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Effect of arbuscular mycorrhizal fungal consortia on growth, quality and nutrient uptake of dracaena (*Dracaena marginata*)

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ABSTRACT

The present research was designed to study the effect of media (soil + FYM (3: 1 v/v), VAM and mineral NPK (19: 19: 19) at 5.0, 10.0, 15.0 g/pot and their combined effect on growth promotion and nutrient uptake of dracaena (*Dracaena marginata*) plant during 2018–19 at Ornamental Horticulture and Landscaping Unit, Indian Agricultural Research Institute, Pusa Campus, New Delhi. The experiment was laid out in a Completely Randomized Design with seven treatments combination, replicated thrice with five pots per replication. Balanced fertilization resulted in increased SOC (soil organic carbon) which resulted in improved soil physical properties such as CEC and *p*H. This consequently enhances growth performance, total biomass weight and nutrient uptake significantly for all treatments against control. Treatment combination of Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19) was found best for growth promotion and nutrient uptake of *Dracaena marginata*

Key words: Biofertilizers, *Dracaena marginata*, Growth, Inorganic fertilizer, VAM

Ornamental house plants possess pivotal importance in human life because of their beauty, beliefs, culture and environmental benefits. Dracaena are most chosen interior ornamental plants because of their diverse shapes and colour forms available in the market.They require minimum care due to its ability to survive under low-light conditions (Chen *et al*. 2002). The species *Dracaena marginata,* Lam. belongs to the family Asperagaceae and is native to Madagascar. No work has been done on standardisation of nutritional requirement of dracaena. Excessive use of chemical fertilizers results in soil degradation and low use efficiency of applied fertilizers by crops whilst organic-inorganic compound fertilizers promote the efficiency and sustainability of agricultural ecosystems over long period of time (Liu *et al.* 2009). Biological fertilizers have ability to increase crop yield by 20–30% as well as replacing chemical nitrogen and phosphorous by 25% (Mahfouz *et al*. 2017). Vesicular arbuscular mycorrhiza (VAM) fungi are known as the most ancient and widespread symbionts which promote the growth and biomass of host plants (Blee *et al*. 1996). In this study, we aim to assess the effect of VAM consortia and mineral fertilizers on growth promotion and nutrient uptake of dracaena.

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MATERIALS AND METHODS

The present investigations were carried out in pots at research farm of Indian Agricultural Research Institute, Pusa Campus, New Delhi during 2018–19. The experiment was laid out in a completely randomised design with 7 (seven) treatment combinations, replicated thrice with five pots per replication. Dracaena plants were planted in a pot consisting of soil: FYM: (3:1, v/v). Uniform population was maintained for all treatments and the recommended cultural practices were followed. Treatment combinations consisted of bio fertilizers VAM, BIO-NPK and inorganic fertilizers. VAM was procured from Department of Microbiology, Indian Agricultural Research Institute, Pusa Campus, New Delhi. VAM was first applied at the bottom and sides of the planting hole prior to placing the root ball of the plant and subsequently applied as top dressing at 3 and 6 months after transplanting @ 15 g/pot. Two doses of combined VAM + BIO-NPK (5 g +100 ml and 5 g + 200 ml/pot respectively) were given at 1, 3 and 6 months after transplanting. Three different doses of combined VAM + NPK (19:19:19), i.e. (3 g +15 g, 5 g + 10 g and 10 g+ 15 g/pot respectively) were given at 1, 3 and 6 months after transplanting.

Growth parameters were measured at 60, 180 and 240 days after transplanting. The observations were recorded for each physical and yield parameter, viz. plant height (cm), stem length (cm), number of leaves/plant, leaf area (sq.cm), plant spread (cm), stem girth (cm), total fresh biomass (g) and total dry biomass (g).

Physico-chemical analysis of soil: The physicochemical

analysis of the soil used in the study is presented in Table 1. Available N was estimated by alkaline permanganate method as modified by Subbiah and Asjia (1956). Available P was determined by stannous chloride reduced ammonium molybdate method in HCl system (Jackson 1973) using Olsen's extracting (Olsen *et al*. 1954). Potassium content was determined according to methods described by Hanway and Heidel (1954). Organic carbon content was determined using Walkey-Black (1934) chromic acid digestion procedure. Soil *p*H was determined electronically using glass electrode using pH meter (Mclean 1982) with a soil: water ratio of 1:2.5 (w/v). EC of air-dried soil was determined by means of an EC meter with a soil: water ratio of 1:5 (w/v).

