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Performance of *Mucuna prurience* under Chirpine (*Pinus roxburghii*) Plantation of Mid Hills of Western Himalayas

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Abstract

The performance of *Mucuna pruriens* under *Pinus roxburghii* (Chir pine) plantation has been studied for consecutive two years to assess the growth and yield for its commercial exploitation and conservation. It was grown on three topographical aspects viz Northern, North western and Western at a spacing of 30 cm x 30 cm, followed by three tillage depths viz minimum (0 cm), Medium (up to 10 cm) and deep tillage (up to 15 cm). The growth parameters viz. vine length, leaf area and leaf area index were statistically not affected by topographical aspects and tillage practices during harvesting stage in both understorey and open conditions. Higher yield was observed in crop growing in open conditions than understorey of Chir pine. However on the basis of positive Net returns *Mucuna pruriens*, under agroforestry system, seems to prove its economic viability as the gross returns was higher than the cost of cultivation. Hence *Mucuna pruriens* can be suggested as potential intercropping for developing *Pinus roxburghii* based silvi- medicinal system which will help utilizing an unutilized part of land and increase total productivity from such lands besides conservation of the species.

Keywords: Topographical aspects; Tillage; Bio-economic appraisal; Leaf area index (LAI); *Mucuna prurience; Pinus roxburghii*

Introduction

Mucuna pruriens, also known as Cowhage, and velvet bean contains a very powerful neurotransmitter precursor L-Dopa. L-Dopa is an amino acid that converts into dopamine which is an essential component of our body and it's required for proper functioning of the brain. All parts of *Mucuna* possess valuable medicinal properties [1,2] and there is a heavy demand of *Mucuna* in Indian drug markets. After the discovery that *Mucuna seeds* contain L-dopa, an anti-Parkinson's disease drug, its demand in international market has increased many fold [3] and demand has motivated Indian farmers to start commercial cultivation. Besides medicinal properties, *Mucuna* fixes nitrogen and is as a green manure and cover crop.

The itching bean *Mucuna pruriens* (L.) DC var. pruriens is an underutilized legume species grown predominantly in Asia, Africa, in parts of America [4]. The plant can grow in a range of habitats and could become naturalised in grasslands, bushland, riverine forest and forest edges throughout tropical and subtropical regions [5]. Most *Mucuna* species exhibit reasonable tolerance to a number of abiotic stresses; including drought, low soil fertility, and high soil acidity, although they are sensitive to frost and grow poorly in cold, wet soils [6]. The genus thrives best under warm, moist conditions, below 1500 m above sea level (asl), and in areas with plentiful rainfall. Velvet bean (*Mucuna pruriens* (L.) is a tropical legume, grown generally for green manure increases the yield of its companion graminaceous crops and smothers the growth of harmful weeds such as nuts edge (*Cyperus spp*.) and alang-alang (*Imperata cylindrica*).

India in particular has as wide range of soil and climatic variation in realms of degraded forests and waste lands which offer a unique situation to try different developmental systems on land use to rehabilitate the environment with renewable green cover of economic species. Chir pine is widely planted for timber in its native area, being one of the most important trees in forestry in northern Pakistan, India and Nepal. Usually, the accumulating carpet of needles on the forest floor under these trees makes it unsuitable for many common plants and trees to grow. This aspect of Chir pine offers a unique situation for the promotion and conservation of suitable medicinal and aromatic plants. So in order to utilize the unutilized space in the understorey of Chir pine a field experiment was conducted to introduce *Mucuna pruriens* in the understorey of Chir pine forest of mid hills of western Himalayas. Therefore present studies are undertaken on the possibility of raising Kaunch (*Mucuna pruriens*) under Chir pine.

