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EFFECT OF GRASSES AND MOISTURE CONSERVATION PRACTICES ON GROWTH, PRODUCTIVITY, MOISTURE CONTENT AND ECONOMICS OF ANJAN TREE BASED SILVOPASTURE SYSTEMS

S. N. RAM*, M. M. DAS AND AKRAM AHMED

Grassland and Silvipasture Management Division,
ICAR-Indian Grassland and Fodder Research Institute, Jhansi- 284003 (U.P.) India
**(e-mail : ramshivnath@yahoo.com)*

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SUMMARY

A field experiment was conducted during 2013 to 2018 on five years old *Hardwickia binata* based silvopasture system at Indian Grassland and Fodder Research Institute, Jhansi. The treatment consisted of establishment of three grasses in association with *H. binata* and construction of three moisture conservation practices. Establishment of *C. fulvus* in association with *H. binata* recorded significantly higher dry pasture yield (6.40 t/ha) as compared to *P. maximum* (6.02 t/ha) and it was found at par with *C. ciliaris* (6.02 t/ha). In moisture conservation practices, staggered trenches recorded significantly higher dry top feed (1.21 t/ha) and fire wood (1.40 t/ha) of *H. binata* as compared to control treatment-without staggered trenches and bund (0.83 and 0.89 t/ha) respectively. *Chrysopogon fulvus* also recorded maximum net return (Rs 35485/ha) and benefit-cost ratio (0.53) followed by *Cenchrus ciliaris* (Rs 33853/ha and 0.51) and *Panicum maximum* (Rs. 32107/ha and 0.49) utilized in grazing mode by goats and sheep at the rate of 2 ACU.

Key words : *Cenchrus ciliaris, Chrysopogon fulvus, Hardwickia binata,* moisture conservation practices, *Panicum maximum,* top feed and net returns

Anjan (*Hardwickia binata* Roxb.) is one of the suitable tree for silvopsture system for degraded lands under semiarid rainfed conditions. It is moderate to large sized tree, leafless for a short time, with drooping slender branchlets and bifoliate leaves. This deciduous tree attains a height of 25-30 m with a clean cylindrical bole. It yields an extremely hard, heavy and durable timber. The bark yields a red-brown fibre used for ropes. The leaves are used as livestock fodder and manure. *H. binata* thrives in a dry climate and even withstand for prolonged drought, scanty to moderate rainfall and intense heat during hot season and is capable of growing on dry shallow soil and rocky ground. In arid and semiarid regions under rainfed conditions productivity of degraded lands is often poor because of dominance of low yielding annual grasses and lack of adequate soil moisture. In this context, introduction of suitable grasses in association with *H. binata* and construction of moisture conservation practices can play a vital role in improving the productivity of degraded lands. In situ moisture conservation practices has a great potential in enhancing moisture availability period and productivity of the system on degraded lands in arid and semiarid regions under rainfed conditions. Yadav and Bhushan (1989) reported that in degraded lands low cost mechanical practices may be adopted for moisture conservation. In hot arid and semiarid regions where erratic rainfall and recurrent drought is the common phenomenon, development of suitable silvopasture system are recommended to increase system productivity, enhancing fodder availability and checking soil erosion (Soni *et. al*. 2013; Sharma, 2014). Establishment of silvopasture system on degraded lands can serve the important role of bridging the gap in fodder supply during lean period of the year. In silvopasture system grasses provide green forage during monsoon season and tree provide top feed during winter and summer seasons (Kumar *et al*. 2017; Ram *et al*. 2019). In view of this the present study was carried out to study the effect of grasses and moisture conservation practices on growth, productivity, moisture content and economics of Anjan tree based silvopasture systems.

MATERIALS AND METHODS

A field experiment was conducted during

2013 to 2018 on five year old *Hardwickia binata* based silvopasture system at Central Research Farm (25^0 27' N latitude, 78^0 37' E longitude and 275 m above mean sea level) of Indian Grassland and Fodder Research Institute, Jhansi to study the effect of grasses and moisture conservation practices on growth, productivity, moisture content and economics of Anjan tree based silvopasture systems. The soil of the experimental field was sandy loam, low in available nitrogen (224.07 kg/ha) and phosphorus (8.16 kg/ha) and medium in organic carbon (0.566%) and available potash (210.52 kg/ha). The total rainfall received was 1510.8, 651.9, 713.3, 827.0 and 486.4 mm in 71, 43, 48, 41 and 35 rainy days during 2013, 2014, 2015, 2016 and 2017 respectively.

