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Screening of Different Grasses and Legumes under Subabul (*Leucaena leucocephala*) based Silvipasture System in Drylands

S.B. Devaranavadgi*, Pradeep Rathod, S.B. Patil and V.H. Ashvathama

Regional Agricultural Research Station, Bijapur 586 001, India

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Abstract: The field experiment was carried out at Regional Agricultural Research Station, Bijapur, during 2008 to 2010 to evaluate performance of four grasses and three legumes grown in association with subabul (*Leucaena leucocephala*) in shallow vertisols of northern dry zone of Karnataka. Among the grass species Guinea grass var. Samruddhi recorded maximum plant height (112.33 cm during 2008-09 and 107.47 cm during 2009-10) and green fodder yield (22.40 Mt ha^{-1} during 2008-09 and 29.80 Mt ha^{-1} during 2009-10) followed by Guinea grass var. Nandini, Rhodes grass and Anjan grass. Among the legumes, *Stylosanthus ciabrana* showed higher yield (9.70 Mt $ha^{-1}$and 12.30 Mt ha^{-1}) and plants per m^2 (33.83 and 34.28), but more height was recorded in *Stylosanthus scabra* (62.30 cm and 63.69 cm during 2008-09 and 2009-10, respectively) at a light intensity ratio of 72.10% and 69.58%, respectively. No significant differences were observed for different silvicultural parameters. However, the economic analysis in terms of gross returns exhibited similar trends in line with the performance of different forage components.

Key words: Grasses, legumes, subabul, green fodder yield, silvipasture, drylands.

Cultivation of crops as the only land use activity in dryland regions is risky and uneconomical because of their inhospitable soil and climatic conditions. The regions, however, are suitable for livestock production provided it is backed by sustained production of fodder through efficient management of grasslands and inclusion of top feed tree species in the land use system. Trees have been found to increase, rather than decrease understorey production in temperate, tropical and arid climates. Trees, besides meeting the fodder needs during the lean period, maintain soil fertility, arrest desertification and create conditions conducive for growth of grasses with little or no adverse effect on yield of the associated forage grasses/ legumes. These beneficial tree canopy effects are due to leaf litter, better nutrient recycling, higher soil organic matter and improved soil physical structure (Young, 1989), and to nitrogen fixation in the case of leguminous trees. Considering all these factors, an experiment was conducted to quantify the productivity of four grasses and three legumes grown in association with subabul.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Bijapur farm of University of Agricultural Sciences, Dharwad, Karnataka, from 2008 to 2010 on degraded soils. The soils of the experimental site were poor in fertility with a soil depth of 30-35 cm, which are classified as shallow black soils. The rainfall at the experimental site was 621.5 mm with 32 rainy days during 2008-09 and 1196 mm with 49 rainy days during 2009-10. Productivity of four understorey grasses viz., Guinea grass (*Panicum maximum* var. samruddhi), Guinea grass (*Panicum maximum* var. nandini), Rhodes grass (*Chloris gayana* var. Gagan) and Anjan grass (*Cenchrus ciliaris*), and three legume viz., *Stylosanthus hamata, Stylosanthus ciabrana* and *Stylosanthus scabra* grown as understorey components in association with subabul (*Leucaena leucocephala*) planted at a spacing of 2 m x 2 m, were examined for two consecutive years (2008-09 and 2009-10). The plant population, plant height and green fodder yield of grasses and legumes with a mean of four cuttings at every three month interval were recorded. The experiment was laid out in randomized block design (RBD) with three replications. The average height, diameter at breast height and crown spread of subabul were also recorded. The silvicultural parameters recorded at 7^{th} and 8^{th} year are presented (Table 2). These parameters were further used to calculate wood volume by using Huber's formula $V = \pi r^2 h \times 0.8$ (Avery and Burkhart, 1983).

where, V = wood volume, π = 22/7, r = radius recorded at 1.3 m height, h = tree height, 0.8 = form of Quotient

$$\text{Wood Volume } (m^3\,ha^{-1}) = \pi d^2 h/4 \times 0.8 \times 2500$$

2500 No. of plants per ha. By 2 x 2 m spacing

*Email: dnavadgi@rediffmail.com

The light intensity ratio (LIR) was measured using lux meter at noon at the grass canopy level. The LIR was worked out using the following formula (Yoshida *et al.*, 1972) and expressed in percentage:

$$\text{LIR}(\%) = \frac{\text{Light intensity under tree canopy over grass}}{\text{Light intensity over grass in absence of trees}} \times 100$$

The data recorded on various characters during the course of investigation were subjected to Fisher's method of analysis of variance and interpretation of data was made as per the procedure given by Gomez and Gomez (1984).

