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Productivity, Quality and Residual Soil Fertility as Influence by Intercropping Row Ratios and Sources of Nitrogen Management in Semi-arid Region of Rajasthan

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ABSTRACT : The field experiment entitled "Productivity, quality and residual soil fertility as influenced by intercropping row ratios and sources of nitrogen management in semi-arid region of Rajasthan was conducted during kharif seasons of 2006 and 2007 in a split plot design, comprising of 18 treatments (3 intercropping row ratios and 6 different sources of N). Results shows that intercropping row ratio of cowpea (*Vigna unguiculata*) and *Cenchrus setigerus* in 2:1 resulted in significantly higher green (13.02 and 14.08 t ha^{-1}) and dry fodder yield (3.25 and 3.44 tonnes/ ha) than other row ratios (1:1 and 1:2). Crude protein content (12.07 and 12.33%) and yield (393.29 and 418.04 kg ha^{-1}) was highest in case of 2:1 row ratio of cowpea and *Cenchrus* over other row ratios of 1:1 and 2:1.The soil organic carbon content, available N and P were improved when legume and grass were grown in 2:1 row ratio and the increase was to the tune of 42.54, 37.64 and 69.17 % over than the initial content of these nutrients. Application of 50 % recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure had improved the green fodder yield by 89.72 % and dry matter by 123.26 % over 100 % recommended dose of N through inorganic source. Different sources of N significantly influenced the crude protein content and yield. Maximum protein content (12.05 and 13.04 %) and yield (423.40 and 446 .02 kg ha^{-1}) was recorded with the application of 50 % recommended dose of N through inorganic source+ 25 % vermicompost + 25 % through sheep manure. At the end of 2 years of experimentation on the same site, bulk density and pH recorded perceptible decrease from the initial values, while soil organic carbon content, available N and P exhibited marked improvement over initial values with the combination of different sources of N.

Keywords : *Cenchrus ciliaris,* cowpea, nitrogen, organic carbon, phosphorus, protein, yield

More than 50 % of the total area of Rajasthan particularly in arid and semi-arid regions can be categorised as grasslands which supports about 22 million animals (Roy, 2003). In such areas, grazing lands are deteriorating rapidly 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 resulting in gradual decline in productivity of such lands over the years. Hence, there is an urgent need to manage these lands by growing cowpea and *Cenchrus* as cover crops (Singh and Jain, 1990). The non arable land can be utilized through cultivation of fodder crops in which N management also play's a vital role because adequate supply of needed nutrients to the system causes significant improvement in productivity. Thus, higher tonnage of green fodder can be achieved through introduction of superior legume and grass for development of pasture and different sources of N to raise horti-pasture productivity. However, information pertaining to legume and grass cultivation as intercropping with aonla plants is meagre. Therefore, the present study was undertaken to mitigate the problem of fodder production which will further increase in coming years due to growing animal population.

Materials and Methods

Field experiment was conducted during *kharif* season of 2006 and 2007 at Central Sheep and Wool Research Institute, Avikanagar, Rajasthan. The experimental soil had initial *p*H (7.8), organic carbon (0.31 %), available N (158.15 kg ha^{-1}), available P (8.46 kg ha^{-1}) and

available K (217.24 kg ha $^{-1}$) in 0-15 cm soil depth. The area received annual rainfall of 458 mm and 514 mm during 2006, 2007 respectively. The experiment comprised of 18 treatment combinations *viz*. 3 intercropping row ratios (1:1, 1:2 and 2:1) and six different sources of N [100 % of recommended N through inorganic source (F1); 75 % of recommended N through inorganic sources + 25 % through vermicompost (F2); 50 % of recommended N through inorganic source + 50 % through vermicompost (F3); 75 % recommended N through inorganic source + 25 % through sheep manure (F4); 50 % recommended N through inorganic source + 50 % through sheep manure(F5) and 50 % of recommended N through inorganic source+ 25 % vermicompost+ 25 % through sheep manure (F6) tested in a split plot design with three replications. The test varieties 'EC 4216' and 'IGFRI 3108' of cowpea and *Cenchrus* were used with a seed rate of 20 kg ha^{-1} for cowpea *and* 6 kg ha^{-1} of *Cenchrus*. The seed of *Cenchrus* was sown at a depth of 2 cm below the ground surface and a dose of 60 kg N ha^{-1} was applied through different sources as per the technical programme. The fodder production was recorded during maturity as well as, at harvest. The biometric observations regarding growth and development of aonla plants were recorded in January and July in each year. The soil samples were collected at post harvest and analysed according to standard procedures to estimate the physio-chemical properties. The statistical analysis of data was done as per standard procedure (Gomez and Gomez, 1984).

