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Influence of Soilless Growing Media Comprising Industrial By-products on Growth of Foliage Plants *Epipremnum aureum* and *Dracaena* sp.

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ABSTRACT

Experiments were conducted during August, 2020 to April, 2021 at the ICAR-Directorate of Floricultural Research, Pune, Maharashtra, India to assess the suitability of industrial by-products fly ash and press mud as growing media component for foliage plants *Epipremnum aureum* and *Dracaena* sp. Different growing media compositions comprising of fly ash, press mud, cocopeat and vermicompost were evaluated in varying proportions. Foliage plants growth was monitored for nine months duration. Initial pH and electrical conductivity of growing media compositions were determined and leaf samples were analyzed for macro and micronutrients content at the end of the experiment. pH of growing media compositions ranged from near neutral to slightly alkaline pH and electrical conductivity of all media compositions was less than 1.0 dS m^{-1}. Results indicated that growing media composition Fly ash+Vermicompost+Cocopeat (20:30:50) was the most suited growing media to grow *Epipremnum aureum* under 50% shade condition. Media compositions Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) and Fly ash+Vermicompost+Cocopeat (20:30:50) were observed to be more suited for growth of *Dracaena sp.* under 50% shade condition. Maximum plant height, number of leaves, leaf size and petiole length were recorded in *Epipremnum aureum* and *Dracaena sp.* plants grown in above media compositions respectively. Results inferred that fly ash along with vermicompost and cocopeat can be used as a growing media component for production of foliage plants *Epipremnum aureum* and *Dracaena* sp.

KEYWORDS: Fly ash, foliage plants, growing media, press mud

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Ornamental plants production is a booming sector of horticulture in terms of volume and value. Among the various contributors of greenhouse production cost, growing media is the most prominent one after labor (Restrepo et al., 2013; Pascual et al., 2018). Potted plants production with soilless growing media is tricky because of small pot volume (Bunt, 1988) and standardization of media properties is important because of small volume of media in pot (Savvas et al., 2013) Achieving balance between pore space and water storage is difficult in soil media at small volume because of its inherent texture and structure. Also, removal of fertile top soil for using as growing media can cause land degradation (Mintah et al., 2022). Soilless substrates offer an array of options to choose from to ensure adequate supply of water, air and nutrients to growing plants (Chrysargyris et al., 2019).

Cocopeat, due to its similarity in properties to peat, has been widely used in containerized production of ornamental potted plants (Erwan et al., 2013). Reduction in volume, water saturation at the lower layers and inadequate anchorage to full grown plants are some of the reasons for not using cocopeat alone as growing media. Apart from cocopeat, substrates like bark, wood fiber, compost derived from several agro-residues and vermicompost either alone or in combination were also identified to have the potential as alternate substrates to replace peat (Tahir et al., 2013; Agarwal et al., 2021). Research is therefore now focused toward the use of locally available materials to identify economic alternate substrates to commercial peat (Bragg and Brough, 2014; Manh and Wang, 2014). In addition to cost, consistency in availability, stability with respect to chemical properties (Agarwal et al., 2021) and environmentally friendly aspects (Khachatryan et al., 2014) are important factors that influence the acceptance of a new growing media by the consumers.

Many agro-industrial residues are gaining popularity as growing media because of availability in terms of quantity, time and low cost. Fly ash is a by-product of coal/lignite based thermal power stations and there has been reports on beneficial effects of fly ash as soil additive (Grace et al., 2016), on plant growth (Schonegger et al., 2018; and presence of essential plant nutrients (Ansari et al., 2022), significant oxide constituents along with heavy metals (Nayak et al., 2015; Bartonova, 2015; Schönegger et al., 2018). Content and ratio of main elements (Zolotova, 2019) and heavy metals concentration in fly ash depends on feed coal and combustion methods (Ram and Masto, 2014; Al-Areqi et al., 2019). Presence of heavy metals in fly ash could be a disapproving factor for using it as a media for vegetables and other edible plants. But its effect on improving compactness of media when added to a lighter media like cocopeat, presence of essential plant nutrients, consistent availability and less cost would make it a feasible alternate media component for ornamental plants nurseries. Press mud which is a by-product of sugar industry (Diaz, 2016) has been used as soil conditioner (Kumar and Chopra, 2014) and organic fertilizer (Budiyanto, 2021). For every hundred tons of sugarcane crushed 3 tons of press mud is produced as by-product (Mohamad et al., 2022). Press mud contains essential macro and micronutrients along with organic carbon (Krishnaveni et al., 2020) and also easily available (Gunjal and Gunjal, 2021). Therefore, in the present study fly ash and press mud were evaluated for their suitability as growing media components for growing two foliage plants *Epipremnum aureum* and *Dracaena* sp.

