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Economic analysis of wheat and *Dalbergia sissoo* based Agrisilviculture system in central India

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Abstract
A field experiment was carried out at Dusty Acre Research Farm, Department of Forestry, JNKVV, Jabalpur to assess the Economic viability of wheat and *Dalbergia sissoo* based Agrisilviculture System. The Cost of cultivation was found more when *D. sissoo* were pruned in different pruning intensities viz 25%, 50% and 75% (Rs. 17803 ha^{-1}) as compared to crop grown alone (Rs. 12000). Tree alone without crop recorded lowest cost (Rs. 3807 ha^{-1}). This might be due to fact that more expenditure was incurred in pruning treatments under managed Agroforestry system where as no pruning (tree alone) has low cost (Rs. 3807 ha^{-1}). 25% pruning with variety MP 3173 recorded maximum benefit: cost ratio (3.68) as compared and sole crop (2.76) Higher gross monetary return was recorded in 25% pruning (Rs. 78782 ha^{-1}) as compared to other pruning. the probable reason of higher gross monetary return in 25% pruning due to more expenditure in cultivation of crop and pruning.

Keywords: Economics, B:C Ratio, net monetary, GMR, agroforestry

Introduction
Agroforestry, the word coined in early seventies, has made its place in all the developed and the developing countries of the world. So, Agroforestry is defined as a "Land use system that involves deliberate retention, introduction of trees or woody perennials with crop and /or animal production to benefit from the resultant ecological and economic interactions" (Nair, 1993) [5]. The agrisilviculture (tree+crop) system is more productive and sustainable than agriculture. Agrisilviculture will receive a major thrust in Madhya Pradesh not only for fuel, fodder and small timber production but also for organic matter build up in poor and marginal soil.

An increasing demand of fuel wood and fodder and lack of the cash and infrastructure in many developing countries are some of the most relevant arguments for tree integration into farming and pastoral areas. Producing a high level of output of economic goods i.e. fuel, fodder, small timber, organic fertilizers etc. and also Providing stable employment improved income and basic material to rural populations (Solanki, 1998) [6]. In Madhya Pradesh, as traditional Agroforestry system, tree legumes (e.g. *Acacia nilotica*, *Butea monosperma* and *Dalbergia sissoo*) were found growing respectively for fuel, fodder and small timber purpose in both extensive grazing system and in association with field crop. The most suitable trees for Agroforestry system are those having less spread canopy, fast growth, and clean bole, nitrogen fixing capacity and protein rich fodder. *Dalbergia sissoo* Roxb (Shisham), is one of them a moderately fast growing and nitrogen fixing tree has an advantage to include in agroforestry system. The species is famous for afforestation/reforestation both in social forestry and in agroforestry programmes in different parts of Madhya Pradesh and India.

Material and Method
The Present investigation or Experiment was conducted at Dusty Acre Research Farm, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur during Rabi season of 2012 in 13 year old *Dalbergia sissoo* based Agrisilviculture. Jabalpur is situated at 23° 9' North Latitude and 79.58' East longitude at an altitude of 411.78 meters above the mean sea level. It comes under the agroclimatic region classified as Kymore plateau and Satpura hills and is broadly known as rice –wheat crop zone of Madhya Pradesh. This region has typically arid & semi arid zone climate with hot dry summer and cold winters.

The mean annual rainfall of Jabalpur is 1350 mm mostly received between mid of June to September with occasional rains during winter. The mean monthly temperature goes down to the limit of 4 °C during winter, while the maximum temperature reaches as high as 45 °C during summer. Generally relative humidity remains very low during summer (15 to 30%), moderate (60 to 75%) during winter and it attains high value (80 to 95%) during rainy season.

Economics of the treatment

The economics of the treatment is very important to find out the most profitable treatment and for determining overall economic advantages of wheat crop from practical point of view to farmers. Therefore economics of different treatments were worked out in terms of cost of cultivation, gross monetary (GMR), net monetary return (NMR) and benefit: cost ratio (B: C ratio) to ascertain economic viability of the treatments.

Cost of Cultivation

The cost of cultivation for each treatment was determined on the basis of different inputs used for raising the crop and tree under different treatments on hectare area basis.

Gross monetary returns (GMR)

The value realized from the produce obtained under each treatment was computed on the basis of existing market price of the produce. Total values of the produce (Grain and straw from crop and pruned biomass and stand biomass from tree) were taken as gross monetary return (GMR) per hectare under different treatments.