Material and Methods

The investigations were carried out at different aspects in Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. The experimental site is located within 30° 51' N latitude and 76° 11' E longitude (survey of India Toposheet No. 55 F/1) at an elevation of 1250 m above mean sea level. The climate of the area is transitional between subtropical to sub-temperate with maximum temperatures risings up to 37.8°C during summer. The mean annual temperature is 19.8°C. In general May and June are the hottest months whereas December and January are the coldest ones. The annual rain fall ranges between 800-1300 mm of which 75 per cent is received during mid June to mid September. Growth and yield of Kaunch (*Mucuna pruriens*) integrated under Chir pine and without Chir pine (Open) on different aspects and under different tillage practices were studied separately. Hence, studies involved three factors i.e. topographical aspects, tillage practices and systems (crop grown in understorey of Chir pine and in open conditions). Kaunch was grown on three aspects viz Northern (A1), North western (A2) and Western (A3) at a spacing of 30 cm x 30 cm, followed by three tillage depths viz minimum (T1: 0 cm), Medium (T2: up to 10 cm) and deep tillage (T3: up to 15 cm). The 18 treatments, including all possible combination of three aspects, three tillage depths and two systems were used for the evaluation of velvet bean performance under three replicates in factorial randomized block design.

Experimental field was prepared by removing the pine needles and tillage practices were done just before the onset of monsoon. Plots were prepared as per the treatment details under different tillage practices. The whole experiment was conducted under rain fed conditions entirely dependent on the monsoon rains. Keeping in view the forest site conditions no irrigation and fertilizer was applied and the selection of Velvet bean as medicinal plant was done on the basis of its minimum input requirement for irrigation and fertilizers. For the transplanting of seedlings nursery was prepared and with the commencement of monsoon and after getting the sufficient moisture availability in the soil in first fortnight of July, direct seeding of velvet bean collected from the local plant communities were done in the experimental field. The crop was harvested in the month of December. The observations on growth parameters (vine length, leaf area and leaf area index) were recorded at vegetative, pre-bloom and harvesting stage. Whereas, the data for the yield and the yield attributes were measured at the time of harvesting. To make the economic appraisal for Velvet bean based silvi-medicinal system, the yield of respective species was subjected to economic analysis by calculating cost of cultivation, gross and net returns per hectare.

Results and Discussion

The year wise data pertaining to growth and yield attributes in understorey and open are presented in Tables 1-5 and is described as follows:

Vine length, leaf area and leaf area index did not differ significantly by different topographical aspects and tillage practices in both understorey and open conditions (Table 1). However, on all aspects and under different tillage practices significantly higher value of vine length, leaf area and leaf area index was found in open conditions as compared to understorey of Chir pine. Seed yield did not vary significantly by different topographical aspects and tillage practices in both understorey of Chir pine and open conditions. However, on all aspect and under different tillage practices significantly higher value of seed yield (1.363 t/ha) was found in open conditions as compared to understorey of Chir pine (1.356 t/ha). Similar trend was found with respect to above ground biomass and below ground biomass by different aspects and tillage practices. The yield reduction (0.5 %) in understorey could be because of the lower value of leaf area (Table 1) and below ground dry weight (Table 2) on all aspect and tillage practices than the open conditions. Thus the significantly lower value of all growth character and yield (Table 1-4) in understorey conditions than open condition can be attributed to adverse effect of tree canopy and higher intensity of shade in understorey conditions than the open conditions. This suggests that the plants grown in the open field as sole crop has better opportunities to reap more solar energy for photosynthetic activity, less intra-specific competition for critical resources like water, nutrients, and photo synthetically active radiations. These favorable factors seem to result in higher values of growth parameters and seed yield of velvet bean grown in the open conditions. Chauhan, Karikalan et al., Thakur and Singh [7-10] have earlier made similar observations for different agricultural crop under agroforestry system. Apart from above the lower values of grown parameters and yield attributes in understorey of *Pinus roxburghii* might be because of the possibility of accumulation of phytotoxin in soil over number of year, which might led to allelopathic interaction with crops, cannot be ruled out.

