Studies on Greengram-Plum based Agroforestry System in Kashmir Valley

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Murtaza Hussain Shah
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Thesis

Submitted to

The Faculty of Postgraduate Studies
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Master of Science in Forestry

2012


Dedicated
to my beloved Parents

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Forestry, Shalimar Campus, Srinagar

Certificate – I

This is to certify that the thesis entitled **"Studies on Greengram-Plum based Agroforestry System in Kashmir Valley"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry**, to the Faculty of Postgraduate Studies, Sher-e-Kahsmir University of Agricultural Sciences and Technology of Kashmir, is a record of bonafide research work carried out by **Mr. Murtaza Hussain Shah (Regd. No. 2010-For-31-M)** 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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We, the members of the Advisory committee of **Mr. Murtaza Hussain Shah (Regd. No. 2010-For-31-M)**, a candidate for the degree of **Master of Science in Forestry**, have gone through the manuscript of the thesis entitled, **"Studies on Greengram-Plum based Agroforestry System in Kashmir Valley"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of degree.

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ABSTRACT

The present investigation entitled "Studies on Greengram-Plum based Agroforestry System in Kashmir valley" was carried out at Experimental Farm of the Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar during the year 2011 and 2012. The study was undertaken with the tripartite objectives (a) to study the response of green gram to organic manures and fertilizers under plum-based agroforestry system, (b) to study the growth and yield of plum in response to organic manures and fertilizers in plum based agrofoestry system and (c) to study the relative economics of the system. The experiment was laid out in a randomized block design with three replications comprising seven treatments and sole cropping of green gram and plum as controls. The tree spacing was 4 x 4 m and spacing of 40 x 10 cm for green gram intercrop was maintained. Seeds were sown in the month of July, 2011. The observations were recorded on growth and yield parameters of greengram and plum trees in response to organic manures and fertilizers. The effect of different doses of organic manures and fertilizers on growth and yield parameters of green gram was significant. The plum trees had a little effect on growth and yield performance of green gram plants. The different doses of organic manures and fertilizers and green gram intercrop had a positive role in making the nutrients more available. Among the different doses of organic manures and fertilizers, 80 per cent of recommended doses of NPK + FYM +

Dalweed + Biofertilizer (rhizobium) was found to be most efficient. The use of organic manures and fertilizers in combination has been found to be more efficient than organic manures alone. Different doses of organic manures and fertilizers are found to be have influence on available nitrogen, available potassium, available phosphorus, soil pH, electrical conductivity and soil moisture. The bioeconomics of the plum based agroforestry system intercropped with green gram plants revealed that the total net return was higher in agroforestry system than sole cropping. It is suggested that the cultivation of green gram by supplying organic manures in combination with inorganic fertilizers under plum based agroforestry system may be recommended for better economic returns.

Key words : Agroforestry, Greengram, Plum, Fertilizers, Organic manure

Signature of Student

Dated : _____

Signature of Major Advisor

Dated: _____

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Murtaza Hussain Shah

Place : Shalimar, Srinagar
Dated :

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Chapter – 1

INTRODUCTION

Agroforestry, the relatively new name for the old practice of growing trees and crops in interacting combination, is now recognized as an approach to increasing farm productivity in low-external-input, resource-limited situations. Many, if not most, agroforestry systems have developed over long periods of time in response to interactions between agroecological conditions, plant diversity, and farmer resources and needs. This new concept which came to be known as agroforestry today is even more relevant in the context of growing human and livestock population especially in developing countries like India. Today the human population in India stands at 1154.00 million and that of livestock at 529.70 million (Anonymous, 2011a). With the result per capita availability of arable land has decreased to 0.13 hectare. Thus there is little scope to increase the area under cultivation for meeting the increasing demand of food, fodder, fuel wood and timber. Hence the need is to increase the production from the land already under cultivation. According to Asian survey of Agrarian reforms and rural development sponsored by FAO, 70 per cent of Indian farmers have marginal land holdings which are living much below the poverty line and the ultimate solution of their economic upliftment lies in the establishment of agro/wood, agro/fruit tree based industry at village level. Though agroforestry appears to be the lone logical solution for sustainable livelihood. It is an integrated land use approach, including cultivation of woody perennials, fruit trees in association with annual crops and holds immense potential to ensure stability and sustainability in production and to provide ecological and economic security as compared to conventional system of monocropping. However, to prove its credibility this farming system requires appropriate selection of tree crop-combinations so as to use available resource most efficiently (Huxley, 1996).

In an agroforestry system competitive interaction develops between trees and crops for the limiting resources, aboveground for light and below ground for soil, water and nutrients. Asymmetry in resource utilization in agroforestry is due to difference in establishment timing of trees and crops (Bhatt *et al.*, 2003).

Agri-horticulture system is one form of agroforestry where the tree component is a fruit tree. Intercropping with fruit trees can fully utilize the land and labour resources, give better vegetative cover for soil and water conservation and provide products for humans, fodder for animals and green manure to improve soil productivity. Fruit-tree-based agroforestry systems in the north temperate zone are able to provide the public environmental services better than monocultured annuals or intensively managed orchards (Herzog, 1998).

Fruit producing species like apple, plum, etc. are the best studied example of intensive fruit tree based agroforestry (Fernandes and Nair, 1986). Plum, an important temperate stone fruit belongs to family Rosaceae and sub-family Prunoideae. It ranks next to peaches in economic importance. Being a delicious juicy fruit, it is used both as fresh and in preserved form. Besides having medicinal properties, it is a fairly good source of citric acid, sugars and vitamin A (Westwood, 1993). In Jammu and Kashmir, the area under plum is 4397 hectares with an annual production of 8603 metric tones (Anonymous, 2011b).

Pulses occupy an indispensable position in the dietary habit of vast majority in the Indian subcontinent. Besides, being nutritionally fulfilling, these contribute to the restoration of the soil fertility. Pulses are mostly of short duration, fit better in rotation and can be grown as main, inter, catch, green manure or cover crop that keeps the soil medium productive and sustainable. In India, pulses are grown on an area of 4.02 million hectares, with production and productivity at 6.43 million tones and 593 kg ha^{-1}, respectively (Anonymous, 2012). In Jammu and Kashmir state, pulses cover an area of 29.99 thousand hectares, with production and productivity at 138.89 thousand quintals and 4.63 quintals per hectare, respectively (Anonymous, 2010).

Unfortunately, growing of agricultural crops under fruit trees has not received any attention so far. It needs a strong research base to identify suitable agricultural crops to be integrated with fruit trees for developing potential, diversified and profitable agroforestry system. Very little information is available with respect to growing of agricultural crops under fruit-tree based agroforestry systems in the Kashmir Valley, therefore, in order to collect information regarding this, a project entitled "Studies on Greengram-Plum based Agroforestry System in Kashmir Valley" has been proposed with the following objectives :

- To study the response of greengram to organic manures and fertilizers under plum-based agroforestry system.
- To study the growth and yield of plum in response to organic manures and fertilizers in plum based agroforestry system.
- To study the relative economics of the system.

Chapter – 2

REVIEW OF LITERATURE

This study 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. No work has been done related to plum-greengram and other field crops. Efforts have been made to review the literature under the following headings :

2.1 Growth and yield parameters of Green gram and other intercrops

In an agroforestry system, competition between tree and crop is usually a significant factor. The complementary effects depend upon the nature of species involved, the manner in which they are grown and the climatic factors. The nature and quantum of these effects depend upon nature of tree species, age and size of trees and nature of agricultural crops.

In Andhra Pradesh, systems based on annual crops with timber producing, fruit producing, and biomass-biological nitrogen producing trees were studied. Sorghum (*Sorghum bicolor*) and black gram (*Vigna mungo*) with *Acacia auriculiformis* (auri), with *Psidium guajava*, and with *Leucaena leucocephala* as alley-crops were evaluated on infertile, rainfed, alfisols. For all forms of mixed cropping, relative yields of sorghum and black gram were reduced compared to yields where trees were absent. Within the mixed systems, sorghum performed best with guava where its yield relative to sole-cropped sorghum ranged from 55 to 100 per cent. Black gram in mixed systems produced best with guava or *Leucaena* with yields from 22 to 32 per cent of sole-cropped black gram. Both crops performed poorly when associated with *Acacia auriculiformis*. Runoff measurements showed that runoff losses were lowest in the fruit-tree-based system (Das *et al*., 1993).

A study of mixed cropping of *Lens culnaris* (lentils) and *Triticum aestivum* (wheat) with *Prunus* spp. (peach) in the northern Sinai of Egypt, showed

that seed yield and harvest index of *Lens* and *Triticum* under mixed cropping increased over those under sole cropping (Ashour *et al.*,1997). Tillering and spike number of wheat were also increased in the mixed system. Peach yield increased marginally when grown with lentils, but not with wheat. Soil moisture was greater in the mixed annual-perennial system than in the sole crops.

Viswananth *et al.* (1998) studied the effect of *Acacia nilotica* (L.) Willd Ex. Del. on rainfed rice crop and observed non-significant difference in plant density and plant height of rice when grown in association with *Acacia nilotica*.

Daniel *et al.* (1991) reported that the growth of chickpea and sunflower was reduced by 21 and 48 per cent, respectively, at 5 m from the trees. However, growth of cotton (in terms of leaf area, leaf number and plant height) was found to be high in sheltered areas as compared to open fields (Puri and Bangarwa, 1992).

Decosta and Chandrapala (2000) observed a clear reduction of leaf area and total biomass and yield of mung bean closer to the trees, whereas no such reduction was observed away from the trees. Newaj *et al.* (2003) reported lowest plant height and branching of blackgram and mustard at the nearest row (1^{st} row) as compared to 2^{nd}, 3^{rd} and 4^{th} row away from the tree base.

Arora and Mohan (1986) in a study on agrihorticulture land use systems involving peach revealed that out of the short duration intercrops, cowpea (587 kg ha^{-1}) and sesame (398 kg ha^{-1}) can be grown until 6 years and beyond this yield declined to uneconomic levels due to shade effect of the trees. In any agroforestry system biomass production in under storey is a function of photosynthetic active radiation (PAR) falling on the ground surfaces (Hazara and Tripathi, 1986).