Estimation of mycorrhizal colonization: Mycorrhizal colonization was assessed following the technique of Phillips and Hayman (1970). Roots were separated through 2-mm sieves from all soil samples from each sampling plot and were stained with methylene blue. Stained roots were mounted on the glass slides and the root length colonization (RLC) was measured at 8X magnification under stereozoom microscope.

Statistical analysis: The data relating to each parameter was statistically analyzed by applying the technique of analysis of variance using Completely Randomized Design (Gomez and Gomez 1984). Pooled analysis of variance was performed to test the significant differences of different treatments.

RESULTS AND DISCUSSION

Root colonization (%): All inoculated plants were colonised by AMF (range of colonisation rates 29–41%) whilst non-inoculated plants were free of AMF. Root colonisation was maximum (40.66 %) in T4, i.e. Soil + FYM (3:1) + 15 g VAM consortia. High dose of fertilization resulted in significant reduction in AMF colonisation which might be due to high amount of phosphorus in the media. Previous research also reported negative correlation between phosphorus amount and colonization rate (Bouamri *et al*. 2006). Also, Akhter *et al*. (2015) reported significant increased effect of AMF complex root colonisation in tomato. Fig 1 showed structures of *Glomus* sp. in roots of dracaena.

Media physicochemical properties: Fertilizer (NPK) level has negative correlation with soil pH and positive correlation with soil EC respectively (Table 1). *p*H was maximum in T1 (control) and minimum in treatment T5 - Soil + FYM (3:1) + 3 g VAM consortia + 15 g NPK (19:19:19). Use of urea fertilizer and build-up of organic matter might have resulted in decrease in *p*H. Benbi *et al*. (2009) reported that decline in soil *p*H have positive impacts on availability of nutrients such as phosphorus, zinc, iron and manganese. The soil EC was minimum in control pots and maximum in treatment T6- Soil + FYM (3:1) + 3 g Urea + 5 g VAM consortia + 10 g NPK (19:19:19). Similar result was also recorded by Isidora Radulov *et al*. (2011).

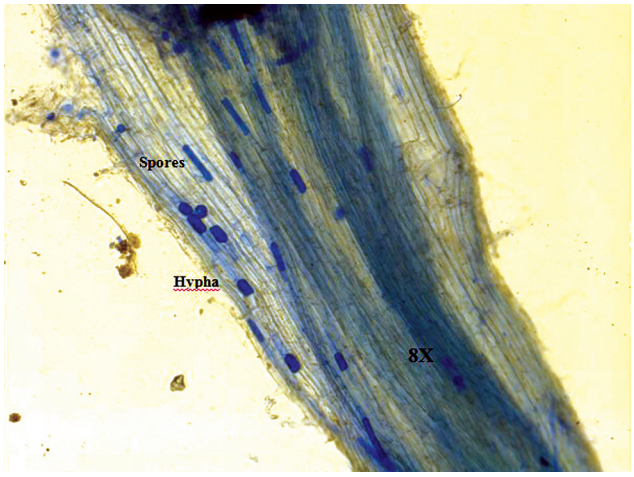

Fig 1 Structures of *Glomus* spp. in roots of dracaena, viz. intra-radical hypha and spores.

Table 1 Physicochemical properties of the media as influenced by VAM inoculation and different doses of NPK (19:19:19) fertilizer in dracaena

Treatment	Media physicochemical properties					
	*p*H	EC (dS/m)	Soil organic carbon (%)	N (mg/kg soil)	P (mg/kg soil)	K (mg/kg soil)
1	7.89	0.17	0.12	129.00	16.50	67.00
2	7.13	0.24	0.96	145.00	29.10	71.00
3	7.56	0.26	0.16	151.00	14.20	68.00
4	7.82	0.33	0.15	139.00	34.10	111.00
5	6.23	0.72	0.32	192.00	37.50	83.00
6	6.47	0.73	0.97	205.00	39.00	88.00
7	6.34	0.61	0.83	194.00	36.80	75.00
CD(P=0.05)	0.65	0.07	0.34	16.39	7.37	4.85

T1, Soil (Control); T2, Soil + FYM (3:1) + 5 g VAM consortia + 100 ml BIO-NPK; T3, Soil + FYM (3:1) + 5 g VAM consortia + 200 ml BIO-NPK; T4, Soil + FYM (3:1) + 15 g VAM consortia; T5, Soil + FYM (3:1) + 3 g VAM consortia + 15 g NPK (19:19:19); T6, Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19); T7, Soil + FYM (3:1) + 3 g Urea + 5 g VAM consortia + 10 g NPK (19:19:19).

