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IMPACT OF PLANT GROWTH PROMOTING ROOT ENDOPHYTES ON FLOWERING ATTRIBUTES OF CROSSANDRA (*CROSSANDRA INFUNDIBULIFORMIS* L.)

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ABSTRACT

Ornamental crops play a crucial role in the global floriculture industry, valued for their aesthetic appeal, socio-cultural significance and commercial importance. Among these, *Crossandra* (firecracker flower) is highly esteemed for its vivid blooms, utility in garlands and decorations especially in South India. But, cultivating *Crossandra* relies heavily on chemical fertilizers, which leads to degrading soil fertility, polluting the environment and inflating production costs. By keeping this view, a field experiment was carried out to investigate the influence of methods of inoculation, PGPRES and their interaction on floral attributes of *Crossandra infundibuliformis* (L.) var. Arka Chenna at College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University. In this experiment, various PGPRES viz., *Piriformospora indica*, *Glomus fasciculatum* and Arka Microbial Consortium were applied through different methods. Among the treatments, the interaction M_1P_8 (Soil application with PGPRES 10 days prior to *Crossandra* seedling planting x *Piriformospora indica*+ *Glomus fasciculatum*+ Arka Microbial Consortium + 25% RDF) reported superior performances among all floral parameters. These findings highlight the potential of PGPRES as a sustainable and eco-friendly approach to improve the ornamental quality of *Crossandra*.

Key words : *Crossandra infundibuliformis*, Arka Chenna, *Piriformospora indica*, *Glomus fasciculatum*, Arka Microbial Consortium.

Introduction

Crossandra (*Crossandra infundibuliformis* L.) being a perennial plant belongs to the Acanthaceae family with a basic chromosome number of $n=10$. It is popularly known as “Fire cracker plant” or “Tropical Flame”. Vernacularly it is called as “Kanakambaram” in Telugu (Rehana *et al.*, 2020), ‘Aboli’ in Marathi and ‘Kanakambara’ in Kannada (Sree *et al.*, 2023). It was believed to be originate from South India and Sri Lanka. The name *Crossandra* was derived from the two Greek words i.e., ‘krossoi’ means fringe and ‘aner’ means male, combinedly known as fringed stamens (Das *et al.*, 2022). Despite lacking any fragrance, it gained significant popularity owing to its remarkable colour, light weight and strong market demand (Vinod and Kannan, 2020).

In India, Karnataka, Andhra Pradesh, Tamil Nadu and Telangana are the regions where *Crossandra* is cultivating in a commercial scale. The flowers serve various purposes, including religious offerings, hair adornments, garlands, venis and are also suitable for garden display (Prasanth *et al.*, 2020). This serves as a significant ornamental pot flower in Sweden, Denmark and Hungary (Bharath *et al.*, 2018).

Piriformospora indica, formerly known as *Serendipita indica* is a root endosymbiotic fungus having a wide host range, belongs to the Sebaciales in the Basidiomycota (Kaboosi *et al.*, 2022). It was isolated by Prof. Dr. Ajit Varma and group from the rhizosphere of two woody shrubs, *Prosopis juliflora* and *Zizyphus nummularia*, in Rajasthan’s Thar desert (Varma *et al.*,

2013). Upon root colonization with the host plant, *P. indica* produces acid phosphatases and nitrate reductases which helps the host plant to access the insoluble, condensed or complex forms of phosphorus and nitrogen present in the soil (Gill *et al.*, 2016). It forms pear shaped chlamydospores in the root region.

On the other hand, *Glomus fasciculatum* belongs to the Glomeromycota taxonomy, which includes 110 species, makes the genus important in the order Glomerales (Dalpe *et al.*, 2005). Arbuscles present in AMF helps in secretion of organic acids, thereby promoting nutrient uptake by the colonised plants (Gong and Tian, 2019). It produces extramatrical hyphae which acts as root extensions and thereby increasing the root surface area, making it easy for absorption of water and diffusion limited nutrients, especially in P-deficient soils (Mamatha *et al.*, 2002). Arka Microbial Consortium is a carrier-based product developed by ICAR-IIHR, Bengaluru, conveniently applied through soil, seed, water and growing media. It contains three types of bacterial strains *i.e.*, *Bacillus aryabhatai*, *Pseudomonas taiwanensis* and *Azotobacter tropicalis* (Aswathi *et al.*, 2020).