Makwana *et al.* (2009) studied the effect of different organic manures and spacing on growth and yield attributes of Kalmegh-Panchang (*Andrographis paniculata* Wall. Ex. Nees.) under middle Gujarat conditions. The results indicated that the growth attributes such as plant height at harvest and Leaf: stem ratio were significantly higher under application of organic manure, FYM @ 10 t

ha^{-1}. The highest fresh and dry yield of Kalmegh (9952 and 4306 kg ha^{-1}, respectively) was obtained under application of FYM @ 10 t ha^{-1}. The growth attributes such as plant height at harvest (71.36 cm) and plant breadth at harvest (23.89 cm) were significantly higher under plant spacing of 30 x 45cm. Similarly the fresh (10335 kg/ha) and dry yield (4375 kg/ha) of Kalmegh were recorded maximum under 30 x 45cm plant spacing.

Gharib *et al.* (2008) studied the effect of compost and bio-fertilizers on growth, yield and essential oil of Sweet Marjoram (*Majorana hortensis*). The results showed that the oil percentage and yield per plant for three cuttings were almost two fold higher on fresh weight basis as a result of application of aqueous extracts of compost at low level + bio-fertilizers compared with control, indicating that combinations of low input system of integrated nutrient management could be beneficial to obtain relatively good yields of essential oil.

The effect of organic manures on performance of ginger (*cv. Nadia*) was studied by Sanwal *et al.* (2007). Results revealed that organic manures enhanced plant height, number of side suckers per plant, number of leaves per plant, chlorophyll a and b contents, transpiration rate, stomatal conductance, photosynthetic rate, water use efficiency (WUE) and yield per plant and quality parameters over control.

Shashidhar *et al.* (2005) also evaluated the effect of different organic manures on the nutrient uptake and yield of garlic (cv. BIG-1) and they observed that the application of sunhemp at 20 t ha^{-1} resulted in the highest uptake of nitrogen, phosphorous and potassium. Vermicompost (5.0 t ha^{-1}) and poultry manure (2.5 t ha^{-1}) were equally effective.

Sehgal (2007) investigated the effect of tree hedge rows and manures on growth and production behaviour of *Ocimum basilicum L.* and *Tagetes minuta* L. The results showed significant effect of organic manures on growth, yield, physiological and root characteristics of both species. Among the organic

manures; comparatively higher yields were obtained in the treatments receiving enriched manure than vermicompost and FYM. The physiological parameters like photosynthesis, transpiration and WUE were not much influenced by organic manures application but their use maintained significantly higher production efficiency even when grown with trees.

Paturde *et al.* (2002) studied the effect of organic manures and plant population on the yield of safed musli. They observed that the number of tubers, fresh and dry tuber yield, and steroid content increased with the application of organic manures. No significant differences in yield were observed between application of FYM and vermicompst.

The effect of organic manures and plant population were also studied by Haripriya and Sriramachandrasekharan (2002) in marigold crop. Three organic manures viz. leaf mould, press mud and FYM were used in combination with lignite mine spoils in a ratio of 1:5, 1:1 and 2:1. All the treatments resulted in better growth and yield of marigold as compared to control. Among different organic manures, application of FYM at all ratios resulted in better growth and yield compared to the application of leaf mould and press mud.

An experiment was conducted by George and Pillai (2000) to study the effect of vermicompost on growth, yield and economics of Guinea grass (*Panicum maximum*), grown as an intercrop in coconut. Results revealed that vermicompost, alone and in combination with chemical fertilizers, stimulated crop growth. The use of vermicompost at 5 t ha^{-1} reduced the amount of recommended NPK by upto 25 per cent.

Significant variability in growth behaviour of four mint species under sole and inter crops was reported by Singh *et al*. (2002). Results indicated increased plant height of intercropped plants compared to respective sole crop treatments.

Pal *et al*. (2000) studied the effect of Nitrogen and Potassium fertilizers on turmeric under sole and alley cropping systems. Fertilizer application in the alley

cropping of turmeric within 2 m distance from 5 year old established tree plantation of *Leucaena leucocephala* and in the sole crop of turmeric for successive years revealed that the turmeric yield was higher in the sole cropping system receiving no fertilizer (control) and N_{120} and K_{120} kg, respectively, than alley cropping system. Due to shading effect of trees, turmeric yield was reduced in the alley cropping system.

Srinivasan *et al.* (1990) while examining the resource sharing ability of multipurpose trees in an intercropping system reported reduced crop yields due to competition with the trees for light.

Kumar (1999) pointed, tree crop interactions in association of mulberry, plum and pomegranate with soyabean influenced negatively to the soyabean growth and yield attributes as compared with sole cropping. Soyabean growth and yield response in general among the tree-crop combinations was in the order of pomegranate soyabean >plum soyabean >mulberry soyabean >pomegranate-mulberry-soyabean >plum-mulberry-soyabean >plum-mulberry-pomegranate-soyabean.

Field crops (cereals, pulses, oil seeds) respond differentially when grown in association with woody components. Trees being the dominant partners of agro-forestry system cause consistent and progressive increase or decrease in yield of crops, depending upon the species, planting geometry and age of the tree (Newaj, 2003). The effect of trees over field crops is greater in the close vicinity of trees and diminishes as the distance from the trees increases. (Dhillon *et al*., 1979; Huxley *et al.,* 1989)

Ghulam *et al*. (1990) studied the effect of boundary plantation of *Eucalyptus camaldulensis*, *Albizzia procera* and *Morus alba* on the yield of wheat and observed that the reduction for all the trees species was not significant.

Pant and Bana (1998) studied the productivity of wheat-urd cropping sequence under *Populus deltoides*, Eucalyptus hybrid, *Syzygium cumini* and

Trewia nudiflora and compared that with the sole cropping system, they observed relatively more reduction of grain yield for both the crops (urd and wheat) under *Populus deltoides* (17.4 and 36.3%) and Eucalyptus hybrid (17.4 and 29.1%) as compared to sole crop respectively.

Kermani (1980) while comparing the yield of field crops viz., cotton, sesamum, sorghum and wheat, grown in association with *Acacia nilotica* and *Eucalyptus camaldulensis* reported that yields were reduced up to a larger distance by *Acacia nilotica* as compared to *Eucalyptus camaldulensis*. Intal (1986) reported that Eucalyptus trees reduced the sunflower yield by 21.0 per cent up to a distance of 8.4 m from the tree base. Ahmed (1989) reported that in the first two years of Eucalyptus plantation, the effect of trees on crop production was almost negligible, but it was significantly high up to longer distances for a short rotation period of 8 years or more.

Ranasinghe and Mayhead (1990) reported that 2-year-old tree of *Populus deltoides* affect the yield of beans over a certain distance, however, the yield was not affected by 1-year-old trees. Sharma *et al.* (1994) observed that the grain and straw yield of both the crops (pearl millet and cluster bean) was reduced in the close vicinity of 4-year-old plantation of both the trees (*Acacia tortilis* and *Zizyphus rotundifolia*). Jain and Singh (1999) also reported that the yield of field crops increases with increasing distance from the trees.

Poschen (1986) reported significantly higher yield (56% on average) of maize and sorghum at the nearest distance from the tree line. Similarly Jama *et al.* (1991) observed that the yield of maize under *Leucaena leucocephala* was increased by 24-76 per cent over the control, however, the influence of trees on the yield of maize was higher at 2 and 4 m distance.

Malik and Sharma (1990) observed higher plant population and growth parameters of wheat on northern side than the southern side of Eucalyptus plantation. Similarly, Tomar *et al.* (2002) reported that during 3 consecutive years

north side of the tree row of *Bauhinia purpurea* produce higher number of tillers in oat than the south side of the plantation.

Dhillon *et al*. (1984) studied the effect of *Dalbergia sissoo* and *Acacia nilotica* planted in east west and north south directions on the yield of rice and wheat grown in south, east and west aspects of the tree rows and found less reduction in yield of wheat on the southern aspect than on the other aspect and more loss in yield of rice on the western aspect than other aspects.

Comparing the performance of maize, soyabean, lentil and wheat sown in north and south direction of *Morus* and *Grewia* tree rows as indicated by Kumar (1996) revealed that yield of these crops was significantly better in southern direction than the northern direction. Saroj *et al.* (1999) observed that the yield of both the crops (jowar and toria) increases with increasing distance from the trees. However, the direction did not influence the yield of crops. Barakoti *et al.* (2000) studied the effect of *Bauhinia purpurea* on yield of crops (maize and finger millet) and observed that the yield was severely affected near tree rows. Further, they revealed that the direction from the tree has less effect than the distance from the trees.

Intercropping field crops with fruit trees in different agroforestry systems has shown vivid effect of fruit trees. Singh *et al.* (2001) in their study on intercropping of medicinal and aromatic plants under four and five year old poplar (*Populus deltoides*) based agroforestry system found that all the MAPs, namely *Mentha Arvensis, Mentha gracilis, Zingiber officinale, Curcuma domestica, Pogostemon cablin, Artemisia annua, Ocimum basilicum and Piper longum* except *Costus speciosus* performed well in the system.

Thakur *et al*. (2010) studied the compatibility of medicinal and aromatic herb species for cultivation in association with poplar trees. Growth with respect to height, leaf number, spread, flower number, branch number and leaf area index, was significantly higher in fertilizer and FYM treated plots in comparison to

control plots. Production increased with the use of fertilizers and FYM even in the presence of tree canopies.

Verma *et al*. (2010) studied the effect of tree-crop combinations and nitrogen levels on growth and herbage yield of *Ocimum sanctum* L. in Solan, Himachal Pradesh. The distinctive tree crop combinations were, peach + grewia + setaria + *O. sanctum*, peach + morus + setaria + *O. sanctum*, peach + setaria + *O. sanctum*, grewia + setaria + *O. sanctum*, morus + setaria + *O. sanctum* and *O. sanctum* as sole crop. Three nitrogen doses applied to *O. sanctum* were 40, 80 and 120 kg ha^{-1}. Plant growth attributes i.e., plant height, leaf area, LAI along with herbage yield increased significantly with the increase in N dose. Maximum plant height (90.70 cm) and leaf area (14.62 cm^2/leaf) of *O. sanctum* was recorded under tree-crop combination peach + morus + setaria.

An experiment was conducted at the research farm of the Department of Forestry and National Resources, PAU Ludhiana by Gill *et al*. (2011) to compare the effects of inorganic and organic sources of nutrients on productivity of trees and crops in agroforestry system i.e. poplar (*Populus deltoides* Bartr.) and dek (*Melia composita* Willd.) with wheat-pearl millet rotation at the age of one, two and three years. The application of inorganic nutrients (N and P) significantly increased the wheat grain as well as pearl millet fodder yield compared to organic nutrients (FYM, vermicompost and FYM + vermicompost). Amongest the organic treatments, the production of pearl millet (fodder) was the highest (20.3 t ha^{-1}) with the application of vermicompost followed by FYM + vermicompost (19.9 t ha^{-1}) and FYM alone (17.6 t ha^{-1}).