2. MATERIALS AND METHODS

Experiments were conducted during August, 2020 to April, 2021 at the ICAR-Directorate of Floricultural Research, Pune, Maharashtra, India. Eleven growing media compositions with graded levels of fly ash and press mud along with vermicompost and cocopeat were formulated as follows-

T_1: Fly ash+Vermicompost+Cocopeat (10:30:60), T_2: Fly ash+Vermicompost+Cocopeat (15:35:50), T_3: Fly ash+Vermicompost+Cocopeat (20:30:50), T_4: Press mud+Vermicompost+Cocopeat (25:25:50), T_5: Press mud+Vermicompost+Cocopeat (35:20:45), T_6: Press mud+Vermicompost+Cocopeat (45:15:40), T_7: Fly ash+Press mud+ Cocopeat+Vermicompost (10:25:25:40), T_8: Fly ash+Press mud+Cocopeat+Vermicompost (12.5:37.5:25:25), T_9: Fly ash Press mud+ Cocopeat +Vermicompost (15:35:40:10), T_{10}: Fly ash+ Press mud+Cocopeat+Vermicompost (20:45:25:10), T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3).

Pot experiments were conducted during August 2020–April 2021 to evaluate the growth of *Epipremnum aureum* and *Dracaena sp.* in different growing media compositions. Each growing media component was weighed on dry weight basis according to the treatments, mixed thoroughly and filled into 10” plastic pots. Treatment 11 comprising Cocopeat+Vermiculite+Perlite at 33.3:33.3:33.3 w/w was considered as standard soilless media. Growing media composition samples were analyzed for their pH and electrical conductivity (EC) levels at the start of the experiment.

Three weeks old cuttings of both the foliage plants were transplanted into each of the pots and pots were kept in shade net house (50% shade). Irrigation was done manually as and when the media surface was observed to be dry. Foliage plants growth was monitored for nine months and growth observations were recorded at 3, 6 and 9 months after planting. Leaf samples were collected at the end of the experiment and analyzed for macro and micronutrients content.

The experiments were laid out in completely randomized block design and replicated thrice. Experimental results were analyzed for statistical significance at 5% level of significance as per the standard procedure given by Panse and Sukatme (1978).

3. RESULTS AND DISCUSSION

3.1. pH and electrical conductivity of growing media compositions

pH of growing media compositions varied from neutral to slightly alkaline with the highest in T_6 Press mud+Vermicompost+Cocopeat (45:15:40) (7.62) and lowest in T_1 Fly ash+Vermicompost+Cocopeat (10:30:60) (6.61) (Figure 1). Electrical conductivity (EC) of all growing media compositions was less than 1.0 dS m^{-1} (Figure 1) indicating that the amount of salts present in them was not harmful to plant growth. It was observed that addition of fly ash to cocopeat and vermicompost resulted near neutral pH and lower EC (T_1, T_2, T_3) while addition of filter press mud increased pH and EC (T_4, T_5, T_6) of growing media compositions. Doli et al. (2020) reported an improvement in physico-chemical properties such as pH, bulk density, particle density and cation exchange capacity with fly ash