Net monetary return (NMR)

Net monetary return (NMR) per hectare under each treatment was determined by subtracting the cost of cultivation of a particular treatment from the GMR of the same treatment.

Benefit: Cost ratio (B: C ratio)

To estimate the benefit obtained from different treatment for each rupee of expenditure incurred, B: C ratio of each treatment was calculated as below:

$$\text{B: C ratio} = \frac{\text{Gross monetary return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Result and discussion

Grain and Straw yield (q ha^{-1})

The date pertaining to grain yield and straw yield clearly showed that grain yield and straw yield of wheat was significantly influenced by different pruning treatments and different wheat varieties (Table 1)

Table 1: Grain yield, straw yield and harvest index of wheat as influenced by different pruning intensities and different varieties in agrisilviculture system.

Treatment	Gran yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)
Pruning treatment			
P0	17.74	34.53	33.92
P25	19.47	38.46	33.62
P50	21.27	41.54	33.83
P75	24.40	47.78	33.78
Open- No tree	27.20	53.23	33.81
SEM	0.66	4.21	0.11
CD at 0.05	1.99	12.55	NS
Wheat varieties			
V1 – Sujata	20.86	43.27	32.51
V2- MP 3173	23.28	43.35	34.96
V3 – MP 3288	21.91	42.71	33.90
SEM±	0.73	4.42	0.25
CD at 0.05	2.09	NS	0.72

Grain yield (q ha^{-1})

Significantly maximum grain yield of wheat was recorded when grown under open condition (27.20 q ha^{-1}). Among different pruning intensities, significantly maximum grain yield was recorded under 75% pruning (24.4 q ha^{-1}) which inturn was significantly superior to 50% pruning (21.27 q ha^{-1}) and 25% pruning (19.47 q ha^{-1}). No pruning recorded significantly lowest grain yield (17.74 q ha^{-1}). The percent reduction in grain yield under no pruning 25%, 50% and 75%. Pruning as compared to open condition was 34.75%, 28.41%, 21.80% and 10.29% respectively.

The wheat Variety MP-3173 recorded significantly higher grain yield (23.28 q ha^{-1}) at par with MP 3288 (21.91 q ha^{-1}) but significantly, superior to variety Sujata which recorded significantly lowest grain yield (20.86 q ha^{-1}). The percent reduction in grain yield under Sujata, MP 3288 as compared to MP 3173 was 10.3% and 7.6% respectively.

Straw yield (q ha^{-1})

Straw yield was recorded higher in Open condition (53.23 q ha^{-1}) which was significantly superior over different pruning treatments and no pruninng. Among different pruning treatment, 75% pruning recorded maximum straw yield (47.78 q ha^{-1}) which was superior to 50% pruning (41.54 q ha^{-1}) and 25% pruning (38.46 q ha^{-1}). No pruning recorded significantly lowest straw yield of 34.53 q ha^{-1}. The percent reduction in straw yield under no pruning, 25% pruning, 50% pruning, 75% pruning over open condition (no tree) was 35.13%, 27.74%, 21.96% and 10.23% respectively.

Wheat varieties showed no significant effect on straw yield, however variety Sujata recorded higher straw yield as compared to variety MP 3173 and MP 3288.

Harvest Index

Different wheat varieties showed significant effect on harvest index. Variety MP 3288 recorded significantly higher harvest index (34.96) followed by MP 3288 (33.90). Variety Sujata recorded lowest harvest index (32.51).

Growth observation on tree

Growth of shisham (*Dalbergia sissoo*)

Growth performance of tree i.e. tree height, dbh, canopy spread (N-S, E-W), pruned biomass, cylindrical volume and stand biomass at 13 years old shisham as influenced by different pruning intensities and different wheat varieties are presented in Table 2

Table2: Morphological growth characters and biomass of *D. sissoo* on influenced by different pruning intensities and wheat varieties under agrisilviculture system.

