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Bael (*Aegle marmelos*) Based Hortipastoral System with Moisture Conservation in Semi Arid Condition.

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ABSTRACT

A study was conducted during 2008-13 on bael based hortipasture system under semi arid rainfed condition of Jhansi. Bael cultivars NB-9 and CISH B-2 were planted under square system with 6 x 6m spacing. The understorey of each plot was intercropped with perennial pasture viz; *Cenchrus ciliaris* + *Stylosanthes seabrana* to utilize interspace available between rows. Growth parameters in terms of plant height, collar diameter, canopy spread were found to be higher in different moisture conservation treatments than control (without treatment). During the fifth year, tree height ranged from 2.99-3.42 m in different treatments with maximum in stone mulch (3.42 m). Collar diameter varied from 6.91-7.66 cm with maximum in stone mulch (7.66 cm) and minimum in control (6.91cm). Tree canopy varied from 1.94-2.49 m with maximum in stone mulch (2.49 m). Forage production was significantly influenced by different moisture conservation treatments and the maximum yield was recorded in staggered trench (7.35 t DM/ha) with minimum in control (5.32 t DM/ha). Fruit production was also influenced by intercropping forage crops under rainfed condition and produced fruit yield of 1.74 t/ha which was maximum in staggered trench and minimum in control (1.11 t/ha).

Keywords:

Bael, *Cenchrus ciliaris*, moisture conservation practices, *Stylosanthes seabrana*

INTRODUCTION

In India, semi arid ecosystem has traditionally been facing varying degrees of land degradation and this region is facing problem of erratic rainfall, low productivity and poor soil condition hence alternate land use system is the viable option to enhance system productivity. Hortipasture is integration of fruit trees suitable for rainfed condition with different pasture combinations in land capability class IV and V (Kumar and Kumar 2001). Similarly, perennial grasses and range legumes are tolerant to extremes of temperatures and drought, can produce substantial biomass even in low rainfall zone. In rainfed situation mono cropping is risky enterprise because of erratic rainfall pattern. Under such situation livestock production is secondary enterprise for small, marginal and medium farmers (Raturi and Hiwale 1993). In animal

husbandry about 65-75% expenditure is incurred in feeds and fodder (Singh 2009). Among the fruit tree based agroforestry system, the hortipasture systems have been recognized as sustainable land use option because of its high productivity and environmental benefits even under fragile agro-ecosystem. In arid and semi arid agro ecosystem water is an important input and *in-situ* moisture conservation is a tool to provide regular moisture regime to root zone for proper growth and development of tree and pasture. Bael (*Aegle marmelos*) belongs to family Rutaceae, is an indigenous fruit tree of India. It is very useful medicinal plants of India. Bael leaf contains 15.1% crude protein which indicate fodder value of bael fruit tree. It is an important fruit species suitable for arid and semi-arid ecosystem due to deep root system, tolerance to water stress, tolerance to high and low temperature and deciduous in nature. In hot summer season leaves are dropped and plant start flowering in monsoon season and fruit matures in the month of May. Intercropping of perennial grasses/range legumes with other fruit crops was fruitful under different moisture conservation practices for high biomass and fruit production in degraded land (Kumar and Choubey 2008). However, the success of developing hortipasture land use system depends largely on selection of fruit plants and pasture species. Intercropping with suitable pasture species can bridge the gap of green and dry fodder.It can ensure food and nutritional security by supplying quality fruits for human consumption and fodder for animal resulting stability in total biomass production. (Shukla and Kumar 2007). However, no information is available on bael based hortipasture system under rainfed condition with *in-situ* moisture conservation. Therefore present study was conducted to study the performance of bael based hortipasure system in semi arid condition.

MATERIALS AND METHODS

Present study was conducted at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi. The climate of Jhansi is semi arid with the occurrence of recurrent drought. The soil of experimental site is red. Plot size is 12x 30 m with ten number of plant in each plot. Two varieties of bael namely NB-9 and CISH B-2 was transplanted during 2008 at 6x6 m spacing under square system of planting. The understorey of each plot was intercropped with perennial pasture (*Cenchrus ciliaris* and *Stylosanthes seabrana*). The new seedlings of *Cenchrus ciliaris* were transplanted in July, 2009 at 100 x 50 cm and *Stylosanthes seabrana* seed @ 4 kg ha^{-1} were sown in line between 2 rows of grass under bael tree and similar practice was adopted for pure pasture block. Application of 15 kg FYM and 100 g N, 75g P_2O_5 and 100 g K_2O to each tree during first year was done and it increased every year in same proportion. For pasture 20 kg N and 30 kg P_2O_5 and 30 kg K_2O ha^{-1} of fertilizers were applied each year. The experiment consist of six treatments viz., Staggered trenches (T_1), Stone mulch (T_2), Water retaining chemical (T_3), Control (without moisture conservation) (T_4), Sole bael(T_5) and Sole pasture (T_6). Each treatment was replicated thrice in randomized block design.

