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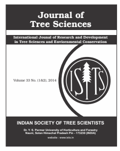

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Fodder Production From Tree-Legume-Grass Based Agroforestry Systems in Sub Tropical Hills of Western Himalayas, India

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ABSTRACT

A field experiment was conducted over a period of two years (2005 and 2006), at Solan, Himachal Pradesh, India to evaluate fodder production from different tree-crop combinations and varying levels of nitrogen (40, 80 and 120 kg ha^{-1}), in which *Mucuna pruriens* was cultivated as fodder crop in association with *Prunus persica* (Peach), *Grewia optiva* and *Morus alba* and *Setaria sphacelata*. The fodder yield was not affected by various agroforestry systems during two years of study. However, nitrogen application significantly increased the *M. pruriens* fodder yield. Nitrogen dose of 120 kg ha^{-1} produced significantly higher green fodder yield in *M. pruriens* i.e. 17.42 and 26.52 t ha^{-1} during first and second year, respectively. Interaction of agroforestry systems and nitrogen levels showed significant effect on fodder yield of *M. pruriens.* Horti-silvi-pasture system (*P. persica + G. optiva + S. sphacelata +M. pruriens*) supplemented with 120 kg N ha^{-1} recorded Mucuna fodder yield to the tune of 17.92 and 27.33 t ha^{-1} in the first and second year respectively. On the basis of total fodder and fodder yield (*G. optiva* or *S. sphacelata* or *M. alba*), silvi-pasture system with *M. alba + S. sphacelata +M. pruriens* gave maximum of 16.72 t ha^{-1} and 25.61 t ha^{-1} in first and second year followed by *G. optiva + S. sphacelata + M. pruriens* system.

Key words:

Agroforestry, fodder, *Mucuna*, nitrogen fertilizer, pasture

INTRODUCTION

Livestock rearing plays a significant role in the economy of the Himalayan people. Grasslands are the major feed resource for this activity. Climatic, topographic, physiographic, altitude and related factors have influenced the distribution of various grass species, which determine the grassland production both qualitatively and quantitatively (Whyte 1968). A non- competitive land use systems for fodder production in the hills is to grow fodder on terrace bunds and risers (Singh et al. 1993). Tree leaf fodder is the major feed resource during lean periods, particularly the winters. The tree leaf fodder provides 50-90 per cent of the fodder demand during lean periods (Negi 1977). In Himachal Pradesh, the green herbage availability varied from 1.5 to 1.74 t ha^{-1} in temperate pastures and 0.5 to 1.0 t ha^{-1} in alpine and sub-alpine pastures (Singh 1995). Ram and Singh (1994) observed that biomass availability varied from 1.62 to 3.96 t ha^{-1} (green herbage) in Himalayan pasture of Uttar Pradesh. Melkania and Singh (1989) have estimated that net above ground biomass varied from 279 to 1568 gm^{-2} for low elevation Himalayas, 219 to 285 gm^{-2} for mid elevation Himalaya and 233-372 gm^{-2} for high elevation Himalayas.

Though livestock rearing is an important occupation of hill farming system, the fodder cultivation has remained almost neglected. Grazing in the forest areas and sub-alpine and alpine pastures is the mainstay for the animals. For augmenting fodder availability, emphasis needs to be given to cultivated fodder crops on large area (Singh 1987). Fodder cultivation is restricted to only about one per cent of the cultivated area in the entire Himalayan region. This is basically because of the preponderance of marginal and small land holdings in the area. Besides grazing and fodder trees, the major local fodder resource is the crop residue, which again is too inadequate to sustain the livestock. Keeping in view the constraints in fodder production and in order to overcome the gap between demand and supply, the emphasis need to be given on several steps for augmenting the fodder production. For developing the models for quality fodder production and year round supply it is important to choose appropriate kind of fodder crop, and fodder species or to cultivate fodder crops under existing land use systems. The species mix should be such which could perform well under rain fed areas and enhance the fertility of soil. Therefore, *Mucuna pruriens* (a fastest growing legume in the World, fodder increase the milk yield, improve soil fertility by fixing nitrogen) (Muinga 1992; Muinga et al. 2000; Muinga et al. 2003), *Grewia optiva*, *Morus alba* and *Setaria sphacelata* based agroforestry systems were evaluated and evolve promising tree crop combinations to augment the fodder demand .