Among the ornamental crops, Crossandra is one of the perennial crop which requires continuous feed of fertilizers throughout its life. Prolonged use of chemical fertilizers causes serious consequences for soil and environmental health *viz.*, soil acidification, leaching salinization, disruption of soil microbial ecology, nutrient imbalance, reducing soil fertility over the time etc. Besides, application of chemical fertilizers is unsafe to humans also. Meanwhile, Plant Growth Promoting Root Endophytes (PGPRE's) are the rhizosphere biota which makes a symbiotic association with the host plant and promotes the growth of host plant. This PGPRE's solubilize the insoluble form of nutrients present in the soil and make them available for the plant. As these PGPRE's are cheaper than chemical fertilizers, the cost of cultivation can also be reduced. The existing research gap pertains to the lack of clear and systematic assessment of various application methods and the combinations of PGPRE's on overall plant performance in Crossandra. Moreover, no prior studies have examined the combined application of *Piriformospora indica*, *Glomus fasciculatum* and Arka Microbial Consortium in this crop, which makes the work novel with increased yield by reducing fertilizer regimes indicates the potentiality of creating a sustainable floriculture in the future. By keeping this in view, the present investigation was carried out to study the influence of PGPRE's on the floral attributes of Crossandra var. Arka Chenna.

Materials and Methods

The field experiment was conducted at College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University (latitude 13.99'N and longitude 79.32'E) during the Rabi season, 2023 under open field conditions. Uniform and healthy rooted cuttings of Crossandra variety Arka Chenna were used for the planting. Before planting, the soil was sterilised with 40% formalin solution to eliminate all the existing microbial population in the soil. After 3 days of covering the soil with the tarpaulin sheet, the soil was exposed to the sunlight for 3 days continuously to get rid of the fumes. Then, the soil was used for planting in the polybags of size 13 × 13 inches. The experiment followed a statistical design of 2 factorial RBD, with 60 treatment combinations and 3 replications. Each replication consisted of five polybags containing single rooted cutting per polybag. The details regarding the factors were listed below:

Factor-1: Method of application

M₁ - Soil application with PGPRE's 10 days prior to Crossandra seedling planting

M₂ - Inoculation of PGPRE's to cuttings prior to planting

M₃ - Seedling root inoculation with PGPRE's through root treatment just prior to planting

M₄ - Seedling root inoculation with PGPRE's through soil drenching on 10th day after transplanting

M₅ - Seedling root inoculation with PGPRE's through soil drenching on 20th day after transplanting

M₆ - Seedling root inoculation with PGPRE's through soil drenching on 30th day after transplanting

Factor-2: Plant Growth Promoting Root Endophytes (Treatments)

T₁ - *Piriformospora indica*

T₂ - *Glomus fasciculatum*

T₃ - Arka Microbial Consortium

T₄ - *Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium

T₅ - *Piriformospora indica* + 50% RDF

T₆ - *Glomus fasciculatum* + 50% RDF

T₇ - Arka Microbial Consortium + 50% RDF

T₈ - *Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium + 25% RDF

T₉ - RDF alone (Dr. YSRHU recommendation for Crossandra)

T₁₀ - Absolute control

Procurement of materials

The rooted cuttings of Crossandra var. Arka Chenna and Arka Microbial Consortium were procured from ICAR-IIHR, Bengaluru. While other PGPRE's viz., *Piriformospora indica* was procured from AMITY University, Noida and *Glomus fasciculatum* was procured from Agricultural Research Station, Amaravathi, Andhra Pradesh.

Floral studies

Flowering parameters like early spike initiation, number of days to first floret bud opening, early spike formation, number of days taken to full flowering, longevity of basal florets and duration of flowering were recorded per each treatment in each replication until the end of the flowering cycle.

Statistical analysis

All the data recorded for floral parameters were analyzed using two-way ANOVA under a two-factorial RBD. Comparison was done at 5% level of probability ($p < 0.05$) to determine significant differences among the treatments. The critical difference (CD) values were determined to differentiate the means of substantially different treatments.

Results

All the floral parameters were recorded throughout the cropping period. Analysis of the data revealed that there was significant difference among the methods of inoculation, PGPRE's and the interactions ($p \leq 0.05$).

