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EFFECT OF ORGANIC NUTRIENT MANAGEMENT ON INTERCROPPING SYSTEMS OF *CENCHRUS* AND *DOLICHOS LAB LAB* FOR QUALITY FODDER PRODUCTION AND FOR IMPROVING SOIL HEALTH UNDER SEMI-ARID CONDITIONS OF RAJASTHAN

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SUMMARY

A field experiment was conducted at Avikanagar during **kharif** seasons of 2010 and 2011 to explore the possibility of improvement in productivity and profitability of mixed pasture inclusion of dhaman grass (*Cenchrus setigerus*) and fodder legume as field bean (*Dolichos lab lab*), which were grown in different row proportions (1 : 1, 1 : 2 and 2 : 1). Further, the nutrient management through organic sources comprising of control, sheep manure @ 10 t/ha, vermicompost @ 3 t/ha and sheep manure@ 5 t/ha+ vermicompost @ 1.5 t/ha were studied. The results of the study revealed that growth indices, green and dry fodder yields, protein yield and available nutrients were influenced significantly by *Cenchrus* and *Dolichos* in 2 : 1 ratio. The maximum increase in green fodder (13.98 t/ha), dry matter (4.22 t/ha) and protein yield (84.3 kg/ha) were recorded in 2 : 1 row ratio of *Dolichos* and *Cenchrus* followed by 1:1 row proportion. Overall, there was 23.52 per cent increase in organic carbon content under the same treatment in comparison to initial soil status. The available N (9.18 and 15.48%), P (21.05 and 34.30%) and K (4.53 and 7.06%) were increased maximum in 2 : 1 row ratio of *Dolichos* and *Cenchrus* than other row ratios (1:1 and 1:2). The net returns (Rs. 21,606/ha) and benefit : cost ratio (2.29) were the maximum in 2 : 1 row ratio followed by 1 : 1 row ratio (Rs. 19, 860 and 2.17). Application of sources of organic manures (sheep manure @ 5 tonnes/ha+vermicompost @ 1.5 t/ha) had produced higher green fodder (12.68 t/ha), dry matter (4.43 t/ha) and protein yield (87.6 kg /ha). The organic carbon content of soil was also improved by 38.23 per cent higher with the application of both the sources of organic manures by half doses. The available N (44%), P (39.7%) and K (27.37%) were reported remarkably better with both the sources of organic manures applied by their half doses. Application of sheep manure @ 5 t/ha+vermicompost@ 1.5 t/ha resulted in higher net returns of Rs. 23, 881/ha.

Key words : *Cenchrus, Dolichos*, economics, sheep manure, residual soil fertility, vermicompost

More than 50 per cent of the total area of Rajasthan particularly in arid and semi-arid regions is available for grazing of about 22 million animal population (Roy, 2003). In such areas, the grasses and legumes are very limited and grazing lands are poorly represented due to intensive grazing and nutritive grasses loose their regenerating capacity due to constant exploitation. In majority of the cases, high quality grasses are generally exterminated and replaced by non-palatable and less nutritive fodder plants. The soils are light in textured, deficient in organic carbon content and fall short of the feeding and nutritional requirements of the animals (Ranjhan, 1984). Thus, more and more area comes under unproductive and fallow due to lack of timely management for vegetation cover and soil and water conservation measures. Therefore, productivity of such lands is reduced over the years. It is essential to have adequate nutrients supply for obtaining higher productivity. But source of supplied nutrients has prime importance. Since climate of arid and semi-arid regions is changing and socio-economic condition of the farmers is poor, resulting in use of chemical fertilizer may not be feasible particularly in fodder crops. Moreover, continuous and excess use of chemical fertilizers deteriorates the soil health, encourages environmental pollution and degrades the quality of produce. Thus, to maintain sustainable productivity and soil health, integrated use of organic manures has great promise under such circumstances. Owing to this, *Dolichos lab*

