



Performance of Indian Indigo (*Indigofera tinctoria* L.) accessions as intercrop in coconut garden

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(Manuscript Received: 14-02-07, Revised: 18-09-09, Accepted: 20-09-09)

Abstract

Thirty accessions of Indian indigo (*Indigofera tinctoria* L.), collected from inside and outside Kerala, were grown in a coconut plantation so as to identify the superior accessions with respect to leaf yield and indigo dye content. Observations were taken at various growth stages namely pre-flowering (90 DAS), flowering (150 DAS) and seed maturation stages (240 DAS). The best ten accessions that recorded maximum leaf yield and glycoside content, obtained from phase I experiment were selected for the phase II experiment. Considerable variations were not noticed in plant height increment in different accessions during both the phases. The accessions differed significantly with respect to plant spread in both the phases. Among the accessions, those that revealed a trend to dominate in plant spread increment during both the phases were IT-105, IT-108 and IT-114. Accession IT-109 dominated in the increment of number of leaves during phase I experiment. Accessions IT-96, IT-99, IT-101, IT-106 and IT-108 were found superior with respect to shoot fresh weight and dry weight in both the phases of the experiment. IT-96, IT-99 and IT-101 were superior in terms of indigo dye content. The present study has revealed the genetic superiority of IT-96, IT-99 and IT-101 accessions in terms of leaf yield and indigo dye content, when grown as intercrop in coconut plantation.

Keywords: Coconut, *Indigofera*, intercrop

Introduction

Indian indigo (*Indigofera tinctoria* L.), known as 'nili' in Sanskrit and 'amari' or 'neelayamari' in Malayalam, is a leguminous medicinal plant valued for the blue dye (indigo) content in its leaves. Use of indigo, the reputed Indian natural dye, is as old as textile making in India (Gokhale *et al.*, 2004). In Ayurveda, the ancient indigenous system of medicine, leaf extract of the plant is used to prevent juvenile greying of hair and to promote hair growth (Nair *et al.*, 1991). The plant is also used to treat hydrophobia, epilepsy, nervous disorders, bronchitis, sores, old ulcers and haemorrhoids (Singh and Khan, 1990). *I. tinctoria* was cultivated in several states of India including Kerala, for natural blue dye production. With the invention of synthetic dyes, in India area of this crop declined from 6 lakh ha in 1890s to 4,000 ha in 1950s. Annual production of indigo dye decreased from 3,000 mt to 50 mt during the above period. Annual export

fluctuated between 2 mt and 20 mt in the 1990s. At present it is cultivated in the northern districts of Karnataka state and to a smaller extent in Kerala state. Sarada and Reghunath (2003) observed that *I. tinctoria* performs better in open condition than under shade, the crop being profit earning under shade also. Suneetha and Chandrakanth (2003) opined that due to less per capita availability of open land, prospects for medicinal plant cultivation in Kerala is to intercrop them with major plantation crops like coconut, arecanut and oil palm. Hence the present investigation was carried out with the objective of evaluating growth and yield of different accessions of *I. tinctoria* for identifying superior accessions with respect to leaf yield and indigo dye content, when intercropped in coconut plantation.

Materials and Methods

The experiments were conducted at the Instructional Farm, College of Agriculture, Vellayani

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during 2001-2003. The experimental site lies at 8.5° N latitude, 76.9° E longitude and at an altitude of 29 m above MSL. The soil of the site is lateritic red loam belonging to Vellayani series (pH 5.2). The mean rainfall during the period was 120 cm. Phase I experiment was conducted during September 2001 to April 2002. Seeds of 30 different accessions of *Indigofera tinctoria* (IT-93 to IT-122) were collected from inside and outside Kerala (Table 1). The accessions were raised under shade in 35 year old coconut garden of Komadan variety in Completely Randomized Design (CRD) with two replications. Twenty one plants of each accession were grown in a line with a spacing of 45 cm within the line and 60 cm between lines. The crop was raised as per KAU package of practices recommendations (KAU, 1996). Sowing was done during the first week of September 2001. From each accession after leaving two border plants, ten plants were retained for data collection at different growth stages viz. pre-flowering (90 Days After Sowing-DAS), flowering (150 DAS) and seed maturation (240 DAS). Nine plants were earmarked for destructive sampling in each of the above three stages. Three adjoining plants were sampled at each time. Plant height was measured from the base of the plant to the tip of the tallest branch. The distance occupied by the plant in the north-south and east-west direction from its axis was measured and the mean value was recorded as 'plant spread'. Total number of leaves per plant was also recorded. Fresh weight of leaves of each observational plant was recorded and the samples were then dried in a hot air oven at 70°C until consistent dry weights were obtained. Statistical analysis was done using standard methods. Discriminant function techniques were adopted for the construction of selection index based on leaf yield and dye (glycoside) content. The accessions were ranked according to the selection index scores. The best ten accessions that recorded maximum leaf yield and glycoside content in the phase I experiment were selected for the phase II experiment.

