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PRODUCTIVITY AND ECONOMICS OF BER (*ZIZIPHUS MAURITIANA*) BASED HORTIPASTURE SYSTEM AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT UNDER RAINFED CONDITION OF RAJASTHAN

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SUMMARY

A field experiment was conducted at CSWRI, Avikanagar (Rajasthan) for two consecutive years during **kharif** seasons of 2012 and 2013 on sandy loam soil to study the response of grasses and ber plants to integrated nutrient management system. The results of study revealed that grass species had significant effect on yield and yield attributes. Yield and yield attributes were attained higher in *Cenchrus setigerus* species than *Cenchrus ciliaris* except spike length. Highest green fodder (19.87 t/ha), dry matter (4.48 t/ha), grass seed (120.18 kg/ha) and protein content (7.36%) were recorded in *C. setigerus.* Ber (*Ziziphus mauritiana*) leaf fodder (3.93 kg/plant), fruit (36.84 kg/plant) and fuel wood (23.31 kg/plant) were higher in association of *C. setigerus* than *C. ciliaris.* The maximum gross returns of Rs. 104 429/ha, net returns of Rs. 72 029/ha and benefit : cost ratio (2.21) were recorded in combination of *C. setigerus* and ber plants in hortipasture system. In integrated nutrient management system where 50 per cent RDF of NPK through fertilizers +50% through sheep manure was promoted grasses as well as ber plants resulted increase in green fodder yield by (80.71%), dry matter (35.07%), grass seed (36.14%), protein (26.62%), ber leaf fodder (42.67%), fruits (47.34%) and fuel wood (90.31%) over control treatment (no fertilizer, no organic manure). The maximum gross return (Rs. 122 374/ha) and net returns (Rs. 79 652/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 hortipasture system. The higher benefit : cost ratio was noticed with 100 per cent RDF of NPK through fertilizers (2.19).

Key words : Productivity, economics, hortipasture system, INM

Over exploitation of production systems by ever increasing human and livestock population results in declining productivity of marginal and sub-marginal lands in semi-arid agro-ecosystem which has more illicit effect on productivity of arable crops. Marginal and sub-marginal lands in semi-arid areas are unable to produce sufficient and sustainable. Therefore, scientific management of underutilized lands can be done though cultivation of horti-pastoral crops in place of high value agricultural crops, thus, productivity of lands can be increased many folds. Thus, legitimate role of poor lands can be increased for human food security and livestock production in present prospect and retrospect's (Meena and Mann, 2011). Under fragile agro eco-system, there is need to mitigate the aberrant climatic conditions through plantation of woody component ber (*Ziziphus mauritiana*) in association of perennial grasses under hortipasture system which could prohibit soil and water erosions from soil surface, thus restoring soil fertility by addition of mulching materials viz., fallen ber leaves and grass residues in the form of plant parts and roots (Ram *et al*., 2005). Ber is very hardy to drought conditions due to well-developed long tap root system than other perennial components. Under low rainfall areas monoculture is often risk prone due to crop failures but grasses and ber plant can be grown very well under

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adverse climatic conditions (Awasthi and Pareek, 2008). Ber based hortipasture system can supply fodder leaf and fodder to animals and fruits to human being during acute shortage. Mohan (2002) reported that ber leaves offered nutritious fodder to small animals because ber leaves generally contained 10 per cent crude protein. The root system of grasses binds clods resulting in reduced uplift of fertile soil by wind erosion and decomposition of grasses parts improves physical and chemical properties of soil in semi-arid climate. Rhizomes of the grasses add organic matter into the soil after their decomposition resulting improvement in fertility status and change in infiltration rate of rainfall water into deeper soil layers. If has been revealed from the results of long term study that organic manures along with chemical fertilizers proved impetus on yield and soil quality. But integrated nutrient management system is conceived with least impact on food quality as well as environment. So, there is a need to evolve economically attractive and ecologically sound means to reduce the use of external inputs and to improve the renewable source of energy and it becomes imperative to select the efficient techniques of crop production (Ram Niwaj and Rai, 2005). Thus, combined use of inorganic and organic sources of plant nutrients has more advantages than their sole application. The present investigation was planned to assess the production potential of grasses under ber based hortipasture system in reference to integrated nutrient management where chances are great for enhancing nutrient use efficiency and profitable production system with precious water resources.

