

**Growth Performance and Economic Analysis of Pulses in
Fruit Based Agroforestry System under Degraded Land
Conditions of Benhama Ganderbal**

Beenish Fayaz
(MSF-2020-128)



Division of Silviculture and Agroforestry

Faculty of Forestry

**Sher-e-Kashmir University of Agricultural Sciences &
Technology of Kashmir**

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Thesis

Submitted to

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partial fulfilment of requirement for the award of the degree of**

**Master of Science in Forestry
(Silviculture and Agroforestry)**

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Dedicated

*To my
Beloved
Parents*

Sher-e-Kashmir
University of Agricultural Sciences and Technology of Kashmir
Division of Silviculture and Agroforestry,
Faculty of Forestry, Benhama, Ganderbal

Certificate – I

This is to certify that the thesis entitled, “**Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System under Degraded Land Conditions of Benhama Ganderbal**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry (Silviculture and Agroforestry)**, to the **Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Ms. Beenish Fayaz (Regd. No. MSF-2020-128)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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ABSTRACT

The present investigation entitled **“Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System under Degraded Land Conditions of Benhama Ganderbal”** was carried out at Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Benhama, Ganderbal during the year 2021 and 2022. 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 seeds of pulses (rajmash {local variety: Tripash} and moong) were sown in the month of April and June respectively. The various agroforestry treatments were found to have a significant effect on the growth and yield parameters of pulses. Growth and yield parameters like number of primary branches, number of pods per plant, pod length, number of seeds per pod, grain yield and total biomass in pulses were less when these crops were grown in combination with fruit trees in comparison to sole cropping. Results revealed that maximum values for number of primary branches (3.79), number of pods per

plant (12.21), pod length (7.56 cm), number of seeds per pod (7.65) were recorded under sole cropping while as lowest values for aforementioned parameters were observed under agroforestry system. In the present study, the maximum (1.71 t ha^{-1}) values for yield in pulses were registered under control (rajmash only) and minimum yield (1.26 t ha^{-1}) under (peach + moong).

The better growth and yield parameters of apricot and peach were observed in agroforestry system than in control (only apple). Results revealed that the highest fruit yield (8.01 t ha^{-1}) was recorded under apricot + rajmash whereas minimum (3.73 t ha^{-1}) was observed under control (only peach). Most of the physico-chemical characteristics of soil (organic carbon, available nitrogen, phosphorus, potassium and soil moisture) were improved when the crops were grown under agroforestry system as compared to open area. In the present study, maximum ecosystem carbon (52.88 t ha^{-1}) was stored in the treatment involving the tree crop combination of apricot + rajmash and apricot + moong (52.25 t ha^{-1}). The findings suggest that combination of pulses and fruit tree species ensures higher profit to the farmer. The total income from diversified system (pulses + fruit trees) was substantially higher than mono cropping of pulses. In the present study, the total returns was found to be highest ($\text{₹ } 1,14,532 \text{ ha}^{-1}$) under apricot + rajmash) and the lowest ($\text{₹ } 18,368 \text{ ha}^{-1}$) under control (moong). On the basis of economic returns, the sequences can be categorized as apricot + ramjash > apricot + moong > peach + rajmash > peach + moong.

Key words: Agroforestry, Pulses, Apricot, Peach, B-C ratio

Signature of Student

Dated _____

Signature of Major Advisor

Dated _____

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Place: Benhama, Ganderbal

Beenish Fayaz

Dated: _____

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ABBREVIATIONS AND SYMBOLS USED

Food and agriculture organization	FAO
Inter-governmental panel on climate change	IPCC
Indian rupees	INR
Benefit cost ratio	BCR
Farm yard manure	FYM
Cation exchange capacity	CEC
Soil organic carbon	SOC
Calcium	Ca
Carbon	C
Sulphur	S
Carbon dioxide	CO ₂

Chapter-1

INTRODUCTION

Agroforestry, a traditional rural practice, meets the demand for wood, fuel, fodder and timber, while also providing insurance against unfavorable weather conditions. Reports indicate that agroforestry systems, which involve growing crops between trees, are cost-effective and offer a steady income (Chauhan and Mangat, 2006). In India, due to its diverse climate, there are various forms and types of agroforestry systems (Dagar *et al.*, 2014). Assessing the precise area covered by different agroforestry systems is challenging. Currently, the estimated area under agroforestry in India is 25.31 million hectares, accounting for 8.2 percent of the country's total reporting geographical area (Dhyani *et al.*, 2013; Dagar *et al.*, 2014; CAFRI, 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. While some studies (Puri *et al.*, 1994) have shown decreased crop production under certain circumstances, others (Newaj *et al.*, 2012) have demonstrated increased crop yields under different tree species. The agroforestry land use system relies largely on photosynthesis, which is influenced by factors like light availability, water, nutrients and microorganisms. Combining multifunctional trees with agricultural crops in well-managed agroforestry methods helps address supply-demand imbalances. Through agroforestry and intercropping, resources like solar radiation, water and soil nutrients can be maximized (Noguchi and Ichimura, 2004). Planting trees on agricultural land brings economic benefits and diversification at the farm level (Yadava and Singh, 1996).

Agroforestry is indeed a land use strategy that offers several benefits, including lower susceptibility to climate and environmental changes and increased

livelihood security. The integration of trees, agricultural crops and animals in agroforestry systems can contribute to various positive outcomes such as enhanced soil fertility, reduced erosion, improved water quality, increased biodiversity, improved aesthetics and carbon sequestration (Nair *et al.*, 2009).

Agroforestry systems are effective in conserving natural resources, particularly soil, by protecting it from erosion caused by wind and water. These systems also mitigate the negative impacts of temperature and wind on soil fertility, soil flora and soil fauna (Subba *et al.*, 2017). By combining agricultural and forestry technologies, agroforestry creates diversified, productive, lucrative, healthy and sustainable land use systems (Dagar and Singh, 2001). Globally, it is estimated that 823 million hectares of land are under agroforestry (Nair *et al.*, 2009), while in India, the current area under agroforestry is 25.32 million hectares, accounting for 8.2% of the country's land area (Dhyani, 2014). The number of trees on farmland is increasing, while forest tree numbers are declining. The IPCC suggests that approximately 600 million hectares of idle pasture and cropland could be transformed into highly productive agroforestry systems (Anonymous, 2010). Agroforestry has significant potential compared to conventional monocropping to ensure production stability, sustainability and provide ecological and economic security. It involves cultivating woody perennials and fruit trees alongside annual crops and the selection of appropriate tree-crop combinations is crucial for the success of this farming system (Huxley, 1996).

Agroforestry systems are designed to make the most use of available land by intercropping perennial, multipurpose plants that provide long-term benefits alongside annual crops. This approach allows for the production of food for people and animals, industrial raw materials, shade, fuelwood and construction materials (Garrity, 2004). Agroforestry systems also support conservation agricultural systems by providing soil cover, animal feed, nutrients, household fuel and protection against soil erosion and wind erosion through shelterbelts

(Sims *et al.*, 2009). In agroforestry systems, trees and crops compete for limited resources such as light, soil, water and nutrients. The timing of tree and crop planting leads to asymmetry in resource use (Bhat *et al.*, 2003) and light availability is a critical factor influencing the growth of understory vegetation in agroforestry systems where trees can reduce the amount of light reaching the intercrops (Basavaraj *et al.*, 2001; Reynolds *et al.*, 2007).

One specific type of agroforestry is the agri-horticultural system, where the tree component consists of fruit trees. This system has gained popularity as a practical choice for land cover and meeting the increasing demand for food grain and fodder. The combination of annual or perennial crops with perennial fruit-producing trees on the same farm unit, known as fruit-tree-based agroforestry, maximizes the use of the growing season and significantly increases the return per unit area over time. Fruit-tree-based agroforestry is particularly favored by resource-constrained farmers worldwide due to the relatively short juvenile period of fruit trees, the high market value of their products and the contribution of fruits to family nutritional needs (Bellow, 2004). Such programs that integrate perennial and annual crops have a greater potential for maintaining ecological services and increasing overall output, especially in areas with limited resources.

Indeed, incorporating crops under fruit trees in agroforestry systems has not received much attention historically. However, to establish a successful and profitable agroforestry system, it is important to select appropriate agricultural products that can be integrated with fruit trees. By choosing compatible crops, farmers can enhance the productivity and diversity of their agroforestry systems.

Fruit trees such as apple, plum, peach and apricot have been extensively researched and utilized in agroforestry systems. These fruit-bearing species offer economic benefits and are cultivated worldwide in various climatic regions. Peaches, for example, are consumed fresh, used in pies and cobblers and canned for preservation. Apricots are also widely grown and can be consumed raw, cooked, dried, or used to make jam and flavor alcoholic beverages.

On the other hand, pulse crops, which include various leguminous crops like field pea, khesari, cowpea, mothbean and Rajmash, have been recognized as environmentally friendly crops that provide protein-rich food sources. Pulse crops are cultivated in more than 171 countries, particularly in tropical regions. They are valued for their ability to fix atmospheric nitrogen, short growing seasons and superior canopy structure, which make them suitable for integration into agroforestry systems. In India, 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. Pulses can be grown as primary crops, intercrops, green manure, or cover crops to enhance soil fertility and maintain productivity. They are relatively short-duration crops that fit well into crop rotations and can be intercropped with agrihorticultural plantations, increasing both revenue and soil fertility. One specific example of a pulse crop is the green gram, also known as mung bean. Green gram has a short growing season, doesn't require nitrogen fertilizer and can be easily incorporated into crop rotations with cereals. It provides an inexpensive source of protein and its seeds are consumed in various forms, including cooked dry beans, stew, flour, sprouts and immature pods. The crop is valuable for both human consumption and fodder, as its biomass can be utilized as animal feed.

While there are successful examples of tree-based farming systems, particularly fruit-tree-based agroforestry systems, further research is needed to understand the specific interactions and optimization of these systems. Fruit-tree-based agroforestry systems have shown economic advantages over sole crop systems, with higher benefit-to-cost ratios. Studying and characterizing competitive interactions will aid in optimizing agroforestry systems, achieving a balance between annual and perennial yields and meeting the goals of farmers.

In conclusion, selecting appropriate crops to integrate with fruit trees in agroforestry systems is essential for establishing diverse and economically viable systems. The combination of well-researched fruit trees, such as apples, plums,

peaches and apricots, with protein-rich pulse crops like green gram, offers the potential for sustainable and lucrative agroforestry practices. Unfortunately, planting crops under fruit trees hasn't gotten much attention up until this point. 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, so a study titled "**Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System Under Degraded Land Conditions of Benhama Ganderbal**" was undertaken with the following objectives:

1. To access growth and yield parameters of pulses
2. To access growth and yield parameters of fruit trees
3. Economic analysis of the agroforestry system

Chapter-2

REVIEW OF LITERATURE

Agroforestry is a nation's age-old tradition that meets the requirements of wood, fuel, feed, timber and also serves as protection against aberrant weather conditions. Growing crops are reported to be more economical in the tree interspaces and provide daily income from the agroforestry system (Chauhan and Mangat, 2006). A fair step towards the diversification of agricultural systems is the incorporation of fruit trees on farmland with agricultural crops. Simultaneous planting of crops and trees under well-managed agroforestry activities helps to reduce the difference between supply and demand (Rao *et al.*,2004).Via agroforestry and intercropping, essential resources such as solar radiation, water and soil nutrients can be optimally utilized. The study entitled “**Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System Under Degraded Land Conditions of Benhama Ganderbal**” addresses important questions related to the relevance of fruit-tree based agroforestry to meet the needs of subsistence farmers in low-input and limited-land situations. Little work has been done related to apple and field crops. Efforts have been made to review the literature under the following headings:

- 2.1 To access growth and yield parameters of pulses
- 2.2 To access growth and yield parameters of fruit trees
- 2.3 Economic analysis of the agroforestry system

2.1 To access growth and yield parameters of pulses

Sharma *et al.* (2017) conducted a comparative study on mango-based agroforestry and mono-cropping systems in rainfed conditions of West Bengal. The researchers documented the highest yield (groundnut equivalent yield) of 14.29 and 15.97 t/ha in mango + gamhar + groundnut, followed by mango +

gamhar + maize. The lowest groundnut equivalent yield was observed in maize mono-cropping.

Subba *et al.* (2017) examined agri-horti-silvi models for sustained land use and conservation in the hill zone of West Bengal. The results indicated that the growth parameters of tree species significantly increased in intercrop combinations compared to sole fruit tree and silvi plantations. Higher yields of intercrops were recorded in sole cropping and intercropping situations, especially when intercropped with *Alnus nepalensis* + *Citrus reticulata* compared to *Alnus nepalensis* + *Pyrus communis*. Soil improvement was observed in all fruit-based agroforestry systems, with maximum improvement noted when intercropped with legume crops.

Patle *et al.* (2016) studied the production potential and economics of crop sequences in aonla (*Emblica officinalis*) based agri-horticultural systems under rainfed conditions. The research revealed that seed yield of intercrops in sole cropping sequences was significantly higher compared to intercropping with aonla. Reduction in seed yield was observed in soybean, pigeon pea and wheat when intercropped with aonla. The magnitude of yield reduction varied among different crop sequences.

Zaman *et al.* (2016) investigated the potential of three napier fodder varieties (V1= BARI Napier-1, V2= BARI Napier-2 and V3= BARI Napier-3) under litchi orchard. The researchers reported a higher number of leaves per plant under the litchi-based agroforestry system compared to open conditions.

Kumar *et al.* (2015) studied the growth and yield of *Vigna radiata* L. under *Terminalia arjuna* and *Mitragyna parvifolia* based agrisilvicultural systems. They compared four varieties of green gram and found that all the varieties performed better in terms of growth and yield parameters under open conditions compared to crops under *Terminalia arjuna* and *Mitragyna parvifolia*. Among the varieties, K-

851 exhibited superior performance in terms of number of leaves, number of branches per plant and grain yield.

Rajalingam *et al.* (2015) conducted research on the evaluation of leafy vegetable crops under *Ailanthus excelsa* based silvihorticulture systems in the northeastern zone of Tamil Nadu. They observed reduced growth and yield of intercrops in association with *Ailanthus excelsa* compared to sole cropping.

Chandra (2014) evaluated the growth and economic parameters of *Curcuma longa* and *Amorphophallus paeoniifolius* intercrops in a medium-aged *Psidium guajava* orchard. The highest yield was recorded in *Curcuma longa* (150.48 q/ha) and *A. paeoniifolius* (304.53 q/ha) under intercropping.

Sarvade *et al.* (2014) studied the performance of wheat (*Triticum aestivum* L.) crop under different spacings of trees and fertility levels. They reported significantly higher grain yield under poplar and melia compared to other spacing treatments at a specific fertility level. Wheat yield attributes were also higher at a wider spacing of 3 × 2.5 m compared to closer spacing.

Hanif and Bari (2013) evaluated the potential of agrisilvicultural systems by planting potato under three different multipurpose tree species. Millet performed better under baobab compared to the control plot and *Parkia biglobosa*. Taro yield was higher under *Parkia biglobosa* compared to the control plot and baobab.

Kiran *et al.* (2013) studied the effect of tree shade on nodulation, arbuscular mycorrhizal colonization and growth of pea in a *Dalbergia sissoo* based agroforestry system. The results showed that the number of nodules and arbuscular mycorrhizal colonization in pea roots was significantly higher in open conditions compared to tree shade. Dry shoot weight was adversely affected by tree shade.

Babu (2012) conducted an experiment to study the growth and yield of chilli and sweet gourd under different spacing of Eucalyptus trees. It was observed

that as the distance from Eucalyptus tree rows increased, plant height, diameter, leaf length, leaf diameter, number of fruits per plant and yield gradually increased. Boundary plantation of Eucalyptus had a negative effect on the growth and yield of chilli and sweet gourd.

Sehgal (2011) examined the effect of spacing and organic manures on *Ocimum basilicum* intercropped with *Leucaena leucocephala*. The results showed that closely spaced *Leucaena leucocephala* hedgerows negatively influenced various growth and yield attributes of the associated herb compared to wider spacing. The growth of *Ocimum basilicum* was suppressed to a greater extent when closer to the hedgerows in all treatments.