In the phase II experiment, the selected accessions were raised in Randomised Block Design (RBD) with three replications in 35 year old coconut garden, the location being same as in phase I experiment. Phase II experiment was conducted from the first week of June 2002 to January 2003. The plot size was 4.5 x 4.05 m with spacing of 45 x 45 cm. Number of plants/plot/replication was 90. In each accession, after leaving two border plants, eight plants were retained for data collection at three growth stages as in phase I experiment. Eight plants from each replication were earmarked for destructive sampling in each of the above three stages.

Plant height, plant spread, number of leaves and fresh and dry weight of leaves were recorded as in phase I experiment. Indigo content in the leaves was estimated during flowering stage (150 DAS) as per Nayar *et al.* (1999) and was expressed in percentage.

Results and Discussion

In the phase I experiment, growth parameters of the accessions did not show any significant difference for increment in plant height in the pre-flowering to flowering stage as well as in the flowering to seed maturation stage. But significant difference was observed among the accessions in increment in plant spread and number of leaves during these growth stages (Table 1). During the period from pre-flowering to flowering stage, IT-95 recorded maximum increment in plant spread (70.40 cm) which was on par with IT-122 (62.42 cm), IT-93 (62.24 cm), IT-101 (61.03 cm) and IT-121 (53.35 cm). The highest increment for number of leaves was recorded by IT-108 (146.58). It was on par with IT-109 (126.65) and IT-94 (126.47). During the period from flowering to seed maturation stage, IT-115 recorded the maximum increment for plant spread (46.95 cm), which was on par with IT-96 (45.83 cm), IT-108 (45.29 cm), IT-105 (36.65 cm), IT-120 (31.01 cm), IT-103 (30.84 cm), IT-98 (28.91 cm), IT-114 (28.91 cm) and IT-119 (28.65 cm). IT-105 recorded maximum increment for number of leaves (254.20), which was on par with IT-106 (234.31), IT-113 (232.55), IT-109 (231.05) and IT-115 (229.80).

In the phase II experiment, there were no significant differences for increment in plant height and number of leaves among the accessions in the pre-flowering to flowering stage as well as in the flowering to seed maturation stage. But significant difference was observed for increment in plant spread during these stages (Table 2). During the period from pre-flowering to flowering stage, IT-105 recorded maximum increment in plant spread (29.83 cm), which was on par with IT-104 (26.27 cm), IT-114 (25.97 cm) and IT-108 (19.75 cm). During the period from flowering to seed maturation stage, IT-111 recorded maximum increment in plant spread (22.85 cm), which was on par with IT-106 (19.54 cm) and IT-101 (18.69 cm).

In both the experiments, considerable variations were not observed in the increment in plant height. However, the accessions differed significantly with respect to plant spread in both the experiments. Among the accessions evaluated, IT-105, IT-108 and IT-114 showed a trend to dominate in plant spread increment during both the phases. Significant difference was

Table 1. Variation in rate of growth in plant height (cm), plant spread (cm) and number of leaves at different growth stages of *Indigofera tinctoria* L. accessions, intercropped in a coconut garden (Phase I experiment) (Crop period: September 2001 to April 2002)

