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Productivity of buffel grass and Caribbean stylo in different row ratio under neem based silvipastoral system in semi-arid region

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Abstract

Neem based silvipastoral system with *Cenchrus ciliaris* and *Stylosanthes hamata* was evaluated under polythene mulch and different row ratio in semi-arid region. Green foliage yield of neem tree was obtained 41-42% more with the application of mulch over no mulch. Plant height of *C. ciliaris* was highest in the row ratio of 1:2 while green fodder, dry fodder and protein yield was more under 2:2 row proportion. The plants of *S. hamata* attained greater height under the row proportion of 2:2. However, green, dry fodder and protein yield was more in row ratio of 1:2. Total green fodder yield, dry fodder yield, crude protein yield, production efficiency, net returns and benefit: cost ratio was greater in neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)] followed by neem alone + [*C. ciliaris* + *S. hamata* (2:2)] and *C. ciliaris* + *S. hamata* (2:2).The silvipastoral system of buffel grass + Caribbean stylo (2:2) under neem plantation with polythene mulch may be advocated for hot semi-arid regions.

Keywords: *Cenchrus ciliaris*, Mulching, Neem, Production efficiency, Rainfall use efficiency, Row ratio, Silvipasture, *Stylosanthes hamata*

Abbreviations: AOAC: Association of analytical chemists; **B: C:** Benefit cost ratio; **DBH:** Diameter at breast height; **E-W:** East - west direction; **N-S:** North - south direction; **PE:** Production efficiency; **RUE:** Rainfall use efficiency

Introduction

Livestock farming has been a lifeline for the rural population of arid and semi-arid regions. Fodder requirement of livestock is generally met through poor-quality available crop residues, which is inadequate for the maintenance of animal health and productivity. The feed and forage resources of India are able to meet only 40% of the requirement leaving a vast deficit of 64 and 16% in green and dry fodder, respectively (Meena *et al.*, 2012). The possibility of expanding more area under fodder is rather limited due to increasing requirement for housing, urbanization, industrialization *etc*. in the face of increasing human population. Opportunities, however, exists to improve the forage productivity through efficient utilization of the natural resources. Trees and shrubs are increasingly recognized as important components of animal feeding, especially as suppliers of protein. In difficult environmental conditions, where the available grazing is not sufficient to meet the maintenance requirements of animals for part of the year, the contribution from trees and shrubs is significant. Neem (*Azadirachta indica* A. Juss), enjoys a wide range of climatic and edaphic factors. It is grown successfully in arid and semi-arid sub-tropical climates and is tolerant to high temperature up to 49^{0}C (Hegde, 1993). High evaporation over low rainfall is great challenge for plant growth at early stage in hot arid and semi-arid regions. Mulching under tree canopy could be solution for retaining soil moisture for longer period.

Grasses are well suited species in dry regions and require a little amount of water to survive throughout the year. Buffel grass (*Cenchrus ciliaris*) is a common and one of the prominent grasses of hot arid and semi-arid India. It is drought tolerant, hardy, fast growing and capable of producing good quality forage. The grass is well fitted in any kind of fodder production system even under low and erratic rainfall situations. Caribbean stylo (*Stylosanthes hamata*) is mostly used for feeding cattle, goats, sheep, pigs and poultry. It is good for cut and carry as green feed or for hay if cut before dry season leaf fall when plants become increasingly steamy. Sowing of *S. hamata* in silvipasture system is increasing in India. In Mediterranean countries, forage grasses and legumes are commonly grown in mixture because of their ability to increase herbage yield and quality as compared to monocropping. Reducing the proximity between plants of the two species may benefit the weaker component of the mixture (Giambalvo *et al.*, 2011). However, the bene-

-fits of intercropping over a monocrop system are not always realized because the efficiency of a grass-legume mixture is strongly affected by agronomic factors. Therefore, the present study was undertaken to evaluate the productivity of *C. ciliaris* and *S. hamata* in different row ratio under neem plantation.

