NANGARHAR UNIVERSITY
INTERNATIONAL JOURNAL OF BIOSCIENCES
ORIGINAL ARTICLE
e-ISSN: 2957-9988
NUIJB Special Issue, 2024

Received: 5 Dec 2023 Accepted After Revision: 22 Jan 2024 Published Online: 10 Feb 2024

Growth Characteristics and Carbon Stock Potential in Horti-Agriculture System under Degraded Land Conditions of Kashmir Himalaya

Bhat,[1]Gh.Mohiudin *, Benish Fayaz[1], Nazir Ahmad Pala[1], and Merajudin Dar[1]
[1]Division of Silviculture & Agroforestry, Faculty of Forestry, SKUAST-Kashmir Benhama Ganderbal, India
*Corresponding author: bhatm67@gmail.com

ABSTRACT
The present study was carried out with the aim to estimate the growth characteristics and carbon stock potential of different studied agroforestry systems under different crop combination. The experiment was laid out in a randomized block design with three replications comprising eight treatments. Two intercrops namely, rajmash and moong were intercropped with 4-year-old orchard of peach and apricot planted at spacing of 4m x 4m and 3m x 3m respectively. The results revealed that both rajmash and moong pulses thrived well under the fruit-based agroforestry systems and demonstrated successful cultivation as intercrops with fruit trees. However, among the intercrops tested, rajmash performed better. The growth and yield parameters of the fruit trees were observed to be better in the agroforestry system than in the control (sole cropping) conditions. The maximum amount of tree carbon density was recorded in agro-forestry system than control (only fruit trees). It was found that the treatment, T_3 (Apricot + Rajmash) recorded significantly highest value (8.71 t ha^{-1}) of the tree carbon density confined to (5.84 t ha^{-1}) for T_6 control (only Peach). Hence these systems are fruitful in terms of food production, soil improvement and carbon stock and can be replicated in other parts of Himalaya.
Keywords: Agroforestry Carbon sequestration, Himalaya, Carbon density

INTRODUCTION
Agroforestry, a traditional rural practice, meets the demand for wood, fuel, fodder and timber, while also providing insurance against unfavorable weather conditions. In India, due to its diverse climate, there are various types of agroforestry systems (Bhattacharaya *et al*., 2015). The presence of trees in agroforestry can have different effects on crops, such as complementary, supplemental, or competitive interactions, depending on the competition for growth resources among woody components, crops and site conditions. Planting trees on agricultural land brings economic benefits and diversification at the farm level and fruit trees based systems have been extensively researched and utilized in agroforestry systems (Zahoor *et al*., 2022). These fruit-bearing species offer economic benefits and are cultivated worldwide in various climatic regions. In India, the inter cropping of pulses have played a crucial role in the diet of many people, especially the underprivileged and are integral to the agricultural practices in the Indian subcontinent and have been potential source of livelihood Mythili & Goedecke (2016). In Jammu and Kashmir due to population explosion the land under agriculture is shrinking day by day as it is used for construction, roads, Government offices, railways etc. Selecting appropriate crops to integrate with fruit trees in agroforestry systems is essential for establishing diverse and economically viable systems. To establish a prospective, diverse and lucrative agroforestry system, it is necessary to choose acceptable agricultural products to be linked with fruit trees. There is a lack of information regarding the cultivation of agricultural crops under fruit-tree-based agroforestry systems in the Kashmir valley. There is vast chunk of land in the UT of J&K which is degraded and its need of the hour to rehabilitate these lands by establishment of proper region-specific agroforestry systems. In the already developed agroforestry model, an attempt was made to assess the Growth characteristics and Carbon stock potential in these systems.

MATERIAL AND METHODS
Study area: The study was carried out in the experimental field of Division of Silviculture and Agroforestry, Faculty of Forestry, Ganderbal, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir (J&K) at 34^0 16′ 46″ N and 74^0 46′ 18″ E with an elevation of 1790 m (5872 feet) above mean sea level(Fig 1 Map). Average minimum and maximum temperature varies from -5.4 to 38° C.
Methodology: The experiment was laid in Randomized Block Design in Horti-Agriculture system with tree component peach and apricot planted at a spacing of 4×4 and 3×3m respectively intercropped with Rajmash and

Moong (Both local varieties sown at spacing of 30cmx 15 cm). Total number of treatments were 8 replicated four times with four trees per replicate. The different treatment combinations were as Peach + Rajmash, Peach + Moon bean, Apricot + Rajmash, Apricot + Moong bean, Control (Only Apricot), Control (Only Peach), Control (Only Moong bean), Control (Only Rajmash).

The height and width of fruit trees was measured with tape. Fruit yield tha-1was recorded during the harvesting by weighing the total number of fruits on each fruit tree and expressed in t/ha on fresh weight basis. The uprooted agricultural crop from 1 m2 plot was weighed and dry weight of the plant samples was recorded in grams and then worked out in tha-1. The biomass of tree components was measured by Brown et al., 1989 and Bhatt and Todaria (1992). Carbon density was estimated by using (IPCC, 2006) and Soil carbon (t ha-1) was measured by (Nelson and Sommers,1996). All the data obtained were subjected to the statistical analysis using R-software.

