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Production Potential of Fodder Crops in Sapota Based Hortipasture System under Shallow Degraded Soils in Transitional Tract of Peninsular India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted during 2013-14 to 2015-16 for 3 consecutive years to study the performance of fodder crops in sapota based hortipasture systems under rainfed conditions on shallow degraded soils. The experiment comprised of 7 treatments *viz.*, sole signal grass, signal grass intercropped with stylosanthes, sole grazing guinea, grazing intercropped with stylosanthes, sole stylosanthes, sole annual fodder sorghum and sole perennial fodder sorghum in 3 years old sapota orchard. The highest green fodder yield in the first year (19.1 t/ha) was observed in perennial fodder sorghum followed by sole signal grass in the second (23.5 t/ha) and third year (26.2 t/ha). Similar trend was observed in dry fodder yield (3.85, 5.76 and 6.58 t/ha in 1st, 2nd and 3rd year, respectively). This was followed by intercropped signal grass with stylosanthes. The lowest green and dry fodder yield was observed in sole stylosanthes in all the 3 years (4.9, 8.6 and 9.3 t/ha green fodder and 1.98, 2.65 and 3.05 t/ha dry fodder, respectively). The highest net return (Rs.

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31450/ha) and B:C ratio (2.93) in first year was observed with perennial fodder sorghum while signal grass intercropped with stylosanthes recorded higher net returns (Rs. 49940/ha and Rs.56990/ha) and B:C ratio (6.37 and 7.13) in 2nd and 3rd year respectively. There was significant improvement in the organic carbon content, available N, P and K content in the soil as compared to initial status in all the treatments.

Keywords: Degraded soil; fodder crops; hortipasture system; sapota; signal grass.

1. INTRODUCTION

India is *numero uno* with the highest number of livestock and milk production in the world [1]. However, the milk productivity is relatively low as compared to other leading countries viz. USA, New Zealand, Australia, Denmark, Netherlands etc. The low milk productivity is attributed to shortage of quality fodder and feed to the dairy animals. A very small fraction of land under fodder cultivation and preponderance of crop residues as source of fodder are the major reasons for non-availability of sufficient quantity of quality green and dry fodder in the country [2]. It is therefore necessary to identify newer niches for increasing the area under fodder crops to meet burgeoning fodder demand. Sapota (*Manilkara zapota*) also called as *chikoo* is an important fruit crops cultivated in shallow degraded soils of northern transitional tract of Karnataka. It is usually planted at 9 m x 9 m planting geometry and comes to fruiting in 5 years after planting. The wide spacing between rows and plants in the sapota orchard is used for cultivation of several food crops without affecting the growth and productivity of sapota. However, the shallow soils with poor soil fertility and low water holding capacity lead to lower yield and uneconomic returns from such intercrops. Fodder crops with their inherent tolerance for moisture stress and ability to grow and record relatively higher yield can be suitable substitutes for food crops in such situation. This could form an excellent newer niche for growing of fodder crops [3]. It is possible to grow both annual and perennial fodder crops depending upon the duration and quantum of rains received. Identification of suitable crops for higher fodder productivity, understating their impact on soil properties and monetary returns will help popularization of fodder production in such areas.

