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Productivity and economics of ber (*Ziziphus mauritiana*) based horti-pasture system as influenced by integrated nutrient management under rainfed condition of Rajasthan

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ABSTRACT

Awareness of food quality has shifted our focus on nutrient management system in crop production. Integrated nutrient management system resulted in good yield improvement and maintenance of soil health having least impact on food quality and environment. In order to assess the impact of different nutrient management systems, an experiment was conducted at ICAR-CSWRI, Avikanagar (Rajasthan) for two consecutive years during *kharif* 2012-13 and 2013-14 on sandy loam soil to ascertain the response of grasses and ber plants against integrated nutrient management system [no fertilizers, no organic manure (control), 100% RDF of NPK through sheep manure, 100% RDF of NPK through fertilizers and 50% RDF (Recommended dose of fertilizers) of NPK through fertilizers+ 50% through sheep manure] under ber based hortipasture system. The results of study revealed that grass species had significant effect on yield and yield attributes. Yield and all the yield attributes were noticed higher in *Cenchrus setigerus* species than *Cenchrus ciliaris* except spike length. The highest green fodder (19.87 tonnes/ha), dry matter (4.48 tonnes/ha), grass seed (120.18 kg/ha) and protein content (7.36%) were found in *Cenchrus setigerus* species. While, ber (*Ziziphus mauritiana*) leaf (3.93 kg/plant), fruit (36.84 kg/plant) and fuel (23.31 kg/plant) were higher in association of *Cenchrus setigerus* than *Cenchrus ciliaris*. The maximum gross return of ₹ 104429/ha, net returns of ₹ 72029/ha and benefit: cost ratio (2.21) was registered in combination of *Cenchrus setigerus* and ber plants under horti-pasture system. In integrated nutrients management system, where 50% RDF of NPK through fertilizers +50% through sheep manure enhanced the growth and development of grasses as well as ber plants resulted significant increase in green fodder (80.71%), dry matter (35.07%), seed yield (36.14%), protein (26.62%), ber leaf (42.67%), fruit (47.34%) and fuel wood (90.31%) over control treatment. The maximum gross return (₹ 122374/ha) and net return (₹ 79652/ha) were realized where combined use of organic and inorganic sources of plant nutrients in grasses as well as in ber plants under ber based horti-pasture system. The higher benefit: cost ratio was also noticed with 100% RDF of NPK through fertilizers (2.19).

Key words: *Cenchrus ciliaris*, *Cenchrus setigerus*, Horti-pasture system, Integrated nutrient management, RDF, Sheep manure, *Ziziphus mauritiana*

Over exploitation of production systems by ever increasing human and livestock population results in declined productivity of marginal and sub-marginal lands in semi-arid agro-ecosystem. Therefore, scientific management of underutilized lands can be made though cultivation of horti-pastoral crops in place of high value agricultural crops, and thus productivity of these lands needs to be increased. Thus, legitimate role of poor lands can be augmented for human food security and livestock production in present scenario (Meena and Mann 2011). Fragile agro-ecosystem needs to be combated by adoption of woody component like ber trees (*Ziziphus mauritiana*) in association of perennial grasses under horti-pasture system. Leaf fall of ber plants helps in prohibiting soil and water erosions and further restore soil fertility (Ram *et al.* 2005). Ber is very hardy under drought spell owing to well developed long tap root system than other perennial crops. Under low rainfall areas, mono cropping is often prone to frequent crop failures but grasses and ber plants are more efficient under adverse climatic conditions (Awasthi and Pareek 2008). Ber based horti-pasture system supplies fodder leaf to animals and fruit to human being during their acute shortage. Inder Mohan (2002) reported that ber leaves offered nutritious fodder to small ruminants because ber leaves generally contain 10% crude protein. The root system of grasses prevent removal of upper layer of fertile soil from wind erosion, besides this decomposition of grasses roots improves physical and chemical properties of soil in semi-arid climate (Singh *et al.* 2014). It has been noticed from the earlier findings of long term studies that organic manures in combination

