

Effect of Intercropping, Row Ratios and Organic Manures on Productivity and Quality of Forage under Semi-arid Regions of Rajasthan

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Abstract: A field experiment was conducted at Central Sheep and Wool Research Institute, Avikanagar (Rajasthan), to find out the production performance of perennial *Cenchrus setigerus* grass with biannual legume *Dolichos lablab* in different row ratios (1:1, 1:2 and 2:1), in which organic manures were applied alone or in different combinations (control, sheep manure 10 t ha⁻¹), vermicompost (3 t ha⁻¹) and sheep manure and vermicompost (5 t ha⁻¹ and 1.5 t ha⁻¹). The results revealed that green herbage and dry matter production were influenced significantly under different intercropping row ratios. However, green fodder and dry matter increased maximum when *D. lablab* and *Cenchrus* were sown in 2:1 row ratio followed by 1:1 and 1:2 row ratios. Similarly, crude protein content was higher in dry matter of *D. lablab* and *Cenchrus* planted in 2:1 row ratio (11.60 and 5.36%). The uptake of nitrogen, phosphorus and potassium was maximum in 2:1 row ratio than other row ratios. Overall, there was 15.38% increase in organic carbon and 42.63, 35.34 and 12.72% in available nitrogen, phosphorus and potassium nutrients with 2:1 row ratio as compared to initial soil status. Application of organic manures increased the green herbage and dry fodder yield by 67.83 and 49.79% over control. The crude protein content and nitrogen, phosphorus and potassium uptake also increased significantly with manure application and these were the highest with both organic manures applied together. Soil organic carbon and available nitrogen, phosphorus and potassium were enhanced by 23.07, 44.01, 39.82 and 27.38% with the application of 10 t ha⁻¹ sheep manure as compared to their initial levels in soil. The soil EC was increased and pH decreased with the application of sheep manure (10 t ha⁻¹).

Key words: *Cenchrus*, *Dolichos lablab*, intercropping, row ratio, sheep manure, vermicompost.

Livestock plays an important role in rural economy of the country by providing employment and supplementary family income, contributes about 27% of the total agricultural income (Government of India, 2010). Fodder requirement of livestock is generally met through crop residues of poor-quality, which are not enough for the maintenance of animal health and productivity. The acute shortage of forage is due to low area under fodder crops (4.4% of the net cultivated area). The feed and forage resources are able to meet only 46% of the requirement leaving vast deficit of 64% and 16% in green and dry fodder, respectively (Ram and Singh, 2003). Further, it is essential to intensify cropping systems involving legumes and grasses on the same piece of land, which increased the herbage yield, utilization of land efficiently and providing stability in forage production (Dwivedi and Kumar, 1998). Adoption of suitable intercropping involving grasses and range legumes resulted in increased fodder production with sustaining soil fertility and also helped in positive ecological niches (Naugraiya, 2005). When the crops of different habits are grown

together intercropping system provides higher productivity. Instead growing of sole *Cenchrus*, intercropping *Cenchrus* with *Dolichos* can be more profitable because of increased productivity of both crops and improved soil fertility. The nutrient supplementation through organic sources in mixed pasture attributed to better availability of nutrients and improved soil bulk density, which resulted in improvement in productivity. Hence, an attempt was made to assess the production potential and suitability of *Cenchrus* and *D. lablab* mixed pasture with application of organic manures under semi-arid conditions of Rajasthan.

Materials and Methods

A field experiment was conducted during kharif seasons of 2005 and 2006 at Central Sheep and Wool Research Institute, Avikanagar at 27°17' N and 75° 22' E. The climate of the location is semi-arid subtropical with dry hot summer (April to June) and cold winters (November to January). The average annual rainfall of the experimental site is 550 mm, of which 85% is received through south-western monsoon during the second fortnight of June to September. The average monthly minimum