MATERIALS AND METHODS

The field experiment was conducted for two consecutive years during **kharif** 2012 and 2013 at 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 location was sandy loam in texture, low in available N (128.51 kg/ha), medium in available P_2O_5 (8.63 kg/ha) and high in available K_2O (258.17 kg/ha) content. The climate of the location was semi-arid sub-tropical with dry hot summers (April to June) and cold winters (November to January). The average annual rainfall was 650 mm and nearly 85 per cent of the total rainfall was received through north-western monsoon from the second fortnight of June to September. The average monthly minimum and maximum temperatures fluctuated from 6.8 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. The two grass species (*C. ciliaris* and *C. setigerus*) were planted in between two rows of ber plants, the spacing of grass species was kept at 50 cm apart from row to row in main plots, whereas in the sub-plots integrated nutrient management systems viz. (i) no fertilizers, no organic manure to both grass species and ber plant (control), (ii) 100 per cent RDF of NPK through sheep manure (10 t/ha) in grass species and 30 kg sheep manure per ber plant, (iii) 100 per cent RDF of NPK (60+40+20 kg/ha) through fertilizers in grass species and 500 g urea+750 g SSP+500 g MOP per ber plant and (iv) 50 per cent RDF of NPK through fertilizers (30+20+10 kg NPK/ha in grass species) and 250 g urea+375 g SSP+250 g MOP per ber plant+50 per cent through sheep manure (5 t/ha sheep manure in grass species and 15 kg sheep manure per ber plant). The ber plants were planted in the configuration of 6.25 x 6.25 m^2 apart from line to line. Soil was treated with 2 per cent of Methyl parathion dust to control the soil-borne insects and pests. The seed-borne diseases were controlled with dressing of systematic fungicide "Bavistin" at the rate of 2 g/kg of seed. The sowing of *C. setigerus* and *C. ciliaris* grasses were done manually at the depth of 2 cm below the ground surface with a seed rate of 4 kg/ha for *C. ciliaris* and 6 kg/ha for *C. setigerus*, respectively. The test varieties of *C. ciliaris* and *C. setigerus* were "CAZRI-75" and "S-3108". The sheep manure consisted of 0.58 per cent N, 0.27 per cent P and 0.63 per cent K on the dry weight basis. The grasses were weeded manually at 20 to 25 days after sowing (DAS). Grasses were harvested at the age of 75 days after sowing by sickle at 10 cm above the ground surface and green and dry fodder production was recorded at harvest in each plot on the basis of per square meter area and values were converted into t/ha by converting factor**.** The grass plant samples were oven dried at 80°C for estimation of dry matter content in green herbage. Ber fruit yield, leaf fodder and fuel wood were also recorded in the last week of April during both the years**.** The grass samples were analyzed for crude protein content (AOAC, 1980). Economics of different treatments was worked out on the basis of

prevailing market prices of input and output. Initial and final (after the harvest of crop) soil properties were determined by standard methods.

RESULTS AND DISCUSSION

Yield and Yield Attributes of Grasses

All the growth and yield attributes of grass species were influenced significantly and were found higher in *C. setigerus* compared to *C. ciliaris* except spike length. This higher increase in growth parameters of *C. setigerus* may be due to inherent character of species. The magnitude of per cent increase in growth and yield traits of *C. setigerus* was 11.11 and 14.99 per cent 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 *C. ciliaris* in 2012 and 2013, respectively (Table 1). Whereas the spike length was recorded higher in *C. ciliaris* by 32.52 and 32.57 per cent over *C. setigerus.* This might be due to that grass species had more positive impact on better utilization of available moisture, nutrients take-up and increased infiltration of rainfall water promoted improvement in soil physiological process and structure which might have helped for better development in growth and yield attributes of *C. setigerus*. The green and dry fodder yields were increased significantly higher due to grass species in 1st and 2nd years, respectively. However, these values were greater in *C. setigerus* than those of *C. ciliaris*. Green and dry fodder production was 13.54 and 17.85 per cent higher over *C. ciliaris* as compared to *C. setigerus* (mean data over 2 years). Green and dry fodder yields increased might be due to significant increase in growth attributing characters of grasses. Further the data clearly indicated that the treatment which received 50 per cent RDF of NPK through fertilizers+50 per cent through sheep manure had more pronounced effect on growth and yield attributes followed by 100 per cent RDF of NPK through fertilizers in respect to growth and yield attributes. While the difference among the treatments for growth and yield attributes was found statistically at par when no fertilizer, no organic manure (control) and 50% RDF of NPK through fertilizers+50 per cent through sheep manure was compared. An integrated nutrient management in ber based hortipasture system had significant effect on green and dry fodder production (Table 2). However, maximum green and dry fodder production was recorded where 50 per cent RDF of NPK through fertilizers+50 per cent through sheep manure was applied (26.00 and 26.85 t/ha) and least green herbage and dry matter production in grasses was recorded under control treatment (no fertilizers, no organic manure) (14.41and 14.83 t/ha).The difference between treatments (control) and (50% RDF of NPK through fertilizers+50% through sheep manure) was exhibited maximum in terms of green (80.71%) and dry fodder production (35.07%). Besides, the difference between no organic manure, no fertilizer (control) and 100 per cent RDF of NPK through sheep manure treatments was found comparable with each other for green and dry fodder production. This might be due to immediate supply of nutrients from the inorganic sources of nutrients, while the release of nutrients from sheep manure was slow and steady. Therefore, there was a narrow difference between these two treatments. Similar results were also observed by Singh *et al*. (2001).

