



Growth and Yield of Trees and Intercrops under Different Agroforestry System in Lohardga District of Jharkhand

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ABSTRACT

*In Bhandra block of Lohardaga district farmers are adopting different land use practices (such as agriculture and agroforestry systems) on their agricultural land, but they do not know the economic importance of different systems. In the present study has been made to emphasize the importance of different land use systems. Among the agroforestry systems viz. agrisilviculture, agrihorticulture, silvipastoral and homegarden systems, the wood production by *Leucaena leucocephala* under agrisilviculture was found highest (112.00 cu.m.ha⁻¹), under agrihorticulture in *Syzygium cumini* (52.00 cu.m.ha⁻¹), in silvipastoral *Dalbergia sissoo* (37.50 cu.m.ha⁻¹), whereas in homegarden *Gmelina arborea* produced maximum wood volume (100.00 cu.m.ha⁻¹). The yield performances of agricultural, vegetables and grasses have indicated addition benefits from same land. Therefore, rural people should make some strategy for the implementation of agroforestry model with suitable combination of trees and field crops, and this combination does not only generate income for the upliftment of socioeconomic value but also concerns the ecological and environmental stability on the sustained basis.*

Key words: Growth, yield, agrisilviculture, agrihorticulture, silvipastoral, homegarden

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INTRODUCTION

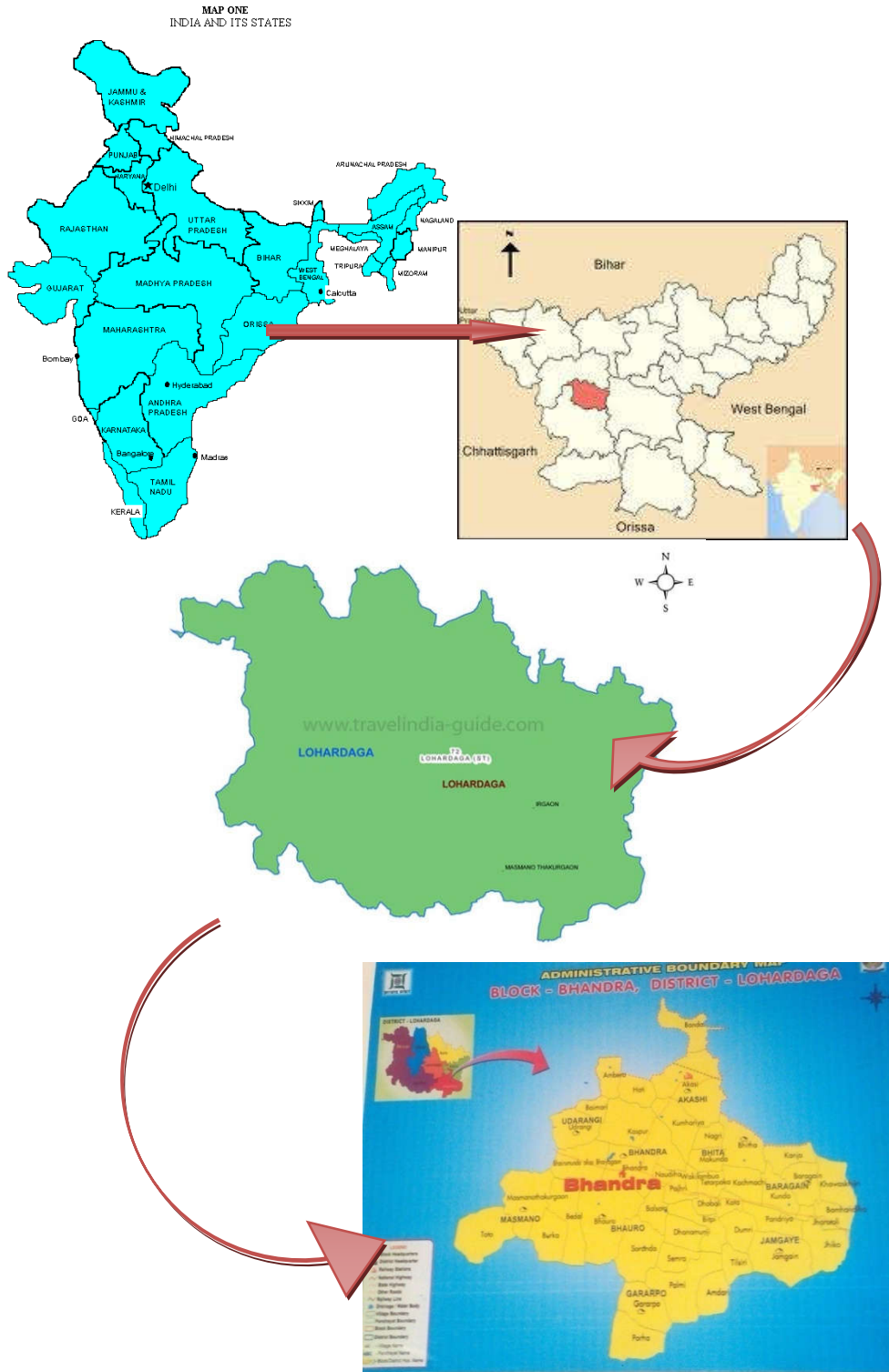
Agroforestry is a dynamic, ecologically based natural resource management system that, through which the integration of trees/ woody perennials in farm and rangelands, diversifies and sustains production for increased social, economic and environmental benefits [1]. The science of agroforestry system centres around four factors – competition, complexity, sustainability and profitability – and there should be a balance among all these factors to get fruitful returns. The density of trees/shrubs varied from one agroforestry system to another, depending upon the availability of the resources [2] Agroforestry can provide a sound ecological basis for increased crop and animal productivity, more dependable economic returns, and greater diversity in social benefits on a sustained basis [3]. Agroforestry although not new in itself, requires new strategies and technologies as compared to traditional or modern agriculture and forestry [4] Agroforestry is only one best alternative to cope these situations and the indigenous and traditional knowledge of agroforestry practices is very essential to explore and document for its betterment. Farmers have ownership to cultivate different agroforestry practices on their farmland. Since the investigation of local practices would be a powerful and efficient means of extending the scientific understanding the identification and dissemination of existing practices will make easy in extending scientific intervention. A complex interaction association of different (tree & crop) components of agroforestry systems is witnessed. The tree has an influence on growth and yield of agriculture crops and vice-versa. Therefore, it becomes necessary to know the comparative performance of tree as well as crops in pure and agroforestry systems. In Bhandra block many farmers grow agriculture crop side by side of tree species. The tree is either grown in isolation or in a planned way on the agriculture fields. However, the farmers are not aware of the relative importance of tree along with agriculture crops. Keeping in view, the significance of agroforestry as one of the most important land use practices, the present study emphasizes the growth and yield of trees and intercrops under different agroforestry system in Bhandra block of Lohardga district.

