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Influence of cocopeat based medium and nutrient scheduling on leather leaf fern

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ABSTRACT

Production and quality of cut foliage in leather leaf fern, is influenced by the growing medium and nutrients. A study was conducted to evaluate the influence of cocopeat based substrates and nutrient doses on production and quality of leather leaf fern. Four substrate combinations along with four nutrient schedules were evaluated. The medium comprising of cocopeat + soil + FYM (1:1:1 v/v) + 2 % Arka Microbial Consortium (AMC) in combination with nutrients @ 100:30:60 kg NPK ha^{-1} $year^{-1}$ i.e., full P as basal dose and N and K at bimonthly intervals in six split doses applied to the substrate, produced 9.81 cut foliage $plant^{-1}$ $month^{-1}$ with good quality attributes of foliage *viz*., length of lamina (28.19 cm), length of stipe (19.76 cm), length of frond (47.85 cm), width of frond (22.93 cm), number of pinnae (11.64), stipe diameter (3.06 mm) and prolonged vase life of 30.12 days. Highest benefit cost ratio of 2.18 was obtained in this treatment combination. Chemical analysis of the substrate revealed slightly acidic pH, normal EC, optimum levels of organic carbon, high levels of available N, P, K, normal range of Ca, Mg, Fe, Mn, Zn and Cu. Leaf nutrient status registered low levels of major nutrient, sufficient levels of Mg, Mn, Zn and Cu and high levels of Ca and Fe. The microbial population was in the range of 10^4:10^6 cfu g^{-1} substrate.

Keywords: *Rumohra adiantiformis*, cut foliage, nutrition schedule, substrates.

INTRODUCTION

Leather leaf fern [*Rumohra adiantiformis.* (G. Forst.) Ching.] *popularly known as the seven week fern is a* shade loving plant *that belongs to the family Dryopteridaceae. The* long foliage frond is used in floral decorations and bouquets and is a highly preferred cut green due to its post harvest longevity, low cost, availability round the year and variable form, texture and colour (D'Souza *et al*., 2). *A*mong the tropical foliage, leather leaf fern alone accounts for half the volume of the global cut foliage trade and is in constant demand. It has been indicated that 25-30% of bouquets consist of foliage compared to 5%, which was the trend 15 years earlier and is likely to increase further with increase in the demand for floral products (Whiriskey and Carthy, 14). The present area under cultivation of this crop in India is negligible but the prospects for its commercial cultivation are high due to the suitable climatic conditions prevailing. According to Singh (8) reliable information is lacking on the demand for the cut foliage of ferns in India but the superiority over the other greens is well established in the trade. The substrate and the nutrients are two crucial factors that determine the production and the quality of the Leather leaf ferns. Substrates influence plant quality and production costs (Salvador and Minami,5). Most tropical foliage plants require regular feeding at fortnightly intervals during the growing season (Sanders, 6). Leather leaf fern retain the dark green colour of foliage if fertilized regularly and nitrogen plays a major role in the growth and development (Scott, 7). In view of the above, a study was conducted to evaluate the influence of substrates and nutrient levels on production and quality of leather leaf fern.

MATERIALS AND METHODS

An experiment was conducted in the Division of Floriculture and Medicinal crops, ICAR-Indian Institute of Horticultural Research, Bengaluru during 2013 to 2016 on leather leaf fern grown on four different substrate compositions along with four nutrient schedules in sixteen treatment combinations. Leather leaf fern (*Rumohra adiantiformis*) plant rhizomes having three fully expanded fronds and at least one circinate frond were planted at 45 × 45 cm on raised beds in four different substrate combinations and with four nutrient schedules in 75% green shade net house and the treatments were replicated thrice in factorial randomised block design. The treatment details were as follows:

Factor A: Substrate combinations

S_1: Cocopeat + sand + FYM (1:1:1 v/v) + 2 % Arka microbial consortium

S_2: Cocopeat + soil + FYM (1:1:1 v/v) +2 % Arka microbial consortium\

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S_3: Cocopeat +sand + vermicompost (1:1:1 v/v) +2 % Arka microbial consortium

S_4: Cocopeat + soil +vermicompost (1:1:1 v/v) + 2 % Arka microbial consortium

Factor B: Nutrient scheduling

N_1: Application of N and K in 12 split doses to substrate (at monthly intervals)

N_2: Application of N and K in 6 split doses to substrate (at bimonthly intervals)

N_3: Application of 50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals

N_4: Application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals

Nutrients were applied to all the treatments @ 100:30:60 kg NPK ha^{-1} $year^{-1}$. Entire amount of phosphorous was incorporated as basal dose for all the treatments. Arka microbial consortium (AMC) which is solid based bioinoculant containing nitrogen fixer, growth promoter, P, Zn and K solubilizer developed at ICAR-IIHR, Bengaluru was applied to all the substrate combinations @ 2 % by thorough drenching. The microbial population particularly the AMC containing *Azotobacter* sp., *Bacillus* spp. and *Pseudomonas* sp. was monitored at quarterly intervals and replenished to optimum levels. Observations were recorded on the number of harvestable foliage, lamina length, stipe length, frond length, width of pinna, stipe diameter, stage of harvest and vase life, chemical and biological properties of substrates. Stage of harvest on foliage quality and post:harvest quality were also recorded. Vase life was evaluated under room condition (20°C -27°C & 55:60% RH) in distilled water. The data recorded during the three years of study was pooled and analysed statistically using SAS 9.3 software.

