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

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2k.8849

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:

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\text{Benefit: Cost ratio (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)

| Treatment       | Grain yield (q ha⁻¹) | Straw yield (q ha⁻¹) | Harvest Index (%) |
|-----------------|----------------------|----------------------|-------------------|
| **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 pruning. 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.

Table 2: Morphological growth characters and biomass of D. sissoo on influenced by different pruning intensities and wheat varieties under agri-silviculture system.

| Treatment     | Height (m) | Dbh (cm) | Canopy spread (m) | Pruned biomass (Kg ha⁻¹) | Cylindrical volume (m² ha⁻¹) | Stand biomass (q ha⁻¹) |
|---------------|------------|----------|-------------------|--------------------------|-----------------------------|------------------------|
| P₀ – No Pruning | 9.68       | 20.49    | 7.76              | 7.48                     | -                           | 138.94                 | 1079.55                |
| P₂₅ – 25%     | 10.83      | 21.61    | 6.19              | 6.82                     | 390                         | 182.31                 | 1416.54                |
| P₅₀ – 50%     | 10.06      | 18.12    | 5.33              | 5.77                     | 488                         | 116.93                 | 908.57                 |
| P₇₅ – 75%     | 9.04       | 14.38    | 3.63              | 4.11                     | 537                         | 65.46                  | 308.65                 |
| CD at 0.05    | 0.43±      | 1.55     | 0.31              | 0.08                     | 11.02                       | 24.32                  | 189.02                 |
| Wheat varieties                              | 1.33±      | 4.77     | 0.96              | 0.24                     | 33.0                        | 74.90                  | 582.18                 |
| 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                 |
| CD at 0.05    | 0.77       | 1.63     | 0.35              | 0.37                     | 43                          | 15.34                  | 119.19                 |
|               | 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 treatments. 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) whereas 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 (m³ ha⁻¹)
Different pruning intensities showed significant effect on cylindrical volume of tree. 25% pruning recorded significantly higher cylindrical volume (182.31 m³ ha⁻¹) followed by no pruning (138.94 m³ ha⁻¹) and 50% pruning (116.93 m³ ha⁻¹). 75% pruning recorded significantly lowest cylindrical volume (65.46 m³ ha⁻¹).

Stand biomass (q ha⁻¹)
Different pruning intensities showed significant effect on stand biomass of 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 highest 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 investment 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 variety, 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 Varieties | Intensity | Sujata | MP 3173 | MP 3288 | Mean | Tree alone (No crop) |
|-----------------|-----------|--------|---------|---------|------|---------------------|
| P₀ – No Pruning | 50726 | 46697 | 34815 | 44080 | 28837 |
| P₂ – 25% pruning | 51334 | 59547 | 35528 | 48800 | 34584 |
| P₀ – 50% pruning | 46017 | 36426 | 41855 | 41433 | 26174 |
| P₇ – 75% pruning | 34262 | 39415 | 26999 | 33559 | 21448 |
| Open – No tree | 29606 | 33224 | 31035 | 31289 | |

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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