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with chemical fertilizers proved improvement in yield and soil quality (Meena *et al*. 2017). Hence, there is an urgent need to evolve economically attractive and ecologically vigorous means and ways for reducing the use of excess external inputs. So it is imperative to select the efficient technology of crop production (Ram Niwaj and Rai 2005). Thus, combined use of organic and inorganic sources of plant nutrients has proper advantage over their sole application. The present investigation was executed to assess the production potential of grasses under ber based horti-pasture system in regard to integrated nutrient management .Indeed; combined application of organic and inorganic sources will not only enhance the nutrient use efficiency and profitable production system but also save the precious water resource to greater extent.

MATERIALS AND METHODS

The field experiment was conducted for two consecutive years during *kharif* 2012-13 and 2013-14 at ICAR- Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) located (27° 17′N altitude and 75° 22′ E longitude and mean sea level height (326 m). The soil of the experimental site was sandy loam in texture, low in available N (128.51 kg/ha), medium in P (8.63 kg/ha) and rich in available K (258.17 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 6.8 to 8.0° and 19.6 to 21.5° in winters and from 22.0 to 24.6° and 45.4 to 48.3° in summers, respectively. The experiment was laid out in factorial randomized block design with three replications. The two grass species (*Cenchrus ciliaris* and *Cenchrus setigerus*) were planted in between two rows of ber plants, the spacing of grass species was kept at 50cm apart from row to row in main-plots, whereas, in the sub-plots integrated nutrient management systems, viz. no fertilizers, no organic manure to both grass species and ber plants (control), 100% RDF of NPK through sheep manure (10 tonnes/ha) in grass species and 30 kg sheep manure per ber plant; 100% RDF of NPK (60+40+20 kg/ha) through fertilizers in grass species and 500g urea+750g SSP+500g MOP per ber plant and 50% RDF of NPK through fertilizers (30+20+10 kg NPK/ha in grass species) and 250g urea+375g SSP+250g MOP per ber plant and 50% through sheep manure (5 tonnes/ha) in grass species and 15 kg sheep manure per ber plant. The ber plants were planted in the configuration of 6.25m×6.25m apart from line to line. Soil was treated with 2% of Methyl parathion dust to control the soil borne insect and pests. The seed borne diseases were controlled with dressing of systematic fungicide Bavistin @ 2 g/kg of seed. The sowing of *Cenchrus ciliaris* and *Cenchrus setigerus* grasses were 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 test varieties of *Cenchrus ciliaris* (Anjan grass) and *Cenchrus setigerus* (Dhaman grass) were CAZRI 75 and S-3108. The sheep manure consisted of 0.58% N, 0.27% P and 0.63% K on the dry weight basis. The grasses were weeded manually 20 to 25 days after sowing. Grasses were harvested at the age of 75 days after sowing by sickle 10 cm above the ground surface and green and dry fodder production were recorded at harvest in each plot on the basis of per square meter area and values were converted into tonnes/ha by converting factor**.** The grass plant samples were oven dried at 70 ^{o}C for estimation of dry matter content in green fodder. Ber fruit yield, leaf fodder and fuel wood were also recorded in the last week of April during both the consecutive years**.** The grass samples were analyzed for crude protein content suggested in AOAC (1990). Economics of different treatments was worked out on the basis of prevailing market prices of input and out puts. Initial and final soil properties were determined by standard methods.