RESULTS

The analyzed data indicated that treatment, T1 recorded highest value of tree height (1.79 m) and crown spread (2.03 m) whereas minimum values (3.29 m) and (2.38 m) were registered under T6 control (only Apricot). The highest fruit yield (3.91 t ha^{-1}) for Peach and (8.01 t ha^{-1}) for Apricot was recorded under T1 and T4 respectively whereas minimum fruit yield (3.73 t ha^{-1}) for Peach and (7.28 t ha-1) for Apricot was observed under T3 control (only Peach) and T6 control (only Apricot) respectively. The maximum amount of tree carbon density was recorded in agroforestry systems than control (only fruit trees). It was found that the treatment, T3 recorded significantly highest value (8.71 t ha^{-1}) of the tree carbon density whereas the lowest value (5.84 t ha^{-1}) was recorded for T6 control (only Peach).

The perusal of data revealed that maximum amount of carbon density was recorded for crops grown in sole cropping systems than agroforestry systems. It was observed that the highest value (0.69 t ha-1) of total crop carbon density was observed for T8(control) whereas the lowest value (0.43 t ha^{-1}) was found under T2. Maximum soil carbon stock was recorded in agroforestry systems as compared to sole crops. The significantly highest value (43.75 t ha^{-1}) of soil carbon stock was recorded for T1 whereas the minimum value (33.50 t ha^{-1}) was found under T7 control. Observation of the data reveals that maximum carbon stock was recorded for agroforestry systems (fruit trees+intercrops) whereas minimum was recorded for sole cropping systems with no tree component. It was found that the treatment, T3 recorded significantly highest value (52.88 t ha^{-1}) whereas the least value (34.13 t ha^{-1}) was found in T7 control. The nutrient status (N, P and K) was higher (361.23kg ha^{-1},17.43 kg ha^{-1} and 224.58 kg ha^{-1} in the agroforestry system as compared to the open conditions. Soil organic carbon was significant influenced by different treatments. Organic carbon content was found maximum 1.68 % under agroforestry system as compared to open treeless area 1.65 %.

Table 1: Growth and yield parameters of Peach and Apricot trees as influenced by intercrops under Peach Apricot based agroforestry system

Treatments	Height (m)	Collar dia. (mm)	Crown spread(m)	Fruit yield (kg/tree)	Fruit Yield(t/ha)	Stem Biomass (t/ha)	Canopy Biomass (t/ha)	Fruit Biomass (t/ha)	Above Ground Biomass (t/ha)	Below Ground Biomass (t/ha)	Total Biomass (t/ha)	Tree carbon Density(t/ha)	Crop Carbon Density (t/ha)	Carbon Density (t/ha)	Soil Carbon Stock (t/ha)	Total Carbon Pool of the system (t/ha)	SOCInitialValue	SOCAt the time f harvesting
T1	1.79	52.3	2.03	6.26	3.91	7.43	2.89	0.86	11.18	3.68	14.86	7.43	0.46	7.89	43.75	51.64	0.63	0.67
T2	1.76	49.8	1.94	6.12	3.82	7.41	2.86	0.84	11.11	3.66	14.77	7.38	0.43	7.81	43.23	51.04	0.64	0.65
T3	1.73	49.1	1.89	5.97	3.73	8.22	3.36	1.52	13.10	4.32	17.42	8.71	0.49	9.20	43.68	52.88	0.64	0.68
T4	3.39	63.2	2.51	7.21	8.01	8.20	3.34	1.45	12.99	4.28	17.27	8.63	0.46	9.09	43.16	52.25	0.65	0.66
T5	3.33	60.8	2.43	6.89	7.65	8.19	3.32	1.38	12.89	4.25	17.14	8.57	-	8.57	39.30	47.87	0.50	0.50
T6	3.29	59.7	2.38	6.56	7.28	7.39	2.84	0.82	11.05	3.64	11.69	5.84	-	5.84	39.04	44.88	0.49	0.49
T7	-	-	-	-	-	7.80	3.01	1.45	12.05	3.97	15.52	-	0.63	0.63	33.50	34.13	0.24	0.25
T8	-	-	-	-	-	0.12	0.36	0.29	0.58	0.18	0.79						0.28	0.32

T_1- Peach + Rajmash; T_2- Peach + Moong bean; T_3- Apricot + Rajmash; T_4- Apricot + Moong bean; T_5- Control (Only Apricot); T_6- Control (Only Peach); T_7- Control (Only Moong bean)*; T_8- Control (Only Rajmash)*