Results and Discussion

Growth parameters

Intercropping row ratios had significant effect on growth parameters of both crops (Table1). However, minimum increase in growth parameters *viz.* plant height, dry matter production/ plant, branches/ plant^{-} in cowpea and number of tillers/ plant in *Cenchrus* were recorded in 2:1 row ratio comparal to other row ratios (1:1 and 1:2). The highest increase in these growth parameters under intercropping row ratios might be due to better utilization of space and light interception along with nutrient contribution of leguminous crop to the cereal. Kumar *et al*. (2005) also reported beneficial

Table 1 : Effect of intercropping row ratios and sources of nitrogen management on growth characters of cowpea and *Cenchrus* under horti-pasture system

Treatment	Plant height (cm)				Dry matter production (g plant^{-1})				Branches plant^{-1}		Tillers plant^{-1}	
	cowpea		*Cenchrus*		cowpea		*Cenchrus*		cowpea		*Cenchrus*	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Intercropping row ratio (cowpea: Cenchrus in alternate paired rows)												
1:1	73.01	76.32	109.09	110.24	27.02	30.08	12.42	13.43	5.23	5.43	7.04	8.48
1:2	65.16	68.40	99.28	103.02	24.12	28.07	10.08	11.30	5.01	5.16	6.11	8.17
2:1	79.27	79.43	115.21	121.30	32.12	34.19	15.08	16.12	5.47	6.02	7.38	9.47
C D (P=0.05)	3.54	4.09	6.08	5.48	2.87	2.95	1.63	1.86	NS	NS	0.87	0.94
Sources of N management												
F1	63.24	69.18	90.03	99.06	21.51	26.41	9.47	10..24	4.41	5.27	5.33	7.16
F2	73.06	74.11	98.14	106.20	23.58	27.23	11.05	12.12	5.04	6.04	6.46	8.01
F3	76.05	77.44	107.07	108.44	28.36	29.07	11.43	14.18	6.16	6.27	7.01	9.23
F4	79.20	81.11	112.06	113.05	29.53	32.11	12.24	16.03	6.34	6.48	7.16	9.36
F5	80.37	85.45	116.34	118.04	31.30	33.10	15.05	17.11	6.49	7.04	8.03	10.02
F6	85.07	87.00	123.46	125.02	33.16	34.06	16.29	20.27	7.11	7.45	9.16	10.16
C D (P=0.05)	3.58	4.25	6.96	5.86	2.52	3.05	1.74	2.24	1.10	1.46	0.98	1.26

effect of intercropping of maize and cowpea on growth parameters in the 2:2 row ratio. But the branches per plant in cowpea was not affected significantly by intercropping row ratios during both the years. Integrated N sources in cowpea and *Cenchrus* had brought about significance increase in growth parameters during 2006 and 2007. However, a remarkable increase was observal in growth parameters with the use of 50 % recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure (F6). There was sizeable variation among the treatments when applied in various combinations which caused improvement in growth parameters compared with 100 % sole application of inorganic source of nitrogen. The minimum increase in all growth parameters was recorded in 100 % recommended source of N applied through inorganic sources(F1) while, other treatments have proved statistically superior over the 100 % recommended source of N applied through inorganic in respect of growth attributes. Combined application of inorganic and organic fertilizers (50 % of recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure) had brought more favourable effect on growth parameters than other treatment combinations.