There were 9 treatment combinations replicated thrice in randomized block design. The treatment consisted of establishment of three grasses *viz*. *Cenchrus ciliaris, Chrysopogon fulvus* and *Panicum maximum* in association with *H. binata* and construction of three moisture conservation practices *viz*. staggered trenches (2.0m × 0.5m × 0.5m), bunding and control (without bunding and staggered trenches). Forage produced from *H. binata* based silvopasture system was utilized in grazing mode by mixed herd of Bundelkhandi goats and Jalauni sheep at the rate of 2 ACU. Uniform grazing in all the experimental plots was carried out from August to January. *H. binata* was established at 6 m x 6 m spacing and grasses were established in association with *H. binata* at 100 m x 50 cm spacing. In fertilizer 40 kg N, 30 kg phosphorus and 30 kg potash/ha were applied each year after onset of monsoon. The trees were pruned once every year during November- December for proper growth, form and yield. Dry matter content was estimated by drying 500 g plant sample of each treatment and replication in hot-air oven at 70^0C for computation of dry matter yield. Observations on soil moisture was taken at three depths (0-15 cm, 15-30 cm and 30-60 cm) after monsoon season (October-April).

RESULTS AND DISCUSSION

Growth parameters of *H. binata*

Establishment of different grasses in association with *H. binata* did not significantly affected the growth parameters of *H. binata* (Table 1). However, construction of staggered trenches recorded significantly higher height (7.47 m), collar diameter (16.45 cm), diameter at breast height (13.36 cm) and canopy spread (3.55 m) of *H. binata* as compared to control treatment-without trenches and bund (7.16 m, 15.91 cm, 12.88 cm and 3.39 m) respectively. The higher growth parameters of *H. binata* in staggered trenches may be attributed to sufficient moisture regime in the root zone of tree during growth period in this treatment. Enhanced tree growth was also reported under staggered trenches by Shukla *et al.* (2014) in bael.

TABLE 1

Effect of grasses and moisture conservation practices on growth parameters, top feed and fire wood of *Hardwickia binata* (2017-18)

Treatment	Height (cm)	Collar diameter (cm)	Diameter at breast height (cm)	Canopy spread (m)	Top feed (t/ha)	Fire wood (t/ha)
Grasses						
C. ciliaris	7.33	16.19	13.13	3.48	1.02	1.19
C. fulvus	7.31	16.34	13.26	3.53	1.06	1.24
P. maximum	7.23	16.07	13.03	3.41	1.00	1.16
SEm±	0.06	0.08	0.06	0.04	0.05	0.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS
MCP						
Control	7.16	15.91	12.88	3.39	0.83	0.89
Trenches	7.47	16.45	13.36	3.55	1.21	1.40
Bund	7.25	16.24	13.18	3.48	1.04	1.31
SEm±	0.06	0.08	0.06	0.04	0.05	0.05
CD (P=0.05)	0.19	0.24	0.18	0.13	0.14	0.16

MCP-Moisture conservation practices.

Top feed and fire wood

Top feed and fire wood yield of *H. binata* also did not affected significantly by establishment of different grasses (Table 1). However, construction of staggered trenches also recorded significantly higher dry top feed (1.21 t/ha) and fire wood (1.40 t/ha) of *H. binata* as compared to control treatment-without trenches and bund (top feed 0.83 t/ha and fire wood 0.89 t/ha). The higher top feed and fire wood yield of *H. binata* in staggered trenches may be attributed to sufficient moisture regime in the root zone of tree in these plots for longer period. Kumar *et al.* (2012) also reported higher growth and productivity of Guava by construction of staggered trenches.

Growth parameters of grasses

Among grasses *Panicum maximum* recorded significantly higher height (146.24 cm) as compared to *Chrysopogon fulvus* (136.75 cm) and *Cenchrus ciliaris* (117.06 cm). However, number of tillers/ plant (89.36) and tussock diameter (37.89 cm) was maximum in *Chrysopogon fulvus* followed by *Cenchrus ciliaris* (74.73 and 34.55 cm) respectively (Table 2). In moisture conservation practices, construction of bund in *H. binata* based silvopasture system significantly increased height (140.06 cm), tillers/plant (79.27) and tussock diameter (36.62 cm) of grasses as compared to staggered trenches (134.89 cm, 74.82 and 34.56 cm) and control treatment-without bund and trenches (125.11 cm, 67.84 and 32.48 cm) respectively. This might be due to higher soil moisture content during growth period of grasses in the field where bund was constructed.

TABLE 2

Effect of grasses and moisture conservation practices on growth parameters and dry forage yield of grasses in *H. binata* based silvopasture system (Pooled data of 5 years)

Treatment	Height (cm)	Tillers/ plant	Tussock diameter (cm)	Pasture yield (t/ha)
Grasses				
C. ciliaris	117.06	74.73	34.55	6.39
C. fulvus	136.75	89.36	37.89	6.40
P. maximum	146.24	57.84	31.21	6.02
SEm±	1.42	1.35	0.59	0.07
CD (P=0.05)	4.31	4.07	1.77	0.23
MCP				
Control	125.11	67.84	32.48	5.72
Trenches	134.89	74.82	34.56	6.37
Bund	140.06	79.27	36.62	6.72
SEm±	1.42	1.35	0.59	0.07
CD (P=0.05)	4.31	4.07	1.77	0.23

MCP-Moisture conservation practices.

