20.41	21.62
SED	0.15	0.07	0.43	0.04	0.05
CD (p=0.05)	0.33	0.15	0.96	0.08	0.11

RDF-NPK@120:150:150 kg/ha
Foliar application-$FeSO_4$, $MnSO_4$ and $ZnSO_4$ and H_3BO_3 @ 0.5% each

CONCLUSIONS

From the present results it could be concluded that the application of RDF (NPK @ 120:150:150 kg ha^{-1}) + Gypsum 300 kg ha^{-1} + Foliar application of $FeSO_4$, $MnSO_4$ $ZnSO_4$ H_3BO_3 @ 0.5% each at 30th and 45th DAP could be adopted to enhance the production of marketable spikes and good quality of corms under coastal region of Tamil Nadu.

LITERATURE CITED

1. Zumberge JH, Nelson CA. 1978. *Elements of Physical Geology*. John Wiley and Sons. In Publishing, New York.
2. Linda CS. 1994. Adding gypsum to your yard or garden will improve solidity and plant health. *Journal of Range Management* 47(3): 206-209.
3. Arafa NM, Badawy OF, Nabih A. 2002. Effect of growing media and soil additions on growth, flowering, bulbs productivity and chemical constituents of *Polianthes tuberosa*, L. Egypt. *Journal of Applied Science* 17(4): 210-233.
4. Lahijie MF. 2012. Application of micronutrients $FeSO_4$ and $ZnSO_4$ on the growth and development of gladiolus variety "Oscar". *International Journal of Agriculture and Crop Science* 4: 718-720.
5. Khosa SS, Younis A, Rayit A, Yasmeen S, Riaz A. 2011. Effect of foliar application of macro and micro nutrients on growth and flowering of *Gerbera jamesonii* L. *Amer. Euras. Journal of Agriculture and Environment Science* 11: 736-757.
6. Singh JP, Kumar K, Katiyar PN. 2012. Effect of zinc, iron and copper on yield parameters of gladiolus. *Hort. Flora Research Spectrum* 1: 64-68.
7. Fahad S, Ahmad M, Akbar AM, Hussain S. 2014. The effect of micronutrients (B, Zn and Fe) foliar application on the growth, flowering and corm production of gladiolus (*Gladiolus grandiflorus* L.) in calcareous soils. *Journal of Agriculture Science and Technology* 16: 1671-1682.
8. Ahmad I, Aslam KM, Qasim M, Ahmad R, Randhawa AM. 2010. Growth, yield and quality of *Rosa hybrid* L. as influenced by various micronutrients. *Pak. Jr. Agric. Sci.* 47(1): 5-12.

