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Enhancing productivity, profitability and soil health through integrated nutrient management in ber-based hortipasture system in Rajasthan

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Abstract
The present study was conducted on ber (*Ziziphus mauritiana*) cv 'Gola' based horti-pasture system established in 2006 to examine the influence of various sources of organic and inorganic nutrients on morphometric, productivity and quality of grasses and soil health during 2011 and 2012 under rainfed condition of semi-arid ecosystem. Over two years mean green herbage yield of 3.16 t/ha, dry matter of 0.55 t/ha, protein yield of 23.15 kg/ha, grass seed yield of 14 kg/ha and ber fruit yield of 339.17 kg/ha were recorded additionally higher under *ber* + *Cenchrus setigerus* plantation as compared to ber + *Cenchrus ciliaris* plantation system. Integrated application of 50% RDF of NPK through fertilizers and 50% through sheep manure brought significant improvement in growth and yield attributes of grasses followed by that under 100% RDF of NPK through fertilizers. Further, yield of dry matter, grass seed, dry ber leaf fodder, fruit yield and fuel wood yield were found higher with integrated application of 50% RDF of NPK through fertilizers and 50% through sheep manure. Application of 50% RDF of NPK through fertilizers and 50% through sheep manure significantly increased in mean green herbage by 62.3%, dry matter by 29.6%, protein yield by 37.0%, seed yield by 38.8%, dry ber leaf (pala) by 30.4%, fruit yield by 25.2% and fuel wood yield by 44.9%. The corresponding values were increase by 46.7, 28.1, 32.9, 45.0, 28.7, 25.2 and 25.2% when 50% RDF of NPK through fertilizers and 50% through sheep manure applied combined and compared with control treatment (no fertilizers, no organic manure). The pH and EC of surface soil declined whereas bulk density, soil organic carbon (SOC), available N, available P and exchangeable K were increased with the integrated application of inorganic nutrients coupled with organic matter through sheep manure. Maximum gross return (Rs. 76131/ha), net return (Rs. 66366/ha) and benefit: cost ratios (2.33) were also accrued with the integrated application of 50% RDF of NPK through fertilizers and 50% through sheep manure.

Keywords: *Cenchrus ciliaris*, *Cenchrus setigerus*, Hortipasture, Integrated nutrient management, Sheep manure

Abbreviations: DAS: Days after sowing; **FYM**: Farm yard manure; **INM**: Integrated nutrient management; **K:** Potassium; **N**: Nitrogen; **P**: Phosphorus

Introduction

There is always inherent risk in production of seasonal crops in semi-arid areas due to unpredictable, meagre and erratic distribution of rainfall. Integration of fruit trees and grasses in interspaces, better known as horti-pasture system, are known to plug the risk of failure of seasonal crops in these areas. Growing of fruit trees and under storey grasses, suited to prevailing agro-climatic conditions, gives many direct and indirect benefits. Directly, farmers get sustained production (fruit, fodder and fuel wood) from both fruit trees and grasses/ fodders for their livelihood and indirectly, system improves the soil fertility, mitigate the climate change, increase the biodiversity etc (Kumar *et al.,* 2015). Ber is prominent fruit tree of dry areas which can be planted in the horti-pastoral system. Raising of grasses in interspaces of ber plantation gives additional production of grasses and income. The improved grasses *viz*. Anjan (*Cenchrus ciliaris*) and Dhaman (*Cenchrus setigerus*) can be taken suitably in interspaces of ber in semi-arid areas. Grasses plays very vital role in protection of deterioration of versatile agro-ecosystem. The development of ber orchard in association of grasses will meet the needs of human and animals especially small ruminants. Ber and grass both are hardiest and suited to drought prone conditions of Rajasthan because they can stand in dry and hot summer and they also utilize precipitation and solar energy efficiently (Lal and Dharamveer, 2012). Ber belong to *Rhamnaceae* family and originated to Indo-Malaysian region of South- East Asia. Samra (2010) also reported that horti-pasture provides tremendous opportunities with high potential