Materials and Methods

The experiment was conducted for 3 years during 2009-11 to evaluate performance of neem based silvipasture system with range grass and legume under semi-arid condition at research farm of Indian Grassland and Fodder Research Institute, Western Regional Research Station, Avikanagar, Tonk (Rajasthan). The weather conditions during the cropping seasons at the experimental site were quite normal with average monthly maximum and minimum humidity 69 and 45% and temperatures of 34 and 20°C, respectively. The monthly average wind velocity was 4 km/hour and average sunshine was 8 hours in a day. The yearly average total evaporation (1983 mm) exceeds the total rainfall (608 mm) received. The rainfall was higher during the month of June, July and August (Fig. 1) in all three years of experimentation. The neem saplings were collected from NRCAF, Jhansi and planted in the month of July 2008. The crop of *C. ciliaris* and *S. hamata* were established during the rainy (*Kharif*) season of 2009. Plant to plant distance of neem was 6×6m with 9 trees/ treatment and perennial grass and legume were sown as per the treatment combinations in the plot size of 18m×18m. Black polythene was used as mulching material under the neem tree canopy. The experiment was arranged in a randomized complete block design replicated thrice. The treatments comprised of [T_1=Neem alone;T_2=Neem with polythene mulch; T_3=Neem + [*C. ciliaris* + *S. hamata* (2:2)];T_4=Neem + [*C. ciliaris* + *S. hamata* (1:2)];T_5=Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)]; T_6=Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (1:2)]; T_7= *C. ciliaris* + *S. hamata* (2:2); and T_8= *C. ciliaris* + *S. hamata*(1:2). Growth parameters of neem tree *viz*., plant height and basal diameter were recorded during the month of December each year. Diameter at breast height (1.37m from ground level) was recorded in 3rd and 4th year. Canopy spread (N-S; E-W) and foliage production was recorded in the 4th year. Plant growth and forage yields of component crops were recorded at the time of 50% flowering and at physiological maturity. Protein content in dry matter was estimated by multiplying the nitrogen content with 6.25 (AOAC, 1990). Rainfall use efficiency of the system was calculated using total biomass and protein yield produced over the rains received during the period per unit area. Production efficiency of the system was calculated on dry matter production over the period per unit area on daily basis. The cost of production and the net profit was worked out on the basis of actual production cost and yield of component crops. Benefit: cost ratio in monetary term as an indicator of economic viability of the system was calculated using net returns over the cost of cultivation. The data were analyzed using appropriate analysis of variance. Differences between treatment means were detected by least significant difference (LSD) at 5% probability level.

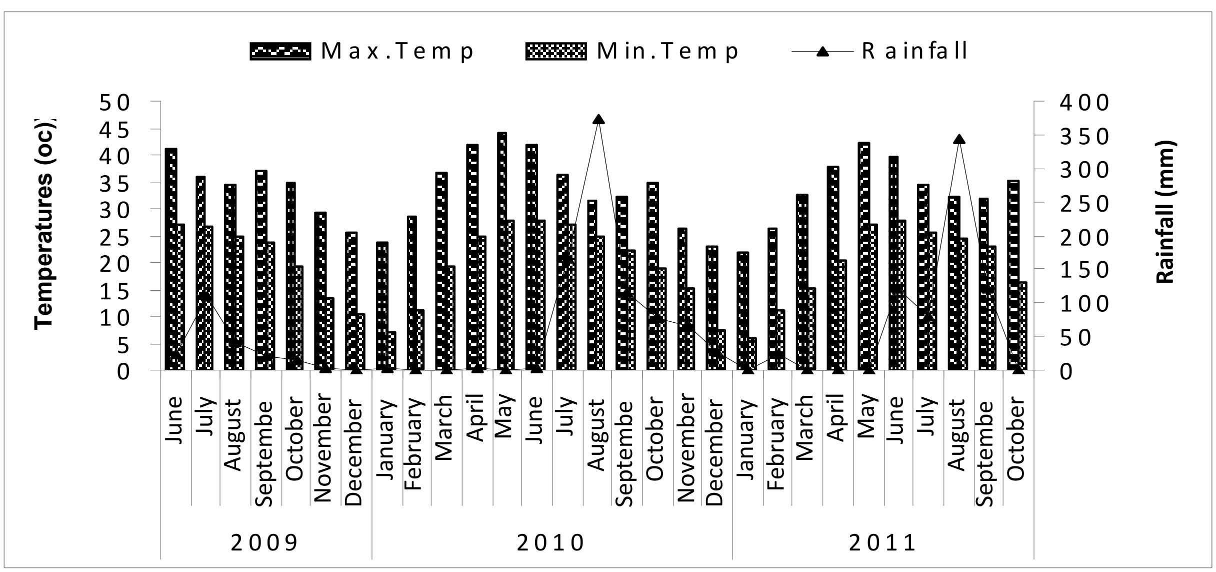

Fig 1. Monthly means of temperature and rainfall received during the cropping period

