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Integrated nutrient management on growth, yield and quality of Crossandra (*Crossandra undulaefolia* Salisb.) hybrid Arka Ambara

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Abstract
Studies were conducted to investigate the effect of integrated nutrient management on growth, yield and quality of Crossandra (*Crossandra undulaefolia* Salisb.) hybrid Arka Ambara. The study carried out at the Department of Horticulture, GKVK, UAS, and Bengaluru. Results recorded at 150 days after imposition of the treatments, the application of 100 per cent recommended dose of nitrogen, phosphorus and potassium + *Azotobacter* + PSB + KSB had significantly improved the growth, flowering and yield attributes. There was a significant increase in plant height (50.07cm), number of branches (16.20) and plant spread (2111cm^2) and it was on par with 75 per cent RDF + *Azotobacter* + PSB + KSB (plant height 48.07cm, number of branches 15.50 and plant spread 2108cm^2).Similarly in reference to flower and yield traits, the first spike initiation occurred as early as 85.03 days, the first flower harvest (93.03), number of flowers per spikes(28.96) and flower yield per ha (3.78 t) recorded were found to be significantly higher and it was found on par with 75 per cent RDF + *Azotobacter* + PSB + KSB (first spike initiation 89.33days, first flower harvest (97.33 days), number of flowers per spikes (30.67) and flower yield per ha (4.15 t).The soil analysis showed significantly increased levels of available nitrogen, phosphorus and potassium content as recorded at the end of experiment. It was also observed that beneficial microbial population of bacteria, fungi and Actinomyces were higher at the end of experiment.

Keywords: Actinomyces, *Azotobacter*, bio-fertilizers, Crossandra, RDF

1. Introduction
Crossandra (*Crossandra undulaefolia* Salisb.) belonging to the family Acanthaceae. It is believed to be native to South India and Sri Lanka. The genus comprising 52 species and is distributed in tropical and sub-tropical regions of the world such as South Asia, South America, South Africa, Madagascar, Arabia and the Indian sub-continent. This flower is also a valuable ornamental pot flower in Sweden, Denmark and Hungary. Crossandra is a small, evergreen ornamental shrub producing beautiful flowers almost round the year. It is a short branching perennial shrub about 30-90 cm in height.

Total organic farming may be a desirable proposition for improving the quality of horticultural produce. It may not be possible to maintain the quality of the produce in commercial horticulture, where mostly the stress will be given mainly on yield. It is impossible to meet the nutrient requirement of the crops, exclusively through the organic farming. Under these circumstances integrated soil fertility management practices involving judicious combination of organic manures, bio-fertilizers and chemical fertilizers seems to be a feasible option for sustained horticulture on a commercial and profitable scale. In addition, they are eco-friendly, easily available and cost effective.

Bio-fertilizers are more appropriately called 'microbial inoculants' it containing live or latent cells of efficient strains of microorganisms. These may be biological nitrogen fixers, P-solubilizer, mineralization of nitrogen and transformation of several elements like sulphur and iron into available forms. These bio-fertilizers benefit agricultural production by supplying nutrients.

2. Materials and Methods
The present study entitled on "Integrated nutrient management on growth, yield and quality of Crossandra (*Crossandra undulaefolia* Salisb.) Hybrid Arka Ambara" was carried out at the Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, and Bengaluru during 2017-18, to study the effect of organic and inorganic nutrient sources on growth and yield of Crossandra hybrid Arka Ambara with integrated nutrient management.

The experiment was conducted by imposing 13 treatments *viz.*, 100% Recommended Dose of Fertilizer as control (T_1), 100% RDF + *Azotobacter* (T_2), 75% RDF + *Azotobacter* (T_3), 100% RDF + PSB (T_4),75% RDF + PSB (T_5), 100% RDF + KSB (T_6), 75% RDF + KSB (T_7), 100% RDF + *Azotobacter*+ PSB (T_8), 75% RDF + *Azotobacter*+ PSB (T_9), 100% RDF + PSB + KSB (T_{10}), 75% RDF + PSB + KSB (T_{11}), 100% RDF + *Azotobacter*+ PSB + KSB (T_{12}), 75% RDF + *Azotobacter*+ PSB + KSB (T_{13}).