lab is a suitable forage legume in semi-arid conditions due to its requirement of less care and maintenance and can be planted with pasture grasses under degraded lands. Moreover, this legume sown with grasses improved the herbage productivity in terms of quality as well as reduced the cost of production by 25-30 per cent. Hence, it makes cost effective cultivation of pasture and maintains soil fertility for a long time. The organic manures offer an opportunity to supply of nutrients for longer period and enhance availability of nutrients from soil to plant. So far use of sheep manure and vermicompost as organic sources in pasture is economically viable in long run. The present investigation was planned to assess the effect of intercropping row ratios and organic manures on herbage productivity and economic returns under rainfed semi-arid conditions of Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted during **kharif** seasons of 2010 and 2011 at Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) located at 27°17' N and 75°22' E longitudes and mean sea level height (326 m).The soil was sandy loam, low in available N (123.4 kg/ha), medium in available P (13.6 kg/ha) and rich in available K (227.2 kg/ha). The climate of the location is semi-arid sub-tropical with dry hot summers (April to June) and cold winters (November to January). The amount of rainfall received during 2005 and 2006 was 514 and 418 mm, respectively. Nearly 85 per cent of the total rainfall is received through north-western monsoons during the second fortnight of June to September. The average monthly minimum and maximum temperatures fluctuate from 6.8 to 8.0°C and 19.6 to 21.5°C in winter and from 22.0 to 24.6°C and 45.4 to 48.3°C in summer, respectively. The experiment was laid out for two consecutive years 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, whereas sub-plot treatments included organic manures viz., control, sheep manure 10 t/ha, vermi-compost 3 t/ha and SM 5 t/ha+VC 1.5 t/ha, respectively. The *Cenchrus setigerus* was grown in lines. Soil was treated with 2.5 per cent *Endosulfan* dust to control insects and pests. The seed-borne diseases were controlled by dressing of seeds with *Bavistene* fungicide @ 2 g/kg of seed. The *Dolichos lab lab* seeds were sown in lines with the help of furrow opener and sowing of *Cenchrus* grass was done manually at the depth of 2 cm below of the ground surface at 50 cm apart with a seed rate of 6 kg/ha and *Dolichos lab lab* (field bean) was sown in lines at 60 cm apart with a seed rate of 40 kg/ha. The test varieties of *Cenchrus* and *Dolichos* were S-3108 and JLP-4. The sheep manure was consisted of 0.58 per cent N, 0.27 per cent P_2O_5 and 0.63 % K_2O and corresponding values for vermicompost consisted of 1.15 per cent N, 0.45 per cent P_2O_5 and 0.65 per cent K_2O, respectively. Green forage yield was recorded at harvest under each treatment. The plant samples were oven-dried at 80°C for recording of dry forage yield. Post-harvest soil status of NPK nutrients was carried as per standard procedures. The plant samples were analyzed for crude protein content (AOAC, 1995). Economics of different treatments were worked on the basis of prevailing market prices of inputs and outputs.

RESULTS AND DISCUSSION

Growth Attributes

The growth of *Cenchrus* and *Dolichos* was measured as plant height, dry matter accumulation/ plant (DMA/plant), tillers/plant in *Cenchrus* and branches/ plant in *Dolichos lab lab* revealed that all the treatments brought about marked variation in growth attributes (Table 1). Intercropping row proportion between *Cenchrus* and *Dolichos lab lab* had brought significant influence upon growth attributes of both the crops which were the 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 in intercropping systems which improved the fertility status of soil leading to increase in availability of N through fixation and increase in other growth promoting substances with the eventual improvement in the growth attributes, besides, increased mycorhizal colonization (George, 1987). Increase in growth attributes of both the component crops with different row ratios of cowpea and *Cenchrus* was also reported by (Meena *et al*., 2003). The differences between treatments 1 : 1 and 1 : 2 row ratios were not marked 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+VC 1.5 t/ha) brought about significant increase in plant height, dry matter accumulation and tillers in *Cenchrus* (11.2) and branches in *Dolichos lab lab* (6.1) over remaining treatments like sheep manure10 t/ha, vermicompost 3 t/ha and control, respectively. But the treatments viz., vermicompost (VC) 3 tonnes/ha and