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and maximum temperature fluctuates from 6.8 to 8.0°C and 19.6 and 21.5°C in winter, from 22.0 and 24.6°C and 45.4 and 48.3°C in summer, respectively. The soil was sandy loam in texture, low in available N (124.52 kg ha⁻¹), medium in available P (8.23 kg ha⁻¹) and high in available K (256.17 kg ha⁻¹) with pH of 7.9. The experiment was laid out in split-plot design with three replications. The main-plot treatments consisted of three intercropping row ratios *viz.* 1:1, 1:2 and 2:1. The organic manures *viz.* control, sheep manure (10 t ha⁻¹), vermicompost (3 t ha⁻¹), and sheep manure 5 t ha⁻¹ + vermicompost 1.5 t ha⁻¹ were in sub plot. The net plot was 8 m x 6 m (48 m²). Both the organic manures were mixed in to the soil 7 days before sowing. *Dolichos* crop was sown in both the years according to configuration of *Cenchrus* rows as paired and in alternate rows. *Cenchrus* was sown only at experiment inception on 9th July in 2005 and 1st July in 2006. The *Cenchrus setigerus* (Dhaman grass) was sown in lines 50 cm apart with a seed rate of 6 kg ha⁻¹ and *D. lablab* (Popat) was sown in lines 60 cm apart with a seed rate of 40 kg ha⁻¹. The test varieties were *Cenchrus* 'IGFRI- S-3018' and *Dolichos* 'JLP-4'. The sheep manure had 0.58% N, 0.27% P₂O₅ and 0.63% K₂O and corresponding values for vermicompost were 1.15%, 0.45% and 0.65%, respectively. Green forage yield was recorded at harvest under all treatments. The plant samples were oven dried at 80°C to record dry fodder yield and analyzed for nitrogen, phosphorus and potassium contents by standard procedures. The plant samples were also analyzed for crude protein content (AOAC, 1995). Post-harvest soil status of organic carbon content, soil pH, EC and available N, P and K nutrients were assessed as per standard procedures.

Results and Discussion

Growth attributes

The growth of *Cenchrus* and *Dolichos* measured as plant height, dry matter plant⁻¹, tillers plant⁻¹ in *Cenchrus* and branches plant⁻¹ in *D. lablab*, revealed that all the treatments brought about marked variation in growth attributes (Table 1). Intercropping row proportion between *Cenchrus* and *D. lablab* had significant influence on growth attributes of both the crops, which were maximum in 2:1 row ratio as compared to rest of the row ratios (1:1 and 1:2). This might be due to inclusion of legume, which improved the soil fertility leading to increased availability of N through fixation and increase in other growth promoting substances along with increased mycorrhizal colonization

(Marinari *et al.*, 2000). The differences between treatments 1:1 and 1:2 row ratios were small for plant height, dry matter accumulation and tillers/plant in *Cenchrus* and branches in *Dolichos*. These results are in accordance with the findings of Sharma (2008). Application of organic manures (SM 5 t ha⁻¹+VC 1.5 t ha⁻¹) brought about significant increase in plant height, dry matter accumulation and tillers in *Cenchrus* (12.07) and branches in *D. lablab* (8.10) over remaining treatments like sheep manure 10 t ha⁻¹, vermicompost 3 t ha⁻¹ and control, respectively. But the treatments *viz.* vermicompost (VC) 3 t ha⁻¹ and half dose of sheep manure (5 t ha⁻¹) and vermicompost (1.5 t ha⁻¹) were at par for all growth parameters of both crops. While, both treatments exhibited significant variation in terms of growth parameters over preceding treatments like sheep manure (10 t ha⁻¹) and control. This might be due to increased availability of plant nutrients from vermicompost than sheep manure.