RESULTS AND DISCUSSION

Substrate combinations had significant effect on the yield and the quality traits which are related to the marketability of the cut foliage (Table 1). Cocopeat + soil + vermicompost (1:1:1 v/v) + 2 % AMC recorded significantly higher number of cut foliages $plant^{-1}$ $month^{-1}$ (9.38), length of lamina (27.38 cm), length of stipe (20.27cm), length of frond (47.62cm), width of frond (22.90 cm), number of pinnae (11.76) and stipe diameter (2.70 mm). Cocopeat+ soil + FYM (1:1:1 v/ v) +2 % AMC was on par with respect to the number of cut foliages $plant^{-1}$ $month^{-1}$ (8.56), length of lamina (26.00 cm), length of frond (43.55 cm), width of frond (21.69 cm) and stipe diameter (2.65 mm). However, cocopeat+ sand + FYM (1:1:1 v/v) + 2 % AMC combination resulted in the lowest values for average number of cut foliages $plant^{-1}$ $month^{-1}$ (5.10), length of lamina (20.81 cm), length of stipe (11.21 cm), length of frond (31.33 cm), average width of frond (17.70 cm), number of pinnae (10.06) and stipe diameter (1.77 mm). Addition of soil to the cocopeat resulted in higher yield and superior quality over sand which might be attributed to the better water holding and nutrient buffering capacity of soil. Organic manures improve the growth and yield,

Table 1. Effect of substrates and nutrient doses on yield and quality of leather leaf fern (pooled data 2013-16).

Treatments	Average number of cut foliage / plant / month	Length of lamina (cm)	Length of stipe (cm)	Length of frond (cm)	Width of frond (cm)	Number of pinnae	Stipe diameter (mm)
S_1	5.10	20.81	11.21	31.33	17.70	10.06	1.77
S_2	8.56	26.00	17.73	43.55	21.69	11.23	2.65
S_3	6.08	21.81	12.86	34.19	18.71	10.38	1.97
S_4	9.38	27.38	20.27	47.62	22.90	11.76	2.70
CD (P=0.05)	1.13	1.86	2.29	4.23	1.62	0.51	0.27
N_1	6.11	22.39	13.92	35.77	18.87	10.47	2.06
N_2	7.37	24.41	15.58	39.64	20.44	10.84	2.33
N_3	7.51	24.37	15.67	39.73	20.66	10.99	2.30
N_4	8.13	24.84	16.92	41.55	21.03	11.12	2.38
CD (P=0.05)	1.13	NS	NS	NS	NS	NS	NS

Treatment details:

Factor A: Substrates S_1: Cocopeat+ Sand + FYM (1:1:1 v/v) + 2 % AMC; S_2: Cocopeat+ Soil + FYM (1:1:1 v/v) +2 % AMC; S_3: Cocopeat+ Sand + Vermicompost (1:1:1 v/v) +2 % AMC; S_4: Cocopeat+ Soil + Vermicompost (1:1:1 v/v) + 2 % AMC

Factor B: Nutrient scheduling N_1: Application of N and K in 12 split doses to substrate (at monthly intervals); N_2: Application of N and K in 6 split doses to substrate (at bimonthly intervals); N_3: Application of 50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals; N_4:Application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals besides improving soil fertility and productivity through microbial proliferation (Keditsu, 4). In confirmation with this, the combination of cocopeat, soil and organic manures has resulted in increased production and superior cut foliage quality.

Production of cut foliage was influenced significantly by nutrient scheduling (Table 1). Split doses of N and K at different growth crop stages proved to be highly beneficial along with basal application of full dose of P across all the treatments. Application of NPK@ 100:30:60 kg NPK ha^{-1} $year^{-1}$ (50% of N and K to substrate in 2 equal splits during June and January + remaining 50% as foliar spray at fortnightly intervals+ basal application of full dose of P) resulted in the maximum number of cut foliage $plant^{-1}$ $month^{-1}$ (8.13). NPK @ 100:30:60 kg ha^{-1} $year^{-1}$ (N and K in 6 split doses to substrate at bimonthly intervals+ basal application of full dose of P) and 100:30:60 kg NPK ha^{-1} $year^{-1}$ (50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals+ basal application of full dose of P) were on par for cut foliage production (7.37 and 7.51 number $plant^{-1}$ $month^{-1}$, respectively). According to Stamps (9), commercially acceptable leather leaf fern can be produced for at least one full year with monthly applications of fertilizer at rates as low as 114 kg N ha^{-1} $year^{-1}$. Split application of the fertilisers has been advocated in asparagus by Walker (13) for efficient fertiliser use which is corroborated by the results of this experiment. The availability of optimum dose of nutrient at each stage of the crop growth might have resulted in enhanced production. Minimum number of cut foliage $plant^{-1}$ $month^{-1}$ (6.11) was recorded in 100:30:60 kg NPK ha^{-1} $year^{-1}$ (N and K in 12 split doses to substrate at monthly intervals+ basal application of full dose of P). However no significant effects on the foliage quality were observed due to the nutrient scheduling.