RESULTS AND DISCUSSION

Yield and yield attributes of grasses

All the growth and yield attributes of both grass species were influenced significantly and found more in *Cenchrus setigerus* compared to *Cenchrus ciliaris* except spike length. The higher increase in growth parameters of *Cenchrus setigerus* may be due to heritable character of the species. The magnitude of increase in terms of growth and yield traits of *Cenchrus setigerus* were (11.11 and 14.99%) in plant height, number of tillers/plant (20.52 and 27.39%), dry matter accumulation/plant (17.61 and 17.43%), tussock diameter (19.32 and 16.57%), seed yield/spike (47.41 and 50.11%) and seed yield/plant (10.37 and 8.80%) over *Cenchrus ciliaris* in 2012-13 and 2013-14, respectively (Table 1).Whereas, the spike length was recorded higher in *Cenchrus ciliaris* in the tune of 32.52 and 32.57% over *Cenchrus setigerus.* The green and dry fodder yields were also increased significantly higher by13.54 and 17.85% due to grass species in 1st and 2nd years, respectively). Variation in the yield of green and dry fodders might be on account of invariable increase in growth parameters of both grasses under ber based horti-pasture system (Rao *et al*. 2018). Further, the data clearly indicated that treatment which received (50% RDF of NPK through fertilizers + 50% through sheep manure) had more pronounced effect on the growth and yield attributes and the next best treatment was found 100% RDF of NPK through fertilizers on growth and yield attributes. While, the differences among the treatments themselves for growth and yield attributes were found numerically at par when control treatment and 50% RDF of NPK through fertilizers+ 50% through sheep manure were compared together. An integrated nutrients management in ber based horti-pasture system had overriding effects on green and dry fodder production (Table 2). However, maximum green and dry fodder yields were quantified where 50% RDF of NPK through fertilizers + 50% through sheep manure was applied (26.00 and 4.61

Table 1 Effect of integrated nutrient management on growth and yield attributes of grass species under ber based horti-pasture system

Treatment	Plant height (cm) at harvest		Number of tillers/ plant		Dry matter accumulation /plant (g) at harvest		Tussock diameter (cm)		Spike length (cm)		Seed yield / spike(mg)		Seed yield /plant (g)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Grass species														
Cenchrus ciliaris	128.50	125.88	9.26	10.33	48.25	50.42	12.16	12.55	14.71	15.39	241.06	243.25	13.21	14.26
Cenchrus setigerus	142.78	144.75	11.16	13.16	56.75	59.21	14.51	14.63	11.10	11.60	355.36	365.16	14.58	15.52
CD (P=0.05)	11.47	12.21	1.85	1.93	1.65	2.17	1.09	1.14	3.21	3.24	21.40	23.50	0.93	0.98
Integrated nutrient management														
No fertilizers, no organic manure (control)	123.14	134.94	6.82	10.50	41.39	44.39	11.25	12.16	11.13	11.29	235.05	247.16	13.10	13.16
100% RDF of NPK through sheep manure	132.83	143.33	8.52	12.50	51.24	56.24	12.98	13.05	12.72	13.42	282.05	287.50	13.72	14.74
100% RDF of NPK through fertilizers	140.50	159.33	11.11	15.50	54.88	57.88	14.23	14.58	13.79	13.71	318.16	329.83	13.90	14.93
50% RDF of NPK through fertilizers+ 50% through sheep manure	146.23	161.66	14.40	16.40	62.49	67.49	14.88	15.72	14.62	14.79	327.00	342.33	14.27	15.29
CD (P=0.05)	12.96	13.27	1.62	2.07	3.30	3.40	3.19	3.46	3.13	3.49	21.03	24.38	1.04	1.27

Table 2 Effect of integrated nutrient management on green fodder, dry matter, grass seed yield, protein content, ber leaf fodder, ber fruit yield and fuel wood under ber based horti-pasture system