Treatment	Height (m)	Dbh (cm)	Canopy spread (m)		Pruned biomass (Kg ha^{-1})	Cylindrical volume (m^2 ha^{-1})	Stand biomass (q ha^{-1})
			N-S	E-W			
Pruning treatment							
P_0 – No Pruning	9.68	20.49	7.76	7.48	-	138.94	1079.55
P_{25} – 25%	10.83	21.61	6.19	6.82	390	182.31	1416.54
P_{50} – 50%	10.06	18.12	5.33	5.77	488	116.93	908.57
P_{75} – 75%	9.04	14.38	3.63	4.11	537	65.46	508.65
SEm ±	0.434	1.55	0.31	0.08	11.02	24.32	189.02
CD at 0.05	1.336	4.77	0.96	0.24	33.0	74.90	582.18
Wheat varieties							
V1 – Sujata	10.65	20.49	5.85	6.10	475	162.87	1265.50
V2- MP 3173	9.59	21.61	5.74	6.12	479	147.11	1143.08
V3 – MP 3288	9.76	18.12	5.75	6.00	464	96.10	750.59
Tree alone	7.62	14.38	5.58	5.96	468	97.06	754.14
SEm±	0.77	1.63	0.35	0.37	43	15.34	119.19
CD at 0.05	NS	NS	NS	NS	NS	43.41	337.3

Tree height (m)

Different pruning intensities and wheat varieties showed significant effect on tree height 25% pruning recorded significantly taller tree height (10.53 m) closely followed by 50% pruning (10.06 m) and no pruning (9.68) but significantly superior to 75% pruning. Varieties showed no significant effect on tree height.

Diameter at breast height

Different pruning intensities showed significant effect on dbh-25%. Pruning recorded significantly higher dbh (21.61 cm) at par with no pruning (20.49 cm) and 50% pruning (18.12 cm) but significantly superior to 75% pruning which recorded significantly lowest diameter (14.38 cm) Varieties showed no significant effect on dbh.

Canopy spread (N-S and E-W direction)

Different pruning intensities showed significant effect on canopy spread in N-S and E-W direction. No pruning recorded significantly higher canopy spread in both N-S (7.76 m) and E-W (7.48 m) directions which was significantly superior to other pruning treatment. As the pruning intensities increased, canopy spread decreased. Among pruning treatments, 25% pruning recorded significantly higher canopy spread in both direction i.e. N-S (6.19 m) and E-W (6.72 m) where as 75% pruning recorded lowest canopy spread in N-S (3.63 m) and E-W (4.2 gm) directions. Varieties showed no significant effect on canopy spread in both directions.

Pruned biomass (kg ha^{-1})

Different pruning intensities showed significant effect on pruned biomass. As the pruning intensities increased pruned biomass increased significantly; hence 75% pruning recorded significantly higher pruned biomass (537 kg ha^{-1}) followed by 50% pruning (488 kg ha^{-1}). 25% pruning recorded significantly lowest pruned biomass (390 kg ha^{-1}) Varieties showed no significant effect on pruned biomass.

Cylindrical volume (m^3 ha^{-1})

Different pruning intensities showed significant effect on cylindrical volume of tree. 25% pruning recorded significantly higher cylindrically volume (182.31 m^3 ha^{-1}) followed by no pruning (138.94 m^3 ha^{-1}) and 50% pruning (116.93 m^3 ha^{-1}). 75% pruning recorded significantly lowest cylindrical volume (65.46 m^3 ha^{-1}).

Varieties showed significant effect on cylindrical volume. Variety Sujata recorded significantly more cylindrical volume (162.87 m^3 ha^{-1}) closely followed by MP 3173 (147.11 m^3 ha^{-1}) and was significantly superior to MP 3288 (96.10 m^3 ha^{-1}) and tree alone (97.06 m^3 ha^{-1}) which were at par.

Stand biomass (q ha^{-1})

Different pruning intensities showed significant effect on stand biomass of the tree. At the age of 13 years, significantly highest stand biomass was recorded in 25% pruning (1413.08 q ha^{-1}) closely followed by no pruning (1079.55 q ha^{-1}) and 50% pruning (908.57 q ha^{-1}). 75% pruning recorded significantly lowest (508.64 q ha^{-1}) stand biomass.

Varieties showed significant effect stand biomass. Sujata recorded significantly higher stand biomass (1265.50 q ha^{-1}) closely followed by MP 3173 (1143.08 q ha^{-1}) and was significantly superior to tree alone (754.14 q ha^{-1}) and MP 3288 (750.59 q ha^{-1}) which were at par.