2.2 Growth and yield attributes of trees

In an intercropping study of banana with annuals in St. Lucia, The Caribbean, Rao and Edmunds (1984) found that intercropping of various annuals with *Musa* spp. resulted in decrease in fruit weight but no loss in total bunch yield. Duration to maturity of banana was prolonged with under planted annuals

as compared to sole-cropped bananas. However, the study did not report any yield differences in annuals. The mixed stand of banana with annuals was found to provide greater overall yields and more uniform distribution of income.

Near Montpellier, France, growth of young *Juglans nigra* (walnut) was superior with intercrops of *Medicago sativa* (alfalfa) or *Onobrychis sativa* (sainfoin) that in controls consisting of spontaneous weed growth, but differences in the relative competitiveness of the three associated crops varied with yearly precipitation effects and tree growth was not always superior with sainfoin compared to with weeds (Dupraz *et al*.,1999).

Mixed cropping systems based on *Theobroma grandiflora* (cupuacu) and *Bactris gasipaes* (peach palm) with a legume understorey (*Pueraria phaseoloides*) in central Amazonia showed that nitrogen competition between the trees and the crop was spatially limited and the trees did not appear to be utilizing biological nitrogen from the legume (Lehman *et al*., 2000).

Majumdar (1991) observed maximum input and withdrawal of nutrients in hortiagriculture and maximum storage in hortisilviculture system.

Arora and Mohan (1986) showed that soyabean and cowpea had no marked adverse effect on the height and crown diameter of the trees as compared to control (tree alone) up to seventh year. Per tree yield of peach trees increased when intercropped with Pine apple (40.1 kg) and turmeric (30 kg) which, however, decreased on intercropping with lemon grass (14 kg) compared to the control (24.6 kg) i.e. peach only.

Gupta *et al.* (1982) reported that intercropping of kharif and rabi crops with five year old peach trees provide about 10-15 kg tree^{-1} of pruned wood and 10 kg tree^{-1} leaf litter during November-December in Doon valley of Uttarakhand. The mean fruit yield (20.66 kg) of peach on per tree basis under pure orchard varies with age and cultivar used (Sankhayan, 1969).

Rao *et al.* (1998) reported increased soil fertility due to nitrogen input into the system through biological nitrogen fixation, reduced soil erosion, reduced leaching of nutrients and uptake of nutrients from deep soil layers. Gupta *et al.* (1982) reported about 10 kg of leaf litter during November-December in peach when trees attained the age of 5 years. The leaf litter gets recycled into the soil, thus providing 35 kg Nitrogen, 8 kg of Phosphorous, 25 kg of Potassium and 15 kg of Ca ha^{-1} yr^{-1}.

Toky *et al.* (1989) while studying the natural agroforestry system in the mid hills of Himachal Pradesh, reported that in agri-hortisilivicultural and agri-horticultural systems, considerable quantities of nutrients up to Nitrogen 169 kg ha yr^{-1}, Phosphorous 14 kg ha yr^{-1} and Potassium 165 kg ha yr^{-1} were recycled through debris of crops and trees leaf litter, while recycling rate was almost half in agrisilivicultural system.

The few studies that have been reported on impact of understorey vegetation on fruit trees primarily consider non-productive weeds and grasses or leguminous crops. The fruit trees were negatively affected by annual crops (Dupraz *et al.,* 1999; Anderson *et al.,* 1992; Lipecki and Berbec, 1997). In general, effects against seedling or immature trees have been found at a time when it can be assumed that there is little to no differentiation in root or canopy space. However, mature fruit trees are also affected, potentially due to low root densities (Atkinson, 1980)

It was found that where annual crops were introduced among established trees, tree height initially increased more rapidly when the competition for light was moderate (i.e. pear + fava, or pear + maize). Where competition for light was greater (pear + maize + fava), trees did not make additional growth, possibly due to resource limitations. The height growth of pear trees in pear + maize + fava mixed cropping was similar to clean cultivated controls. It was expected that competition for light would result in extensive growth of the components (Ritchie, 1997; Holbrook and Putz, 1989; Scott *et al.,* 1998)

It is known that moisture stress may favour fruit growth over vegetative growth (Chalmers *et al.,* 1986 and Mitchell *et al.,* 1986).

Kappel (1989) reported that, canopy shading contributes to reductions in fruit size in pear in pear-based agroforestry system. The competitive effect of grasses with fruit trees are well known (Kumar *et al.,* 2001; Tworkoski and Glenn, 2001; Meyer *et al.,* 1992).

The study on mixed cropping of pear with annual crops, evaluated the photosynthetic light environment within a mature pear orchard in the United Kingdom (Newman, 1983). Another study of pear, focused on water use, noted that canopy radiation interception within the orchard at mid day was approximately 38 per cent of incident. However, the yield of high grade fruits (size based) was reduced, highlighting the need for adoptive management in order to obtain optimal economic yields (Marsal *et al.,* 2002).

Intercropping of several annual crop combinations with *Taxodium acendens* resulted in LER values greater than 1.0 in all instances. Crop yields were substantially depressed as the trees grew. The depressive effect was not equal among crop species, illustrating that crop species differ in their ability to perform adequately in shaded conditions. Also, an increase in humidity and a reduction in wind speed were observed in this study (Huang and Xu, 1999). Another study evaluating mixed cropping of M*angifera indica* (mango) and vegetables indicating that vegetative yield was unaffected by distance from trees, so long was water was not limiting. However, since light levels beneath the mangoes were not reported, it is not possible to comment on the importance of that aspect (Emebiri and Nwufo, 1994).

Agroforestry systems of eucalyptus and *Leucaena* with maize and wheat have shown higher water use efficiencies since a greater percentage of water was used for plant growth versus surface runoff at the Central Soil and Water Conservation Research and Training Institute in Dehradun, India (Narain *et al.,*

1998). Jackson *et al.* (2000) reported that *Grevillea robusta* + maize mixed cropping resulted in greater use of available soil moisture compared to sole crops or trees in semiarid areas in Kenya.

Unlike many agricultural crops, where harvest index may be more conservative and final yields closely related to total production, conditions that promote maximal growth may not produce the highest yields in deciduous fruit trees. In Spain, reduced irrigation levels (regulated deficit irrigation), relative to the evaporate demand as calculated by FAO (1993) resulted in greater yields and higher fruit number in pear trees.

2.3 Relative economics of the system

Integration of the trees with arable crops increase the overall productivity and the marginal fall in agricultural production is compensated through the general environmentally beneficial impacts. Riley (1986) suggested that it would be better to compare the biomass in terms of money to get a conclusive idea about the system. For the individual farmers the financial returns from sale of wood compensates the reduction in agricultural yields (Chaturvedi, 1986) but the overall economics favour tree crop combinations (Harsh and Tewari, 1993).

Dutt and Thakur (2004) calculated the monetary status of cropping systems for two consecutive years under Shivalik Ranges of outer Himalayas, combining medicinal plants with commercial timber species. Four herbal crops namely *Ocimum sanctum, Spilanthes acmella, Tagetus minuta and Withania somnifera* were intercropped with 6 years old plantation of Populus hybrid having spacing 8 x 3 m, 6 x 4 m, 5 x 5 m and 4 x 6m. Net returns were comparatively more under the agroforestry system combining *Ocimum sanctum* and *Tagetus minuta* with poplar at different spacing in comparison to monocropping.

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

four and five year old poplar based agroforestry system. All crops *Mentha arvensis, Mentha gracilis, Zingiber officinale, Curcuma domestica, Pogostemon cablin, Artemisia annua, Ocimum basilicum* and *Piper longum,* except *Costus speciosus,* performed well in the system. However, the maximum net return was obtained in *Curcuma domestica* (Rs. 64, 700 and 68,300) followed by *Zingiber officinale* (Rs. 59,750 and 61,700) in the first and second year, respectively. The intercropping of *Costus speciosus* gave least net returns (Rs. 1710 and 550) in the years respectively. However, the net returns per rupee invested, was highest in *Artemisia annua* (4.83 and 5.14) followed by *Pogostemon cablin* (4.81 and 3.98).

Kadam *et al.* (1993) reported that on an average, the maximum yield and the highest net return (Rs. 34400/ha) were obtained in pepper with application of 200 kg N ha^{-1} in the form of neem cake.

Majumdar (1991) showed that hortiagricultural system furnished the highest gross returns amounting to Rs. 91, 557.20 annually. Grewal *et al.* (1992) reported that agri-silvi-horticultural system could provide average net returns of Rs. 17,066 ha^{-1} over a period of 4 years as compared to an average net return of Rs. 7852 from cropping alone.

Sood (1999) conducted an experiment to study tree crop interaction in an agri-horticulture system in which he reported that the total cost incurred as well as net return were higher in agri-horticulture system as compared to sole crop. Kumar (1996) conducted the study on bio-economic appraisal of agroforestry systems in Himachal Pradesh and found that agri-horticulture system yielded the highest return followed by agri-horti-silviculture, agri-silviculture and minimum in sole cropping.

In the northwest hill region of India, researchers have reported that the returns from intercrops with temperate fruit trees are negligible but did not elaborate on whether they were unproductive or simply contributed little cash earnings to the system (Azad and Sikka, 1991).

The results showed that fruit production was more profitable than comparative areas of annual crops. The farm to market link was described as the most tenuous and problematic in the production chain. Generally, growers were not able to profit from higher market value for their fruits because value was withheld at the farm gate by middlemen. In the Bhopal region of central India, fruit-tree-based systems were found to have higher benefit to cost ratio (B:C ratio 2.7) than agroforestry based on non- fruit trees (B:C ratio 1.8).When cash crop systems were assessed, fruit-tree based agroforestry had B:C ratios of 2.9 versus 1.8 for timber and cash crops (Appropriate Technology Centre, 2003).

Farmers preferred a fruit and fodder system incorporating *Ananus comosus* (pineapple) and *Psidium guajava* (guava) with *Morus alba* (mulberry) for sericulture over a system of *Morus* with vegetables or rice in Meghalaya in northeastern India. The fruit-tree based system was highly profitable, as compared to other systems (Dhyani *et al.*, 1996). Trees provide benefits to farmers and to ecosystems by capturing and suing water, light, and/or nutrient resources that would remain unexploited in tree less systems (Cannel *et al.,* 1996).