The interaction effects between the substrates and the nutrient regimes were significant for the number of cut foliages $plant^{-1}$ $month^{-1}$, foliage quality parameters *viz*., length of lamina, length of stipe, length of frond, width of frond, number of pinnae and stipe diameter (Table 2). Cocopeat + soil + vermicompost (1:1:1 v/v) + 2 % AMC along with

Table 2. Interaction effect of substrates and nutrient doses on yield and quality of leather leaf fern (pooled data 2013-16).

Treatments	Number of cut foliage/ plant/month	Length of lamina (cm)	Length of stipe (cm)	Length of frond (cm)	Width of frond (cm)	Number of pinnae pairs	Stipe diameter (mm)
S_1N_1	4.24	20.02	10.01	29.48	17.13	9.94	1.62
S_1N_2	3.96	18.68	8.76	26.04	15.37	9.23	1.47
S_1N_3	4.22	19.30	9.06	27.57	16.39	9.62	1.58
S_1N_4	7.99	25.25	17.03	42.25	21.90	11.43	2.39
S_2N_1	6.91	23.85	15.47	38.75	19.65	10.77	2.20
S_2N_2	9.81	28.19	19.76	47.85	22.93	11.64	3.06
S_2N_3	9.37	27.06	19.03	46.04	22.94	11.59	2.78
S_2N_4	8.17	24.91	16.66	41.55	21.24	10.90	2.55
S_3N_1	4.74	19.12	10.86	29.00	16.13	9.52	1.74
S_3N_2	6.04	22.38	12.47	35.00	19.72	10.48	1.96
S_3N_3	7.13	24.06	15.28	38.98	20.67	11.14	2.26
S_3N_4	6.41	21.68	12.83	33.78	18.32	10.36	1.92
S_4N_1	8.55	26.57	19.32	45.84	22.55	11.63	2.68
S_4N_2	9.67	28.38	21.32	49.67	23.76	12.02	2.84
S_4N_3	9.34	27.06	19.31	46.33	22.64	11.61	2.60
S_4N_4	9.94	27.52	21.14	48.63	22.67	11.78	2.68
CD (P=0.05)	2.26	3.73	4.58	8.47	3.23	1.03	0.54

Treatment details: Factor A: Substrates S_1: Cocopeat+ Sand + FYM (1:1:1 v/v) + 2 % AMC; S_2: Cocopeat+ Soil + FYM (1:1:1 v/v) +2 % AMC; S_3: Cocopeat+ Sand + Vermicompost (1:1:1 v/v) +2 % AMC; S_4: Cocopeat+ Soil + Vermicompost (1:1:1 v/v) + 2 % AMC
Factor B: Nutrient scheduling N_1: Application of N and K in 12 split doses to substrate (at monthly intervals); N_2: Application of N and K in 6 split doses to substrate (at bimonthly intervals); N_3: Application of 50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals; N_4:Application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals

application of 100:30:60 kg NPK ha^{-1} $year^{-1}$ (N and K in two splits i.e., 50% N and K to substrate in 2 equal splits during June and January + remaining 50% as foliar spray at fortnightly intervals+ basal application of full dose of P) resulted in the maximum number of cut foliage $plant^{-1}$ $month^{-1}$ (9.94). Cut foliage production in the treatment combination of cocopeat+ soil + FYM (1:1:1 v/v) +2 % AMC with application of N and K in 6 equal split doses to substrate at bimonthly intervals (9.81) was at par. The minimum number of cut foliage $plant^{-1}$ $month^{-1}$ (3.96) was recorded incocopeat+ sand + FYM (1:1:1 v/v) + 2 % AMC along with full P as basal dose and N , K in 6 split doses to substrate at bimonthly intervals. Soil along with vermicompost and FYM has higher organic matter content which would have substantially contributed to moisture retention in the medium and nutrient availability for the crop. Sand as a component of the growing medium might be lacking in these two crucial aspects resulting in a much lower yield. Foliar application of part of the nutrient dose, though not significantly superior, resulted in a marginally higher production over substrate application.

The substrate combination of cocopeat+ soil + vermicompost (1:1:1 v/v) + 2 % AMC along with application of N and K in 6 split doses to substrate at bimonthly intervals @ 100:30:60 kg NPK ha^{-1} $year^{-1}$recorded the maximum length of lamina (28.38 cm), length of stipe (21.32 cm), length of frond (49.67 cm), width of frond (23.76 cm) and number of pinnae (12.02) with a stipe diameter (2.84 mm) was on par with S_2N_2 : cocopeat+ soil + FYM (1:1:1 v/v) +2 % AMC with application of N and K in 6 equal split doses to substrate at bimonthly intervals for length of lamina (28.19 cm), length of stipe (19.76 cm), length of frond (47.85 cm), width of frond (22.93 cm) and number of pinnae (11.64) and the maximum stipe diameter (3.06 mm). The other treatment combinations were also at par for each of the quality attribute of the cut foliage (Table 2). Cocopeat+ sand + FYM (1:1:1 v/v) + 2 % AMC along with application of full P as basal dose and N , K in 6 split doses to substrate at bimonthly intervals recorded the minimum values for all the quality parameters such as length of lamina (18.68 cm), length of stipe (8.76 cm), length of frond (26.04 cm), width of frond (15.37 cm) and number of pinnae (9.23) and stipe diameter (1.47 mm). The differences in the growth of the foliage of leather leaf fern has been illustrated in Fig 4 and Fig 5.