Treatment	Green fodder yield (tonnes/ha)		Dry matter yield (tonnes/ha)		Grass seed yield (kg /ha)		Protein content in DM of grasses		Dry ber leaf fodder yield (kg/plant)		Ber fruit yield (kg/plant)		Fuel wood yield (kg/plant)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Grass species														
Cenchrus ciliaris	17.29	17.71	3.71	3.92	87.02	93.51	6.56	6.61	2.98	3.51	28.25	32.64	18.71	19.14
Cenchrus setigerus	19.41	20.33	4.46	4.51	117.13	123.24	7.31	7.42	3.73	4.13	34.75	38.94	22.89	23.74
CD (P=0.05)	0.80	1.14	0.37	0.46	2.86	3.62	0.59	0.68	0.72	0.89	4.65	5.49	2.98	3.02
Integrated nutrient management														
No fertilizers, no organic manure (control)	14.41	14.83	3.37	3.54	87.03	91.65	4.71	4.83	2.77	3.16	31.39	34.17	13.97	15.77
100% RDF of NPK through sheep manure	15.20	16.60	3.71	4.01	97.40	98.43	5.04	5.09	3.11	3.50	41.24	43.34	19.32	21.08
100% RDF of NPK through fertilizers	21.31	22.27	4.12	4.30	108.03	114.23	5.82	5.94	3.53	4.20	44.88	45.55	22.01	25.29
50% RDF of NPK through fertilizers+ 50% through sheep manure	26.00	26.85	4.61	4.71	116.05	127.22	6.02	6.06	4.01	4.43	46.49	50.12	27.91	28.69
CD (P=0.05)	2.96	3.08	0.36	0.56	5.73	6.71	0.64	0.72	1.02	1.26	4.90	6.11	3.79	4.25

and 26.85 and 4.71 tonnes/ha) during 1st and 2nd year, respectively) and the minimum green and dry fodder yield in grasses was recorded under control treatment (14.41 and3.37 and 14.83 and 3.54 tonnes/ha during the period of study). The difference between two treatments likes (control) and (50% RDF of NPK through fertilizers + 50% through sheep manure) exhibited steep surge in green (80.71%) and dry fodder yield (35.07%). While, the difference between control and 100% RDF of NPK through sheep manure treatment was found comparable with each other for green and dry fodder production. This might be due to fast supply of nutrients from the inorganic sources than sheep manure which gradually release nutrients to the grasses and ber plants. Similar results were also observed by Singh *et al*. (2001) and Meena and Mann (2011).

Protein content in dry matter of grasses

Protein content in dry matter of grasses was estimated at the harvest in both consecutive years. The observations revealed that protein content in dry matter was found variably increased in the species (Table 2). However, more protein content was estimated in the dry matter of *Cenchrus setigerus* (7.36%) than *Cenchrus ciliaris* (6.58%).The protein content in dry matter of *Cenchrus setigerus* increased to the tune of 11.85% higher than *Cenchrus ciliaris*. Crude protein content in dry matter of grasses was higher where 50% RDF of NPK through fertilizers and 50% through sheep manure (6.04%) applied. However, the difference between treatments, *viz.* control, 100% RDF of NPK through sheep manure, 100% RDF of NPK through fertilizers and 50% RDF of NPK through fertilizers+ 50% through sheep manure were remained statistically at par with each other owing to protein content in dry matter of both grass species. In fact, higher protein content in dry matter of grasses might be due to better growth of plant species under judicious use of organic and inorganic sources of nutrients management as compared to their separate application. These results are in conformity with the findings of (Meena and Man 2013) and (Kumar and Ram 2009). They have also reported that combined use of organic and inorganic nutrients in ber and annona based horti-pasture systems may achieve better performance than their alone application.

Seed production in grasses

Seed production in *Cenchrus setigerus* was increased tangibly higher by 34.60 and 31.79% over *Cenchrus ciliaris* in first and second year, respectively (Table 2). This quantum increase in seed yield of *Cenchrus setigerus* might be due to surge in yield component traits viz. spike length, seed yield/ spike and seed yield/plant as compared to *Cenchrus ciliaris*. Although, grass seed yield was recorded higher significantly due to integrated nutrient management in grasses species and ber plants as also reported by Subhash *et al.* (2005). However, mean seed yield over 2 consecutive years was recorded higher under 50% RDF of NPK through fertilizers + 50% through sheep manure (121.63 kg/ha). While, the lowest seed yield was recorded under control treatment

Table 3 Effect of integrated nutrient management system on grass return, net return and benefit: cost ratio of various components of ber based horti-pasture system