MATERIALS AND METHODS

Site condition

The experiential site located at Bhandra block under Lohardaga districts lies at 23° 21' 0" North, 84° 48' 0" East longitude and is situated at distance of 75 Km from Birsa Agricultural University campus. The experiential site is surrounded by mountains. The general climate of the region is sub-tropical and the annual average temperature is 23 °C the highest temperature goes to 42 °C in summer and lowest of 8 °C in winter. The site receives an annual rainfall of 1000 to 1600 mm. The mean relative humidity is about 76.28% in the area. The monsoon breaks out in the middle of June and lasts until mid-October.

Site location



MATERIAL AND METHODS

The investigation is based on a sample of 80 households practising agroforestry selected randomly from a total population, using questionnaire specially designed for the purpose. The farmers are classified on the basis of landholding into Below 1 ha, 1 to 2 ha, 2 to 4 ha, 4 to 10 ha and more than 10 ha. The agroforestry practices were classified as per the standard classification of [5]. Four agroforestry practices (agrisilvicultural, Agri-horticulture, silvopastoral and home garden) were identified on the basis their components. The distribution of land into major agricultural crops is related to the crop year 2014-15. For growth measurement of 20 tree species were randomly selected from each agroforestry system and different growth parameters such as diameter at breast height (DBH) and height were measured to see the performance of tree species in the different system. On this basis of height and DBH, bole wood volume of individual species was calculated. Quadrate of 1m × 1m size selected randomly to measure the yield of agricultural crops, vegetables crops and grasses, which were converted on a hectare basis in agriculture, agrisilviculture, agrihorticulture, silvopastoral and home garden.