From the study, it was clear that among the methods of inoculation, M_1 (Soil application with PGPRE's 10 days prior to Crossandra seedling planting) was shown significant response and recorded early spike initiation (122.81 days), early opening of first floret bud (139.98

days), quick spike formation (154.81 days), complete flowering (165.38 days), longevity of basal florets (7.61 days) and more duration of flowering (187.66 days). While, M_2 (Inoculation of PGPRE's to cuttings prior to planting) took more number of days for first spike initiation (135.98 days), number of days for first floret bud opening (152.36 days), complete spike formation (165.33 days), full flowering (180.23 days), less longevity of basal florets (4.84 days) and less duration of flowering (158.67 days).

Among the PGPRE's, the combinational application of PGPRE's i.e., P_8 (*Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium + 25% RDF) elicited a statistically significant impact on early spike initiation (122.30 days), early opening of first floret bud (138.20 days), longevity of basal florets (8.94 days) and more duration of flowering (218.81 days) except days taken to full spike formation and complete flowering. Early full spike formation (150.69 days) was found in P_4 (*Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium), while early days to complete flowering (162.54 days) was exhibited in P_7 (Arka Microbial Consortium + 50% RDF). Meanwhile, P_{10} (Absolute control) took long time for first spike initiation (145.09 days), number of days for first floret bud opening (162.07 days), complete spike formation (176.76 days), full flowering (197.00 days), less longevity of basal florets (2.96 days) and less duration of flowering (110.98 days).

The interactional treatment of M_1P_8 (Soil application with PGPRE's 10 days prior to Crossandra seedling planting x *Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium + 25% RDF) recorded a consistent and pronounced enhancement in almost all the floral parameters viz., early spike initiation (109.67 days), early opening of first floret bud (126.22 days), longevity of basal florets (11.89 days) and more

Table 1 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on number of days taken to early spike initiation in Crossandra var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	MeanM
M_1	118.67	123.67	118.44	119.56	119.78	127.56	113.78	109.67	139.89	137.11	122.81
M_2	137.78	127.00	127.78	132.22	137.33	134.44	129.67	129.56	149.11	154.89	135.98
M_3	124.33	123.00	125.89	120.44	120.33	130.11	118.78	118.22	138.67	148.11	126.79
M_4	119.22	126.56	134.00	124.89	129.00	130.89	121.00	120.78	137.22	153.44	129.70
M_5	130.67	123.00	122.11	126.44	122.22	138.00	138.56	130.33	133.22	134.00	129.86
M_6	132.11	131.44	132.11	121.00	123.67	139.00	123.44	125.22	132.22	143.00	130.32
Mean P	127.13	125.78	126.72	124.09	125.39	133.33	124.20	122.30	138.39	145.09	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S. Em±	2.231				2.880				7.054		
CD ($P=0.05$)	6.247				8.065				19.755		

Table 2 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on number of days taken to early floret bud initiation in *Crossandra* var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	MeanM
M ₁	118.67	123.67	118.44	119.56	119.78	127.56	113.78	109.67	139.89	137.11	122.81
M ₂	137.78	127.00	127.78	132.22	137.33	134.44	129.67	129.56	149.11	154.89	135.98
M ₃	124.33	123.00	125.89	120.44	120.33	130.11	118.78	118.22	138.67	148.11	126.79
M ₄	119.22	126.56	134.00	124.89	129.00	130.89	121.00	120.78	137.22	153.44	129.70
M ₅	130.67	123.00	122.11	126.44	122.22	138.00	138.56	130.33	133.22	134.00	129.86
M ₆	132.11	131.44	132.11	121.00	123.67	139.00	123.44	125.22	132.22	143.00	130.32
Mean P	127.13	125.78	126.72	124.09	125.39	133.33	124.20	122.30	138.39	145.09	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S.Em±	2.231				2.880				7.054		
CD (P=0.05)	6.247				8.065				19.755		

Table 3 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on number of days taken to full spike initiation in *Crossandra* var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	MeanM
M ₁	146.78	149.78	146.56	143.33	152.44	161.56	141.44	152.56	175.22	178.44	154.81
M ₂	165.22	153.33	166.11	159.33	165.78	161.56	159.00	159.67	177.67	185.67	165.33
M ₃	153.44	152.56	151.22	145.89	154.67	159.44	147.56	151.33	169.22	180.44	156.58
M ₄	150.44	163.44	161.33	147.11	158.56	169.67	150.22	165.33	173.78	171.11	161.10
M ₅	161.11	148.56	163.44	158.44	157.22	159.22	164.78	153.78	166.89	171.00	160.44
M ₆	164.78	158.44	155.33	150.00	151.44	158.00	152.22	149.22	160.00	173.89	157.33
Mean P	156.96	154.35	157.33	150.69	156.69	161.57	152.54	155.31	170.46	176.76	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S.Em±	2.251				2.906				7.117		
CD (P=0.05)	6.303				8.137				19.932		