Results and Discussion

Performance of neem tree: Significant differences were observed in plant height, collar diameter, diameter at breast height, canopy spread, and foliage production and protein yield of neem due to application of polythene mulch under the canopy of the tree (Table 1). The tree growth characters were not influenced significantly by intercropping of pasture crops. Similar trend was observed in all three years of tree growth period. Yearly increments in the growth characters were also significant. Plant height and collar diameter on 4th year of crop establishment were increased by 138 and 156% over 2nd year and 50 and 135% over 3rd year, respectively. Diameter at breast height (DBH) was recorded for 3rd and 4th year of experimentation. It was increased by 215% within a year of plant growth. The tree canopy was spreaded 6% more in N-S direction over the direction of E-W. It might be due to the availability of sun light for longer period in N-S direction. Over all 41-42% more foliage yield of neem tree was obtained under the application of mulch treatment over no mulch. Mulching with polythene could have prevented the loss of water due to evaporation in to the atmosphere. Hence, plant could utilize the conserved water for longer time for growth and biomass production. Zegada-Lizarazu and Berliner (2011) reported that inter-row polyethylene mulch is an efficient technique by which soil evaporation is reduced and productivity of maize increased.

Performance of buffel grass: Plant height, green and dry fodder and protein yield of the grass was influenced significantly due to different row ratio of crop planting (Table 2).Taller plants were observed in the row ratio of 1:2 might be the reason associated with *Stylosanthes* as legume could fix more atmospheric nitrogen, readily available to *Cenchrus*. However, the highest green and dry fodders as well as protein yield were obtained under the sole stand of the crop which might be due to its plant density. The trend of plant growth character, biomass production and protein yield under the row ratios were similar in 2nd and 3rd year as well. The tallest plants observed in 2nd year may be associated with more rains (838 mm) received during the year. Plants were shorter in the 3rd year. Similarly higher green and dry fodder yield was obtained in 2nd year of the experimentation than 1st and 3rd year. Greater yield of green fodder, dry fodder and protein yield were obtained under the row ratio of 2:2.This might be due to the fact that number of rows of grass was more as compared to 1:2 ratio. Similarly Baba *et al*. (2011) observed higher dry matter production in the mixture of grasses with legumes, and recommended guinea-centro at 2:2 row ratio as the most compatible combination.

Performance of Caribbean stylo: A significant difference was observed in the plant height, green fodder, dry fodder and protein yield of *S. hamata* due to variations of row arrangements with *C. ciliaris* (Table 2). Ram and Parihar (2008) also observed intercropping of dhawalu grass with *S. hamata* in 1:1 row ratio which resulted in significantly higher green forage, dry matter and crude protein yields compared to sole stand of grass. The plants of *S. hamata* attained greater height under the row proportion of 2:2. However, higher green fodder, dry fodder and protein yield of *S. hamata* was obtained in the row ratio of 1:2 which might be due to its plant density. The trend of plant height over the years was increasing. Similar trend was observed in green fodder, dry fodder and protein yield. The better performance of *S. hamata* with *C. ciliaris* under annona tree was also recorded by Ram *et al*. (2006). The crop could not perform well in the first year because of poor establishment associated with low rainfall during the year. It could be stated that *S. hamata* is more sensitive to moisture availability than *C. ciliaris*.