Sl. No.	Accession No.	Collected location	Variation in growth rate between stages of plant growth					
			Pre-flowering to flowering (90-150 DAS)			Flowering to seed maturation (150- 240 DAS)		
			Plant height (cm)	Plant spread (cm)	No. of leaves	Plant height (cm)	Plant spread (cm)	No. of leaves
1	IT-93	Thrissur	42.48	62.24	87.03	36.50	25.28	176.68
2	IT-94	Palakkad	33.67	41.51	126.47	34.33	24.94	181.01
3	IT-95	Pathanamthitta	35.97	70.40	111.71	41.28	9.08	191.10
4	IT-96	Thiruvananthapuram	37.28	39.09	109.62	52.39	45.83	161.15
5	IT-97	Thiruvananthapuram	38.80	47.48	95.24	36.21	17.16	166.50
6	IT-98	Thiruvananthapuram	40.77	39.78	84.47	38.29	28.91	193.15
7	IT-99	Idukki	30.50	29.90	110.06	33.68	19.21	152.15
8	IT-100	Thiruvananthapuram	31.63	45.99	104.98	33.08	9.75	154.08
9	IT-101	Thrissur	37.61	61.03	76.88	45.73	25.48	215.13
10	IT-102	Idukki	36.51	39.91	110.81	32.15	27.24	140.88
11	IT-103	Thiruvananthapuram	32.67	28.37	99.01	43.28	30.84	145.54
12	IT-104	Kottayam	43.35	27.86	103.00	44.60	25.34	204.18
13	IT-105	Malappuram	49.28	30.26	92.88	39.32	36.65	254.20
14	IT-106	UAS, Bangalore	49.93	36.37	118.56	42.37	13.11	234.31
15	IT-107	NBRI, Lucknow	40.39	31.49	105.29	28.89	24.81	197.06
16	IT-108	Thiruvananthapuram	50.31	30.67	146.58	35.19	45.29	150.99
17	IT-109	Pathanamthitta	44.06	39.64	126.65	35.93	26.17	231.05
18	IT-110	Thrissur	36.26	20.99	91.56	40.44	18.95	210.99
19	IT-111	Ernakulam	39.43	52.07	87.14	47.21	26.73	209.93
20	IT-112	IITA, Nigeria	47.24	33.84	95.21	33.80	14.76	215.18
21	IT-113	Thiruvananthapuram	38.63	13.74	100.57	44.79	19.00	232.55
22	IT-114	Thiruvananthapuram	43.11	38.07	104.04	42.76	28.91	215.21
23	IT-115	Palakkad	41.73	24.14	94.63	32.98	46.95	229.80
24	IT-116	Kozhikode	42.07	23.27	91.96	31.18	23.28	195.21
25	IT-117	Thiruvananthapuram	45.29	37.68	82.86	34.61	21.96	198.72
26	IT-118	Pathanamthitta	43.21	40.77	98.03	30.28	20.73	213.72
27	IT-119	Thiruvananthapuram	37.77	31.46	118.14	37.76	28.65	176.51
28	IT-120	Thiruvananthapuram	36.24	29.17	110.97	38.68	31.01	195.90
29	IT-121	Thiruvananthapuram	34.8	53.35	100.99	36.83	19.01	219.98
30	IT-122	Kannur	41.25	62.42	102.08	33.99	16.00	217.16
	CD (P = 0.05)		NS	17.07	23.04	NS	19.03	30.87

DAS - Days After Sowing, NS = Not Significant

observed among the accessions in the increment in number of leaves during phase I experiment. IT-109 dominated in this parameter which could be attributed to its increased genetic vigour. Gardner *et al.* (1988) had suggested that variation in the performance of accessions may be purely a function of genetic make up and environmental conditions. In both the phases of experiments, during the period from pre-flowering to flowering stage (2 months), the increment in plant height and spread was found to be proportionately greater when compared to that from flowering to seed maturation stage (3 months). This may be attributed to the increased

vegetative growth during the initial stages of plant growth.

Among the yield parameters studied, significant difference could be observed among the accessions in fresh weight and dry weight of leaves in all the three stages of growth in the phase I experiment (Table 3). At pre-flowering stage, IT-98 recorded the maximum fresh weight of leaves (80.17 g). It was on par with IT-101 (71.32 g), IT-99 (67.62 g) and IT-108 (63.42 g). The highest value for dry weight of leaves (25.83 g) was observed in IT-98 followed by IT-101 (23.28 g), IT-99 (21.8 g) and IT-108 (20.75 g). The highest value for leaf

Table 2. Variation in rate of growth in plant height (cm), plant spread (cm) and number of leaves at different growth stages of selected *Indigofera tinctoria* L. accessions, intercropped in a coconut garden (Phase II experiment) (Crop period : June 2002 to January 2003)

Sl. No.	Accession No.	No. Variation in growth rate between stages of plant growth					
		Pre-flowering to flowering (90 -150 DAS)			Flowering to seed maturation (150- 240 DAS)		
		Plant height (cm)	Plant spread (cm)	No. of leaves	Plant height (cm)	Plant spread (cm)	No. of leaves
1	IT-96	26.52	15.84	54.07	27.51	9.69	205.42
2	IT-97	14.57	7.46	62.67	18.27	12.01	173.02
3	IT-99	7.03	11.52	80.69	28.70	8.39	156.41
4	IT-101	18.58	15.46	74.00	27.39	18.69	146.83
5	IT-104	23.13	26.27	76.85	18.52	15.41	165.32
6	IT-105	20.30	29.83	66.86	34.79	9.58	215.02
7	IT-106	15.39	12.07	73.06	27.09	19.54	149.09
8	IT-108	14.09	19.75	68.61	31.35	9.36	130.47
9	IT-111	4.74	9.16	39.14	44.06	22.85	197.03
10	IT-114	29.88	25.97	86.36	18.97	5.84	156.22
	CD (P = 0.05)	NS	11.33	NS	NS	7.26	NS