Pant *et al.* (2010) investigated the performance of taro under poplar trees in the subtropical zone of Himachal Pradesh. The researchers observed a drastic reduction in growth and yield of the crop under the shade of trees compared to open conditions.

Sayed *et al.* (2009) recorded the highest vegetable production in control conditions (without trees), which was similar to distances of 3 and 4 feet from the tree base. The lowest production was observed at a distance of one foot, which was almost similar to the 2-foot distance

2.2 To assess growth and yield of fruit trees (Apricot and Peach)

Kumar *et al.* (2017) studied the effect of teak (*Tectona grandis*) on *Ocimum* spp. in silvi-medicinal systems and found that the growth parameters of *Ocimum* spp. were better in sole cropping compared to silvi-medicinal systems. *Ocimum tenuiflorum* exhibited superior growth characteristics under sole cropping, including plant height, number of branches, leaves per plant and plant spread. Specific leaf weight was higher in sole cropping, while the chlorophyll content index was higher in the silvi-medicinal system.

Gao *et al.* (2013) investigated intercropping competition between apple trees and agricultural crops (soybean and peanut) in agroforestry systems on the

Loess Plateau of China. They found that soil moisture was the primary factor affecting crop yield, followed by light. Peanut performed better than soybean in the intercropping system with apple trees.

Manuel (2011) studied the growth of *Gmelina arborea* and *Eucalyptus deglupta* and their impact on maize grain yield in intercropping systems. Maize grain yield was lower in the presence of *Gmelina* and *Eucalyptus* compared to monocropping. The reduction in maize grain yield was higher in the block arrangement with *Gmelina* and *Eucalyptus* than in the hedgerow arrangement.

Sanou *et al.* (2011) conducted an experiment in Burkina Faso to assess the effect of shade from two indigenous fruit trees, *Adansonia digitata* (Baobab) and *Parkia biglobosa*, on the performance of taro and millet. They found that millet performed better under baobab, while taro had a higher yield under *Parkia biglobosa* compared to the control plot and baobab.

Gandhi and Dhiman (2010) studied the productivity of wheat crop under a poplar-wheat-based agrisilviculture system. They observed that the spacing of poplar trees significantly influenced the height and diameter growth of the trees. Wheat crop grown under certain tree spacing (6 x 6 m) produced maximum grain yield and other yield-related parameters.

Hanif *et al.* (2010) studied the performance of different okra varieties under a litchi-based agroforestry system. They reported the highest yield in monocropping of hybrid okra and the lowest yield in the litchi + local okra variety. They found the litchi-based agroforestry system to be more sustainable than sole cropping.

Verma *et al.* (2010) investigated the effect of tree-crop combinations and nitrogen levels on the growth and herbage yield of *Ocimum sanctum* (holy basil). They recorded maximum plant height and leaf area of *Ocimum sanctum* under certain tree-crop combinations.

Mishra *et al.* (2006) evaluated the productivity of soybean and wheat under different clones of *Populus deltoides* in an agrisilviculture system. They observed reduced grain and straw yield in soybean and wheat under poplar clones compared to sole cropping.

Baghel *et al.* (2004) studied intercropping systems in a bearing orchard of mango under rainfed conditions. They reported maximum production from mango intercropped with cowpea in the kharif season and mango-bengal gram in the rabi season.

Fadl and Gebauer (2004) examined the crop performance and yield of groundnut, sesame and roselle in an agroforestry cropping system with *Acacia senegal*. They found reduced crop performance and yield in the intercropping system compared to sole cropping, with the highest yield reduction observed in groundnut.

Handa *et al.* (2004) conducted an experiment on the growth of fruit trees (guava, ber, pomegranate and kinnow) and their effect on crops under different crop rotations. They found that wheat yield varied significantly with distance from the tree base, with an increase in yield as the distance from the tree increased.

Rahman (2004) reported that morphological characters and yield of vegetables (tomato, brinjal, chilli) were highest in open field conditions compared to agroforestry systems, except for plant height. They observed the highest yield in a *Terminalia chebula*-lemon-vegetable-based agroforestry system.

2.3 Economic analysis of the agroforestry system

Sharma *et al.* (2017) carried out research on comparative study of mango based agroforestry and mono-cropping system under rainfed condition of West Bengal. They recorded highest gross return of 3,57,334 and 4,78,996 INR under mango + gamhar + groundnut based system during 2014-15 and 2015-16 respectively as compared to mono-cropping system. Zaman & associates (2016) investigated potentiality of three napier fodder varieties (V1= BARI Napier-1

(Bazra), V2= BARI Napier-2 (Arusha) and V3= BARI Napier-3 (Hybrid) under litchi orchard. They recorded maximum BCR (5.20) in the litchi based agroforestry systems over sole cropping (BCR=4.38).

Chauhan *et al.* (2015) studied biomass production, carbon sequestration and economics of on-farm poplar plantations in Punjab, India and recorded highest benefit cost ratio (3.30, 1.90 and 1.61) in block plantation than boundary and sole cropping of rice-wheat respectively.

Rajalingam *et al.* (2015) conducted research on evaluation of leafy vegetable crops under *Ailanthus excelsa* based silvihorticulture system in north eastern zone of Tamil Nadu. They intercropped five leafy vegetables (chinese amaranth, spleen amaranthus, tropical amaranth, chinese spinach and palak) with three year old *Ailanthus excelsa*. They reported highest benefit cost ratio for chinese spinach (3.45) and lowest for tropical amaranth (1.77) under intercropping.

Chandra (2014) carried out research on evaluation of growth and economic parameters of *Curcuma longa* and *Amorphophallus paeoniifolius* intercrops in 30 medium aged *Psidium guajava* orchard. They reported gross profit of ₹ 3.76 lakh/ha for *C. longa* and ₹ 5.48 lakh/ ha for *A. paeoniifolius* in intercropping than pure crops which rendered gross profit of ₹3.32 lakh/ha and ₹4.51 lakh/ha respectively. They recorded benefit cost ratio (BCR) of 4.74 for fruit tree + *C. longa* and 2.70 for fruit tree + *A. paeoniifolius* respectively while the same parameters computed 2.78 and 1.52 for *C. longa* and *A. paeoniifolius* with monocropping. They observed cultivation of *A. paeoniifolius* more remunerative than *C. longa*.

Nayak *et al.* (2014) studied economics and yield performance of some short duration fruit and medicinal crops under agrisilvicultural system consisting of two silvicultural species *viz.* *Acacia mangium* (mangium) and *Gmelina arborea* (gamhar) and four agricultural crops *viz.* *Ananas comosus* (pineapple), *Aloe vera*

(aloevera), *Andrographis paniculata* (kalmegh) and *Curcuma amada* (mangoginger). They recorded highest gross return, net return and benefit cost ratio in *A. mangium* with pineapple based agrisilvicultural system as compared to other agrisilvicultural systems and sole crops.

Hanif and Bari (2013) evaluated potential of the agrisilvicultural system by planting potato on the floor of three different multipurpose tree species viz. *Leucaena leucocephala*, *Melia azedarach* and *Albizia lebbeck*. They reported highest benefit cost ratio (3.75) in agrisilvicultural system as compared to sole cropping of potato.

Mandal *et al.* (2012) conducted a case study on poplar based agroforestry system on farmer's field in Haryana (village Haripur in district Panchkula) to ascertain the performance of different intercrops with poplar. They observed that agroforestry system (poplar and intercrop) yielded a benefit of rupees 8,70,350 from one acre in five year rotation as compared to rupees 1,36,990 from one acre of mono cropping system.

Patil *et al.* (2012) conducted a field trial on *Melia azedarach* based agroforestry system. They recorded significantly higher net returns and benefit cost ratio in *Melia azedarach* + soybean as compared to the other treatments.

Shah (2012) conducted studies on greengram-plum based agroforestry system in Kashmir valley. The results revealed comparatively more returns (₹255,671.39) from agroforestry system which was provided with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) and lowest total net returns (₹34,553.10) from sole cropping of greengram without organic manure and fertilizer application.

Wekesa *et al.* (2012) recorded highest profitability when *Melia* was intercropped with green gram. They reported that one ha of *Melia* stand gave net present value of US\$ 15,128 translating to a discounted annual profit margin of

US\$ 2,055 for 10 years. They observed higher profitability in *Melia* than *Eucalyptus camaldulensis* and *Grevillea robusta* in a similar environment.

Rajput (2010) in his study on bio-economic appraisals of different land use systems in Kullu district (HP) of temperate north-west Himalaya observed that orchard (apple) + vegetable land use system earned a net profit of ₹ 10,23,430 ha⁻¹ yr⁻¹ while agri-horticulture land use system earned a net profit of ₹ 9,69,194 ha⁻¹ yr⁻¹. He reported that total benefits (net profit + carbon credits) were maximum in orchard (apple) + vegetable based cropping system.

Sharma *et al.* (2008) studied the economics of kinnow based agroforestry system with wheat and gobhi - sarson in Himachal Pradesh. They observed higher overall return from agrihorticulture system in comparison to sole crops. They reported cultivation of gobhi - sarson with kinnow to be more profitable than wheat. They recorded maximum returns per hectare (₹56,407.55) under kinnow - gobhi - sarson combination.

Dwivedi *et al.* (2007) conducted research on socio-economic analysis of agroforestry systems in western Uttar Pradesh. They recorded highest benefit cost ratio (3.00) for poplar based agrisilviculture as compared to poplar (2.84) and *Eucalyptus* (2.68) based bund system.

Sharma *et al.* (2007) studied the role of traditional large cardamom agroforestry systems (*Amomum subulatum*) on enhancing the ecosystem services in the Eastern Himalayas. They contended that agroforestry systems are efficient management systems with output to input ratio of more than 13 as compared to rainfed agriculture with value of 1.85. They reported that cardamom agroforestry is 5.7 times more profitable to farmers as compared to the rainfed agriculture.

Nandal and Hooda (2005) studied the production potential of various agricultural crops under various spacings of mango plantation and revealed that the yield of all agricultural crops, including cowpea and moongbean, increased with wider spacing of mango plantation and decreased with increasing age of

mango plantation. During rainy seasons, cowpea for feed was determined to be the most suitable with mango.

Dutt and Thakur (2004) calculated monetary status of cropping systems for two consecutive years under Shivalik ranges of outer Himalayas, combining medicinal and aromatic herbs with commercial timber species. They intercropped four herbal crops *Ocimum sanctum*, *Spilanthes acmella*, *Tagetes minuta* and *Withania somnifera* with 6- year old plantation of *Populus* hybrid (G-48) having 8 × 3m, 6 × 4m, 5 × 5m and 4 × 6m spacing. They recorded highest net returns under agroforestry systems combining *Ocimum sanctum* and *Tagetes minuta* with poplar at different spacing in comparison to monocropping whereas in *Spilanthes*, the net return were higher from sole cropping and in *Withania somnifera* due to high cost of cultivation, the net return became negative. They reported that among different spacing 8 × 3m and 6 × 4m spacing excelled over 5 × 5m and 4 × 6m spacing which ensured significantly higher net returns from the combination.

Tomar and Bhatt (2004) conducted field experiment on a six year old plantation of guava (*Psidium guajava* cv. Allahabad safeda), assam lemon (*Citrus* lemon cv. Local) and Peach (*Prunus persica* cv. TA 170) to study the performance of upland rice cultivars (intercrops) in the existing fruit plantation and overall productivity of agrihorticulture systems. They recorded maximum net monetary benefit per hectare from Peach intercropped with rice (₹48,044), followed by guava (₹27,887) and assam lemon (₹20,991). They found Peach based agroforestry systems most promising for rain fed agricultural conditions in the north-eastern region of India in general and Meghalaya in particular.

Koli *et al.* (2003) observed that intercropping system of redgram + clusterbean recorded significantly higher monetary returns (₹19,419 ha⁻¹) as compared to standard check with sole redgram (₹10,820 ha⁻¹).

Singh *et al.* (2001) carried out research to analyze the economic profitability of raising medicinal and aromatic plants as intercrops in a four and

five year old poplar based agroforestry system. They obtained maximum net return in *Curcuma domestica* (₹64,700 and 68,300) followed by *Zingiber officinale* (₹59,750 and 61,700) in the first and second year, respectively. They observed that net returns per rupee invested, was highest in *Artemisia annua* (4.83 and 5.14) followed by *Pogostemon cablin* (4.81 and 3.98).

Jain and Singh (1999) reported substantial increase in the farm income from the poplar based agroforestry systems compared to sole crops which were due to the increased poplar yield and income. They reported that net returns from wheat in poplar + wheat system was 5636, 4310 and 3858 Rs ha⁻¹ during first, second and third year, respectively compared to average net returns from sole crop of wheat (₹2731 ha⁻¹) and net returns from sugarcane followed same trend i.e. 18626, 14227 and 10184 Rs ha⁻¹ during first, second and third year, respectively compared to average sole crop income of 17,285 Rs ha⁻¹. They recorded highest benefit cost ratio of 1.75 and 2.30 in poplar based wheat and sugarcane systems compared to their sole agricultural crops (1.29 and 1.80 respectively)

Chapter-3

MATERIAL AND METHODS

A study entitled “**Growth Performance And Economic Analysis of Pulses In Fruit Based Agroforestry System Under Degraded Land Conditions Of Benhama Ganderbal**” 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) during 2021-2023.

3.1 Experimental site

3.1.1 Location

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^o 16' 46" N and 74^o 46' 18" E with an elevation of 1790 m (5872 feet) above mean sea level.

3.1.2 Climate and rainfall

The climate varies considerable with the altitude. It is mild and salubrious in the lower elevations but very cold in higher ups. All the four seasons of the year are represented. Spring is cool and rather wet. Average minimum and maximum temperature varies from -5.4 to 38° C. Autumn is bright and pleasant while as winter is extremely cold and experiences heavy snow falls. Frost is experienced from middle of November onwards. The district receives an average annual precipitation of about 1327 mm in the form of rain and snow for about 70 days. Unlike the outer Himalayas there is no distinct rainy season in Kashmir Valley. The main form of precipitation is snow in winter and some stray rains, showering in spring or the other months of year.

3.2 Experimental methodology

The details of techniques followed and material and methods adopted during course of investigation are given below:

Experimental details

Agroforestry system	Horti-agriculture
Structural components	1. Agricultural crops: Rajmash and Moong Bean 2. Tree components: Peach and Apricot
Planting direction	East-West
Tree spacing	1. Peach (4m ×4m) 2. Apricot (3m × 3m)
Spacing for intercrop (Rajmash and Moong)	30 cm x15 cm
Number of treatments	08
Replications	04
No. of plants per replicate	04
Design	RBD (Randomized Block Design)

Treatments

Symbol	Treatment
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)

3.2.1 Field preparation

The experimental field was thoroughly ploughed two times and made smooth by harrowing, followed by planking. Stones, pebbles and residues of previous crop were removed manually. The experimental field was prepared as per the treatment details to accommodate the pulse crops (Rajmash and moong) during kharif season.

3.2.2 Seed sowing

Agricultural crop	Season (kharif/rabi)	Month
Rajmash (<i>Phaseolus vulgaris</i>)	Kharif	April
Moong bean (<i>Vigna radiate</i>)	Kharif	June

3.2.3 Harvesting of the crops

First harvesting of Rajmash was done in June followed by second in September and harvesting of moong was done in the month of October respectively.