9. Said-Al Ahl HAH, Mahmoud A. 2010. Effect of boron and / or iron foliar application on growth and essential oil of sweet basil (*Ocimum basilicum* L.) under salt stress. *Ozean Journal of Applied Science*. 3: 97-111.
10. Panse VJ, Sukhatme PV. 1967. *Statistical Methods for Agricultural Workers.* Indian Council of Agricultural Research, New Delhi.
11. Chaudhari SR, Patil AB, Patel NK. 2013. Effect of organics, inorganics and biofertilizers on growth and yield of gladiolus (*Gladiolus grandiflorus* L.) cv. American beauty. *Journal of Bio Infolet* 10(4B): 1214-1217.
12. Kumar M. 2014. Effect of different sources of nutrients on growth and flowering in gladiolus (*Gladiolus hybridus* hort.) cv. “peater pears”. *Annals of Horticulture* 7(2): 154-158.
13. Narendra C, Swaroop K, Janakiram T, Biswas DR, Singh G. 2013. Effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus. *Indian Journal of Horticulture* 70(1): 156-159.
14. Godse SB, Golliwar VJ, Bramhankar KS, Kore MS. 2006. Effect of organic manures and bio-fertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of gladiolus. *Journal of Soils and Crops* 16(2): 445-449.
15. Gehan H, Abdel F, Amal S, El-Fouly, Azza AM. 2014. Effect of using mono potassium phosphate and gypsum in alleviating the deleterious effect of saline water irrigation on *Polianthes tuberosa*, L. Plant. *Middle East Journal of Agriculture Research* 3(4): 890-899.
16. Pansuriya PB, Chauhan RV. 2015. Effect of integrated nutrient management on growth, yield and quality of gladiolus (*Gladiolus grandiflorus* L.) cv. *Psittacinus Hybrid*. *Journal of Ornamental Horticulture* 2(2): 2376-0354.
17. Barman D, Datta M, De LC, Banik S. 2003. Efficacy of phosphate solubilizing and phytohormone producing bacteria on growth and yield of tuberose in acid soil of Tripura. *Indian Journal of Horticulture* 60(3): 303-306.
18. Jayamma N, Jagadeesh KS, Patil VS. 2008. Growth and flower yield of jasmine (*Jasminum auriculatum*) as influenced by biofertilizers and graded doses of chemical fertilizers. *Journal of Ornamental Horticulture* 11(4): 275-280.
19. Chaitra R. 2006. Integrated nutrient management for growth, yield and quality of china aster (*Callistephus chinensis* (L.) Nees.). *M. Sc. (Agriculture) Thesis*, University of Agricultural Sciences, Dharwad, Karnataka.
20. Basoli M, Kumar P, Kumar S. 2012. Impact of integrated nutrient management on growth and flowering of gladiolus (*Gladiolus hybrida*) cv. Novalux. *Indian Journal of Agricultural Sciences* 85(5): 649-654.
21. Ali A, Mehmood T, Hussain R, Bashir A, Raza S, Din NU, Ahmad A. 2013. Investigation of biofertilizers influence on vegetative growth, flower quality, bulb yield nutrient uptake in gladiolus (*Gladiolus grandiflorus* L.). *International Journal of Plant, Animal and Environmental Science* 4(1): 94-99.
22. Sunitha HM, Ravi H, Vyakaranahal BS, Bablad HB. 2007. Effect of plant spacing and integrated nutrient management on yield, quality of seed and vegetative growth parameters in African marigold (*Tagetes erecta* Linn). *Journal of Ornamental Horticulture* 10(4): 245-249.
23. Kode SL, Reddy SA, Pratap M, Rao PV, Raju GB. 2015. Effect of different micronutrient sprays on growth, flower yield and vase life of rose. *International Journal of Tropical Agriculture* 33(2): 1191-1195.
24. Virender SL. 2018. Synthetic hydrogels break down by gypsum and fertilizers by making these unsuitable for agricultural uses. *Curr. Inves. Agri. Curr. Res*. 5(5): 727-729. DOI: 10.32474/CIACR.2018.05.000221.
25. Kumar P, Arora JS. 2000. Effect of micro nutrients on gladiolus. *Journal of Ornamental Horticulture* 3(2): 91-93.
26. Singh AK, Singh CS. 2000. Effect of spacing and zinc on production of corms and cormlets in gladiolus (*Gladiolus grandiflorus*) cv. Sylvia. *Journal of Horticulture* 13(2): 61-64.
27. Ahmed MJ, Akbar A, Kosar N, Khan ZA. 2002. Introduction and evaluation of exotic gladiolus (*Gladiolus grandiflorus*) cultivars. *Asian Journal of Plant Science* 1: 560-562.
28. Halder NK, Ahmed R, Sharifuzzaman SM, Bagam KA, Siddiky MA. 2007. Effect of boron and zinc fertilization on corm and cormel production of gladiolus in grey terrace soils of Bangladesh. *Int. Jr. Sustain. Crop Prod*. 2: 85-89.
29. Kumari VR, Kumar DP, Kumar AB, Mahadevamma M. 2014. Effect of integrated nutrient management on floral and cormel parameters in gladiolus (*Gladiolus hybridus* L.) cv. American Beauty. *International Journal of Agricultural Science* 10(1): 15-22.
30. Basoli M, Kumar P, Kumar S. 2014. Impact of integrated nutrient management on post-harvest and corm characters of gladiolus cv. Novalux. *Annals of Horticulture* 7(2): 109-114.
31. Baboo R, Singh RD. 2006. Response of nitrogen, phosphorus and corm size on flowering and corm production in gladiolus. *Journal of Ornamental Horticulture* 9(1): 66-68.
32. Chaturvedi OP, Shukla IN, Singh AR. 1986. Effect of Agromin on growth and flowering in gladiolus. *Progressive Horticulture* 18: 196-199.
33. Pratap M, Reddy AS, Reddy YN. 2005. Response of pre-harvest micro nutrient foliar spray on leaf nutrients and corm production in gladiolus. *Journal of Orn*amental *Horticulture* 8(1): 18-22.
34. Usherwood NR. 1985. The role of potassium in crop quality. *In*: Potassium in Agriculture. (Eds) Munson R. D. pp. 489-514. ASA/CSSA/SSSA, Madison, WI.
35. Yun L, Li Quan Z, Yun L, Guo Xing C, Zhang Cheny Z. 2004. Effect of potassium nutrition on corm expansion of saffron (*Crocus sativus* L.). *Journal of Plant Nutrition and Fertilizers Scimago* 10(1): 96-100.