2. MATERIALS AND METHODS

A 3 year field experiment was carried out during 2013-14 to 2015-16 at the Research Farm of the Indian Grassland and Fodder Research Institute, Regional Research Station, Dharwad, Karnataka to study the fodder production potential of different fodder crops in sapota based hortipasture system. The soil of the experimental site was shallow in depth, sandy loam to gravelly in texture, acidic in reaction with a bulk density of 1.67 g/cm^3, medium in organic carbon, low in available N and medium in available P and K. The experiment comprised of 7 treatments viz. sole signal grass (*Brachiaria decumbence*) (T_1), intercropping of signal grass and stylosanthes (*Stylosanthes hamata*) (1:1 row ratio) (T_2), sole grazing guinea (*Panicum maximum*) (T_2), intercropping of grazing guinea and stylosanthes (1:1 row ratio) (T_4), sole stylosanthes (T_5), sole fodder sorghum (var. 'SSV 74') (T_6) and sole perennial fodder sorghum (var. 'CoFS 29') (T_7) replicated thrice and laid out in randomized block design in the pre-established 3 year old sapota orchard having a planting geometry of 9 m x 9m. Each treatment plot was 18 m x 18 m with 4 sapota plants in the middle of the treatment plot. Fodder crops were raised in the sapota orchard at 45 cm x 45 cm planting geometry for signal grass and grazing guinea through transplanting of root slips and remaining fodder crops by sowing seeds at 45 cm row spacing during rainy season in 2013. Fodder crops were established leaving 0.9 m space on two sides of the sapota plants along the rows. There were 32 rows of fodder crops in each plot. A common dose 50 kg urea, 100 kg diammonium phosphate and 50 kg muriate of potash were applied through band placement before planting/sowing of the crops and incorporated in the soil. One inter-cultivation was carried out 30 days after planting/sowing to remove the weeds. Similarly at the start of the rainy season in the second and third year, 50 kg urea, 100 kg diammonium phosphate (DAP) and 50 kg muriate of potash (MOP) were applied through band placement near the crop rows followed by one inter-cultivation. The plant height from ground level to tip of the vegetative growth of tiller/plant and number of tiller/m row length were recorded at each harvest from 3 randomly selected spots in each treatment and their average was computed. The number of cuttings varied from year to year depending on the distribution and quantum of rainfall from 3 to 4. The fresh green fodder yield was recorded from net plot at each cutting and converted into tonnes per hectare and the sum of all the cuttings was recorded as fodder yield per year per hectare. The dry fodder yield was computed from the green fodder yield using the green fodder to dry fodder conversion factor through oven drying a unit of green fodder to constant weight. Soil samples were collected from 0-15 cm depth after the harvest in the third year and analyzed for organic carbon, available N, P and K as per the standard procedures. Treatment wise gross expenditures and returns were computed considering the costs of operations and the prevailing prices of inputs and outputs. The net returns were estimated by deducting the gross expenditure from gross returns. The benefit:cost ratios were worked out by dividing the gross return by gross expenditure. The data recorded on each of the parameters studied was statistically analyzed as per the analysis of variance (ANOVA) technique and critical differences between treatment means were computed at 0.5 probability for comparison [4].

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The plant height and number of tillers per meter row length varied significantly among the fodder crops in sapota based hortipasture system (Table 1). The highest plant height was recorded with perennial fodder sorghum followed by annual sorghum. The lowest plant height was recorded in intercropped stylosanthes. The highest number of tillers per meter row length was observed in in intercropped grazing guinea followed by sole signal grass in first year and sole grazing guinea in subsequent years. The lowest number of tillers was observed in annual sorghum followed by perennial sorghum in all the years of experimentation. The inherent genetic nature of crops might be the reason for higher plant height in sorghum and higher number of tillers in grazing guinea and signal grass among the fodder crops. The variation in plant height and number of tillers due to genotypes and crops was also observed by Anita and Lakshmi [5] and Kumawat et al. [6]. Further the intercropping of stylosanthes enhanced the tillering ability of grazing guinea and signal grass due wider row spacing and small statured stylosanthes which could not offer any competition for the intercropped grass crops. Arshadullah et al. [7] too reported significant increase in tillering of *Panicum maximum* due intercropping of *Vicia sativa* and cowpeas.

3.2 Fodder Yield

The highest green fodder yield was recorded in perennial fodder sorghum in the first year (Table 2). It was closely followed by sole signal grass and grazing guinea. The lowest yield was observed in sole stylosanthes. In the subsequent years, sole signal grass recorded the highest green fodder yield followed by grazing guinea. However, the combined yield of signal grass and stylosanthes was higher as compared to sole signal grass. These were followed by perennial fodder sorghum. The lowest yield was recorded in sole stylosanthes followed by annual fodder sorghum. The dry fodder yield also followed the same trend as that of green fodder yield. The intercropping of stylosanthes had no adverse influence on the green and dry fodder yield of fodder crops. On the contrary, it benefited them recording higher growth parameters and very low to no negative impact on the yield intercropped signal and grazing guinea grasses. Njarui et al. [8] reported that the productivity of the associated fodder grasses was not affected due to intercropping of leguminous fodder crop. Further the combined yield of grasses and legume was higher as compared to sole grass crop. Arshadulla et al. [7] reported substantial increase in fodder yield due to intercropping of *Panicum maximum* with *Vicia sativa* and cowpeas. Gulwa et al. (2017) reported that the overall total dry matter yield of grass+legume mixtures was higher than that of sole natural grasses, with grasses constituting the major component of the herbage yield. The dissimilar growth patterns of grasses and legumes led to efficient use of resources specially light when grown in a mixture than in sole cropping. The different functional traits contributed to complementary interactions between the species resulting in higher yields for mixtures in comparison to sole crops [9]. There was gradual increase in the productivity of fodder crops over the years indicating the improvement in growing conditions and their establishment as compared to the establishment year as also observed in plant height and tillering nature of the fodder crops. Dubis et al. [10] also reported increasing fodder yield of fodder galega (*Galega orientalis* Lam.) up to 4^{th} year and declining thereafter.

