PERFORMANCE OF MUNGBEAN AS GREEN MANURING CROP IN AGROFORESTRY SYSTEMS

A Thesis

By

MD. AL MUZAHID SARKER
Student no. 0505002
Session: 2005-06
Thesis Semester: January-June, 2006

MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY

DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR

June 2006

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Submitted to the Department of Agroforestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur in partial fulfillment of the requirements for the degree of

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Dedication

Those who are trying to
Change the world through
the GRASS ROOTS
program of
Dawat-E-Tabligh.

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The Author

ABSTRACT

A field experiment was conducted at the Agroforestry Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur during April to July 2005 to examine the performance of mungbean varieties for improving soil health as green manuring crop in different agroforestry systems. The treatments of the experiment were three tree species with the control one viz. open field (T_1), Mango (T_2), Ghoraneem (T_3), Ipil-ipil (T_4) and five varieties of mungbean, viz. V_1 (BARI Mug-3), V_2 (BARI Mug-4), V_3 (BARI Mug-5), V_4 (BARI Mug-6), V_5 (Local variety). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The aim of the study was to select the suitability of the above Mungbean variety for agroforestry system.

Considering varietals performance, BARI Mug-6 showed the best performance compared to other varieties in respect of biomass contribution except root weight/plant at 50 DAS. Considering tree effect, the best contribution was found in T_1 (open field) and lowest in T_3 (Ghoraneem) compared to other tree species in biomass production.

In case of interaction effect BARI Mug-6 was the best performer (V_4T_1combination) compared to other combinations in biomass contributing parameter except root weight/plant in both 50 DAS and 75 DAS.

In term of varietals performance for yield BARI Mug-5 was found the best variety over other varieties. BARI Mug-5 was also found superior than other varieties in all yields contributing parameter except the number of pod/plant.

In case of tree effect, the highest yield was obtained from T_1 (open field) that was followed by Mango. While the lowest performance was recorded under ghoraneem.

Considering the interaction effects on yield, BARI Mug-5 in open field (V_3T_1 combination) ensures the best performance in respect of other combinations followed by V_3T_2 combination (BARI Mug-5 under mango).The result clearly revealed that the production of mungbean under the agroforestry species ranked as mango>ipil-ipil>ghoraneem and the best variety BARI Mug-5 for yield while BARI Mug-6 for biomass.

ABBREVIATION AND ACRONYMS

%	:	Percent
abst.	:	Abstract
AEZ	:	Agro-Ecological Zone
cm	:	Centimeter
DAS	:	Days after sowing
et al.	:	And others
FAO	:	Food and Agriculture Organization
g	:	Gram
i.e.	:	That is
m	:	Meter
t/ha	:	Ton per hectare
viz.	:	Namely
BBS	:	Bangladesh Bureau of Statistics
kg	:	Kilogram
mm	:	Millimeter
Fig.	:	Figure
LSD	:	Least significant difference
RCBD	:	Randomized Complete Block Design
DC	:	Degree Celsius
* *	:	1% level of significance
*	:	5% level of significance
&	:	And
µm	:	Micrometer
me	:	Mole equivalent
BARC	:	Bangladesh Agricultural Research Council
>	:	Greater than
CEC	:	Cataion exchange capacity.
dbh	:	Diameter at breast height.

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CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

Bangladesh is situated in the north eastern part of south Asia. It is a small country with an area of 1, 47,570 sq. km. sheltering a population of 141.80 million spreads over the area, Bangladesh is claimed to have the densest population in the world. Here the current population growth rate is 1.8% (UNFPA, 2005). The demand for food, shelters, fuel, fodder etc. is rising up at a geometric rate as rapid population growth and increasing per capita consumption jointly influence it. With these factors operating uncontrolled, the net effect is worsening the deficit of basic needs over time. To meet the above basic needs, soils are intensively cultivated without considering soil health. Introduction of green manuring crops in different agroforestry systems, developed in the poor soils, is beneficial from the aspect of maintaining soil health, production as well as income and socio-economic status.

According to Walt (1989) "agroforestry has two dimensions. One is the way of thinking. It means looking for ways to maximize the production from the land using a mixture of wood fibre, wildlife recreation and farm crops, both plant and animal, to make the biggest buck possible consistent with keeping the land productive. The second dimension echoes the first. It is the actual management of land according to this ethic."

According to Lundgren and Raintree (1982) agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboo etc.) are deliberately grown on the same land management unit as agricultural crops and/or animals either in spatial mixture or in temporal sequences.

Introducing of green manuring crops into different agroforestry system is not always important, because forestry species itself play an important role in maintaining soil sustainability, equilibrium environment and socio-economic condition of the people, but a substantial depletion of forest resources has been occurred in the last few decades and now it is reduced to less than 0.02 ha per person, one of the lowest ratio of the world (BBS, 1996) under these alarming situations, forest resources must be increased cultivating in farmland.