for enhancing nutrition security, sustainability, profitability, and livelihood security in rainfed areas through vertical expansion of area under horticulture and forage crops especially in fragile ecosystems. The solution therefore, lies in maximizing forage production in space and time, through integrations as well as rejuvenation of old ber orchard in the rainfed areas (Kumar *et al*., 2006). The grass planted in ber orchard as hortipasture system would supply more fodder to animals and utilized post and pre-monsoon rainfalls thus giving additional gain in the form of grass fodder when these are in short supply. In the recent years, decline in soil health with respect to physical, chemical and biological properties has surfaced up owing to indiscriminate use of chemical fertilizers without organic fertilizers, while use of organic fertilizers without augmentation of inorganic fertilizers may not be able to meet the high nutrient requirement of the crop due to their low nutrient content and slow acting nature (Marathe *et al*., 2009). Under prevailing situations, crop cultivation alone is not risk free or profitable without livestock farming therefore farmers have to integrate both hortipasture and livestock at one place as integrated farming system that will fulfil more demands of the farmers as well as market. The informations on grass species with fruit ber plant is meagre. In view of this, the present investigation was planned to ascertain the productivity of ber based hortipasture through conjunctive use of organic and inorganic sources of plant nutrients.

Materials and Methods

***Study site*:** The present study was conducted at research farm of ICAR-Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) for two consecutive years (2011 and 2012) located at (27° 17' N latitude and 75° 22' E longitude and 326m height (above mean sea level). The soil of the experimental site was sandy loam in texture, low in available N (129 kg/ha) and medium in available P (8.63 kg/ha) but rich in available K (258 kg/ha) content. The climate of the location is semi-arid subtropical with dry hot summers (April to June) and cold winters (November to January). The average annual rainfall is 650 mm and nearly 85% of the total rainfall is received through North-Western monsoon from the second fortnight of June to September. The average monthly minimum and maximum temperatures fluctuate from 6.80 to 8.0 °c and 19.6 to 21.5 °c in winters and from 22.0 to 24.6 °c and 45.4 to 48.3 °c in summers, respectively. The experiment was laid out in factorial randomized block design with three replications.

Experimental details: The grafted ber plants (Var. Gola) were planted in configuration of 6.25 X 6.25 m apart from plant to plant and row to row. Treatments consisted of two grass species in main plot and four integrated nutrient management systems in sub plots. The size of main plot was 400 m^2 (20 m X 20 m) and sub plot was100 m^2 (5 m X 20 m). Between the interspaces of ber, two grass species (*Cenchrus ciliaris* and *Cenchrus setigerus*) were planted at a row spacing of 50 cm. Integrated nutrient management systems consisted of i) no fertilizers, no organic manure (T_0), ii) 100% RDF of NPK through sheep manure (T_M), iii) 100% RDF of NPK (60+40+20 kg/ha) through fertilizers (T_F), iv) 50% RDF of NPK through fertilizers + 50% through sheep manure (T_{MF}). Soil was treated with 2% *Methyl parathion* dust to control soil borne insects. The seed borne diseases were controlled with the help of systematic fungicide "*Bavistin"* at the rate of 2 g/kg of seed. The Sowing of *Cenchrus setigerus* (Var. S-3108) and *Cenchrus ciliaris* (Var. CAZRI-75) grasses seed was done manually at the depth of 2 cm below the ground surface with a seed rates of 4 kg/ha for *Cenchrus ciliaris* and 6 kg/ha for *Cenchrus setigerus*, respectively. The sheep manure used for experimental purpose contained 0.58% N, 0.27% P_2O_5 and 0.63% K_2O. The grasses were weeded manually at 20 to 25 days after sowing (DAS).

Observations and methods of analysis: The grasses were harvested at physiological maturity stage *i.e.* 75 days after sowing by sickle at 10 cm above the ground surface and green and dry fodder production was recorded in each plot on the basis of per square meter area and values were converted into t/ha**.** The grass plant samples were oven dried at 80 ° for estimating dry matter content in green fodder. Ber fruit, leaf fodder and fuel wood yields per plant was also recorded in last week of April in both years**.** The grass samples were grinded for estimation of crude protein content (AOAC, 1994). Economics of different treatments was worked on the basis of prevailing market prices of input and outputs.

Results and Discussion

Growth and yield of grasses: The data presented in Table 1 clearly indicated that the growth and yield parameters of grasses in the form of plant height, tillers/ plant, dry matter accumulation/plant, tussock diameter, spike length, seed yield/spike and seed yield/plant were differed in each year (Table1). However, these were increased higher under *Cenchrus setigerus* as compared to *Cenchrus ciliaris* except spike length during both years of observations. In general, all the growth and yield parameters were higher in 2012 over previous year