MATERIALS AND METHODS

The field experiment was carried for two years 2004-5 to 2005-6 at experimental farm of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, located 30°51' N and 76°11' E, at an of 1250 m amsl. Climate of the area may be characterized as subtropical to sub-temperate. The maximum temperature of 30.4, 27.9, 25.3, 23.8, 22.5 and 18.0 and minimum was 19.6, 19.2, 16.5, 10.4, 5.9, 4.1 and 2.7 from July 2004 to January 2005 prevailed in first year study. In second year, the maximum temperature of 29.0, 29.0, 29.1, 27.1, 24.6, 21.8 and 20.6 and minimum of 20.3, 19.4, 17.8, 10.4, 5.0, 1.4 and 3.4 prevailed from July 205 to January, 2006. The precipitation during experimental months i.e. July, 2004 to January (first year of experiment), 2005 was, 87.2, 339.6, 88.8, 95.8, 4.0, 6.0 and 67.8 and from July, 2005 to January, 2006 it was, 368.6, 58.2, 157.6, 0.0, 0.0, 11.4 and 68.0 cm (Meteorological Observatory, Department of Soil Science and Water Management, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni Solan, H. P.)

The surface soil was neutral in reaction (pH 7), high in organic carbon (1.01 %), medium in nitrogen (457.70 kg ha^{-1}), high in available phosphorus (31.50 kg ha^{-1}) and potassium content (354.20 kg ha^{-1}). The structural components of agroforestry system were *Prunus persica* (Peach), *M. alba* and *G. optiva* (fodder) and *S.sphacelata* (grass), planted during the years 1992, 2001 and 2002, respectively.

G. optiva and M. alba trees were pollarded at 1.5 m height from ground level. Velvet bean was cultivated between the alleys of above woody and non-woody components. The tree-crop combinations formed were, T_1 [(*P. persica* + *G. optiva* + *S. sphacelata* + *M. pruriens*), horti-silvi-pastoral], T_2 (*P. persica* + *M. alba* + *S. sphacelata* + *M. pruriens*) horti-silvi-pastoral], T_3[(*P. persica* + *S. sphacelata* + *M. pruriens*) horti-pastoral], T_4 [(*G. optiva* + *S. sphacelata* + *M. pruriens*) silvi-pastoral], T_5 [(*M. alba* + *S. sphacelata* + *M. pruriens*) silvi-pastoral] and T_6 [(*M. pruriens* sole) pastoral]. Three nitrogen doses in the dosage of 40 (N_{40}), 80 (N_{80}) and 120 (N_{120}) kg ha^{-1}, were applied to find out the effect on fodder yield of *M. pruriens*. The experiment was laid out in randomized block design replicated thrice. The detail of area occupancy and lay out of each tree-crop combination are presented in table 1. The field preparation involved two ploughings followed by harrowing and planking. Well rotten farm yard manure @ 20 t ha^{-1} was added at the time of field preparation and recommended basal doses of phosphorus and potassium for *M. pruriens* (80 kg P_2O_5 and 40 kg K_2O ha^{-1}) was also applied. Seeds of *M. pruriens* were direct sown in field at a spacing of 1x1 m, with the commencement of monsoon rains in last week of June. Nitrogen was applied two split doses. Half dose of N in the form of urea along with full basal doses of P and K was applied at time of seed sowing and remaining half dose was applied 60-70 days after seed sowing.

After germination, staking was done with wooden sticks of about 3 to 4 m length to provide support to growing vines. Hand weeding was done as and when required. The fodder yield (leaves and stems) was recorded 3 months after sowing. Fresh weight was recorded immediately after harvesting. Representative samples were weighed and oven dried to find out the dry fodder yield per hectare. The growth parameters (tree height, diameter, basal area and crown area) were measured following standard mensuration techniques and formulae. The growth parameters of all tree components are presented in table 2. The yield of fodder was recorded when the lower leaves turned yellow. Fodder yield for *G. optiva* and *M. alba* was recorded by removing all the leaves. The four cuttings (each year) were taken from *S. sphacelata*.