On the other hand, Bangladesh agriculture has been suffering from acute shortage of biomass to regenerate her soil from degradation or depletion of organic matter due to intensive cropping. The scale of reduction (0.01%/ year) dry basis of the level of organic matter is alarming. It has been seen that huge amount (9 t ha^{-1} dry matter) of organic materials would be needed to maintain the current organic matter status (Hossain *et al.* 1997). These problems can be solved partially through the leaves litter of perennial species of agroforestry system. But the problem can be addressed significantly by growing green manuring crops at the beginning of agroforestry practice or to introduce green manuring crops in the cropping pattern. A huge amount of organic matter is added into crop land soil from green manuring crops cultivation than using farmyard manure and use of any other organic source (Ullah *et al.*, 2002). In every year 1.00-13.33 ton dry matter is gained into soil from 70-80 fresh matter (BARC, 1997).

Nitrogen is the food element chiefly supplied by green manuring, since nearly all the soil nitrogen is associated with organic matter and the supply of nitrogen can be increased by turning under legumes (Pieters, 2004).

Decomposing organic matter is the home of the millions of microorganisms, and it is through the activities of these minute living things that nitrogen is made available to crop plants (Pieters, 2004).

The practice of green manuring has been shown to increase the yields of corn, small grain, cotton, beets, potatoes, sugarcane and to be successful in tobacco culture in the tropics though good results have not always been secured in tobacco culture in the United State. There is a marked residual effect from green manure crops and the value of the residual effect must be included in considering the profits from green manuring (Pieters, 2004).

Although green manuring crops give various adventitious status to soil and may cause the maximum production of above crops, but farmers are not interested as it has no direct economic return.

Mungbean [(*Vigna radiata* (L) Wilczek] is one of the important pulse crops in Bangladesh for its high digestibility and good flavor flatulent effects. It ranks fifth in terms of area under production but first with respect to price (Rahman and Miah, 1988). It is an important source of different vitamins and minerals. Biological nitrogen fixation (BNF) technology in the form of *Rhizobium* inoculant is used mungbean, which can be an attractive alternative of expensive urea fertilizer. It can fix atmospheric nitrogen with the help of *Rhizobium* bacteria and increases the nitrogen nutrition in soil within profit/cost ratio of 27/1 (Sattar and Ahmed, 1992).

Many works have done about mungbean varieties in different aspects. BARI, BINA released several varieties of mungbean but performances of mungbean varieties in agroforestry systems are not tested. To know the varietals performance in respect of biomass contribution and grain yield in agroforestry is essential. From the above view and aspect, the present investigation is under taken with following objectives.

(i) To characterize the morphological behavior of different mungbean varieties under different MPTs as agroforestry practice.

(ii) To know the performance of total biomass and grain yield of different mungbean varieties.

(iii) To find out the best combination of trees and mungbean varieties

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2: REVIEW OF LITERATURE

2.1 Agroforestry and multilayered cropping systems

Islam (2005) conducted an experiment to investigate the performance of lemon and guava grown under multistoried coconut based agroforestry system and observed a significant influence of multistoried agroforestry system on yield, yield attributing and quality parameters of lemon and guava. The best yield contributing characters of lemon was found in coconut +lemon based agroforestry systems, which in case of guava the highest yield would obtain from open condition.

American ginseng (*Panax quinquefolium*), a medicinal herb exported to China from the United States and Canada is grown as an understorey in red maple (*Acerrubrum*) forests (Nadeau *et al.,* 1999) or deciduous hardwoods such as black walnut (*Juglans nigra*) and sugar maple (*Acer saccharum*), instead of growing under artificial shade with considerable expense (Hill and Buck, 2000). Indeed, cultivation of ginseng and several other medicinal plants in the forests is a common and growing form of forest farming practice of agroforestry in North America.

Solanki (1998) stated that Agroforestry can significantly contribute in increasing fuel wood, fodder, cash income and infrastructure in many developing countries. He also stated that agroforestry has high potential to simultaneously satisfy three important objectives: (i) protecting and stabilizing the ecosystems, (ii) producing a high level of output of economic goods (fuel, fodder, small timber, organic fertilizer, etc.) and (iii) providing stable employment, improved income and materials to rural populations.

Homestead Agroforestry plays a very important role in Bangladesh economy. Income from home gardens ranges from 26 to 47% of the total family expenses (Millat-e-Mostofa, 1997).

Groot and Sourmare (1995) observed that decomposition of tree roots and the substances of the root exudes greatly enhance soil organic matter and thereby soil fertility. Tree lateral roots may reduce loss of nutrients from the soil by recycling them that would have been otherwise leached from the system. Tap roots may take up nutrients which are released by weathering from deeper soil layer.

