Mysore J. Agric. Sci., 56 (4) : 371-378 (2022)

Productivity and Profitability of Hedge Lucerne (*Desmanthus virgatus* (L.) Willd.) as Intercrop in Different Perennial Fodder Crops

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Received : July 2022
Accepted : August 2022

Abstract

Quality green fodder production throughout the year is a major drive for increasing the livestock productivity in the country. It can be possible through inclusion of suitable perennial cereal-legume mixtures based fodder cropping systems. A filed investigation was carried out at Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya, Karnataka during 2020-21 to identify the suitability of hedge lucerne (*Desmanthus virgatus* (L.) Willd.) as intercrop with perennial fodders (B×N hybrid, guinea grass and fodder sorghum) for quality green fodder production throughout the year under irrigated condition. The experiment was consisted of twelve different cropping systems involving one perennial fodder legume (*Desmanthus)* and three cereal fodder crops laid out in randomized complete block design and replicated thrice. The results revealed that, the paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair x 180 cm between the pair with a row ratio of 2:5) recorded higher green fodder yield (1717.16 q ha^{-1} year^{-1}), dry matter yield (339.60 q ha^{-1} year^{-1}), crude protein yield (39.48 q ha^{-1} year^{-1}), net returns (Rs.2,38,083 ha^{-1} year^{-1}) and benefit cost ratio (3.65).

Keywords : Hedge lucerne, Perennial fodder, Cropping systems, Fodder yield, Fodder quality and economics

India has the largest cattle population in the world. As per 20th livestock census the population is increased by 4.6 per cent. But, the land available for fodder cultivation is limited (8.4 m ha). On the other hand, the availability of green fodder, dry fodder and concentrates are 734.2, 326.4 and 61 million tons in the country against the requirement of 827.19, 426.1 and 85.78 million tons with a net deficit of 11.24, 23.4 and 28.9 per cent, respectively (Roy *et al.,* 2019). Considering the huge gap between the demand and supply of green nutritious fodder and quality dry matter along with the static or decreasing land availability, it is essential to bridge this gap through intensifying forage production through development of high yielding varieties and better management practices including viable and economical cropping systems involving perennial fodder crops. Further, the adoption of perennial fodder cropping systems will enhance the productivity of fodder through efficient utilization of available resources and inclusion of green fodders in ration of dairy animals throughout the year which may decrease amount of concentrate feeding and thus increase the profit. Apart from these, addition of legume as component crop helps to fix atmospheric nitrogen and retain the soil fertility and productivity.

Hedge lucerne is a very good perennial fodder legume which is comparable with that of lucerne with respect to yield and quality. It is shade tolerant, require less water and free from anti-nutritional factor as compared to lucerne. Hence, it can be cultivated as intercrop in perennial grasses and orchards. Since, hedge lucerne is a perennial fodder legume rich in crude protein and dry matter content, which is essential for providing balanced nutrition for good animal health and to sustain milk production with lower cost by cultivating as grass legume mixture and it also improve the soil health by fixing atmospheric nitrogen. The hedge lucerne with huge many advantages over other perennial fodder legume which demands more focus on research to identify the suitability of hedge lucerne as intercrop in perennial grass based fodder cropping systems.

Material and Methods

The field experiment was conducted during 2020-21 at Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya, University of Agricultural Sciences, Bangalore, which is situated in Southern Dry Zone (ACZ-VI) of Karnataka between 12° 45 and 13° 57 North latitude and 76° 45 and 78° 242 East longitude at an altitude of 695 m above mean sea level. The soil of the experimental site is neutral in reaction (7.44) with electrical conductivity of 0.38 dS m^{-1}, medium in organic carbon (0.51 %), low in available nitrogen (263.42 kg ha^{-1}), medium in available phosphorous (47.61 kg ha^{-1}) and potassium (161.28 kg ha^{-1}). The experiment was laid out in randomized complete block design with twelve treatments comprising different perennial fodder cropping systems and replicated thrice. The treatments *viz.,* T_1: B×N hybrid + *Desmanthus* (1:1), T_2: B×N hybrid + *Desmanthus* (2:1), T_3: B×N hybrid + *Desmanthus* (Paired row of B×N hybrid as 60 cm within the pair and 180 cm between the pair with 2:5 row ratio), T_4: Guinea grass + *Desmanthus* (1:1), T_5: Guinea grass + *Desmanthus* (2:1), T_6: Guinea grass + *Desmanthus* (Paired row of guinea grass as 45 cm within the pair and 120 cm between the pair with 2:3 row ratio), T_7: Perennial fodder sorghum + *Desmanthus* (4:1), T_8: Perennial fodder sorghum + *Desmanthus* (8:2), T_9: B×N hybrid (Sole), T_{10}: Guinea grass (Sole), T_{11}: Perennial fodder sorghum (Sole) and T_{12}: *Desmanthus* (Sole). The recommended package of practices were followed for the establishment of crops. The first harvest of B×N hybrid, guinea grass, sorghum and *Desmanthus* was done at 75 days after sowing by leaving stubbles at height of 15 cm above the soil and subsequent harvests at 40-45 days interval in B×N hybrid, sorghum and *Desmanthus* while, 25-35 days interval in guinea grass. At the time of harvesting plant height and green fodder yield were recorded and known quantity of sample was taken, separated into leaf and stem and kept in thermo statically controlled oven at 70 ± 2°C temperature and dried till it attains constant weight for the computation of leaf to stem ratio and dry matter content. The oven dried samples were powdered for crude protein estimation. The dry matter yield, crude protein content (By multiplying nitrogen per cent with 6.25 - as per AOAC, 1965) and crude protein yield were calculated by using the following formulae;