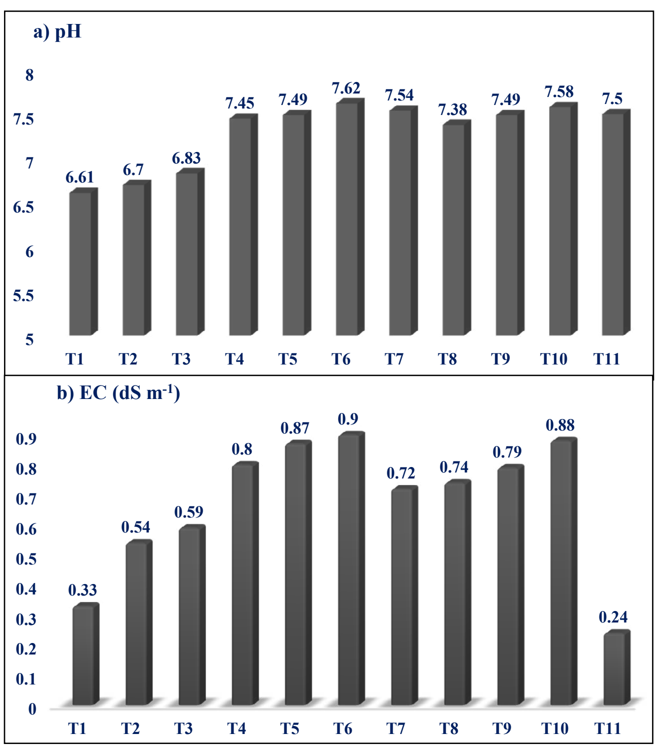

Figure 1: Initial pH and electrical conductivity (EC) of growing media compositions

application to soil at the rate 20–40 g/m^2. pH and EC of substrates play a significant role in plant growth and development (Chen et al., 1999) as they impact nutrient and water availability to growing plants.

3.2. Epipremnum aureum

Significant variation was observed in growth of *Epipremnum aureum* plants grown in different growing media compositions. Growth observations of *Epipremnum aureum* as influenced by different growing media compositions at 3, 6 and 9 months after planting are depicted in Table 1.

Highest plant height of *Epipremnum aureum* was recorded in growing media compositions T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) followed by T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) at 3, 6 and 9 months after planting (Table 1). However, effect of these growing media compositions on plant height was found to be at par with each other. The lowest plant height was recorded in plants grown in media composition T_8: Fly ash+Press mud+Cocopeat+Vermicompost (12.5:37.5:25:25). Use of fly ash as an amendment and as source of micronutrients has been well established (Grace et al., 2016). Upadhyay et al. (2021) reported good growth performance of chickpea in terms of fresh weight and dry weight with 15 days preincubated application of fly ash (40%) and manure.

Amending soil or media with fly ash has been reported to improve texture, water retention and stability, alter pH and supply essential nutrients particularly micronutrients to plants (Ram and Reginald, 2010; Riehl et al., 2010). Addition of fly ash as an amendment at 20% level has increased growth of eggplant as reported by Rizvi and Khan (2009). Plants grown in media composition T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) were observed to record maximum leaf length and differed significantly from all media compositions except T_2: Fly ash+Vermicompost+Cocopeat (15:35:50). Maximum leaf width was recorded in media T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) and non-significant differences were observed among media compositions T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) T_1: Fly ash+Vermicompost+Cocopeat (10:30:60) and T_5: Press mud+Vermicompost+Cocopeat (35:20:45) for leaf width. However minimum leaf length and width were recorded in media composition T_8: Fly ash+Press mud+Cocopeat+Vermicompost (12.5:37.5:25:25). Similar to other growth attributes, highest petiole length was recorded in media composition T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) followed by media T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) and T_1: Fly ash+Vermicompost+Cocopeat (10:30:60). However, effect of these media compositions on petiole length was found to be at par with each other. Fly ash addition at lowers rates of 10–30% has been proven beneficial to many crops

Table 1: Effect of different growing media containing industrial by-products on growth of *Epipremnum aureum*