RESULTS AND DISCUSSION

Table1: Land holding size of respondents of Bhandra block

Landholding size	Average Land Holding Size	Number & Percentage
Below 1 ha	0.85	5 (6.25)
1 to 2 ha	1.55	40(50.00)
2 to 4 ha	2.84	30(37.50)
4 to 10 ha	5.20	5(6.25)

The data of the landholding size of the household has indicated that the maximum 50.00% of respondents were under 1-2 ha followed by 37.50% in 2-4 ha and the minimum was 6.25% in 1ha. Similar, study carried by [6] the marginal farmers had an average land holding of 0.71 ha, the small farmer had a land holding of 3.14 Ha while the medium to large farmer holding size was 3.46 ha thus the overall holding size of the sample farmers in Aligarh district was 1.52 ha. In Ranchi district, the average land holding of the farmers ranges between 2.79 to 3.75 acres in all surveyed village [7]. In North West India 52% of the large farmers (those owning more than 2.5 ha.) 17.5 % of the small farmers (owning between 0.5 and 2.5 ha) and 5% of tiny farmers (with less than 0.5 ha) planted trees on their farm under agroforestry concept [8]. [9] have presented a survey of agroforestry system undertaking in the Mussoorie hills near Dehradun (U.P.). About 80% of landholdings were <1 ha, 15% were 1-2.5 ha and 5% were 2.5-10 ha and also [10] describe the most of the farmers were small, having > 1 ha of land for agricultural production. This finding supports the present finding become a percentage of small landholding are more than large landholding.

Performance of biological components

Growth performance

The Growth parameters diameter and height of tree species under the Agrisilvicultural system is presented in Table. The tree species like *Artocarpus heterophyllus*, *Azadirachta indica*, *Dalbergia sissoo*, *Gmelina arborea*, *Leucaena leucocephala*, *Melia azadarech*, *Syzygium cumini*, *Tectona grandis*, etc were found in agrisilvicultural system in Bhandra block. A perusal of data has indicated that *Gmelina arborea* had attained maximum height (8.18 m) followed by *Azadirachta indica* (7.41 m) and minimum height was found in *Tectona grandis* (6.16 m). In case of diameter, the maximum diameter was found in *Leucaena leucocephala* (16.20 cm) followed by *Artocarpus heterophyllus* (15.39 cm) and the minimum was found in *Tectona grandis* (9.70 cm). In Agri-horticultural system tree species like *Artocarpus heterophyllus*, *Litchi chinensis*, *Mangifera indica* and *Syzygium cumini* were found in Agri-horticultural system in Bhandra block. A perusal of data has indicated that *Artocarpus heterophyllus* had attained maximum height (7.08 m) followed by *Syzygium cumini* (6.92 m) and minimum height was found in *Litchi chinensis* (4.28 m). In case of diameter the maximum diameter was found in *Syzygium cumini* (15.61 cm) followed by *Artocarpus heterophyllus* (12.13 cm) and the minimum was found in *Mangifera indica* (10.30 cm). In Silvopastoral system tree species like *Dalbergia sissoo* and *Mangifera indica* were found in silvopastoral system in Bhandra block. Perusal of data has indicated that *Dalbergia sissoo* had attained maximum height (6.34 m) and minimum height *Mangifera indica* (4.33m). In case of diameter the maximum diameter was found in *Dalbergia sissoo* (10.51 cm) and minimum in *Mangifera indica* (9.96 cm) and in Homegarden system tree species like *Artocarpus heterophyllus*, *Azadirachta indica*, *Dalbergia sissoo*, *Gmelina arborea*, *Litchi chinensis*, *Mangifera indica*, *Syzygium cumini* and *Tectona grandis* were found in homegarden system in Bhandra block. Perusal of data has indicated that *Gmelina arborea* had attained maximum height (8.87 m) followed by *Artocarpus heterophyllus* (7.17 m) and minimum height was found in *Litchi*