Observations were made on 3 growth traits *viz.,* plant height(cm), number of branches and plant spread (cm^2) at 30, 60, 90, 120 and 150 days after planting were recorded, and 3 flowering traits *viz.*, days taken to flower initiation, days taken for first harvest, duration of flowering(days)and 5 yield traits *viz.*, number of flowers per spike, number of spikes per plant, flower yield per plant (g.), flower yield per plot (kg), flower yield per ha (t). Soil analysis (kg/ha.) and microbial count (cfu g^{-1} soil) for bacteria, fungi actinomycetes were carried out at the end of the experiment.

3. Results and Discussion
On the basis of results obtained in the study it is concluded that among the growth parameters, significantly highest plant height (50.07cm), highest number of branches (16.20) and highest plant spread (2111cm^2) was recorded the plant receiving 100 per cent RDF+ *Azotobacter*+ PSB+ KSB(T_{12})

and it was on par with (T_{13}) *viz.,* 75 per cent RDF + *Azotobacter*+ PSB + KSB plant height (48.07cm), number of branches (15.50) and plant spread (2108 cm^2). Lowest plant height (36.07 cm), lowest number of branches (12.83) and lowest plant spread (1223 cm^2) recorded in plants receiving the 100 per cent RDF only (T_1).

The early spike initiation (85.03 DAP), less number of days taken to first harvest (93.03DAP) and highest flower duration (31.57 days) was achieved by application of 100 per cent RDF +*Azotobacter*+ PSB+ KSB (T_{12}) and it was on par with (T_{13}) *viz.,* 75 per cent RDF + *Azotobacter*+ PSB + KSB (spike emergence 89.33 DAP, days taken to first harvest 97.33DAP and flower duration 31.40days). The control treatment (T_1) *viz.,*100 per cent RDF showed delayed spike emergence(99.67), less number of days taken to first harvest (107.60 DAP) and lowest flowering duration (28.87 days). Number of flowers per spike (32.00), number of spikes per plant (45.67), flower yield per plant (152.05g), flower yield per plot (1.22 kg) and flower yield per hectare (4.22 tons) were significantly highest in (T_{12}) *viz.,*100 per cent RDF +*Azotobacter*+ PSB + KSBand it was on par with T_{13} receiving 75 per cent RDF + *Azotobacter*+ PSB + KSB*viz.,* number of flowers per spike (30.67), number of spikes per plant (45.00), flower yield per plant (149.33g), flower yield per plot (1.19 kg) and flower yield per hectare (4.15 tons). 100 per RDF (T_1) shows less number of flowers per spike (26.83), less number of spikes per plant (39.17), less flower yield per plant (115.61g), less flower yield per plot (0.92 kg) and less flower yield per hectare (3.21tons).

The chemical analysis of soil after crop harvest has highest N, P and K (299.53, 37.56 and 306.46 N, P_2O_5 and K_2O_5 kg per hectare respectively) availability was in the treatment of 100 per cent RDF +*Azotobacter*+ PSB + KSB (T_{12})and it is par with 75 per cent RDF + *Azotobacter*+ PSB + KSB (T_{13})*viz.,* 298.98 N, 37.30 P and 306.26 K kg per hectare. The availability of N,P,K were lowest in the soils of plots supplemented only with recommended dose of fertilizers *viz.,* 259.13, 28.06 and 273.33 N, P_2O_5 and K_2O_5 kg per hectare respectively.