Rainfall use efficiency: Rainfall is the only source of water for such neglected crops grown for fodder production under arid and semi-arid environments. It is important to utilize every drop of rain water received in short period of time. The practice of silvipasture coupled with polythene mulching under the tree canopy could be one of the solutions to utilise rain water efficiently. That is why we involved three kinds of forage crops to harness the natural resources efficiently aimed at increasing fodder productivity in semi-arid regions. There was good rainfall during 2010 and 2011 but it was quite low in 2009 (Fig. 1). The rainfall use efficiency (RUE) was calculated using dry matter produce and protein yield over the rainfall received during the period. The highest rainfall use efficiency was recorded in *C. ciliaris* + *S. hamata* (2:2) followed by Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)] and Neem + [*C. ciliaris* + *S. hamata* (2:2)] (Fig. 2). Less rainfall was received during the cropping season of 2009 but the yields were comparatively good indicating higher rainfall use efficiency in the year 2009.

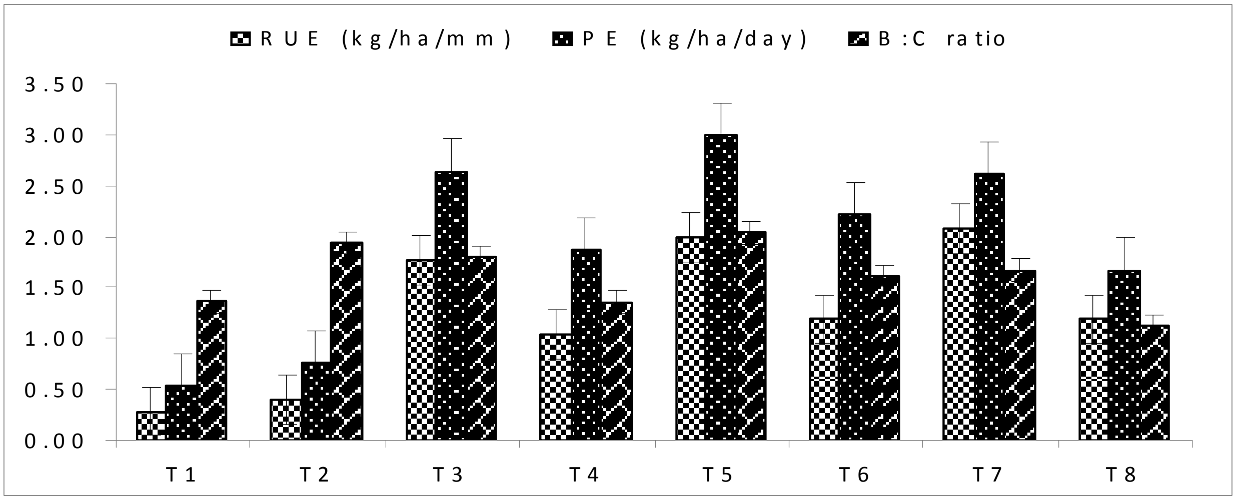

Fig 2. Rainfall use efficiency (RUE), production efficiency (PE) and benefit: cost (B:C) ratio of the systems

Table 1. Growth, fresh & dry foliage production and protein yield of neem as influenced by polythene mulch and intercrops

Treatment	Plant height (cm)			Collar diameter (cm)			DBH (cm)		Canopy spread (cm)		Yields of foliage (kg/ha)		
	2nd year	3rd year	4th year	2nd year	3rd year	4th year	3rd year	4th year	N-S	E-W	Fresh	Dry	Protein
T_1	91.7	212	336	0.87	2.14	4.92	1.23	3.65	157	155	584	194	34.1
T_2	111.4	258	394	1.15	2.53	6.63	1.61	5.35	218	206	832	277	48.5
T_3	90.8	205	306	0.79	2.11	4.77	1.23	3.58	157	146	600	200	35.0
T_4	90.4	211	310	0.76	2.07	4.67	1.20	3.38	151	131	545	181	31.8
T_5	101.3	238	363	0.99	2.33	5.31	1.33	3.96	188	179	639	213	37.3
T_6	99.2	237	336	1.03	2.46	5.88	1.45	4.54	179	171	701	233	40.9
SE(m)±	2.67	6.56	7.39	0.05	0.08	0.25	0.07	0.25	8.79	10.12	29.64	9.9	1.73
CD (*P=0.05*)	8.40	20.66	23.28	0.16	0.26	0.78	0.21	0.79	27.69	31.89	93.41	31.1	5.44

DBH= diameter at breast height; N-S= north-south direction; E-W= east-west direction

