Effect of planting materials, fertilizers and microsite improvement on yield and quality of henna (Lawsonia inermis) in Alfisols of semi-arid regions

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Effect of planting materials, fertilizers and microsite improvement on yield and quality of henna (*Lawsonia inermis*) in Alfisols of semi-arid regions

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ABSTRACT

A field study was conducted for 6 years (1998–2004) at Hyderabad to evaluate the influence of planting materials, microsite improvement and fertilizers on productivity, lawsone content and economic returns of henna (*Lawsonia inermis* L). The leaf yield and quality were influenced by different treatments. During rainy season the yield increase in cuttings over seedlings was 100, 50.7, 37.7, 63.8, 29.6, 61.3 % during 1998, 1999, 2000, 2001, 2002 and 2003 respectively. Whereas the increase in post-rainy season yields were 360, 26.7,100, 49.3, 41.7, and 60.7 % during 1998, 1999, 2000, 2001, 2002 and 2003 respectively. This indicates that the increase in yields was more in high rainfall years (1998, 2001, 2003) compared with the low rainfall years (1999,2000, 2002). Significant increase in leaf yields was observed with microsite improvement over the no microsite improvement during low rainfall years. The treatments having seedlings, microsite improvement and fertilizer application recorded significantly higher lawsone content. At the end of 9 years cuttings recorded 73, 112, 73 % higher gross, net monetary returns and B: C ratio respectively over the seedlings. Microsite improvement improved gross and net returns by Rs 53 150 and Rs 43 425 compared with the no microsite improvement. The comparison of regression coefficients has shown that, the rate of increase in leaf yield with rainfall differed significantly between the two planting materials and microsite improvement, indicating that seedlings are more drought tolerant than the cuttings. The microsite improvement helps in increase of yields during low rainfall years.

Key words: *Lawsonia inermis,* Lawsone, Microsite, Planting dates, Quality, Economic viability, Hydraulic conductivity

Henna (*Lawsonia inermis* L.) is one of the oldest natural dye, which is used in textile industry as well as cosmetic dye. This is the only dye crop, that persisted even after the invention of synthetic dye (Pratap Narain *et al.* 2005). The realization of toxic effects of synthetic dyes has led to increase in interest on natural dyes. The leaves constitute the main economic produce in henna. Major part of the crop is exported as herbal hair dye to other countries. In arid and semi-arid fringes the arable crops give unproductive yields due to intermittent dry spells and unproductive lands. Henna cultivation provides some assured income to growers owing to its deep root system and drought hardiness in dry spells also (Pratibha and Korwar 2002). Henna is a low input requiring crop and once it is established this crop does not require any special attention or annual recurring expenditure unlike arable crops. Hence cultivation of henna is gaining popularity in rainfed Alfisols of semi-arid tropics. Well-managed conditions can improve the yield and quality of the crop. Lawsone, a secondary metabolite is a natural colourant. The compound belongs to quinone group. In India, a considerable attention has been focused on agronomy of medicinal and aromatic plants, but very little attention was given to study of the dye yielding species. Keeping in view the above facts an attempt was made to study the influence of planting materials, microsite improvement and fertilizers on yield and quality of henna under semi-arid rainfed regions.

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MATERIALS AND METHODS

A field experiment was conducted for 6 years during 1998–2004 in the rainfed Alfisols of Hayatnagar research Farm of the Institute, Hyderabad, and Andhra Pradesh. The climate was semi-arid tropical with the average annual rainfall during experimental years was 600 mm and 90 mm rainy season and post-rainy season respectively. The soil was shallow marginal Alfisol and was low in organic carbon (0.3%), available nitrogen (250 kg/ha), phosphorus (8.1 kg/ha) and medium in potassium (210 kg/ha). The waterholding capacity of the soil was very low (10 % by volume).

