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Long term effect of organic manures and microbial inoculants on nutrient uptake and yield of *Plumbago rosea* when grown as an intercrop in coconut garden

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ABSTRACT

An experiment was carried out at College of Agriculture, Vellayani, Kerala, India during 2004-2005 with twelve treatments and one control in Randomized Block Design with three replications to study the long term effect of basal application of three different organic manures (Farm Yard Manure , Neem Cake and Vermi Compost) alone and in combination with microbial inoculants mixture (Arbuscular Micorhizzal Fungi (AMF), *Azospirillum* and Phosphobacteria) on the nutrient uptake and yield of *Plumbago rosea.* The study revealed that treatment supplying 50% RDN through farm yard manure and neem cake along with the microbial inoculants mixture recorded the highest leaf count, fresh weight of plants, total dry matter production, root length and root girth. This treatment also recorded highest nutrient uptake, fresh and dry root yield per plant and benefit cost ratio. This experiment shows that the use of neem cake and FYM in the ratio 1:4 along with the microbial inoculants as basal dose has a long term effect on the nutrient supplying capacity of the soil thus reducing the cost of production of organic cultivation and enhancing the benefit cost ratio of the farmers.

Key words: Farmyard manure, microbial inoculants, neem cake, *Plumbago rosea*, vermicompost.

INTRODUCTION

Plumbago rosea (Family: Plumbaginaceae), known as Rosy flowered lead wort or fire plant in English, is an important medicinal plant, the root of which is used in more than 100 ayurvedic formulations such as Chitrakasava, Koduvelisudhachoorna etc. The roots are acrid, astringent, thermogenic, anthelmintic, digestive, gastric, sudorific and are useful in fever, cough, ring worms, leucoderma, dyspepsia, skin diseases, scabies and anaemia. They are also narcotic, carminative, antiperiodic, nervine tonic and rejuvenating [8]. Agro-technology for the cultivation of this crop as an intercrop in coconut garden has been developed by the Kerala Agricultural University which includes the use of both organic and chemical fertilizers [3, 4, 7]. Growing medicinal plants using chemical fertilizers and pesticides may alter their active ingredients and cause deterioration in their quality [9]. In view of the global trend away from the synthetics and towards herbal products in health care and consequent steep rise in demand, there is a need for systematic cultivation of this crop in an organic way. But the high cost of production is the limiting factor in organic cultivation. Hence this study is taken up to find out the best treatment combination using different organic manures alone and in combination with microbial inoculants to find out its long term nutrient supplying capacity when applied as a single basal dose on nutrient uptake and yield of *Plumbago rosea* . A field experiment was conducted with the following objectives

a) To study the combined long term effect of organic manures and microbial inoculants in the nutrient uptake and yield of *Plumbago rosea.*

b) To assess the relative efficiency of organic manures and microbial inoculants as substitutes for inorganic fertilizers

MATERIALS AND METHODS

A field experiment was conducted at Instructional farm, College of Agriculture, Vellayani, Kerala state, India during 2004-2005. The area is situated at 8^0 30' North latitude and 76^0 54' East longitude, at an altitude of 29 m above MSL. The soil of the experimental site is red loam, which belonged to the Vellayani series under the order oxisol. Texturally the soil is classified as clay loam. The pH of the soil was 5.2 and had soil N, P and K content of 188.16 kg ha^{-1}, 41.40 kg ha^{-1} and 138.08 kg ha^{-1} respectively. Coconut garden with palms above forty years of age, spaced at 7.5m was selected for the study. The shade intensity of the field was estimated as 25 per cent using Model LI-250 Light meter. The soil microbial population was also low. It had a bacterial, fungal and actinomycetes count of 9×10^7, 1×10^5 and 1×10^5 respectively.

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The climate of the experimental site is humid tropical. The mean annual rainfall during the period was 140 mm. The mean annual maximum and minimum temperatures were 31.77 and 21.9^{0}C respectively. The mean annual evaporation during the cropping period was 3.49 cm.

The field was ploughed to a fine tilth and plots of size 2.5 m x 0.75 m were taken in the interspaces of coconut garden leaving an area of 2 m radius from the base of the palms. Between plots a spacing of 30 cm was maintained. Lime was applied @ 600 kg ha-1 and was well incorporated. After four weeks three different organic manures (farm yard manure (FYM), neem cake and vermi compost) alone and in combination with equal quantity of microbial inoculants mixture were applied to respective plots as per the treatments. Microbial inoculants (mi) mixture containing AMF, *Azospirillum* and phosphate solubilizers were added to those plots along with organic manures as per the treatment. Full dose of organic manures and mi were applied as basal dose before planting. Commercial inoculum of AMF containing a mixture of *Glomus fasciculatum, Glomus etunicatum* and *Glomus* sp. maintained in pots using sorghum as host was used. The inoculum consisted of root bits, mycelial fragments, and rhizosphere soil or vermiculite-perlite substrate carrying chlamydospores of AMF. The vermiculite-perlite inoculum containing 400 propagules per gram was used for the study. It was well mixed with top soil @ 200 g m-2. *Azospirillum* and phosphate solublizers (*Bacillus megatherium*) applied as soil drench (2 kg ha^{-1}).