RESULTS AND DISCUSSION

Tree Survival and vegetative growth

Based on five year observation there was consistently higher tree growth and more than 94% tree survival in different moisture conservation treatments over control (Table 1). Tree survival varied from 94.65 to 98.10% in different treatments with maximum in Staggered trench (98.1%) followed by stone mulch (97.2%), water retaining chemical (96.8%) and minimum in control (94.65%). Average tree height was recorded maximum in stone mulch (2.39 m) closely followed by staggered trench (2.36 m), water retaining chemical (2.15 m) and minimum was in control (2.08 m). Tree growth was significantly affected by moisture conservation treatments, however difference between T_1 and T_2 was at par. Maximum average collar diameter was also recorded in stone mulch (5.57 cm) followed by staggered trench (5.46 cm), water retaining chemical (5.11 cm) and minimum was recorded in control (4.76 cm). Canopy spread (average) was maximum in stone mulch (1.87 m) closely followed by staggered trench (1.78 m), water retaining chemical (1.67 m) and minimum was found in control (1.58 m). The

Table 1: Tree growth characters of bael under hortipasture system with different moisture conservation treatments.

Treatment	Survival and Tree growth characters of bael											
	2008-09	2009-10		2010-11			2011-12			2012-13		
	Survival (%)	Height (m)	Collar diameter (cm)	Height (m)	Collar diameter (cm)	Canopy Spread (m)	Height (m)	Collar diameter (cm)	Canopy Spread (m)	Height (m)	Collar diameter (cm)	Canopy Spread (m)
Staggered trenches (T1)	98.10	1.30	2.82	2.13	5.00	1.24	2.65	6.91	1.84	3.37	7.10	2.25
Stone mulch (T2)	97.20	1.27	2.49	2.04	4.97	1.30	2.85	7.15	1.82	3.42	7.66	2.49
Water retaining chemical (T3)	96.80	1.17	2.61	1.92	4.49	1.11	2.48	6.15	1.72	3.04	7.18	2.19
Control (without moisture conservation) (T4)	94.65	0.99	1.81	1.94	4.39	1.05	2.41	5.94	1.52	2.99	6.91	2.18
Sole bael (T5)	95.13	1.09	2.40	1.90	4.62	1.31	2.43	6.34	1.59	3.18	6.97	1.94
Sole pasture (T6)	--	---	---	---	---	---	---	---	---	---	----	---
Mean	96.38	1.16	2.32	1.98	4.69	1.20	2.56	6.49	1.69	3.20	7.16	2.21
CD** (P=0.05)	1.83	NS	0.91	NS	1.03	NS*	NS	1.36	NS	0.13	0.11	0.35

*NS-Nonsignificant; **CD: Critical Difference

higher tree survival and vegetative growth may be attributed to sufficient moisture regime in the root zone of tree during establishment phase. Relatively enhanced tree growth was also reported under *in-situ* moisture conservation practices by Kumar and Shukla (2010) in ber, Shukla et al. (2006) in aonla.

Forage production

Based on experimentation, there was clear positive correlation between moisture content in soil and forage production. Different moisture conservation treatments influenced the forage production right from first year (2009-10) of forage establishment (table 2) and it varied from 1.51 to

Table 2: Forage production in bael based hortipasture system

Treatment	Forage production (t DM ha^{-1})*				
	2009-10	2010-11	2011-12	2012-13	Mean
Staggered trenches (T1)	2.25	6.49	6.98	7.35	5.78
Stone mulch (T2)	1.78	5.31	5.59	5.56	4.56
Water retaining chemical (T3)	1.71	5.21	5.73	5.67	4.58
Control (without moisture conservation) (T4)	1.51	4.53	5.16	5.32	4.13
Sole bael (T5)	----	---	---	---	--
Sole pasture (T6)	1.91	4.91	5.25	5.43	4.38
Mean	1.83	5.29	5.74	5.86	4.69
CD (P=0.05)	0.76	1.31	1.41	0.25	0.13

* tDM- Tonne Dry Matter

2.25 t DM ha^{-1}. There was consistent increase in average forage production and it was maximum in staggered trench (5.78 t DM) followed by water retaining chemical (4.58 t DM), stone mulch (4.56 t DM) and minimum was recorded in control (4.13 t DM) however, T_2 and T_3 were at par. Pasture

production was consistently higher under staggered trench (2.25, 6.49, 6.98, 7.35 t DM/ha) as compared to control (1.51, 4.53, 5.16, 5.32 t DM ha^{-1}) during four years of study. Through *in-situ* moisture conservation, there was regular moisture regime in the root zone of pasture which enhanced total biomass production. Kumar et al. (2009) have also reported highest forage production i.e.>7.0 t DM ha^{-1} in aonla through *in-situ* moisture conservation.