Treatments significantly affected the nutritional build up in the medium profile. Highest available N, P and K build-up (205.00, 39.00 and 111.00 mg/kg soil respectively) was recorded in treatment T6. The increase in the available nutrients might be attributed to the high fertilizer concentration which after meeting out the plant requirements has contributed to the build up of the available N, P and K in the medium. Bhalla (2007) reported significant increase in the available N, P and K content in the soil of carnation with the subsequent increase in the dose of N, P and K. Different fertilizer treatments had significant positive effect SOC (ranging from 0.12–0.97%). The highest SOC (0.97%) was recorded in treatment T6, i.e. Soil + FYM (3:1) + 3 g Urea + 5 g VAM consortia + 10 g NPK (19:19:19), whereas lowest (0.12%) was recorded control pots. Increment in SOC might be due to addition of carbon source through FYM, shoot and root biomass. Abundance of arbuscular mycorrhizal fungi is positively correlated with the carbon and nitrogen content in the soil (Haishui Yang *et al*. 2011). Derek *et al*. (2005) also reported that biomass content, photosynthetic rate and organic matter content is higher in mycorrhizal plants compared to non-mycorrhizal plants.

Growth parameters: The results of analysis of variance show that treatments significantly influenced all the growth attributes of the plants (Table 2). The maximum increased plant height (47.60 cm) was recorded in T6, i.e. Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19), whereas minimum height (32.88 cm) was recorded in T1 (control). Mycorrhizal fungi enhanced nutrient uptake, photosynthesis, source-sink relation, better physical and biochemical activities which might have increased the plant height and stem length. Similar results have been reported earlier in Crossandra (Narsimha Raju and Haripriya 2001). Gayithri *et al*. (2004) also reported enhanced plant growth and quality spikes in statice with application of bio fertilizers along with 50% of recommended N, P and 100% K, under green house condition. Gnanadevi and Haripriya (1999) reported increased plant height with VAM inoculation in chrysanthemum. Treatment T6 recorded maximum plant spread (49.17 cm) and minimum was recorded in control. Maximum plant spread and better architecture with biofertilizer application might be due to the supply of macro and micronutrients, enzymes and growth hormones by VAM. This finding is in conformity with those obtained by Nisha and Rajeshkumar (2010) in medicinal plants.

VAM and mineral fertilizers significantly affected stem size and number of leaves per plant and leave area of dracaena. Data revealed that treatment T6, i.e. Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19) resulted in maximum increased stem diameter (9.13 cm) and least increment (7.54 cm) in T1 (control). Nitrogen, being an essential part of nucleic acid this plays vital role in promoting the plant growth. Shabbir *et al*. (2010) also reported that AMF inoculums and low fertilization level (1/3 of full dose) enhanced trunk diameter on *in vitro* seedling of date palm cv. Khenizi.

Maximum number of leaves per plant was recorded in treatment T6, i.e. Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19), i.e. 39.75 and T1 (control) recorded minimum leaves, i.e. 23.67. Maximum increased leaf area (34.03 sq.cm) was also observed in the treatment T6 i,e., Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19) and minimum (26.84 sq.cm) in T1 (control). VAM fungi enhanced uptake of nutrient contents and also increased the number of leaves. Biofertilizers improves availability of nutrients by way of producing phytohormones (Jagnow *et al*. 1991). Dillon (1987) reported that phosphate act as an activator of some enzymes, leading to enhancement of the metabolism processes and formation of new cells, thus, increasing the vegetative growth. This result is in close conformity with the findings of Seema *et al*. (2015) who reported that AM fungi significantly increased the number of leaves in black pepper.