Farmyard manure (FYM) was applied @ 10 t ha^{-1} uniformly to all the plots. The treatments were formulated based on the Package of Practices (POP) Recommendations of Kerala Agricultural University (KAU). The major nutrient requirement of the crop based on Nitrogen equivalents were calculated and supplied to the plants as 100%, 75% and 50% of recommended dose of nitrogen (RDN) through organic manures and additional P & K as rock phosphate and wood ash respectively. Quantity of neem cake and vermicompost was so fixed as to supply 25 per cent of the N requirement of the respective treatment and the remaining quantity of N through FYM. The treatments supplying 75% and 50% of the nitrogen requirement were supplemented with equal quantity of microbial inoculants mixture consisting of AMF (*Glomus* spp.), Azospirillum and Phosphobacteria (*Bacillus megatherium*), obtained from the department of Plant Pathology, College of Agriculture Vellayani. AMF was well mixed with top soil @ 200 g m^{-2}, Azospirillum and phosphate solublizers (*Bacillus megatherium*) applied as soil drench (each @2 kg ha^{-1}). Full dose of organic manures and microbial inoculants as per the treatments were applied as basal dose before planting. In the control plot (T_1) fertilizers (50:50:50 kg NPK ha^{-1}) and FYM (10t ha^{-1}) were applied as per POP recommendations of KAU. Nitrogen was applied in the form of urea, potash as muriate of potash and phosphorus as rock phosphate. N and K were applied in two equal splits i.e., 2 MAP and 4 MAP. FYM and full dose of P were applied as basal dose. The treatment combinations were given in detail in Table 1.

Rooted cuttings of *Plumbago rosea* were planted two weeks after the addition of organic manures and microbial inoculants at a spacing of 50 x 15 cm. The experimental design was laid out in RBD (randomized block design) with three replications.

The crop was harvested 12 months after planting (MAP) by digging out using spade. The roots were washed and shade dried. The plant uptake of NPK was analysed after oven drying and powdering the whole plant. The fresh weight of roots, yield attributing factors and dry weight of roots were recorded and statistically analyzed.

Table 1. Treatment combinations

Notation	Treatments
T_1	FYM @ 10 t ha^{-1} + 50 :50:50 kg NPK ha^{-1} (POP recommendations of KAU)
T_2	FYM @ 10 t ha^{-1} +FYM (100 % RDN of POP recommendations of KAU)
T_3	FYM @ 10 t ha^{-1} +FYM (75 % RDN of POP recommendations of KAU)+ microbial inoculants
T_4	FYM @ 10 t ha^{-1} +FYM (50 % RDN of POP recommendations of KAU)+ microbial inoculants
T_5	FYM @ 10 t ha^{-1} +FYM (75 % RDN)+ Neem cake (25 % RDN of POP recommendations of KAU)
T_6	FYM @ 10 t ha^{-1} +FYM(50 % RDN) + Neem cake (25 % RDN of POP recommendations of KAU)+ microbial inoculants
T_7	FYM @ 10 t ha^{-1} +FYM (25 % RDN) + Neem cake (25 % RDN of POP recommendations of KAU) + microbial inoculants
T_8	FYM @ 10 t ha^{-1} +FYM (75 % RDN) + Vermicompost (25% RDN of POP recommendations of KAU
T_9	FYM @ 10 t ha^{-1} +FYM (50 % RDN) + Vermicompost (25 % RDN of POP recommendations of KAU)+ microbial inoculants
T_{10}	FYM @ 10 t ha^{-1} +FYM (25 % RDN) + Vermicompost (25 % RDN of POP recommendations of KAU) + microbial inoculants
T_{11}	FYM @ 10 t ha^{-1} +FYM (75 % RDN)+ Neem cake + Vermicompost (25 % RDN of POP recommendations of KAU)
T_{12}	FYM @ 10 t ha^{-1} +FYM (50 % RDN) + Neem cake + Vermicompost (25 % RDN of POP recommendations of KAU + microbial inoculants
T_{13}	FYM @ 10 t ha^{-1} +FYM (25 % RDN) + Neem cake + Vermicompost (25 % RDN of POP recommendations of KAU) + microbial inoculants

The soil samples were grouped into three (Group A, B and C) based on the statistical analyses of dry root yield of *P. rosea*.