Treatment	Gross return from the sale of dry matter (₹/ha)		Gross return from the sale of grass seed matter (₹/ha)		Gross return from the sale of ber leaves (₹./ha)		Gross return from the sale of ber fruit (₹./ha)		Gross return from the sale of ber fuel wood (₹./ha)		Gross return from the whole system (₹./ha)		Net return from whole system (₹./ha)		B:C ratio	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Grass species																
Cenchrus ciliaris	18550	21560	10442	12156	5340	7188	36160	41779	7185	9800	77677	92483	47217	58977	1.55	1.76
Cenchrus setigerus	22300	24805	14042	16021	6684	8458	44480	49843	8790	13435	96296	112562	65446	78612	2.12	2.31
Integrated nutrient management																
No fertilizers, no organic manure (control)	16850	19470	10444	11915	4964	6472	40179	43738	5365	8074	77802	89669	48542	56769	1.65	1.72
100% RDF of NPK through sheep manure	18530	22055	11688	12796	5573	7168	52787	55475	7419	10793	95997	108287	65446	78612	2.12	2.31
100% RDF of NPK through fertilizers	20600	23650	12964	14850	6326	8602	57446	58304	8452	12948	105788	118354	72566	81492	2.18	2.21
50% RDF of NPK through fertilizers+ 50% through sheep manure	23050	25905	13926	16539	7186	9073	59507	64154	10718	14689	114387	130360	73485	85818	1.79	1.92

(89.34 kg/ha). The increasing trend in seed yield of grasses was recorded in accordance with increasing fertility levels which lead to enhancement in yield attributes such as spike length, seed yield/spike and seed yield/plant resulting in more seed production from grasses. Similar, findings were also reported by Kumar *et al*. (2005) and Singh *et al*. (2014).

Ber leaf, fruit and fuel wood production

Ber leaf, fruit and fuel wood yields were ascribed higher along with *Cenchrus setigerus* than *Cenchrus ciliaris* pasture. The magnitude of increase in dry ber leaf fodder/ plant was (25.16 and 17.66%), fruit yield/plant (22.34 and 24.03%) and fuel wood yield/plant (23.00 and 19.30%) in both the consecutive years (2012-13 and 2013-14) in association with *Cenchrus setigerus* than ber planted with *Cenchrus ciliaris*. Instead, ber leaf fodder, fruit and fuel wood were also increased significantly higher due to integrated nutrient management in ber based horti-pasture system (Table 2). However, the values of ber leaf fodder, fruit and fuel wood were increased remarkably with conjunctive use of both organic and inorganic sources of nutrients (50% RDF of fertilizers+ 50% RDF through sheep manure). But, the difference between the treatments under study with respect to ber leaf, fruit and fuel wood yield were found statistically at par with each other when 50% RDF of NPK through fertilizer + 50% through sheep manure and 100% RDF of NPK through fertilizers applied. The ber leaf production was increased (44.76 and 40.18%), fruit (48.10 and 46.67%) and fuel wood (99.78 and 81.92%) with the application of 50% RDF of NPK through fertilizer + 50% through sheep manure than control treatment during both the years.

Economics

The highest gross return (₹ 104429/ha), net return (₹ 72029/ha) and benefit: cost ratio (2.21) were achieved from *Cenchrus setigerus* and ber plants in horti-pasture system. The higher net return account for higher production of dry matter, leaf fodder and fuel wood from the *Cenchrus setigerus* and ber plantation system than that of *Cenchrus ciliaris* and ber plantation system. The application of 50% RDF through inorganic fertilizers + 50% RDF through sheep manure gave highest gross return (₹ 114387/ha and 130360/ ha), net return (₹ 73485/ ha and 85818/ha). However, higher benefit: cost ratio was worked out with the application of 100% RDF of NPK through fertilizers alone (2.18 and 2.21) in 1st and 2nd years, respectively (Table3). Indeed, benefit: coat ratio went down due to higher prices of sheep manure as compared to inorganic sources of nutrients (NPK) applied. These results are in corroboration with the findings of Kumar *et al*. (2005). Thus, it can be inferred from the present study that *Cenchrus setigerus* raised along with grafted ber plants with the application of 50% RDF of fertilizers+ 50% RDF through sheep manure in horti-pasture system under semi-arid condition of Rajasthan found more lucrative, remunerative and profitable system than other systems in vogue.

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