Total fresh biomass and total dry biomass (g): Maximum plant fresh biomass (47.67 g) and dry biomass (4.50 g) was observed in treatment T6 and lowest was recorded in T1 (control) for both the parameters. Better root profilation and nutrient uptake, higher leaf number and area, higher

Table 2 Means plant height (cm), stem length (cm), stem diameter (cm), number of leaves, leaf area (sq.cm), plant fresh biomass (g) and plant dry biomass (g) of dracaena as influenced by biological and mineral fertilizer and during 2018–19

Treatment	Plant height (cm)	Stem length (cm)	Number of leaves	Leaf area (sq. cm)	Plant spread (cm)	Stem diameter (cm)	Plant fresh biomass (g)	Plant dry biomass (g)
T1	32.88 ± 5.27	17.67 ± 7.12	23.67 ± 4.91	26.84 ± 5.68	35.00 ± 3.18	7.54 ± 0.30	13.33 ± 1.20	2.30 ± 0.23
T2	35.96 ± 5.99	19.67 ± 8.08	33.17 ± 2.40	31.21 ± 6.27	42.46 ± 6.21	8.01 ± 0.41	37.00 ± 0.94	3.30 ± 0.29
T3	34.80 ± 5.12	18.39 ± 7.28	32.75 ± 2.07	29.22 ± 4.19	43.67 ± 4.91	8.45 ± 0.55	24.50 ± 1.28	2.50 ± 0.38
T4	35.42 ± 4.19	19.42 ± 6.59	29.17 ± 2.98	29.14 ± 4.66	42.04 ± 5.20	9.05 ± 0.45	25.33 ± 1.20	2.50 ± 0.29
T5	38.04 ± 5.56	18.92 ± 5.63	34.00 ± 5.01	29.14 ± 3.51	36.99 ± 4.63	8.61 ± 0.71	35.00 ± 1.15	3.70 ± 0.26
T6	47.60 ± 6.83	22.09 ± 7.27	39.75 ± 5.53	34.03 ± 6.56	49.17 ± 5.63	9.13 ± 0.53	47.67 ± 1.13	4.50 ± 0.58
T7	39.50 ± 10.05	24.17 ± 8.56	31.50 ± 4.52	29.01 ± 5.15	42.21 ± 5.48	8.70 ± 0.76	47.33 ± 1.44	4.20 ± 0.35

T1, Soil (Control); T2, Soil + FYM (3:1) + 5 g VAM consortia + 100 ml BIO-NPK; T3, Soil + FYM (3:1) + 5 g VAM consortia + 200 ml BIO-NPK; T4, Soil + FYM (3:1) + 15 g VAM consortia; T5, Soil + FYM (3:1) + 3 g VAM consortia + 15 g NPK (19:19:19); T6, Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19); T7, Soil + FYM (3:1) + 3 g Urea + 5 g VAM consortia + 10 g NPK (19:19:19).

photosynthetic activity and enhanced food accumulation might lead to better plant growth and subsequently higher plant biomass. AM inoculation also enhanced plant biomass through the activities of dehydrogenase, phosphatase and nitrogen as enzymes (Rao and Tak 2001). The findings are in line with those observed by Seema *et al*. (2015) in black pepper and Akhter *et al*. (2015) in tomato.

Foliar P%: Treatment significantly increased foliar phosphorous uptake. Treatment T6 recorded the highest foliar phosphorus content (0.207%), whereas the minimum (0.130%) was recorded in control (T1). VAM inoculation in the media reinforced phosphorus leaf content by way of enhancing phosphorus exchange with root system. High P uptake might be due to better P mobilisation and consequent P uptake by fungal hyphae. VAM associations increased P and N uptake of the plants by enthralling phosphate, nitrate and ammonium in the soil (Khan *et al.* 2008). El-Naggar (2009) reported increased foliar P content with the application of higher dose of water soluble fertilizer in carnation cv. Red Sim. The observations are also in close agreement with the findings of Nielson *et al.* (2002) in carnation.

Mycorrhizal inoculation combined with balanced application of organic and inorganic fertilizers reinforced growth performance, plant biomass weight and nutrient uptake. The biological approaches provide its reliability and efficiency in the promotion of plant growth and quality of dracaena. Balanced fertilization resulted in increased SOC (Soil Organic Carbon) which resulted in improved soil physical properties such as *p*H, CEC etc. This consequently increases growth, yield and nutrient uptake significantly for all treatments against control. Treatment combination of Soil + FYM (3:1) + 3 g Urea + 10 g VAM consortia + 5 g NPK (19:19:19) was found best for growth promotion and nutrient uptake of *Dracaena marginata.*

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