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Effect of nutrient management and row spacing on henna (*Lawsonia inermis*) leaf production and quality

S S RAO[1], P L REGAR[2], P K ROY[3] and Y V SINGH[4]

Regional Research Station, Central Arid Zone Research Institute, Pali-Marwar, Rajasthan 306 401

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ABSTRACT

A field experiment was conducted to find out the effect of conjunctive use of organics, ie farmyard manure and inorganic sources of nutrients and row spacing on henna (*Lawsonia inermis* L.) during 2003–04 to 2005–06 at Pali (Rajasthan). The application of farmyard manure of 5 tonnes/ha significantly increased dry leaf yield by 11.4% over no farmyard manure treatment. Fertilizer application at 80 kg N and 40 kg P_2O_5/ha recorded 19.3% higher dry leaf yield compared with the control. Significant improvement in dry leaf yield was also obtained with non-monetary input, ie increasing width of row spacing from 30 cm to 45 cm or 60 cm. Highest dry leaf yield of 1 302.6 kg/ha was obtained under 80 kg N and 40 kg P_2O_5/ha with 45 cm row spacing compared with the 945.2 kg/ha dry leaf yield obtained under 30 cm row spacing with no fertilizer. The results indicate that at higher levels of nutrient supply, more plants/unit area are required to exploit fully the higher fertility potentials. Leaf dye yield increased significantly due to application of farmyard manure, fertility levels and row spacing. Fertilizer at 80 kg N and 40 kg P_2O_5/ha gave Rs 14 749 net return compared to Rs 13 184 over no fertilizer application. The crop row spacing of 45 cm being at par with 60 cm gave net return as high as Rs 1 213/ha over 30 cm row spacing.

Key words: *Lawsonia inermis*, Leaf yield, Dye content, Organic manure, Row spacing, Arid fringes

Henna (*Lawsonia inermis* L.), a drought hardy perennial shrub cultivated for its dye bearing leaves used as natural dyestuff and other industrial uses (WWW 2004). Cultivation of henna is now mostly concentrated in Pali district of Rajasthan contributing over 90% of the henna area and produce best quality internationally renowned 'Sojat brand' of henna. The hot and arid climate of western Rajasthan where production and life support system is constrained by low and erratic rainfall, high evapotranspiration and poor soil conditions, cultivation of henna gives reasonable returns when most arable crops often ends in failure (Khemchand *et al.* 2002). The overall demand for henna is estimated to grow by 8% annually the scope for increasing production by area expansion is limited (Narain *et al.* 2005). As henna plantations are maintained as annual ratoon crop and are viable for next 15–20 years, hence the maintenance and enhancement of declining soil productivity for this crop is a major problem. The integrated nutrient management involving organic and inorganic sources of nutrient will help to improve the soil productivity. Further, plant population vis-à-vis row spacing is one of the major management variable available for high yield in rainfed agriculture (Rao *et al.* 2003). The objective of the present study was to evaluate effect of organic and inorganic sources of nutrient and row spacing on dry leaf yield and quality of henna leaves.

MATERIALS AND METHODS

Henna was planted in the experimental field in 2001 at the Regional Research Station of the Institute, Pali-Marwar. The soil was fine loamy in texture, mixed hyper-thermic belonging to the family lithic calciorthids having 30–45 cm depth and dense underlying layer of *murrum* (highly calcareous weathered granite fragment coated with lime) up to 10–15 m depth. It had *p*H 7.9, EC 0.16 dS/m, field capacity 17.1% and permanent wilting point 7.1%. The soil had 231.0 kg/ha available N, 11.5 kg/ha Olson's P and 260.0 kg/ha exchangeable K. The treatment comprised organic manure (control, farmyard manure @ 5 tonnes/ha), 3 fertility levels (control, 40 kg N and 20 kg P_2O_5/ha, 80 kg N and 40 kg P_2O_5/ha) and 3 row spacing (30 cm, 45 cm and 60 cm). The treatments were laid out in factorial randomized block design with 3 replications and each plot was measuring 5 m × 5.4 m in size.