Mixed systems of *Prunus* spp. with *Lens culinaris* (lentils) and *Triticum aestivum* (wheat) showed an economic advantage compared to cropping systems without fruit. There, B:C ratios of sole peach-annual crops (1.56) were observed (Ashour *et al*.,1997). Another evaluation of economic returns of *Sorghum bicolor* and *Vigna mungo*, cropped with *Psidium guajava* (guava), and alley-cropped with *Leucaena leucocephala* in Andhra Pradesh, India, showed B:C ratios ranging from 1.52 for crops with *Leucaena* to 2.16 for crops with guava (Das *et al*.,1993).

An investigation consisting of three MPTs viz., *Acacia nilotica* var *cupressiformis*, *Dalbergia sissoo* and *Hardwickia binata* in a silvipastoral system was carried out at Research Farm, National Research Centre for Agroforestry, Jhansi by Rai *et al*. (2009). Compared to pasture alone, *Dalbergia sissoo* based silvopastoral system yielded higher returns followed by *Hardwickia binata* based system as compared to pasture alone (B:C ratio 1.91).

Chapter – 3

MATERIALS AND METHODS

The present investigation entitled "Studies on Greengram-Plum based Agroforestry System in Kashmir Valley" was carried out in the Experimental orchard of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar (J&K) during the year 2011-12.

3.1 Experimental site

3.1.1 Location and climate

The experimental orchard, the study area, is situated at a latitude of 32^{o} N and an altitude of 1650 meters above sea level. The study area lies in temperate zone of Jammu and Kashmir state, which received an annual rainfall of 23.7 mm. The average maximum monthly temperature ranged from 18 to 35 ^{o}C and average minimum monthly temperature varied from 7.4 to 21.5 ^{o}C. The details regarding meteorological data are given in Appendix-I.

3.1.2 Soil characteristics

Before laying out the experiment, random soil samples were collected from the depth of 0-20 cm from different spots and the composite sample was prepared which was analysed for various soil characteristics in order to get before hand information about the physico-chemical properties of the soil. The methods employed and results obtained for important physico-chemical characteristics (initial) of the soil of experimental area have been summarized in Table-1.

Table-1 : Physico-chemical properties of soil before planting (0-20 cm)

S. No.	Parameters	Test value	Method employed
1.	Available nitrogen (kg ha^{-1})	328.6	Alkaline permagnate method (Subbiah and Asija, 1956)
2.	Available phosphorus (kg ha^{-1})	16.8	Olsen method (Olsen *et al.*, 1954)
3.	Available potassium (kg ha^{-1})	130.8	Flame Photometer method (Jackson, 1973)
4.	Soil pH	6.90	Glass electrode method (Jackson, 1973)
5.	Electric conductivity (dSm^{-1}) at 25°C (1:2 soil-water suspension)	0.28	Solu bridge conductivity meter (Piper, 1966)
6.	Soil moisture (%)	5.31	Gravimetric method

At the completion of the experiment, the samples from each plot were again drawn and analyzed for various characteristics by the standard methods.

3.1.2.1 Soil moisture (%)

The soil moisture content was determined gravimetrically. Before laying out the experiment, random soil samples were collected upto 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.

3.2 Experimental methodology

The green-gram crop was studied with respect to its growth and yield in response to manures and fertilizers in an agrihorticulture system. The experimental details followed and methods adopted are given below :

Agroforestry system	:	Agrihorticulture
Structural components	:	The system was based on the following components
Agricultural crop	:	Greengram or Mung bean (*Vigna radiata*) (SM-1)
Tree component	:	Plum (*Prunus salicina*) cv. Santa Rosa
Tree spacing	:	4 x 4 m
Age of the tree component	:	6 years
Spacing for greengram intercrop	:	40 x 10 cm
Number of treatments	:	9
Replications	:	03
Total Number of plots	:	27
Design	:	RBD (Randomized Block Design)

3.2.1 Treatments

Symbol	Treatment		
T_1	Control (only Plum)	:	No Manure and Fertilizer applied
T_2	Control (only Greengram)	:	No Manure and Fertilizer applied
T_3	FYM	:	2 t/ha
T_4	Dalweed Manure	:	2 t/ha
T_5	Biofertiliser (Rhizobium)	:	5 g/kg seed
T_6	Vermicompost	:	1 t/ha
T_7	Biofertiliser + Vermicompost (50%)	:	5 g/kg seed + 500 kg/ha

Plate-1 : Plum intercropped with greengram

T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	:	8 N: 32 P_2O_5 : 28K_2O kg/ha + 2 t/ha + 2 t/ha + 5 g/kg seed
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	:	6 N: 24 P_2O_5: 21K_2O kg/ha + 2 t/ha + 2 t/ha + 5 g/kg seed

3.2.2 Field preparation

The field was thoroughly ploughed 2 times with the help of tiller followed by planking. Stones, pebbles and residues of previous crop were removed manually.

3.2.3 Fertilizer application

80 and 60 per cent of recommended doses of nitrogen, phosphorus and potassium as per treatments in the form of DAP (80% = 69.56 kg ha^{-1}, 60% = 52.17 kg ha^{-1}) and MOP (80% = 48.27 kg ha^{-1}, 60% = 36.20 kg ha^{-1}), respectively were applied below the seed at the time of sowing of crop. Organic manures like FYM, Dalweed manure and Vermicompost were applied in the individual plots at the time of sowing.

3.2.4 Rhizobium procurement and inoculation

The carrier based cultures of Rhizobium species was obtained from Division of Soil Science, SKUAST-Kashmir, Shalimar.

Inoculation of Rhizobium species was done through seed @ 5 g kg^{-1} seed as per package of practice. For this, slurry was prepared in which 200 g gur (Jaggery) dissolved properly in one litre of sterilized water, by heating the solution for 15 minutes. After heating, solution was cooled to room temperature and mixed with the carrier based culture to form a slurry. The seeds were added and mixed with the inoculum slurry by hand so as to uniformly coat the seeds

with the inoculums. The seeds were dried in shade and after that, sown immediately.

3.2.5 Seed sowing

Green gram (*Vigna radiata* L. Wilczek) var Shalimar Moong-1 was sown in line with or without inoculation as per treatment on July 2, 2011 @ 45 kg ha^{-1}. The lines were drawn manually with the help of rope maintaining row to row and plant to plant distances of 40 cm and 10 cm, respectively.

3.2.6 After care of crop

Hand weedings were done from time to time to keep the beds free from weeds. Hoeing and irrigations were given as per crop requirement.

3.2.7 Harvesting of the crop

Harvesting of green gram was done during the month of October, 2011.

3.3 Details of observation recorded

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

3.3.1 Agricultural Crop

3.3.1.1 Number of primary branches

The number of primary branches of three randomly selected plants from each plot was counted at harvesting stage.

3.3.1.2 Number of pods $plant^{-1}$

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

3.3.1.3 Pod length (cm)

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

3.3.1.4 Number of seeds pod^{-1}

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

3.3.1.5 Above ground biomass (kg ha^{-1})

Plants in each plot of 1 m^2 area were cut above ground from the base at harvesting stage of greengram. 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 ^{o}C till constant weight. Dry weight of the plant samples was recorded in grams and then worked out in kg ha^{-1}.

3.3.1.6 Grain yield (kg 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^{-1} was converted to kg ha^{-1} and expressed as yield (kg ha^{-1}).

3.3.2 Tree

3.3.2.1 Crown spread (m)

The crown width was measured in meters from the tree trunk in its widest range with the help of a measuring tape.

3.3.2.2 Leaf area (cm^2)

The leaf area of fully expanded leaf was measured before harvesting. Sixteen leaves per replication were selected for this purpose. The leaves were randomly detached from the plants and collected in envelops. These leaves were brought to the laboratory and the leaf area was determined using pre-calibrated portable leaf area meter. Each leaf was placed under the arm of leaf area meter and thereafter scanned to determine the leaf area digitally. The leaf was replaced with other leaf and data recorded. The procedure was followed for rest of the samples. Each value is the mean of three replications. Leaf area is expressed in cm^2 per leaf.

3.3.2.3 Total N, P, K in leaves

Forty-eight healthy and undamaged leaves were selected. To make sample more homogenous, leaves from all the compass sides were collected. Leaf samples were collected randomly at the time of sowing of mungbean, harvesting of mungbean and harvesting of fruits to serve as a substrate for analysis of concentration of nutrient contents in leaves of plum. The leaves were collected in perforated paper bags and brought to the laboratory. The leaf samples were cleaned with tap water, dilute HCl (5 ml litre^{-1} of water) and distilled water. The washed samples were first dried in shade and, subsequently in oven at 68^{o}C till constant weight was obtained. The samples were then grinded with stainless blade blender and kept in butter paper bags for chemical analysis.

For estimating nitrogen concentration, the powdered material (0.5 g) was digested in concentrated sulphuric acid in presence of digestion mixture containing 10:1:0.5 of K_2SO_4, $FeSO_4$ and $CuSO_4$, respectively. Then 10 ml of concentrated H_2SO_4 was added and the tube was kept overnight. Then the tube was kept in the digestion block for saturation, obtained for one hour at 380^{o}C, till a clear digest. For estimation of P and K, 0.5 gram processed sample of plum leaves was taken in 100 ml flask and was digested in a di-acid mixture prepared by mixing nitric acid and per-chloric acid in the ratio of 4:1. The flasks were placed on a hot plate at 115-118^{o}C for digestion till a watery transparent aliquat was obtained. The digested sample was diluted with double distilled water to make a volume of 50 ml and filtered. The filtrate was ultimately used for estimation of N, P and K.

Method used for estimation of concentration of nutrients at the time of sowing of mungbean, harvesting of mungbean and time of harvesting of fruits.

3.3.2.3.1 Nitrogen (%)

Nitrogen concentration was determined by using micro-Kjeldahls distillation method as outlined by Tandon (1993).

3.3.2.3.2 Phosphorus (%)

Phosphorus concentration was determined by Vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973).

3.3.2.3.3 Potassium (%)

Potassium concentration was estimated by flame photometer as per the procedure outlined by Jackson (1973).

3.3.2.4 Fruit yield (kg tree^{-1})

Fruit yield was recorded during harvesting by weighing the total number of fruits on each tree and expressed in kg ha^{-1} on fresh weight basis.

3.3.2.5 Branch angle (degrees)

The angle of the branch where it joins the trunk was measured by establishing the centre line of the branch where attached to trunk and measuring the angle of the intersection of this line with the trunk centre line, using a 150 cm diameter protractor. Mean branch angle was determined for each tree as taken by Warner (1991).