$$\text{Dry matter yield (q ha}^{-1}\text{)} = \frac{\text{Dry matter (\%)} \times \text{Green forage yield (q ha}^{-1}\text{)}}{100}$$

$$\text{Crude protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

$$\text{Crude protein yield (q ha-1)} = \frac{\text{Crude protein (\%)} \times \text{Dry matter yield (q ha-1)}}{100}$$

The economics of each cropping system was worked out with the prevailing market price of inputs and outputs and assessed the profitability of the cropping systems. The statistical analysis of data was carried out for interpretation of the results and drawing conclusions.

Results and Discussion

Plant Height

Plant height is a reliable indicator for growth of the plants particularly in forage crops, which represents the infrastructure development for other growth parameters over a period of time. The mean plant height of multiple cuts differed significantly with different perennial fodder crops and cropping systems (Table 1). Among the different main crops, sole crop of sorghum recorded significantly higher plant height (189.55 cm) and it was at par with plant height of sorghum in Sorghum + *Desmanthus* 4:1 and 8:2 row

TABLE 1

Growth attributes of different fodder crops as influenced by perennial fodder cropping systems

Treatments	Plant height (cm)		Leaf : Stem ratio	
	Main crop	Inter crop	Main crop	Inter crop
T_1 : B×N hybrid + *Desmanthus* (1:1)	174.98	95.87	0.59	0.62
T_2 : B×N hybrid + *Desmanthus* (2:1)	172.63	95.68	0.60	0.61
T_3 : B×N hybrid + *Desmanthus* (paired row: 60 cm x 180 cm)	178.94	91.42	0.61	0.65
T_4 : Guinea grass + *Desmanthus* (1:1)	75.62	92.71	0.68	0.63
T_5 : Guinea grass + *Desmanthus* (2:1)	74.70	92.39	0.69	0.63
T_6 : Guinea grass + *Desmanthus* (Paired row: 45 cm x 120 cm)	76.10	91.33	0.70	0.64
T_7 : Perennial fodder sorghum + *Desmanthus* (4:1)	189.20	97.97	0.29	0.60
T_8 : Perennial fodder sorghum + *Desmanthus* (8:2)	188.61	96.31	0.29	0.61
T_9 : B×N hybrid (Sole)	171.16	-	0.62	-
T_{10} : Guinea grass (Sole)	73.93	-	0.71	-
T_{11} : Perennial fodder sorghum (Sole)	189.55	-	0.29	-
T_{12} : *Desmanthus* (Sole)	91.25	-	0.65	-
S. Em.±	8.23	5.17	0.01	0.01
C. D. @ 5%	24.13	NS	0.04	NS

ratio (189.20 cm and 188.61 cm, respectively), B×N hybrid in paired row system, 1:1, 2:1 row ratio with *Desmanthus* and sole B×N hybrid (178.94, 174.98, 173.63 and 171.16 cm, respectively). Whereas, lower plant height was observed with sole crop of guinea grass (73.93 cm). The variation in plant height of different fodder crops is mainly due to their different genetic potential and morphological structures. These results are in close conformity with the findings of Johnson and Lenhard (2011) and Hindoriya *et al.* (2019).

