Economic feasibility of *Melia composite* - radish based agrisilviculture systems

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**Abstract**

The present study was undertaken to assess the economic feasibility of *Melia composita* (8m × 5m, 8m × 4m) - radish based agrisilviculture and sole radish cropping systems. Among different cropping systems 

[M. composita (8m × 5m)-radish, *M. composita* (8m × 4m) - radish, and sole radish], the highest net returns of Rs. 2,92,364 per hectare and benefit-cost ratio (3.60) were obtained from *M. composita* (8m × 5m) - radish based system followed by sole cropping system while the lowest net returns of Rs. 2,19,918 ha⁻¹ were obtained from closer spacing (8m × 4m) of *M. composita*. The present study pointed out that, intercropping of radish with *M. composita* at the spatial arrangement of 8m × 5m contributed the highest net returns even in later growth of tree development (up to 12 years). It indicates that *M. composita* - radish based agrisilviculture system can give better economic returns compared to the sole cropping system.

**Keywords:** Agroforestry, *Melia composita*, radish, economics, net returns

**Introduction**

Agroforestry is an agriculture technique of growing food crops and trees on the same land and has been labeled as “the future of agriculture”. It is widely practiced in the Himalayan region particularly; the Indian Himalayas represent 18% of India’s land area. The Indian Himalayas occupy a special place in the mountain ecosystems of the world. This region is not only important from the standpoint of climate and as a provider of life, giving water to a large part of the Indian subcontinent, but it also harbours a rich variety of flora, fauna, human communities, and cultural diversity. Agroforestry plays a vital role in the Indian economy by way of tangible and intangible benefits. In fact, agroforestry has high potential for simultaneously satisfying three important objectives viz., protecting and stabilizing the ecosystems, producing a high level of output of economic goods, and improving income and basic materials to the rural population. It has helped in the rehabilitation of degraded lands on one hand and has increased farm productivity on the other. At present agroforestry meets almost half of the demand of fuelwood, 2/3 of the small timber, 70-80 per cent wood for plywood, 60 per cent raw material for paper pulp, and 9-11 per cent of the green fodder requirement of livestock, besides meeting the subsistence needs of households for food, fruit, fiber, medicine, etc. It is also realized that agroforestry is the only alternative to meet the target of increasing forest cover to 33 per cent from the present level of less than 25 per cent (Dhyan et al., 2013) [4].

*M. composita* Willd. (Syn. *M. dubia* Cav.), commonly known as Malabar neem, is an indigenous, fast-growing, multipurpose, short rotation, and valuable timber species that emerged as one of the most suitable tree species for different agroforestry systems. It is being planted in the agroforestry system either in block plantation or along the farm boundary. It occurs mostly in tropical moist deciduous forests of the Sikkim, Himalayas, north Bengal, upper Assam, Khasi Hills, north circle, Deccan, and the Western Ghats at an altitude of 1200 to 1800 meters. It is valued for its high-quality fungus and termite resistant timber for furniture, agricultural implements (Suprapti et al., 2004) [14], as substitute pulpwood species, fuelwood, and leaf used as a fodder. The flowers are said to provide excellent bee forage. The industrial and ecological significance of *M. composita* has encouraged the farmers to take large scale plantations with different intercrops (Parthiban et al., 2009) [10].
In the mid-Himalayan range, it is being preferred by the farmers to meet for fodder in scarcity, fuel, charcoal, tool handles, and making agricultural implements. Radish (Raphanus sativus L.) belongs to the genus Raphanus, family Brassicaceae or Cruciferae, originated from the Central and Western China and India. It is one of the most ancient vegetables. Radish is a good source of vitamin A and vitamin C and minerals like calcium, potassium, iron, and phosphorus. The most popular eating part of radish is the tuberous roots although the entire plant is edible and the tops can be used as a leafy vegetable. It is a popular root vegetable in both tropical and temperate regions. It is a fast-growing winter crop and produces large bio-mass in a short time. It can be cultivated undercover for early production but large scale production in field is more common in India. It is invariably suggested that the adoption of any agroforestry technology is believed and adopted if it is economically viable (Bhusara et al., 2016, Mohanty et al., 2017) [1, 8]. Therefore, a combination of Radish - M. composita was evaluated for its economic feasibility in the mid-Hill zone of Himachal Pradesh.