Fruit yield and quality parameters

Data on yield and quality attributing traits of bael was recorded (table 3) and it was found that *in-situ* moisture conservation treatment influenced the fruit size, fruit weight and ultimately the total yield of fruits. Besides, TSS and pulp content was also affected by treatments in both the cultivars. In cultivar NB-9, the highest fruit weight was recorded in staggered trench (1.85 kg) followed by stone mulch (1.56 kg), water retaining chemical (1.41 kg) and minimum was recorded in control (1.24 kg). The maximum fruit length was recorded in staggered trench (16.56 cm) followed by water retaining chemical (16.03 cm), stone mulch (15.15 cm), and lowest was recorded in control (14.22 cm). The maximum fruit breadth was recorded in staggered trench (14.95 cm) followed by stone mulch (13.58 cm), water retaining chemical (13.24 cm) and lowest was recorded in control (12.85 cm). TSS was highest in staggered trench (33.5%) followed by stone mulch (32.8%), water retaining chemical (32.3%) whereas minimum was recorded in control (31.1%). The highest pulp content was recorded in staggered trench (69.5%) and minimum was noted in (64.9%) however, statistically T_3 (65.3%) and T_5 (65.1%) were at par. Fruit yield in cultivar NB-9 was significantly affected by moisture conservation treatments and the maximum fruit yield was observed in staggered trench (2.41 t ha^{-1}) followed by stone mulch (1.75 t ha^{-1}), water retaining chemical (1.25 t ha^{-1}) however, minimum was found in control (1.14 t ha^{-1}). Seed weight has shown reverse trend and minimum seed weight was observed in staggered trench (12.2g) and maximum in control (14.9 g).

In cultivar CISH B-2, the highest fruit weight was recorded in staggered trench (1.75 kg) followed by stone mulch (1.45 kg) water retaining chemical (1.36 kg) however, the minimum fruit weight was observed in control (1.21 kg). Fruit size (LxB) was recorded in staggered trench (17.25 x 14.15 cm) followed by stone mulch ((16.15 x 13.35 cm), water retaining chemical (15.86 x 12.93 cm) and lowest was recorded in control (15.52 x 12.03 cm). The maximum TSS was recorded in staggered trench (31.2%) followed by stone mulch (29.4%),

Table 3: Yield and quality characters of bael fruits under hortipastoral system with different moisture conservation

Treatments	CISH B-2							NB-9						
	Fruit weight (kg)	Fruit length (cm)	Fruit breadth (cm)	TSS (%)	Pulp content (%)	Seed Wt (g)	Fruit yield (t ha^{-1})	Fruit weight (kg)	Fruit length (cm)	Fruit breadth. (cm)	TSS (%)	Pulp content (%)	Seed Wt (g)	Fruit yield (t ha^{-1})
Staggered trenches (T1)	1.75	17.25	14.15	31.2	62.3	9.1	1.74	1.85	16.56	14.95	33.5	69.5	12.2	2.41
Stone mulch (T2)	1.45	16.15	13.35	29.4	60.2	9.5	1.34	1.56	15.15	13.58	32.8	67.8	13.5	1.75
Water retaining chemical (T3)	1.36	15.86	12.93	28.5	59.4	9.7	1.26	1.41	16.03	13.24	32.3	65.3	14.7	1.25
Control (without moisture conservation) (T4)	1.21	15.52	12.03	27.6	58.8	9.9	1.11	1.24	14.22	12.85	31.1	64.9	14.9	1.14
Sole bael (T5)	1.33	15.95	12.52	28.3	59.5	9.4	1.17	1.32	15.50	13.13	31.9	65.1	13.7	1.20
Sole pasture (T6)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mean	1.45	16.17	12.99	29.00	60.04	9.52	1.32	1.47	15.49	13.55	32.32	66.52	13.8	1.55
CD** (P=0.05)	0.10	0.25	0.22	0.11	0.13	NS	0.09	0.11	0.32	0.08	0.10	1.02	NS	0.11

water retaining chemical (28.5%) and minimum was observed in control (27.6%). The maximum pulp content was observed in staggered trench (62.3%) followed by stone mulch (60.2%), water retaining chemical (59.4%) the minimum was recorded in control (58.8%) however, statistically T_3 (59.4.3%) and T_5 (59.5%) were at par.. The fruit yield was maximum in staggered trench (1.74 t ha^{-1}) followed by stone mulch (1.34 t ha^{-1}), water retaining chemical (1.26 t ha-1) however, the minimum was found in control (1.11 t ha^{-1}). Seed weight showed a reverse trend with minimum in Staggered trench (9.1g) and maximum in control (9.9 g). Kumar and Shukla (2010) also reported significantly higher yield and improvement in quality of Indian jujube through *in-situ* moisture conservation (bunding).

CONCLUSION

Based on five year study it may be concluded that *in-situ* moisture conservation was found to be effective in improving the tree survival and growth, canopy spread, forage and fruit yield. Besides, physico-chemical and quality parameters of bael fruits were also positively affected with application of *in-situ* moisture conservation treatments under semiarid conditions.

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