Based on an earlier study, foliage cut at light green stage were used for evaluating the effect of substrates and nutrient scheduling on vase life of leather leaf fern. Vase life of cut foliage of leather leaf fern was evaluated under room condition (20°C -27°C & 55:60% RH) in distilled water (Table 3). Maximum vase life of 36.10 days was obtained with cut foliage of leather leaf fern grown in coco peat + soil + vermicompost (1:1:1 v/v) +2% AMC in combination with application of 50% N and K in two equal splits during June and January along with 50% as foliar spray at fortnightly intervals (S_4N_4) and was on par with S_4N_2 (34.66 days) ,S_4N_1 (34.44 days),S_3N_3 (33.38 days),S_4N_3 (33.32 days),S_3N_4 (30.60 days),S_2N_2 (30.12 days) and S_2N_1 (29.66 days). Shortest vase life of 25.26 days was obtained with cut foliage of leather leaf fern grown in substrate of coco peat + sand +FYM (1:1:1 v/v) in combination of application of N and K in 6 split doses at bimonthly intervals (S_1N_2). The effect of substrate and nutrients on the vase life is evident in this study. Stamps (11) reported that the vase life of ferns depends on frond maturity, shade levels during production, fertilization, time of harvesting, postharvest and storage conditions, which corroborates this finding.

Substrate combinations Cocopeat+ Soil + FYM (1:1:1 v/v) and cocopeat+ Soil + Vermicompost (1:1:1 v/v) had near neutral pH, higher levels of organic carbon content, major, secondary and micronutrients amenable for higher production as well as for better quality of foliage (Table 4). The final substrate nutrient status (Fig. 1a & 1b) and leaf nutrient status of the plants (Fig. 2a & 2b) were analyzed. Results of the chemical analysis of the substrate recorded different parameters in the range of pH (5.6-7.2), EC 0.41-1.08 dsm^{-1}),OC (1.65-4.92%), N (267.3-796.5ppm), P (32.71-82.55 ppm),K (107.5 -440.0ppm), Ca (1141.5-2358.5 ppm), Mg (207.5-426.5 ppm), S (43.0-119.4 ppm), Zn (1.60-15.33 ppm),Cu (1.00-4.28 ppm), Fe (0.93-17.15 ppm) and Mn (4.40-18.95 ppm). The range of available nutrients in the substrate was high for major nutrients, normal for secondary nutrients and in the sufficient range for micronutrients. Leaf nutrient analysis recorded different parameters in the range of N (0.15- 0.90%), P (0.15- 0.25%), K (0.20- 2.50%), Ca (1.74- 4.52%), Mg (0.21-0.80%), Zn (10.00-32.00 ppm), Cu (2.80-8.60 ppm), Fe (204.5-471.9 ppm) and Mn (6.60-77.80 ppm).The leaf nutrient status in this study with regard to major nutrients was low, normal in case of secondary nutrients and high in case of micronutrients when compared to the nutrient standard in ferns established by Jones *et al*.(3). Leather leaf fern is tolerant of a wide range of soil pH but performs well in mildly acidic soils according to Stamps (9).This might have accounted for better performance of the plants in some of the media combinations. Similarly higher levels of available nutrients in the substrates might have led to increased cut foliage yield and quality of foliage. According to Tatte *et al*. (12) in anthurium, nutrients in combination with the growing media had significant influence on leaf production, area and