Materials and methods
The present study was conducted at the experimental farm of Agroforestry, Dr. Y S Parmar University of Horticuluture and Forestry, Nauni. The area is located at 30° 51’ N latitude and 76° 11’ E longitude, with an elevation of 1200 m above mean sea level and slope of 7-8 per cent, which falls in the sub-tropical, sub-humid agro-climatic zone of Himachal Pradesh, India. Radish (Var. Japanese white) was intercropped in 5.4 m² plots size at 30 cm × 10 cm spacing under 13-year old M. composita spaced at 8m × 5m and 8m × 4m and as sole cropping systems. The experiment was conducted in a randomized block design with three replications and the treatments were; T1- M. composita (8m × 5m) + Radish, T2- M. composita (8m × 4m) + Radish, and T3- (Sole Radish).

The radish crop was harvested and cumulative yield was considered in economic analysis. In the case of M. composita, standing biomass at the age of 12 years was taken into account. Stem wood biomass of M. composita was computed following the standard formula: \[ ff = \frac{2h}{3h} \] where, \( ff \) - form factor, \( h_i \) - height at which diameter is half of dbh, which was measured manually by climbing on trees, \( h \) - total height of the tree (Pressler, 1865 and Bitterlich, 1984) [12]. The volume of standing trees was calculated by Pressler’s formula (1865) [12] and expressed in cubic meters. \[ V = ff \times h \times g, \text{ where, } V \text{ - volume, } ff \text{ - form factor, } h \text{ - total tree height, } g \text{ - basal area.} \]

The volume per hectare was calculated by multiplying the mean volume with the number of trees per hectare. Biomass = average specific gravity of stem wood × volume. The specific gravity used for M. composita, 0.93 (Ranot and Sharma, 2013) [13].

The branch wood biomass of M. composita was estimated as per following procedure; the total numbers of branches irrespective of size were counted on each of the sample tree, and then these were categorized on the basis of basal diameter into three groups, viz., < 6 cm, 6-10 cm and >10 cm. The fresh weight of two sampled branches from each group was recorded separately in the field and representative samples were taken to the laboratory for moisture and dry weight determination.

The dry weight of branches was determined using following formula;

\[ \text{moiture per cent} = \frac{\text{Fresh weight—oven dry weight}}{\text{oven dry weight}} \times 100 \]

Total green biomass = Average fresh weight of sample × number of branches,

\[ \text{Total dry biomass} = \frac{\text{Dry weight of sample}}{\text{Fresh weight of sample}} \times \text{Total fresh weight of branches/ leaves and twigs.} \]

Total branch biomass per sample tree was determined as given by:

\[ \text{Bbt} = n_1bw_1 + n_2bw_2 + n_3bw_3 = S \text{nibwi} \]

Where, Bbt - Branch biomass (fresh/dry) per tree, \( n_i \) - Number of branches in the \( i \)th branch group, \( bw_i \) - average weight of branch of \( i \)th group, \( i = 1, 2, 3 \).

Results and discussion
The prices of inputs and cost of cultivation of M. composita + radish based agroforesticulture and as sole cropping systems are given in Tables 1 and 2. The gross and net returns from radish and wood biomass production (per hectare under each land-use system) was worked out on the basis of prevailing market rates of radish and M. composita wood (Table 1). The net returns from agroforesticulture systems are based on the annual standing biomass of M. composita up to the age of 12 years.

The outcomes introduced in Table 3 pointed out that, among M. composita - radish based agroforesticulture and sole radish cropping systems, on account of radish production, the most noteworthy net returns of Rs. 244689 ha"” were gained from the sole cropping system followed by M. composita (8m × 5m) + radish and minimum (Rs. 160454 ha"”) were acquired from M. composita (8m × 4m) + radish based agri-silviculture system. This is ascribed to the higher production of radish in sole cropping. Slightly lower production under trees is attributed to competition and low light under trees in the early stage of the growth of radish. On the other hand, on account of the stem and branch wood biomass (annual average of 12 years) of M. composita, the highest (Rs. 59464 ha"”) net returns were accrued from closer spacing of M. composita (8m × 4m) while, least (Rs. 50039 ha"”) were acquired from wider spacing of M. composita (8m × 5m). The higher net return from closer spacing is ascribed to the fact that closer spacing accommodates more numbers of trees per hectare.