Table 1. Plant height (cm) and number of tillers per meter row length of fodder crops intercropped in sapota based hortipasture systems

Treatment	Plant height			No. of tillers/m row		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
T_1:Sapota + signal grass sole	136.2	165.5	164.1	51	69	82
T_2:Sapota + signal grass + stylosanthes	133.4	173.7	181.2	48.6	71	91
	(21.2)	(41.2)	(51.7)	(19)	(37)	(46)
T_3:Sapota + Grazing guinea sole	142.1	161.2	142.5	45	75	87
T_4:Sapota + Grazing guinea + stylosanthes	128.7	169.5	157.8	53	83	91
	(22.6)	(39.7)	(43.5)	(23)	(35)	(41)
T_5:Sapota + Stylosanthes sole	51.2	65.6	68.7	39.8	79	69
T_6:Sapota + Annual fodder sorghum	151.9	201.3	227.6	17	35	34
T_7:Sapota + Perennial fodder sorghum	163.5	262.4	244.7	44	56	51
SEm±	12.2	11.5	8.7	5.8	6.7	7.9
CD at 5%	36.9	34.7	26.2	16.1	20.3	23.8

Values in parentheses refer to stylosanthes

Table 2. Green fodder yield (t/ha) and dry fodder yield (t/ha) of fodder crops intercropped in sapota based hortipasture systems

Treatment	Green fodder yield			Dry fodder yield		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
T_1:Sapota + signal grass sole	18.5	23.5	26.2	3.81	5.76	6.58
T_2:Sapota + signal grass + stylosanthes	18.1	22.7	25.4	3.57	5.52	5.92
	(0.43)	(0.83)	(0.93)	(0.17)	(0.21)	(0.35)
T_3:Sapota + Grazing guinea sole	18.5	22.6	24.7	3.18	4.29	4.89
T_4:Sapota + Grazing guinea + stylosanthes	14.2	20.1	19.6	3.19	4.38	4.73
	(0.41)	(0.72)	(0.83)	(0.13)	(0.17)	(0.27)
T_5:Sapota + Stylosanthes sole	4.9	8.6	9.3	1.98	2.65	3.05
T_6:Sapota + Annual fodder sorghum	10.1	12.6	10.9	3.14	3.52	3.32
T_7:Sapota + Perennial fodder sorghum	19.1	21.3	23.8	3.85	4.83	4.96
SEm±	0.74	0.85	0.91	0.45	0.30	0.44
CD at 5%	2.26	2.56	2.74	1.32	0.91	1.26

Values in parentheses refer to stylosanthes

Table 3. Organic carbon (%), available N, P and K (kg/ha) as influenced by intercropping of fodder crops in sapota based hortipasture systems after 3 years of experimentation

Treatment	OC	N	P	K
Initial (2013)	0.61	126.0	13.51	150.2
T_1:Sapota + signal grass sole	0.66	156.3	14.81	249.9
T_2:Sapota + signal grass + stylosanthes	0.73	161.4	14.67	283.5
T_3:Sapota + Grazing guinea sole	0.67	156.3	14.41	233.2
T_4:Sapota + Grazing guinea + stylosanthes	0.78	181.5	14.85	311.1
T_5:Sapota + Stylosanthes sole	0.76	176.5	14.41	301.9
T_6:Sapota + Annual fodder sorghum	0.68	171.4	16.69	291.8
T_7:Sapota + Perennial fodder sorghum	0.69	176.5	15.53	260.4
SEm±	0.01	5.22	0.81	8.36
CD at 5%	0.04	15.71	2.46	25.21

Table 4. Economics of intercropping of fodder crops in sapota based hortipasture systems

Treatment	2013-14			2014-15			2015-16		
	Gross Return	Net Return	B:C ratio	Gross Return	Net Return	B:C ratio	Gross Return	Net Return	B:C ratio
T_1:Sapota + signal grass sole	46250	12950	1.39	58750	49450	6.32	65500	56200	7.04
T_2:Sapota + signal grass + stylosanthes	45250	21740	1.88	56750	49940	6.37	63500	56990	7.13
T_3:Sapota + Grazing guinea sole	46250	12950	1.39	56500	47200	6.08	61750	52450	6.64
T_4:Sapota + Grazing guinea + stylosanthes	35500	15930	1.77	50250	43110	5.64	49000	42190	5.54
T_5:Sapota + Stylosanthes sole	12250	-4050	0.75	25800	16500	2.77	27900	18600	3.00
T_6:Sapota + Annual fodder sorghum	25250	11750	1.87	31500	18000	2.33	27250	13750	2.02
T_7:Sapota + Perennial fodder sorghum	47750	31450	2.93	53250	43950	5.73	59500	50200	6.40
SEm±	879	713	0.18	1209	698	0.31	924	1053	0.35
CD at 5%	2640	2134	0.55	3620	2072	0.96	2767	3165	1.08

