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Variation in root yield and ephedrine content of Bala (*Sida cordifolia* Linn.) at differential harvesting under open and shaded situation

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Key words

Dry root yield
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ABSTRACT

A field experiment was conducted under rainfed condition to study the effect of light intensity on yield and quality of *Sida cordifolia and to find out the optimum stage of harvest for higher root yield and quality. The experiment was laid out in randomized block design with three replications. There were nine treatments comprising of stages of harvest from six months after planting to fourteen months after planting at monthly intervals. The experiment on stage of harvest was repeated under direct sunlight and shaded situation to study the effect of shade. Observations on growth characters, yield attributes, fresh and dry yields were recorded. The results indicated that vigorous plants and higher fresh and dry root yields were observed under open compared to shaded condition. Under shaded situation, the plants took more time for dry matter accumulation and higher root yield was noticed at twelve months after planting and the yield was very low compared to that under open situation. With respect to ephedrine yield also, higher yield was noticed under hundred per cent sunlight. The maximum root yield and ephedrine content were recorded at eight months after planting and further delay in harvesting showed a sharp decline in both root yield and ephedrine content. The results indicated that Sida cordiflia cannot tolerate shade and the optimum stage of harvest is eight months after planting*

INTRODUCTION

Sida cordifolia Linn., belonging to the family Malvaceae, is found in tropical and subtropical regions of India. The common names of the crop are country mallow (English), Bala (Hindi), Kurumthotti (Malayalam) and ayurvedic names are *Vatyâlaka, úîtapâki, vâtyodarâhva, bhadraudanî, samangâ, samâmsa* and *svarayastikâ.* The species has been equated with Bala, one of the most celebrated traditional medicines [11]. According to Nadkarni [6] a major percent of total alkaloid content in *Sida spp.* is ephedrine. The roots of this species are demulcent, diuretic, astringent and stomachic and are used as raw material in many ayurvedic preparations. They are used in the treatment of nervous and urinary diseases, bleeding piles, gonorrhoea and rheumatism. The

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roots have been used to cure Parkinson's disease and as a food supplement for rapid fat loss. During a survey of different drug markets in the country, most commercial samples were found to be a mixture of other species of Sida, viz. *S. acuta, S. cordata* and *S. rhombifolia* and these were being sold under the same vernacular name 'Bala' by many pharmaceutical companies. Sometimes, because of the non-availability of the roots, the whole plant (95% aerial parts) is also being sold and used as 'Bala'. Domestication and commercialization of cultivation is one of the area to secure the medicinal plant supply having the required quantity to the pharmaceutical companies. Due to high demand of the crop in ayurvedic industry, cultivation has to be encouraged to encash the demand. The biosynthesis of secondary metablites although controlled genetically, is affected strongly by environmental influences. Hence it is necessary to study the reaction of *Sida cordiflia* to light intensity and to find out the optimum harvesting stage for maximum root yield and quality. This would help to supply uniform quality roots of *Sida cordifolia* according to market demand.

Considering the medicinal value of *Sida* spp., its increasing demand and meager information on the agronomic management, the present investigation was undertaken to study the reaction of *Sida cordiflia* to light intensity and to find out the optimum stage of harvest for higher root yield and ephedrine content in *Sida cordifolia*.

MATERIALS AND METHODS

A field experiment was conducted during 2008-10 at All India Co-ordinated Research Project on Medicinal and Aromatic Plants, Kerala Agricultural University, Vellanikkara, Kerala under rain fed condition . The soil of the experimental field was sandy clay loam laterite with pH of 5.78 and EC of 0.41 dSm^{-1}. The nutrient status of the soil was 1.24% organic carbon, 25.92 kg/ha of available P_2O_5 and 440.50 kg/ha of available K_2O. The experiment was laid out in randomized block design with three replications. There were nine treatments comprising of stage of harvests from six months after planting to fourteen months after planting at monthly intervals. The experiment on stage of harvest was repeated under open condition in direct sunlight and under shade in a D x T hybrid coconut garden aged over 30 years. The light availability in the interspaces of coconut garden was measured as 60 percent using Luxmeter. The different stages of harvest were fixed based on the data of root yield from the preliminary observational trial conducted for growth analysis. The seeds of *Sida cordifolia* were sown in the nursery by April 15th and one month old seedlings were transplanted under open and shaded situation at a spacing of 50 x 25 cm. Two seedlings were planted per hole. Farmyard manure at the rate of 10 t/ha was applied basally and incorporated in the soil. The total rainfall during the experimental period was 2159.8 mm and 2638.3 mm in 2008 and 2009 respectively. The other management practices were done as per the Package of Practices Recommendations [2]. Five plants from each plot were selected for recording growth and yield parameters. The plants from net plots were uprooted at different stages of harvest as per the treatment. Observations on fresh yield and biomass production were recorded. They were oven dried at 70^{o}C for recording dry yield and dry matter production. The root yield was recorded as kg per plot and expressed in kg per hectare. The ephedrine content of the root was estimated by HPLC analysis [7]. The extracted samples were filtered through 0.4µ filter paper and used for analysis in HPLC (C18 reverse phase column and UV-Vis detector of 210 nm). 20µl of extracted sample was injected into the system with a flow rate of 1ml/minute using Acetonitrile-water (65:35) as solvents. Retention time of ephedrine was 2.8 minutes. The ephedrine yield per hectare was calculated from ephedrine content of the root and root yield. The statistical analysis of the data of individual years and pooled data were done by adopting standard procedures [12].