Further, there is no significant difference between the plant height of *Desmanthus* which was grown as inter crop at different row ratio in perennial grass fodders. But, numerically higher plant height of *Desmanthus* was recorded with Sorghum + *Desmanthus* (4:1) intercropping system (97.97 cm) followed by 8:2 row ratio system (96.31 cm). This might be due more auxin production in *Desmanthus* under deficit sunlight due to simultaneous competition for sunlight by closer spaced sorghum which led to lanky growth of *Desmanthus* and resulted in higher plant height. Similar results were obtained by Jyothi *et al.* (2021) and Salmankhan *et al.* (2021) who observed slight increase in plant height at closer spacing as compared to wider row spacing.

Leaf : Stem Ratio

The data on leaf stem ratio as influenced by different cropping systems is presented in Table 1. Among different perennial fodder crops and cropping systems, sole crop of guinea grass recorded significantly higher leaf stem ratio (0.71) which is at par with guinea grass in paired row system (2:3), 2:1 and 1:1 row ratio with *Desmanthus* (0.70, 0.69 and 0.68, respectively). Whereas, lower leaf to stem ratio was observed with sorghum (0.29). Among the intercropping system, the leaf stem ratio of *Desmanthus* did not differed significantly at different row ratio but numerically higher leaf stem ratio of *Desmanthus* was recorded in B×N hybrid + *Desmanthus* in a paired system (0.65). The increase in leaf stem ratio of guinea grass might be due to lesser plant height and more leafiness as compared to other fodder crops. These results are supported by the findings of Singh *et al.* (2018).

Green Fodder Yield

The perennial fodders intercropped with *Desmanthus* recorded higher green fodder yield compared to sole cropping systems (Table 2). Among different intercropping systems, paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair) recorded significantly higher total green fodder yield (1717.16 q ha^{-1} $year^{-1}$) and found on par with B×N hybrid + *Desmanthus* in 1:1 and 2:1 row ratio (1574.85 and 1509.29 q ha^{-1} $year^{-1}$, respectively) as compared to other fodder cropping systems. The magnitude of increase in total green fodder yield in a paired row system of B×N hybrid + *Desmanthus*, B×N hybrid + *Desmanthus* in 1:1 and 2:1 row ratio was to the tune of 123, 105 and 96 per cent, respectively over sole *Desmanthus*. The sole crop of *Desmanthus* in a perennial system recorded significantly lower green fodder yield (769.53 q ha^{-1} $year^{-1}$). The complementary nature of legume intercrop under perennial systems might have resulted in efficient utilization of available resources like nutrients, water and solar energy which led to higher plant height, leaf stem ratio and dry matter accumulation besides, additional nitrogen supply by legume crops through atmospheric nitrogen fixation. The lower GFY in sole *Desmanthus* might be due to lesser yield potential of a legume crops as compared to cereal/grass fodder crops. These results are in accordance with the findings of Patil *et al.* (2018), Singh and Verma (2018), Gangaiah and Kundu (2020) and Manoj *et al.* (2021).

TABLE 2

Green fodder and dry matter yield of different perennial fodder cropping systems

Treatments		Green fodder yield (q ha^{-1} $year^{-1}$)			Dry matter yield (q ha^{-1} $year^{-1}$)		
		Main crop	Inter crop	Total GFY	Main crop	Inter crop	Total DMY
T_1 :	B×N hybrid + *Desmanthus* (1:1)	1427.36	147.49	1574.85	281.26	29.37	310.63
T_2 :	B×N hybrid + *Desmanthus* (2:1)	1449.44	59.85	1509.29	285.62	11.90	297.53
T_3 :	B×N hybrid + *Desmanthus* (paired row: 60 cm x 180 cm)	1353.79	363.37	1717.16	267.05	72.55	339.60
T_4 :	Guinea grass + *Desmanthus* (1:1)	1100.43	263.34	1363.77	231.54	52.43	283.96
T_5 :	Guinea grass + *Desmanthus* (2:1)	1141.85	136.80	1278.65	240.64	27.24	267.88
T_6 :	Guinea grass + *Desmanthus* (Paired row: 45 cm x 120 cm)	1064.93	334.73	1399.67	224.86	66.68	291.54
T_7 :	Perennial fodder sorghum + *Desmanthus* (4:1)	940.18	89.77	1029.96	215.89	17.78	233.67
T_8 :	Perennial fodder sorghum + *Desmanthus* (8:2)	1002.86	62.41	1065.28	230.84	12.40	243.24
T_9 :	B × N hybrid (Sole)	1471.51	-	1471.51	291.03	-	291.03
T_{10} :	Guinea grass (Sole)	1168.26	-	1168.26	246.91	-	246.91
T_{11} :	Perennial fodder sorghum (Sole)	1117.05	-	1117.05	256.76	-	256.76
T_{12} :	*Desmanthus* (Sole)	769.53	-	769.53	154.21	-	154.21
	S. Em.±	68.36	10.58	74.42	17.32	2.22	18.54
	C. D. @ 5%	200.5	32.10	218.3	50.81	6.74	54.39