2011 with the already established grass pasture. The vegetative and reproductive growth parameters were recorded under various treatments indicated that use of only organic source of major nutrients (NPK) is insufficient to promote better growth and development of grasses under ber based hortipasture system. In fact, the inorganic sources coupled with organic source (sheep manure) for major nutrients promote better growth and yield attributes by increasing various macro and micro nutrients and increasing availability of soil nutrients. Pathan and Kamble (2014) also reported that application of 10 t FYM/ha along with inorganic nutrients were found more beneficial because FYM consisted of all the essential as well as beneficial elements. Probably, the application of organic source produced variety of growth substances which ultimately helpful in promoting vegetative vigour of the grasses. Data in Table 1 and 2 indicated that mean growth and yield attributes were increased greater in *Cenchrus setigerus* such as plant height by 8.26%, number of tillers/plant by 20.7%, dry matter accumulation at harvest/plant by 16.4%, tussock diameter by 18.1%, seed yield/spike by 50.8% and seed yield/plant by 25.2% as compare to *Cenchrus ciliaris*. However, spike length was recorded higher by 16.6% under *Cenchrus ciliaris*. Such variation in improvement of growth and yield attributing characters in both these two-grass species might be due to genetic makeup. These results are in conformity with those of Meena *et al.* (2010) who reported that each grass species has morphological variation over other species. It is discernable from Table 1 and 2 that integrated use of nutrients (50% RDF of NPK through fertilizers + 50% through sheep manure) had produced maximum mean growth and yield attributes such as plant height (152.48 cm), number of tillers/plant (16.79), dry matter accumulation at harvest/plant (64.15 g), tussock diameter (15.87 cm), seed yield/spike (13.69 g) and seed yield/plant (359.66 mg) which were followed by 100% RDF of NPK (60+40+20 kg/ha) through fertilizers and 100% RDF of NPK through sheep manure and minimum in control treatment, plant height (129.64 cm), number of tillers/plant (12.15), dry matter accumulation at harvest/plant (42.83 g), spike length (10.82 cm) tussock diameter (12.74 cm), seed yield/spike (10.70 g) and seed yield/plant (271.10 mg), respectively. It might be due to supply of nutrients and induction of growth hormones which might have stimulated cell division, cell elongation, and better transportation of water uptake and accumulation of nutrients. These findings are in agreement with the results of Singh *et al*. (2014).

Green herbage, dry matter, seed yield and protein content: The green herbage, dry matter, seed yield, protein content and protein yield were influenced significantly in the grass species (Table 3). In general, green herbage, dry matter, seed yield and protein content were more pronounced under *Cenchrus setigerus* than *Cenchrus ciliaris* in 1st and 2nd year. The mean green herbage yield (21.97 t/ha), dry matter (4.61 t/ha), seed yield (100.95 kg/ha) and protein content (7.75%) were recorded with *Cenchrus setigerus* followed by *Cenchrus ciliaris*. Similar trend was also observed with respect to protein yield (224.53 kg/ha) and higher protein content was recorded in *Cenchrus setigerus* than *Cenchrus ciliaris*. These findings are in accordance with the results of Gill *et al*. (2004). The mean green herbage, dry matter, seed yield and protein content and protein yield were affected significantly due to various treatments of fertility management (Table 3). The addition of 50% RDF of NPK through fertilizers + 50% through sheep manure was increased maximum in mean green herbage (25.06 t/ha), dry matter (4.91 t/ha), crude protein content (8.93%) and protein yield (265.89 kg/ha). Where the control treatment there was lowest mean green herbage (16.26 t/ha), dry matter (3.81 t/ha), crude protein content (6.77%) and protein yield (214.41 kg/ha) and seed yield (78.81 kg/ha). The higher increase in values under conjunctive use of organic and inorganic sources of nutrients in their half doses resulted immediate supply of nutrients from the chemical fertilizers but slow and steady supply of plant nutrients from sheep manure especially at early stage of plant growth might have improved adequate biomass production resulting in higher seed yield. Similar results have also been observed by Kumar *et al.* (2005), who also reported that seed production of buffel grass was also increased significantly due to fertility management.

Tree growth parameters: Ber growth attributes *viz.* tree height, collar diameter and canopy spread were influenced significantly during both years (Table 4). However, the increase in tree height, collar diameter and canopy spread of ber was higher when *Cenchrus setigerus* was intercropped. Combined application of organic and inorganic nutrients resulted into significant increase in all growth parameters of ber tree compared to control. The highest increase in growth attributes was observed under treatment T_{MF} as compared to the remaining treatments (Table 4).