DISCUSSION

The quantity of fruit yield (t ha^{-1}) from Peach and Apricot trees in the present study was lower than average fruit production of Peach and Apricot (t ha^{-1}) in Kashmir valley. This may be due to young age of Peach and Apricot orchard coupled with the drier climatic conditions of study site. Better growth and fruit yield of Peach and Apricot under Peach-Apricot based agroforestry system is attributed to better intercultural operations and additional inputs applied to the intercrops than in sole plantation (control). Addition of leaf biomass to the soil and their further decomposition in the soil must have favored better source-sink relationship, resulting in increased fruit yield under Peach-Apricot based agroforestry system. Positive influence of crop sequences on yield of perennial crops have been reported by Patle *et al.,* 2016. Geographical region, plant species and age are the major determinants of biomass and carbon stock in vegetation (Liu *et al.,* 2015). There is a tendency that biomass and carbon stock is varied in the presence of tree and with diverse tree species in different land use system. Tree-crop systems sequester carbon at a rate higher than those containing only annual crops, which accumulate limited carbon. Therefore, significant quantities of carbon can be sequestered by moving away from only annual crops to tree based systems like agroforestry and forest plantations.

Maximum amount of carbon density was recorded for crops grown in sole cropping systems than agroforestry systems. This is because of maximum biomass production by crops in sole cropping systems as compared to agroforestry systems. Yadav & associates (2015) reported that fruit tree based land use systems in Indian Himalaya have higher potential for carbon stock and carbon accumulation in aboveground biomass. Organic carbon content was found maximum 1.68 % under agroforestry system as compared to open treeless area 1.65 %. Litter fall and fine-root turnover may increase soil organic matter concentration. The repeated application of tree biomass to the soil increases soil organic matter that leads to increase in soil water retention capacity providing good environment for soil microbes and plant nutrients during its decomposition.

CONCLUSION

The study concluded that Fruit-based agroforestry systems could potentially generate food energy, and, thus potential enough to change diet of the farming community and a potential support for health of community members as a whole through assuring food security towards achieving SDGs. These systems reported higher carbon stock, improved soil-physical properties and higher food production. These systems can be potential candidates for mitigating climate change crisis and enhance livelihood potential of local inhabitations in this fragile Himalayan region.

Conflict of interest: All the authors declare that they do not have any conflict of interest.

Authors contribution: GMB & BF proposed the idea and completed filed work and prepared the draft. GMB, NAP & MAD reviewed and finalised the manuscript.

REFERENCES

Avery, T. E. and Burkhart, H. E. (2002). Forest Measurements (5th Ed.). New York: McGraw-Hill Higher Educationpp. 137-

Bhatt, B. P. and Toderia, N. P. (1992). Fuel wood characteristics of some mountain trees and shrubs. *Biomass* 21: 233-238.

Bhattacharyya, R., Ghosh, B. N., Mishra, P. K., Mandal, B., Rao, C. S., Sarkar, D., et al. (2015). Soil degradation in India: challenges and potential solutions. *Sustainability* 7, 3528–3570. doi: 10.3390/su7043528

Bowen, W. T., Quitena, J. Q., Pereira, J., Bouldin, D. R., Reid, W. S. and Lathwell, D. J. (1989). Screening green manures as nitrogen sources to successing non-legume crops. *Plant Soil*, **111**: 75-89.

Liu, Z., Chen, R., Song, Y. and Han, C. (2015). Aboveground biomass and water storage allocation in alpine willow shrubs in the Qilian Mountains in China. *Journal of Mountain Science* 12: 207-217.

Mythili, G., and Goedecke, J. (2016). "Economics of land degradation in India. Economics of land degradation and improvement" in *A global assessment for sustainable development*. eds. E. Nkonya, A. Mirzabaev, and J. V. Braun (Berlin, Germany: Springer), 431–471.

Nelson, D. W. and Sommers, L. E. (1996). Total Carbon, Organic Carbon and Organic matter. In: Methods of Soil Analysis. Part 3. Chemical Methods. Soil Science Society of America. Book Series no. 5 *pp*. 961-1010.

Olsen, S. R., Cole, C. V., Watanate, I. S. and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture, Washington, D. C. Circular No. 939.

Patle, N., Upadhyaya, S. D. and Bansal, S. (2016). Production potential and economics of crop sequences in aonla (*Emblicaofficinalis*Gaertn.) based agrihorticultural system under rainfed condition. *Indian Journal of Agroforestry* 18(2): 59-65.

Tomich, T. P., deForesta, H. and Dennis, R. (2002). Carbon offsets for conservation and development in Indonesia. *American Journal of Alternative Agriculture* 17: 125-137.

Yadav, R. P., Bisht, A. K. and Pandey, B. M. (2015). Above Ground Biomass and Carbon Stock of Fruit Tree Based Land Use Systems in Indian Himalaya. *An International Quarterly Journal of Environmental* Sciences 9(3): 779-783.

Zahoor, S., Dutt, V, Pala NA and Khan PA (2022) Influence of intercropping on soil properties and nutrientstatus of fruit based agroforestry systems in north westernregion of Indian Himalaya Indian Journal of Agroforestry 24(1): 85-92