The amount of rainfall received during the pendency of crop growth in 3 years was 393.5, 308.7 and 440.2 mm during 2003, 2004 and 2005 respectively. The crop was raised as rainfed by transplanting 3–4 months-old seedlings raised by seeds with the onset of monsoon rains during July 2001. The crop was harvested at about 140 days after

[1]Senior Scientist (Agronomy), [2]Scientist Selection Grade (Soil and Water Conservation), [3]Senior Scientist (Plant Breeding), [4]Head

Table 1 Effect of nutrient management and row spacing on henna growth, yield attributes and quality parameters (3 years pooled data)

Treatment	Plant height (cm)	Branches/ plant	Leaf weight (g/ plant)	Total bio-mass (kg/ha)	Leaf: stem ratio	Leaf dye content (mg/g dry weight)
Organic manure						
No FYM	91.3	5.4	24.8	2 282	0.86	26.7
FYM 5 tonnes/ha	98.1	6.2	27.5	2 509	0.88	26.7
SEm±	0.8	0.07	0.35	34.5	0.01	0.18
CD (P=0.05)	2.3	0.19	0.96	95.5	NS	NS
Fertility levels						
N_0P_0	90.1	5.5	24.3	2 228	0.85	26.3
$N_{40}P_{20}$	95.3	5.9	26.8	2 356	0.87	27.4
$N_{80}P_{40}$	98.7	6.0	27.2	2 602	0.89	26.4
SEm±	1.0	0.08	0.43	42.2	0.01	0.22
CD (P=0.05)	2.8	0.23	1.18	117.0	NS	0.61
Row spacing						
30 cm	89.5	5.4	23.6	2 284	0.86	26.7
45 cm	98.1	5.8	26.7	2 500	0.88	26.5
60 cm	96.5	6.2	28.1	2 402	0.86	26.9
SEm±	1.0	0.08	0.43	42.2	0.01	0.22
CD (P=0.05)	2.8	0.23	1.18	117.0	NS	NS

FYM, Farmyard manure

plantation in the first year. In subsequent years henna plantation was maintained as annual ratoon crop and harvested at 100–110 days after onset of monsoon rains during September. Farmyard manure @ 5 tonnes/ha was applied during June every year and N and P was applied through diammonium phosphate and urea. Data were recorded year-wise and presented here from 2003 to 2005 as this crop gives economic yield from third year onward after establishment. Leaf dye content was estimated by the standard procedure (BIS 1984).

RESULTS AND DISCUSSION

Growth and yield attributes

Plant height, branches/plant, leaf weight/plant and total biomass production (above ground) were significantly increased due to application of farmyard manure @ 5 tonnes/ha over the control. However the increases in leaf: stem ratio and leaf dye content were not significant due to farmyard manure application (Table 1). The better plant growth and yield attributing characters might be due to the beneficial effect of farmyard manure by way of slow release of nutrients to soil for longer duration after decomposition that reflected in higher biomass production.

Increasing rate of fertilizer application significantly enhanced the plant height, branches per plant, leaf weight per plant and total biomass production, over no fertilizer. The magnitude of increase in total biomass was 16.8% due to application of 80 kg N and 40 kg P_2O_5/ha over the control on pooled basis. Direct supply of nutrients to the crop through fertilizer may be the reason for better growth performance.

The effect of row spacing on henna was significant. Maximum branches/plant and leaf weight/plant were recorded under 60 cm row spacing. Data show that row spacing of 45 cm being at par with 60 cm, significantly increased total biomass production (above ground) by 11.8% over the row spacing of 30 cm on pooled basis. However leaf: stem ratio and leaf dye content remain unaffected due to row spacing. The improvements in yield at wider row spacing of 45 cm or 60 cm may be ascribed to reduced inter row competition between the plants for growth resources, like water and nutrients that encouraged efficient use of these resources leading to improvement in plant growth and yield attributes which in turn increased biomass production. Wider row spacing under moisture stress condition, owing to low and erratic rainfall might have helped in efficient use of moisture and minerals.

The interaction effect of farmyard manure and fertility levels with row spacing on leaf weight per plant was significant (Table 2). Maximum leaf weight of 32.5 g/plant was recorded under farmyard manure @ 5 tonnes/ha with highest fertility level and 60 cm row spacing, whereas minimum leaf weight of 20.3 g/plant was recorded under no farmyard manure, no fertilizer and 30 cm row spacing.