The experiment was laid out in a split-split plot design with 4 replications. The treatments consisted of planting materials (cutting and seedlings), microsite improvement (M_1 with and Mo without microsite improvement) and fertilizer (F_1 fertilizer and no fertilizer F_0) in main, sub and sub-sub plots respectively. The gross and net plot sizes were 72 m^2 (12 m × 6 m) and 32 m^2 (8 m × 4 m) respectively. The cuttings and seeds from same plants were planted in the nursery during April and May respectively and they were transplanted in the experimental plot in 1996. Fertilizer treatments (30 N kg/ha and 40 kg P_2O_5/ha) were given on well-established three-year-old plants.

Henna was planted in pits of 30 cm diameter and 30 cm depth dug at a spacing of 2 m × 1 m. In the microsite-improved treatment, pits were filled with a mixture of soil, farmyard manure and tank silt (1/3 of each by volume) along with 100 g each of diammonium phosphate and benzene hexachloride (10%). In the non-microsite improved treatment, pits were filled with original soil (without amendment) and 100 g each of diammonium phosphate and benzene hexachloride (10%). Henna, leaves were harvested twice in a year, ie first cutting in December (rainy season harvest) and second in May (post-rainy season harvest). For harvesting, the plants were cut at 0.5 m height from the ground level and shade dried. Leaves were separated from the stem by beating with sticks. The dry leaf yield in the 2 seasons was recorded separately. The 2 seasons yields were added to obtain total yields. The lawsone content in henna leaf was estimated as per the procedure given by Pratibha and Korwar (1999). Statistical analysis of the data and the homogeneity of two regression coefficients were done as suggested by Gomez and Gomez (1984). The economics were calculated from the time of planting because the microsite improvement treatments were applied at the time of sowing. The fertilizer application was done on 3-years-old plantation.

RESULTS AND DISCUSSION

Leaf yield

Leaf yield of henna was significantly influenced by the different treatments in all the years. Rainy season harvest (December) recorded higher yield than post-rainy season harvest (May) during all the years (Table 1). The yields of rainy season and post - rainy season harvest of the following year were added and taken as the total yields of five years 1998–99, 1999–2000, 2000–01, 2001–02, 2002–03 and 2003–04. Results indicate that there is variation in leaf yield within years. Such variations were due to variations in amount and distribution of rainfall. Planting materials in both the seasons significantly influenced the dry leaf yield of henna. Cuttings increased the yields in rainy season by 100, 50.7, 37.7, 63.8, 29.6, 61.3 % during 1998, 1999, 2000, 2001, 2002 and 2003 respectively over the seedlings. Whereas the increases in post-rainy season yields were 360, 26.7,100, 49.3, 41.7, 60.7 % during 1999, 2000, 2001, 2002, 2003 and 2004 respectively. The increment in yield of cuttings over seedlings was higher in high rainfall years than that in low rainfall years. The better performance of seedlings during low rainfall years

Table 1 Influence of planting materials, microsite improvement and fertilizers on leaf yield of henna (tonnes/ha)