chinensis (4.21 m). In case of diameter the maximum diameter was observed in *Syzygium cumini* (15.15 cm) followed by *Artocarpus heterophyllus* (14.43 cm) and minimum was found in *Tectona grandis* (9.73 cm). A tree growth (height and collar diameter) was better in agroforestry than in sole tree plantings [11]. The growth of *Eucalyptus* attained the maximum tree height (13.94 m) followed by *Leucaena* (13.02 m) and *Casuarina* (10.40 m), in seventh year [12]. According to [13] growth of ten tree species of agroforestry system and noticed maximum height growth in *Albizia lebbeck* (9.10m) followed by *Melia azedarach* (6.8m) and *Eucalyptus* hybrid (7.3m) at five year age, where as the maximum girth was found in *Melia azedarach* (66.0 cm) followed by *Albizia lebbeck* (39.67cm) and *Eucalyptus* hybrid (37.00cm). [14] It have presented data on tree growth rate and forages production under 6 multipurpose tree species (*Eucalyptus camaldulensis*, *Dalbergia sissoo*, *Acacia nilotica*, *Ziziphus mauritiana*, *Tecomella undulate* and *Prosopis cineraria*). *E. camaldulensis* attained the maximum height and collar girth (12.85 m and 55 cm, respectively) and minimum growth was observed with *P. cineraria* (height 3.87 m and collar girth (22 cm). however, forage production was maximum under *P.cineraria* and minimum under *E.camaldulensis*. [15] Describe that in Silvipastoral system average DBH of Gamhar (13.72 cm) was found more than Akashi (8.23 cm). Similarly, average height of Gamhar (10.20 m) was also found more than Akashi (6.45 m). [15] Observed under home gardens a subtype of agroforestry land use practices maximum DBH growth was observed in *Eucalyptus* (16.58 cm) followed by Gamhar (13.64 cm), while Bakain Showed a DBH growth of 11.01 cm. Similarly, maximum height was noticed for *Eucalyptus* (12.25 m) followed by Bakain (7.87 m) and lowest height growth was observed in case of Gamhar (7.12 m).

Table2:- Growth parameters diameter and height of tree species under Agroforestry Systems at 10 years age

S.N.	Name of species	Agrisilvcultural system		Agrihorticultural system		Silvipastoral system		Homegarden system	
		Height (m)	Diameter (cm)	Height (m)	Diameter (cm)	Height (m)	Diameter (cm)	Height (m)	Diameter (cm)
1.	<i>Artocarpus heterophyllus</i>	7.41 ± 0.23	15.39 ± 0.49	7.08 ± 0.10	12.13 ± 1.26	-	-	7.17 ± 0.16	14.43 ± 0.26
2.	<i>Azadirachta indica</i>	6.88 ± 0.23	12.82 ± 2.34	-	-	-	-	6.78 ± 0.10	13.22 ± 0.35
3.	<i>Dalbergia sissoo</i>	6.30 ± 0.37	12.17 ± 1.14	-	-	6.34 ± 0.83	10.51 ± 1.14	6.54 ± 0.26	13.69 ± 0.81
4.	<i>Gmelina arborea</i>	8.18 ± 0.13	12.24 ± 0.55	-	-	-	-	8.87 ± 0.32	13.63 ± 1.04
5.	<i>Leucaena leucocephala</i>	6.63 ± 0.26	16.20 ± 0.79	-	-	-	-	-	-
6.	<i>Litchi chinensis</i>	-	-	4.28 ± 0.69	10.83 ± 0.71	-	-	4.21 ± 0.87	12.46 ± 0.37
7.	<i>Mangifera indica</i>	-	-	4.31 ± 0.18	10.30 ± 0.46	4.33 ± 0.20	9.96 ± 0.24	4.44 ± 0.16	11.87 ± 1.18
8.	<i>Melia azadarech</i>	7.15 ± 0.18	14.41 ± 0.30	-	-	-	-	-	-
9.	<i>Syzygium cumini</i>	6.78 ± 0.25	14.89 ± 0.37	6.92 ± 0.18	15.61 ± 0.36	-	-	6.69 ± 0.13	15.15 ± 0.43
10.	<i>Tectona grandis</i>	6.16 ± 0.33	9.70 ± 0.32	-	-	-	-	6.41 ± 0.35	9.73 ± 0.43