Table 4 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on number of days taken to full flowering in *Crossandra* var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	MeanM
M ₁	156.78	159.78	156.56	155.33	162.44	171.56	151.44	162.56	193.22	184.11	165.38
M ₂	175.22	163.33	179.00	181.56	175.78	171.56	169.00	169.67	196.00	221.22	180.23
M ₃	163.44	162.56	161.22	157.44	164.67	169.44	157.56	161.33	187.22	194.89	167.98
M ₄	160.44	173.44	173.44	160.33	168.56	179.67	160.22	175.33	192.22	192.33	173.60
M ₅	171.11	158.56	174.22	171.56	167.22	169.22	174.78	163.78	184.44	195.11	173.00
M ₆	174.78	168.44	165.33	177.78	161.44	168.00	162.22	159.22	177.44	194.33	170.90
Mean P	166.96	164.35	168.30	167.33	166.69	171.57	162.54	165.31	188.43	197.00	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S.Em±	2.610				3.369				8.253		
CD (P=0.05)	7.309				9.435				23.112		

duration of flowering (241.11 days) except days taken to full spike formation and complete flowering. While, days taken to full spike formation (141.44 days) and early days to complete flowering (151.44 days) was exhibited in

M₁P₇ (Soil application with PGPRE's 10 days prior to *Crossandra* seedling planting x Arka Microbial Consortium + 50% RDF). However, M₂P₁₀ (Inoculation of PGPRE's to cuttings prior to planting x Absolute control) took

Table 5 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on flowering duration in Crossandra var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										MeanM
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	
M ₁	175.78	183.44	185.56	228.89	202.00	196.78	222.67	241.11	134.00	106.33	187.66
M ₂	195.00	178.67	153.11	189.78	179.33	125.78	150.33	209.56	103.33	101.78	158.67
M ₃	157.22	161.67	181.78	201.56	195.78	182.67	214.56	228.44	137.78	107.11	176.86
M ₄	147.44	163.56	121.56	198.67	153.22	175.33	172.56	200.11	136.44	127.44	159.63
M ₅	151.00	169.78	143.00	201.67	152.78	159.78	183.89	218.89	133.33	105.89	162.00
M ₆	173.44	200.11	155.78	199.67	182.22	172.89	160.56	214.78	130.56	117.33	170.73
Mean P	166.65	176.20	156.80	203.37	177.56	168.87	184.09	218.81	129.24	110.98	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S. Em±	0.462				0.597				1.462		
CD (P=0.05)	1.295				1.671				4.094		

Table 6 : Effect of methods of inoculation, Plant Growth Promoting Root Endophytes (PGPRE's) and their interaction on longevity of basal florets on the spike (days) in Crossandra var. Arka Chenna.

Method of inoculation (M)	Plant Growth Promoting Root Endophytes (P)										MeanM
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	
M ₁	6.89	7.56	6.22	10.44	7.33	10.11	8.67	11.89	3.56	3.44	7.61
M ₂	4.22	6.22	3.22	7.44	4.56	3.56	4.11	8.44	4.56	2.11	4.84
M ₃	6.78	8.78	5.78	10.11	6.56	5.11	6.56	10.22	2.89	2.67	6.54
M ₄	5.33	4.56	4.22	8.11	4.56	4.89	8.56	9.44	4.56	3.33	5.76
M ₅	4.33	4.44	3.22	5.56	6.11	4.78	8.67	4.56	4.56	3.00	4.92
M ₆	5.78	6.11	4.11	9.78	5.44	4.89	4.89	9.11	3.78	3.22	5.71
Mean P	5.56	6.28	4.46	8.57	5.76	5.56	6.91	8.94	3.98	2.96	
Source	Method of inoculation (M)				PGPRE's (P)				M x P		
S. Em±	0.092				0.119				0.292		
CD (P=0.05)	0.259				0.334				0.818		

maximum number of days took for first spike initiation (154.89 days), number of days for first floret bud opening (177.44 days), complete spike formation (185.67 days), full flowering (221.22 days), less longevity of basal florets (2.11 days) and less duration of flowering (101.78 days).

