Effect of organic manures and biofertilisers on herbage yield, quality and soil nutrient balance in *Indigofera tinctoria* cultivation

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Abstract

Experiments were conducted to study the effect of combined application of organic manures and biofertilisers on herbage yield and quality of *Indigofera tinctoria* during September 2012 -13 and 2013-14 at All India Co-ordinated Research Project on Medicinal, Aromatic Plants and Betel Vine Centre, Kerala Agricultural University Thrissur, Kerala, India. The treatments included FYM 10 Mg ha^{-1}, FYM 10 Mg ha^{-1} + Azospirillum (2 kg ha^{-1}), FYM 10 Mg ha^{-1} + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}), Vermicompost (3 Mg ha^{-1}), Vermicompost (3 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}), Vermicompost (3 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}), Coirpith compost (4 Mg ha^{-1}), Coirpith compost (4 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) and Coirpith compost (4 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}). The pooled herbage yield was higher in plots with basal application of farm yard manure 10 Mg ha^{-1} and azospirillum 2 kg ha^{-1} (5691 kg ha^{-1}). However, it was statistically on par with individual application of coirpith compost @ 4 Mg ha^{-1} (5542 kg ha^{-1}) and combined application of vermicompost @ 3 Mg ha^{-1} along with Azospirillum 2 kg ha^{-1} (5304 kg ha^{-1}). The quality as indicated by glycoside indican was more in plants which received basal application of FYM alone. The uptake of N and K were higher in treatments which recorded higher herbage yield. Due to combined application of organic manures and biofertilisers, N and K contents in the post experimental soil increased significantly, while the content of P decreased. The highest B: C ratio of 3.51 was in treatment with Farmyard manure 10 Mg ha^{-1} and Azospirillum 2 kg ha^{-1}.

Keywords: Biofertilisers, Farm yard manure, *Indigofera tinctoria*, Organic manuring, Soil nutrient balance.

Introduction

Indigofera tinctoria L., a member of the family Leguminosae, is one of the oldest coloring agents known to man. *Indigofera tinctoria* is native to India, the oldest known centres of indigo dye production. This is the original source of natural indigo dye. Dye is obtained from the processing of the plant leaves. Due to its antitoxic properties, it is used as a good remedy against poisonous infections. The plant is also used against epilepsy, chronic bronchitis, asthma, ulcers, skin diseases and also effective for promoting hair growth. In Ayurvedic system of medicine, *Indigofera tinctoria* is used as a major ingredient of "Neelibhringadi thailam", "Neeli thulasiadhi thailam" and "Neeli thulasiadhi kashayam". Ved and Goraya (2007) included *Indigofera* as a medicinal plant species of high volume trade (>100 MT per year) sourced largely from cultivation. Being a leguminous crop, it fixes nitrogen and hence it is also used for biofencing. Galactomannan, glycoside (Indican), coloring matter (Indigotin) and indiruben are the major phytochemical compounds present in *Indigofera*. Indican is the precursor to indigotin.

While going for commercial cultivation, it essential to achieve both quantity and quality especially in crops used as medicinal plants. Since most of the medicinal plants are grown in wild as organic per se, organic manuring will be ideal for developing their quality parameters. Many researchers have

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reported that both quantity and quality can be achieved by organic manuring (Puttanna et al., 2005, Khalil et al., 2007), accordingly the present study was undertaken to understand the effect of different organic manures and bio fertilizers on herbage yield and quality of *Indigofera tinctoria* and also to assess its impact on soil nutrient balance.

Materials and Methods

The experiment was conducted at All India Co ordinated Research Project on Medicinal, Aromatic plants and Betel vine (AICRP on MAP & B), Thrissur, Kerala, India during September 2012 - 13 and 2013- 14. The experimental site enjoys a typical humid tropical climate, lying between 13° 32' N latitude and 76° 26' E longitude with an elevation of about 40 m from MSL. The crop received a total rainfall of 3362 mm during 2012-13 and 3312 mm during 2013-14. The soil was lateritic sandy loam of the Oxisol group with 47.8% sand, 20.8% silt, 31.1% clay, 0.47% organic carbon, 246.70 kg ha^{-1} available N, 34.96 kg ha^{-1} available P, 223.20 kg ha^{-1} available K and a pH of 5.6.

The trials were laid out in RBD with nine treatments and three replications. The treatments included: T1- FYM 10 Mg ha^{-1}, T2 - FYM 10 Mg ha^{-1} + Azospirillum (2 kg ha^{-1}), T3 - FYM 10 Mg ha^{-1} + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}), T4 - Vermicompost (3 Mg ha^{-1}), T5 - Vermicompost (3 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}), T6 - Vermicompost (3 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}), T7 - Coirpith compost (4 Mg ha^{-1}), T8 - Coirpith compost (4 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) and T9 - Coirpith compost (4 Mg ha^{-1}) + Azospirillum (2 kg ha^{-1}) + VAM (2 kg ha^{-1}). The quantities of vermicompost and coir pith compost were fixed based on nitrogen equivalence with farmyard manure.