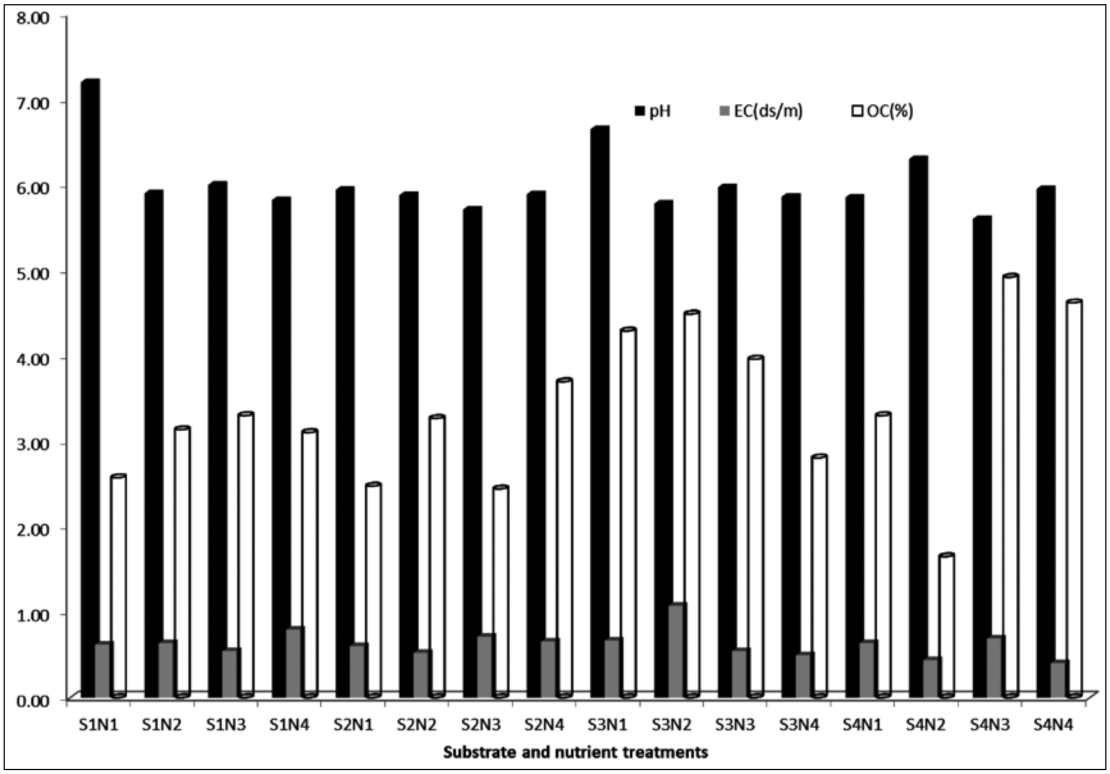

Fig 1a. Electro-chemical properties and organic carbon content of the substrates.

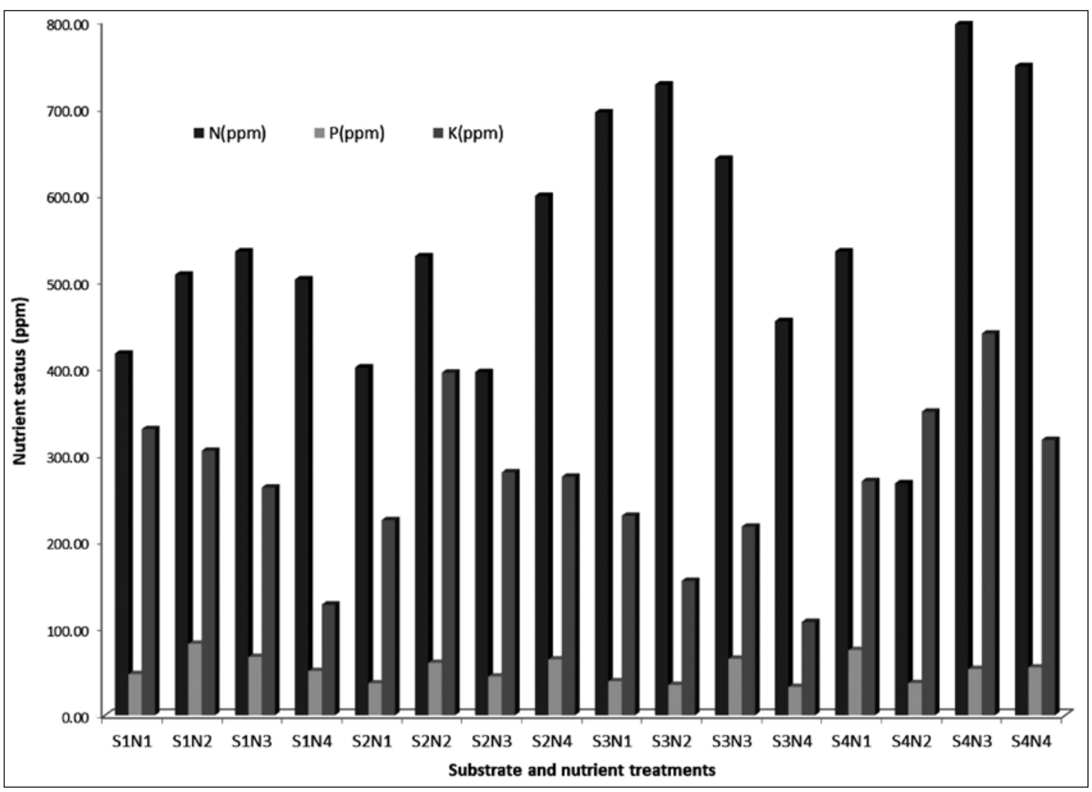

Fig 1b. Major nutrient contents in the substrates.