3.3.3 Light transmission ratio (%)

The relative light illumination under the plum trees was recorded by using Lux meter. These readings were taken on cloudless day. Three readings were taken in open, away from shade and five readings below the canopy of intercrop. The ratio was calculated as under :

$$\text{LTR (\%)} = \frac{\text{Total solar radiation beneath canopy of intercrop}}{\text{Total solar radiation in open}} \times 100$$

3.3.4 Net return from the system

3.3.4.1 Cost of cultivation

The cost of cultivation of greengram as well as maintenance of fruits trees and harvest of its produce was worked out on the basis of net cropped area and number of tress ha^{-1}. The requirements of labour and mechanical power for different operations such as ploughing, harrowing, weeding, irrigation and harvesting etc. were calculated on ha^{-1} basis as per rates prevalent at Experimental Farm. Costs of inputs such as seeding, fertilizers, weedings were calculated (Appendix-II).

3.3.4.2 Gross returns

The prevailing local market prices were used to convert the yield of greengram plants and plum fruits in rupees per hectares (Appendix-III).

3.3.4.3 Net returns

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

Net returns = Gross returns – Total cost

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

The present investigation entitled "Studies on Greengram-Plum Based Agroforestry System in Kashmir Valley" was carried out at the experimental farm of the Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during the year 2011 and 2012. 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 heads :

4.1 Growth and yield parameters of greengram

4.2 Growth and yield parameters of plum

4.3 Physico-chemical characteristics of soil

4.4 Light transmission ratio

4.5 Net return from the system

4.1 Growth and yield parameters of greengram

4.1.1 Number of primary branches

The observations with regard to number of primary branches of greengram intercropped under plum and sole cropping (control) have been tabulated and presented in Table-2. The data revealed a significant influence of different doses of organic manures and fertilizers on the number of primary branches of greengram.

The maximum number of primary branches (5.60) was recorded in plants supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by those supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_9),

Table-2 : Effect of organic manures and fertilizers on growth characteristics of greengram under plum based agroforestry system

	Treatment	Number of primary branches	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}
T_1	Control (only Plum)*	-	-	-	-
T_2	Control (only Greengram)	3.46	16.78	7.11	8.60
T_3	FYM	4.36	19.53	10.07	10.83
T_4	Dalweed Manure	3.86	17.69	7.83	9.15
T_5	Biofertiliser (Rhizobium)	4.10	19.00	9.65	10.33
T_6	Vermicompost	5.00	20.29	11.22	11.70
T_7	Biofertiliser + Vermicompost (50%)	4.80	19.43	10.85	11.16
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	5.60	23.32	12.36	13.16
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	5.20	21.42	11.34	12.50
	SEm±	**0.27**	**0.67**	**0.48**	**0.42**
	CD (p≤0.05)	**0.83**	**2.05**	**1.47**	**1.28**

*T_1 not included in statistical analysis

the value being 5.20 and minimum was 3.46 in control i.e. sole cropping of greengram without organic manure and fertilizer application.

4.1.2 Number of pods plant^{-1}

The observations with regard to number of pods plant^{-1} of greengram intercropped under plum and sole cropping (control) have been tabulated and presented in Table-2. The data revealed a significant influence of different doses of organic manures and fertilizers on the number of pods plant^{-1} of greengram.

The maximum number of pods plant^{-1} (23.32) was recorded in plants supplied with 80 per cent recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by those supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_9), the value being 21.42 and minimum was 16.78 in control i.e., sole cropping of greengram without organic manure and fertilizer application.

4.1.3 Pod length (cm)

The data collected with regard to the impact of organic manures and fertilizers on pod length of green gram intercropped under plum and sole cropping (control) have been tabulated and presented in Table-2.

The data in table reveal that there was a significant influence of different doses of organic manures and fertilizers on the pod length of greengram. The maximum average pod length (12.36 cm) was recorded in plants supplied with 80 per cent recommended dose of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by those supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_9), the value being 11.34 cm and minimum was 7.11 cm in control i.e. sole cropping of greengram without organic manure and fertilizer application.

4.1.4 Number of seeds pod^{-1}

The observations with regard to number of seeds per pod of greengram intercropped under plum and sole cropping (control) have been tabulated and presented in Table-2. The data revealed a significant influence of different doses of organic manures and fertilizers on the number of seeds pod^{-1} of green gram.

The maximum number of seeds pod^{-1} (13.16) was recorded in plants supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by those supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_9), the value being 12.50 and minimum was 8.60 in control i.e. sole cropping of greengram without organic manure and fertilizer application.

4.1.5 Above ground biomass (kg ha^{-1})

4.1.5.1 Fresh weight of shoot (kg ha^{-1})

The fresh weight of shoot of greengram has been found to be significantly influenced by the application of different doses of organic manures and fertilizers (Table-3). Among different treatments, T_8 where plants were supplied with 80 per cent recommended doses of NPK + FYM + dalweed + biofertilizers (Rhizobium) was found to produce maximum fresh weight of 4090.36 kg ha^{-1} followed by 3850.23 kg ha^{-1} in T_9 in which plants were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) where as the minimum was 2560.18 kg ha^{-1} in control i.e. sole cropping of greengram without organic manure and fertilizer application.

4.1.5.2 Dry weight of shoot (kg ha^{-1})

On the basis of observations recorded on dry weight of shoot of greengram there has been significant differences among various treatments as shown in the Table-3. Among different treatments, T_8 where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), was found to produce maximum dry weight of 1552.91 kg ha^{-1}

Table-3 : Effect of organic manures and fertilizers on above ground biomass of greengram under plum based agroforestry system

	Treatment	Fresh weight (kg ha^{-1})	Dry weight (kg ha^{-1})
T_1	Control (only Plum)*	-	-
T_2	Control (only Greengram)	2560.18	1033.31
T_3	FYM	3100.21	1240.36
T_4	Dalweed Manure	2764.30	1109.10
T_5	Biofertiliser (Rhizobium)	2985.10	1170.36
T_6	Vermicompost	3760.71	1372.48
T_7	Biofertiliser + Vermicompost (50%)	3340.91	1290.16
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	4090.36	1552.91
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	3850.23	1443.56
	SEm±	**20.87**	**5.04**
	CD (p≤0.05)	**63.92**	**15.44**

*T_1 not included in statistical analysis

followed by 1443.56 kg ha^{-1} in T_9 supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) where as the minimum was 1033.31 kg ha^{-1} in control i.e., sole cropping of greengram without organic manure and fertilizer application.

4.1.6 Grain yield (kg ha^{-1})

The observations recorded and presented in Table-4 show that application of different doses of organic manures and fertilizers caused significant influence on grain yield of greengram.

Among different treatments for greengram, T_8 supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) was found to produce maximum grain yield of 1041.66 kg ha^{-1} followed by T_9 (955 kg ha^{-1}) where plants were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) where as the minimum (703.33 kg ha^{-1}) was recorded in control i.e. sole cropping of greengram without organic manure and fertilizer application. Grain yields were comparatively higher in combination of manures and fertilizers treatments as compared to organic manures alone.

4.1.7 Straw yield

The observations recorded and presented in Table-4 shows that application of different doses of organic manures and fertilizers caused significant influence on straw yield of greengram.

Among different treatments for greengram, T_8 supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) was found to produce maximum straw yield of 1950.00 kg ha^{-1} followed by T_9 (1816.66 kg ha^{-1}) where plants were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) where as the minimum (1370.00 kg ha^{-1}) was recorded in control i.e. sole cropping of

Table-4 : Effect of organic manures and fertilizers on yield characteristics of greengram under plum based agroforestry system

	Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Control (only Plum)*	-	-
T_2	Control (only Greengram)	703.33	1370.00
T_3	FYM	833.33	1520.00
T_4	Dalweed Manure	763.33	1410.00
T_5	Biofertiliser (Rhizobium)	799.33	1448.33
T_6	Vermicompost	910.00	1653.33
T_7	Biofertiliser + Vermicompost (50%)	874.33	1568.33
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	1041.66	1950.00
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	955.00	1816.66
	SEm±	**16.55**	**5.88**
	CD (p≤0.05)	**50.69**	**18.03**

*T_1 not included in statistical analysis

greengram without organic manure and fertilizer application. The differences (CDs) were statically significant at 5 per cent level of significance.

4.2 Growth and yield parameters of plum

4.2.1 Tree height (m)

The average height of plum trees was recorded as 3.60 m (Table-5).

4.2.2 Basal diameter (cm)

The mean trunk diameter of plum trees at basal height, growing with green gram was found to be 17.57 cm (Table-5).

4.2.3 Crown spread (m)

The crown spread was measured in east-west and north-south directions from the tree trunk and the mean crown spread of trees growing with greengram was found to be 2.20 m (Table-5).

4.2.4 Branch angle (degrees)

The mean branch angle of plum trees, growing with green gram was found to be 30 degree (Table-5).

4.2.5 Leaf area (cm^2)

Leaf area of plum intercropped with greengram and sole cropping (only plum without manure and fertilizer application) was determined at the time of harvesting of greengram. The data obtained are presented in Table-6.

The perusal of the data presented in the Table-6 results that the variation in leaf area of plum as affected by different treatments exhibited no significant difference.

Table-5 : Growth characteristics of plum

Average height (m)	Average basal diameter (cm)	Average Crown spread (m)	Average Branch angle (degrees)
3.60	17.57	2.20	30

Table-6 : Leaf area of plum as influenced by organic manures and fertilizers under plum based agroforestry system

	Treatment	Leaf area (cm^2)
T_1	Control (only Plum)	29.60
T_2	Control (only Greengram)*	-
T_3	FYM	30.90
T_4	Dalweed Manure	29.66
T_5	Biofertiliser (Rhizobium)	31.10
T_6	Vermicompost	30.00
T_7	Biofertiliser + Vermicompost (50%)	31.63
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	30.20
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	31.27
	SEm±	**0.59**
	CD ($p \leq 0.05$)	**NS**

*T_2 not included in statistical analysis; NS = Non-significant

4.2.6 Fruit yield (kg tree^{-1})

The harvesting of fruits of plum trees was done during the month of July and it was found that the average yield per tree was 23.83 kg (Table-7).

The perusal of the data presented in the Table-7 results that the variation in fruit yield of plum as affected by different treatments exhibited no significant difference.

4.2.7 Total N, P, K in leaves (% dry weight)

The variation in total N, P and K in plum leaves after growing of mungbean intercrop at the time of sowing and harvesting of mungbean in one season and the harvesting of fruits in the next season is shown in Table-8.