Treatments	3 months after planting					6 months after planting					9 months after planting				
	PH	NLP	LL	LW	PL	PH	NLP	LL	LW	PL	PH	NLP	LL	LW	PL
T_1	15.3	5.8	9.6	5.7	4.3	34.5	35.1	9.9	6.1	5.0	130.8	53.1	11.5	7.4	5.9
T_2	15.8	7.0	9.8	5.8	4.6	34.8	39.1	9.9	6.2	5.7	135.3	65.5	11.7	7.5	6.1
T_3	16.7	7.9	10.3	5.9	5.0	39.9	53.3	10.4	6.3	5.8	148.4	91.9	12.0	7.7	6.6
T_4	14.2	5.3	8.3	4.8	3.1	19.2	26.2	9.2	5.0	4.0	60.7	48.5	10.1	6.3	4.8
T_5	15.3	7.4	9.5	5.6	4.2	31.8	53.0	9.9	5.8	4.8	120.4	80.7	11.0	7.3	5.6
T_6	15.1	7.4	9.5	5.4	3.8	25.3	42.1	9.9	5.6	4.6	104.7	83.9	10.7	7.1	5.6
T_7	15.0	7.0	9.4	5.2	3.7	25.1	39.5	9.9	5.5	4.5	102.9	60.1	10.6	7.1	5.6
T_8	10.4	4.7	7.8	4.0	3.0	13.4	10.8	7.8	4.2	3.6	43.3	39.6	8.9	4.9	4.1
T_9	13.5	4.8	8.2	4.7	3.1	16.7	25.5	9.0	4.9	3.8	46.9	52.8	9.8	6.2	4.2
T_{10}	14.9	5.5	9.3	5.1	3.6	25.0	33.8	9.4	5.3	4.4	99.1	36.2	10.6	6.8	5.5
T_{11}	14.3	4.5	8.4	4.9	3.5	23.8	13.7	9.3	5.0	4.3	78.7	24.1	10.5	6.5	5.2
SEm±	0.36	0.3	0.18	0.12	0.27	2.3	3.6	0.31	0.25	0.26	7.95	4.7	0.32	0.23	0.26
CD (*p<0.05)	1.05	1.08	0.52	0.35	0.79	6.88	10.6	0.9	0.8	0.76	23.4	14.09	0.95	0.68	0.79

PH: Plant height (cm); NLP: No. of leaves plant^{-1}; LL: Leaf length (cm); LW: Leaf width (cm); PL: Petiole length (cm)

as observed by Swain and Padhi (2012) and Sethi (1996) in guava and Kuchanwar and Matte (1997) in groundnut. Kumar and Kumar (2022) reported that fly ash has adequate quantity of micro-nutrients (Mn, Fe, Cu, Zn, Se) and macro-nutrients and was helpful as a fertilizer in improving the productivity of legume crops *Vigna mungo, Vigna radiata* and *Vigna unguiculata* crops when used at lower amount of 25 g m^{-2}. Number of leaves plant^{-1} recorded in *Epipremnum aureum* plants showed non-significant differences among T_3: Fly ash+Vermicompost+Cocopeat (20:30:50), T_5: Press mud+Vermicompost+Cocopeat (35:20:45), T_6: Press mud+Vermicompost+Cocopeat (45:15:40), T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) and T_7: Fly ash+Press mud+Cocopeat+Vermicompost (10:25:25:40). However, minimum number of leaves plant^{-1} was recorded in *Epipremnum aureum* plants raised media composition T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3). Gupta et al. (2002) reported an enhanced growth response and biomass production of cashew graft due to fly ash addition as a media component along with soil and they attributed this growth response to increased availability of nutrients and moisture in the soil mixture containing fly ash.