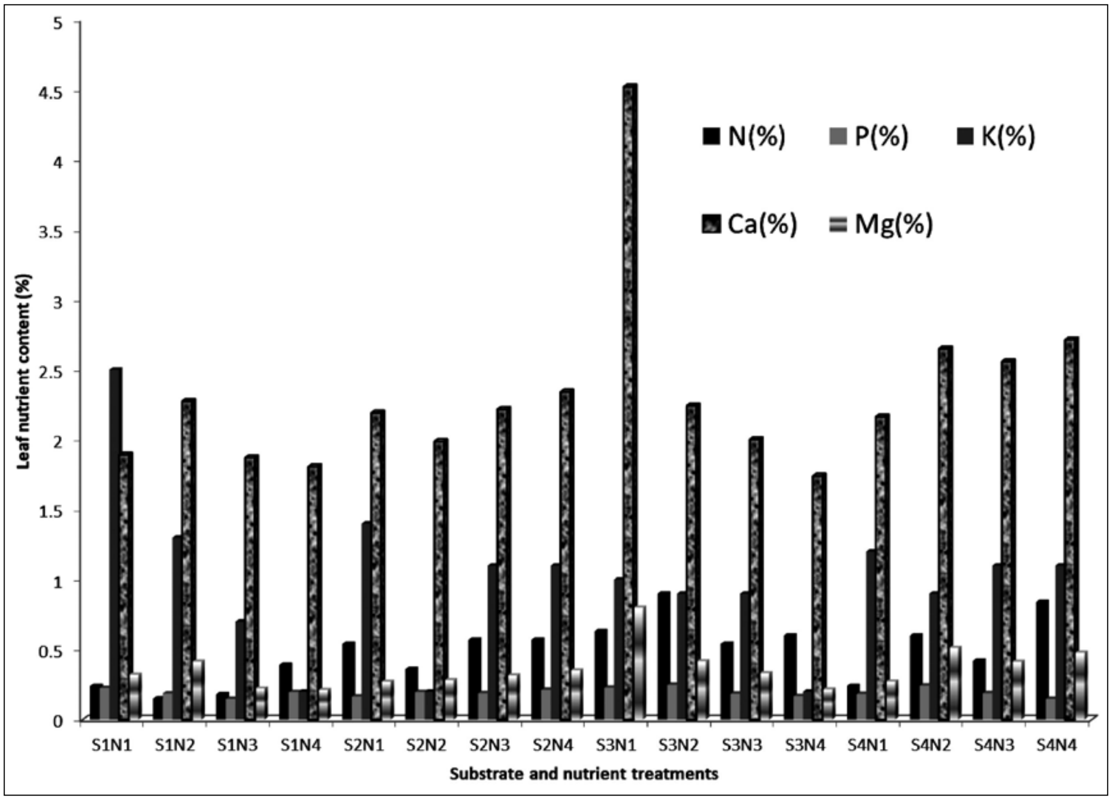

Fig 2a. Leaf nutrient status of major and secondary nutrients as influenced by substrates and nutrients.

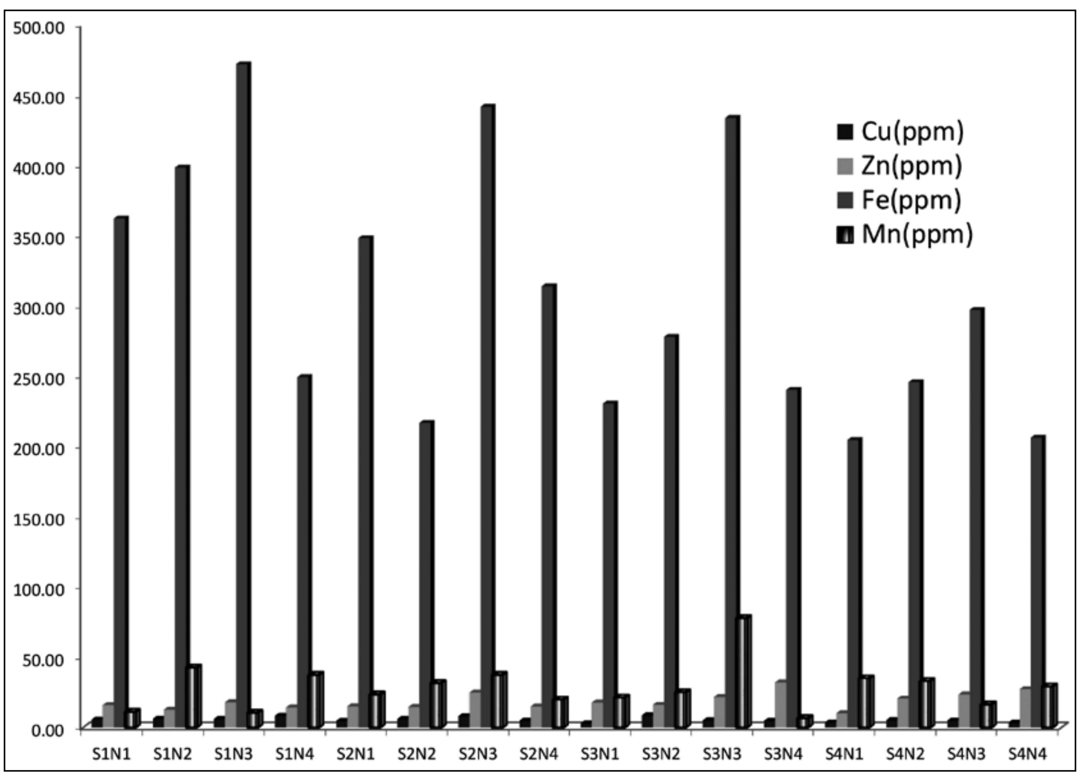

Fig 2b. Leaf micronutrient status as influenced by substrates and nutrients.

flower production including earliness in flowering. Vermicompost contains microorganisms which form synergistic relationships in plant rhizospheres, thereby increasing the capacity of plants to utilize soil moisture and nutrients. Microbial activities also promote plant growth. Farmyard manure enhances soil fertility as they release nutrients slowly and also activates the soil microbial biomass (Belay *et al*., 1).