The microbial analysis of soil after the crop harvest, showed that micro flora *viz.,* bacteria, fungi and actinomycetes (59.33×10^6 cfu g^{-1}, 22.68×10^3 cfu $g^{-1}$and 15.68×10^4 cfu g^{-1} soil respectively was highest in the treatment (T_{12}) *viz.,* 100 per cent RDF +*Azotobacter*+ PSB + KSBand it was on par with (T_{13})*viz.,* 75 per cent RDF + *Azotobacter*+ PSB + KSB (bacteria -58.66×10^6 $cfug^{-1}$, fungi-$22.34 \times 10^3$$cfug^{-1}$ and actinomycetes -$15.34 \times 10^4$$cfug^{-1}$) and lowest microbial population was recorded in the soil of un-inoculated control plots (T_1) *viz.,* bacteria 34.34×10^6 cfu g^{-1}, fungi 13.01×10^3 cfu $g^{-1}$and actinomycetes 9.00×10^4 cfu g^{-1}.

Table 1: Effect of integrated nutrient management on plant height of hybrid Arka Ambara at different stages of plant growth.

Treatment combinations	Plant height (cm)				
	Days after imposing treatments				
	30	60	90	120	150
T_1 - Control (100% NPK)	16.17	22.50	27.03	31.90	36.07
T_2 - 75 per cent RDF + *Azotobacter*	18.00	27.00	32.00	37.10	39.03
T_3 - 75 per cent RDF + *Azotobacter*	18.13	24.04	27.07	32.17	37.10
T_4 - 100 per cent RDF + PSB	17.67	22.03	29.10	34.03	39.13
T_5 - 75 per cent RDF + PSB	17.24	24.16	29.17	34.23	39.04
T_6 - 100 per cent RDF + KSB	16.67	23.03	28.20	33.20	38.20
T_7 - 75 per cent RDF + KSB	17.25	22.00	27.00	32.00	37.20
T_8 - 100 per cent RDF + *Azotobacter*+ PSB	19.33	28.13	33.10	38.10	43.03
T_9 - 75 per cent RDF + *Azotobacter*+ PSB	18.33	29.00	31.13	36.04	43.80
T_{10} - 100 per cent RDF + PSB + KSB	19.10	26.03	31.02	35.34	40.13
T_{11} - 75 per cent RDF + PSB + KSB	19.33	27.10	32.13	37.04	41.33
T_{12} - 100 per cent RDF + *Azotobacter*+ PSB + KSB	19.67	32.00	37.20	43.29	50.07
T_{13} - 75 per cent RDF + *Azotobacter*+ PSB + KSB	19.00	31.01	37.07	42.01	48.07
F-test	*	*	*	*	*
S. Em ±	0.89	0.32	0.09	0.45	0.77
CD @ 5%	2.61	0.93	0.27	1.30	2.23

*significant at 5%

Table 2: Effect of integrated nutrient management on days taken for first spike initiation, days taken for first flower harvest and flower duration of crossandra hybrid Arka Ambara.

Treatment combinations	First spike initiation	First flower harvest	Duration of flowering
T_1 - Control (100% NPK)	99.67	107.60	28.87
T_2 - 75 per cent RDF + *Azotobacter*	96.33	104.31	28.93
T_3 - 75 per cent RDF + *Azotobacter*	92.67	100.60	29.47
T_4 - 100 per cent RDF + PSB	96.00	104.00	29.40
T_5 - 75 per cent RDF + PSB	98.17	106.10	29.63
T_6 - 100 per cent RDF + KSB	94.50	102.50	30.45
T_7 - 75 per cent RDF + KSB	95.00	101.50	29.91
T_8 - 100 per cent RDF + *Azotobacter*+ PSB	93.50	101.50	30.51
T_9 - 75 per cent RDF + *Azotobacter*+ PSB	91.67	99.60	31.07
T_{10} - 100 per cent RDF + PSB + KSB	97.00	105.00	30.35
T_{11} - 75 per cent RDF + PSB + KSB	95.00	102.67	30.52
T_{12} - 100 per cent RDF + *Azotobacter*+ PSB + KSB	85.03	93.03	31.57
T_{13} - 75 per cent RDF + *Azotobacter*+ PSB + KSB	89.33	97.33	31.40
F-test	*	*	*
S.Em ±	1.09	1.41	0.50
C.D. @ 5%	3.18	4.5	1.46

*significant at 5%

Table 3: Number of flowers per spikes, number spikes per plant, flower yield per plant, flower yield per plot and flower yield per hectare as influenced by integrated nutrient management in crossandra hybrid Arka Ambara.