Nutrient content data of leaf samples of *Epipremnum aureum* showed that nitrogen, phosphorous and potassium contents ranged from 2.22 to 3.64%, 0.41–0.68% and 1.28 to 2.68% respectively (Figure 2). Maximum nitrogen contents were recorded in plants grown in media compositions T_3: Fly ash+Vermicompost+Cocopeat (20:30:50), T_5: Press mud+Vermicompost+Cocopeat (35:20:45), T_9: Fly ash+Press mud+Cocopeat+Vermicompost (15:35:40:10) and T_{10}: Fly ash+Press mud+Cocopeat+Vermicompost (20:45:25:10). Plants grown in media compositions T_3 and T_2 and T_1 had accumulated comparatively higher phosphorous content than plants grown in other media compositions. Iftikar et al. (2020) reported increased availability of nutrients due to application of vermicomposted

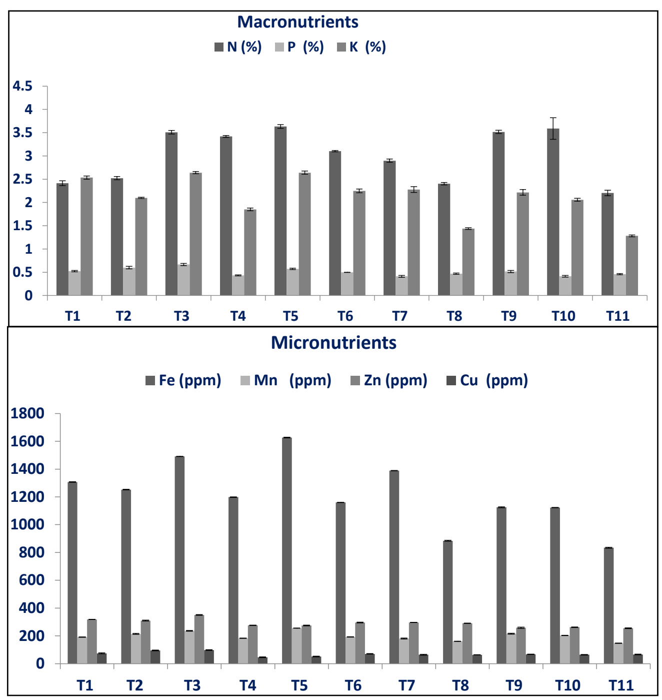

Figure 2: Nutrient content of *Epipremnum aureum* leaves as influenced by different growing media containing industrial by-products

fly ash which enhanced soil fertility in integrated nutrient management of potato. Among micronutrients, maximum copper and manganese contents were recorded in T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) (Figure 2). A higher absorption of micronutrients like copper, iron, manganese, molybdenum, zinc, boron in vegetables, millets and apple trees grown in poly pots of neutral soil amended with fly ash has been reported by Furr et al. (1979). Sahoo et al. (2021) reported higher accumulation of manganese, zinc, iron in rice seeds along with Cd, Ni and Co due to co-application of fly ash and municipal biosolid.

3.3. *Dracaena sp.*

Growth observations of *Dracaena* sp. as influenced by different growing media compositions at 3, 6 and 9 months after planting are depicted in Table 2.

Table 2: Effect of different growing media containing industrial by-products on growth of *Dracaena* sp.