The N, P and K content of organic manures, plants and soil were analyzed by standard procedures as described in Jackson (1973) and Piper (1942).

One month old seedlings were transplanted at a spacing of 45 cm x 30 cm during the month of September in both years. Gross plot size was 10 m^2 and the net plot size was 5.74 m^2. The full quantities of manures and biofertilisers were applied basally. The nutrient content of the organic manures tried *viz.,* FYM, vermicompost and coirpith compost were 0.90, 3.01 and 2.30; 0.02, 0.70 and 0.03; 1.55, 2.56 and 3.09 per cent N, P and K, respectively. First harvesting was done at two months after planting and subsequent cuts at 45 days interval. Total of four cuts were taken.

Indican content of leaves at the time of first cut was analyzed spectrophotometrically at 280 nm (Wu et al., 1999). The uptake of N, P and K were calculated as the product of the content of these nutrients and the plant dry weight and expressed in kg ha^{-1}. Nutrient balance of the soil was worked out by subtracting the initial value from the soil available nutrient status after crop harvest adopting the method suggested by Palaniappan (1985).

The data were pooled and subjected to analysis of variance using the statistical package 'MSTAT - C' (Freed 2006).

Results and Discussion

Herbage yield and quality

Combined application of farm yard manure 10 Mg ha^{-1} and azospirillum 2 kg ha^{-1} gave the highest herbage yield consecutively in two years of study (5450 kg ha^{-1} and 5932 kg ha^{-1} respectively). The pooled analysis of the data also revealed the same trend. However, it was statistically on par with individual application of coirpith compost @ 4 Mg ha^{-1} (5542 kg ha^{-1}) and combined application of vermicompost @ 3 Mg ha^{-1} along with Azospirillum 2 kg ha^{-1} (5304 kg ha^{-1}) (Table 1). Compared to individual application, combined application of farm yard manure or vermicompost

Table 1. Effect of organic manures and bio-fertilizers on herbage yield, indican content and nutrient uptake of *Indigofera tinctoria*

Treatment	Herbage yield (kg ha^{-1})			Indican (%)			Nutrient uptake (kg ha^{-1}) (Pooled mean)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	N	P	K
Farmyard manure	4485	4894	4691	1.11	1.35	1.23	320.35	17.63	148.14
Farmyard manure + Azospirillum	5450	5932	5691	0.84	1.11	0.977	385.25	15.41	161.88
Farmyard manure + Azospirillum + VAM	4641	5221	4931	1.11	1.26	1.188	365.37	18.45	143.20
Vermicompost	4371	4501	4436	0.74	0.99	0.867	290.58	16.40	152.98
Vermicompost+ Azospirillum	5209	5365	5304	0.88	0.99	0.933	405.44	18.95	188.23
Vermicompost+ Azospirillum + VAM	4630	5229	4929	1.08	1.01	1.042	335.81	17.56	163.68
Coirpith compost	5054	5698	5542	0.99	1.01	1.002	387.75	14.72	155.98
Coirpith compost + Azospirillum	4116	3416	3766	0.74	0.98	0.860	225.72	8.78	98.52
Coirpith compost + Azospirillum+VAM	2752	3199	2976	1.02	1.03	1.028	202.21	10.40	94.11
SEm +	130.02	433.23	214.59	0.016	0.066	0.04	12.76	0.67	5.85
CD (0.05)	389.8	1299	613.4	0.06	0.197	0.12	36.46	1.91	16.71
CV (%)	14.98	15.54	11.19	2.84	10.63	10.01	9.63	10.67	9.86

with biofertilisers increased the herbage yield. As per reports of Mekki and Ahmmed (2005), pod yield of soyabean was increased by the combined application of organic manures and biofertilisers. Quality of *Indigofera tinctoria* as assessed by its indican content was more in plants which received basal application of farmyard manure alone (1.11% during first year and 1.35 per cent during second year). Improvement in oil content in the seeds of European dill (*Anethum graveolens* L.) due to the application of farm yard manure was reported by Vineeta et al. (2013). Increase in the content of indican due to application of VAM is evident from the study. Dual inoculation of organic manure with azospirillum and VAM increased the indican content, while combination of organic manure with azospirillum alone decreased it, which shows the ability of VAM in increasing the quality of crops. In *Indigofera tinctoria*, increase in the alkaloid content due to application of VAM fungi was reported by Sundar et al. (2012).