Table 2. Plant heights, green & dry fodder and protein yield of Buffel grass and Caribbean stylo as influenced by row ratio under neem plantation (Mean of 3 years)

Treatment	Plant height (cm)		Green fodder yield (kg/ha)		Dry fodder yield (kg/ha)		Crude protein yield (kg/ha)	
	Cenchrus ciliaris	***Stylosanthes hamata***	***Cenchrus ciliaris***	***Stylosanthes hamata***	***Cenchrus ciliaris***	***Stylosanthes hamata***	***Cenchrus ciliaris***	***Stylo santhes hamata***
T3	69.6	35.0	2391	199	804	74.3	68.4	9.3
T4	76.1	29.6	1384	317	471	105.3	40.0	13.2
T5	71.8	36.0	2734	246	879	75.3	74.8	9.4
T6	78.2	29.1	1599	348	507	102.7	43.1	12.8
T7	67.3	35.3	2990	249	703	60.3	59.8	7.6
T8	73.3	29.2	1721	338	407	96.0	34.6	12.0
SE(m)±	2.00	0.77	263.00	27.30	77.33	8.27	6.58	1.03
CD (P=0.05)	6.08	5.09	785.67	81.33	231.10	24.63	19.64	3.08

(T_1=Neem alone;T_2=Neem with polythene mulch; T_3=Neem + [*C. ciliaris* + *S. hamata* (2:2)];T_4=Neem + [*C. ciliaris* + *S. hamata* (1:2)];T_5=Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)]; T_6=Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (1:2)]; T_7= *C. ciliaris* + *S. hamata* (2:2); and T_8= *C. ciliaris* + *S. hamata*(1:2)

Production efficiency: It is an indication for productivity of the system for a given period of time. Itȁs also an indicator for resource use efficiency as well. The total dry matter and protein yield were found to be highest in the treatment combination of Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)] followed by Neem + [*C. ciliaris* + *S. hamata* (2:2)] followed by Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (1:2)], *C. ciliaris* + *S. hamata* (2:2) and Neem + [*C. ciliaris* + *S. hamata* (1:2)]. Polythene mulching influenced protein yield significantly over no mulch. It might be due to higher foliage production as mulching conserve the moisture for longer period. Significantly more protein yield was obtained under the row ratio of 2:2 over 1:2 may be due to higher density and productivity of *C. ciliaris*. Patidar *et al.* (2008) also obtained higher crude protein yield of grasses due to inclusion of legume in silvipastoral system under hot arid condition. The production efficiency (PE) was greater in Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)] followed by Neem+ [*C. ciliaris* + *S. hamata* (2:2)] and *C. ciliaris* + *S. hamata* (2:2) (Fig. 2). Exudation of nitrogenous compounds from the roots of nitrogen-fixing plants is a potential source of nitrogen for adjacent plants in intercropping systems. A close contact between the root systems of nitrogen donor and recipient plants directly seems to be a precondition of the apparently direct nitrogen transfer. It was observed earlier by Jalonen *et al*. (2009) in field studies of the same soil-plant system. Similar results of intercropping of oilseed with pulse have been tested by Meena *et al*. (2009) as profitable system. Arya (2006) found that *Zizyphus mauritiana* and *C. ciliaris* were the best silvipastoral combination for maximum dry fodder yield under arid conditions.

Economics: The highest net returns and (B: C) ratio (Fig. 2) was obtained under Neem with polythene mulch + [*C. ciliaris* + *S. hamata* (2:2)] followed by Neem + [*C. ciliaris* + *S. hamata* (2:2)] and *C. ciliaris* + *S. hamata* (2:2). The effect of polythene mulch was visualized directly on the performance of neem tree while it might have some beneficial and indirect effect on grass and legumes and *vice-versa*. Growing of two different species as companion crops would have been more economically viable. This is in conformity with the findings of Meena *et al.* (2009) with clusterbean and sesame intercropping under arid conditions. Ram *et al.* (2006) also obtained maximum net returns and benefit: cost ratio by the intercropping of *S. hamata* along with buffel grass under annona trees.

The present findings indicated Cenchrus *ciliaris* + *Stylosanthes hamata* grown in 2:2 row proportions under neem plantation along with polythene mulch as the most productive and remunerative forage production system in semi-arid regions.

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