3.3 Details of observation recorded

The details about the methods adopted for different parameters studied are given below:

3.3.1 Trees

a. Tree height (m)

Height of experimental fruit trees in each plot was measured with the help of measuring tape. Two trees per plot were used for the purpose.

b. Tree diameter (cm)

Collar diameter was measured with the help of vernier caliper. Two trees per plot were used for the purpose.

c. Crown spread (m)

The crown width was measured in meters with the help of a measuring tape on north to south and east to west directions and expressed by using the formula.

$$CS = \frac{D_1 + D_2}{2}$$

Where,

CS = Crown spread

D₁ = Crown diameter NS direction

D₂ = Crown diameter EW direction

d. Fruit yield (t ha⁻¹)

Fruit yield was recorded during the harvesting by weighing the total number of fruits on each fruit tree and expressed in t/ha on fresh weight basis.

e. Fruit color

The fruit color of Peach and Apricot was determined using colour chart.

f. Fruit maturity time

It was recorded by paying regular visits to the field. The fruit maturity time was recorded as the time between initiation of fruiting and the time at which the fruit matured (determined on the basis of colour and size of fruit).

g. Fruit Maturity

The fruit maturity was recorded as the date at which fruit was ready to be harvested.

3.3.2 Agricultural crop (Pulses)

a. Number of primary branches

The numbers of primary branches of ten randomly selected plants from each plot were counted at harvesting stage.

b. Number of pods/plant

Pods of three randomly selected plants from each plot were counted and averaged as pods per plant.

c. Pod length (cm)

Length of pods was taken from three randomly selected plants from each plot and average pod length was recorded in centimeter.

d. Number of seeds/pod

The seeds of mature pods selected at random from each plot were counted and expressed as seeds per pod.

e. Above ground biomass ($t\ ha^{-1}$)

Plants in each plot of $1\ m^2$ area were cut above ground from the base for each replication at harvesting stage of agricultural crops. The plants were weighed together to determine the fresh weight. The plant samples were sun dried for 4 to 5 days followed by oven drying at $60^\circ C$ till constant weight. Dry weight of the plant samples was recorded in grams and then worked out in $t\ ha^{-1}$.

f. Grain yield ($t\ ha^{-1}$)

The grain yield obtained from each plot was thoroughly cleaned and sun dried and weighed separately for each plot. The yield obtained in $kg/plot$ was converted to t/ha and expressed as yield ($t\ ha^{-1}$).

g. Pod yield ($t\ ha^{-1}$)

In Pulses, the pod yield obtained from each plot was weighed separately for each plot. The pod yield obtained in kg/m^2 was converted to $t\ ha^{-1}$ and expressed as yield ($t\ ha^{-1}$).

h. Total biomass ($t\ ha^{-1}$)

Plants of all agricultural crops were uprooted from $1\ m^2$ plot for each replication at harvesting stage and their different plant parts (roots and above

ground) were separated. The plant parts were weighed separately to determine the fresh weight. The plant samples were sun dried for 5 to 8 days followed by oven drying at 60°C till constant weight. Dry weight of the plant samples was recorded in grams and then worked out in t ha⁻¹.

$$\text{Total biomass} = \text{Above ground biomass} + \text{Below ground biomass}$$

i. Harvesting Index

It was determined using given formula:-

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.3.3 Physico-chemical characteristics of soil:

Before laying out the experiment, random soil samples were collected from the depth of 0-20 cm from different spots and the composite sample for each replication was prepared which was analyzed for various soil characteristics in order to get information about the physico-chemical properties of the soil. At the completion of the experiment, the samples from each plot were again drawn and analyzed for various characteristics by the standard methods.

Methods employed to determine physico-chemical properties of soil

S.No.	Parameters	Method employed
a)	Available nitrogen (kg ha ⁻¹)	Alkaline permagnate method (Subbiah and Asija, 1956)
b)	Available phosphorus (kg ha ⁻¹)	Olsen method (Olsen <i>et al.</i> , 1954)
c)	Available potassium (kg ha ⁻¹)	Flame Photometer method (Jackson, 1973)
d)	Soil pH	Glass electrode method (Jackson, 1973)
e)	Electric conductivity (dSm ⁻¹) at 25°C (1:2 soil-water suspension)	Solu bridge conductivity meter (Piper, 1966)
f)	Soil organic carbon (%)	Walkley and Black, 1934

g) Soil moisture (%)

The soil moisture content was determined gravimetrically. Before laying out the experiment, random soil samples were collected up to the depth of 20 cm, by using auger and the composite sample was prepared. The composite sample was dried at 105°C till constant weight and the soil moisture content was calculated as under:

$$\text{Soil moisture \%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

At the completion of the experiment, the samples from each plot were again drawn and soil moisture (%) content was determined.

h) Soil bulk density

Bulk density is the ratio of the oven-dry mass of the solids to the volume (the bulk volume includes the volume of the solids and of the pore space) of the soil. It was analyzed following weighing bottle method. Measuring cylinder of 100 ml was weighed and filled with soil with continuous tapping of the bottom of cylinder until soil volume of 100ml was obtained. Then the weight of the cylinder containing soil was recorded. The procedure was replicated thrice and average weight was taken. The bulk density of the soil samples was calculated by the formula:

$$\text{Bulk density (g/cm}^2\text{)} = \frac{\text{Dry weight of soil sample (g)}}{\text{Volume occupied by the same soil sample (cm}^2\text{)}} \times 100$$

3.3.4 Carbon stock

a. Stem biomass

Fruit Trees:

$$Y = \exp\{-2.4090 + 0.9522 \ln(D^2HS)\}$$

(Brown *et al.*, 1989)

Where,

Y= Biomass per tree in kg

D= collar diameter of fruit trees

H= Tree height in cm

S= Wood density (g cm^{-3})

b. Wood density (g cm^{-3})

The wood density was calculated following the procedure prescribed by Bhatt and Toderia (1992).

Wood density = Mass/volume.

c. Estimation of biomass of canopy

Canopy Biomass = Crown Volume x Specific gravity

The vol. occupied by crown was be estimated by;

d. Crown volume (m^3)

$$CV = \frac{\pi Db^2 L}{12}$$

The Crown volume was calculated following the procedure prescribed by (Avery and Burkhart, 2002).

Where,

CV= Crown volume (m^3)

Db= Diameter (m) at crown base

L= Crown length (m)

e. Specific gravity:

The stem cores were taken to find out specific gravity which was used further to determine the biomass of stem using the maximum moisture method (Smith, 1954).

$$G_f = \frac{1}{\frac{M_n}{M_o} - \frac{M_o l}{G_{so}}}$$

Where,

G_f = specific gravity based on gross volume

M_n = weight of saturated volume sample

M_o = weight of oven dried sample

G_{so} = Average density of wood substance equal to 1.53

f. Fruit biomass $t\ ha^{-1}$

The fruit samples (1 kg) were sun dried for 4 to 5 days followed by oven drying at 60°C till constant weight. Dry weight of the fruit samples was recorded in grams and then worked out in $t\ ha^{-1}$.

Tree Biomass = Stem Biomass + Canopy Biomass + fruit biomass

g. Estimation of below ground biomass

Below ground biomass = Above ground biomass x 0.33 (Singh, 2010)

Total biomass = Above ground biomass + below ground biomass.

h. Estimation of Carbon Density

$C\ (t\ ha^{-1}) = \text{Total biomass}\ (t\ ha^{-1}) \times 0.5$ (IPCC, 2006)

i. Soil carbon ($t\ ha^{-1}$) = [(soil bulk density ($g\ cm^{-3}$) x (soil depth (cm) x C (%)] x100

(Nelson and Sommers, 1996).

j. Total carbon pool of system ($t\ ha^{-1}$) = crop carbon density + tree carbon density + soil carbon.

3.3.5 Net returns from the system

a. Cost of cultivation

The cost of cultivation of pulse crops and oats as well as maintenance of fruit trees and harvest of its produce was worked out on the basis of net cropped area and number of trees/ha. The requirements of labour and mechanical power

for different operations such as ploughing, harrowing, weeding, irrigation and harvesting etc. were calculated on per hectare basis as per rates prevalent at experimental farm. Costs of inputs such as seeding, weeding etc were calculated.

b. Gross returns

The prevailing local market prices were used to convert the yield of agricultural and fruit crops in rupees per hectare.

c. Net returns

Net returns were calculated by deducing total cost from gross returns.

$$\text{Net returns} = \text{Gross returns} - \text{Total cost}$$

d. Benefit cost Ratio

After discounting the benefit cost ratio was calculated by dividing discounted benefit by discounted cost and net present value was calculated by subtracting discounted input cost from output.

$$\text{BCR} = \frac{\text{Cost of Cultivation}}{\text{Gross Returns}}$$

3.3.6 Physical parameters of fruit, stone and kernel

The physical parameters of Apricot fruits such as length, breadth and thickness were measured with the help of vernier caliper.

3.3.7 Oil content (%)

The oil content of Apricot kernels were determined by Soxhlet extraction (250 mL capacity). 250 g of kernels in 3 replicates were used for oil percentage analysis.

3.4 Statistical analysis

All the data obtained were subjected to the statistical analysis as per procedure given by Gomez and Gomez (1984) using R-software.

Chapter – 4

EXPERIMENTAL FINDINGS

An experiment entitled “**Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System Under Degraded Land Conditions of Benhama Ganderbal**” was carried out in the trail field of Division of Silviculture and Agroforestry, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during the year 2021-2022. The data recorded on different characters were statistically analyzed and significance of results was verified. The results obtained in the present investigation have been presented under the following headings:

- 4.1 Growth and yield parameters of Fruit trees
- 4.2 Growth and yield parameters of Pulses
- 4.3 Physico-chemical characteristics of soil
- 4.4 Physical parameters of fruit, stone and kernel and Oil concentration of Apricot kernels
- 4.5 Carbon stock of the agroforestry system
- 4.6 Economic analysis of the system

4.1 Growth and yield parameters of Fruit trees

4.1.1 Height (m)

The data pertaining to apple height have been presented in Table-1. The analysis of data presented in Table-1, reveals that the height of Peach and Apricot trees were significantly influenced by different treatments. The results indicate that significantly highest value (1.79 m) of tree height was recorded for T₁ (Peach + Rajmash) followed by T₂ (Peach + Moong) which recorded a value of 1.76 m whereas minimum value (1.73 m) was recorded for T₃ control (only Peach). However, for Apricot highest value for tree height of (3.39 m) was recorded by T₄

(Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 3.33 m whereas minimum value (3.29 m) was recorded for T₆ control (only Apricot).

4.1.2 Collar diameter (mm)

Observation of data presented in Table-6, indicates that the variation in collar diameter of fruit trees as affected by different treatments exhibited no significant difference. The results indicate the maximum collar diameter (63.20 mm) for T₄ (Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 60.80 mm whereas minimum value (49.10 mm) was recorded for T₃ control (only Peach).

4.1.3 Crown spread (m)

The data obtained for influence of different treatments on crown spread have been tabulated in Table-1. The influence of treatments was significant on crown spread of fruit trees. The results indicate the maximum crown spread (2.03 m) for T₁ (Peach + Rajmash) followed by T₂ (Peach + moong) which recorded a value of 1.94 m whereas minimum value (1.89 m) was recorded for T₃ control (only Peach). For Apricot highest value of crown spread of (2.51 m) was recorded by T₄ (Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 2.43 m whereas minimum value (2.38 m) was recorded for T₆ control (only Apricot).

4.1.4 Fruit yield (kg tree⁻¹)

The perusal of data presented in Table-1, indicates that the variation in fruit yield of apple as affected by different treatments exhibited no significant difference. The results indicate the maximum fruit yield (7.21 kg tree⁻¹) for T₄ (Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 6.89 kg tree⁻¹ whereas minimum value (5.97 kg tree⁻¹) was recorded for T₃ control (only Peach).

4.1.5 Fruit yield (t ha⁻¹)

The perusal of data (Table-1), indicates that the variation in leaf area of apple as affected by different treatments exhibited no significant difference. The results indicate the maximum fruit yield (8.01 t ha⁻¹) for T₄ (Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 7.65 t ha⁻¹ whereas minimum value (3.73 t ha⁻¹) was recorded for T₃ control (only Peach).

4.1.6 Fruit Maturity

Observation of data presented in Table-2, indicates that the different treatments had no significant influence on fruit maturity of Peach and Apricot. The maturity was observed in last week of July (Peach), whereas it was recorded as last week of June (Apricot).

4.1.7 Fruit Maturity time

The critical examination of data presented in Table-2, indicates that the fruit maturity time of Peach and Apricot was significantly influenced by different treatments. The data presented in Table-2, also reveals that significantly higher value of fruit maturity time (86 days) for T₁ (Peach + Rajmash) followed by T₂ (Peach + moong) which recorded a value of 85 days whereas minimum value (82 days) was recorded for T₃ control (only Peach). For Apricot highest value of (75 days) was recorded by T₄ (Apricot + Rajmash) followed by T₅ (Apricot + moong) which recorded a value of 73 days whereas minimum value (71 days) was recorded for T₆ control (only Apricot).

4.1.8 Fruit colour

Observation of data presented in Table-2, indicates that the fruit colour of Peach and Apricot was not significantly influenced by different treatments. The fruit colour of Peach was recorded as Green to reddish green while as for Apricot it was recorded as Green to light yellowish-orangish green.

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)
T₁- Peach + Rajmash	1.79	52.3	2.03	6.26	3.91
T₂- Peach + Moong bean	1.76	49.8	1.94	6.12	3.82
T₃- Apricot + Rajmash	1.73	49.1	1.89	5.97	3.73
T₄- Apricot + Moong bean	3.39	63.2	2.51	7.21	8.01
T₅- Control (Only Apricot)	3.33	60.8	2.43	6.89	7.65
T₆- Control (Only Peach)	3.29	59.7	2.38	6.56	7.28
T₇- Control (Only Moong bean)*	-	-	-	-	-
T₈- Control (Only Rajmash)*	-	-	-	-	-
Mean	2.54	55.81	2.19	6.51	5.73
CD (p≤0.05)	1.07	NS	0.34	NS	NS
S.E(m)	0.35	2.50	0.11	1.23	2.01

*Not included in statistical analysis

Table 2: Fruit Maturity indices of Peach and Apricot

Treatments	Fruit maturity time	Fruit maturity	Fruit colour
T₁- Peach + Rajmash	86	Last week of July	Green to reddish Green
T₂- Peach + Moong bean	85	Last week of July	Green to reddish Green
T₃- Apricot + Rajmash	82	Last week of July	Green to reddish Green
T₄- Apricot + Moong bean	75	Last week of June	Green to light yellowish-orangish green
T₅- Control (Only Apricot)	73	Last week of June	Green to light yellowish-orangish green
T₆- Control (Only Peach)	71	Last week of June	Green to light yellowish-orangish green
T₇- Control (Only Moong bean)	-	-	-
T₈- Control (Only Rajmash)	-	-	-