Green and dry fodder yield

Intercropping row ratios between cowpea and *Cenchrus* caused significant increase in green fodder and dry matter yield during 2006 and 2007 (Table 2), respectively. In general, productivity in terms of green fodder and dry matter production was higher in second year (2007) than first year (2006). This might be due to better establishment of pasture in succeeding year in comparison to preceding year resulting in higher biomass production. However, the highest green fodder production was recorded in row ratio 2:1 (13.02 and 14.08 tonnes/ ha) over 1:1 and 1:2 row ratios. The magnitude of increase in dry matter yield was 7.84 and 34.80 % in 2006 and 6.82 and 30.52 % in 2007 compared to 1:1 and 1:2 row ratios. The higher forage yield at 2:1 row ratio could be due to integration of legume as intercrop in rainfed grass pasture under semi-arid environment. The productivity of improved mixed pasture in the presence of legume may be because of biological nitrogen –fixation (BNF) by legume as the grasses are usually N- deficient (Tripathi and Singh 2003). Further, higher dry forage yield in 2 : 1 intercropping row ratios of cowpea and *Cenchrus* might be attributed to complementary effect of cowpea that

Table 2 : Effect of intercropping row ratios and sources of nitrogen management on green fodder, dry matter, protein content and protein yield under horti-pasture system

Treatment	Green fodder yield (t ha^{-1})		Dry matter yield (t ha^{-1})		Crude protein content (%)		Protein yield (kg ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007
Intercropping row ratio (cowpea: Cenchrus in alternate paired rows)								
1:1	12.01	13.01	3.01	3.22	10.37	11.32	340.10	343.08
1:2	9.03	10.05	2.41	2.69	9.04	9.38	207.04	214.05
2:1	13.02	14.08	3.25	3.44	12.07	12.33	393.29	418.04
C D (P=0.05)	0.61	0.68	0.33	0.26	1.04	1.44	34.80	29.64
Sources of N management								
F1	9.03	10.23	2.40	2.51	8.49	9.04	193.34	202.23
F2	10.01	11.13	2.71	2.83	9.09	9.41	228.23	245.10
F3	12.01	13.41	2.94	3.50	10.27	11.04	301.10	303.33
F4	13.01	14.22	3.11	3.20	11.06	11.40	350.03	352.05
F5	15.43	16.21	4.25	4.31	11.49	12.24	384.37	399.01
F6	18.15	18.40	5.44	5.50	12.05	13.04	423.40	446.02
C D (P=0.05)	0.69	0.84	0.41	0.38	1.47	2.04	49.21	41.90

supplemented N to *Cenchrus* and better utilization of solar radiation. Similar positive response of cowpea + C*enchrus* system has been reported by Meena *et al.* (2003). The higher dry forage yield in these treatments may be attributed to taller plant height and more dry matter accumulation per plant. The possible reason for more increase in green and dry fodder yields being that legume act as nurse crop by N_2 - fixation which lead to improvement in soil fertility status (Singh *et al*. 1986). Application of 50 % recommended N through inorganic source+ 25 % vermicompost+ 25 % through sheep manure (F6) resulted in improvement in green fodder and dry matter yield. On an average, green fodder yield was increased to the extent of 100.99, 81.31, 51.12, 39.50, 12.52 % and dry fodder yield was increased by 79.86, 65.31, 37.21, 29.39 and 12.05 % with 50 % of recommended N through inorganic source+ 25 % vermicompost+ 25 % through sheep manure as compared to the treatments of 100 % of recommended N through inorganic source (F1), 75 % of recommended N through inorganic sources+25 % through vermicompost (F2), 50% of recommended N through inorganic source + 50 % through vermicompost (F3), 75 % recommended N through inorganic source + 25 % through sheep manure (F4), 50% recommended N through inorganic source + 50 % through sheep manure (F5),respectively. The green fodder and dry matter yields were remarkably increased under different treatment combinations. This was in agreement to the earlier results obtained by Sood and Sharma (1996), who, reported significant improvement in herbage yield with different sources of N in mixed pasture of grass and legume.

Crude protein (%) and protein yield

The greater crude protein content was due to higher dry matter yield in cowpea with *Cenchrus* in 2:1 row ratio. Crude protein content in *Cenchrus* component increased with increase in cowpea proportion and it was significantly higher where cowpea proportion was more than that of *Cenchrus*. The highest crude protein content was in 2 :1 row ratio (12.07 and 12.33 %) followed by 1:1 row ratio (10.37 and 11.32 %) and the minimum crude protein content was observed in case of 1:2 row ratio (9.04 and 9.38 %). Higher crude protein content is attributed to increase nitrogen absorption by plant and its transformation in the form of protein (Kumar, *et al*. 2003). These results are in close conformity with the findings of Sood and Sharma (1996). Maximum crude protein content (12.05 and 13.04%) was observed in 50 % of recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure as compared to other treatment combinations. However, the differences among treatments for crude protein content and its yield remained at par with each other during both the years.