Table 1: Effect of topographical aspect on vine length, leaf area and leaf area index of *Mucuna pruriens* in understorey and open condition.

Aspect	Vine length (m)		Leaf area (cm^2)		Leaf area index (LAI)	
	Harvesting stage		Harvesting stage		Harvesting stage	
	Understorey	Open	Understorey	Open	Understorey	Open
A_1:Northern	3.20	3.23	193.20	194.20	2.13	2.14
A_2:NorthWestern	3.24	3.27	194.80	197.00	2.14	2.15
A_3:Western	3.29	3.34	198.60	201.00	2.15	2.17
Mean (S: System)	3.24	3.28	195.50	197.60	2.14	2.15
$CD_{0.05}$	NS		0.35		NS	
SEm±	0.01		0.17		0.002	
$CD_{0.05}$ (S)	0.02		0.20		0.002	
SEm ± (S)	0.01		0.10		0.001	

Table 2: Effect of topographical on biomass and yield (t/ha) of *Mucuna pruriens* in understorey and open condition.

Aspect	Above ground dry weight (t/ha)		Below ground dry weight (t/ha)		Yield (seed) (t/ha)	
	Understorey	Open	Understorey	Open	Understorey	Open
A_1:Northern	9.280	9.470	0.173	0.176	1.348	1.356
A_2:NorthWestern	9.360	9.540	0.176	0.181	1.356	1.362
A_3:Western	9.410	9.600	0.180	0.184	1.365	1.371
Mean (S: System)	9.350	9.540	1.760	1.800	1.356	1.363
$CD_{0.05}$	NS		0.0006		NS	
SEm±	0.02		0.0003		0.003	
$CD_{0.05}$ (S)	0.02		0.0004		0.003	
SEm± (S)	0.01		0.0002		0.002	

Table 3: Effect of tillage practices on vine length, leaf area and leaf area index of *Mucuna pruriens* in understorey and open condition.

Tillage	Vine length (m)		Leaf area (cm^2)		Leaf area index (LAI)	
	Harvesting stage		Harvesting stage		Harvesting stage	
	Understorey	Open	Understorey	Open	Understorey	Open
T_1: Minimum	3.21	3.23	194.50	196.50	2.13	2.14
T_2: Medium	3.24	3.27	195.60	198.70	2.14	2.16
T_3: Deep	3.28	3.34	196.50	197.60	2.15	2.16
Mean (S: System)	3.24	3.28	195.50	197.60	2.14	2.15
$CD_{0.05}$	NS		NS		NS	
SEm±	0.03		0.17		0.002	
$CD_{0.05}$ (S)	0.02		0.20		0.002	
SEm± (S)	0.01		0.10		0.001	

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Table 4: Effect of tillage practices on biomass and yield (t/ha) of *Mucuna pruriens* in understorey and open condition.

Tillage	Above ground dry weight (t/ha)		Below ground dry weight (t/ha)		Yield (seed) (t/ha)	
	Understorey	Open	Understorey	Open	Understorey	Open
T_1: Minimum	9.19	9.36	0.174	0.177	1.340	1.347
T_2: Medium	9.38	9.56	0.177	0.181	1.359	1.365
T_3: Deep	9.48	9.69	0.179	0.183	1.369	1.377
Mean (S: System)	9.35	9.54	1.760	1.800	1.356	1.363
$CD_{0.05}$	NS		NS		NS	
SEm±	0.02		0.0003		0.003	
$CD_{0.05}$ (S)	0.02		0.0004		0.003	
SEm± (S)	0.01		0.0002		0.002	

Table 5: Bio-economic appraisal of *Mucuna pruriens* (Rs/ha).