Figures shows with ± are standard error of mean

Volume produced by tree species

The data on bole volume production of tree species grown under different agroforestry systems are shown in table. The volume production of Agrisilvcultural system tree species like *Artocarpus heterophyllus*, *Azadirachta indica*, *Dalbergia sissoo*, *Gmelina arborea*, *Leucaena leucocephala*, *Melia azadarech*, *Syzygium cumini*, *Tectona grandis*, etc were found in agrisilvcultural system in Bhandra block. A perusal of data has indicated that the species the maximum volume was found in *Leucaena leucocephala* (112 m³.ha⁻¹) followed by *Artocarpus heterophyllus* (81.25 m³.ha⁻¹) and the minimum was found in *Melia azadarech* (68.75 m³.ha⁻¹). However volume production Agri-horticultural system tree species like *Artocarpus heterophyllus*, *Litchi chinensis*, *Mangifera indica* and *Syzygium cumini* were found in Agri-horticultural system in Bhandra block. A perusal of data has indicated that the maximum volume was found in *Syzygium cumini* (52 m³.ha⁻¹) followed by *Artocarpus heterophyllus* (32 m³.ha⁻¹) and the minimum was found in *Mangifera indica* (20 m³.ha⁻¹). The volume production of silvipastoral systems tree species like *Dalbergia sissoo* and *Mangifera indica* were found in silvipastoral system in Bhandra block.

Perusal of data has indicated that *Dalbergia sissoo* had attained the maximum volume was found in *Dalbergia sissoo* (37.5 m³.ha⁻¹) and minimum was found in *Mangifera indica* (12.00 m³.ha⁻¹) and volume production of Homegarden system tree species like *Artocarpus heterophyllus*, *Azadirachta indica*, *Dalbergia sissoo*, *Gmelina arborea*, *Litchi chinensis*, *Mangifera indica*, *Syzygium cumini* and *Tectona grandis* were found in homegarden system in Bhandra block. A perusal of data has indicated that the maximum volume was found in *Gmelina arborea* (100.00 m³.ha⁻¹) followed by *Artocarpus heterophyllus* (68.75 m³.ha⁻¹) and the minimum was found in *Azadirachta indica* and *Dalbergia sissoo* (62.5 m³.ha⁻¹). According to [15] volume production in agrisilviculture system for individual tree species has shown higher value for Subabul (422.50 m³ha⁻¹) followed by Shisham (417.50 m³ha⁻¹), whereas volume production of Gamhar was found less (122.50 m³ha⁻¹) as compared to other species and in Silvipastoral system volume production was noticed by Gamhar (377.50 m³ha⁻¹). Similarly, volume of Eucalyptus for (168.75 m³ha⁻¹) under Homegardens was found highest than any other species of three agroforestry sub-systems (agrisilviculture, Silvipastoral and Homegardens).

Table 3: Growth parameters volume production of tree species under Agroforestry Systems at 10 years age

S.N.	Name of species	Agrisilvicultural system	Agrihorticultural system	Silvipastoral system	Homegarden system
		Volume (m ³ .ha ⁻¹)	Volume (m ³ .ha ⁻¹)	Volume (m ³ .ha ⁻¹)	Volume (m ³ .ha ⁻¹)
1.	<i>Artocarpus heterophyllus</i>	81.25	32	-	68.75
2.	<i>Azadirachta indica</i>	62.5	-	-	62.5
3.	<i>Dalbergia sissoo</i>	62.5	-	37.5	62.5
4.	<i>Gmelina arborea</i>	62.5	-	-	100
5.	<i>Leucaena leucocephala</i>	112	-	-	-
6.	<i>Litchi chinensis</i>	-	16	-	20
7.	<i>Mangifera indica</i>	-	20	12.00	20
8.	<i>Melia azadarech</i>	68.75	-	-	-
9.	<i>Syzygium cumini</i>	48	52	-	75
10.	<i>Tectona grandis</i>	31.25	-	-	37.5

Yield of agricultural, horticultural and grasses

The major agricultural crops *Oryza sativa*, *Zea mays*, *Zingiber officinale*, *Capsicum annum* and *Colocasia schott* are mainly grown in Kharif season under agroforestry system whereas *Triticum aestivum*, *Brassica nigra*, *Pisum sativum*, *Lycopersicon esculentum*, *Allium cepa*, *Solanum melongena* and *Solanum melongena* in rabi season under agroforestry system. Perusal of data has indicated that in kharif season, *Zingiber officinale*, *Capsicum annum* and *Colocasia schott* were grown in both agrihorticulture and homegarden system whereas *Zea mays* was grown in agrisilvicultural and homegarden system. The *Oryza sativa* was grown only in agrisilvicultural system in kharif season. The yield of *Oryza sativa* was 24.17qha⁻¹ in agrisilvicultural system whereas the yield of *Zea mays* was 20.65qha⁻¹ in agrisilvicultural system and 20.5qha⁻¹ in homegarden system. The yield of *Zingiber officinale*, *Capsicum annum* and *Colocasia schott* were 3.45, 8.47, 3.85 qha⁻¹ respectively in agrihorticultural system whereas 3.41, 7.95, 3.55 qha⁻¹ respectively in homegarden system.