Group A consisting of soil samples of T_7, $T_{10,}$ T_{12} and T_3 treatments which gave high dry root yield (33.03 g to 27.7 g plant $^{-1}$)

Group B consisting of soil samples of T_4, $T_{11,}$ $T_{13,}$ T_8 and T_5 treatments which gave medium dry root yield (27g to 22.47 g plant $^{-1}$)

Group C consisting of soil samples of with T_1, T_9, T_6 and T_2 treatments which gave low dry root yield (19.73 g to 17.73 g plant $^{-1}$)

The soil samples from the plots belonging to each group were mixed separately and composite samples were prepared. These samples were analysed for NPK and microbial inoculants and compared with the soil sample values before the experiment.The microbial population in the rhizosphere soil was estimated by the serial dilution plate technique (2). The media used were:

Bacteria	:	Nutrient Agar Medium
Fungi	:	Potato Dextrose Agar Medium
Actinomycetes	:	Kenknight's Agar

RESULTS AND DISCUSSION

The fresh root weight of *P.rosea* showed significant difference under different treatment combinations (Table 2). The treatment combination FYM @ 10 t ha^{-1} +FYM (25% RDN) + Neem cake (25% RDN of POP recommendations of KAU) + microbial inoculants (T_7) recorded the highest fresh weight of roots (86.33 g/plant).The application of different organic manures recorded increased yield in white yam and addition of microbial inoculants and neemcake increased the yield in green ginger [10, 11]. The increased length and girth of roots, NPK uptake and the resultant higher leaf chlorophyll content of T_7 plants contributed the higher fresh root yield (Table 3). Among the organic manure applied plots T_8 (FYM @ 10 t ha^{-1} +FYM (75 % RDN) + Vermicompost (25% RDN of POP recommendations of KAU) recorded the lowest yield. The N and P uptake was lower in these plants (Table 4). As vermicompost is already composted manure, the net loss of nutrients was the highest in this treatment as the full dose is applied as single basal dose [11]. Reduction in fresh yield in vermicompost alone treated plants was also reported in ginger [11]. The plants which had better dry root weight recorded higher root girth. Thus, root thickness can be taken as an indication of better yield in *P. rosea.*

The influence of microbial inoculants on NPK uptake was significant in all the treatments. The treatment combination FYM @ 10 t ha^{-1} + FYM (25 % RDN) + Neem cake (25 % RDN

Table 2. Effect of organic manures and microbial inoculants on fresh weight of roots per plant (g), dry weight of roots per plant (g) fresh root yield (kg ha^{-1}) and BCR of *P. rosea* as intercrop in coconut garden

Treatments	Fresh weight of roots (g plant^{-1})	Dry weight of roots (g plant^{-1})	Yield (kg ha^{-1}) (FW basis)	Benefit cost ratio(BCR)
T_1	32.47	17.83	2857.07	1.14
T_2	40.80	19.73	3590.40	1.37
T_3	68.17	27.80	5998.67	2.20
T_4	63.83	27.00	5617.30	2.05
T_5	56.97	22.47	5013.07	1.88
T_6	60.57	19.50	5229.87	1.83
T_7	86.33	33.03	7597.30	**2.73**
T_8	39.17	26.77	3446.67	1.20
T_9	47.17	17.73	4150.70	1.47
T_{10}	60.10	30.63	5288.80	1.93
T_{11}	58.23	25.33	5124.50	2.00
T_{12}	57.57	27.70	5065.87	1.80
T_{13}	49.30	23.73	4338.40	1.53
SE	2.17	1.98	193.17	0.089
CD	6.34	5.79	563.86	0.262

CD-Significant @ 5% level of significance

Table 3. Effect of organic manures and microbial inoculants on number of roots per plant, length of roots (cm) and girth of roots (cm) of *P. rosea* as intercrop in coconut garden

Treatments	Number of roots	Length of roots (cm)	Girth of roots (cm)
T_1	8.00	45.67	2.60
T_2	7.30	36.43	1.80
T_3	10.30	35.00	3.10
T_4	10.70	64.03	2.73
T_5	9.30	46.40	2.87
T_6	22.00	47.67	2.53
T_7	11.30	80.10	3.03
T_8	8.00	59.37	2.23
T_9	23.30	29.10	2.07
T_{10}	10.70	69.80	3.03
T_{11}	14.30	40.80	2.90
T_{12}	7.30	36.73	3.00
T_{13}	16.00	43.50	2.73
SE	0.82	1.46	0.047
CD	2.40	4.25	0.138