The total N, P and K content of plum leaves declined from July to October in the first season (2011) in T_1 i.e., control (only plum without manure and fertilizer application). Similar trend was observed for all other treatments with insignificant variation between the treatments. Thus the growing of intercrop with or without organic manures and fertilizers did not have any effect on total N, P and K content of plum leaves in the first season. However, total N, P and K content of plum leaves at the time of harvesting of fruits in the next season (July, 2012) showed significantly higher values as compared to the corresponding figures in previous season. The treatment effect varied significantly among themselves with highest N, P and K content (2.83, 0.25 and 2.72 % dry weight, respectively) in leaves of plum trees under treatment T_8 supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), followed by those supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_9), the value being (2.80, 0.23 and 2.69 % dry weight, respectively). The minimum value of N, P and K content was 2.66, 0.17 and 2.45 per cent dry weight, respectively in T_1 i.e. control (only plum without organic manure and fertilizer application).

Table-7: Fruit yield of plum as influenced by organic manures and fertilizers under plum based agroforestry system

	Treatment	Fruit yield (kg tree^{-1})
T_1	Control (only Plum)	23.20
T_2	Control (only Greengram)*	-
T_3	FYM	23.45
T_4	Dalweed Manure	23.13
T_5	Biofertiliser (Rhizobium)	23.17
T_6	Vermicompost	24.73
T_7	Biofertiliser + Vermicompost (50%)	23.58
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	24.83
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	24.57
	SEm±	**0.34**
	CD (p≤0.05)	**NS**

*T_2 not included in statistical analysis
NS = Non-significant

Table-8 : Leaf nutrient status (% dry weight) in plum at three different stages as influenced by organic manures and fertilizers under plum based agroforestry system

	Treatment	At the time of sowing of Mung bean			At the time harvesting of Mung bean			At the time of harvesting of fruits		
		N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1	Control (only Plum)	2.64	0.15	2.60	2.05	0.09	1.85	2.66	0.17	2.45
T_2	Control (only Greengram)*	-	-	-	-	-	-	-	-	-
T_3	FYM	2.62	0.18	2.61	2.02	0.12	1.86	2.76	0.20	2.65
T_4	Dalweed Manure	2.63	0.17	2.58	2.03	0.12	1.84	2.75	0.19	2.64
T_5	Biofertiliser (Rhizobium)	2.60	0.17	2.56	2.01	0.13	1.85	2.70	0.18	2.59
T_6	Vermicompost	2.60	0.13	2.49	2.02	0.08	1.67	2.78	0.22	2.67
T_7	Biofertiliser + Vermicompost (50%)	2.61	0.15	2.60	2.01	0.08	1.85	2.77	0.21	2.66
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	2.54	0.15	2.58	1.95	0.09	1.84	2.86	0.25	2.72
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	2.62	0.17	2.58	2.02	0.12	1.84	2.80	0.23	2.69
	SEm±	**0.06**	**0.01**	**0.04**	**0.04**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**
	CD (p≤0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.03**	**0.02**	**0.04**

*T_2 not included in statistical analysis; NS = Non-significant

4.3 Physico-chemical characteristics of soil

4.3.1 Available nitrogen (kg ha^{-1})

Application of different doses of organic manures and fertilizers significantly influenced the available N content of soil (Table-9). In the surface soil (0-20 cm), the maximum available N (346.82 kg ha^{-1}) was recorded for the treatment T_8 where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) followed by treatment T_9 (343.13 kg ha^{-1}) where plants were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium). In the same depth the least value (332.00) of available N, was observed in T_1 i.e. control (only plum without organic manure and fertilizer application).

4.3.2 Available phosphorus (kg ha^{-1})

It is evident from the data in Table-9 that different doses of organic manures and fertilizers significantly influenced the available P content of soil. In the surface soil (0-20 cm), the maximum available P (23.15 kg ha^{-1}) was recorded for the treatment T_8, where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), followed by T_9 (21.00 kg ha^{-1}). In the same depth the least value for available P (17.11 kg ha^{-1}) was observed in treatment T_2 i.e., control (only greengram without organic manure and fertilizer application.

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

A perusal of data enumerated in Table-9 reveal that there was significant effect of different treatments on available K content of soil. In the surface soil (0-20 cm), the maximum available K (150.82 kg ha-^{1}) was recorded for the treatment T_8 where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), followed by T_9 (147.32 kg ha^{-1}) supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium). In the same depth, the least value for available K

Table-9 : Effect of organic manure and fertilizers on soil physico-chemical characteristics at the time harvesting of greengram

Treatment		Available nutrient content (kg ha^{-1})			Soil pH	EC (dSm^{-1})	Soil moisture (%)
		Nitrogen	Phosphorus	Potassium			
T_1	Control (only Plum)	332.00	17.96	136.40	6.41	0.26	5.65
T_2	Control (only Greengram)	333.02	17.11	137.00	6.46	0.27	5.60
T_3	FYM	336.07	18.91	139.33	6.60	0.30	6.00
T_4	Dalweed Manure	334.06	18.11	138.00	6.49	0.29	5.90
T_5	Biofertiliser (Rhizobium)	335.00	18.00	140.00	6.68	0.28	5.70
T_6	Vermicompost	339.51	20.05	143.61	6.78	0.30	6.20
T_7	Biofertiliser + Vermicompost (50%)	337.93	19.08	142.81	6.74	0.31	5.85
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	346.82	23.15	150.82	6.89	0.33	6.40
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	343.13	21.00	147.32	6.85	0.32	6.10
	SEm±	**0.70**	**0.11**	**0.15**	**0.01**	**0.01**	**0.01**
	CD (p≤0.05)	**2.13**	**0.33**	**0.47**	**0.03**	**0.02**	**0.04**

(136.40 kg ha^{-1}) was observed in T_1 i.e. control (only plum without organic manure and fertilizer application).

4.3.4 Soil pH

The data pertaining to the effect of different levels of organic manures and fertilizers on soil pH are given in Table-9. It indicates that the treatments significantly influenced pH. The highest value (6.89) of pH was observed under treatment T_8 supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), followed by T_9 (6.85) in which plants were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) and the least value (6.41) was found in T_1 i.e. control (only plum without organic manure and fertilizer application).

4.3.5 Electrical conductivity (dSm^{-1})

A perusal of data enumerated in Table-9 reveals that all the treatments had a significant influence on electric conductivity (EC). In the depth 0-20 cm, 0.33 dSm^{-1} was the highest value of EC under treatment T_8 i.e., plots supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium), followed by T_9 (0.32 dSm^{-1}) in which plots were supplied with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) and the least value (0.26 dSm^{-1}) was found in T_1 i.e., control (only plum without organic manure and fertilizer application).

4.3.6 Soil moisture

A perusal of data enumerated in Table-9 reveals that all the treatments had a significant influence on soil moisture. The highest value (6.40%) of soil moisture was observed under T_8 supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) followed by T_6 (6.20 %) in which plants were supplied with vermicompost and the least (5.60%) was found in T_2 i.e., control (sole cropping of greengram without organic manure and fertilizer application).

4.4 Light transmission ratio (%)

The observations recorded and presented in Table-10 show that application of different doses of organic manures and fertilizers caused significant influence on light transmission ratio for green gram. 78.95 per cent LTR was available under T_1 i.e. control (only plum without organic manure and fertilizer application).

Among different treatments for greengram, the maximum (66.50%) LTR was obtained in T_1 i.e., control (sole cropping of greengram without organic manure and fertilizer application) followed by T_4 in which plants were supplied with dalweed manure and the minimum was 49.05 per cent in T_8, where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium).

4.5 Net return from the system

The economics of the plum based agroforestry system intercropped with green gram was calculated. The cost of cultivation, gross return, net returns and total net returns of the system was determined to know the economic profitability of the tree crop combination.

4.5.1 Cost of cultivation

It is clear from the Table-11 that among different treatments, the maximum cost of cultivation Rs. 31,050 ha^{-1} was incurred in T_6, where the combination was plum + greengram + vermicompost followed by T_7, where the combination was plum + greengram + biofertilizer + vermicompost (50%). However, the minimum cost of cultivation (Rs. 16,050 ha^{-1}) was incurred in T_2 i.e., control (sole cropping of greengram without organic manure and fertilizer application).

Table-10 : Effect of organic manures and fertilizers on Light Transmission Ratio (%)

	Treatment	LTR (%)
T_1	Control (only Plum)	78.95
T_2	Control (only Greengram)	66.50
T_3	FYM	56.30
T_4	Dalweed Manure	60.60
T_5	Biofertiliser (Rhizobium)	58.10
T_6	Vermicompost	52.20
T_7	Biofertiliser + Vermicompost (50%)	56.10
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	49.05
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	50.00
	SEm±	**0.62**
	CD (p≤0.05)	**1.88**

Table-11 : Net return of plum based agroforestry system intercropped with greengram

	Treatment	Gross return from intercrop (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns from intercrop (Rs ha^{-1})	Net returns from trees (Rs ha^{-1})	Total net returns from the system (Rs ha^{-1})
T_1	Control (only Plum)	-	-	-	188500.00	188500.00
T_2	Control (only Greengram)	50603.10	16050	345531.10	-	34553.10
T_3	FYM	59853.10	17250	42603.10	190843.75	233446.85
T_4	Dalweed Manure	54843.10	20050	34793.10	187843.75	222636.85
T_5	Biofertiliser (Rhizobium)	57401.43	16064	41337.13	188218.75	229555.88
T_6	Vermicompost	65353.33	31050	34303.33	202843.75	237147.08
T_7	Biofertiliser + Vermicompost (50%)	62771.33	23564	39207.00	192062.50	231269.50
T_8	80% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	74866.20	22976	51890.14	203781.25	255671.39
T_9	60% of recommended doses of NPK + FYM + Dalweed + Biofertiliser (Rhizobium)	68666.66	22548	46118.61	201343.75	247462.36

4.5.2 Gross return

Gross return from green gram was found to be highest in (Rs. 74,866.20) in agroforestry systems which was provided with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), and the lowest gross returns (Rs. 50,603.10) from T_2 i.e., control (sole cropping of greengram without organic manure and fertilizer application).

4.5.3 Net returns

The net return from greengram was found to be highest in (Rs. 51,890.14) in agroforestry systems which was provided with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by T_9 which was provided with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) and the lowest net return (Rs. 34,303.33) from T_6 i.e., greengram + vermicompost with plum.