Data introduced in Table 4 revealed that, overall, M. composita (8m × 5m) - radish based system provided the maximum net returns to the tune of Rs. 292364 ha"" followed by sole cropping system (Rs. 244689 ha"”) while M. composita (8m × 4m) - radish based agri-silviculture system provided the most reduced net returns (Rs. 219918 ha"”) Dutt and Thakur, (2004) [5] detailed that net returns were relatively more under agroforestry systems by combining Ocimum sanctum and Tegetes minuta with poplar at various spacing in contrast with mono-cropping. Similarly, Prajapati et al. (2020) [11] revealed the most elevated net returns of Rs. 164135 ha"” from M. dubia - Sorghum Sudan grass-based silvipasture system. Jilariya et al. (2019) [6] reported net returns of Rs. 336360 ha"” from M. dubia - Aloe vera based silvi-medicinal systems, which are higher contrasted with the present study. Chandana et al. (2020) [3] in rainfed conditions of Hyderabad have revealed net returns (Rs. 166775 ha"”) from 6 years of old M. composita and Rs. 169732 ha"” from M. composita - Pearl millet-based agri-silviculture system. Meena (2015) [7] has reported average net
returns of Rs. 79,652 ha from ber based horti-pasture system. Verma and Thakur (2011) have reported returns ranging from Rs. 20286 to 58614 per hectare from agroforestry systems. The variation in net returns from various agroforestry systems might be because of nature, age, and prevailing market rates of outputs. Results on the economic feasibility of M. composita + radish based agrosilviculture and as sole radish cropping on BCR, NPV and IRR pointed out that, among M. composita - radish based agrosilviculture and sole cropping systems, the maximum BCR (3.60) and IRR (24%) were estimated from M. composita (8m × 5m) - radish based agrosilviculture system followed by sole radish cropping system with BCR (3.21) however, it showed higher NPV (222444.7) compared to tree-based land-use systems. The economic feasibility analysis expressed that wider (8m × 5m) spacing of M. composita is more viable compared to sole cropping. Among all the systems under study, higher net returns were obtained from M. composita (8m × 5m) - radish based agrosilviculture system hence, found economically superior compared to the rest of the land-use systems in the study. Nandal and Kumar (2010) gained the highest NPV (67326), B: C ratio (1.75:1), and IRR (55%) from M. azedarach based agroforestry system involving dhaincha barseem as intercrop. The economics of agroforestry systems vary with the nature of components, prevailing edpho-climatic conditions, and market rates of outputs derived.

**Conclusion**

The economic returns from agroforestry systems are well documented by earlier researchers however, most of them are only up to 5 to 6 years of plantation and have suggested intercropping in the early stage of tree growth. The present study pointed out that, intercropping of radish with M. composita at the spatial arrangement of 8m × 5m contributed the highest net returns even in later growth of tree development (up to 12 years). It indicates that M. composita - radish based agrosilviculture system can give better economic returns compared to the sole cropping system. The IRR and BCR analysis likewise expressed that wider spacing (8m × 5m) of M. composita when intercropped with radish could be the most economically viable system. Consequently, wider spacing (8m × 5m) of M. composita is proposed for intercropping of radish even in the later stage of tree growth and development.

**Table 1:** Prevailing of inputs prices (Rs.) used and outputs from land use systems

| S. No. | Commodity                  | Price (Rs.) |
|-------|---------------------------|-------------|
| I.    | Cost of per unit inputs   |             |
| 1     | Radish seeds              | 1000 kg dub |
| 2     | M. composita seedlings    | 5 seedling  |
| 3     | Farmyard manure           | 250 quintal |
| 4     | Urea                      | 15 kg       |
| 5     | Single super phosphate    | 10 kg       |
| 6     | Murate of potash          | 18 kg       |
| 7     | Labour wages              | 300 day     |
| 8     | Tractor charges per hour  | 600 hr      |
| II.   | Per unit output price     |             |
| 9     | Fresh Radish (leaves + root) | 10 kg |
| 10    | M. composita stem wood    | 4500 t      |
| 11    | M. composita branch wood  | 2000 t      |

*Price used as per local retailer in Nauni, Solan. **https://www.indiamart.com/sriraghavendranurseries-plantations.