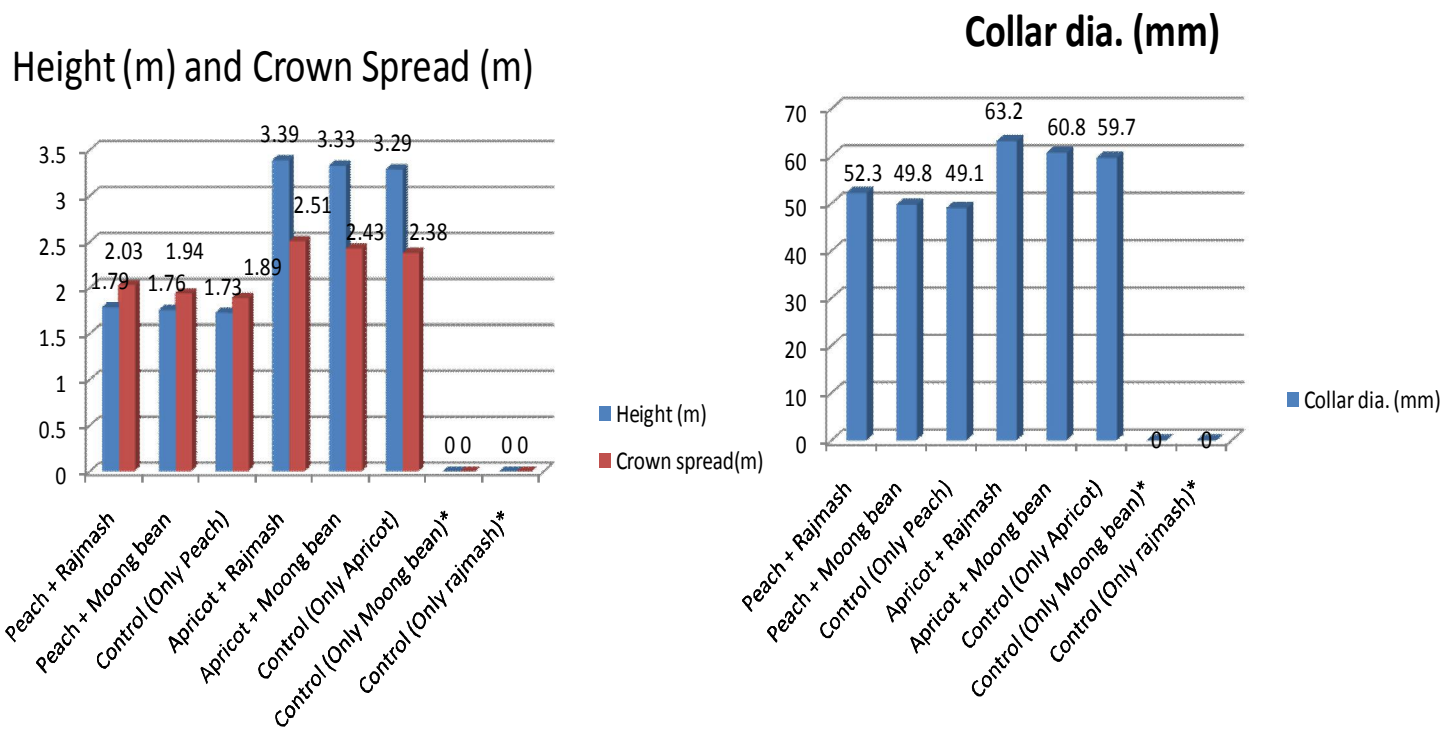


Fig. 1: Growth parameters of fruit trees



Plate 1: Measurement of height



Plate 2: Measurement of collar diameter

4.2 Growth and yield parameters of Pulses

4.2.1 Number of primary branches

The observations with regard to number of primary branches of pulses intercropped under Peach, Apricot and sole cropping (control) have been tabulated and presented in Table-3. The data reveals that the number of primary branches vary significantly among different treatments and distances. The number of primary branches recorded was less for agroforestry treatments as compared to sole cropping treatments. The treatment T₃ control (Rajmash only) recorded significantly highest number of primary branches (3.79) which was statistically at par with T₂ control (Apricot + Rajmash) which recorded 3.48 number of primary branches whereas minimum number of primary branches (2.81) were observed for T₅ (Peach + moong).

4.2.2 Number of pods plant⁻¹

The perusal of data (Table-3) shows that the number of pods per plant of pulses intercropped under Peach, Apricot and sole cropping (control) was significantly influenced by different treatments and distances. The maximum number of pods per plant were observed among plants in sole cropping treatments as compared to agroforestry treatments. Among different treatments, T₆ control (only moong) recorded significantly highest number of pods per plant (12.21) followed by T₄ (Peach + moong) which recorded 11.20 number of pods per plant whereas minimum number of pods per plant (9.56) were observed in T₁ (Peach + Rajmash).

4.2.3 Pod Length (cm)

The pod length of pulses intercropped under apple and sole cropping (control) differed significantly under different treatments and distances (Table-3). In general, pulses in the open field (without trees) registered higher pod length than in the inter cropped field. It is clear from Table-3, that significantly highest value of pod length (7.56 cm) was recorded for T₃ Control (only Rajmash)

followed by T₂ (Apricot + Rajmash) which recorded a value of 9.93 cm whereas minimum pod length was observed for T₄ (Apricot + moong) with a value of 5.97 cm.

4.2.4 Number of seeds pod⁻¹

The data collected with regard to number of seeds per pod of pulses intercropped under apple and sole cropping (control) have been presented in Table-3. The data reveals that the number of seeds per pod vary significantly among different treatments and distances. The number of seeds per pod were more for sole cropping treatments as compared to agroforestry treatments. The treatment, T₆ control (only moong) recorded significantly highest number of seeds per pod (7.56) followed by T₅ (Peach + moong) with 7.12 number of seeds per pod and minimum number of seeds per pod (4.08) were recorded for T₁ (Peach + Rajmash).

4.2.5 Pod yield (t ha⁻¹)

The pod yield of pulses was significantly influenced by the treatments (Table-4). The pod yield of pulses in the open field was higher than that of the pulse crops under agroforestry systems. The significantly highest pod yield of pulses (1.71 t ha⁻¹) was observed for T₃ control (Rajmash only) followed by T₆ control (moong only) which recorded a value of 1.59 t ha⁻¹ whereas minimum grain yield (1.26 t ha⁻¹) was observed for treatment T₄ (Peach + moong).

4.2.6 Grain yield (t ha⁻¹)

The pod yield of pulses was significantly influenced by the treatments (Table-4). The pod yield of pulses in the open field was higher than that of the pulse crops under agroforestry systems. The significantly highest pod yield of pulses (0.96 t ha⁻¹) was observed for T₃ control (Rajmash only) followed by T₆ control (moong only) which recorded a value of 0.89 t ha⁻¹ whereas minimum grain yield (0.71 t ha⁻¹) was observed for treatment T₄ (Peach + moong).

Table 3: Growth parameters of pulses under Peach-Apricot based agroforestry system

Treatments	No. of primary branches	No. of pods/plant	Pod length (cm)	No. of seeds/pod
Peach + Rajmash	3.27	9.56	9.58	4.08
Apricot + Rajmash	3.48	9.86	9.93	4.56
Control (Only Rajmash)	3.79	10.35	10.46	5.34
Apricot + Moong bean	3.01	11.68	5.97	6.69
Peach + Moong bean	2.81	11.20	6.44	7.12
Control (Only Moong bean)	3.35	12.21	6.91	7.56
Control (Only Peach)*	-	-	-	-
Control (Only Apricot)*	-	-	-	-
Mean	3.28	10.81	8.21	5.89
CD (p≤0.05)	0.43	1.03	0.32	0.24
S.E(m)	0.14	0.43	0.81	0.58

*Not included in statistical analysis

Table 4: Yield parameters of pulses under Peach-Apricot based agroforestry system

Treatments	Pod yield (t/ha)	Grain yield (t/ha)
Peach + Rajmash	1.31	0.79
Apricot + Rajmash	1.37	0.84
Control (Only Rajmash)	1.71	0.96
Peach + Moong bean	1.26	0.71
Apricot + Moong bean	1.33	0.77
Control (Only Moong bean)	1.59	0.89
Control (Only Peach)*	-	-
Control (Only Apricot)*	-	-
Mean	1.42	0.83
CD (p≤0.05)	0.22	0.11
S.E(m)	0.07	0.03

*Not included in statistical analysis

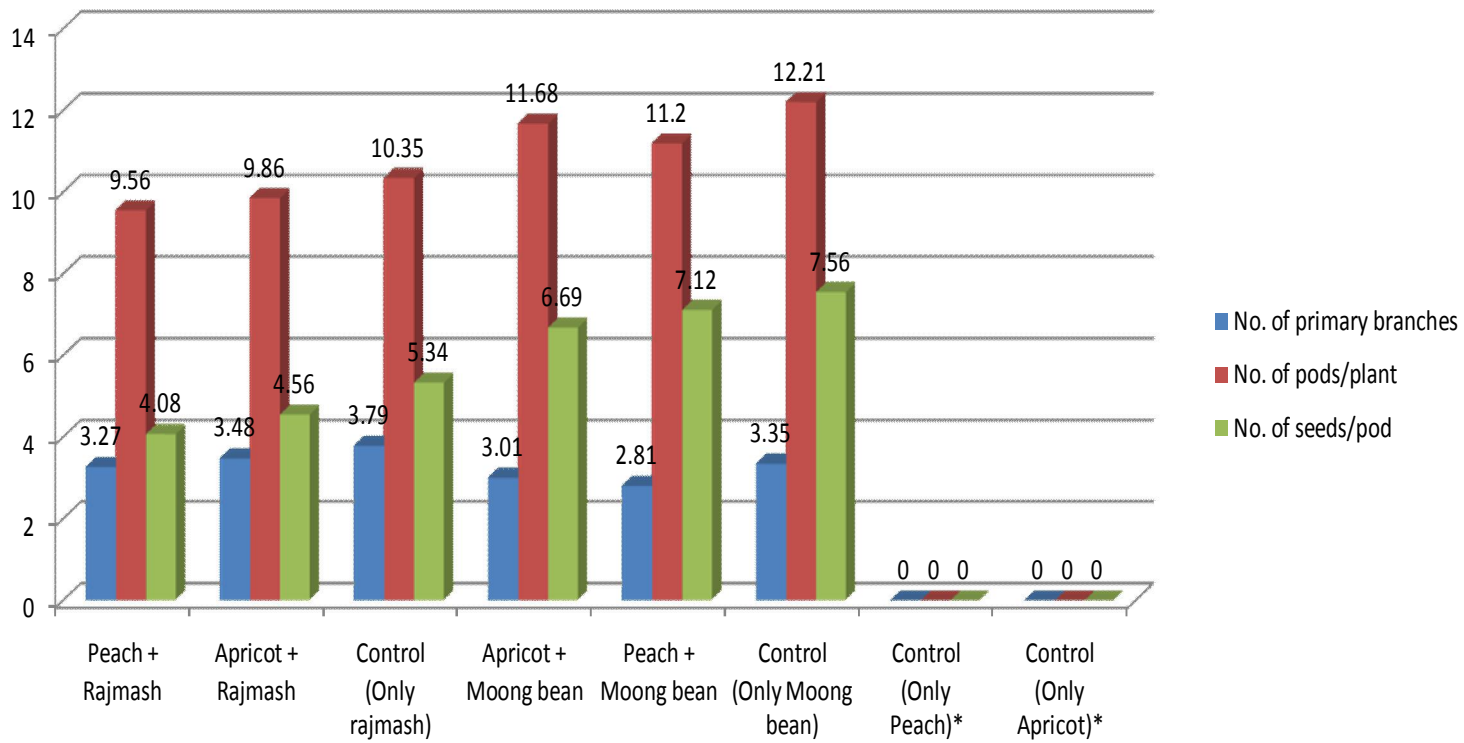


Fig. 2: Growth parameters of pulses

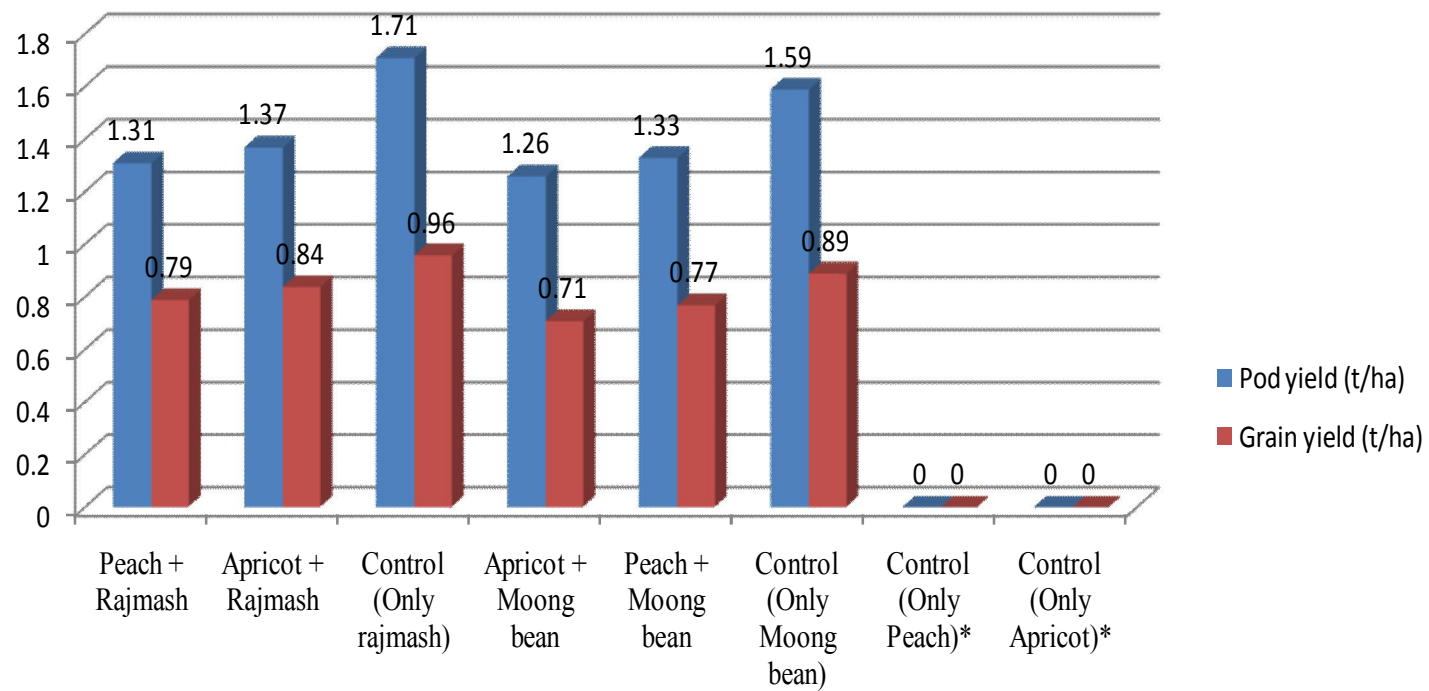


Fig. 3: Pod and grain yield of pulses



Plate 3: Sowing of Pulses



Plate 4: Seedlings of Pulses (Rajmash)



Plate 5: Harvesting of Pulses



Plate 6: Harvesting of fruits



Plate 7: After harvesting processing of Pulses

4.2.7 Aboveground biomass (t ha⁻¹) (Pulses)

4.2.7.1 Fresh above ground biomass (t ha⁻¹)

The fresh above ground biomass of pulses was significantly influenced by treatments (Table-5). The fresh above ground biomass production was higher in sole cropping treatments as compared to agroforestry treatments. Among different treatments, T₃ control (Rajmash only) was found to produce significantly highest fresh above ground biomass (2.25 t ha⁻¹) followed by 2.16 t ha⁻¹ in T₆ control (only moong) whereas the minimum was 1.85 t ha⁻¹ for T₄ (Peach + moong).

4.2.7.2 Dry above ground biomass (t ha⁻¹)

The data recorded and presented in Table-5, show significant influence of treatments and distances on dry aboveground biomass of pulses. In general, pulses in the open field (without trees) registered higher dry aboveground biomass than in the inter cropped field. Among different treatment combinations, T₃ control (Rajmash only) recorded significantly highest dry above ground biomass (1.03 t ha⁻¹) followed by T₆ (only moong) which recorded a value of 0.95 t ha⁻¹ whereas minimum dry above ground biomass (0.81 t ha⁻¹) was observed for T₄ (Peach + moong).

4.7.8 Below ground biomass (t ha⁻¹)

4.2.8.1 Fresh below ground biomass (t ha⁻¹)

The perusal of data (Table-5) shows that fresh below ground biomass of pulses intercropped under apple and sole cropping (control) was significantly influenced by different treatments and distances. The fresh below ground biomass in the open field was higher than that of the pulse crops under agroforestry systems. The treatment, T₃ control (Rajmash only) recorded significantly highest fresh below ground biomass (0.20 t ha⁻¹) followed by T₆ control (moong only) which recorded a value of 0.19 t ha⁻¹ whereas minimum fresh below ground biomass (0.12 t ha⁻¹) was observed for T₆ (Peach + moong).

4.2.8.2 Dry below ground biomass (t ha^{-1})

The critical analysis of data presented in Table-5, reveal that the dry below ground biomass of pulses was significantly influenced by the treatments. The dry below ground biomass was higher in sole cropping treatments as compared to agroforestry treatments. Among different treatments, T₃ control (Rajmash only) recorded significantly highest dry below ground biomass (0.11 t ha^{-1}) followed by T₆ control (moong only) which recorded a value of 0.10 t ha^{-1} whereas minimum dry below ground biomass (0.05 t ha^{-1}) was observed for T₄ (Peach + moong).