3.3 Soil Properties

There was a significant improvement in organic carbon, available N, P and K due to intercropping of fodder crops in hortipasture system in the soil samples collected after 3 years of experimentation in 2016 (Table 3). The highest organic carbon content was recorded with intercropping of grazing guinea with stylosanthes in 1:1 ratio followed by the treatments involving the stylosanthes. The lowest organic carbon content was observed with sole signal grass followed by sole grazing guinea. This may be due to addition of biomass in the soil through leaf shedding and root proliferation. The positive effect of increasing organic carbon by perennial fodder crops has also been reported by Shivakumar et al. [11] Sarkar et al. [12]. The highest available N in soil was observed with intercropping of grazing guinea with stylosanthes in 1:1 ratio followed by sole stylosanthes. The lowest available N was observed with sole crops of signal grass and grazing guinea. The highest available P was observed with sole crop of annual sorghum followed by perennial sorghum. The lowest available P was noticed with sole grazing guinea and sole crop of stylosanthes. The highest available K was observed with sole stylosanthes followed by sole crop of annual sorghum. The lowest available K was observed in sole grazing guinea followed by sole signal grass. The leafy nature of grazing guinea and leaf shedding of stylosanthes might have added higher biomass before harvest and contributed for the organic carbon content. Similarly lower uptake of N by grazing guinea and biological nitrogen fixation by stylosanthes might be the reason for higher available N in that treatment. The shorter duration of annual fodder sorghum could have spared the applied phosphorus leading to higher available P as compared to other fodder crops which were all perennial in nature. The higher available K in intercropping of grazing guinea with stylosanthes and sole stylosanthes may be attributed to proliferated root systems of stylosanthes mobilizing K from deeper layer and sparing the K applied on the surface soil as compared to other crops which had their root system confined to shallow surface soil. Similar increase in available N, P and K status due to different cropping systems were also observed by Macharia et al. [13] and Kumari et al. [14].

3.4 Economics

The highest gross returns, net returns and B:C ratio were recorded in perennial fodder sorghum followed by sole grazing guinea and signal grass with regard to gross returns and intercropped signal grass with stylosanthes with regard to net returns and B:C ratio (Table 4). This may due to better adoption of perennial fodder sorghum and higher productivity in first year. The higher cost of establishment in grazing guinea and signal grass both in sole and intercropped systems and their lower productivity in first year might be the reasons for lower net returns and B:C ratio vis-à-vis perennial fodder sorghum. The lowest gross returns, net returns and B:C ratio were observed in stylosanthes. This may be attributed slow growth and establishment leading to lower yield and subsequently poor monetary returns in stylosanthes. Further due to its growing only during rainy season the annual fodder sorghum could not match with the performance of other fodder crops with regard to gross return, net return and B:C ratio. In the second and third year, the highest gross return was observed in sole signal grass but signal grass intercropped with stylosanthes recorded the highest net returns and B:C ratio. This may be attributed to lower grass expenditure in second and third year as there was no transplanting owing perennial nature of signal grass and increased yield owing better establishment. The lowest gross returns, net returns in the stylosanthes in second year and in annual fodder sorghum in third year may be due to poor growth and yield in stylosanthes and higher cost of cultivation in annual fodder sorghum due to cost of seeds and sowing every year unlike in other fodder crops. Cereal-legumes intercropping systems yield higher quantities of green forage with improved quality traits, which increase monetary benefits. Further cereal-legume intercropping systems are effective in reducing weed infestations and soil erosion by providing extended soil cover, as well as in increasing water use efficiency and improving soil fertility making the intercropping economically more remunerative [15].

4. CONCLUSION

On the basis of the findings of this experiment it may be concluded that intercropping of signal grass with stylosanthes in 1:1 ratio could be an ideal sapota based hortipasture system in shallow degraded soils of transitional tract of Karnataka. Besides higher production of fodder crops and monetary returns, it also improves the soil properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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