Dry Matter Yield

Among different fodder cropping systems, paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair) recorded significantly higher total dry matter yield of 339.60 q ha^{-1} year^{-1} (Table 2) and found on par with perennial system of B×N hybrid + *Desmanthus* in 1:1 and 1:2 row ratio (310.63 and 297.53 q ha^{-1} year^{-1}, respectively) followed by paired system of Guinea grass + *Desmanthus* (2:3), sole crop of B×N hybrid and Guinea + *Desmanthus* in 1:1 ratio (291.54, 291.03 and 283.96 q ha^{-1} year^{-1}, respectively) as compared to other fodder cropping systems. The magnitude of increase in total dry matter yield in a paired system of B×N hybrid + *Desmanthus* (2:5) was to the tune of 120 per cent over sole *Desmanthus*. Whereas, the sole crop of *Desmanthus* recorded significantly lower total dry matter yield (154.21 q ha^{-1} year^{-1}). The higher dry matter yield in perennial fodder intercropping system modules might be due to higher green fodder yield of the component crops even with considerable lower dry matter content. The lower total dry matter yield in sole *Desmanthus* even with medium dry matter content might be due to lesser green fodder yield as compared to the other crops and cropping systems. These results are confined with the findings of Deore *et al.* (2013); Shekara *et al.* (2015) and Manoj *et al.* (2021).

Crude Protein Content

Among the different fodder crops, *Desmanthus* recorded significantly higher crude protein content (20.42 %) as compared to perennial grasses. Significantly lower crude protein content of 8.14 to 8.17 per cent was recorded by perennial fodder sorghum crop (Table 3). There is no significant difference was observed with respect to crude protein content of *Desmanthus* which was grown as intercrop at different row ratio with perennial grasses. The higher crude protein content in sole *Desmanthus* might be attributed to nitrogen fixation by this crop due to symbiosis between biological nitrogen fixing micro-

TABLE 3

Crude protein content and crude protein yield of different fodder crops as influenced by fodder based cropping systems

Treatments	Crude protein (%)		Crude protein yield (q ha^{-1} year^{-1})		
	Main crop	Inter crop	Main crop	Inter crop	Total CPY
T_1 : B × N hybrid + *Desmanthus* (1:1)	9.22	20.39	25.88	5.99	31.87
T_2 : B × N hybrid + *Desmanthus* (2:1)	9.19	20.39	26.21	2.43	28.64
T_3 : B × N hybrid + *Desmanthus* (paired row : 60 cm x 180 cm)	9.25	20.42	24.67	14.81	39.48
T_4 : Guinea grass + *Desmanthus* (1:1)	9.95	20.36	23.01	10.67	33.68
T_5 : Guinea grass + *Desmanthus* (2:1)	9.92	20.36	23.83	5.55	29.37
T_6 : Guinea grass + *Desmanthus* (Paired row : 45 cm x 120 cm)	9.98	20.39	22.38	13.59	35.97
T_7 : Perennial fodder sorghum + *Desmanthus* (4:1)	8.17	20.33	17.62	3.61	21.23
T_8 : Perennial fodder sorghum + *Desmanthus* (8:2)	8.17	20.33	18.81	2.52	21.33
T_9 : B×N hybrid (Sole)	9.19	-	26.69	-	26.69
T_{10} : Guinea grass (Sole)	9.92	-	24.45	-	24.45
T_{11} : Perennial fodder sorghum (Sole)	8.14	-	20.88	-	20.88
T_{12} : *Desmanthus* (Sole)	20.42	-	31.45	-	31.45
S. Em.±	0.11	0.07	1.64	0.43	1.87
C. D. @ 5%	0.31	NS	4.82	1.30	5.48

organisms present in the soil that led to more availability and uptake of nitrogen which would have resulted better protein biosynthesis. The lower protein content of grass fodder crops was mainly because of their genetic characters. These results are in agreement with the findings of Yadav *et al.* (2019), Mallikarjun *et al.* (2018) and Manoj *et al.* (2020).