4.2.8.3 Total biomass (t ha^{-1})

The total biomass of pulses was significantly influenced by the treatments (Table-5). The total biomass was significantly higher in pulse crops without fruit trees. The treatment, T₃ control (Rajmash only) recorded significantly highest total biomass (1.14 t ha^{-1}) followed by T₄ control (moong only) with a value of 1.05 t ha^{-1} whereas minimum dry below ground biomass (0.86 t ha^{-1}) was observed for T₄ (Peach + moong).

Table 5: Biomass of pulses under Peach-Apricot based agroforestry system

Treatments		Fresh above ground biomass (t/ha)	Dry above ground biomass (t/ha)	Fresh below ground biomass (t/ha)	Dry below ground biomass (t/ha)	Total biomass (t/ha)	Harvesting index
T ₁	Peach + Rajmash	1.92	0.87	0.13	0.06	0.93	41.14%
T ₂	Apricot + Rajmash	2.06	0.91	0.15	0.07	0.98	40.77%
T ₃	Control (Only Rajmash)	2.25	1.03	0.20	0.11	1.14	42.66%
T ₄	Peach + Moong bean	1.85	0.81	0.12	0.05	0.86	38.37%
T ₅	Apricot + Moong bean	1.95	0.86	0.14	0.06	0.92	39.48%
T ₆	Control (Only Moong bean)	2.16	0.95	0.19	0.10	1.05	41.20%
T ₇	Control (Only Peach)*	-	-	-	-	-	-
T ₈	Control (Only Apricot)*	-	-	-	-	-	-
Mean		2.03	0.90	0.15	0.07	0.98	40%
CD (p≤0.05)		0.19	0.09	0.04	NS	0.12	

*Not included in statistical analysis

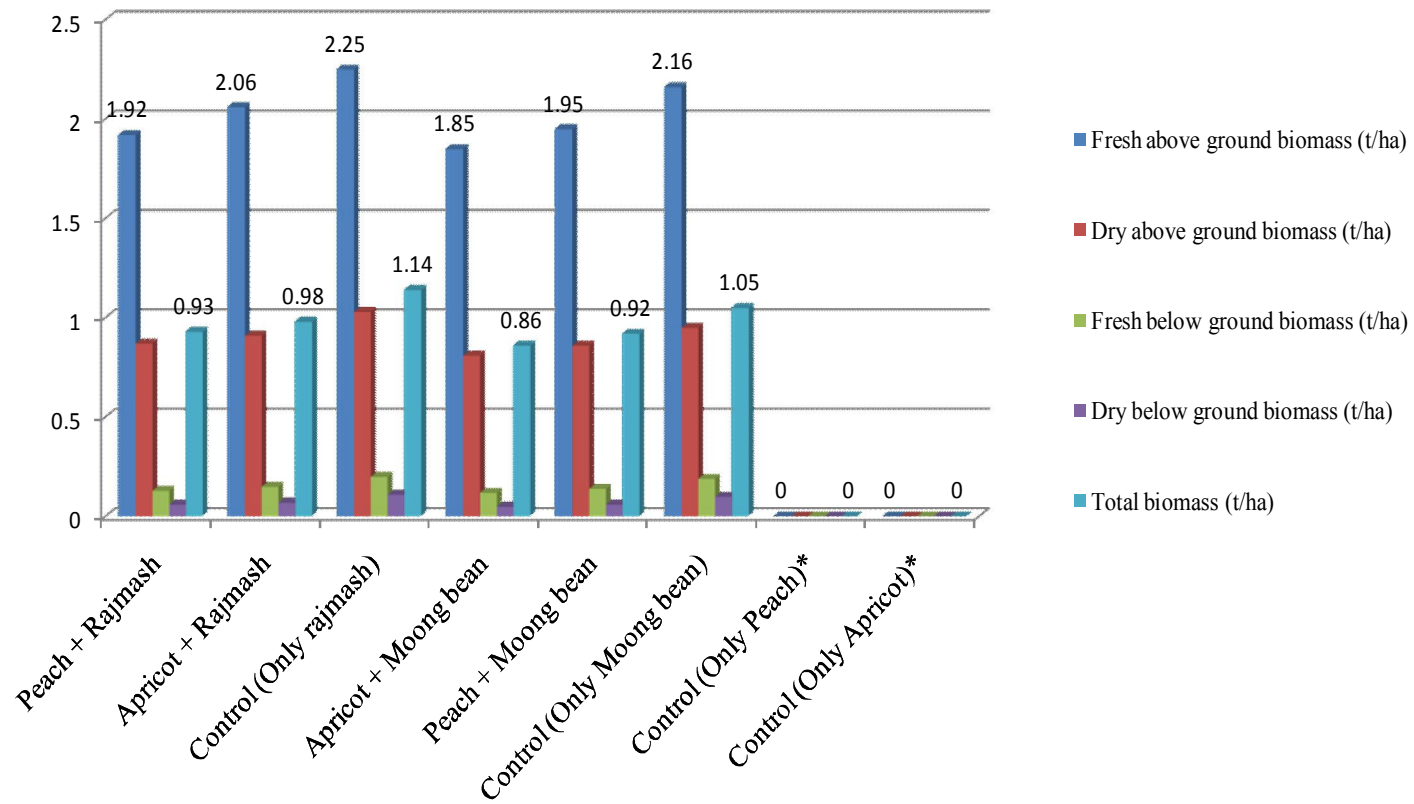


Fig. 4: Biomass pulses

4.3 Physico-chemical characteristics of soil

4.3.1 Soil bulk density (g cm^{-3})

The perusal of data presented Table-6, reveals that at the time of harvesting of pulses soil bulk density was significantly influenced by different treatments. Critical analysis of data indicate that at the time of harvesting of pulses, T₇ control (moong only) recorded significantly highest value of soil bulk density (1.31 g cm^{-3}) followed by T₈ control (Rajmash only) which recorded a value of 1.33 g cm^{-3} . The lowest value of bulk density was recorded for T₃ (Apricot + Rajmash) and T₄ control (Apricot + moong) which recorded similar values of 1.30 g cm^{-3} each.

4.3.2 Soil pH

Among the physical attributes, soil pH at the time of harvesting of pulses was significantly affected by different treatments. As is evident from Table-6, at the time of harvesting of pulses significantly highest value of soil pH was recorded under T₈ control (Rajmash only) recorded (6.92) followed by T₇ control (moong only) which recorded the value of 6.75. The lowest value of soil pH (6.61) was recorded for T₅ control (only Apricot).

4.3.3 Electrical conductivity (dSm^{-1})

The observation of data enumerated in Table-6, indicates that electric conductivity (EC) of soil at the time of harvesting of pulses was significantly influenced by the treatments. At the time of harvesting of pulses, among different treatment combinations, the maximum value of EC was recorded for T₇ control (Rajmash only) and T₈ control (only moong) which recorded similar values of 0.35 dSm^{-1} each followed by T₄ control (only Apricot) which recorded a value of 0.32 dSm^{-1} , however all of them were statistically at par. The lowest value (0.21 dSm^{-1}) was found under T₃ (Apricot + Rajmash).

Table 6: Physico- chemical characteristics of soil

Treatments	Soil bulk density (g cm ⁻³)		Soil pH		Soil EC (dSm ⁻¹)	
	Initial Value	At the time of harvesting of pulses	Initial Value	At the time of harvesting of pulses	Initial Value	At the time of harvesting of pulses
T ₁ - Peach + Rajmash	1.30	1.31	6.62	6.69	0.24	0.22
T ₂ - Peach + Moong bean	1.30	1.31	6.67	6.72	0.25	0.28
T ₃ - Apricot + Rajmash	1.29	1.30	6.68	6.74	0.22	0.21
T ₄ - Apricot + Moong bean	1.29	1.30	6.71	6.76	0.23	0.25
T ₅ - Control (Only Apricot)	1.31	1.31	6.61	6.61	0.29	0.32
T ₆ - Control (Only Peach)	1.31	1.31	6.69	6.69	0.28	0.31
T ₇ - Control (Only Moong bean)	1.31	1.34	6.73	6.75	0.35	0.35
T ₈ - Control (Only Rajmash)	1.31	1.33	6.81	6.92	0.34	0.35
Mean	1.30	1.31	6.69	6.73	0.27	0.28
CD (p≤0.05)	NS	0.01	0.06	0.09	NS	0.02
S.E(m)	0.003	0.005	0.02	0.03	0.01	0.02



Plate 8: Physico-chemical analysis of soil samples

4.3.4 Available nitrogen (kg ha⁻¹)

The examination of data presented in Table-7, shows that at the start of experiment, T₆ (Peach only) recorded maximum value of soil available nitrogen (309.67 kg ha⁻¹) followed by T₄ control (Apricot + moong) which recorded a value of 307.92 kg ha⁻¹, however both of them were statistically at par whereas the lowest value (289.41 kg ha⁻¹) was recorded for T₈ (control Rajmash only).

The perusal of data presented in Table-7, indicates significant influence of different treatments on soil available nitrogen at the time of harvesting of pulses. At the time of harvesting of pulses, T₄ (Apricot + moong) recorded significantly highest value of soil available nitrogen (361.23 kg ha⁻¹) followed by T₃ (Apricot + Rajmash) with a value of 359.14 kg ha⁻¹. The lowest value (304.92 kg ha⁻¹) of soil available nitrogen was recorded for T₅ control (only Apricot).

4.3.5 Available phosphorus (kg ha⁻¹)

The observations with regard to impact of different treatments on available phosphorus content of soil (Table-7) shows that at the start of experiment, the maximum available P (14.75 kg ha⁻¹) was recorded for T₁ (Peach + Rajmash) which was statistically at par with T₂ (Peach + moong) which recorded the value of 14.68 kg ha⁻¹. The lowest value (12.76 kg ha⁻¹) for available P was observed for T₇ (control moong only).

The data obtained for influence of different treatments on available P content of soil at the time of harvesting of pulses have been tabulated in Table-7. Among different treatments, the maximum available P (17.46 kg ha⁻¹) was recorded for T₂ (Peach + moong) followed by T₄ (Apricot + moong) which recorded the value of 17.43 kg ha⁻¹, however both were statistically at par whereas the least value (15.01 kg ha⁻¹) was observed for T₅ (control Apricot only).

4.3.6 Available potassium (kg ha^{-1})

The data enumerated in Table-7, shows that at the start of experiment, T₅ control (only Apricot) registered maximum value of available K ($210.56 \text{ kg ha}^{-1}$) followed by T₃ (Apricot + Rajmash) with a value of $209.34 \text{ kg ha}^{-1}$, however both of them were statistically at par. The lowest value of available K ($184.43 \text{ kg ha}^{-1}$) was recorded for T₈ control (Rajmash only). The data obtained for influence of different treatments on available K content of soil at the time of harvesting of pulses have been tabulated in Table-7. Among different treatments, the maximum available K ($222.57 \text{ kg ha}^{-1}$) was recorded for T₃ (Apricot + Rajmash) followed by T₁ (Peach + Rajmash) which recorded the value of $221.52 \text{ kg ha}^{-1}$, however both were statistically at par whereas the least value ($211.65 \text{ kg ha}^{-1}$) was observed for T₆ (Control Peach only).

Table 7: Physico- chemical characteristics of soil

Treatments	Available Nitrogen (kg/ha)		Available Phosphorus (kg/ha)		Available Potassium (kg/ha)	
	Initial Value	At the time of harvesting of pulses	Initial Value	At the time of harvesting of pulses	Initial Value	At the time of harvesting of pulses
T₁- Peach + Rajmash	302.06	353.75	14.75	17.31	208.85	221.52
T₂- Peach + Moong bean	301.56	357.29	14.68	17.46	208.26	221.03
T₃- Apricot + Rajmash	306.49	359.14	14.43	17.03	209.34	222.57
T₄- Apricot + Moong bean	307.92	361.23	14.11	17.43	209.13	220.18
T₅- Control (Only Apricot)	302.17	304.92	14.56	15.01	210.56	213.49
T₆- Control (Only Peach)	309.67	311.09	14.49	15.98	209.23	211.65
T₇- Control (Only Moong bean)	292.22	324.86	12.76	15.16	184.89	212.45
T₈- Control (Only Rajmash)	289.41	317.16	12.81	15.21	184.43	214.12
Mean	301.43	336.18	14.07	16.31	203.08	217.12
CD (p≤0.05)	1.78	3.18	0.68	0.26	1.17	2.53

4.3.7 Soil organic carbon (%)

Critical analysis of data (Table-8) reveals that maximum value (1.65 %) of soil organic carbon (%) was recorded under T₄ (Apricot + moong) followed by T₂ (Peach + moong) and T₃ (Apricot + Rajmash) which recorded a value of 1.65 %, however both of them were statistically at par whereas the lowest value (1.24 %) was found in T₇ control (moong only).

The data obtained for influence of different treatments on soil organic carbon at the time of harvesting of pulses have been tabulated in Table-7. Among different treatments, highest value of soil organic carbon (%) was recorded for T₃ (Apricot + Rajmash) which recorded a value of 0.68 % followed by T₁ (Peach + Rajmash) which recorded a value of 0.67 % however both of them were statistically at par. The lowest value (0.25 %) was found in T₇ control (moong only).

4.3.8 Soil moisture (%)

The perusal of data enumerated in Table-8, reveals that at the start of experiment, the maximum value (8.89 %) of soil moisture was observed for T₃ (Apricot + Rajmash) which was statistically at par with T₁ (Peach + Rajmash) which recorded the value of 8.86 %, whereas the least value (7.77 %) was found in T₇ control (moong only).

The perusal of data enumerated in Table-8, reveals that at the time of harvesting of pulses all treatments had a significant influence on soil moisture. The soil moisture was found higher in agroforestry treatments as compared to sole cropping treatments. At the time of harvesting of pulses, the significantly highest value (10.01%) of soil moisture was observed for T₄ (Apricot + moong) which was statistically at par with T₂ (Peach + moong) which recorded the value of 9.95 % whereas the least (8.49%) was found in T₇ control (moong only).

Table 8: Physico- chemical characteristics of soil

Treatments	Soil organic Carbon (%)		Soil Moisture (%)	
	Initial Value	At the time of harvesting of pulses	Initial Value	At the time of harvesting of pulses
T₁- Peach + Rajmash	0.63	0.67	8.86	9.53
T₂- Peach + Moong bean	0.64	0.65	8.69	9.95
T₃- Apricot + Rajmash	0.64	0.68	8.89	9.57
T₄- Apricot + Moong bean	0.65	0.66	8.71	10.01
T₅- Control (Only Apricot)	0.50	0.50	8.49	9.77
T₆- Control (Only Peach)	0.49	0.49	8.46	9.71
T₇- Control (Only Moong bean)	0.24	0.25	7.77	8.49
T₈- Control (Only Rajmash)	0.28	0.32	7.97	9.43
Mean	0.50	0.52	8.48	9.55
CD (p≤0.05)	0.03	0.04	0.62	0.65

4.4 Physical parameters of fruit, stone and kernel and Oil concentration of Apricot kernels

4.4.1 Fruit length (mm)

It is clear from the Table-9, that among different treatments, the maximum Fruit length(23.11 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where fruit length obtained was 22.26 mm whereas the minimum fruit length (21.09 mm) was obtained in T₃ control (Apricot only).

4.4.2 Fruit breadth (mm)

It is clear from the Table-9, that among different treatments, the maximum Fruit breadth(20.81 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where fruit breadth obtained was 19.61 mm whereas the minimum fruit breadth (19.54 mm) was obtained in T₃ control (Apricot only).

4.4.3 Fruit thickness (mm)

It is clear from the Table-9, that among different treatments, the maximum Fruit thickness (19.53 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where fruit thickness obtained was 19.44 mm whereas the minimum fruit thickness (19.36 mm) was obtained in T₃ control (Apricot only).