Forage yield and quality

The green and dry fodder yields were significantly influenced by intercropping row ratios (Table 2). However, maximum increase in green and dry fodder yield was with 2:1 row ratio, which increased to the tune of 23.41, 70.63, 13.25 and 45.34% over 1:1 and 1:2 row ratios. Similarly, crude protein in dry forage of individual crop was highest when *D. lablab* and *Cenchrus* were grown in 2:1 row ratio in comparison to other row ratios (1:1 and 1:2). The magnitude of increase in crude protein content in dry forage at 2:1 row ratio was 1.70 and 12.84% in *Cenchrus* and 30.77 and 75.75% in *Dolichos* over 1:1 and 1:2 row ratios on the basis of mean data over 2 years. Higher green fodder, dry matter and crude protein were observed where higher proportion of legume was there in mixed pasture. This might be due to higher contribution of legume than grass towards total biomass production. Keshwa and Singh (2004) also reported increase in crude protein content with the introduction of legume in the grassland. Application of organic manures *viz.* sheep manure @ 10 t ha⁻¹, vermicompost 3 t ha⁻¹ and sheep manure 5 t ha⁻¹+vermicompost 1.5 t ha⁻¹ resulted in significant increase in green and dry forage production over no application. Combined use of organic manures had more pronounced effects on green and dry forage production than their use alone. The combined application of sheep manure @ 5 t ha⁻¹ + vermicompost 1.5 t ha⁻¹ gave the highest green fodder (14.87 t ha⁻¹), dry fodder (3.73 t ha⁻¹) and crude protein content (6.20 and 9.96%) in dry forage of *Cenchrus* and *Dolichos* as compared to

Table 1. Effect of intercropping row ratios and organic manures on growth components of *Cenchrus* and *Dolichos lablab* (mean data of 2 years)

Treatment	Plant height (cm)		Tillers plant ⁻¹		DMP plant ⁻¹ (g)	
	<i>Cenchrus</i>	<i>Dolichos</i>	<i>Cenchrus</i>	<i>Dolichos</i>	<i>Cenchrus</i>	<i>Dolichos</i>
Intercropping row ratio						
1:1	73.04	105.34	8.06	5.86	29.22	35.04
1:2	82.06	126.40	10.71	6.98	30.37	38.06
2:1	95.21	133.47	13.71	8.54	35.64	46.17
CD (P=0.05)	1.15	3.50	0.65	0.42	0.92	1.50
Organic manure levels						
Control	76.43	108.18	10.04	6.19	28.81	35.81
Sheep manure @ 10 t ha ⁻¹	83.01	119.07	11.04	7.12	31.85	39.32
Vermicompost @ 3 t ha ⁻¹	86.28	125.40	11.09	7.38	32.44	40.03
SM 5 t ha ⁻¹ + VC 1.5 t ha ⁻¹	88.04	132.08	12.07	8.10	33.86	44.11
CD (P=0.05)	3.81	4.04	0.75	0.48	1.07	1.73

other treatments (control, sheep manure: 10 t ha⁻¹ and vermicompost: 3 t ha⁻¹). The highest yield under organic treatments was mainly due to accumulation of nutrients over the years and improvement in physico-chemical properties of soil. The next best treatment was found to be vermicompost applied @ 3 t ha⁻¹ in the mixed pasture than sheep manure applied @10 t ha⁻¹.

N, P and K uptake

The uptake of N, P and K nutrients were influenced significantly with different intercropping row ratios. However, maximum uptake of these nutrients was recorded in 2:1 row ratio of *Dolichos* and *Cenchrus* (Table 2). The next best intercropping row ratio was 1:1. It indicates that introduction of legume in grass improved biomass production, which led to higher uptake of these nutrients. Meena and Mann (2011) observed similar results in *Cenchrus* and moth bean intercropping system. The uptake of N, P and K improved progressively

with use of organic manures and the increase was highest when sheep manure and vermicompost were applied together. Besides, supplying nutrients, organic manures have also solubilizing effect on fixed form of other nutrients and therefore improve the yield of crops. Singh and Singh (2005) also reported 29.9, 18.8, 35.5 and 15.2% increase in yield due to FYM application at 15 t ha⁻¹ and vermicompost at 7.5, 10 and 15 t ha⁻¹ in wheat. This might be due to easier release of plant nutrients from vermicompost than sheep manure.