Treatment	Rainy 1998	Post-rainy 1998	Total	Rainy 1999	Post-rainy 1999	Total	Rainy 2000	Post-rainy 2000	Total	Rainy 2001	Post-rainy 2001	Total	Rainy 2002	Post-rainy 2002	Total	Rainy 2003	Post-rainy 2003	Total	Pooled
Planting materials																			
Cuttings	3.55	0.85	4.40	2.19	0.22	2.41	2.47	1.15	3.62	2.7	0.44	3.14	1.49	0.120	1.62	2.32	0.79	3.1	3.05
Seedlings	1.77	0.19	1.95	1.43	0.17	1.59	1.79	0.56	2.35	1.36	0.29	1.66	1.14	0.085	1.23	1.44	0.49	1.9	1.73
CD (P= 0.05)	0.249	0.056	0.26	0.28	.014	0.277	0.207	0.24	0.38	0.075	0.025	0.12	0.193	0.007	0.19	0.094	0.06	0.15	0.201
Microsite improvement																			
M_0	2.57	0.49	3.07	1.7	0.17	1.92	1.71	0.71	2.42	1.89	0.35	2.26	1.10	0.08	1.18	1.72	0.646	2.34	2.2
M_1	2.74	0.55	3.29	1.87	0.22	2.08	2.56	0.99	3.55	2.17	0.37	2.54	1.54	0.12	1.66	2.04	0.641	2.67	2.58
CD (P= 0.05)	NS	NS	0.16	NS	0.014	0.14	0.198	0.05	0.21	0.18	NS	0.234	0.27	0.006	0.27	2.68	NS	0.27	0.22
Fertilizers																			
F_0	2.50	0.49	2.99	1.98	0.157	1.78	1.78	0.85	2.64	1.93	0.28	2.22	1.12	0.110	1.24	1.82	0.63	2.45	2.25
F_1	2.81	0.54	3.35	1.63	0.233	2.22	2.48	0.85	3.34	2.13	0.44	2.57	1.51	0.094	1.61	1.94	0.65	2.59	2.53
CD (P= 0.05)	0.22	0.050	0.19	0.05	0.007	0.055	0.134	Ns	0.17	0.095	0.034	0.11	0.165	0.006	0.66	NS	Ns	NS	0.152

over cuttings is attributed to better root growth, which contributes to drought hardiness (Rao *et al.* 2003).

Microsite improvement gave higher yields both in rainy season and post-rainy season harvest during low rainfall years. Whereas, during high rainfall years the increase in yields in microsite improvement over no microsite improvement were non-significant. Whereas the positive response on leaf yield was observed with microsite improvement. The positive response in yield due to microsite improvement could be ascribed to better moisture retention in microsite-improved plots due to addition of tank silt and farmyard manure. Moreover addition of tank silt and farmyard manure decreases the bulk density in the microsite-improved treatments (1.23 g/cc against 1.64 in outside). This decrease in bulk density increases the soil porosity and help in better lateral root growth. Simmons and Pope (1988) observed increase in root growth with decreased bulk density. The microsite improvement also improved the soil environment, which encourages proliferous root system resulting in better storage of moisture in the root zone and absorption of moisture and nutrients thus resulting in higher yield. At present little or no fertilization is applied to the crop. Application of fertilizers proved beneficial and recorded higher yields. Significant increase in the yields with fertilizer application were observed during high rainfall years when compared to low rainfall years. There was increase in yields in fertilizer application to the tune of 12% over no fertilizer application. The fertilizer application might have stimulated the more growth and development of leaf in the presence of moisture when compared to low moisture (Rao *et al.* 2003)

Quality

The quality of leaf was assessed separately for the two seasons (rainy season and post-rainy season). The rainy season harvest recorded higher lawsone content than the post-rainy season. On an average the lawsone content was 2.32 mg/g, 2.24 mg/g in rainy and post-rainy season harvests respectively. The planting materials and microsite improvement differed significantly in lawsone content (Table 2). Seedlings recorded higher lawsone than cuttings. There was differential response of microsite improvement on lawsone content in different years. In general microsite treatments recorded higher lawsone content than no microsite treatments. Whereas the significant difference in lawsone content in microsite improved plots was observed only in high rainfall years. Fertilizer application recorded significantly higher lawsone content than no fertilizer application. In general, fertilizer application recorded 16% higher lawsone content than no fertilizer application. Increase in leaf-stem ratio with fertilizer application might have reduced the fiber content and consequently have improved the quality of leaf. The low lawsone content in the cuttings is attributed to early flowering in cuttings than seedlings. This early flowering results in diversion of the photosynthates to flowers and seed formation, hence the photosynthates available for synthesis of secondary metabolites are reduced and this lead to the reduced lawsone content in cuttings.