Treatment combination	Yeild				
	No. of flowers per spike	No. of spikes per plant	Flower yield per plant (g)	Flower yield per plot (kg)	Flower yield per ha (t)
T_1 - Control (100% NPK)	26.83	39.17	115.61	0.92	3.21
T_2 - 75 per cent RDF + *Azotobacter*	27.81	41.47	126.18	1.01	3.50
T_3 - 75 per cent RDF + *Azotobacter*	27.88	40.23	122.74	0.99	3.41
T_4 - 100 per cent RDF + PSB	28.10	42.83	131.93	1.06	3.66
T_5 - 75 per cent RDF + PSB	27.73	43.33	131.11	1.05	3.64
T_6 - 100 per cent RDF + KSB	28.04	40.33	124.38	1.00	3.45
T_7 - 75 per cent RDF + KSB	28.11	42.17	130.50	1.04	3.62
T_8 - 100 per cent RDF + *Azotobacter*+ PSB	28.97	44.50	138.55	1.11	3.85
T_9 - 75 per cent RDF + *Azotobacter*+ PSB	28.37	42.00	130.97	1.05	3.64
T_{10} - 100 per cent RDF + PSB + KSB	28.04	44.40	137.57	1.10	3.82
T_{11} - 75 per cent RDF + PSB + KSB	28.96	43.17	136.14	1.09	3.78
T_{12} - 100 per cent RDF + *Azotobacter*+ PSB + KSB	32.00	45.67	152.05	1.22	4.22
T_{13} - 75 per cent RDF + *Azotobacter*+ PSB + KSB	30.67	45.00	149.33	1.19	4.15
F-test	*	*	*	*	*
S.Em ±	0.45	0.33	2.33	0.02	0.06
C.D. @ 5%	1.35	0.97	6.80	0.05	0.19

*significant at 5%

Table 4: Soil microbial population as influenced by integrated nutrient management in crossandra hybrid Arka Ambara.

Treatment combinations	Microbial population (cfug^{-1} soil)		
	Bacteria (No.x10^6)	Fungi (No.x10^3)	Actinomycetes (No.x10^4)
T_1 - Control (100% NPK)	34.34	13.01	9.00
T_2 - 75 per cent RDF + *Azotobacter*	38.66	14.67	10.33
T_3 - 75 per cent RDF + *Azotobacter*	37.66	18.00	11.00
T_4 - 100 per cent RDF + PSB	37.33	17.67	10.33
T_5 - 75 per cent RDF + PSB	45.33	18.00	11.00
T_6 - 100 per cent RDF + KSB	42.00	18.33	11.67
T_7 - 75 per cent RDF + KSB	41.67	18.67	12.33
T_8 - 100 per cent RDF + *Azotobacter*+ PSB	49.33	18.67	12.33
T_9 - 75 per cent RDF + *Azotobacter*+ PSB	47.00	19.67	13.33
T_{10} - 100 per cent RDF + PSB + KSB	46.33	18.67	13.39
T_{11} - 75 per cent RDF + PSB + KSB	55.67	20.67	15.00
T_{12} - 100 per cent RDF + *Azotobacter*+ PSB + KSB	59.33	22.68	15.68
T_{13} - 75 per cent RDF + *Azotobacter*+ PSB + KSB	58.66	22.34	15.34
F-test	*	*	*
S.Em±	0.301	0.332	0.241
C.D. @ 5%	0.90	0.99	0.72

*significant at 5%

4. Summary

Based on the present investigation, it could be concluded that integrated nutrient management had significant influence on growth and yield attributes of crossandra. Application of 100 per cent RDF +5g each of *Azotobacter* + PSB + KSBwas ideal for maximizing growth and yield parameters and it is on par with 75 per cent RDF +*Azotobacter*+ PSB + KSB, so 25 per cent RDF can be saved and cost can be reduced. Thus, the integral use of inorganic fertilizers along with bio-fertilizers can be recommended for achieving maximum sustainable flower yield in crossandra.

5. References

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