4.4.4 Stone length (mm)

The interpretation of data presented in Table-9, shows that the maximum stone length (19.26 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where stone length obtained was 18.48 mm whereas the minimum stone length (17.21 mm) was obtained in T₃ control (Apricot only).

4.4.5 Stone breadth (mm)

The interpretation of data presented in Table-9, shows that the maximum stone breadth (14.91 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where stone breadth obtained was 14.30 mm whereas the minimum stone breadth (12.12 mm) was obtained in T₃ control (Apricot only).

4.4.6 Stone thickness (mm)

The interpretation of data presented in Table-9, shows that the maximum stone thickness (9.36 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where stone thickness obtained was 8.97 mm whereas the minimum stone thickness (8.81 mm) was obtained in T₃ control (Apricot only).

4.4.7 Kernel length (mm)

The perusal of data enumerated in Table-9, shows that the maximum kernel length (12.21 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where kernel length obtained was 11.05 mm whereas the minimum kernel length (10.91 mm) was obtained in T₃ control (Apricot only).

4.4.8 Kernel breadth (mm)

The perusal of data enumerated in Table-9, shows that the maximum kernel breadth (7.87 mm) was obtained from T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where kernel breadth obtained was 7.18 mm whereas the minimum kernel breadth (7.12 mm) was obtained in T₃ control (Apricot only).

4.4.9 Kernel thickness (mm)

The perusal of data enumerated in Table-9, shows that the maximum kernel thickness (4.91 mm) was obtained from T₁ control (Apricot + Rajmash)

followed by T₂ (Apricot + moong) where kernel thickness obtained was 4.74 mm whereas the minimum kernel thickness (4.65 mm) was obtained in T₃ control (Apricot only).

4.4.10 Oil content (%)

The observations with regard to impact of different treatments on oil content of Apricot kernels (Table-9) shows that Oil content per cent recovered from kernels showed significant variations and ranged between 38.24% to 37.87%. The maximum oil content (38.24%) was registered by T₁ control (Apricot + Rajmash) followed by T₂ (Apricot + moong) where oil content obtained was 38.02 % whereas the minimum oil content (37.87 %) was obtained in T₃ control (Apricot only).

Table 9: Variation in fruit, stone, kernel characteristics and oil content (%) in Apricot (*P. armeniaca* L.)

Treatment		Fruit Length (mm)	Fruit Breadth (mm)	Fruit Thickness (mm)	Stone Length (mm)	Stone Breadth (mm)	Stone Thickness (mm)	Kernel Length (mm)	Kernel Breadth (mm)	Kernel Thickness (mm)	Oil Content (%)
T ₁	Apricot + Rajmash	23.11	20.81	19.53	19.26	14.91	9.36	12.21	7.87	4.91	38.24
T ₂	Apricot + Moong	22.26	19.61	19.44	18.48	14.30	8.97	11.05	7.18	4.74	38.02
T ₃	Control (Apricot only)	21.09	19.54	19.36	17.21	12.12	8.81	10.91	7.12	4.65	37.87
Mean		22.15	19.99	19.44	18.32	13.78	9.05	11.39	7.39	4.77	38.04
CD (p≤0.05)		1.18	1.23	1.26	1.15	0.87	0.39	0.37	0.82	0.53	0.11



Plate 9: Oil extraction from Apricot kernels

4.5 Carbon stock of the agroforestry system

4.5.1 Biomass of fruit trees

4.5.1.1 Stem biomass ($t\ ha^{-1}$)

The examination of the data presented in the Table-10, reveals that the stem biomass of fruit trees was significantly affected by different treatments. As evident from Table-9, T₃ (Apricot + Rajmash) recorded significantly highest value ($8.22\ t\ ha^{-1}$) followed by T₄ (Apricot + moong) which recorded the value of $8.20\ t\ ha^{-1}$, however both of them were statistically at par whereas the lowest value ($7.39\ t\ ha^{-1}$) was recorded for T₆ control (only Peach).

4.5.1.2 Canopy biomass ($t\ ha^{-1}$)

The data obtained for influence of different treatments on canopy biomass of fruit trees have been tabulated in Table-10. The influence of treatments was significant on canopy biomass of fruit trees. As evident from Table-10, T₃ (Apricot + Rajmash) recorded significantly highest value of canopy biomass ($3.36\ t\ ha^{-1}$) followed by T₄ (Apricot + moong) which recorded the value of $3.34\ t\ ha^{-1}$, however both of them were statistically at par. The lowest value of canopy biomass ($2.84\ t\ ha^{-1}$) was recorded for T₆ control (only Peach).

4.5.1.3 Fruit biomass ($t\ ha^{-1}$)

The perusal of data presented in the Table-10, reveals that different treatments influenced fruit biomass of fruit trees significantly. The data presented in Table-10, also reveals that significantly highest value of fruit biomass ($1.52\ t\ ha^{-1}$) was recorded for T₃ (Apricot + Rajmash) followed by T₄ (Apricot + moong) which recorded a value of $1.45\ t\ ha^{-1}$, however both of them were statistically at par whereas the minimum value ($0.82\ t\ ha^{-1}$) was recorded for T₆ control (only Peach).

4.5.1.4 Total above ground biomass (t ha⁻¹)

The perusal of data presented in the Table-10, reveals that different treatments influenced total above ground biomass of fruit trees significantly. The data presented in Table-10, also reveals that significantly highest value of total above ground biomass (13.10 t ha⁻¹) was recorded for T₃ (Apricot + Rajmash) followed by T₄ (Apricot + moong) which recorded a value of 12.99 t ha⁻¹, however both of them were statistically at par whereas the minimum value (11.05 t ha⁻¹) was recorded for T₆ control (only Peach).

4.5.1.5 Below ground biomass (t ha⁻¹)

Critical examination of data presented in Table-10, indicates that below ground biomass of fruit trees was significantly influenced by different treatments. The significantly highest value of the total below ground biomass (4.32 t ha⁻¹) was recorded under T₃ (Apricot + Rajmash) which was statistically at par with T₄ (Apricot + moong) which recorded a value of 4.28 t ha⁻¹ whereas the lowest value (3.64 t ha⁻¹) was recorded for T₆ control (only Peach).

4.5.1.6 Total tree biomass (t ha⁻¹)

The observation of data presented in Table-10, shows significant influence of different treatments on total tree biomass of fruit trees. As evident from Table-10, T₃ (Apricot + Rajmash) recorded significantly highest value of the total biomass (17.42 t ha⁻¹) followed by T₄ (Apricot + moong) with a value of 17.27 t ha⁻¹, however both of them were statistically at par. The lowest value of (11.69 t ha⁻¹) was recorded for T₆ control (only Peach).

Table 10: Dry Biomass of Peach and Apricot trees

Treatments		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)
T₁	Peach+ Rajmash	7.43	2.89	0.86	11.18	3.68	14.86
T₂	Peach + Moong	7.41	2.86	0.84	11.11	3.66	14.77
T₃	Apricot + Rajmash	8.22	3.36	1.52	13.10	4.32	17.42
T₄	Apricot + Moong	8.20	3.34	1.45	12.99	4.28	17.27
T₅	Control (Only Apricot)	8.19	3.32	1.38	12.89	4.25	17.14
T₆	Control (Only Peach)	7.39	2.84	0.82	11.05	3.64	11.69
	Mean	7.80	3.01	1.45	12.05	3.97	15.52
	CD (p≤0.05)	0.12	0.36	0.29	0.58	0.18	0.79

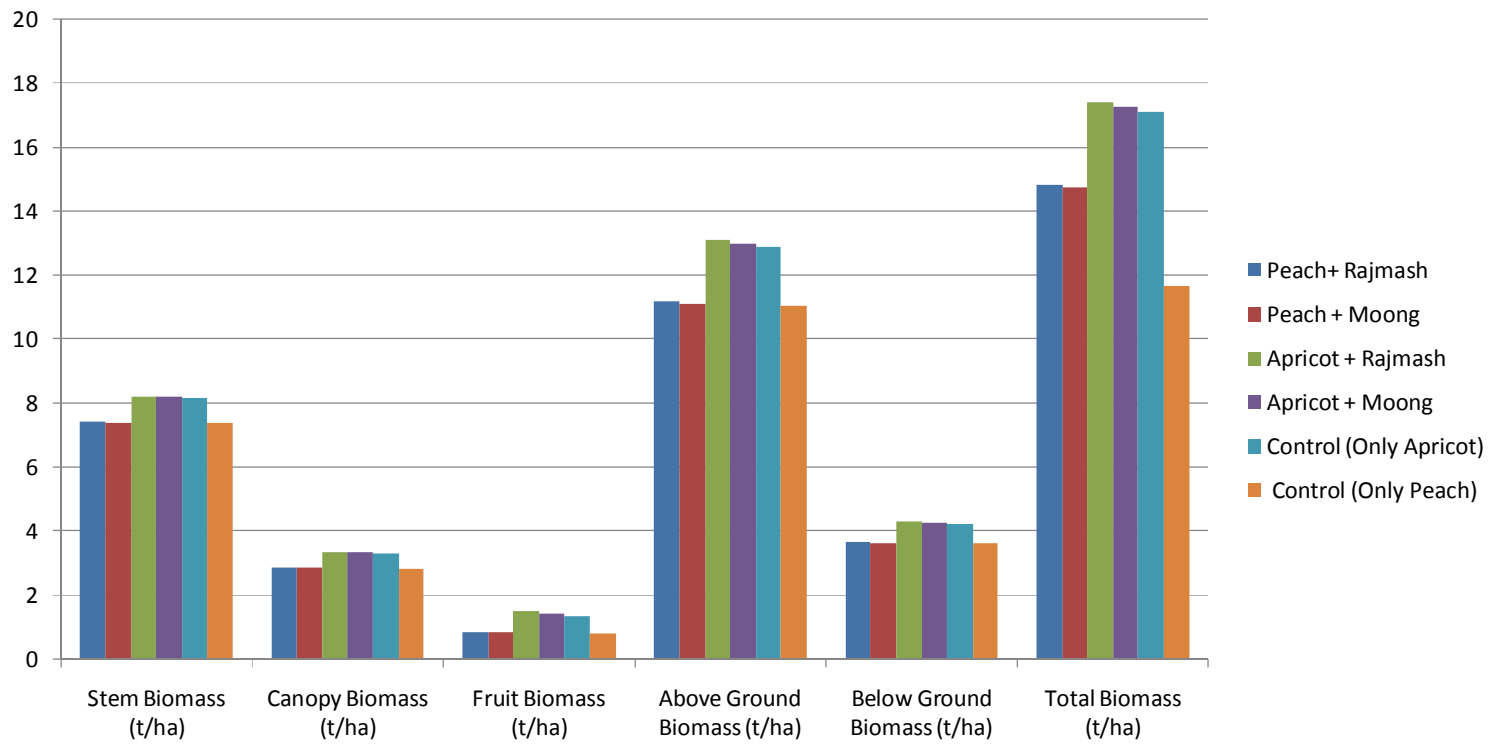


Fig. 5: Dry biomass of peach and Apricot trees

4.5.2 Carbon density of agroforestry system

4.5.2.1 Tree carbon density (t ha^{-1})

The data presented in the Table-11, indicates that the tree carbon density of fruit trees was significantly affected by different treatments. The treatment, T₃ (Apricot + Rajmash) recorded significantly highest value (8.71 t ha^{-1}) of the tree carbon density followed by T₄ (Apricot + moong) which recorded the value of 8.63 t ha^{-1} , however both of them were statistically at par whereas the lowest value (5.84 t ha^{-1}) was recorded for T₄ control (only Peach).

4.5.2.2 Crop carbon density (t ha^{-1}) of pulses

The perusal of data enumerated in Table-11, reveals that all the treatments had significant influence on carbon density of pulses. The significantly highest value (0.69 t ha^{-1}) of crop carbon density was observed for T₈ control (only Rajmash) followed by T₇ control (only moong) which recorded the value of 0.63 t ha^{-1} of crop carbon density whereas the lowest value (0.43 t ha^{-1}) was found for T₂ (Peach + moong).

4.5.2.3 Tree + crop carbon density (t ha^{-1})

The perusal of data enumerated in Table-11, shows that tree + crop carbon density was significantly influenced by different treatments. The treatment, T₃ (Apricot + Rajmash) recorded significantly highest value (9.20 t ha^{-1}) followed by T₄ (Apricot + moong) which recorded the value of 9.09 t ha^{-1} . The lowest value (0.63 t ha^{-1}) was found in T₇ control (only moong).

4.5.2.4 Soil carbon stock (t ha^{-1})

The examination of data presented in Table-11, reveals that various treatments had a significant influence on soil carbon stock. The significantly highest value (43.75 t ha^{-1}) of soil carbon stock was recorded for T₁ (Peach + Rajmash) followed by T₃ (Apricot + Rajmash) which recorded a value of 43.68 t

ha⁻¹, however both of them were statistically at par, whereas the minimum value (33.50 t ha⁻¹) was found under T₇ control (only moong).

4.5.2.5 Total carbon pool of the system (t ha⁻¹)

The data obtained for influence of different treatments on total carbon pool of the system have been tabulated in Table-11. The influence of treatments was significant on total carbon pool of the system. The treatment, T₃ (Apricot + Rajmash) recorded significantly highest value (52.88 t ha⁻¹) followed by T₄ (Apricot + moong) which recorded a value of 52.25 t ha⁻¹, however both of them were statistically at par whereas the least value (34.13 t ha⁻¹) was found in T₇ control (only moong).

Table 11: Carbon density of agroforestry system

Treatments		Tree carbon Density(t/ha)	Crop Carbon Density (t/ha)	Tree + Crop Carbon Density (t/ha)	Soil Carbon Stock (t/ha)	Total Carbon Pool of the system (t/ha)
T₁	Peach + Rajmash	7.43	0.46	7.89	43.75	51.64
T₂	Peach + Moong bean	7.38	0.43	7.81	43.23	51.04
T₃	Apricot + Rajmash	8.71	0.49	9.20	43.68	52.88
T₄	Apricot + Moong bean	8.63	0.46	9.09	43.16	52.25
T₅	Control (Only Apricot)	8.57	-	8.57	39.30	47.87
T₆	Control (Only Peach)	5.84	-	5.84	39.04	44.88
T₇	Control (Only Moong bean)	-	0.63	0.63	33.50	34.13
T₈	Control (Only Rajmash)	-	0.69	0.69	35.11	35.8
Mean		7.76	0.52	6.21	40.09	46.31
CD (p≤0.05)		0.26	0.007	0.02	2.36	2.33

4.6 Net return from the system

The economics of the Peach-Apricot based agroforestry system intercropped with pulses was calculated. The cost of cultivation, gross return, net returns and total net returns of the system were determined to know the economic profitability of the tree crop combination.

4.6.1 Cost of cultivation

The interpretation of data presented in Table-12, shows that the maximum cost of cultivation ₹42,152 ha⁻¹ was incurred in T₆ (control only moong) followed by T₃ (control Rajmash) where cost of cultivation incurred was ₹41,694 ha⁻¹. However, the minimum cost of cultivation (₹15,790 ha⁻¹) was incurred in T₁ (Peach +Rajmash) and T₂ (Apricot + Rajmash).

4.6.2 Gross return

It is clear from the Table-12, that among different treatments, the maximum gross return ₹65,280 ha⁻¹ was obtained from T₃ control (Rajmash only) followed by T₆ (control only moong) where gross return obtained was ₹60,520 ha⁻¹ whereas the minimum gross return (₹48,280 ha⁻¹) was obtained in T₄ (Peach + moong).

4.6.3 Net returns

The net return from intercrops was found to be highest (₹41,330 ha⁻¹) under T₂ (Apricot + Rajmash) followed by T₁ (Peach +Rajmash) which resulted in net return of (₹37,930 ha⁻¹) and the lowest net return (₹18,368 ha⁻¹) from T₆ (control only moong).