Economic viability

Initially cuttings and microsite improvement had higher cost of cultivation than seedlings and no microsite treatment. The economic analysis of the treatments during experimental

Table 2 Influence of Planting materials, microsite improvement and fertilizers on lawsone content (%)

Treatments	Rainy 1998	Post-rainy 1998	Rainy 1999	Post-rainy 1999	Rainy 2000	Post-rainy 2000	Rainy 2001	Post-rainy 2001	Rainy 2002	Post-rainy 2002	Rainy 2003	Post-rainy 2003
Planting materials												
Cuttings	2.40	2.81	2.34	1.44	1.44	3.30	3.17	2.88	1.54	1.29	2.36	1.49
Seedlings	2.81	3.11	2.51	1.46	1.50	2.95	3.35	3.15	1.64	1.40	2.45	1.69
SEm±	0.032	0.04	0.01	0.016	0.014	0.049	0.025	0.047	0.039	0.009	0.028	0.018
CD ($P = 0.05$)	0.196	0.244	0.058	NS	NS	0.301	NS	NS	NS	0.053	NS	0.11
Microsite improvement												
M_0	2.65	2.57	1.80	1.51	1.49	3.23	3.38	3.07	1.43	1.37	2.58	1.58
M_1	2.55	3.34	3.05	1.39	1.45	3.02	3.14	2.96	1.75	1.32	2.22	1.56
SEm±	0.035	0.024	0.04	0.012	0.006	0.038	0.071	0.026	0.045	0.007	0.06	0.014
CD ($P = 0.05$)	NS	0.094	0.156	0.047	0.024	0.148	NS	0.103	0.177	0.028	0.23	NS
Fertilizers												
F_0	2.62	2.54	1.7	1.43	1.42	3.16	3.27	2.98	1.42	1.36	3.09	1.61
F_1	2.59	3.38	3.16	1.47	1.52	3.09	3.29	3.05	1.77	1.33	1.72	1.53
SEm±	0.032	0.032	0.033	0.033	0.017	0.04	0.05	0.061	0.081	0.007	0.068	0.023
CD ($P = 0.05$)	NS	0.104	0.107	NS	0.055	NS	NS	NS	0.263	0.021	0.222	0.075

M_0, No Microsite improvement; M_1, microsite improvement; F_0, no fertilizer; F_1, with fertilizer

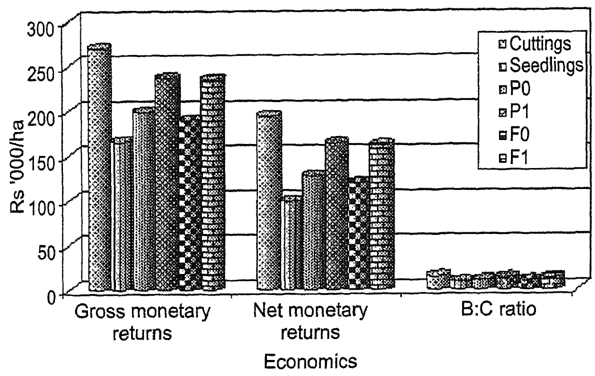

Fig 1 Influence of different treatments on economics of henna

period, that is at the end of 6 years (Fig 1) indicated that the cuttings recorded 98 and 68 % higher gross monetary returns and net monetary returns respectively over seedlings. Pit modification and fertilizer application recorded higher returns over the no microsite improvement and no fertilizer application.

Influence of rainfall on leaf yield and lawsone content

The relationship between leaf yield and lawsone content with rainfall in various treatments was assessed using linear regression analysis. A positive significant correlation (r = 0.80) between the yield and rainfall was observed in cuttings during rainy and post-rainy season, but the regression coefficient (R = 0.263) was not significant in post-rainy season harvest (Table 3 and 4). Whereas seedlings had no significant correlation between yield and rainfall (r = 0.22) in rainy season, while it was significantly correlated in post-rainy season. During rainy season, in microsite improvement treatments, the yields were not correlated with rainfall, whereas in no microsite modification yields were positively correlated with rainfall. In post-rainy season both microsite and no microsite improvement were significantly influenced by rainfall. Similarly the yields with fertilizer application were significantly correlated with rainfall during rainy and post-rainy season.