**Table 2:** Cultivation and maintenance cost (Rs. /ha) of Radish and M. composita

| A | radish | Land use systems | T1 | T2 | T3 |
|---|--------|------------------|----|----|----|
| 1 | Material Cost |                |    |    |    |
| A | Cost of seeds  | 8000            | 8000 | 8000 |    |
| B | FYM         | 25000           | 25000 | 25000 |    |
| C | Urea        | 1413.03         | 1413.03 | 1413.03 |    |
| D | Single super phosphate | 3000 | 3000 | 3000 |    |
| E | Murate of potash | 1080 | 1080 | 1080 |    |
| 2 | Labour Cost |                |    |    |    |
| a) | Ploughing | 2400           | 2400 | 2400 |    |
| b) | Preparation of beds | 4500 | 4500 | 4500 |    |
| c) | Sowing | 3000            | 3000 | 3000 |    |
| d) | Manures application | 3000 | 3000 | 3000 |    |
| e) | Weeding/Hoeing/earthing up | 15000 | 16500 | 16500 |    |
| f) | Irrigation | 6000 | 6000 | 6000 |    |
| g) | Picking/ Harvesting | 13500 | 12900 | 13500 |    |
| b) | Transportation | 3000 | 3000 | 3630 |    |
| 3 | Miscellaneous cost (2% of sub-total) | 1668 | 1686 | 1722.6 |    |
| 4 | Interest on working capital (7% of sub-total) | 5838 | 5901 | 6029.1 |    |
| Total Variable Cost | 90906 | 91887 | 93881.7 |    |
| 5 | Fixed Cost |                |    |    |    |
| Land rent | 10000 | 10000 | 10000 |    |
| Depreciation | 250 | 250 | 250 |    |
| Land revenue | 31.25 | 31.25 | 31.25 |    |
| Interest on fixed capital (7% of sub-total) | 719.68 | 719.68 | 719.68 |    |
| Total Fixed Cost | 11000.93 | 11000.93 | 11000.938 |    |
| Total Cost | 101906.94 | 102887.94 | 104882.64 |    |

| B | M. composita (up to 12 years) |    |    |    |
|---|-------------------------------|----|----|----|
| 1 | Site Preparation | 1000 | 1000 |    |
Table 3: Gross and net returns (Rs. /ha) from Melia composita – Radish based Agrisilviculture and sole cropping systems

| Land use systems | Total radish yield (t/ha) | Cost of cultivation (Rs. /ha) | Gross Returns (t/ha) | Net returns (t/ha) | Wood biomass (t/ha) | Cost of Cultivation (Rs. /ha) | Gross Returns (Rs. /ha) | Net Returns (Rs. /ha) | Net returns (Rs. /ha/yr) | Total net returns from land use systems |
|------------------|---------------------------|-------------------------------|---------------------|-------------------|-------------------|-----------------------------|------------------------|----------------------|-------------------------|--------------------------------------|
| Radish           |                           |                               |                     |                   |                   |                             |                        |                      |                         |                                      |
| T1               | 350.22                    | 107895                        | 350220              | 242325            | 24.18             | 44.02                       | 5                     | 56380               | 656850                  | 308.91                               |
| T2               | 269.33                    | 108786                        | 269330              | 160454            | 52.08             | 38.80                       | 6                     | 60387               | 773960                  | 244689                               |
| T3               | 355.56                    | 110871                        | 355560              | 244689            | -                 | -                           | -                     | -                   | -                       | -                                    |

Table 4: Overall economic feasibility of Melia composita – Radish based Agrisilviculture and sole cropping systems

| Land use Systems | Total Cost (ha⁻¹ yr⁻¹) | Gross returns (ha⁻¹ yr⁻¹) | Net returns (ha⁻¹ yr⁻¹) | Benefit cost ratio (BCR) | Net present value (NPV) | Internal rate of return (IRR) |
|------------------|------------------------|---------------------------|-------------------------|--------------------------|-------------------------|-------------------------------|
| M. composita (8 × 5) + Radish | 112593 | 404958 | 292364 | 3.60 | 189759.9 | 24% |
| M. composita (8 × 4) + Radish | 113908 | 333827 | 210918 | 2.93 | 188487.8 | 23% |
| Sole Radish | 110871 | 355560 | 244689 | 3.21 | 222444.7 | - |

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