The data were analyzed statistically using the technique of analysis of variance for factorial randomized design in accordance with the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Fodder yield from intercrop

During first year of experiment, agroforestry systems did not influence the fodder yield significantly. However, it ranged from 15.26 to 15.76 t ha^{-1} (Table 3). The nitrogen doses applied to intercrop had a significant effect on fodder production. Maximum fodder yield of 17.42 t ha^{-1} was achieved with the application of 120 kg N ha^{-1}, whereas, it was minimum (13.50 t ha^{-1}) at 40 kg N ha^{-1}. The interaction effect due to agroforestry systems and nitrogen levels also showed significant effect on *M. pruriens* fodder yield. In first year, the maximum fodder yield of 17.92 t ha^{-1} was obtained from hortisilvi-pasture system (*P. persica* + *G. optiva* + *S. sphacelata* +*M. pruriens*) at nitrogen level of 120 kg ha^{-1}. However, interactions between T_2, T_3, T_4, T_5 and T_6 X 120 kg N ha^{-1} were statistically at par. The hortisilvi-pasture system (T_1) comprising *P. persica* + *G. optiva* + *S. sphacelata* +*M. pruieins* and application of 40 kg N ha^{-1} gave minimum *M. pruriens* fodder yield (12.84 t ha^{-1}), which was at statistically at par with T_2 and T_4 with respective fodder yield of 13.46 and 13.34 t ha^{-1}.

The second year studies showed that tree-crop combinations did not impart any significant effect on fodder yield; however, nitrogen levels as well as interaction effect of agroforestry systems X nitrogen doses had significant effect on fodder production (Table 3). The fodder yield ranged between 23.40 to 23.94 t ha^{-1}. Nitrogen dose of 120 kg ha^{-1} gave higher fodder yield (26.52 t ha^{-1}) over 40 and 80 kg N ha^{-1} and least was at an application of 40 kg N ha^{-1}. The interaction hortisilvi-pasture [T_1 (*P. persica* + *G. optiva* + *S. sphacelata* +*M. pruriens*)] and 120 kg N ha^{-1} produced maximum fodder (27.33 t ha^{-1}), however, interaction between agroforestry systems horti-silvipasture (T_2), hortipasture (T_3), silvi-pasture (T_4)and sole cropping (T_6) and nitrogen dose of 120 kg ha^{-1} were also at par at $P \leq 0.05$.

The study showed that the agroforestry systems had no significant influence on dry fodder yield of *M. pruriens* , which implies that it can be grown under all the systems. The nitrogen being responsible for vegetative growth had a positive effect on fodder yield. It is deduced from the present study that *M. pruriens* can be intercropped with fruit and fodder trees and fodder yield can be enhanced with the application of nitrogen. Fujii et al. (1991) have reported fodder yield from 20 to 30 t ha^{-1}, and the fodder yield obtained in the present study confirm the earlier findings.

Table 1 : Details of area occupancy and magnitude (per hectare) of different tree-crop combinations

Treatment code	Tree- crop combinations	Component	Spacing	No. of trees ha^{-1}	Land Area under Trees /grasses (m^2)	Land Area for intercropping Mucuna (m^2)
T_1	(*P. persica* +*G. optiva*+*S. sphacelata* +*MP*)	*P. persica*	5 x 10 m	200	2000	8000
		Grewia	1 x 10 m (3 trees in between 2 trees of peach)	600		
		Setaria	Planted in blocks (400 m^2) on strip for trees			
T_2	(*P. persica* +*M. alba* +*S. sphacelata*) + *MP*	*P. persica*	5 x 10 m	200	2000	8000
		Morus	1 x 10 m (3 trees in between two trees of peach)	600		
		Setaria	Planted in blocks (400 m^2) on strip for trees			
T_3	(*P. persica* +*S. sphacelata*+*MP*)	Peach	5 x 10 m	200	2000	8000
		Setaria	Planted in blocks (1200 m^2) on strip for trees			
T_4	(Grewia + *Setaria* + *MP*)	Grewia	1 x 10 m	1000	2000	8000
		Setaria	Planted in blocks (1000 m^2) on strip for trees			
T_5	(Morus +*S. sphacelata*+*MP*)	Morus	1 x 10 m	1000	2000	8000
		Setaria	Planted in blocks (1000 m^2) on strip for trees			
T_6	(*MP*)		-	Nil	Nil	8000