Soil fertility improvement

Organic carbon content, available soil N and P were influenced by intercropping row ratios, the highest values were in 2:1 row ratio observed followed by 1:1 row ratio during 2006 and 2007, respectively. Whereas, the physio-chemical properties like bulk density and pH recorded perceptible decrease from initial values. These results were corroborated by the findings of Singh (1999). He also reported improvement in available P and K status of the soil after grasses and legumes. Higher residual soil nutrients content was observed under the application of 50 % of recommended N through inorganic source + 25 % vermicompost + 25 % through sheep manure than other combinations. This might be due to improvement of soil environment and better N and P availability over the remaining sources of N management. These results are in accordance with the findings of Sarawgi *et a*l. (1998). Further, application of 50 % recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure led to increase in available soil N by 27.08 and 26.74 kg ha^{-1} and available soil P by 5.98 and 7.17 kg ha^{-1} in 2006 and 2007 of experimentation as compared to 100 % of recommended N through inorganic source (F1). This clearly indicated that residual N was inadequate to obtain healthy growth and higher yield of pasture crops over sole source of N through inorganic fertilization, hence supplemental application of chemical fertilizers and organic sources of N up to the desire level of substitution is essential. Similar results were reported by Suresh *et al*. (2009). The available P status of soil had also improved over initial status in the treatment where 50 % of recommended N through inorganic source+ 25 % vermicompost + 25 % through sheep manure was applied (Table 3).

Table 3 : Effect of intercropping row ratios and sources of nitrogen management on physico-chemical properties changes after 2 years in horti-pasture system

Treatment	Bulk density (Mg / M^3)		Organic C (%)		pH		EC (dSm^{-1})		Available soil nutrient status at harvest (kg ha^{-1})			
									N		P	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Intercropping row ratio (cowpea: Cenchrus in alternate paired rows)												
1:1	1.34	1.31	0.329	0.349	7.5	7.5	0.236	0.208	144.07	151.10	10.44	12.05
1:2	1.35	1.33	0.300	0.334	7.7	7.3	0.243	0.223	113.04	117.20	9.06	10.10
2:1	1.21	1.21	0.383	0.401	7.3	7.8	0.207	0.196	169.03	175.09	12.08	13.07
C D (P=0.05)	0.11	0.08	0.025	0.030	NS	NS	0.034	0.035	9.46	9.50	1.00	1.09
Sources of N management												
F1	1.37	1.32	0.276	0.296	7.8	7.8	0.266	0.244	129.12	132.29	8.08	8.25
F2	1.25	1.25	0.306	0.327	7.4	7.4	0.198	0.187	134.40	143.29	8.32	9.08
F3	1.32	1.30	0.331	0.351	7.5	7.5	0.250	0.191	141.12	147.29	10.02	11.06
F4	1.31	1.26	0.351	0.383	7.5	7.5	0.212	0.205	146.12	153.37	11.00	12.22
F5	1.31	1.28	0.366	0.385	7.5	7.5	0.243	0.225	147.14	156.48	12.05	13.32
F6	1.26	1.31	0.394	0.426	7.8	7.4	0.202	0.201	156.10	159.03	14.06	15.42
C D (P=0.05)	0.16	0.12	0.035	0.042	NS	NS	0.048	0.052	13.38	13.99	1.41	1.54
**Initial soil status*	1.38	1.34	0.263	0.287	7.8	7.8	0.271	0.248	123	127	7.42	7.45

Conclusion

Thus, intercropping row ratio between grass and legumes in 2:1 with fertilization of 50 % recommended N through inorganic source + 25 % vermicompost + 25 % through sheep manure was found adequate to maintain higher level of fodder productivity and improve soil fertility status under aonla based hortipasture system in rainfed areas of Rajasthan.

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