DAS - Days After Sowing, NS = Not Significant

Table 3. Leaf yield (fresh and dry) per plant (g) of *Indigofera tinctoria* L. accessions, intercropped in coconut garden (Phase I experiment)

Sl. No.	Accession No.	Stages of plant growth		
		Pre flowering (90 DAS)	Flowering (150 DAS)	Seed maturation (240 DAS)
1	IT-93	21.30 (6.92)	48.08 (16.05)	143.07 (47.83)
2	IT-94	25.92 (7.86)	46.94 (14.56)	90.50 (39.40)
3	IT-95	60.63 (19.10)	70.38 (22.40)	154.08 (50.95)
4	IT-96	57.76 (18.22)	352.98 (112.26)	675.27 (225.10)
5	IT-97	53.62 (17.58)	199.38 (64.35)	254.02 (83.92)
6	IT-98	80.17 (25.83)	262.51 (82.85)	214.58 (68.38)
7	IT-99	67.62 (21.80)	261.95 (85.26)	249.27 (79.53)
8	IT-100	58.82 (19.44)	220.73 (71.55)	212.73 (67.13)
9	IT-101	71.32 (23.28)	332.82 (107.71)	639.85 (206.37)
10	IT-102	38.50 (12.30)	157.28 (53.21)	141.25 (45.99)
11	IT-103	38.59 (12.08)	212.83 (67.19)	308.43 (100.93)
12	IT-104	54.38 (17.98)	327.55 (107.08)	619.75 (205.59)
13	IT-105	51.96 (16.58)	373.08 (121.03)	570.35 (190.20)
14	IT-106	58.28 (17.84)	377.46 (122.45)	725.02 (237.07)
15	IT-107	33.22 (10.16)	73.59 (24.47)	145.62 (47.83)
16	IT-108	63.42 (20.75)	343.62 (111.73)	727.02 (228.62)
17	IT-109	44.57 (14.48)	181.77 (58.99)	226.06 (72.89)
18	IT-110	48.74 (15.44)	272.63 (89.22)	239.41 (76.32)
19	IT-111	54.00 (17.29)	325.99 (106.40)	375.84 (120.64)
20	IT-112	50.70 (15.79)	201.05 (63.70)	207.45 (63.38)
21	IT-113	51.60 (16.68)	207.20 (64.96)	237.77 (77.34)
22	IT-114	60.80 (18.37)	360.69 (113.34)	747.46 (246.86)
23	IT-115	29.58 (9.21)	185.33 (58.89)	259.77 (85.19)
24	IT-116	43.32 (13.22)	204.61 (56.07)	274.35 (87.32)
25	IT-117	48.53 (15.48)	243.50 (77.33)	268.98 (90.64)
26	IT-118	41.67 (14.10)	237.35 (76.78)	284.99 (88.58)
27	IT-119	41.54 (12.43)	187.50 (59.59)	265.26 (82.91)
28	IT-120	48.47 (15.10)	236.83 (77.75)	239.68 (80.78)
29	IT-121	49.75 (15.94)	203.67 (66.51)	264.15 (88.39)
30	IT-122	37.82 (12.75)	152.71 (49.33)	180.23 (59.88)
	CD (P = 0.05)	17.80 (6.32)	71.48 (25.11)	131.15 (46.63)

Dry weight in parentheses, DAS - Days After Sowing

fresh weight during flowering stage was recorded by IT-106 (377.46 g) which was on par with IT-105 (373.08 g), IT-114 (360.69 g), IT-96 (352.98 g), IT-108 (343.62 g), IT-101 (332.82 g), IT-104 (327.55 g) and IT-111 (325.99 g). Accession IT-106 recorded the maximum leaf dry weight (122.45 g) also. It was on par with IT-105 (121.03 g), IT-114 (113.34 g), IT-96 (112.26 g), IT-108 (111.73 g), IT-101 (107.71 g), IT-104 (107.08 g) and IT-111 (106.40 g). At seed maturation stage, IT-114 recorded maximum fresh weight of leaves (747.46 g) which was on par with IT-108 (727.02 g), IT-106 (725.02 g), IT-96 (675.27 g), IT-101 (639.85 g) and IT-104 (619.75 g). The highest value for dry weight of leaves was observed in IT-114 (246.86 g) and was on par with IT-106 (237.07 g), IT-108 (228.62 g), IT-96 (225.10 g), IT-101 (206.37 g) and IT-104 (205.59 g).