4.5.4 Total net returns

The total net returns from the agroforestry system were calculated from the net returns of intercrops and plum trees. The total returns was found to be highest in (Rs. 255,671.39) in agroforestry systems which was provided with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) (T_8), followed by T_9 which was provided with 60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) and the lowest total net returns (Rs. 34,553.10) from T_2 i.e., sole cropping of greengram without organic manure and fertilizer application (Table-11).

Chapter – 5

DISCUSSION

The present study entitled "Studies on Greengram-Plum based Agroforestry System in Kashmir Valley" was undertaken to investigate the effect of different doses of organic manures and fertilizers on growth and yield of greengram and plum under plum-based agroforestry system and explore the possibility of successful integration of greengram as an intercrop in plum orchards. The findings of the study are discussed in light of the available literature under appropriate heading as below :

5.1 Growth and yield parameters of greengram

5.2 Growth and yield parameters of plum

5.3 Physico-chemical characteristics of soil

5.4 Light transmission ratio

5.5 Net return from the system

5.1 Growth and yield parameters of greengram

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 the 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 may be affected by various factors like climatic, edaphic and topographic factors. Among them, one of the most important factors is the maintenance of appropriate nutrient status in the soil. The organic manures are said to contribute to the organic matter and

improve nutrient status of soil and quality and quantity of produce. During the present study, the influence of different doses of organic manures and fertilizers on different growth and yield parameters were monitored. The results in general indicated that organic manures and fertilizers improved the growth and performance of greengram plants. The growth and yield parameters like number of primary branches, above ground biomass, pod length, number of pods per plant, number of seeds per pod and grain yield were significantly influenced by different doses of organic manures and fertilizers. The application of organic manures viz., vermicompost, FYM, dalweed, biofertilizer (Rhizobium) substantially enhanced the growth of greengram. However, different doses of organic manures and fertilizers were found to have different impact on greengram plants.

Among different treatments, treatment T_8 [80 per cent recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium)] was found to result in higher values for most of the growth and yield parameters (Tables-2 to 4). This was followed by treatment T_9 [60 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium)]. The minimum values for most of the growth and yield parameters were found in T_2 i.e., control (sole cropping of greengram without organic manure and fertilizer application. This could be due to the nutrient enrichment of soil by the use of organic manures and fertilizers in combination. These results are in line with that of Scheffer *et al*. (1993), Singh *et al.* (1993), Paturde *et al*. (2002) and Zohra *et al*. (2005). Also, the low nutrient present in organic manures in comparison with inorganic fertilizer might have been balanced by combined application of both (Singh *et al*. (2002).

Perusal of the results reveal that the greengram plants receiving organic manures and fertilizers in combination had better yield compared to organic manures alone. This could be attributed to the better residual build up of organic carbon and available NPK in soil and the easy and faster availability of nutrients in fertilizers and organic manures in combination. The analysed data on grain and

straw yields revealed that application of 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) showed significant improvement compared to vermicompost, biofertilizer + vermicompost (50%), FYM, dalweed, biofertilizer and the control. These results are fully supported by the findings of Sarkar and Banik (1991), Kumar *et al*. (2002), Patel *et al*. (2003) and Sharma *et al*. (2003).

Rhizobium inoculation had a significantly marked influence on primary branches plant^{-1} and yield attributes viz., pod length, number of pods plant^{-1}, number of seeds pod^{-1}. Similar results have also been reported by several workers (Singh *et al*., 1993; Shukla and Dixit, 1996).

The data further indicated that the combined use of organic manures and fertilizers was most effective in enhancing growth and yield parameters. The increment in growth performance is attributed to the nitrogen, phosphorus and potassium provided by the organic manures and fertilizers and this improvement at micro level in soil physico-chemical properties further contributed to the better growth of plants. These results are in conformity with Sehgal (2007) who reported improved growth of intercrop by the use of organic manures under agroforestry condition. Maheswarappa *et al*. (1998) and George and Pillai (2000) also reported that organic manures in combination with chemical fertilizers stimulated the growth of intercrop under coconut trees. Similar results were observed for fresh weight of shoot and dry weight of shoot of greengram. Chaves *et al*. (2002) also observed organic fertilizer application in *Ocimum basilicum* increased dry mass production of leaves. The possibility that the greengram plants can be benefited from the microclimate of trees was somewhat apparent as growth and yield parameters of greengram plants were found to have higher values inside plum orchards than the outside without trees (control).

5.2 Growth and yield parameters of plum

The growth and yield parameters of plum such as crown spread, leaf area, branch angle and fruit yield were recorded and given in Tables-5 and 6. The data suggested that the plum trees do not experience any type of competition for critical resources from the intercrop. So the effect of different treatments and intercrop on the growth of plum trees have neither been quantified nor discussed and the effect of these treatments was also non-significant on fruit yield of plum trees. The findings of Kumar (2004), Gill *et al*. (2004) and Joshi (2008) were in corroboration with the present findings.

Leaf nutrient status was analysed at three different stages at the time of sowing and harvesting of mung bean in the first season and at the harvesting of fruits in the next season (Table-8). Total N, P and K content of plum leaves showed a steady decline from July onwards in the first season. The decrease in N, P and K content from July and October during the first year of present investigation might be due to the growth dilution effect (Smith, 1962; Leece and Gilmour, 1974 and Chuntanaparb and George, 1980) and also might be due to utilization of these nutrients by various sinks at different developmental stages (Cameron *et al.,* 1952). The decline in the nutrient content (N, P and K) of plum leaves by the end of sampling season may be due to remobilization of N, P and K in the plant prior to leaf fall (Clark and Smith, 1990).

Higher N, P and K was recorded in second year of study than the first year study in both the sampling dates indicating that greengram intercrop and different doses of organic manures and fertilizers had more positive effect on N, P and K availability. These observations point towards positive role of legume intercrop and different nutrient sources in making the nutrients more available (Trujillo *et al.*, 2003). Among the treatments, the highest N, P and K content was observed in treatment containing the intercrop and 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium).

5.3 Physico-chemical characteristics of soil

The application of different doses of organic manures and fertilizers found to have influence on available nitrogen, available phosphorus, available potassium, soil pH, EC (dSm^{-1}) and soil moisture (Table-9).

5.3.1 Available N, P and K

Data pertaining to available N, P and K revealed that different doses of organic manures and fertilizers significantly influenced the amount of available N, P and K in surface soil. Addition of organic manures with lower C:N ratio (less than 20:1) increases the microbial activity, thereby, accelerating the rate of mineralization. This might have lead to greater release of N from native organic sources, ultimately, resulting in higher N content in soils. Raina and Goswami (1988) have also reported that the addition of organic material accelerates the decomposition of native soil organic matter (a positive priming effect) thus, leading to higher mineralization and release of nutrient elements. Other workers Sreenivas *et al.* (2000), Marimuthu *et al*. (2001) and Singh *et al*. (2002) have also reported that the inclusion of organic amendments and inorganic fertilizers at variable rates increased the soil N, P and K content. Prakash *et al*. (2002) in their study on comparative efficacy of organic manures and inorganic fertilizers in relation to nutrient availability, reported higher availability of all major nutrient elements in treatments supplemented with organic nutrient sources compared to manures and fertilizers alone.

5.3.2 Soil pH

The present study revealed that as the amount of organic manure is increased, there was a decline in the values of pH. The slight decline in the soil pH under organic manure treatment could be attributed to the production of organic acids formed during decomposition of organic matter. The results are in accordance with the findings of Srikanth *et al*. (2000) and Jayabhaskaran *et al*.

(2001), who also reported a decline in the soil pH with application of poultry manure and vermicompost.

5.3.3 Electrical conductivity (EC)

The data pertaining to electrical conductivity revealed that application of organic manures and fertilizers significantly influenced electrical conductivity during the study. Soils which had received organic manures and fertilizers recorded more increase in EC over initial value which is obviously due to addition of salts in the soil. These results are in line with the findings of Vijay *et al*. (2007).

5.3.4 Soil moisture

The data pertaining to soil moisture reveal that application of organic manures and fertilizers significantly influenced soil moisture during the study. The increase in soil moisture (%) can be attributed to the improvement in soil structure and water holding capacity of the soil due to addition of organic manures. These results are in line with the findings of Gupta *et al*. (1977), Khaleel *et al*. (1981), Metzger and Yaron (1987). 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 also be attributed to reduction in water evaporation, therefore, conserving the available water in soil (Agele, 2000).

5.4 Light transmission ratio

Light transmission ratio (LTR) is an indication of the availability of solar radiation to the intercrop in agro-forestry system. During the present investigation, maximum LTR was recorded in greengram grown as sole crop and minimum in greengram plants supplied with organic manures and fertilizers and grown with tree component. Lower the LTR value status, lesser is the transmission of PAR beneath the canopy, which indicates higher shade intensity under agroforestry conditions than in open. Thus, shade caused by the presence of tree canopies emerges as a critical and deciding factor in regulating the growth and production potential of the intercrops. Reduced LTR during the present study was found to

help greengram plants, probably by improving radiation environment. Lesser LTR under agroforestry conditions was also reported by Thakur and Kaur (2001), Thakur and Singh (2002) and Dutt (2004).

5.5 Net return from the system

The cost of cultivation along with gross and net returns was determined for plum based agroforestry system (Table-11). The maximum cost of cultivation was incurred in the practice where greengram plants were grown under plum and supplied with vermicompost, because of the higher cost of the vermicompost and minimum cost of cultivation was in T_2 i.e., control (sole cropping of greengram without organic manure and fertilizer application).

The monetary gain or total net returns was maximum from plots, which were grown under plum and provided 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) as the biomass yield was higher. Sole cropping systems, either of plum (T_1) or greengram (T_2) were found to have lowest net returns. Comparatively more returns were obtained from agroforestry systems than in sole cropping. It is due to the additional income produced from the plum trees. The results are in line with the findings of Yadava and Singh (1996), Chauhan (2000) and Dutt and Thakur (2004).

Chapter – 6

SUMMARY AND CONCLUSION

Growing of agricultural crops under fruit trees has not received any attention so far. Very little information is available with respect to growing of agricultural crops under fruit-tree based agro-forestry systems in the Kashmir Valley. Thus, the present investigation entitled "Studies on Greengram-Plum based Agroforestry System in Kashmir Valley" was carried out at the experimental farm of the Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar.