Crude Protein Yield

The paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair) recorded significantly higher total crude protein yield (39.48 q ha^{-1} $year^{-1}$) which is at par with paired row system of Guinea grass + *Desmanthus* (45 cm within the pair × 120 cm between the pair) with a crude protein yield of 35.97 q ha^{-1} $year^{-1}$ (Table 3). The magnitude of increase in total crude protein yield in a paired system of B×N hybrid + *Desmanthus* (2:5) and Guinea grass + *Desmanthus* (2:3) was to the tune of 48 and 47 per cent, respectively over sole B×N hybrid and sole guinea grass, respectively. On the other hand, significantly lower crude protein yield was noticed with sole fodder sorghum (20.88 q ha^{-1} $year^{-1}$) followed by Sorghum + *Desmanthus* in 4:1 and 8:2 row ratio (21.23 and 21.33 q ha^{-1} $year^{-1}$, respectively) cultivated throughout the year. The crude protein yield is the function of dry matter yield and crude protein content of the fodder. The higher crude protein yield in a paired row system of B×N hybrid + *Desmanthus* (2:5) and Guinea grass + *Desmanthus* (2:3) is mainly due to higher dry matter yield of main crop and higher crude protein content of intercrop of *Desmanthus* which resulted in higher total crude protein yield of the system. The significantly lower crude protein yield in sorghum is mainly due to lower content of crude protein even with considerable amount of dry matter content and dry matter yield. These results are in conformity with the findings of Prajapati *et al.* (2019); Hindoriya *et al.* (2019) and Manoj *et al.* (2020).

Economics

Among the different perennial fodder cropping systems, paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair) recorded higher gross returns (Rs.3,27,757 ha^{-1} $year^{-1}$), net returns (Rs.2,38,083 ha^{-1} $year^{-1}$) and

TABLE 4
Economics of different perennial fodder cropping systems

Treatments	Cost of cultivation (Rs. ha^{-1} $year^{-1}$)	Gross returns (Rs. ha^{-1} $year^{-1}$)	Net returns (Rs. ha^{-1} $year^{-1}$)	B : C Ratio
T_1 : B × N hybrid + *Desmanthus* (1:1)	86654	286661	200007	3.31
T_2 : B × N hybrid + *Desmanthus* (2:1)	84302	268614	184312	3.19
T_3 : B × N hybrid + *Desmanthus* (paired row: 60 cm x 180 cm)	89674	327757	238083	3.65
T_4 : Guinea grass + *Desmanthus* (1:1)	79877	258411	178534	3.24
T_5 : Guinea grass + *Desmanthus* (2:1)	74657	234023	159366	3.13
T_6 : Guinea grass + *Desmanthus* (Paired row: 45 cm x 120 cm)	81161	270047	188886	3.33
T_7 : Perennial fodder sorghum + *Desmanthus* (4:1)	66958	186976	120018	2.79
T_8 : Perennial fodder sorghum + *Desmanthus* (8:2)	67546	191105	123559	2.83
T_9 : B × N hybrid (Sole)	82934	257514	174580	3.11
T_{10} : Guinea grass (Sole)	67005	204446	137441	3.05
T_{11} : Perennial fodder sorghum (Sole)	65726	195484	129758	2.97
T_{12} : *Desmanthus* (Sole)	62940	192383	129443	3.06

Selling price of green fodder: *Desmanthus* - Rs. 250 q^{-1}, other cereal fodders - Rs. 175 q^{-1}

benefit cost ratio (3.65) as compared to the other perennial fodder cropping systems (Table 4). While, Sorghum + *Desmanthus* (4:1) registered lower gross returns (Rs. 1,86,976 ha^{-1} year^{-1}), net returns (Rs. 1,20,018 ha^{-1} year^{-1}) and benefit cost ratio (2.79). The higher gross returns, net returns and benefit cost ratio with paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair) was mainly attributed to higher green fodder yield. These results are in line with the findings of Shekara *et al.* (2015); Patil *et al.* (2018); Hindoriya *et al.* (2019) and Manoj *et al.* (2020).

Based on the results it can be inferred that, the paired row system of B×N hybrid + *Desmanthus* (60 cm within the pair × 180 cm between the pair with a row ratio of 2:5) resulted higher green biomass yield (1717.16 q ha^{-1} year^{-1}), dry matter yield (339.60 q ha^{-1} year^{-1}) and crude protein yield (39.48 q ha^{-1} year^{-1}) throughout the year. The same perennial fodder cropping system also proved as profitable system with higher net returns (Rs.2,38,083 ha^{-1} year^{-1}) and benefit cost ratio (3.65) as compared to other perennial fodder cropping systems.

Acknowledgement : The authors are thankful to the AICRP on Forage Crop Utilization, Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya, Karnataka for providing facilities for execution of the experiment.

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