MP=*M. pruriens*

Table 2: Growth characteristics of fruit and fodder tree under tree-crop combinations

Tree-crop combinations	*P. persica*			*G. optiva*			*M. alba*		
	Average Height (m)	Average Diameter * (cm)	Average Crown area (m^2)	Average Height (m)	Average DBH (cm)	Average Crown area (m^2)	Average Height (m)	Average DBH (cm)	Average Crown area (m^2)
T_1 (P+G+S+MP)	3.31	13.13	7.31	3.60	4.91	3.41	-	-	-
T_2 (P+M+S+MP)	3.39	12.28	9.74	-	-	-	3.88	4.94	4.37
T_3 (P+S+MP)	4.11	19.79	16.09	-	-	-	-	-	-
T_4 (G+S+MP)	-	-	-	3.39	4.77	3.96	-	-	-
T_5 (M+S+MP)	-	-	-	-	-	-	4.59	5.31	9.75
T_6 (MP)	-	-	-	-	-	-	-	-	-

* 5cm above the graft union; P = *P. persica*, G = *G. optiva*, M = *M. alba*, S = *S. sphacelata*, MP = *M. pruriens*

Table 3: Effect of tree-crop combinations and nitrogen levels on fodder production ($t\ ha^{-1}$) from *M. pruriens* under different agroforestry systems

Nitrogen levels ($kg\ ha^{-1}$) / Agroforestry Systems	Mucuna fodder ($t\ ha^{-1}$)							
	2005				2006			
	N_{40}	N_{80}	N_{120}	Mean	N_{40}	N_{80}	N_{120}	Mean
T_1(P+G+S+ M)	12.85	15.01	17.92	15.26	19.41	23.45	27.33	23.40
T_2(P+M+S+ M)	13.46	15.97	17.80	15.74	20.29	24.21	26.87	23.79
T_3(P+S+ M)	13.77	15.84	17.19	15.60	20.85	24.10	26.41	23.79
T_4(G+S+ M)	13.34	15.48	17.36	15.39	20.34	23.46	26.45	23.41
T_5(M+S+ M)	13.93	15.66	16.94	15.51	21.18	23.83	25.69	23.57
T_6(M)	13.64	16.33	17.32	15.76	20.69	24.74	26.39	23.94
Mean	13.50	15.72	17.42		20.46	23.96	26.52	
$CD_{0.05}$								
T				NS				NS
N				0.27				0.49
T x N				0.67				1.20

P = *P. persica* , G = *G. optiva*, M = *M. alba*, S = *S. sphacelata*, M = *M. pruriens*

Table 4 : Total fodder production under different Tree-legume-grass based agroforestry systems

Agroforestry Systems	***G. optiva***	***M. alba***	***S. sphacelata***	***M. pruriens***	**Total**
			2005		
T_1[P+G+S+ M) Hortisilvi -pasture]	0.13	-	0.22	15.26	15.61
T_2[(P+M+S+ M) Hortisilvi -pasture]	-	0.28	0.22	15.74	16.24
T_3[(P+S+ M) Horti -pasture]	-	-	0.58	15.60	16.18
T_4[(G+S+ M) Silvipasture]	0.45	-	0.64	15.39	16.48
T_5[(M+S+ M) Silvipasture]	-	0.65	0.56	15.51	16.72
T_6[(M) pasture]	-	-	-	15.76	15.76
			2006		
T_1[P+G+S+ M) Hortisilvi -pasture]	0.25	-	0.23	23.40	23.88
T_2[(P+M+S+ M) Hortisilvi -pasture]	-	0.62	0.21	23.79	24.62
T_3[(P+S+ M) Horti -pasture]	-	-	0.65	23.79	24.44
T_4[(G+S+ M) Silvipasture]	0.67	-	0.65	23.41	24.73
T_5[(M+S+ M) Silvipasture]	-	1.5	0.54	23.57	25.61
T_6[(M) pasture]	-	-	-	23.94	23.94