TABLE 1
Effect of intercropping systems and organic manures on growth parameters of Cenchrus and Dolichos lab lab (Mean data over two years)

Treatment	Plant height		Dry matter /plant (g)		Tillers/plant at harvest	Branches/plant
	Grass	Legume	Grass	Legume	Grass	Legume
Intercropping row ratio						
1 : 1	82.0	125.0	10.6	12.3	8.7	6.6
1 : 2	80.4	118.4	10.2	10.4	8.4	5.4
2 : 1	87.0	134.5	11.7	13.2	10.1	7.2
C. D. (P=0.05)	4.14	6.32	0.48	0.55	0.67	0.37
Organic manures management						
Control	71.7	74.2	7.8	7.8	7.5	4.0
SM (10 t/ha)	77.8	80.1	9.8	10.4	9.7	4.6
VC (3 t/ha)	95.8	100.6	13.2	13.3	10.1	6.0
SM (5 t/ha+VC 1.5 t/ha)	97.7	104.0	14.0	14.4	11.2	6.1
C. D. (P=0.05)	5.53	8.43	0.53	1.26	1.05	0.76

SM–Sheep manure and VC–Vermicompost.

half dose of sheep manure (5 t/ha) and vermicompost (1.5 t/ha) were remained at par for all growth parameters of both the crops. While both treatments exhibited significant variation in terms of growth parameters over preceding treatments like sheep manure @ 10 tonnes /ha and control. This might be due to easily and more available of plant nutrients from vermicompost than sheep manure. Results of studies conducted at Avikanagar on sheep manure application in pasture species showed that slow decomposition of sheep manure occurred in presence of insufficient soil moisture during crop season and thereby slow release of plant nutrients from hard pellets of sheep manure than vermicompost.

Forage Yield and Quality

Intercropping row ratios and organic manures markedly influenced the green fodder, dry matter, crude protein content and its yield on pooled data basis (Table 2). The intercropping row ratio in 2 : 1 (*Dolichos* and *Cenchrus*) gave the maximum green fodder (13.98 t/ha), dry matter (4.22 t/ha) and protein yield (84.3 kg/ha) which proved significantly superior to the yields obtained with other intercropping row ratios (1 : 1 and 1 : 2), except total protein yield turn over from both the crops (*Cenchrus* and *Dolichos*). Whereas protein yield was not influenced significantly with 1 : 1 and 1 : 2 row ratios. 2 : 1 row ratio gave the maximum protein yield than rest of the row combinations between *Cenchrus* and *Dolichos* viz., 1 : 1 and 1 : 2. It might be due to beneficial symbiotic

TABLE 2
Effect of intercropping row ratio and organic manures on green herbage, dry forage and protein yield of Cenchrus and Dolichos lab lab (Pooled data of two years)

Treatment	Green fodder (t/ha)			Dry matter (t/ha)			N content (%)		C P content (%)		Protein yield (kg/ha)		
	Gross	Legume	Total	Gross	Legume	Total	Gross	Legume	Gross	Legume	Gross	Legume	Total
Intercropping row ratio													
1 : 1	35.3	70.2	105.7	15.8	19.8	35.6	1.41	1.96	5.27	12.76	29.2	36.0	55.2
1 : 2	30.9	55.1	86.1	13.6	18.2	31.8	1.05	1.72	4.75	10.76	23.4	28.1	51.4
2 : 1	43.9	95.9	139.8	18.1	24.2	42.2	1.85	2.15	5.36	13.08	35.7	48.6	84.3
C. D. (P=0.05)	3.64	4.51	6.50	2.43	2.05	3.52	0.03	0.17	0.56	0.95	3.68	2.45	6.27
Organic manure sources													
Control	31.7	61.4	93.1	12.5	16.5	29.1	1.30	1.65	4.22	9.85	18.6	27.0	45.9
SM (10 t/ha)	33.8	73.1	107.1	15.0	20.2	35.2	1.38	1.89	5.00	11.81	26.4	35.1	61.5
VC (3 t/ha)	38.2	77.1	115.2	18.0	22.6	40.6	1.48	2.11	5.80	13.24	36.6	40.4	77.0
SM (5 t/ha+VC 1.5 t/ha)	43.1	83.7	126.8	20.2	24.2	44.3	1.59	2.12	6.20	13.91	39.9	47.7	87.6
C. D. (P=0.05)	4.21	5.20	7.51	2.80	2.37	4.06	0.05	0.18	0.65	1.10	4.25	2.83	7.25