Pasture yield

Establishment of *C. fulvus* in association with *H. binata* recorded significantly higher dry pasture yield (6.40 t/ha) as compared to *P. maximum* (6.02 t/ ha) and it was found at par with *C. ciliaris* (6.02 t/ ha). In moisture conservation practices, construction of bund in *H. binata* based silvopasture system was also significantly increased understorey pasture yield (6.72 t/ha) than control treatment-without bund and trenches (5.72 t/ha) and staggered trenches (6.37 t/ ha). This might be due to increase in the availability of soil moisture in field for longer period by construction of bund in field during rainy season which act as barrier against the runoff of water and therefore the maximum water was absorbed in the soil and resulted in higher moisture regime in the root zone of pasture which enhanced forage yield. Kumar *et al.* (2010) have also reported significantly higher pasture yield by construction of bund than without bund in ber based hortipasture system. Patil *et al.* (2000), Meena *et al.* (2002) and Regar *et al.* (2007) also found higher yield of different crops with the construction of bunds.

Moisture content

Pooled data of five years showed that establishment of different grasses in association with *H. binata* did not significantly affected the soil moisture content (Table 3). In moisture conservation practices, construction of bund recorded significantly higher moisture content (8.71%) at 0-15 and (9.78%) at 15-30 cm soil depth as compared to control treatment-without moisture conservation practices (7.50 and 8.39%) respectively. While at 30-60 cm soil depth moisture content was significantly increased (9.63%) in trenches than control treatment-without moisture conservation practices (8.65%). The higher moisture contents in bund and staggered trenches might be due to minimum runoff and higher infiltration of water in these plots. Ahmed *et al.* (2014) also reported higher moisture content in soil by *in-situ* moisture conservation practices in aonla based hortipasture system.

TABLE 3
Effect of grasses and moisture conservation practices on moisture content (pooled data of 5 yrs), net returns and benefit-cost ratio (2017-18) of *H. binata* based silvopasture system

Treatment	Moisture content (%)			Net returns (Rs/ha)	Benefit-cost ratio
	0-15 cm	15-30 cm	30-60 cm		
Grasses					
C. ciliaris	8.18	9.20	9.18	33853	0.51
C. fulvus	8.17	9.16	9.15	35485	0.53
P. maximum	8.22	9.20	9.22	32107	0.49
SEm±	0.10	0.15	0.15	172	0.01
CD (P=0.05)	NS	NS	NS	520	0.02
MCP					
Control	7.50	8.39	8.65	32663	0.50
Trenches	8.35	9.39	9.63	34271	0.52
Bund	8.71	9.78	9.27	34512	0.52
SEm±	0.10	0.15	0.15	172	0.01
CD (P=0.05)	0.31	0.45	0.46	520	0.02

MCP-Moisture conservation practices.

Economic returns

In term of monetary return, *C. fulvus* recorded maximum net return (Rs 35485 /ha) and benefit-cost ratio (0.53) in association with *H. binata* followed by *Cenchrus ciliaris* (Rs 33853/ha and 0.51) and *Panicum maximum* (Rs 32107/ha and 0.49) utilized in grazing mode by goats and sheep at the rate of 2 ACU. The higher net returns and benefit-cost ratio from establishment of *C. fulvus* in association with *H. binata* was due to higher forage yield obtained from this treatment. Construction of bund also recorded significantly higher net return (Rs 34512/ha) and benefit-cost ratio (0.52) from *H. binata* based silvopasture system utilized in grazing mode by goats and sheep at the rate of 2 ACU as compared to control treatment- without moisture conservation practices (Rs 32663/ha and 0.50). The higher net returns and benefit-cost ratio from construction of bund was due to higher forage yield obtained from this treatment.

CONCLUSION

On the basis of results obtained, it could be concluded that integration of perennial pasture (*Chrysopogon fulvus, Cenchrus ciliaris* and *Panicum maximum*) with Anjan tree (*Hardwickia binata*) along with moisture conservation practices (bunds and staggered trenches) and utilization in grazing mode by goats and sheep at the rate of 2 ACU have the potential to enhance system productivity (top feed, fire wood and pasture), improve soil moisture content and monetary return under semi-arid rainfed ecosystem of India. *H. binata* being hardy and deep root system, it is proved to be a potential tree suitable for silvopasture system on degraded lands in rainfed areas of semiarid region. Thus, *H. binata* based silvopastoral system is an ideal and profitable alternate land-use option for degraded lands for minimization of risk due to abnormal weather under semi-arid rainfed situation.

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