The experiment was planned to find out the effect of different doses of organic manures and fertilizers on growth and yield of greengram and plum under plum-based agroforestry system and to study the relative economics of the system. The experiment was laid out in a randomized block design. The major findings of this investigation are summarized as follows :

6.1 Growth and yield parameters of greengram

6.2 Growth and yield parameters of plum

6.3 Physico-chemical characteristics of soil

6.4 Light transmission ratio

6.5 Net return from the system

6.1 Growth and yield parameters of green gram

The growth and yield parameters like number of primary branches, above ground biomass, pod length, number of pods per plant, number of seed per pod and grain yield were significantly influenced by different doses of organic manures and fertilizers. Among different treatments, treatment T_8, where plants were supplied with 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium) found to have higher values for most of the growth

and yield parameters of greengram. The reason may be the nutrient enrichment of soil due to the use of organic manures and fertilizers in combination. Also, the low nutrient present in organic manures in comparison with inorganic fertilizers might have been balanced by the combined application of both. The greengram with organic manure and fertilizers performed better under plum based agroforestry system than sole cropping system which might be because of improved microclimate and radiation environment underneath the trees.

6.2 Growth and yield parameters of plum

The growth and yield parameters of plum such as crown spread, leaf area, branch angle and fruit yield suggest that the intercropping is generally not expected to influence tree parameters substantially. However, these parameters were recorded to elucidate the influence of plum trees on greengram plants.

The treatments (intercrop and different doses of organic manures and fertilizers) did not have any effect on the N, P and K content of plum leaves during first year. Higher N, P and K was recorded in second year of study than the first year study in both the sampling dates indicating that greengram intercrop and different doses of organic manures and fertilizers had more positive effect on N, P and K availability. These observations point towards positive role of greengram intercrop and different nutrient sources in making the nutrients more available.

6.3 Physico-chemical characteristics of soil

Different doses of organic manures and fertilizers were found to have influence on available N, P, K, soil pH, EC and soil moisture. As the amount of organic manure is increased, there was a decline in the values of pH and a rise in the amount of soil moisture per cent, EC and available NPK. The treatments where organic manures and fertilizers were used in combination are found to have higher values for soil moisture, EC, available N, P, K.

6.4 Light transmission ratio

The present study revealed that the LTR was substantially affected by the application of organic manures and fertilizers. Maximum LTR was recorded in greengram plants in open and minimum in greengram plants supplied with organic manures and fertilizers and grown with tree component which indicates the availability of solar radiation to the intercrop in agroforestry system.

6.5 Net return from the system

The economics of the plum based agroforestry system intercropped with greengram revealed that the cost of cultivation was maximum from plots, which were grown under plum and supplied with vermicompost (100%). The monetary gain or total net return was maximum from plots, which were grown under plum and provided 80 per cent of recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium). Comparatively, more returns were obtained from agroforestry systems than in sole cropping. It is due to additional income procured from the plum trees.

CONCLUSION

The results obtained from the present investigation indicated that the greengram plants thrive well under plum based agroforestry system and can be cultivated successfully as intercrop with fruit trees. Growth and yield attributes of greengram plants were positively affected by application of different doses of organic manures and fertilizers. The use of organic manures and chemical fertilizers in combination has been found to be more efficient than organic manures alone. Also, the production potential and economic returns were higher inside the agroforestry system than sole cropping. Based on the findings of this study, it can be concluded that greengram (*Vigna radiata*) can be grown successfully under plum based agroforestry system and this diversification practice can be a viable option for boosting the economy of farming community.

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***Original not seen.**

APPENDIX – I

Meteorological data for the year 2011

Month	Temperature (^{o}C)		Relative humidity		Rainfall (mm)	Wind speed (km/hr)
	Max.	Min.	Max.	Min.		
January	6.89	-3.03	92.80	70.96	107.6	2.12
February	8.56	1.16	87.03	71.00	99.6	3.07
March	16.13	2.91	48.03	43.35	86.3	3.41
April	18.09	5175	79.50	56.16	93.1	3.05
May	27.46	10.29	73.48	37.74	19.8	3.06
June	30.57	14.61	69.80	44.03	42.9	2.62
July	29.95	16.90	77.90	53.45	31.0	2.05
August	30.55	16.83	79.25	51.35	45.2	1.96
September	27.72	13.14	86.86	53.46	59.8	1.71
October	22.80	5.56	90.51	60.19	27.9	1.83
November	15.26	2.16	89.60	67.46	24.4	1.76
December	9.79	-2.03	91.29	69.83	24.3	1.78

APPENDIX – II

Cost of cultivation of greengram

A)	**Cost of inputs**	
	Particular	**Cost (Rs. ha^{-1})**
i)	Human labour	150/day
ii)	Land preparation	
	a) Ploughing and harrowing	4300
iii)	Cost of seed	4500
	a) Sowing charges	600
iv)	Cost of fertilizers	varying with treatments
	a) Application charges	600
v)	Inter-cultivation	750
vi)	Weedings	1350
vii)	Cost of chemicals	1000
	a) Application charges	450
viii)	Harvesting	600
	a) Harvesting and cleaning	900
ix)	Miscellaneous	1000
	Treatments	
i)	FYM (2 t ha^{-1})	1200
ii)	Dalweed manure (2 t ha^{-1})	4000
iii)	Biofertilizer (rhizobium) (5 g kg^{-1} seed)	14
iv)	Vermicompost (1 t ha^{-1})	15000
v)	Biofertilizer + vermicompost (50%)	7514
vi)	80% recommended doses of NPK + FYM + dalweed + biofertilizer (Rhizobium)	6926.059
vii)	60% recommended doses of NPK + FYM + dalweed + biofertilizer (rhizobium)	6498.043

APPENDIX – III

Prevailing market prices of the produce

Produce	**Price (Rs. kg^{-1})**
Grain	70
Straw	1
Plum (Fruit)	15

APPENDIX – IV

Analysis of variance for number of primary branches

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.37			
Treatment	7	10.98	1.57	6.97	0.001078
Error	14	3.15	0.23		
Total	23	14.50			

Analysis of variance for number of pods plant^{-1}

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	9.25			
Treatment	7	88.75	12.68	9.36	0.000233
Error	14	18.96	1.35		
Total	23	116.96			

Analysis of variance for pod length (cm)

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.18			
Treatment	7	68.32	9.76	14.04	0.000024
Error	14	9.73	0.70		
Total	23	78.23			

Analysis of variance for number of seeds pod^{-1}

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.29			
Treatment	7	51.26	7.32	13.78	0.000026
Error	14	7.44	0.53		
Total	23	58.98			

Analysis of variance for above ground biomass-fresh weight (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	220900.00			
Treatment	7	6343185.14	906169.31	693.24	0.000002
Error	14	18300.0	1307.14		
Total	23	6582385.14			

Analysis of variance for above ground biomass-dry weight (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	65181.15			
Treatment	7	640338.65	91476.95	1200.00	0.000001
Error	14	1067.23	76.23		
Total	23	706587.03			

Analysis of variance for grain yield (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	2602.58			
Treatment	7	249040.96	35577.28	43.28	0.000001
Error	14	11509.42	822.18		
Total	23	263152.96			

Analysis of variance for straw yield (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	101388.91			
Treatment	7	873572.31	124796.04	1200.00	0.000001
Error	14	1455.95	104.00		
Total	23	976417.17			

Analysis of variance for leaf area (cm^2)

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	10.38			
Treatment	7	12.67	1.81	1.36	0.293633
Error	14	18.58	1.33		
Total	23	41.63			

Analysis of variance for fruit yield (kg tree^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.01			
Treatment	7	11.40	1.63	1.85	0.098210
Error	14	12.35	0.88		
Total	23	12.04			

Analysis of variance for leaf nutrient status (% dry weight) in plum

1) N (at the time of sowing of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.03			
Treatment	7	0.02	0.00	0.41	0.877309
Error	14	0.09	0.01		
Total	23	0.13			

2) P (at the time of sowing of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.00	0.00	2.66	0.056548
Error	14	0.00	0.00		
Total	23	0.01			

3) K (at the time of sowing of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.03	0.00	0.25	0.963043
Error	14	0.24	0.02		
Total	23	0.27			

4) N (at the time of harvesting of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.02	0.001	0.35	0.0681
Error	14	0.04	0.0028		
Total	23	0.02			

5) P (at the time of harvesting of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.01	0.001	0.50	0.0611
Error	14	0.03	0.002		
Total	23	0.01			

6) K (at the time of harvesting of mung bean)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.08	0.01	1.42	0.0723
Error	14	0.10	0.007		
Total	23	0.09			

7) N (at the time of harvesting of fruits)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.01			
Treatment	7	0.07	0.01	4.05	0.012458
Error	14	0.04	0.00		
Total	23	0.12			

8) P (at the time of harvesting of fruits)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.02	0.00	2.45	0.042936
Error	14	0.01	0.00		
Total	23	0.03			

9) K (at the time of harvesting of fruits)

Source	D.F.	S.S	M.S.	F-Cal	Significance
Replications	2	0.00			
Treatment	7	0.14	0.02	5.79	0.002639
Error	14	0.05	0.00		
Total	23	0.20			

Analysis of variance for available N (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	4.18			
Treatment	8	579.63	72.45	48.58	0.000002
Error	16	23.86	1.49		
Total	26	607.67			

Analysis of variance for available P (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.64			
Treatment	8	84.48	10.56	292.44	0.000001
Error	16	0.58	0.04		
Total	26	85.70			

Analysis of variance for available K (kg ha^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.02			
Treatment	8	576.05	72.01	960.08	0.000001
Error	16	1.20	0.08		
Total	26	577.27			

Analysis of variance for soil pH

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.02			
Treatment	8	0.74	0.09	367.53	0.000002
Error	16	0.00	0.00		
Total	26	0.76			

Analysis of variance for EC (dSm^{-1})

Source	d.f.	S.S	M.S.	F-Cal	Significance
Treatment	8	0.01	0.00	15.83	0.000001
Error	18	0.00	0.00		
Total	26	0.01			

Analysis of variance for soil moisture (%)

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	0.08			
Treatment	8	1.73	0.22	345.00	0.000001
Error	16	0.01	0.00		
Total	26	1.82			

Analysis of variance for light transmission ratio (%)

Source	d.f.	S.S	M.S.	F-Cal	Significance
Replications	2	1.06			
Treatment	8	2093.53	261.69	224.43	0.000001
Error	16	18.66	1.17		
Total	26	2113.24			

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. S.K. Gupta, Professor & Head, Division of Agroforestry, SKUAST-Jammu during Viva-Voce examination held on 8th of April, 2013 have been incorporated in the manuscript entitled **"Studies on Greengram-Plum based Agroforestry System in Kashmir Valley"** submitted by **Mr. Murtaza Hussain Shah (Regd. No. 2010-For-31-M).**

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