Dry leaf yield

Dry leaf production in henna was influenced significantly due to organic manuring over the years as well as on pooled basis (Table 3). The dry leaf yield increased significantly

Table 2 Combined effects of organic manure, fertility levels and row spacing on leaf dry weight/plant and dry leaf yield (3 years pooled data)

Treatment	Leaf dry weight (g/plant)						Dry leaf yield (kg/ha)				
	No FYM			FYM (5 tonnes/ha)			Organic manure		Fertility levels		
	N_0P_0	$N_{40}P_{20}$	$N_{80}P_{40}$	N_0P_0	$N_{40}P_{20}$	$N_{80}P_{40}$	No FYM	FYM @ 5 tonnes/ha	N_0P_0	$N_{40}P_{20}$	$N_{80}P_{40}$
30 cm	20.3	23.6	25.6	23.0	23.7	25.6	1 087.3	1 030.0	945.2	985.5	1 245.2
45 cm	21.6	27.5	27.5	27.7	27.7	27.1	1 079.5	1 250.1	1 019.1	1 172.7	1 302.6
60 cm	25.3	26.2	25.2	28.2	28.2	32.5	991.0	1 231.3	1 100.3	1 125.9	1 107.2
SEm±			1.04				37.5		45.9		
CD (P=0.05)			2.89				105.0		128.6		

FYM, Farmyard manure

Table 3 Effect of nutrient management and row spacing on dry leaf yield and economics of henna cultivation (pooled)

Treatment	Dry leaf yield (kg/ha)				Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Leaf dye yield (kg/ha)
	2003	2004	2005	Pooled				
Organic manure								
No FYM	970	848	1 340	1 053	6 189	19 712	13 523	29.8
FYM 5tonnes/ha	1 099	947	1 466	1 170	7 889	21 943	14 053	32.9
SEm±	29	25	40	22		280	338	0.6
CD (P=0.05)	84	71	114	61		776	NS	1.7
Fertility levels								
N_0P_0	983	838	1 243	1 022	6 003	19 187	13 184	28.4
$N_{40}P_{20}$	1 010	851	1 424	1 095	7 039	20 471	13 431	31.8
$N_{80}P_{40}$	1 109	1 003	1 542	1 218	8 075	22 824	14 749	33.9
SEm±	35	30	49	27		343	414	0.7
CD (P=0.05)	102	87	140	74		951	1 148	2.1
Row spacing								
30 cm	985	865	1326	1 059	7 194	19 847	12 653	29.8
45 cm	1 085	967	1443	1 165	7 008	21 853	14 845	32.7
60 cm	1 033	860	1441	1 111	6 916	20 782	13 866	31.6
SEm±	35	30	49	27		343	414	0.7
CD (P=0.05)	NS	87	NS	74		951	1 148	2.1

Henna leaf rate- Rs 20, 22 and 17 per kg during 2003, 2004 and 2005 respectively

under farmyard manure @ 5 tonnes/ha by 13.2, 11.6 and 9.4% over no farmyard manure in the year 2003, 2004 and 2005 respectively. The increase in dry leaf yield may be attributed to improvement in plant growth and total biomass production owing to farmyard manure incorporation.

Application of 80 kg N and 40 kg P_2O_5/ha significantly increased dry leaf yield by 12.8, 19.8 and 24.0% over the control during 2003, 2004 and 2005 respectively. The effect of 40 kg N and 20 kg P_2O_5/ha on dry leaf yield was also significant during 2005. On pooled basis fertilizer application at 80 kg N and 40 kg P_2O_5/ha recorded 19.3% higher dry leaf yield as compared to control. The increase in dry leaf yield following application of N and P fertilizer might be due to increased availability of N to the plant causing accelerated photosynthetic rate leading to the production of more carbohydrate. Phosphorus fertilization also improved the various metabolic and physiological processes in the plant system (Kozolowski and Pallardy 1997).