Treat-ments	3 months after planting						6 months after planting						9 months after planting					
	PH	NLP	PS	LL	LW	PL	PH	NLP	PS	LL	LW	PL	PH	NLP	PS	LL	LW	PL
T_1	13.6	9.9	13.7	8.4	2.9	1.3	32.6	17.3	20.5	15.3	5.1	1.9	53.7	31.4	28.3	18.1	7.2	4.4
T_2	17.5	10.6	16.3	9.4	3.1	1.3	33.3	17.3	25.1	16.5	5.6	2.2	59.1	41.6	29.3	19.5	8.2	4.7
T_3	14.7	9.7	14.5	8.5	2.9	1.0	27.2	14.7	22.1	14.1	4.9	2.0	54.5	34.9	26.4	18.5	7.6	4.4
T_4	16.3	9.7	15.3	9.1	3.1	1.1	27.4	14.7	23.1	14.6	5.0	2.0	54.8	35.5	26.8	18.9	7.6	4.4
T_5	13.5	9.6	13.6	8.4	2.7	1.0	27.1	14.5	20.1	14.1	4.6	1.9	53.1	31.3	25.9	18.1	7.1	4.4
T_6	16.6	11.2	15.6	9.4	3.1	1.3	33.6	19.6	23.8	17.2	5.7	2.1	57.3	36.4	29.9	19.4	7.6	4.6
T_7	13.0	8.6	11.7	7.4	2.5	0.4	26.0	13.5	18.6	13.1	3.8	1.3	44.8	25.2	23.5	16.9	5.9	3.6
T_8	13.1	8.9	12.3	8.3	2.6	0.9	26.7	14.1	19.7	13.4	4.4	1.6	52.5	29.8	23.6	17.7	6.6	4.2
T_9	14.2	9.9	14.1	8.5	2.9	1.2	30.6	15.0	21.2	14.7	5.1	2.0	54.1	32.5	27.6	18.2	7.2	4.4
T_{10}	13.1	8.6	11.8	7.7	2.5	1.0	26.8	14.4	19.3	13.9	4.5	1.5	51.8	29.3	25.1	17.7	6.4	3.7
T_{11}	20.8	11.3	16.4	10.6	3.8	1.4	34.5	24.8	31.9	18.1	6	2.6	64.8	49.4	33.5	19.9	8.5	5.1
SEm±	1.98	0.66	0.8	0.46	0.14	0.28	1.62	2.17	1.81	0.8	0.3	0.16	3.93	3.93	1.13	0.87	0.49	0.13
CD	5.86	1.95	2.38	1.38	0.42	0.84	4.77	6.41	5.36	2.37	0.89	0.47	11.6	11.61	3.35	2.58	1.46	0.38

PH: Plant height (cm); NLP: No. of leaves plant^{-1}; PS: Plant spread (cm); LL: Leaf length (cm); LW: Leaf width (cm); PL: Petiole length (cm); CD: CD (*p<0.05)

Maximum plant height was recorded in *Dracaena* sp. plants grown in media composition T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) followed by T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) at 3, 6 and 9 months after planting. However, effect of media compositions T_2: Fly ash+Vermicompost+Cocopeat (15:35:50), T_6: Press mud+Vermicompost+Cocopeat (45:15:40) and T_4: Press mud+Vermicompost+Cocopeat (25:25:50) on plant height was found to be at par with each other. Shorter plants were observed in media T_7: Fly ash+Press mud+Cocopeat+Vermicompost (10:25:25:40). Combination of perlite and vermiculite has the ability to provide adequate aeration in the root zone (Kazzaz and Kazzaz, 2017) and better nutrient availability particularly more available potassium and magnesium owing to its higher cation exchange capacity (Hindman, 2006) Perlite with vermiculite medium has been reported to give better root growth parameters and survival percentage of pomegranate cuttings (Rajkumar et al., 2017). Mahala and Sharma (2020) reported highest plant height of tomato seedling in media containing Vermiculite+Perlite+ Vermicompost (1:1:2). Effect of all media compositions on number of leaves plant^{-1} was observed to be at par with each other except media T_7, T_8 and T_{10}. Highest plant spread was observed in plants grown in media composition T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) followed by T_2: Fly ash+Vermicompost+Cocopeat (15:35:50). However, effect of growing media compositions T_{11}, T_2, T_6, T_4 and T_3 on plant spread was found to be at par with each other. Plant spread was minimum in T_7: Fly ash+Press mud+Cocopeat+Vermicompost (10:25:25:40). Media composition T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) was observed to record maximum leaf length and differed significantly from all media compositions except T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) and T_6: Press mud+Vermicompost+Cocopeat (45:15:40). Significantly higher leaf width was observed in plants grown media composition T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) when compared with all other treatments. Leaf length and width were minimum in plants grown in T_7: Fly ash+Press mud+Cocopeat+Vermicompost (10:25:25:40). Vermiculite is a 2:1 layered expandable clay mineral and has the ability to hold and steadily release moisture encouraging optimal hydration levels in the root zone (Liu et al., 2016). Perlite is porous in nature, promotes drainage and allows adequate aeration to plant roots (Beeson et al., 2018). Combination of perlite and vermiculite has the ability to provide adequate aeration in the root zone (Kazzaz and Kazzaz, 2017) and better nutrient availability due to higher cation exchange capacity of vermiculite (Hindman, 2006). This combination of appropriate nutrient availability, water holding capacity and aeration in the media might have resulted in better growth of *Dracaena* sp. plants in Cocopeat+Vermiculite+Perlite media. Petiole length did not vary significantly among the media compositions except in T_7. Maximum petiole length was recorded in plants grown in T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) and minimum petiole length which was significantly lesser than T_{11} was recorded in plants grown in T_7: Fly ash+Press mud+Cocopeat+Vermicompost (10:25:25:40).