The rhizosphere colonization of Arka microbial consortium on leather leaf fern indicated that there was significant variation in survival of microbes among different treatment combinations. The

Table 3. Influence of substrates and nutrient doses on vase life.

Treatments	Vase life (days)
S_1N_1	28.16
S_1N_2	25.26
S_1N_3	26.34
S_1N_4	29.06
S_2N_1	29.66
S_2N_2	30.12
S_2N_3	26.78
S_2N_4	28.36
S_3N_1	26.48
S_3N_2	28.32
S_3N_3	33.38
S_3N_4	30.60
S_4N_1	34.44
S_4N_2	34.66
S_4N_3	33.32
S_4N_4	36.10
CD (P=0.01)	6.72

Table 5. Microbial population in the rhizosphere of leather fern as influenced by the substrate combinations and nutrient schedules.

Treatments	Fluorescent pseudomonads (10^6 cfu/g substrate)	Azotobacter sp (10^3 cfu/g substrate)	P solubilizer (*Bacillus* spp.) (10^6cfu/g substrate)
S_1N_1	2.9	24.8	4.2
S_1N_2	3.9	40.3	7.6
S_1N_3	2.4	30.0	5.8
S_1N_4	2.7	31.7	7.9
S_2N_1	2.6	30.0	2.5
S_2N_2	2.5	22.0	5.8
S_2N_3	2.9	29.6	2.6
S_2N_4	2.9	26.3	7.3
S_3N_1	1.8	28.5	6.2
S_3N_2	4.3	42.3	10.3
S_3N_3	2.7	36.0	6.2
S_3N_4	2.8	31.3	3.6
S_4N_1	2.3	30.3	3.9
S_4N_2	2.1	28.3	7.6
S_4N_3	2.7	32.3	2.6
S_4N_4	3.7	38.3	7.6
CD (P=0.01)	0.96	10.6	3.2

Treatment details:
Factor A: Substrates S_1: Cocopeat+ Sand + FYM (1:1:1 v/v) + 2 % AMC; S_2: Cocopeat+ Soil + FYM (1:1:1 v/v) +2 % AMC; S_3: Cocopeat+ Sand + Vermicompost (1:1:1 v/v) +2 % AMC; S_4: Cocopeat+ Soil + Vermicompost (1:1:1 v/v) + 2 % AMC
Factor B: Nutrient scheduling N_1: Application of N and K in 12 split doses to substrate (at monthly intervals); N_2: Application of N and K in 6 split doses to substrate (at bimonthly intervals); N_3: Application of 50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals; N_4: Application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals

Table 4. Initial chemical analysis of the substrate combinations for leather leaf fern cultivation.

Treatments	pH	EC dSm^{-1}	OC %	N ppm	P ppm	K ppm	Ca ppm	Mg ppm	Mn ppm	Fe ppm	Zn ppm	Cu ppm
S_1	7.2	1.58	1.09	176.18	47.49	1581.3	710.4	503.0	14.5	3.69	2.89	0.85
S_2	6.9	1.18	3.51	568.62	50.66	1575.6	2153.3	848.8	29.7	2.71	4.76	1.71
S_3	6.9	1.30	2.38	385.16	78.12	1151.2	1316.4	815.0	11.8	4.11	3.18	0.89
S_4	6.7	1.21	5.19	840.78	59.78	1267.5	2493.8	957.3	32.6	4.17	4.25	1.74

Treatment details:
Factor A: Substrates S_1: Cocopeat+ Sand + FYM (1:1:1 v/v) + 2 % AMC; S_2: Cocopeat+ Soil + FYM (1:1:1 v/v) +2 % AMC; S_3: Cocopeat+ Sand + Vermicompost (1:1:1 v/v) +2 % AMC; S_4: Cocopeat+ Soil + Vermicompost (1:1:1 v/v) + 2 % AMC
Factor B: Nutrient scheduling N_1: Application of N and K in 12 split doses to substrate (at monthly intervals); N_2: Application of N and K in 6 split doses to substrate (at bimonthly intervals); N_3: Application of 50% N and K to substrate as a single dose + 50% as foliar spray at monthly intervals; N_4: Application of 50% N and K to substrate in 2 equal splits during June and January + 50% as foliar spray at fortnightly intervals.

data has been presented in Table 5. Microbial population in the rhizosphere in general ranged from 10^3 to10^6 cfu g^{-1} after three months of inoculation. On analysis of the samples drawn from the different treatment combinations, the population of fluorescent pseudomonads *Azotobacter* sp and P, Zn & K solubilizer (*Bacillus* spp.) were recorded in the range of 1.8 to 4.3 x10^6 cfu/g substrate, 22 to 42.3 x10^3