Discussion

Perusal of data from the study clearly showed that all of the floral parameters were performed superiorly under the interaction treatment of M₁P₈ (Soil application with PGPRE's 10 days prior to Crossandra seedling planting x *Piriformospora indica* + *Glomus fasciculatum* + Arka Microbial Consortium + 25% RDF) except days taken to full spike formation and complete flowering. Due to pre-planting microbial application, bio-availability of phosphorus- a key nutrient for the development of floral primordia, nitrogen, zinc and boron was enhanced and ready for uptake when the plant was introduced. This enables in early transformation of plants from vegetative phase to reproductive phase and early

spike initiation and early first floret bud opening (Bohra and Kumar, 2014). This result was in favour with Pathak and Kumar (2009) in gladiolus. According to Goswami *et al.* (2016), better establishment of microbes and higher microbial activity was observed when the microbes were applied early, which primes the plant for early reproductive transition. Patil and Narayana (2018) and Kusagur *et al.* (2022) found that combined application of microbes along with fertilizers resulted in early flowering. More duration of flowering might be due to application of *Piriformospora indica* which helps in altering C:N ratio and balancing the management of vegetative as well as reproductive phase and enhances flowering days (Noorjahan *et al.*, 2018). Similar results were found by Naik (2015) in marigold. Bohra and Kumar (2014) reported that the extension of blooming length is related to enhanced protein synthesis, accelerated nutrient mobilisation and the inhibition of chlorophyll degradation, resulting from adequate nutrient availability in soils supplemented with VAM. The improved longevity of

basal florets was due to presence of ethylene inhibitors or cytokinins (Pathak and Kumar, 2009) or due to delayed senescence, induced by microbial regulation of ethylene biosynthesis and antioxidant activity as exhibited by Tongon *et al.* (2015) in snapdragon flowers.

Conclusion

Till now, no research had done with the combination of *Piriformospora indica*, *Glomus fasciculatum* and Arka Microbial Consortium in Crossandra. Based on the findings, the plants treated with the combination of these three PGPRES along with supplemented nutrients particularly through soil application of 10 days prior to planting enhances all the floral attributes than control. This study suggested that early application of PGPRES will result in early microbial colonisation in the rhizosphere, united with the synergistic generation of plant growth promoting chemicals like auxins and cytokinins, making the environment favourable for vigorous plant growth and development. These experimental findings highlighted the interesting utilisation of microbial consortia in sustainable floriculture. Using these microbial inoculants not only improves the crop quality and production, but also eliminates the need of chemical fertilizers, thereby making it a feasible and eco-friendly approach for commercial producers. Furthermore, the incorporation of bioinoculants with diminished fertiliser application is a sustainable alternative to traditional high-input floricultural methods.