Table 3: Economic analysis of different treatments on per hectare area basis

S.N	Treatment	Cost of cultivation (Rs ha^{-1})	Gross monetary return (Rs ha^{-1})	Net Monetary return (Rs ha^{-1})	Benefit cost ratio
1.	No Pruning + Sujata	15807	55596	39789	2.51
2.	No Pruning + MP 3173	15807	52968	37161	2.35
3.	No Pruning + MP 3288	15807	43015	27208	2.72
4.	Tree alone	3807	12603	8796	2.30
5.	25% Pruning + Sujata	16807	70623	53816	3.20
6.	25% Pruning + MP 3173	16807	78782	61975	3.68
7.	25% Pruning + MP 3288	16807	54159	37352	2.22
8.	Tree alone	4807	34972	30165	6.27
9.	50% Pruning + Sujata	17807	58834	41027	2.31
10.	50% Pruning + MP 3173	17807	51306	33499	1.88
11.	50% Pruning + MP 3288	17807	50912	33105	1.85
12.	Tree alone	5807	11302	5496	0.96
13.	75% Pruning + Sujata	18807	53751	34944	1.85
14.	75% Pruning + MP 3173	18807	58489	39682	2.10
15.	75% Pruning + MP 3288	18807	46376	27569	1.46
16.	Tree alone	6807	13147	6340	0.93
17.	Open – crop only (Sujata)	12000	41606	29606	2.46
18.	Open – crop only (MP 3173)	12000	45224	33224	2.76
19.	Open – crop only (MP 3288)	12000	43035	31035	2.58

Note: - Sale rate of paddy, straw, pruned biomass and standing tree biomass @ Rs. 12, Rs. 2, Rs. 1 and Rs. 3 per kg respectively.

Cost cultivation

Cost of cultivation for wheat crop varied under different treatments. Under Semi irrigated condition, wheat crop required an investiment of Rs. 12000 for common expenditure on different operations and inputs (Appendix-III). Result presented in table 4.6 revealed that cost of expenditure on raising one hectare of wheat was maximum (Rs. 17807 ha^{-1}) under different pruning intensities (25,50, and 75%) with different varieties of wheat through the expenditure cost varies from Rs. 3807 ha^{-1} (tree alone) to Rs. 17807 ha^{-1} (pruning with different wheat varieties).

Gross monetary return (Rs. ha^{-1})

The GMR in table 3 Indication that different treatments showed significant effect on gross monetary return maximum GMR (Rs. 75355 ha^{-1}) was recorded in 25% pruning with MP 3173 wheat varieity, where as lowest GMR (Rs. 11374 ha^{-1}) was recorded when tree grown alone.

Table 4: Net monetary return (Rs. ha^{-1}) of different pruning intensities in *D. sissoo* with different varieties of wheat

Wheat Pruning varieties Intensity	Sujata	MP 3173	MP 3288	Mean	Tree alone (No crop)
P_0 – No Pruning	50726	46697	34815	44080	28837
P_{25} – 25% pruning	51334	59547	35528	48800	34584
P_{50} – 50% pruning	46017	36426	41855	41433	26174
P_{75} – 75% pruning	34262	39415	26999	33559	21448
Open – No tree	29606	33224	31035	31289	
Mean	42387	43062	34046	39831	27760
SEm ± CD at 0.05					
Pruning intensities	4537	13567			
Wheat Varieties	1926	5489			

Net monetary return (Rs. ha^{-1})

Higher monetary return was recorded in *D. sissoo* 25% pruning + wheat crop (Rs. 48800 ha^{-1}) followed by no pruning (Rs. 44080 ha^{-1}) 50% pruning (Rs. 41433 ha^{-1}). 75% pruning recorded lowest monetary return (Rs. 33559 ha^{-1}). Managed agroforestry system, 25% pruning (Rs. 48800 ha^{-1}) gave higher monetary return as compared to crop alone (Rs. 39831 ha^{-1}) and tree alone (Rs. 27760 ha^{-1}). The probable reason of higher return in unmanaged agroforestry system is that sufficient return obtained from both tree and crop components as compared to tree alone and crop alone, whereas in tree alone or crop alone, return obtained only from one component either from tree or crop alone. Several studies in different part of the country suggest that agroforestry system is more profitable than only agriculture or forestry (Chaturvedi 1981; Lahiri, 1983; Mathur *et al.* 1984; Chandra, 1986 and Patel, 1988) [2, 3, 4, 1]

Benefit: Cost Ratio

It refers to net monetary return under a particular treatment with each rupee of investment. It was recorded that B:C ratio is maximum (4.76) in 25% pruning with variety MP 3173. Variety MP 3173 recorded highest B:C ratio (2.76) as compared to variety MP 3288 (2.58) and Sujata (2.46).

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