Protein Content in Dry Matter of Grasses

Protein content in dry matter of grasses was estimated at harvest in both the years. The data presented showed that protein content in dry matter varied due to species (Table 2). However, more protein content was estimated in dry matter of *C. setigerus* (7.36%) than *C. ciliaris* (6.58%).The protein content in dry matter of *C. setigerus* increased in the tune of 11.85 per cent higher than *C. ciliaris* (mean value basis). Average higher crude protein content in dry matter of grasses was shown where 50% RDF of NPK through fertilizers and 50 per cent through sheep manure was supplied (6.04%). However, the difference between treatments no fertilizer, no organic manure (control) and 100 per cent RDF of NPK through sheep manure and 100 per cent RDF of NPK through fertilizers and 50 per cent RDF of NPK through fertilizers+50 per cent through sheep manure remained statistically at par with each other owing to protein content in dry matter of both the grass species, namely, *C. ciliaris* and *C. setigerus.* Quiet higher protein content in dry matter of grasses might be due to better growth of plant species under conjunctive use of organic and inorganic sources of nutrients as compared to their

TABLE 1
Effect of integrated nutrient management system (INMS) on growth and yield attributes of grass species under ber based hortipasture system

Treatment	Plant height (cm)		No. 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
C. D. (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 system														
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
C. D. (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 system (INMS) on green fodder, dry matter, grass seed yield, protein content, ber leaf fodder, ber fruit yield and fuel wood under ber based hortipasture system

Treatment	Green fodder yield (t/ha)		Dry matter yield (t/ha)		Grass seed yield (kg/ha)		Protein content in dry matter 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
C. D. (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 system														
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
C. D. (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

TABLE 3
Effect of integrated nutrient management system on gross returns, net return and benefit : cost ratio of various components of ber based hortipasture system

Treatment	Gross returns dry matter (Rs./ha)		Gross returns from grass seed (Rs./ha)		Gross returns from ber leaves (Rs./ha)		Gross returns from ber fruit (Rs./ha)		Gross returns from fuel wood (Rs./ha)		Gross returns from hortipasture system (Rs./ha)		Cost of production (Rs./ha)		Net returns (Rs./ha)		B : C ratio	
	2012	2013	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	30460	33506	47217	58977	1.55	1.76
Cenchrus setigerus	22300	24805	14042	16021	6684	8458	44480	49843	8790	13435	96296	112562	30850	33950	65446	78612	2.12	2.31
Integrated nutrient management system																		
No fertilizers, no organic manure (control)	16850	19470	10444	11915	4964	6472	40179	43738	5365	8074	77802	89669	29260	32900	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	36940	38500	59057	69787	1.59	1.81
100% RDF of NPK through fertilizers	20600	23650	12964	14850	6326	8602	57446	58304	8452	12948	105788	118354	33222	36862	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	40902	44542	73485	85818	1.79	1.92

Prevailing market prices of produce during 2012 : Dry matter (Rs. 500/q), grass seed (Rs. 120/kg), Ber leaves (Rs. 7/kg), ber fruit (Rs. 5/kg), Fuel wood (Rs. 1.5/kg).
Prevailing market prices of produce during 2013 : Dry matter (Rs. 550/q), grass seed (Rs. 130/kg), ber leaves (Rs. 8/kg), ber fruit (Rs. 5/kg), Fuel wood (Rs. 2/kg).

separate application under ber based hortipasture system. These results are in conformity with the results reported by Ram and Kumar (2009) and Meena and Mann (2013). They also reported that combined use of organic and inorganic nutrients of plant in ber and annona based hortipasture systems may achieve better performance than their separate application.