SM–Sheep manure and VC–Vermicompost.

effect of legume component to the cereal component, which could be able to produce higher quantity of fodder. Ram (2009) also reported higher value of green fodder of Guinea grass and *Stylosanthes hamata* in intercropping systems. The corresponding values were increased to the tune of 32.26 and 62.36 per cent in green fodder, 18.53 and 32.70 per cent in dry fodder and 52.71 and 64 per cent in protein yield in 2 : 1 row ratio over to 1 : 1 and 1 : 2 row ratios, respectively, when total yield received from grass and legume which was brought together. This might be due to higher production potential of *Dolichos lab lab* than *Cenchrus setigerus* in intercropping systems. While maximum increase in crude protein yield was mainly because of higher area allocation for legume component than cereal in the existing system.

When both organic manures were applied in *Cenchrus* and *Dolichos* led to significant improvement in green fodder, dry matter, N content, crude protein content and protein yield (Table 2). The extent of increase was 10.06, 18.39 and 36.19 per cent in green fodder, 9.11, 25.85 and 52.23 per cent in dry matter and 13.76, 42.43 and 90.84 per cent in protein when comparison was made with other treatments as vermicompost @ 3 t/ha, sheep manure @ 10 t/ha and control, respectively. The crude protein content in dry matter of both the crops was increased consistently at each level of organic manure either in isolated or in combination over the control treatment. The differences between vermicompost @ 3 t/ha and sheep manure @ 5 t/ha were found non-significant for crude protein content in both the fodder crops. Whereas crude protein content in *Dolichos* was observed double (13.91%) than *Cenchrus* (6.20%). Similarly, in case of dry matter yield the differences between the treatments like VC 3 t/ha and SM 5 t/ha+VC 1.5 t/ha did not show significant effect. Thus, increase in fodder yield seemed to be the function of improved growth attributes under all treatments as compared to control. While improvement in protein yield might be due to combined effect of higher dry matter yields and slight increase in N content of plant due to increase in N mineralization in the soil and greater uptake by plants. The beneficial effect of sheep manure and vermicompost was also reported by Meena *et al*. (2010) for crude protein content. The favourable better effects of sheep manure and vermicompost on growth attributing characters might be due to increase in availability of soil nutrients and increased the activities of heterophic bacteria and fungi, which in turn increase the activity of enzymes which were responsible for conversion of unavailable form of nutrients in to available form which led to higher intake and improvement in crop growth attributes. Singh *et al*. (2005) reported significant improvement in growth attributing characters of cereal and *stylo* due to application of sheep manure and vermicompost. This may be ascribed to the better macro and micro-nutrients availability as well as physical condition of the soil. Similarly, Kubra Bano (1997) also reported that use of vermicompost would be beneficial to maintain higher fertility status of the soils, hence, reducing the need for application of inorganic nutrients and increasing the quality of fodder.