Nutrient uptake and soil nutrient balance

The highest uptake of 405.44 kg N, 18.95 kg P and 188.23 kg K were noticed in treatments with Vermicompost 3 Mg ha^{-1} and Azospirillum 2 kg

Table 2. Soil nutrient balance (kg ha^{-1}) as influenced by application of organic manures and bio-fertilizers after two years

Treatment	Nutrients added (kg ha^{-1})			Nutrients removed (Kg ha^{-1}) (Total of 2 years)			Nutrient status of soil after experiment (Kg ha^{-1})			Actual gain per loss(kg ha^{-1}) (Initial soil status - final soil status)		
	N	P	K	N	P	K	N	P	K	N	P	K
Farmyard manure	180	4.0	310	599.57	32.76	277.64	330	15.60	296	83	-19.40	73
Farmyard manure + Azospirillum	180	4.0	310	733.26	29.10	308.08	332	16.30	310	85	-18.70	87
Farmyard manure + Azospirillum + VAM	180	4.0	310	682.89	34.84	266.73	350	16.40	302	103	-18.60	79
Vermicompost	181	5.6	154	564.15	32.04	297.33	334	14.40	300	87	-20.60	77
Vermicompost+ Azospirillum	181	5.6	154	798.98	36.89	371.28	344	14.50	296	97	-20.50	73
Vermicompost+ Azospirillum + VAM	181	5.6	154	628.20	32.66	306.35	343	15.40	279	96	-19.60	56
Coirpith compost	184	2.4	247	751.48	27.78	301.89	313	15.80	337	66	-19.20	114
Coirpith compost + Azospirillum	184	2.4	247	477.90	19.63	209.11	388	15.80	334	141	-19.20	111
Coirpith compost + Azospirillum+VAM	184	2.4	247	373.74	20.61	174.80	381	15.50	315	134	-19.50	92
Initial soil status	247	35	223									

Table 3. Economics of organic manuring for *Indigofera tinctoria*

Treatment	Cost of cultivation ha^{-1}(Rs.)	Herbage yield(kg ha^{-1})	Income (Rs)	Profit (Rs.)	B:C ratio
Farmyard manure	40375	4691	117275	76900	2.90
Farmyard manure + Azospirillum	40500	5691	142275	101775	3.51
Farmyard manure + Azospirillum + VAM	40650	4931	123275	82625	3.03
Vermicompost	56375	4436	110900	54525	1.97
Vermicompost+ Azospirillum	56500	5303	132575	76075	2.35
Vermicompost+ Azospirillum + VAM	56650	4229	105725	49075	1.87
Coirpith compost	64375	5542	138550	74175	2.15
Coirpith compost + Azospirillum	64500	3766	94150	29650	1.46
Coirpith compost + Azospirillum+ VAM	64650	2976	74400	9750	1.15

Price for fresh leaves Rs.25/- , Cost of FYM - Rs. 880 Mg^{-1} , Cost of vermicompost - Rs. 8000 Mg^{-1} , Cost of coirpith compost - Rs. 8000 Mg $^{-1}$, Cost of Azospirillum - Rs. 5 kg^{-1} , Cost of VAM – Rs. 60 kg^{-1}

ha^{-1}. The uptake of nitrogen was higher and statistically on par in treatments which recorded higher herbage yield. Similarly in better yielded treatments, vermicompost with Azospirillum and farmyard manure with Azospirillum the uptake of K was higher. This shows the positive influence of nitrogen and potassium on increasing yield. Positive correlation of nitrogen uptake and dry matter yield was reported by Verma et al., (2005). Nutrient uptake decreased significantly when biofertilisers were mixed with coirpith compost.

Soil nutrient status at the end of two consecutive years of experiment is presented in Table 2. The data revealed that there was a net gain in the content of N and K while P content decreased significantly. Compared to plots which received organic manures alone, the soil nitrogen content after the experiment was higher in treatments with combined application of organic manures and biofertilisers. Except for combinations of biofertilisers with coirpith compost, soil P status also showed same trend. According to Biswas (2014), biofertilizers play critical role in maintaining long term soil fertility by mobilizing fixed macro and micro nutrients or convert insoluble forms into forms available to plants. Compared to farmyard manure and vermicompost, coir pith compost applied plots showed significant increase in the content of potassium.

Economics of cultivation

Cost for production (Table 3) was the lowest for treatment which received farm yard manure alone (Rs.40, 375/-). The highest B: C ratio of 3.51 was in treatment with Farmyard manure 10 Mg ha^{-1} and Azospirillum 2 kg ha^{-1}. Combination of FYM, Azospirillum and VAM was the next best treatment with B: C ratio of 3.03. Though the yield in coirpith compost alone applied plots were higher, the B: C ratio was lower due to high price of coirpith compost compared to farmyard manure.

Combined application of farmyard manure 10 Mg ha^{-1} and Azospirillum 2 kg ha^{-1} can be recommended as an organic manuring package for higher herbage yield, quality and benefit cost ratio for *Indigofera tinctoria* in the warm humid tropics of Kerala.

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