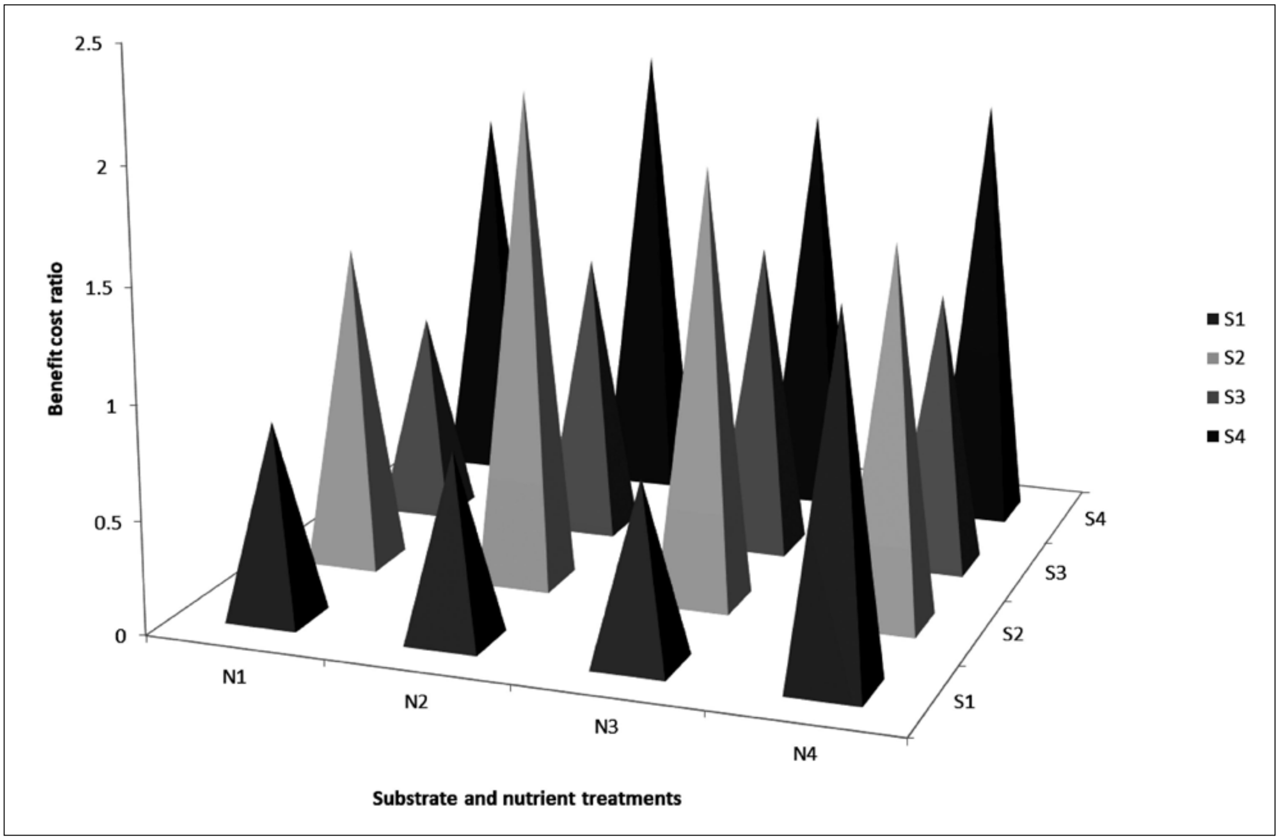

Fig. 3. Influence of substrates and nutrient scheduling on the benefit cost ratio.

Fig. 4. Plants grown on a. cocopeat+ soil + vermicompost (1:1:1 v/v) b. cocopeat+ soil + FYM (1:1:1 v/v) c. cocopeat+ sand + FYM (1:1:1 v/v).

Fig. 5. Plants grown on the medium of cocopeat + soil + FYM (1:1:1 v/v) + 2 % Arka Microbial Consortium + NPK @ 100:30:60 kg ha^{-1} $year^{-1}$ (full P as basal dose, N and K at bimonthly intervals in six equal split doses).

cfu/g substrate and 2.5 to 10.3 × 10^6cfu/g substrate, respectively.Microbial colonization of the rhizosphere leading to nitrogen fixation, P and Zn solubilisation, making available the nutrients in adequate quantities to the plants at critical growth stages might have lead to production of more number of superior quality foliage. This is in corroboration of the findings in banana wherein foliar N, P, K content was also found to be significantly high in the mycorrhizal plantlets as compared to non-mycorrhized plantlets at 60 days after inoculation (Srivastava and Singh,10)

Cocopeat + soil + FYM (1:1:1 v/v) + 2 % AMC in combination with application of N and K at bimonthly intervals to substrate (S_2N_2) recorded the highest benefit cost ratio of 2.18, followed by S_4N_2 (2.05) whereas, S_4N_4 which produced the maximum number of cut foliage recorded the B: C ratio of 1.92. This is attributed to the higher inputs and operational costs. Cocopeat+ sand + FYM (1:1:1 v/v) + 2 % AMC in combination with 50% N and K to substrate + 50% as foliar spray at monthly intervals gave the lowest benefit cost ratio of 0.79 (Fig. 3).

It can be concluded from the present study that leather leaf ferns can be grown on a substrate combination of cocopeat + soil + FYM (1:1:1 v/v) + 2 % Arka Microbial Consortium along with application of nutrients @ 100:30:60 kg NPK ha^{-1} $year^{-1}$ i.e., full P as basal dose and N and K at bimonthly intervals in six equal split doses to substrate under 75% shade. This was found to be optimum in terms of production, foliage quality, post harvest longevity and benefit cost ratio in leather leaf fern.

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