The homogeneity of the two regression coefficients for the two planting materials and microsite improvement were tested to study the response of the planting materials and microsite improvement to rainfall. The test revealed that, the response of planting materials (cuttings and seedlings), microsite improvement and no microsite improvement to rainfall differed significantly, indicating that the rate of increase in yield with incremental change in rainfall is different. The increment in yield with rainfall is higher in cuttings and no microsite improvement modification during rainy season, whereas seedlings had higher increment during post-rainy season. This indicates that the rate of increment with rainfall is more in cuttings indicating that cuttings respond to higher rainfall. Higher increment in post-rainy season indicates that, seedlings are more drought tolerant than cuttings. Similarly in no microsite improvement the increase in yields with rainfall was positive and more when compared to microsite improvement. This indicates that moisture retention in microsite improvement had helped in realizing more yields even if rainfall is less. The regression coefficient of fertilizer application with rainfall is not significant indicating that the increase in yield with and without fertilizer application to rainfall is similar. The regression coefficients of rainfall and lawsone content in planting materials and fertilizer application is non-significant in rainy season. Where as the coefficients of microsite improvement with rainfall is significant.

Thus it may be concluded that the planting of henna

Table 3 Response functions of yield and quality of henna to rainfall

Treatment	Response equation		r		R^2	
	Rainy	Post rainy	Rainy	Post- rainy	Rainy	Post rainy
		Yield				
Cuttings	465.1+ 3.3206x	54.163–6.6908x	0.800**	0.513**	0.646**	0.263
Seedlings	1275.1+ 0.3585x	249.83+ 6.664x	0.229	0.729**	0.052	0.530**
Microsite improvement	1518.4 +0.9858x	98.095–6.4695x	0.351	0.610**	0.124	0.373**
No Microsite improvement	216 + 2.7013x	203.13 + 6.8456x	0.880**	0.800**	0.780**	0.649**
Fertilizer	903.69 +1.9304x	115.89–6.5298x	0.539**	0.722**	0.290	0.520**
No fertilizer	837.48+1.7478x	188.65–6.839x	0.813**	0.687**	0.660**	0.472**
		Lawsone				
Cuttings	0.2479 + 0.0033x	1.3847+ 0.0097x	0.846**	0.309	0.716**	0.095
Seedlings	0.0196 + 0.0039x	1.252 + 0.0111x	0.911**	0.407	0.830**	0.165
Microsite improvement	0.5452+ 0.003x	1.1442+0.0126x	0.720**	0.402	0.520**	0.161
No Microsite improvement	0.2745–0.0042x	1.4925+ 0.0082x	0.880**	0.293	0.789**	0.086
Fertilizer	0.0295 + 0.0036x	1.1606 + 0.0129x	0.723**	0.411	0.524**	0.169
No fertilizer	0.2441+ 0.0036x	1.4737+ 0.0079x	0.747**	0.282	0.559**	0.080

Table 4 Significance of estimated linear relationship between yield and lawsone content with rainfall in different treatments

Treatment	t value	
	Yield	Lawsone
Cuttings vs seedlings (Rainy)	*	NS
Cuttings vs seedlings (Post-rainy)	*	NS
No pit mixture vs pit mixture (Rainy)	*	*
No pit mixture vs pit mixture (Post-rainy)	NS	NS
Fertilizer vs no fertilizer (Rainy season)		
Fertilizer vs no fertilizer (Post-rainy)		
Cuttings rainy vs post-rainy	NS	NS
Seedlings rainy vs post-rainy	*	NS
No pit mixture rainy vs post-rainy	*	NS
Pit mixture rainy vs post-rainy	*	NS

through cuttings with microsite improvement and fertilizer application gives higher yields and proved to be economically viable compared to seedlings and no microsite improvement.

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