Results and Discussion

The data on plant population, plant height and green fodder yield of grasses and legumes are presented for two years (2008-09 and 2009-10) with a mean of four cuttings (Table 1). The plant population in one square meter among the grasses was higher in Anjan grass (24.33 and 24.67) followed by Guinea grass (Nandini) (22.99 and 22.27), respectively, during 2008-09 and 2009-10. The performance of Guinea grass (Samruddhi) was poor (15.50) compared to Rhodes grass (Gagan) (18.88) during 2008-09. Where as it recovered during 2009-10 with 22.40 plants per m^2. Among the legumes *S. ciabrana* (33.83 and 34.28) showed more plants per m^2 followed by *S. scabra* (27.99 and 29.00) and *S. hamata,* respectively, during 2008-09 and 2009-10. The population of legumes is more as the legumes are very competitive and can successfully compete with most associated species under shade. Further after grazing, regrowth occurs from buds along the aerial stems that are rarely removed due to their hard woody nature (Skerman *et al.,* 1988).

The data on plant height revealed the superior performance of Guinea grass (Samruddhi and Nandini) with 104.18 and 112.33 cm during 2008-09 and 89.83 and 107.47 cm, respectively, during 2009-10 followed by Rhodes grass (86.73 and 88.67 cm, respectively) and Anjan grass. Where as among the legumes, *S. scabra* (62.30 cm and 63.69 cm, respectively during 2008-09 and 2009-10) was found to be highly superior, followed by *S. ciabrana* (56.05 and 59.37 cm) and *S. hamata*.

Among the grasses, Guinea grass (Samruddhi and Nandini) produced significantly higher green fodder yield (22.40 Mt ha^{-1} and 19.20 Mt ha^{-1} during 2008-09; 29.80 Mt ha^{-1} and 22.50 Mt ha^{-1} during 2009-10) followed by Rhodes grass (9.80 and 12.50 Mt ha^{-1}) and Anjan grass. Where as among the legumes, *S. ciabrana* (9.70 Mt ha^{-1} and 12.30 Mt ha^{-1}, respectively during 2008-09 and 2009-10) was found to be superior, followed by *S. hamata* (5.90 and 10.60 Mt ha^{-1}) and *S. scabra*.

All the silvicultural parameters (height, DBH and crown spread) of subabul (K-8) were found to be encouraging and they were not affected due to grass/legume species. However, the silvicultural component of subabul studied did not show any significant difference. This indicates that there is negligible influence of the forage grasses and legumes on the tree component, which may be due to tap root systems of subabul. The results (Table 2) indicate that different forage species have no significant effect on the tree component as indicated in terms of plant height, DBH, crown spread and wood volume.

The average light transmission ratio was maximum during 2008-09 (72.10%) and minimum during 2009-10 (69.50%). The LTR above the

Table 1. Performance of different grasses/legumes under semi-arid conditions

Treatments	2008-09			2009-10		
	Plant height (cm)	Plant population (m^{-2})	Green fodder yield* (Mt ha^{-1})	Plant height (cm)	Plant population (m^{-2})	Green fodder yield* (Mt ha^{-1})
Grasses						
T_1: *Panicum maximum* var. Samruddhi	104.18	15.50	22.40	112.33	22.40	29.80
T_2: *Panicum maximum* var. Nandini	89.83	22.99	19.20	107.47	22.27	22.50
T_3: *Chloris gayana* var. Gagan	86.73	18.88	9.80	88.67	20.56	12.50
T_4: *Cenchrus ciliaris*	70.85	24.33	4.70	71.11	24.67	9.60
Legumes						
T_5: *Stylosanthus hamata*	45.55	24.50	5.90	49.04	25.25	10.60
T_6: *Stylosanthus ciabrana*	56.05	33.83	9.70	59.37	34.28	12.30
T_7: *Stylosanthus scabra*	62.30	27.99	5.30	63.69	29.00	10.00
S.Em±	4.12	1.33		2.39	0.94	
C.D. @ 5%	12.70	4.11		7.36	2.89	

* Mean of four cuttings.