Table 4:Yield of agricultural crop, horticultural crops and grasses under agroforestry system in Bhandra block

Name of crops	Local name	Agrisilvicultural (qha ⁻¹)	Agrihorticultural (qha ⁻¹)	Silvipastoral (qha ⁻¹)	Homegarden (qha ⁻¹)
Kharif crop					
<i>Oryza sativa</i>	Paddy	24.17 ± 0.18			
<i>Zea mays</i>	Maize	20.65 ± 0.21			20.5 ± 0.21
<i>Zingiber officinale</i>	Ginger		3.45 ± 0.09		3.41 ± 0.09
<i>Capsicum annum</i>	Chilly		8.47 ± 0.13		7.95 ± 0.13
<i>Colocasia schott</i>	Kacchu		3.85 ± 0.09		3.55 ± 0.12
Rabi crop					
<i>Triticum aestivum</i>	Wheat	19.9 ± 0.23			
<i>Brassica nigra</i>	Mustard	5.55 ± 0.16			
<i>Solanum tuberosum</i>	Potato	15.85 ± 0.22			14.85 ± 0.22
<i>Pisum sativum</i>	Pea	9.07 ± 0.13			8.62 ± 0.14
<i>Lycopersicon esculentum</i>	Tomato	13.15 ± 0.20	12.15 ± 0.21		12.55 ± 0.36
<i>Allium cepa</i>	Onion				10 ± 0.53
<i>Solanum melongena</i>	Brinjal		4.85 ± 0.48		4.75 ± 0.52
<i>Cynodon dactylon</i> + <i>Cyperus scariosus</i> etc.	Grasses			340 ± 5.55	

Figures shows with ± are standard error of mean

In rabi season, *Triticum aestivum* and *Brassica nigra* were grown under agrisilvicultural system where as *Solanum tuberosum* and *Pisum sativum* were grown both under agrisilvicultural system and homegarden system respectively. *Lycopersicon esculentum* was grown in all the agroforestry system i.e. in agrisilvicultural, agrihorticultural and homegarden system. whereas *Allium cepa* was only grown in homegarden system. *Solanum melongena* was grown in agrihorticultural and homegarden system. . The yield of *Triticum aestivum* and *Brassica nigra* was 19.9 and 5.55 q ha⁻¹ respectively under agrisilvicultural system whereas the yield of *Solanum tuberosum* and *Pisum sativum* was 15.85 and 9.07 qha⁻¹ respectively under agrisilvicultural system and 14.85 and 8.62 qha⁻¹ respectively under homegarden system. The yield of *Lycopersicon esculentum* was 13.15, 12.15, 12.55 qha⁻¹ respectively in agrisilvicultural, agrihorticultural and homegarden system respectively. The yield of *Allium cepa* was 10 q ha⁻¹ in homegarden system whereas the yield of *Solanum melongena* was 4.85 and 4.75 qha⁻¹ respectively in agrihorticultural and homegarden system respectively. Whereas, in silvipastoral system the yield of *Cynodon dactylon*, *Cyperus scariosus* etc. 340 q ha⁻¹. According to [15] in agrisilvicultural system the yield of Kurthi and Sarguja were found 7.5 qha⁻¹ and Sarguja 4.1 qha⁻¹, respectively. Thus, yield of Kurthi was about double to that of Sarguja. In case of Homegardens, the maximum yield (221.20 qha⁻¹) of Tomato was noticed followed by cabbage (210.00 qha⁻¹), whereas lowest yield was found for pea (17.20 qha⁻¹).

CONCLUSION

The crop yield is certainly affected by the shade of the trees in tree-crop combinations but the resources use efficiency is better under trees than in open conditions. However, on system basis the productivity of the combination is more than pure cropping. Additionally, the multiple outputs can be realized by the small farmers with limited land holdings. There is a need to encouraged farmers to adopt these models scientifically and technically for betterment of peoples. Therefore, scientific research and proper extension work is needed in this area before practicing of different agroforestry models and better management practices comprises tending operation should be used properly for a long way in improving the productivity of lands and also in increasing the resources of the area. Similarly, incorporation of research related to different models as per locality factors and their extension will help to make sustainability in different Agroforestry models.

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