Dry ber leaf fodder, fruit yield and fuel wood yield: The data on dry ber leaf fodder, fruit yield and fuel wood yield

as influenced by grass species are presented in Table 4 Significant differences were observed in dry ber leaf fodder fodder, fruit yield and fuel wood yield during 1st and 2nd year. The mean dry ber leaf fodder yield (647.13 kg/ha), fruit yield (5325.95 kg/ha) and fuel wood yield (5278.32 kg/ha) were recorded maximum with *Cenchrus setigerus*

Table 1. Effect of species and integrated nutrient management on growth parameters of grasses under horti-pasture system

Treatment	Plant height (cm) at harvest		Tillers /plant		Dry matter/plant (g) at harvest		Tussock diameter (cm)	
	2011	2012	2011	2012	2011	2012	2011	2012
Grass species								
C. ciliaris	142.78	146.63	12.33	13.72	48.25	50.41	12.16	13.11
C. setigerus	128.50	138.81	15.16	16.27	56.75	58.09	14.51	15.34
CD (P<0.05)	5.47	6.09	2.39	2.53	4.56	4.78	1.81	1.92
Integrated nutrient management system								
T_0	123.14	136.14	10.50	13.81	41.39	44.27	11.25	14.24
T_M	132.83	146.63	12.50	14.80	51.24	54.23	12.89	15.72
T_F	140.50	155.36	15.50	16.20	54.88	56.89	14.23	16.43
T_{MF}	146.23	158.74	16.40	17.18	62.49	65.81	14.88	16.87
CD (P<0.05)	4.76	5.84	2.47	2.59	5.30	5.12	2.19	2.25

Table 2. Effect of species and integrated nutrient management on yield attributingcharacteristics and seed yield (kg/ ha) of grasses under hortipasture system

Treatment	Spike length (cm)		Seed yield/spike (mg)		Seed yield/ plant (g)		Seed yield (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012
Grass species								
C. ciliaris	11.79	13.39	241.06	243.25	9.26	10.50	85.89	88.02
C. setigerus	9.98	11.60	355.36	375.16	11.16	13.58	98.78	103.13
CD (P<0.05)	2.24	2.25	11.40	12.50	2.85	2.56	4.27	4.86
Integrated nutrient management system								
T_0	10.05	11.36	265.05	277.16	9.82	11.83	77.60	80.03
T_M	11.55	13.42	282.05	287.50	11.52	14.16	86.04	97.40
T_F	11.73	13.71	318.16	329.83	14.11	15.66	99.95	108.03
T_{MF}	12.86	14.49	327.00	392.33	16.40	16.87	107.75	116.05
CD (P<0.05)	2.49	2.63	9.81	12.38	2.62	2.62	5.22	5.73

Table 3. Effect of grass species and integrated nutrient management on green herbage, dry matter and protein content in dry matter of grasses under hortipasture system

Treatment	Green herbage (tonnes/ha)		Dry matter of grasses (tonnes/ha)		Protein content in dry matter of grasses (%)		Protein yield (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012
Grass species								
C. ciliaris	18.11	19.51	3.91	4.21	6.07	6.67	190.69	212.07
C. setigerus	21.42	22.52	4.52	4.71	7.64	7.87	212.74	236.32
CD (P<0.05)	3.04	3.11	0.31	0.39	0.87	1.04	16.82	19.26
Integrated nutrient management system								
T_0	15.41	17.12	3.71	3.91	6.57	6.98	189.39	204.76
T_M	18.22	19.81	3.92	4.21	7.14	7.76	208.87	219.96
T_F	22.31	22.51	4.32	4.41	7.72	8.05	221.48	242.95
T_{MF}	25.01	25.12	4.81	5.01	8.91	8.96	259.54	272.24
CD (P<0.05)	3.08	3.23	0.56	0.62	1.23	1.31	15.76	20.16

Table 4. Effect of grass species and integrated nutrient management on growth parameters of ber trees, ber leaf, fruit and fuel wood yield in hortipasture system