ECONOMICS

Significantly higher gross returns and net

TABLE 3
Effect of intercropping systems and organic manures on economics and soil fertility status after 2 years

Treatment	Post-harvest physico-chemical properties of soil							Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C
	Bulk density	Organic C	Available N	Available P	Available K	pH	Electrical				
Intercropping row ratio											
1 : 1	1.30	0.41	161.2	15.2	245.0	7.6	0.23	9,120	28,980	19,860	2.17
1 : 2	1.34	0.36	152.4	13.7	239.2	7.8	0.27	9,298	26,118	16,820	1.80
2 : 1	1.29	0.42	176.0	18.4	256.1	7.5	0.21	9,423	31,029	21,606	2.29
C. D. (P=0.05)	0.03	0.053	7.20	2.37	17.93	0.09	0.014	600	1426	1436	0.068
Organic manure sources											
Control	1.34	0.36	147.6	12.7	204.1	7.8	0.27	7,543	25,880	18,337	2.43
SM (10 t/ha)	1.26	0.39	157.7	14.8	231.4	7.7	0.24	11,143	32,032	20,889	1.87
VC (3 t/ha)	1.23	0.43	170.0	16.8	261.8	7.6	0.23	12,143	34,284	22,141	1.82
SM (5 t/ha+VC 1.5 t/ha)	1.21	0.47	177.7	19.0	289.4	7.5	0.20	11,893	35,774	23,881	2.01
C. D. (P=0.05)	0.04	0.062	8.31	2.74	20.70	0.11	0.014	646	1647	1652	0.079
Initial soil test value	1.34	0.34	123.4	13.6	227.2	7.9	0.21				

SM–Sheep manure and VC–Vermicompost.

profit were accrued by yields of *Cenchrus* and *Dolichos* and market price. Pooled data of two years' showed that among the intercropping row ratios 2 : 1 gave the maximum values in terms of gross returns (Rs. 31,029/ha), net returns (Rs. 21,606/ha) and benefit : cost ratio (2.29). These were followed by 1 : 1 row ratio with gross returns (Rs. 28,980/ha), net returns (Rs. 19,860/ha) and benefit : cost ratio (2.17). Whereas both the row ratios (1 : 1 and 2 : 1) were found superior over 1 : 2 row ratio for these values (Table 3). The lower values were obtained at the ratio of 1 : 2 for gross returns (Rs. 26,118/ha), net return (Rs. 16, 820/ ha) and benefit : cost ratio (1.80). This might be due to higher market prices of legume fodder than cereal fodder owing to higher monetary advantages from legume component than cereal. The minimum net returns and B : C ratio in 1 : 2 row ratio may be accrued due to lower fodder and higher cost of cultivation under this treatment. Kumar *et al*. (2005) in maize+cowpea in 2 : 2 row ratio and Singh *et al*. (2005) in sorghum+cowpea also reported higher values of gross returns, net returns and B : C ratio. The economics of organic manures treatments showed that highest net profit (Rs. 23,881/ha) was received with the use of SM 5 t/ha in combination of VC 1.5tonnes/ha, followed by the application of VC 3 t/ha (Rs. 22,141/ ha). However, the minimum gross returns and net profit were recorded with the control treatment (Rs. 25,880) and (Rs. 18,337). But the benefit : cost ratio was the highest with control treatment (2.43) in comparison to other treatments (SM 10 t/ha, VC 3 t/ha and SM 5 t/ha+VC 1.5 t/ha, respectively). The next best treatment which gave more benefit : cost ratio was found SM 5 t/ha+VC 1.5 t/ha (2.01). While the lowest benefit : cost ratio was received from VC 3 t/ha (1.82). This might be due to high cost involved in vermicompost (Rs. 12,143/ha).