P = *P. persica* , G = *G. optiva*, M = *M. alba*, S = *S. sphacelata*, M = *M. pruriens*

Fodder yield from trees and *Setaria* grass

The fodder yield from *G. optiva* under hortisilvi-pasture system (*P. persica* + *G. optiva* + *S. sphacelata* + *M. pruriens*) and silvipasture (*G. optiva* + *S. sphacelata* + *M. pruriens*) was 0.13 and 0.45 t ha^{-1} during 2005 and it was 0.25 and 0.67 t ha^{-1}, during 2006 from later two agroforestry systems (Table 4). The fodder yield of *M. alba* was 0.28 and 0.65 t ha^{-1} from hortisilvi-pasture system (*P. persica* + *G. optiva* + *S. sphacelata* +*M. pruriens*) and silvipasture system (*G. optiva* + *S. sphacelata* + *M. pruriens*), respectively, during 2005. In second year of experiment under same agroforestry systems *M. alba* fodder yield was 0.62 and 1.50 t ha^{-1}.

Setaria grass planted on the bunds between the fruit and fodder trees gave fodder yield ranging from 0.22 to 0.64 t ha^{-1} and 0.21 to 0.65 t ha^{-1} during 2005 and 2006, respectively (Table 4). The variation in *S. sphacelata* yield is attributed to the difference in net area under each agroforestry system. Similarly, the variation in yield of fodder trees under different tree-crop combinations is attributed to the magnitude of the respective tree species (Table 1). Whereas, variation during first and second year may be ascribed to the growth and effect of pollarding (1.5 m above ground level), which resulted in more coppice shoots and hence higher fodder yield.

In Himachal Pradesh, 36 per cent of the total geographical area is under pastures and grazing lands. Due to poor irrigation facilities and the climatic limitations, only 0.8 per cent (8,000 ha) of the total cultivated area is utilized for fodder crops production (Sood et al. 1995). There exists a gap of about 35.0 and 57.0 per cent from dry and green fodders, respectively. Every year on an average about 7450 t of wheat straw is imported annually from the neighboring states (Vashist et al. 2000). *M. pruriens* as fodder crop in association with fodder and fruit trees can be successfully grown and such models which would be able to reduce the gap of fodder supply. Agroforestry models would augment the quality fodder production and would provide fodder supply throughout the year. There is considerable area under orchards in sub tropical and temperate regions in States like Himachal. Inter spaces between fruit trees could be utilized for the production of fodder by growing legumes. Thus, the study revealed that *M. pruriens*, could be included for quality fodder production along with fodder and fruit trees under rain fed conditions. These systems if adopted will surely enhance the fodder production and milk yield of live stock in the hill farming system.

CONCLUSIONS

It can be concluded from the present study that *M. pruriens* can be grown as fodder crop in association with *P. persica* , *G. optiva*, *M. alba* and *S. sphacelata* and fodder yield can be increased with application of nitrogen. The models could be beneficial to the farmers of rain fed regions of W. Himalayas. To ensure year round supply of quality fodder these tree-crop combinations like *G. optiva*+*S. sphacelata* +*M. pruriens* or *Morua*+*S. sphacelata* +*M. pruriens* can be adopted. The *M. pruriens* being legume would not only provide fodder, increase milk yield of livestock but also improve the fertility of grass lands and fallows. The *G. optiva* and *M. alba* being multipurpose trees would also provide fuel wood and branches to obtain fiber and basket making, respectively, to the rural cottage industry.

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