Nutrient content data of leaf samples of *Dracaena sp*. plants grown in different media compositions is presented in Figure 3. Maximum nitrogen content was observed in plants grown in media composition T_3: Fly ash+Vermicompost+Cocopeat (20:30:50) followed by T_2: Fly ash+Vermicompost+Cocopeat (15:35:50) and T_4: Press mud+Vermicompost+Cocopeat (25:25:50). *Dracaena* sp. plants grown in media compositions T_{11}: Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) had accumulated comparatively higher phosphorous and potassium contents than plants grown in other media compositions. Vermiculite which has lamellar structure and perlite with its honeycomb structure have good adsorption properties and can adsorb more phosphorus (Xu et al., 2021). Among micronutrients higher manganese, iron and copper contents were recorded in leaves of plants grown in T_3: Fly ash+Vermicompost+Cocopeat (20:30:50). Zinc content of leaves did not vary much among different media compositions. Higher accumulation of micronutrients like manganese, zinc, iron along with Cd, Ni and Co was observed in rice seeds due to co-application of fly ash and municipal biosolid (Sahoo et al., 2021). Higher absorption of micronutrients was reported in vegetables, millets and apple trees grown in poly pots of neutral soil amended with fly ash by Furr et al. (1979).

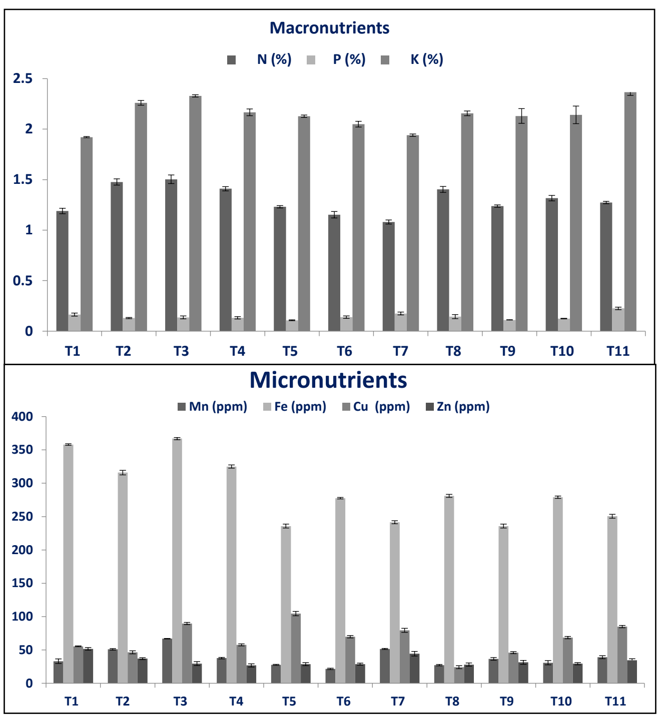

Figure 3: Nutrient content of *Dracaena* sp. leaves as influenced by different rowing media containing industrial by-products

4. CONCLUSION

Media composition Fly ash+Vermicompost+Cocopeat (20:30:50) was found to be the best growing media to grow *Epipremnum aureum* under 50% shade condition. Media compositions Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) and Fly ash+Vermicompost+Cocopeat (20:30:50) were observed to produce vigorous growth of *Dracaena* sp. under 50% shade condition. Therefore, it can be inferred that fly ash along with vermicompost and cocopeat can be used as a growing media component for production of foliage plants *Epipremnum aureum* and *Dracaena* sp.

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