CD-Significant @ 5% level of significance of POP recommendations of KAU) + microbial inoculants recorded the highest nutrient uptake of 285.6 kg N ha^{-1}, 16.1 kg P ha^{-1} and 197.97 kg K ha^{-1}. The beneficial effect of AMF and P solubilisers can be attributed as the reason for enhanced P uptake in microbial inoculant supplied plants (12). Higher uptake of P and root production by the treatments involving FYM @ 48 t ha-1 substituting 59 per cent N and 25 per cent N through Azospirillum has been reported (4). The lowest uptake was recorded by T_8 (FYM + VC), T_2 (FYM alone) and T_5 (FYM + NC) treatments (Table 4). The lower uptake might be due to the lack of microbial inoculants, which have the capacity to solubilise unavailable sources of nutrients to available form. Farm yard manure take more time for nutrient decomposition in the absence of microbial inoculants, which might have resulted in poor N uptake in plants treated with organic manures alone. The combined effect of FYM and microbial inoculants in enhancing N uptake was reported in betel vine and ginger [4, 6].

Soil analyses were done after grouping the soils into three based on the statistical data of the dry root yield. It was estimated that the plots with higher yield had higher soil N (288.5 kg ha^{-1}). Soil P and K was found to be on par in all the plots. Group A soils also recorded higher count of soil microbial population (Tables 5 and 6), which might have influenced N and P availability of soil for better plant uptake. It was the nutrient use efficiency rather than the soil NPK content that determined the root yield of plants. Even though the plots are supplied with lesser NPK, the presence of microbial inoculants

Table 4. Effect of organic manures and microbial inoculants on N, P and K uptake of *P. rosea* at the time of harvest, kg ha^{-1}

Treatments	N	P	K
T_1	126.83	6.73	90.54
T_2	107.53	10.47	125.70
T_3	188.37	15.33	125.00
T_4	151.77	9.59	141.20
T_5	108.23	8.17	112.13
T_6	121.93	9.43	102.93
T_7	285.60	16.10	197.97
T_8	97.57	9.39	126.27
T_9	235.13	13.10	99.73
T_{10}	205.87	8.73	98.04
T_{11}	167.80	11.67	111.33
T_{12}	167.23	9.87	149.30
T_{13}	224.40	14.57	110.20
SE	5.99	0.43	5.55
CD	17.48	1.26	16.19

CD-Significant @ 5% level of significance

Table 5. Effect of organic manures and microbial inoculants on soil N, P and K content before and after the experiment, kg ha^{-1}

Soil nutrients	Before experiment	After experiment		
		A	B	C
N	188.16	288.50	244.60	208.60
P	41.40	44.00	44.00	42.30
K	138.08	131.36	135.84	134.80

Table 6. Effect of organic manures and microbial inoculants on soil microbial population before and after the experiment, population count

Soil microbes	Before experiment	After experiment		
		A	B	C
Bacteria	9×10^7	216×10^7	148×10^7	21×10^7
Fungi	1×10^5	6×10^5	4×10^5	3×10^5
Actinomycetes	1×10^5	3×10^5	3×10^5	2×10^5

and slow releasing organic manures resulted in higher plant uptake and yield. The study reveals the long term effect of organic manures such as FYM and neem cake in releasing nutrients for plant uptake even though they are applied as a single basal dose at the time of planting. The plants treated with vermicompost and inorganic fertilizers recorded higher growth during initial stages but further growth rate after six months of planting was found to be reduced. This might be because of the increased leaching loss of the already composted vermicompost and inorganic fertilizers. The efficiency of microbial inoculants in substituting nitrogen fertilizer was recorded in periwinkle and turmeric also [1, 12]. The higher soil microbial population and the consequent better availability of nutrients attributed to the production of higher dry root yield of *P. rosea* in plots treated with organic manures and microbial inoculants.

Increased nitrogen use efficiency of neem cake [5] coupled with the nutrient solublising microbial inoculants resulted in the long term nutrient supplying capacity. The study revealed that treatment supplying 50 % RDN through farm yard manure and neem cake in the ratio 4:1 along with the microbial inoculants mixture recorded the highest nutrient uptake, fresh and dry root yield per plant and benefit cost ratio. To conclude, the use of neem cake along with FYM and microbial inoculants as a single basal dose has a long term effect on the nutrient supplying capacity of the soil thus reducing the cost of production of organic cultivation and enhancing the benefit cost ratio of the farmers.

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