4.6.4 Total net returns

The total net returns from the agroforestry system were calculated from the net returns of intercrops and apple trees. The total net return was found higher in agroforestry treatments as compared to sole cropping treatments. The total returns was found to be highest (₹1,14,532 ha⁻¹) in T₂ (Apricot + Rajmash) followed by

T₅ (Apricot + moong) with total net returns of ₹1,02,576 ha⁻¹ and the lowest total net returns (₹18,368 ha⁻¹) from T₆ control (moong only) (Table-12).

4.6.5 Benefit cost ratio

The benefit cost ratio from the agroforestry system was calculated for the agroforestry system. The benefit cost ratio was found higher in agroforestry treatments as compared to sole cropping treatments. The benefit cost ratio was found to be highest (2.21) in T₂ (Apricot + Rajmash) followed by T₅ (Apricot + moong) as (2.08) and the lowest 1.32 from T₇ control (Peach only) (Table-12).

Table 12: Net returns from Peach and Apricot based agroforestry system intercropped with pulses

Treatments	Gross returns from intercrop (₹ha ⁻¹)	Cost on cultivation on intercrop (₹ha ⁻¹)	Net returns on intercrop (₹ ha ⁻¹)	Gross returns on Fruit trees (₹ ha ⁻¹)	Cost of cultivation on fruit trees (₹ ha ⁻¹)	Net returns on fruit trees (₹ ha ⁻¹)	Total net returns from System (₹ ha ⁻¹)	Discounted B.C Ratio @ 12%
T ₁ - Peach + Rajmash	53720	15,790	37,930	89930	64977	24953	62,883	1.78
T ₂ -Apricot + Rajmash	57120	15,790	41330	152190	78988	73202	114,532	2.21
T ₃ -Control (Only Rajmash)	65280	41,694	23586	-	-	-	23,586	1.57
T ₄ -Peach + Moong bean	48280	16,143	32137	87860	64977	22883	55,020	1.68
T ₅ -Apricot + Moong bean	52360	16,143	36,217	145350	78988	66362	102,576	2.08
T ₆ -Control (Only Moong bean)	60520	42,152	18,368	-	-	-	18,368	1.44
T ₇ -Control (Only Peach)	-	-	-	85790	64977	20813	20,813	1.32
T ₈ - Control (Only Apricot)	-	-	-	138320	78988	59332	59,332	1.75

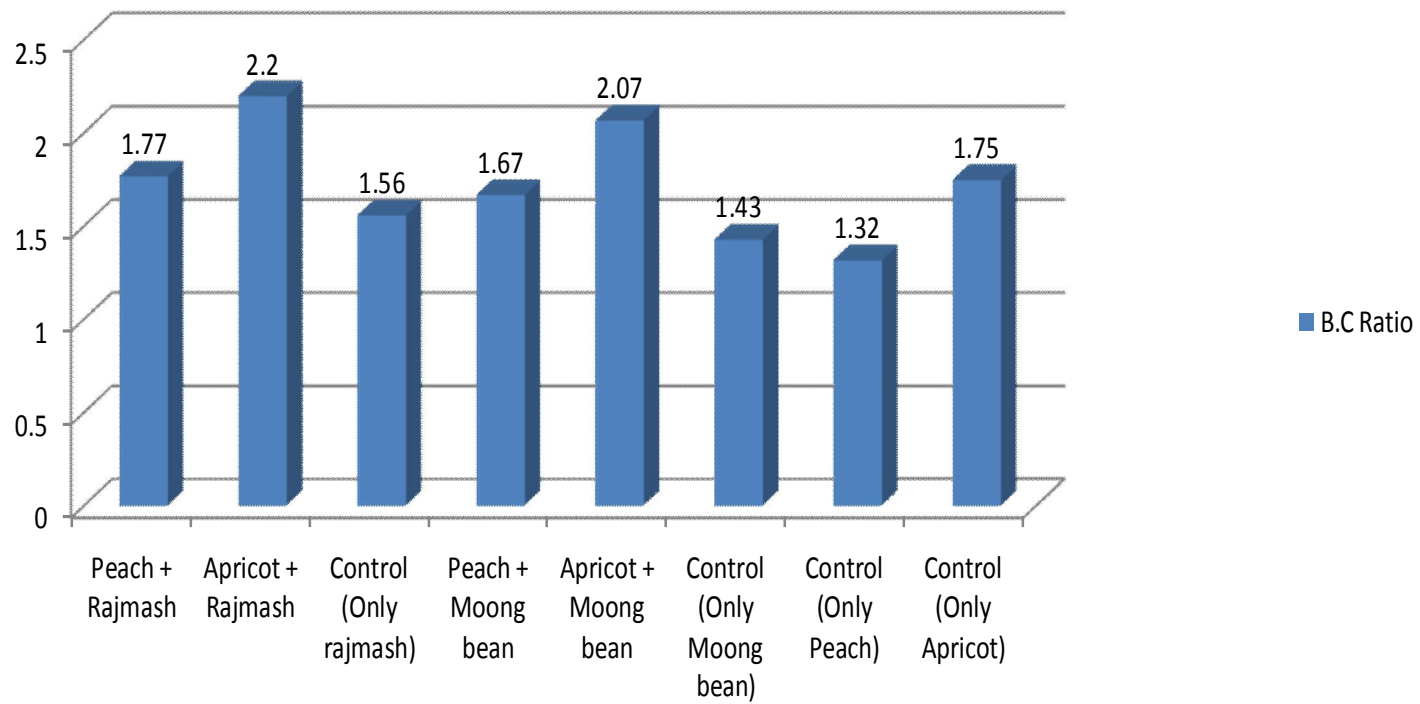


Fig. 6: Benefit cost ratio under different treatment

Chapter -5

DISCUSSION

The results obtained from the present investigation entitled “**Growth Performance And Economic Analysis of Pulses In Fruit Based Agroforestry System Under Degraded Land Conditions Of Benhama Ganderbal**” have been discussed in this chapter and an effort has been made to establish cause and effect relationships supported by available literature. The results are discussed under following headings:

- 5.1 Growth and yield parameters of Fruit trees
- 5.2 Growth and yield parameters of Pulses
- 5.3 Physico-chemical characteristics of soil
- 5.4 Physical parameters of fruit, stone and kernel and Oil concentration of Apricot kernels
- 5.5 Carbon stock of the agroforestry system
- 5.6 Economic analysis of the system

5.1 Growth and yield parameters of Fruit trees

The data presented in Table-1, indicate that the height, collar diameter, crown spread, fruit yield were significantly influenced by different treatments. The treatment, T₁ (Peach + Rajmash) recorded highest value of tree height (1.79 m) and crown spread (2.03 m) whereas minimum values of tree height (3.29 m) and crown spread (2.38 m) were registered under T₆ control (only Apricot). 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 is due to young age of Peach and Apricot orchard coupled with the drier climatic conditions of study site. The highest fruit yield (3.91 t ha⁻¹) for Peach and (8.01 t ha⁻¹) for Apricot was recorded under T₁ (Peach + Rajmash) and

T₄ (Apricot + Rajmash) 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. 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. Thus, productivity of Peach and Apricot could be increased through intercropping by careful selection of crops, which differ in nature, morphology and growth rhythms so that the peak demands for moisture, nutrients and light occur at different stages in the crop season. Positive influence of crop sequences on yield of perennial crops have been reported by Dhyani and Tripathi (1999) (Gill *et al.*, 2000), Bhatt and Mishra (2008) (Awasthi *et al.*, 2009) (Arya *et al.*, 2010) (Negi *et al.*, 2013) and (Patle *et al.*, 2016). The findings of Kumar (2004) (Gill *et al.*, 2004), Joshi (2008) and Shah (2012) are in corroboration with the present findings.

5.2 Growth and yield parameters of Pulses

The components of agroforestry system often greatly differ in size, texture, nature, growing period etc. It is an established fact that the integration of trees on the farmland paves a way for the improvement as well as the diversification of the existing systems. Growth, broadly speaking, refers to the irreversible increase in the shape, size and weight of an organism/plant whereas yield refers to the amount harvested at the end of the cropping cycle. Higher growth rate means more accumulation of fresh and/or dry weight by the plant resulting in higher yield. This growth and yield relationship is affected by various factors like climatic, edaphic and topographic factors. In an agroforestry system, the integration of trees with field crops results into a number of above and below ground biological interactions. Woody and non-woody components of the system compete with each

other for the critical resources. During the present study, the effect of different agroforestry systems and yield parameters of pulses were monitored. The results in general indicate that the presence of woody component (fruit trees) adversely affected the growth and yield parameters of crops.

Results of the present study depicted that pod length (cm), number of pods per plant, number of primary branches and number of seeds per pod of pulses was significantly influenced by different treatments. The treatment, T₃ control (only Rajmash) recorded highest number of primary branches (3.79) and pod length (10.46 cm) whereas minimum number of primary branches (2.81) and pod length (5.97 cm) were recorded for T₅ (Peach + moong) and T₄ (Apricot + moong) respectively. The highest number of pods per plant (11.68) and number of seeds per pod (7.56) were observed for treatment, T₄ (Apricot + moong) and T₆ control (moong only) respectively, whereas the treatment, T₁ (Peach + Rajmash) recorded minimum number of pods per plant (9.56) and number of seeds per pod (4.08). The values for growth parameters in all pulse crops (Rajmash and moong) were higher in the open field than in the intercropped field. The possible reason for this is increased availability of light, space, water and nutrients in a pure cropping system resulting in production of more number of branches, number of seeds per pod, number of pods per plant and pod length. As light passes through the tree canopy, changes perceived by the plants through the phytochemical system induce marked morphogenetic changes in plant and inhibit branching. Similar results were corroborated by Kabir and Sarkar (2008) (Rathod *et al.*, 2010), Patil (2010), Solanki (2013) and Bhat (2015).

Perusal of the results (Table-4) reveals that the grain and pod yield of pulses were significantly influenced by the treatments. In all three pulse crops, comparatively higher production of grain and pod was observed in open (sole crops) as compared to agroforestry systems. This is due to high competition between the roots of the crop and the tree in the upper soil layer probably resulting in high yield reduction in pulse crop. Shading can also be seen as a factor which

can lead to reduction in crop performance and yield in the intercropping (agroforestry) systems (Newman *et al.*, 1998; Rao *et al.*, 1998). The highest grain yield and pod in the present study were obtained under T₃, control only Rajmash (0.96 t ha⁻¹ and 1.71 t ha⁻¹ respectively) whereas the lowest yield (grain and pod) were recorded under T₄, Peach + moong (0.65 t ha⁻¹ and 1.20 t ha⁻¹ respectively). Patil (2010) also reported similar trend of results for french bean and green gram. Adverse influence of different tree based intercropping system on growth and yield of sole crops have been reported by (Xiaobang Peng *et al.*, 2009); (Pandey *et al.*, 2010); (Palsaniya *et al.*, 2012); (Balyan *et al.*, 2014) and (Patle *et al.*, 2016).

Exposition of data presented in Table-4, revealed that among different treatments, treatment T₃ control (Rajmash only) recorded maximum value of fresh above ground biomass (2.25 t ha⁻¹), dry above ground biomass (10.3 t ha⁻¹), fresh below ground biomass (0.20 t ha⁻¹), dry below ground biomass (0.11 t ha⁻¹) and total biomass (1.14 t ha⁻¹) whereas minimum value of fresh above ground biomass (1.85 t ha⁻¹), dry above ground biomass (0.81 t ha⁻¹), fresh below ground biomass (0.12 t ha⁻¹), dry below ground biomass (0.05 t ha⁻¹) and total biomass (0.86 t ha⁻¹) were observed under T₄ (Peach + moong). The values for biomass parameters in all pulse crops (Rajmash and moong) were higher in sole cropping system as compared to agroforestry systems. This might be due to the uninterrupted and adequate amount of incident sunlight besides, zero tree-crop competition for light, nutrient and moisture in open condition for synthesizing food material. Similar results have been reported by George and Nair (1987) (Nair *et al.*, 1991) (Singh *et al.*, 1997), Shinde (2001) (Venugopal *et al.*, 2008) (Thakur *et al.*, 2010), Vanlalhluna and Sahoo (2010) and Bhat (2015).

5.3 Physico-chemical characteristics of soil

The data obtained from soil analysis indicates that there was reduction in soil bulk density, EC, pH and improvement in organic carbon, available nitrogen, phosphorus, potassium and soil moisture when the crops were grown under agroforestry system as compared to open area (Table 6, 7 and 8). The reason

behind this might be that the annual crops covered the whole area and various cultural operations such as ploughing and weeding were performed regularly in the cropped area. Besides this, the perennial plants also ameliorate the soil through litter fall every year. The results are also in accordance with (Gangwar *et al.*, 1995) for agri-silviculture system of agro- forestry. This overall improvement of soil status is achieved not only due to the addition of leaf-litter from tree species but also due to ameliorative effect of fruit trees on chemical properties of the soil.

Scrutiny of the data obtained from soil analysis indicates that there was significant effect of different treatments on available N, P and K content in soil. Results of the present investigation revealed that nutrient status (N, P and K) was higher ($361.23 \text{ kg ha}^{-1}$, 17.43 kg ha^{-1} and $224.58 \text{ kg ha}^{-1}$ in the agroforestry system as compared to the open conditions ($307.92 \text{ kg ha}^{-1}$, 14.68 kg ha^{-1} and $210.56 \text{ kg ha}^{-1}$ respectively. This is due to the more organic decomposition in the agroforestry system due to the addition of more leaf litter in the system. The results of the present findings can be supported with findings of (Cardoso *et al.*, 2001) (Chaudhry *et al.*, 2007) (Lima *et al.*, 2010) (Ahmed *et al.*, 2010), Wang and Cao (2011) (Benbi *et al.*, 2012) (Santiago *et al.*, 2013) (Bhat 2015) and (Shah *et al.*, 2017).

Data of the present study revealed that 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 %. 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. Bowen & associates (1988) also reported that plant residues or litter has multi beneficial effects which include maintenance of good soil physical conditions as well as soil organic matter, provision of nutrients and stimulation of biological activity as well as

moderate acidity in soil (Gupta *et al.*, 2009) (Singh *et al.*, 2010) (Borja *et al.*, 2011) (Yadav *et al.*, 2011) (Benbi *et al.*, 2012) and Bhat (2015) also reported the similar trend of results.

Observation of the data in the present study reveals that different treatments registered significant effect on soil pH and electrical conductivity. Perusal of results revealed that maximum soil pH 6.92 and electrical conductivity 0.35 dSm^{-1} were observed under sole cropping systems and minimum soil pH 6.61 and electrical conductivity 0.21 dSm^{-1} under agroforestry systems. This is attributed to ability of fruit trees to produce leaf litter and thereby cause reduction in pH and EC. These findings corroborates with that of Sharma and Singh (1997) (Devaranavadi *et al.*, 2004) and (Imayavaramban *et al.*, 2001).

The data pertaining to soil moisture obtained from soil analysis revealed that different treatments significantly influenced soil moisture during the study. The increased soil moisture 10.01 % was observed in agroforestry systems as compared to sole cropping 8.49 %. Bijalwan (2010) reported that soil moisture was higher in agri-horticulture compared to sole agriculture (tree less or control). The highest moisture status of soil can be attributed to reduction in water evaporation, therefore, conserving the available water in soil (Agele, 2000). Similar trend of results were reported by Dutt (2004), Dubey (2010) and (Siriri *et al.*, 2013).

Perusal of data presented in Table 7, revealed that maximum soil bulk density 1.34 g cm^{-3} was recorded in sole cropping system as compared to agroforestry systems 1.29 g cm^{-3} . Similar trend of results was reported by Biswas *et al.*, 2003) and (Oyedele *et al.*, 2009). Chaudhari & associates (2013) reported high degree of reverse correlation between soil organic matter and soil bulk density. Similar trend of results were seen in the present study.