Treatment	Tree height (m)		Crown canopy diameter (m)		Collar girth (cm)		Ber leaf fodder yield (kg/ha)		Ber fruit yield (kg/ha)		Ber fuel wood yield (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Grass species												
C. ciliaris	3.05	3.19	3.40	3.66	34.71	36.37	537.24	610.10	4429.15	5544.41	4240.40	5543.76
C. setigerus	4.19	4.26	4.52	4.81	43.22	45.97	626.29	667.97	4686.64	5965.26	4594.27	5962.37
CD (P<0.05)	0.056	0.047	0.105	0.110	0.658	0.467	55.00	35.74	159.06	259.98	218.60	258.60
Integrated nutrient management system												
T_O	3.07	3.29	3.72	3.90	36.94	39.27	517.04	562.35	4057.29	5132.12	3698.14	5132.43
T_M	3.64	3.71	3.95	4.13	38.20	39.66	522.05	613.08	4285.14	5529.53	4131.91	5531.36
T_F	3.72	3.77	3.99	4.36	38.49	42.37	613.70	657.09	4809.22	5931.17	4477.90	5923.11
T_{MF}	4.04	4.15	4.19	4.59	42.22	43.39	674.28	723.61	5079.94	6426.53	5361.38	6425.36
CD (P<0.05)	0.079	0.067	0.149	0.156	0.931	0.661	59.15	37.04	171.04	262.98	221.65	260.15

followed by *Cenchrus ciliaris*. The dry ber leaf fodder, fruit yield and fuel wood yield of 'Gola' ber were influenced significantly by the different sources of nutrients management in ber and grasses. In general, nutrients added to ber plants in the forms of organic and inorganic were produced maximum average dry ber leaf fodder (698.94 kg/ha), ber fruit yield (5753.23 kg/ha) and fuel wood yield (5893.37 kg/ha) than separately application of organic and inorganic sources of plant nutrients. Minimum yield was recorded with control (no organic and no fertilizers). The increase in ber fruit yield due to combined use of organic and inorganic sources of nutrients attributed to better vegetative growth, better availability of nutrients at vital growth period and greater synthesis of carbohydrates and their translocation to the storage organs as reported by Ghosh (2008) who noticed that prolonged availability of nutrients during the growth period from FYM might have enhanced the fruit setting and increased ber fruit yield.

Soil moisture status: On the perusal of data from Table 5, it is clearly indicated that moisture content in soil was differed due to grass species and it was numerically significantly when comparison was made between two grasses namely *Cenchrus setigerus* and *Cenchrus ciliaris* species. The soil moisture content was also increased due to integrated nutrients management. However, maximum moisture content in soil (8.00%) was estimated where 50% RDF of NPK through fertilizers + 50% through sheep manure was applied to ber and grasses followed by100% RDF through sheep manure (7.08%) and 100% RDF through chemical fertilizers (7.44%) and minimum soil moisture content was under control treatment (6.87%). However, the moisture content under different treatments was statistically at par with each other except control and 50% RDF of NPK through fertilizers + 50% through sheep manure treatment. In nutshell moisture content was increased by 16.45% higher cover control treatment (no organic, no fertilizers) than 50% RDF of NPK through fertilizers + 50% through sheep manure treatment. The water holding capacity of the soil under ber based horti-pasture system was recorded higher than other tree species in the system and at open site. The result is in close conformity with the findings of Singh *et al*. (2010) who have also reported that higher availability of organic carbon obtained from higher annual return of ber leaf litter resulting increase in microspores of soil leading to increase in water holding capacity under ber based hortipasture system by 6.17% higher.

Soil physical and chemical properties: Perusal of data

of indicated that the physiological and chemical properties soil were influenced significantly by grass species and use of different kind of organic and inorganic sources of nutrients (Table 5). The bulk density was decreased significantly from its initial value of 1.34 to 1.21 (Mg/m^3) and soil pH was also declined of 7.9 to 7.5 by use of organic and inorganic sources of nutrients. The EC of the soil decreased from its initial value 0.27 dS/m to 0.20 dS/m being lowest under the 50% RDF of NPK through fertilizers + 50% through sheep manure treatment, but the difference between treatments100% RDF of NPK through fertilizers and100% through sheep manure treatment was found to be non-significant. This decrease in soil pH and EC may be attributed to the continuous use of organic manure which release various organic acids upon its decomposition and leaching of salts to the lower layers of the soil during rainy season. A decrease in pH of soil under farmyard manure may be due to the activation of Al^{3+} and continuous release of basic cation upon its decomposition and gravitational movement of cations into lower horizons of soil. These results are in close conformity with the findings of Marathe *et al*. (2009). The available NPK were influenced significantly due to grass species and integrated nutrient management in ber based hortipasture system. However, these values were higher under *Cenchrus setigerus* than *Cenchrus ciliaris*. The higher available NPK concentration increased from their initial values (147.6, 12.7 and 204.1 kg/ha) to (177.7, 19.0 and 289.4 kg /ha). Release of P and K in the soil from unavailable to available forms because of reaction of organic acids produced after decomposition of organic manure. More or less similar results have been reported by Korwar *et al*. (2006). The average increase in K was observed maximum with application of 50% RDF of NPK through fertilizers + 50% through sheep manure treatment. It increased from initial value 227.2 to 231.4, 261.8 and 289.4 kg/ha. This may be due to application of organic manure and different fertilizers combindly.