RESULTS AND DISCUSSION

Effect of light intensity

The plants grown under open condition consistently showed higher number of branches, root length, number of roots and root: shoot ratio

(Table 1). The plants were found to be lanky under shade compared to open situation. The yield attributing characters viz. number of roots and root length were also considerably higher with full sunlight compared to shade. The R:S ratio was maximum at eight months after planting with plants grown under open and was almost 400 times higher compare to the plants of the same age under shade. Higher R:S ratio with open condition signified that proportionally more photosynthates are allocated to root tissue under full sunlight. It was reported that to utilize available photosynthetic photon flux density efficiently the plants maximize production of photosynthetic tissues by redistributing dry matter [10]. The fresh as well as dry root yields were also followed the same trend of higher values under open condition. On the contrary, higher R:S ratio with increasing shade intensities was reported in *Adathoda beddomei* [8]. The dry root yield under open condition was 550 times higher compared to that under shade at eight months of age. Under shade the plants took more time for the allocation of dry matter to roots and the highest root yield was recorded at twelve months after planting and it was 288 times lower compared to the highest root yield under open situation(Fig.1). With respect to ephedrine yield also the same trend of higher ephedrine yield at hundred per cent sunlight was noticed. As the dry matter partitioning was slower under shade, the quality development was also in the same pace and highest ephedrine yield was observed at thirteen months after planting and was very low compared to that under open situation (Fig.2). The maximum yield and ephedrine content was noticed under open condition.

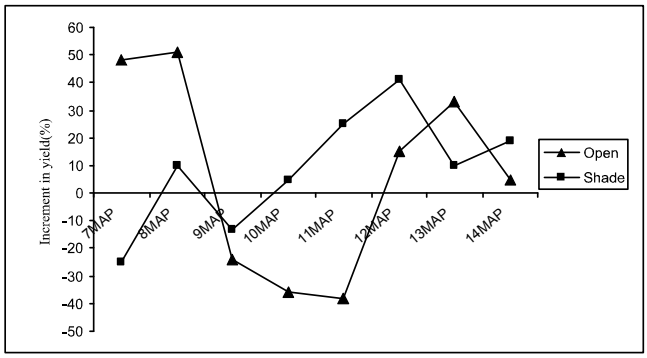

Fig.1.Percent increment in dry root yield at different stgaes of harvesting under open and shaded condition

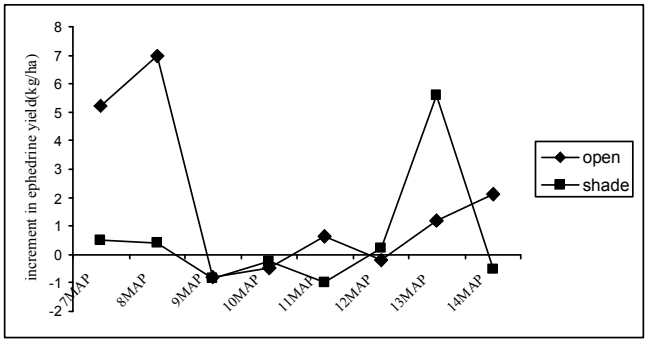

Fig.2. Variation in ephedrine yield at different stages of harvesting under open and shaded condition

Effect of harvesting stage

Significant variability on account of differential harvesting was noticed in respect of growth and

Table 1. Effect of harvesting stage on yield-contributing morphological attributes of *Sida cordifolia* under open and shaded conditions.

Treatments	Height		No of branches		Root length (cm)		No of roots	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade
6MAP	27.53	76.10	11.30	9.40	29.37	14.07	17.70	4.17
7MAP	47.30	87.17	16.63	18.33	48.10	19.17	18.87	10.48
8MAP	65.53	92.87	29.20	19.33	49.77	21.27	19.37	10.95
9MAP	85.52	111.50	24.47	11.17	32.47	21.60	20.38	11.23
10MAP	46.73	97.40	25.07	15.90	20.20	15.63	14.57	11.17
11MAP	32.17	86.37	24.03	15.03	22.77	16.27	13.13	5.57
12MAP	26.92	69.32	9.33	12.83	21.33	22.68	9.14	8.13
13MAP	30.36	93.36	12.00	19.70	18.43	14.58	14.50	7.53
14MAP	76.23	59.12	7.20	7.06	15.83	20.00	10.77	3.03
CD(0.05)	11.56		3.96		4.91	5.01	2.42	2.39