5.4 Physical parameters of fruit, stone and kernel and Oil concentration of Apricot kernels

The study conducted revealed that different treatments yielded varying results for fruit characteristics. The highest fruit length, measuring 23.11 mm, was obtained from the T₁ control (Apricot + Rajmash), followed by T₂ (Apricot + moong) with a fruit length of 22.26 mm. The lowest fruit length of 21.09 mm was observed in the T₃ control (Apricot only). Similarly, the maximum fruit breadth of 20.81 mm was obtained from the T₁ control, followed by T₂ with a breadth of 19.61 mm. The minimum fruit breadth of 19.54 mm was recorded in the T₃ control g. In terms of fruit thickness, the highest measurement of 19.53 mm was found in the T₁ control, followed by T₂ with a thickness of 19.44 mm. The lowest fruit thickness of 19.36 mm was observed in the T₃ control. Regarding stone characteristics, the maximum stone length of 19.26 mm was recorded in the T₁ control group, while T₂ had a length of 18.48 mm. The minimum stone length of 17.21 mm was observed in the T₃ control. Similarly, the maximum stone breadth of 14.91 mm was obtained from the T₁ control, followed by T₂ with a breadth of 14.30 mm. The minimum stone breadth of 12.12 mm was recorded in the T₃ control. The maximum stone thickness of 9.36 mm was found in the T₁ control, followed by T₂ with a thickness of 8.97 mm. The minimum stone thickness of 8.81 mm was observed in the T₃ control. In case of kernel characteristics, the maximum kernel length of 12.21 mm was obtained from the T₁ control, while T₂ had a length of 11.05 mm. The minimum kernel length of 10.91 mm was recorded in the T₃ control. The maximum kernel breadth of 7.87 mm was observed in the T₁ control, followed by T₂ with a breadth of 7.18 mm. The minimum kernel breadth of 7.12 mm was obtained in the T₃ control. Lastly, the maximum kernel thickness of 4.91 mm was found in the T₁ control, while T₂ had a thickness of 4.74 mm. The minimum kernel thickness of 4.65 mm was observed in the T₃ control group. The oil content recovered from the kernels exhibited significant variations, ranging from 38.24% to 37.87%. The T₁ control group registered the

highest oil content of 38.24%, followed by T₂ with an oil content of 38.02%. The T₃ control group had the lowest oil content of 37.87%.

My findings gets conformity from researchers who studied physical characteristics of Apricot throughout Globe. In a study by Ahmadi *et al.* (2009), they examined the physical and mechanical properties of Sonnati Salmas Apricot fruits, pits and kernels. They determined various technological properties such as dimensions, geometric mean diameter, sphericity, surface area, bulk density, true density, porosity, volume, mass, true density, bulk density, porosity, 1000-unit mass, coefficient of static friction on different surfaces and rupture force in three axes. The moisture contents for Apricot fruits, pits and kernels were 82.34%, 16.48% and 13.03%, respectively. The fruits had larger volumes, mass and surface area compared to the pits and kernels. The static coefficient of friction for fruits on various surfaces (wood, glass, galvanized sheet and fiber glass sheet) was measured and the value was lower for pits and kernels on glass (0.474 and 0.188, respectively). The rupture force of the fruit, pit and kernel were as follows: 10.11 N, 497.79 N and 18.92 N in length; 7.98 N, 322.59 N and 41.97 N in width; and 7.01 N, 337.21 N and 99.58 N in thickness.

In another study by Wani *et al.* (2015), they investigated the physical characteristics of different Apricot varieties. They examined eleven varieties, including Chinese, Rival, Tilton, Cuminis Haley, Harcot, Margulam, Narmu, Khante, Halman, Badam Chuli and Cuban, focusing on mineral analysis, physical characteristics and antioxidant properties. The physical characteristics of the Apricot varieties showed significant variation ($p \leq 0.05$). Cuban and Harcot had comparatively larger fruit sizes. However, Cuminis Haley and Harcot exhibited the highest edible bulk.

In their study, Wani and Mughal (2017) observed variations in the characteristics of stone, kernel and oil content among 22 candidate plus trees of the wild Apricot tree. The analysis of variance revealed significant differences among the 22 candidate plus trees for all the studied traits. The oil content

percentage extracted from the kernels exhibited significant variations, ranging from 25.52% for CPT 15/075 (S5) to 54.64% for CPT 14/075 (S5). The highest oil content value of 54.64% was recorded for CPT 15/075 (S5), followed by CPT 20/075 (S8) with 53.00% oil content. Among the 22 seed sources, four sources recorded oil content above 50%. There was a variation of more than 29.00% in oil content among all the 22 CPTs, indicating the potential for utilizing this trait in tree improvement programs.

5.5 Carbon stock of the agroforestry system

Geographical region, plant species and age are the major determinants of biomass and carbon stock in vegetation (Dash and Behera, 2013; 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. Annual crops only accumulate carbon through the roots and retention of crop residues, whereas the tree crops accumulate carbon through roots, litter and above ground biomass. The total biomass (above ground + below ground) and tree carbon density by fruit trees were observed to be significantly influenced by different treatments (Table 10 and 11). The maximum amount of tree carbon density was recorded in agroforestry systems than control (only fruit trees). It was found that the treatment, T₃ (Apricot + Rajmash) 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). This is due to higher biomass production by fruit trees in agroforestry systems as compared to sole cropping system. This is consistent with findings of (Tomich *et al.*, 2002); and (Yadav *et al.*, 2015).

The perusal of data presented in Table-10, 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 (only Rajmash) whereas the lowest value (0.43 t ha^{-1}) was found under T₂ (Peach + moong). This is because of maximum biomass production by crops in sole cropping systems as compared to agroforestry systems.

Observation of the data in the present study reveals that, during both the cropping seasons, different treatments registered significant effect on soil carbon stock. 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 (Peach + Rajmash) whereas the minimum value (33.50 t ha^{-1}) was found under T₇ control (only moong). Pinho & associates (2012) and Ramesh & associates (2013) reported that various interacting factors through which a tree influences carbon stock in the soil under agroforestry are addition of litter, maintenance of higher soil moisture content, reduced surface soil temperature, proliferated root system, enhanced biological activities and decreased risk of soil erosion. Chauhan and associates (2015) also reported higher soil organic carbon in agroforestry systems than sole crop cultivation. Similar trend of result was seen in the present study.

Observation of the data (Table-11) 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 (Apricot + Rajmash) recorded significantly highest value (52.88 t ha^{-1}) whereas the least value (34.13 t ha^{-1}) was found in T₇ control (only moong). Benbi & associates (2012) and Jose and Bardhan (2012) reported that agroforestry systems likely have a greater capacity to sequester Carbon in long-term than the annual cropping systems. Cultivating agricultural crops with fruit trees plantation, therefore, is an attractive option for storage of atmospheric CO₂. 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. The present findings are in line with Yadava (2010) (Prasad *et al.*, 2012) (Labata *et al.*, 2012) (Harsh *et al.*, 2012) (Chauhan *et al.*, 2015) (Mangalassery *et al.*, 2015) (Yadav *et al.*, 2015) and Kumar (2017).

5.6 Economic analysis of the system

The cost of cultivation along with gross and net returns was determined for fruit based agroforestry system. The economic analysis of different cropping system (Table-12) showed that higher returns were obtained when the intercrops were grown in association with fruit trees rather than sole cropping. The total returns was found to be highest (₹1,14,532 ha⁻¹) in T₂ (Apricot + Rajmash) followed by T₅ (Apricot + moong) with total net returns of ₹ 1,02,576 ha⁻¹ and the lowest total net returns (₹20,813 ha⁻¹) from T₇ control (only moong).

Intercropping of Rajmash and moong crop sequences with fruit trees gave highest fruit yield of Peach and Apricot along with gross monetary return. The highest gross returns were registered in open (sole cropping treatment) in all the crops which is due to the higher yield of these crops in control. The total net returns were significantly higher under agroforestry systems compared to sole cropping of pulses and oats. The higher net returns under agroforestry intervention is due to additional income procured from the fruit trees, while this extra benefit is absent under sole cropping. The results are in line with the findings of Yadava and Singh (1996), Chauhan (2000), Dutt and Thakur (2004), Bhatt and Mishra (2008) (Sharma *et al.*, 2008) (Awasthi *et al.*, 2009) (Mandal *et al.*, 2012) (Patil *et al.*, 2012) (Palsaniya *et al.*, 2012) (Wekesa *et al.*, 2012), Shah (2012), Chandra (2014) (Nayak *et al.*, 2014), Bhat (2015) (Rajalingam *et al.*, 2015) (Zaman *et al.*, 2016) and (Patle *et al.*, 2016). The findings of present study suggest that the growing of pulses with Peach and Apricot trees ensures regular income from agroforestry intervention. The growing all crops (Rajmash and moong) is highly remunerative if farmers have their own land and the cost of cultivation is minimized.

Examination of data present in Table 12 revealed that highest benefit cost ratio among different treatments was noticed when the intercrops were grown in association with fruit trees rather than sole cropping. Maximum benefit cost ratio ascribed to higher benefits from crops and fruit trees. Highest benefit cost ratio was noticed in T₂ Apricot + Rajmash (2.20) followed by T₅ Apricot + Moong bean (2.07) while as lowest benefit cost ratio (1.32) was registered by T₇ Control (Only Peach). These findings are in agreement with Singh (2010) and Bhatt and Mishra (2008).

Chapter-6

SUMMARY AND CONCLUSION

The study titled " Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System Under Degraded Land Conditions of Benhama Ganderbal " was conducted in the research field of the Division of Silviculture and Agroforestry, Faculty of Forestry, SKUAST-K, Benhama, under degraded land conditions. The aim of the study was to evaluate the growth and yield performance of intercrops, specifically Rajmash and Moong pulses, in conjunction with fruit trees, (Apricot and Peach).

The results of the investigation revealed that both Rajmash and Moong pulses thrived well under the fruit-based agroforestry system and demonstrated successful cultivation as intercrops with fruit trees. However, among the intercrops tested, Rajmash performed better. When compared to sole cropping, the growth and yield parameters of intercrops, including the number of primary branches, number of pods per plant, pod length, number of seeds per pod, grain yield and total biomass, were slightly lower when grown in combination with fruit trees.

On the other hand, 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 highest fruit yield was recorded in the (Apricot + Rajmash) combination, while the minimum yield was observed in the control group (Peach only).

Furthermore, the study indicated that the physico-chemical characteristics of the soil, such as organic carbon, available nitrogen, phosphorus, potassium and soil moisture, were improved when crops were grown under the agroforestry system compared to open areas. The maximum values of soil carbon and total carbon stock were observed in the agroforestry systems with fruit trees and intercrops, while the minimum values were recorded in the sole cropping systems

without any tree component. Specifically, the highest total carbon stock was observed in the (Apricot + Rajmash) and (Apricot + Moong) combinations.

Economically, the agroforestry system outperformed sole cropping, with higher production potential and economic returns. In terms of total returns, the (Apricot + Rajmash) combination yielded the highest returns, while the control group (Moong only) had the lowest returns. Based on economic returns, the sequences can be ranked as follows: Apricot + Rajmash > Apricot + Moong > Peach + Rajmash > Peach + Moong.

Based on the findings of this study, it can be concluded that all the intercrops tested can be successfully cultivated under fruit-based agroforestry systems, specifically with Apricot or Peach trees. Implementing such diversification practices can prove to be a viable option for enhancing the economic potential of farming communities.

CONCLUSIONS

- Growth and yield parameters like number of primary branches, number of pods per plant, pod length, number of seeds per pod, grain yield, harvesting index and total biomass in pulses were found maximum in control (rajmash only and moong only).
- The highest yield of pulses (both rajmash and moong) was obtained under sole crop cultures whereas among the tree and crop combination treatments the highest yield was obtained from apricot and rajmash.
- The highest fruit yield was obtained in apricot and rajmash.
- Most of the physico- chemical characteristics of soil (organic carbon, available nitrogen, phosphorus and potassium and soil moisture) were improved when the crops were grown under agroforestry system as compared to open area.

- Maximum value of soil carbon and total carbon stock was recorded for agroforestry systems (fruit trees + intercrops) whereas minimum was recorded for sole cropping systems with no tree component.
- Highest economic returns were obtained from the agroforestry system than sole cropping. The highest total returns was found to be highest under (Apricot + Rajmash) followed by (Apricot + moong).
- The Apricot and Rajmash based agroforestry system has highest potential of acting as a source of Carbon sink as concluded from system. It can prove to be a viable option for climate change mitigation.
- The Apricot and Rajmash based Agroforestry system can be concluded as a suitable crop combination under degraded land conditions. However, further investigation needs to be done to fully comprehend the intricate nuances and potential applications of the findings, paving the way for future advancements in this field.

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APPENDIX – I**Meteorological data for the year 2022**

		Temperature (°C)		Relative humidity (%)	
S. No.	Months	Maximum	Minimum	I	II
1.	January	9.84	-2.84	92.32	63.26
2.	February	13.99	-1.02	89.07	45.24
3.	March	15.06	2.75	85.71	60.35
4.	April	18.72	6.05	87.77	68.97
5.	May	26.29	9.76	79.26	52.65
6.	June	3.043	14.22	73.27	47.17
7.	July	30.29	16.61	80.61	49.23
8.	August	27.32	15.56	86.39	57.77
9.	September	28.93	11.09	58.23	46.57
10.	October	24.82	3.55	82.35	38.42
11.	November	16.03	-1.49	89.37	47.00
12.	December	11.26	-3.98	93.97	55.39

APPENDIX – II**Meteorological data for the year 2022**

S. No.	Months	Sun Shine (hr)	Wind Speed (km/hr)	Rain/Precipitation (mm)	Evaporation (mm)
13.	January	3.34	1.81	33	0.77
14.	February	5.85	2.38	54.40	1.71
15.	March	6.50	2.31	194.30	1.59
16.	April	4.59	2.08	116.80	2.49
17.	May	7.11	1.65	63.80	3.16
18.	June	8.98	1.24	45.00	4.74
19.	July	7.26	1.0	107.40	4.83
20.	August	5.88	0.89	98.20	4.34
21.	September	7.52	1.32	12.10	4.12
22.	October	6.92	1.13	6.40	2.99
23.	November	1.72	0.48	45.00	0.90
24.	December	0.73	0.40	13.00	0.58

APPENDIX -III**Economics of Rajmash (control)**

S. No.	Particulars	Cost (₹ ha⁻¹)
1.	Land rental	25,904
2.	Labour	5,243
3.	Ploughing and harrowing	5,312
4.	Seed	2,400
5.	Manure and Fertilizer	1,443
6.	Irrigation	430
7.	Plant protection	180
8.	Overhead cost	782
Total cost		20,225

Economics of moong (control)

S. No.	Particulars	Cost (₹ ha⁻¹)
1.	Land rental	25,904
2.	Labour	5,346
3.	Ploughing and harrowing	5,289
4.	Seed	2,600
5.	Manure and Fertilizer	1,562
6.	Irrigation	460
7.	Plant protection	189
8.	Overhead cost	838
Total cost		16,284

APPENDIX – IV

Economics of Peach

S. No.	Particulars	Cost (₹ ha⁻¹)
1.	Land rental	25,904
2.	Manures	21,025
3.	Plant protection	11,033
4.	Irrigation	2,885
5.	Overhead cost	4,030
Total cost		64,877

Economics of Apricot

S. No.	Particulars	Cost (₹ha⁻¹)
6.	Land rental	25,904
7.	Manures	24,756
8.	Plant protection	14,062
9.	Irrigation	3,546
10.	Overhead cost	9,280
Total cost		77,548

APPENDIX – V

Prevailing market prices of the produce

Produce	Price (₹ kg⁻¹)
Rajmash	68
Moong	68
Peach	23
Apricot	19

Sher-e-Kashmir
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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner **Dr. Javid Iqbal Mir**, Principal Scientist, ICAR-CITH, Srinagar during Viva-Voce examination held on **27-07-2023** have been incorporated in the manuscript entitled “**Growth Performance and Economic Analysis of Pulses in Fruit Based Agroforestry System under Degraded Land Conditions of Benhama Ganderbal**” submitted by **Ms. Beenish Fayaz (Regd. No. MSF-2020-128)**.

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