Residual soil Fertility Status

The organic carbon content was increased significantly with intercropping row ratios of *Cenchrus* and *Dolichos*. However, it was the maximum when legume proportion was higher than cereal (0.42%). Further, analysis of soil samples after two years, the bulk density was decreased under where higher proportion of legume than cereal (1.29) and followed by 1 : 1 row ratio treatment (1.30). However, it was the highest under 1 : 2 row ratio (1.26). The build-up in organic carbon under higher proportion of legume than cereal plots resulted in improved soil structure and lowering of bulk density. In Italy, Marinari *et al*. (2000) reported increased macro-pores due to addition of vermicompost. Similarly, pH and EC of the soil were decreased with 2 : 1 ratio (7.5 and 0.21) and followed by 1 : 1 ratio (7.6 and 0.23). Besides, electrical conductivity was the highest with 1 : 2 row ratios (0.27). The available N (9.18 and 15.48%), P (21.05 and 34.30%) and K (4.53 and 7.06%) were increased significantly under 2 : 1 ratio over 1 : 1 and 1 : 2, respectively. It was closely followed by 1 : 1 row ratio. Both these ratios were found significantly superior over 1 : 2 row ratio for all the three available soil nutrients. The continuous application of sheep manure and vermicompost for two years significantly improved the soil-organic carbon content (C) when compared with control treatment (Table 3). The soil organic C content increased from 0.36 per cent on no organic manures to 0.47 per cent under the treatment of SM 5 t/ha+VC 1.5 t/ha. The increase was extended up to 38.23 per cent compared with initial value. However, at the end of experiment, it was estimated lowest with control treatment (0.26 %), being near to equal with initial value. Similarly, bulk density was deceased progressively with the application of both the organic manures than no use of organic manures. The initial value of bulk density was higher than wherever organic manures were applied as well as under control treatment. This might be due to increase in porosity of soil which was occupied by decomposed organic manures resulted in increase in fineness of the soil. After the harvest of both the fodder crops, the available N, P and K nutrients increased remarkably under all organic manure treatments in comparison to control and initial soil content with these nutrients. However, at 0-15 cm soil layer, maximum increase in available N, P and K was recorded under SM 5 t/ ha+VC 1.5 t/ha, followed by VC 3 t/ha, SM 10 t/ha and control. The increase in build-up of available soil N, P and K content might have attributed to maximum left-over N, P and K content into the soil due to application of both the organic manures such as sheep manure (5 t/ha) and vermicompost (1.5 t/ha). These results confirmed the findings of Sharma *et al*. (2009). The magnitude of increase in availability of major nutrients like N was by 4.52, 12.68 and 20.39 per cent, available P increased by 13.09, 28.37 and 49.60 per cent and available K was increased to the tune of 10.54, 25.06 and 41.79 per cent higher over control treatment due to residual effect of SM 10 t/ha, VC 3 t/ha and half doses of respective SM and VC (5/ha and 1.5 t/ ha) applied together in comparison to control treatment. There was a meagre decrease in soil pH and electrical conductivity after the harvest of fodder

crops due to residual effect of organic manures. The highest decrease in soil pH (7.5) and EC (0.20) was estimated with SM 5 t/ha+VC 1.5 t/ha treatment followed by VC 3 t/ha, SM 10 t/ha in comparison to control treatment on the basis of two years' mean data (Table 3). This magnificent improvement of soil status was possible not only owing to organic sources but also because of decomposition of root nodules of legume crop and rhizomes of *Cenchrus* grass after the harvest of both these two crops. Besides, litter fall from both the crops may also be the one additional factor to increase organic carbon content and available soil nutrients. Sheep manure and vermi-compost had synergistic effects and gradually released needed plants nutrients. The changes in physico-chemical properties of soil may create more favourable condition to soil microorganisms and better root development of the plants. Ahlawat *et al*. (1981) also reported that legume in rotation increased the total N and P_2O_5 status of the soil. Further, the significance of legumes as intercropping system with grass may nurse companion crops by N_2 fixation and also provide nutritious more green fodder and finally lead to improve the soil fertility (Singh *et al*, 1986). It may be concluded that intercropping of *Dolichos lab lab* and *Cenchrus* in 2 : 1 row ratio with application of SM 5 tonnes ha+VC 1.5 t/ha was found the most productive and remunerative system for getting higher tonnage of quality fodder and more economic returns under rainfed conditions of Rajasthan.

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