MAP- months after planting

yield components of *Sida cordifolia* during both years and with pooled data (Table 1 and 2). The different harvesting stages produced remarkable influence on height of the plant, number of branches and dry matter production. The dry matter production was significantly higher with the crop harvested at eight months after planting which was forty one and sixty seven per cent higher compared to harvesting at seven months and nine months after planting respectively. Significantly higher root yield recorded at eight months of age was due to higher dry matter production and consequently increased partitioning of photosynthates to the roots. This might have contributed to increased root length and more number of roots at eight months of age which resulted in higher root yield compared to other stages of harvest (Table 1). The root yield at eight months of age was 95 per cent higher than that at nine months of age

(Table 2). The decline in root yield due to further delay in harvesting after eight months of age and more may be due to the high temperature and dry climate prevailed as the summer proceeded and consequent drying of the plant. Further increase in the fresh root yield from twelve months of age was due to reflushing and regrowth of the plant due to the receipt of South West Monsoon and seasonal variations. The dry root yield also followed the same trend (Table 3). The percent variation in dry root yield with stage of harvest is depicted in Fig.1. The result indicated an increment in dry root yield up to eight months of age and after that a steep decline was noticed. Similar results of variation in yield due to difference in stages of harvest was reported in *Withania somnifera* [4], *Aerva lanata* [1] and *Chlorophytum borivilianum* [3]. The ephedrine content also followed the same trend and found to be maximum at eight months of age. The data on ephedrine yield estimated from ephedrine content and root yield also indicated that the ephedrine yield was maximum at eight months after planting and further delay in harvesting after eight months showed a large decline in the ephedrine yield (Table 3). The increment in ephedrine yield was progressing up to eight months after planting and further a sharp decrement was noticed from 9th month onwards(Fig.2). The variation in distribution of dry matter production with differential harvesting time might have also resulted in changes of

Table 2. Effect of harvesting stage on biomass accmulation in *Sida cordifolia* under open and shaded conditions

Treatments	R:S ratio		Biomass production(g/pl)		Dry matter production(g/pl)		Fresh root yield (kg/ha)	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade
6MAP	0.108	0.074	68.83	30.23	45.94	15.64	587.17	165.83
7MAP	0.174	0.073	68.90	51.93	46.45	36.30	1283.00	315.83
8MAP	0.304	0.072	85.51	55.18	62.04	32.36	1498.33	329.17
9MAP	0.153	0.081	56.61	45.68	29.68	29.31	912.50	159.17
10MAP	0.133	0.087	46.69	35.62	20.63	19.65	735.66	175.83
11MAP	0.085	0.079	35.15	29.60	14.23	18.36	565.66	221.00
12MAP	0.076	0.198	42.79	33.45	21.69	19.65	766.00	359.00
13MAP	0.203	0.172	49.65	39.87	24.58	25.34	819.66	317.00
14MAP	0.269	0.229	55.63	46.58	25.98	25.67	923.66	391.00
CD(0.05)	0.102	0.102	11.21	9.65	7.86	7.64	86.14	58.48

MAP- months after planting

Table 3. Effect of harvesting stage on root and ephedrine yield of *Sida cordifolia* under open and shaded conditions

Treatments	Dry root yield(kg/ha)		Ephedrine yield(kg/ha)	
	Open	Shade	Open	Shade
6MAP	490.55	79.17	0.07	0.079
7MAP	726.17	99.17	4.59	0.126
8MAP	1100.50	109.17	36.74	0.184
9MAP	826.67	95.00	7.20	0.075
10MAP	524.67	94.67	3.64	0.051
11MAP	322.17	119.17	1.21	0.044
12MAP	370.83	168.33	0.97	0.061
13MAP	494.00	171.33	2.13	0.407
14MAP	497.00	186.83	6.65	0.183
CD(0.05)	68.12	46.98	0.18	0.180

MAP- months after planting

secondary metabolite production and their accumulation. The increment in root yield as well as ephedrine content over months of growth indicated a peak at eight months of age which gives an indication of the correct stage for harvesting the crop. Similar findings were noticed in andrographaloid content of *Andrographis paniculata* [13] and essential oil quality in *Thymus* species [1,5].

Cultivation of shade loving medicinal plants in the homesteads which is a unique system prevalent in Kerala holds promise as a source of subsidiary income. This in turn necessitates identification of appropriate species for cultivation under different light regimes. The reaction of *Sida cordifolia* to light intensity clearly indicated that it cannot be recommended for cultivation in the homesteads of Kerala as it cannot tolerate shade.

Thus it can be concluded from the present study that *Sida cordifolia* cannot tolerate shade and requires open condition for higher root yield and quality development. The optimum stage for the harvest of *Sida cordifolia* is eight months after planting at which maximum root yield and ephedrine content was noticed.

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