Treatment combination	*Mucuna pruriens*		
	Gross return (Rs.)	Cost of cultivation (Rs.)	Net return (Rs.)
$A_1T_1S_1$	22835	7268	15567
$A_1T_2S_1$	23007	8367	14640
$A_1T_3S_1$	23165	8965	14200
$A_1T_1S_0$	20123	8283	11840
$A_1T_2S_0$	20340	9246	11094
$A_1T_3S_0$	20565	10271	10294
$A_2T_1S_1$	22438	7796	14643
$A_2T_2S_1$	22746	8870	13876
$A_2T_3s_1$	22933	9835	13098
$A_2T_1S_0$	20205	8855	11350
$A_2T_2S_0$	20498	9839	10658
$A_2T_3S_0$	20610	10875	9735
$A_3T_1S_1$	22720	8823	13898
$A_3T_2S_1$	23110	9630	13480
$A_3T_3S_1$	23230	10762	12469
$A_3T_1S_0$	20303	9756	10547
$A_3T_2S_0$	20610	10909	9701
$A_3T_3S_0$	20790	12105	8685

A_1: Northern aspect, A_2: North-Western aspect, A_3: Western aspect, T_1: Minimum tillage, T_2: Medium tillage, T_3: Deep tillage, S_1: Understorey, S_0: Open

Bio-economic appraisal of *Mucuna pruriens*

The total cost of cultivation in *Mucuna pruriens* have been found different for different treatments which include the fixed and the variable cost. The experiment involving *Mucuna pruriens* as intercrop clearly indicates higher net returns when crop was growing on northern aspect under minimum tillage in understorey conditions followed by Rs 14,643 ha^{-1} for crops grown on north western aspect under minimum tillage in understorey conditions. The minimum net returns (Rs. 8685 ha^{-1}) were obtained for crops growing on western aspect

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under deep tillage in open conditions. In all different treatment combinations, higher net returns were observed in understorey than open conditions (Table 5).

The higher value of gross returns in *Mucuna pruriens,* in understorey conditions is attributed to the additional returns from the trees, which resulted in average higher gross returns from crops cultivated in understorey conditions than open (Table 5).

The positive net returns in case of, *Mucuna pruriens* may be due to their suitability in the environment given in open conditions and in association with the Chir pine. This finding can be supported by the Harrington et al. [11] who initiated a research to determine the separate effects of above and below ground competition and needles fall from overstorey pines on understorey plant performance and found that depending on species the effects of needle fall were positive, negative, or negligible. While the positive net returns in *Mucuna pruriens* are attributed to lower cost of cultivation than gross returns (Table 5). The lower cost of cultivation in the given condition can be due to three distinct reasons viz. the lower rental value of land in association with Chir pine in understorey and open conditions; no application of fertilizers and irrigation practices and lower cost of planting material as direct seeding was done in case of *Mucuna pruriens* in the given conditions.

Thus the successful cultivation of these species namely *Mucuna pruriens,* can be recommended only in the wasted land having lower rental value like land in association with Chir pine. This finding can be supported by Chatterjee et al. [12] who reported that targeted species like *Andrographis paniculata* etc. could better flourish on natural ecosystem under *in-situ* conditions and the conservation and cultivation of these species under controlled cultural practices did not prove to be economically feasible under *ex-situ*.

Conclusion

As there is a greater demand for *Mucuna pruriens* in international market and also the pressure on the natural forests for these plants is increasing day by day. Hence in a situation like Chir Pine forests having very less or no understorey growth, the integration of *Mucuna pruriens* led to the successful performance of *Mucuna prurience* with positive net returns. Thus *Mucuna pruriens* and *Pinus roxburghii* based innovative silvi- *medicinal system* endeavour to use the unutilized lands of Chir Pine forest by associating vines of *Mucuna pruriens* to improve the productivity of these forests. This agroforestry model can have a potential implications not only in improving the fertility of soil as velvet beans being nitrogen fixing in nature but also in reducing the fire hazards when pine needles piled up on the forest floor. This study leaves a scope of its implementation in the Chir pine growing belt of the continent if this innovative silvi-medicinal system is adopted by the local farmers or the forest department.

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