Table 2. Silvicultural parameters of Leucaena leucocephala

Treatments	2008-09						2009-10					
	Plant height (m)	DBH (cm)	Crown spread (m)		Volume (m^3)	LTR (%)	Plant height (m)	DBH (cm)	Crown spread (m)		Volume (m^3)	LTR (%)
			E-W	N-S					E-W	N-S		
Grasses												
T_1	8.16	8.18	2.82	2.86	85.80	72.12	9.28	8.53	2.83	2.86	106.11	70.10
T_2	8.12	8.23	2.73	2.76	86.43	72.20	9.30	8.33	2.91	2.93	101.41	69.40
T_3	8.13	8.15	2.66	2.67	84.86	71.98	9.25	8.45	2.78	2.83	103.79	69.80
T_4	8.21	8.23	2.65	2.68	87.39	73.10	9.21	8.60	2.79	2.83	107.04	68.90
Legumes												
T_5	8.04	8.18	2.78	2.80	84.54	72.03	9.20	8.61	2.85	2.87	107.17	69.10
T_6	8.11	8.20	2.68	2.69	85.69	71.15	9.10	8.72	2.81	2.84	108.73	69.20
T_7	8.18	8.11	2.83	2.85	84.55	72.10	9.30	8.50	2.73	2.76	105.59	70.00
Average	8.13	8.18	2.74	2.76	85.61	72.10	9.23	8.53	2.81	2.84	105.69	69.50
S.Em±	0.003	0.001	0.009	0.009			0.012	0.009	0.0091	0.012		
C.D. @ 5%	NS	NS	NS	NS			NS	NS	NS	NS		

understorey of all the grass/legume forage species did not vary much and was around 70%. As such the LTR is low, but the economic returns are in terms of vegetative part and hence the yields were not affected. The results indicate that at around 70% LTR level the yields of forage component are found to be encouraging.

The increased production might have been influenced by the light availability and available nitrogen under leguminous tree species. Physiological differences are also present between sun and shade plants with sun leaves having higher light-saturation rates of photosynthesis, compensation points, light saturation points, dark respiration rates, photorespiration rates and transpiration rates than shade leaves. Shade leaves in turn tend to have higher quantum yields and a greater likelihood of photo-inhibition than sun leaves (Nilsen and Orcutt, 1996). South African savannas have reported especially good growth of grasses under the canopy of leguminous trees. Wilson *et al*. (1990) showed that such responses are not confined to grasses in the understorey of leguminous trees. They reported a 35% greater growth of bahia grass (*Paspalum notatum*) under approximately 55% light transmission within a plantation of *Eucalyptus grandis*.

The economic returns (Table 3) of different silvi-pastoral systems were worked out in terms of gross returns. The highest returns of Rs. 29,360 (2008-09) and Rs. 36,573 were obtained in case of subabul+Guinea grass (Samruddhi)

Table 3. System productivity of different silvi-pastoral systems

Treatments	Green fodder yield (Mt ha^{-1})		Wood volume (m^3 ha^{-1})		Gross return (Rs.)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Grasses						
T_1	22.40	29.80	85.80	106.11	29360	36573
T_2	19.20	22.50	86.43	101.41	26884	30169
T_3	9.80	12.50	84.86	103.79	19155	22455
T_4	4.70	9.60	87.39	107.04	15412	20525
Legumes						
T_5	5.90	10.60	84.54	107.17	18352	25580
T_6	9.70	12.30	85.69	108.73	23065	27808
T_7	5.30	10.00	84.55	105.59	17633	24671

Note: 1. Market prices considered to work out gross returns of systems Subabul wood: Rs. 1200.00/m^3, Green grass: Rs. 800.00/ton, and Green legume fodder: Rs. 1200.00/ton.

2. The plantation is 10 years old hence the wood volume at the end is divided by 9 for 2008-09 and by 10 for 2009-10 while calculating the gross returns.

followed by subabul+Guinea grass (Nandini). Among the legumes the returns were found to be higher in case of subabul+*S. ciabrana* during both the years (Rs. 23,065 for 2008-09 and Rs. 27,807 for 2009-10.

Considering all these parameters, it may be inferred that Guinea grass (Samruddhi and Nandini) and *S. ciabrana* are more suitable to grow as the understorey of subabul in silvipasture systems of dry zones.

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