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References

- Aswathi, N.C., Prasad V.M. and Sreekumar G. (2020). Effect of Different Concentration of Arka Microbial Consortium on the Growth Yield and Quality of Lettuce (*Lactuca sativa*) cv. Grand rapid under Poly House in Prayagraj Agro Climatic Condition. *Int. J. Curr. Microbiol. Appl. Sci.*, **9**, 1135-1143.
- Bharath, T.U., Rao T.M. and Aswath C. (2018). Assessing the suitability of Crossandra. *Int. J. Curr. Microbiol. Appl. Sci.*, **7**, 1028-1035.
- Bohra, M. and Kumar A. (2014). Studies on effect of organic manures and bioinoculants on vegetative and floral attributes of chrysanthemum cv. little darling. *The Bioscan*, **9**, 1007-1010.
- Dalpe, Y., Souza F.A. and Declerck S. (2005). Life Cycle of Glomus Species in Monoxenic Culture. *In Vitro Culture of Mycorrhizas*. Berlin, Heidelberg, vol 4.
- Das, R., Munikrishnappa P.M., Seetharamu G.K., Rajesh A.M. and Kumar P. (2022). Evaluation of crossandra (*Crossandra undulaefolia* Salisb.) genotypes under Eastern dry zone of Karnataka. *The Pharma Innov. J.*, **11**, 1950-1954.
- Gill, S.S., Gill R., Trivedi D.K., Anjum N.A., Sharma K.K., Ansari M.W., Ansari A.A., Johri A.K., Prasad R., Pereira E., Varma A. and Tuteja N. (2016). *Piriformospora indica*: Potential and Significance in Plant Stress Tolerance. *Front. Microbiol.*, **7**, 332. doi: 10.3389/fmicb.2016.00332.
- Gong, X. and Tian D.Q. (2019). Study on the effect mechanism of Arbuscular Mycorrhiza on the absorption of heavy metal elements in soil by plants. *IOP Conf. Ser.: Earth Environ. Sci.*, **267**. doi:10.1088/1755-1315/267/5/052064.
- Goswami, D., Thakker J.N. and Dhandhukia P.C. (2016). Portraying mechanics of plant growth promoting rhizobacteria (PGPR): A review. *Cogent Food & Agriculture*, **2**:1, 1127500. DOI: 10.1080/23311932.2015.1127500.
- Kaboosi, E., Ghabooli M. and Karimi R. (2022). *Piriformospora indica* inoculants enhance flowering, yield, and physiological characteristics of tomato (*Solanum lycopersicum*) in different growth phases. *Iranian J. Plant Physiol.*, **1**, 4183-4194.
- Kusagur, N., Manjunatha B., Patil C. and Maruthesh A.M. (2022). A studies on impact of chemical and bio-fertilizers in cucumber (*Cucumis sativus* L.) production under Zone number 7 of Karnataka. *The Pharma Innov. J.*, **11**, 3068-3071.
- Mamatha, G., Bagyaraj D.J. and Jaganath S. (2002). Inoculation of field-established mulberry and papaya with arbuscular mycorrhizal fungi and a mycorrhiza helper bacterium, *Mycorrhiza*, **12**, 313-316. DOI 10.1007/s00572-002-0200-y.
- Naik, M.R. (2015). Influence of nitrogen and phosphorus on flowering, N and P content of African marigold, *Tagetes erecta* L. var. Cracker Jack. *Int. J. Farm Sci.*, **5**, 42-50.
- Noorjahan, K., Naik M.R., Ramaiah M. and Gopal K. (2018). Influence of nutrients and *Piriformospora indica* on growth and biochemical attributes of African marigold cv. Pusa Basanthi Gaiinda. *J. Pharmacog. Phytochem.*, **7**, 55-60.
- Pathak, G. and Kumar P. (2009). Influence of organics on floral attributes and shelf life of gladiolus (*Gladiolus hybrida*) cv. White Prosperity. *Progressive Horticulture*, **41**, 116-119.
- Patil, C. and Narayana J. (2018). Study of gherkin (*Cucumis anguria* L.) production by using optimum quantity of chemical and bio fertilizers. *J. Pharmacog. Phytochem.*, **7**, 968-971.
- Prasanth, P., Girwani A., Salma Z. and Kumar S.P. (2020). Suitability evaluation of crossandra genotypes under Hyderabad conditions. *Int. J. Chem. Stud.*, **8**, 484-486.

- Rehana, S.K., Madhavi M., Rao A.V.D. and Subbaramamma P. (2020). Effect of cutting types and IBA treatments on success of vegetative propagation in crossandra (*Crossandra infundibuliformis* L.) var. Arka Shravya. *J. Pharmacog. Phytochem.*, **9**, 1469-1475.
- Sree, G.K, Srinivas P.T, Rao A.V.D. and Rajasekharam T. (2023). Growth and flowering as influenced by genotypes in Crossandra (*Crossandra infundibuliformis* L.) under Rayalaseema conditions. *The Pharma Innov. J.*, **12**, 2150-2153.
- Tongon, G.B., Sanmartin C., Alcolea V., Cuquel F.L. and Goicoechea N. (2015). Mycorrhizal inoculation and/or selenium application affect postharvest performance of snapdragon flowers. *Plant Growth Regulation*. DOI 10.1007/s10725-015-0100-8.
- Varma, A, Sree K.S., Arora M., Bajaj R., Prasad R. and Kharkwal A.C. (2014). Functions of Novel Symbiotic Fungus-*Piriformospora indica*. *Proc. Indian Nat. Sci. Acad.*, **80**(2), 429-441. DOI: 10.16943/ptinsa/2014/v80i2/55119.
- Vinodh, S. and Kannan M. (2020). Variability studies in Crossandra (*Crossandra infundibuliformis*). *J. Pharmacog. Phytochem.*, **9**(1), 312-314.