Residual soil fertility status

The organic carbon content in the soil increased significantly due to intercropping. However, it was maximum (0.30%) when legume proportion was higher than grass and minimum (0.27%) where grass proportion was higher than legume. But pH and EC of the soil decreased with 2:1 row ratio (7.77 and 0.176) followed by 1:1 row ratio (7.86 and 0.228). Besides electrical conductivity was the

Table 2. Effect of intercropping row ratios and organic manures on green fodder, dry matter production, crude protein content and nutrient uptake by *Cenchrus* and *Dolichos lablab* (mean data of 2 years)

Treatment	Green fodder yield (t ha ⁻¹)	Dry fodder yield (t ha ⁻¹)	Crude protein content (%)		Nutrient uptake (kg ha ⁻¹)		
			<i>Cenchrus</i>	<i>Dolichos</i>	N	P	K
Intercropping row ratio							
1:1	12.43	3.17	5.27	8.87	43.70	20.29	27.05
1:2	8.99	2.47	4.75	6.60	24.81	15.07	20.75
2:1	15.34	3.59	5.36	11.60	59.97	24.11	32.07
CD (P=0.05)	0.49	0.09	0.56	0.23	2.29	3.40	4.39
Organic manure levels							
Control	8.86	2.49	4.22	8.17	32.04	15.44	22.18
Sheep manure @ 10 t ha ⁻¹	11.78	2.87	5.00	8.68	38.29	18.04	26.08
Vermicompost @ 3 t ha ⁻¹	13.52	3.23	5.80	9.27	46.03	21.08	30.34
SM 5 t ha ⁻¹ +VC 1.5 t ha ⁻¹	14.87	3.73	6.20	9.96	54.95	24.05	37.04
CD (P=0.05)	0.58	0.12	0.65	0.30	3.05	4.28	4.59

Table 3. Effect of intercropping row ratios and organic manures on soil fertility status after 2 years

Treatment	Organic carbon (%)	EC dS m ⁻¹	Soil pH	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
Intercropping row ratio						
1:1	0.29	0.228	7.86	161.22	15.20	245.02
1:2	0.27	0.240	7.89	152.42	13.71	239.21
2:1	0.30	0.176	7.77	176.01	18.42	256.11
CD (P=0.05)	0.009	0.012	NS	7.20	2.37	17.93
Organic manure levels						
Control	0.28	0.212	7.90	147.61	12.71	204.11
Sheep manure @ 10 t ha ⁻¹	0.32	0.222	7.38	177.71	19.03	289.41
Vermicompost @ 3 t ha ⁻¹	0.30	0.215	7.75	157.73	14.82	231.40
SM 5 t ha ⁻¹ + VC 1.5 t ha ⁻¹	0.31	0.217	7.71	170.03	16.81	261.80
CD (P=0.05)	0.006	0.06	0.19	8.31	2.74	20.70
Initial soil test value	0.26	0.174	7.90	123.40	13.61	227.20

highest (0.240) with 1:2 row ratio. The available N, P and K increased significantly with different intercropping row ratios. While the maximum increase in available N, P and K was at 2:1 row ratio as compared to initial content in soil. The increases in available nutrients were 9.17 and 15.42% in N, 21.18 and 34.35% in P and 45.26 and 70.64% in K, respectively. Dwivedi and Kumar (1998) also concluded that productivity of legume-based cropping sequences increases due to effective and economic utilization of residual and cumulative carry-over nutrients and moisture. Thus, it is clear that inclusion of legumes in intercropping system improves the soil fertility status after harvest of the crops as reported by Singh and Singh (2005). The availability of N, P and K were the maximum with use of sheep manure (10 t ha⁻¹) followed by application of sheep manure and vermicompost together (sheep manure 5 t ha⁻¹ and vermicompost 1.5 t ha⁻¹). The increase in available N, P and K with application of sheep manure 10 t ha⁻¹ were extended upto 44.01, 39.82 and 27.38% higher in comparison to initial soil content. Besides supplying nutrients, organic manures have also solubilizing effect on fixed form of other nutrients and therefore, improve the soil fertility. This might be due to gradual release of plant nutrients from sheep manure than from vermicompost. The lowering of soil pH and EC with organic manures as compared to initial soil values and control treatment was observed, but difference among the treatments themselves for soil pH was found at par. Similarly, Kumar *et al.* (2007) also reported improvement in soil organic carbon content and decrease in soil pH due to addition of organic manures.

It is concluded that two rows of *D. lablab* with one row of *Cenchrus setigerus* can be intercropped in mixed pasture, fertilized with sheep manure and vermicompost (5 t ha⁻¹+1.5 t ha⁻¹) to achieve high fodder productivity under semi-arid condition of Rajasthan.

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