The effect of row spacing on dry leaf yield was significant. Row spacing of 45 cm being at par with 60 cm caused significant improvement in dry leaf yield over the 30 cm spacing. Pooled analysis show that maximum dry leaf production of 1 164.8 kg/ha was recorded under row spacing of 45 cm followed by 1 111.1 kg/ha under 60 cm as compared to 1 058.6 kg/ha under 30 cm row spacing. Rao *et al.* (2003) also reported similar results. The interaction effect of farmyard manure and fertility levels with row spacing was significant on dry leaf yield (Table 2). Maximum dry leaf yield of 1 250.1 kg/ha was obtained under farmyard manure @ 5 tonnes/ha with 45 cm row spacing followed by 1 231.0 kg/ha under farmyard manure @ 5 tonnes/ha with 60 cm row spacing as compared to 1 087.3 kg/ha dry leaf yield obtained under 30 cm row spacing with no farmyard manure. Similarly maximum dry leaf yield of 1 302.6 kg/ha was obtained under highest level of fertility, ie 80 kg N and 40 kg P_2O_5/ha with 45 cm row spacing followed by 1245.2 kg/ha under same fertility level with 30 cm row spacing as compared to 945.2 kg/ha dry leaf yield obtained under 30 cm row spacing with no fertilizer. The results indicate that at higher levels of nutrient supply more plants/unit area is required to exploit fully the higher fertility potentials and thereby to produce maximum yields than is the case at lower levels of supply. Conversely as plant density increases up to a certain limit, the crop will continue to respond to higher levels of added nutrients.

A significant point worth to mention here is non-significant effect of farmyard manure, fertility levels (except 40 kg N and 20 kg P_2O_5/ha) and row spacing on leaf dye content. In other words, the applied treatments had succeeded in maintaining leaf dye content while increasing dry leaf yield that might have other wise got diluted with increased production (Table 1). Leaf dye yield increased significantly due to application of farmyard manure @ 5 tonnes/ha by 10.4% over the control. An increasing rate of fertilizer application significantly increased dye yield over its lower dose. Row spacing of 45 cm significantly increased dye yield over 30 cm (Table 3). Since the dye yield is a function of dye content and dry leaf yield; it is largely the level of dry leaf yield that reflects variation in dye yield.

The effect of year is significant and variable on plant height, branches/plant, leaf weight/plant, total biomass production, dry leaf yield, leaf dye content and leaf dye yield while leaf: stem ratio remain unaffected (Table 4). Such

Table 4 Effect of years on growth, yield and quality of henna

Year	Plant height (cm)	Branches/ plant	Leaf dry weight (g/plant)	Total biomass (kg/ha)	Dry leaf yield (kg/ha)	Leaf: stem ratio	Dye content (mg/g dry weight)	Dye yield (kg/ha)
2003	95.1	4.95	24.0	2209	1034	0.88	24.0	24.8
2004	86.9	6.01	22.4	1928	897	0.87	31.0	27.8
2005	102.1	6.39	32.0	3049	1403	0.85	25.0	41.4
SEm±	1.0	0.10	0.41	45	26.5	0.01	0.24	0.74
CD(P=0.05)	3.3	0.33	1.42	156	91.8	NS	0.83	2.55

effect could primarily be ascribed to variation in the amount and distribution of rainfall received. Since the crop is generally raised as rainfed and harvested by whole plant cutting (above ground), there would be little growth of roots until regeneration in the next year due to lack of moisture, hence the effect of age is secondary.

Economics

Khemchand *et al.* (2002) reported henna being a perennial crop involves initial high cost of establishment for labour and seedling. In subsequent years, recurring cost involves mainly family labour and variable input. This crop gave economic yield from third year onwards after establishment. Hence the annual fixed cost was calculated and added to the annual maintenance cost to arrive at the cost of cultivation. The cost of cultivation was high under 30 cm row spacing due to more number of seedlings required for planting as compared to other spacing. Application of farmyard manure @ 5 tonnes/ha gave Rs 21 943/ha gross return and Rs 14 053/ha net return as compared to Rs 19 712/ha gross return and Rs 13 523/ha net return obtained under no farmyard manure on pooled basis (Table 3). Fertilizer application proved beneficial to this crop and maximum gross and net returns were obtained when 80 kg N and 40 kg P_2O_5/ha was applied and that gave Rs 22 824/ha and Rs 14 749/ha gross and net return as compared to Rs 19 187/ha and Rs 13 184/ha over no fertilizer application. The crop row spacing of 45 cm being at par with 60 cm gave gross return and net return as high as Rs 2 935/ha and Rs 1 213/ha over 30 cm row spacing. Vyas (2005) also reported similar results.

Thus it can be safely inferred that farmyard manure @ 5 tonnes/ha or application of fertilizer at 80 kg N and 40 kg P_2O_5/ha at crop spacing of 45 cm and/ or 60 cm proved out to be most productive and remunerative for higher production and quality of henna leaves in arid fringes.

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