Seed Production in Grasses

Seed production of *C. ciliaris* was increased tangible higher by 34.60 and 31.79 per cent over *C. ciliaris* (Table 2). The higher increase in seed yield of *C. setigerus* might be due to more increase in yield attributing characters viz., spike length, seed yield/spike (mg) and seed yield/plant (g) as compared to *C. ciliaris*. Grass seed yield increased significantly and invariably due to integrated nutrient management in grasses and ber plants. However, mean higher seed yield over two years was recorded under 50 per cent RDF of NPK through fertilizers+50 per cent through sheep manure (121.63 kg/ha) and lowest seed yield was recorded under control treatment (89.34 kg/ha). The increasing trend in seed yield of grasses was recorded with increasing fertility levels and finally led to increase in yield in yield attributes such as spike length (cm), seed yield/spike (mg) and seed yield/plant (g) resulting in more seed production from grasses. Similar results were also observed by Kumar *et al*. (2005).

Ber Leaf Fodder, Fruit and Fuel Wood Production

Ber leaf, fruit and fuel wood yields were ascribed higher with *C. setigerus* pasture than *C. ciliaris* pasture. The per cent higher increase in dry ber leafy fodder/plant was 25.16 and 17.66 per cent fruit yield/ plant (22.34 and 24.03%) and fuel wood yield/plant (23.00 and 19.30%) in association with *C. setigerus* pasture as compared to ber planted with *C. ciliaris*. Ber leaf fodder, fruit and fuel wood also increased significantly higher due to integrated nutrient management in ber based hortipasture system (Table 2). However, the values of ber leaf fodder, fruit and fuel wood increased remarkably with conjunctive use of both organic and inorganic sources of nutrients in the form of 50 per cent RDF of fertilizers+50 per cent RDF through sheep manure. But the difference among the treatments for ber leaf fodder, fruit and fuel wood yield was found statistically at par with each other when 50 per cent RDF of NPK through fertilizers+50 per cent through sheep manure and 100 per cent RDF of NPK through fertilizers was applied. The yield of ber leaf increased by 44.76 and 40.18 per cent, fruit (48.10 and 46.67%) and fuel wood yield (99.78 and 81.92%) due to supply of 50% RDF of NPK through fertilizer+50 per cent through sheep manure over to control treatment (no fertilizers, no organic manure) during both the years of study.

Economic Analysis

The higher gross returns (Rs. 104429/ha), net returns (Rs. 72029/ha) and benefit : cost ratio (2.21) were attained from the sale of dry matter of grasses, ber fruit, ber leaf fodder and fuel wood on the basis of mean value of two years under *C. setigerus* and ber plants in hortipasture system. The higher net returns were attributed to higher production in the form of dry matter, leaf fodder and fuel wood from the *C. setigerus* and ber plantation system in comparison to *C. ciliaris* and ber plantation system. The additional gross returns (Rs. 19 349/ha) net returns (Rs. 18 932) and B : C ratio (0.56) were obtained from the sale of different produce of *C. setigerus* and ber plants. Application of 50 per cent through inorganic fertilizers+50 per cent RDF through sheep manure observed highest gross returns (Rs. 114387/ ha and 130360/ha) and net returns (Rs. 73485 and 85818/ha). However, higher benefit : cost ratio was estimated with 100 per cent RDF of NPK through fertilizers applied (2.18 and 2.21) in 1st and 2nd years, respectively as compared to other treatments (Table 3). This might be due to higher price of sheep manure treatment as compared to inorganic sources of nutrients (NPK). These findings are in corroboration with those reported by Kumar and Ram (2009). With the results of above findings, it may be concluded that *C. setigerus* (Dhaman grass) raised with grafted ber plant (*Ziziphus mauritiana*) in hortipasture system under semi-arid environment was found more remunerative and profitable entrepreneur than other cropping modules for food and fodder production. The conjunctive use of 50 per cent RDF of fertilizers+50 per cent RDF through sheep manure resulted in higher pasture productivity and earned more income from the ber based hortipasture

system. Thus, high density multi species system is capable of generating high biomass production, more income and meets the various needs.

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