Economics: The two years mean data revealed that grass + ber plants in hortipasture system gave higher gross return (Rs. 70334/ha), net return (Rs. 59543/ha) and benefit: cost ratio (2.20), which were realized from dry matter, grass seed, dry ber leaf fodder, fruit and fuel wood production when combined grown of in association of *Cenchrus setigerus* and ber plants under hort-ipastoral system as compared to *Cenchrus ciliaris* and ber plants planted on the same piece of land (Table 6). The higher net return was attributed to the higher dry matter production, higher grass seed, dry ber leaf fodder, fruit and fuel wood production under grass and ber plantation. The fertility levels, application of 50% RDF of NPK through fertilizers + 50% through sheep manure observed highest gross return (Rs. 76131/ha), net return (Rs. 66366/ha) and benefit: cost ratio (2.33). Higher net return and benefit ratio with 50% RDF of NPK through fertilizers + 50% through sheep manure were mainly because of higher fodder, seed, fuel wood and fruit productivity with comparatively lower cost of cultivation. Singh *et al.* (2014) who reported that combined use of farm yard manure and NPK in different combinations improved plant growth and yield of aonla than other combinations of fertilizer management.

Table 5. Effect of grass species and integrated nutrient management system on physio-chemical properties of soil (after five years of experimentation) at 0-15 cm depth

Treatment	Organic C (%)	Bulk density (Mg/m^3)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	pH	EC (dS/m)	Soil moisture content (%)
Grass species								
C. ciliaris	1.30	0.41	161.2	15.2	245.0	7.6	0.23	6.76
C. setigerus	1.29	0.42	176.0	18.4	256.1	7.5	0.21	7.62
CD (P<0.05)	0.03	0.053	7.20	2.37	17.93	0.09	0.014	0.29
Integrated nutrient management system								
T_0	1.34	0.36	147.6	12.7	204.1	7.8	0.27	6.87
T_M	1.26	0.39	157.7	14.8	231.4	7.7	0.24	7.08
T_F	1.23	0.43	170.0	16.8	261.8	7.6	0.23	7.44
T_{MF}	1.21	0.47	177.7	19.0	289.4	7.5	0.20	8.00
CD(P<0.05)	0.04	0.06	8.31	2.74	20.70	0.11	0.02	0.41
Initial soiltest value	1.34	0.34	123.4	13.6	227.2	7.9	0.21	-

Table 6. Effect of grass species and integrated nutrient management system on gross and net returns from hortipasture produces (Mean over 2 years)

Treatment	Gross return (Rs./ha)						Net return (Rs./ha)						Benefit: cost ratio
	Return from dry matter	Return from grass seed	Return from ber leaf	Return from Fruit	Return from fuel wood	Total gross returns	Return from dry matter	Return from grass seed	Return from ber leaf	Return from fuel wood	Return from fruit	Total Net returns	
Grass species													
C. ciliaris	20300	10435	2868	24934	4892	63429	19405	10667	4578	4673	13954	53276	1.98
C. setigerus	23075	12115	3236	26630	5278	70334	23565	11614	4914	5067	14383	59543	2.20
Integrated nutrient management system													
T_0	19050	9458	2698	22974	4415	58595	19315	9312	4025	3672	11131	47455	1.77
T_M	20325	11006	2838	24537	4832	63538	20945	10325	4337	4477	12511	52595	1.91
T_F	21825	12479	3177	26851	5201	69533	21755	11994	4883	4926	15693	59251	2.15
T_{MF}	24550	13428	3495	28765	5893	76131	23935	12930	5741	6405	17355	66366	2.33

Prevailing Market Prices of Produces: Dry matter (Rs. 525/q), Grass seed (Rs.125/ kg), Dry ber leaves (Rs.7.5/ kg), Ber fruit (Rs.5/ kg), Fuel wood (Rs.1.75/ kg)

Conclusion

Based on the study, it was inferred that growing of *Cenchrus* in association of ber plantation under horti-pasture system with balanced fertilization is a mutually complementary, productive and remunerative alternate land use system in semi-arid agro ecosystem of south-eastern part of the Rajasthan.

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