In the phase II experiment also, significant difference could be observed among the accessions in the fresh and dry weight of leaves at all the three stages of growth (Table 4). At pre-flowering stage, maximum fresh weight of leaves was recorded by IT-101 (63.26 g), which was on par with IT-99 (61.23 g) and IT-108 (60.88 g). Dry weight of leaves was also maximum for IT-101 (21.50 g), which was on par with IT-99 (20.73 g), IT-108 (20.62 g) and IT-96 (19.72 g). At flowering stage, IT-106 recorded maximum fresh weight (308.43 g) and dry weight (102.59 g) of leaves. Accessions IT-96 (101.68 g) and IT-108 (99.54 g) were on par with IT-106 (102.59 g) for dry weight of leaves. At seed maturation stage, maximum leaf weight was recorded by IT-114 (963.93 g). Dry weight of leaves was also maximum in this accession (325.73 g), which was on par with IT-106 (322.81 g). Difference was observed among the

Table 4. Leaf yield (fresh and dry) per plant (g) of selected *Indigofera tinctoria* accessions, intercropped in coconut garden (Phase II experiment)

Sl. No.	Accession No.	Stages of plant growth		
		Pre flowering (90 DAS)	Flowering (150 DAS)	Seed maturation (240 DAS)
1	IT-96	58.69 (19.72)	296.16 (101.68)	863.36 (300.41)
2	IT-97	51.19 (16.82)	237.51 (79.52)	512.20 (179.92)
3	IT-99	61.23 (20.73)	239.74 (79.55)	520.31 (185.63)
4	IT-101	63.26 (21.50)	256.41 (86.77)	817.03 (288.54)
5	IT-104	51.65 (16.96)	275.78 (95.50)	764.14 (269.99)
6	IT-105	54.31 (18.35)	264.04 (85.97)	693.92 (227.36)
7	IT-106	55.26 (18.56)	308.43 (102.59)	904.37 (322.81)
8	IT-108	60.88 (20.62)	284.72 (99.54)	914.25 (314.95)
9	IT-111	51.89 (17.72)	268.00 (92.30)	551.38 (190.61)
10	IT-114	55.33 (17.62)	279.13 (97.86)	963.93 (325.73)
CD (P = 0.05)		4.34 (1.87)	11.82 (3.72)	26.32 (9.58)

Dry weight in parentheses, DAS - Days After Sowing

accessions for indigo dye content (Table 5). Indigo content in leaves was maximum in the leaves of IT-96 (1.21%) which was on par with IT-99 (1.11%) and IT-101 (1.03%).

Table 5. Indigo dye content in the leaves (%) during flowering stage (150 DAS) of selected *Indigofera tinctoria* accessions, intercropped in coconut garden

Sl. No.	Accession No.	Indigo dye content (%)
1	IT-96	1.21
2	IT-97	0.79
3	IT-99	1.11
4	IT-101	1.03
5	IT-104	0.77
6	IT-105	0.84
7	IT-106	0.63
8	IT-108	0.50
9	IT-111	0.78
10	IT-114	0.75
CD (P = 0.05)		0.32

Results showed that accessions IT-96, IT-99, IT-101, IT-106 and IT-108 were superior in shoot yield (fresh as well as dry) in both the phases of experiments. IT-96, IT-99 and IT-101 were superior in leaf indigo content. However, from flowering to seed maturation stage the increase in fresh and dry weight of leaves was found to be less, when compared to that from pre-flowering to flowering stage. The decline in fresh and dry weight of

leaves during flowering to seed maturation stage can be attributed to the leaf shedding and senescence. Similar observation has been reported by Kulkarni and Karadge (1991) in moth bean. According to Gardner *et al.* (1988) when leaf senescence sets in, the assimilate synthesised gets diverted for seed setting. A similar phenomenon may be taking place in the case of Indigo also. The present study has revealed the genetic superiority of the accessions IT-96, IT-99 and IT-101 with respect to leaf yield and leaf indigo dye content when cultivated as intercrop in coconut plantation.

Acknowledgement

The paper forms a part of Ph. D. (Hort.) research work of the senior author. The Senior Fellowship granted by the Kerala Agricultural University to the senior author is gratefully acknowledged.

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