According to Miah *et al,.* (1995), agroforestry system that incorporates a range of tree and crop species offers much more scope for useful management of light interception and distribution than do monoculture forests and agricultural crops.

Bhatia and Singh (1994) stated that the agroforestry in India plays an important role in increasing biomass production, maintaining soil fertility and improving soil and averting risk.

Yantashath *et al.* (1992) stated that first growing multipurpose tree species in agroforestry play an important role through providing food, fuel wood, fodder, green manure soil and environment conservation, and other wood uses.

In Yunnan province, China, traditional 'Dai and Jinuo' agroforestry systems involve the medicinal crop *Amomum villosum* in the forest areas cleared of undergrowth (Pierre, 1991).

Trees have an important role in risk management mechanism in household economy (Akter *et al.,* 1990). They provide cash during ceremonies, economic hardships and many other occasions like marriages, school expenses of children, buying land and other assets (Abedin and Quddus, 1990).

Only 0.07 cubic feet of fuel wood and 0.03 cubic feet of timber are produced per head from natural forest, which is the lowest in the world (Hossain and Bari, 1996). On the contrary about 90% of bamboo, 70% of timber and 90% of fuel wood demands are meeting from the homestead plantation (Chowdhury and Hossain, 1990).

MacDicken and Vergara (1990) stated that agroforestry in a means of managing or using land (i.e. a land use system) that combines trees or shrubs with agricultural/horticultural crops and/or livestock.

In China, cultivation of medicinal plants has been an age-old practice under the name of 'silvo-medicinal' systems. In northeast China, ginseng (*Panax ginseng*) and other medicinal plants are grown in pine (*Pinus* spp) forests; in Central China, many medicinal plants are planted with *Paulownia tomentosa* and in southern China medicinal herbs are often planted in bamboo(*Bambusa* spp.) and Chinese fir (*Cunninghamia lanceolata*) forests (Zou and Sanford 1990).

According to Rang *et al.* (1990), homestead gardens are common in Bangladesh where the farmers take up combination of 10-15 species of fruits, ornamental and multipurpose trees along with vegetables to meet up their own or aesthetic value.

Akter *et al.* (1989) observed in traditional agroforestry systems of Bangladesh, farmers consider trees as saving and insurance against risk of crop failure or compensate low yields of crop.

According to Ong (1988), incorporating trees with arable crops, biomass production per unit area could be increased substantially when the roots of trees exploit water and nutrients below the shallow roots of crops and when a mixed canopy intercepts more solar energy.

Acacia nilotica, Phoenix sylvestris, Artocarpus heterophyllus and *Borasus flabellifer* are the major tree species grown haphazardly with litter or no management in the crop field for fruit, fuel, timber, juice and building materials (Abedin *et al.,* 1988).

Nair (1987) stated that an agroforestry system can play an important role in improving soil fertility by: (i) increasing organic matter content of soil through addition of leaf litter, pruning and other biomass, (ii) efficient nutrient recycling within the system, (iii) biological nitrogen fixation in case of leguminous shrubs and trees and (iv) possible complementary interactions among associated species due to differences in canopy structure, root system and active zone of water and nutrient absorption.

Nair (1985) and Young (1984) stated that the physical, chemical and biological conditions of the soil are greatly influenced by the addition of organic matter through pruning and hedge row.

According to Shankarnarya (1984), tree in agroforestry systems conserve soil moisture increase atmospheric humidity and improve soil fertility. The process is enhanced by tree canopy cover which moderates the microclimate and enhances organic matter accumulation, microbial activity and mineralization (Verinumbe, 1987).

According to Saxena (1984), agroforestry utilizes the inter space between trees rows for intercropping with agricultural crops and this does not impair the growth and development of the trees but enable farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Harou (1983) pointed out that agroforestry is a combined agriculture-tree crop farming system which enables a farmers or land user to make more effective use of his land which may yield a higher net economic return on a sustainable basis.

Vergara (1982) defined agroforestry as a system of combining agricultural and tree crops of various longevity (ranging from annual through, biennial and perennial plants), arranged either temporally (crop rotation) or spatially (intercropping) to maximize and sustain agricultural production.

2.2 Effect of light on plant components

Light demanding understorey species (e.g., *Echinacea* sp.) may be intercropped initially to provide early returns from plantations and after canopy closure, shadetolerant species such as ginseng and goldenseal can be intercropped (Teel and Buck, 2002).

In agroforestry, multistrata canopies offer scope for regulating the light distribution between the plant components and also of using the light more efficiently over all (Wallace, 1996).

Miah *et al.* (1995) reported that the mean light availability on crop rows decreased as they approached the tree rows across the alleys. The rate of decrease was greater in unpruned than in pruned alleys. Rice and mungbean yield decreased more in unpruned conditions (13 kg/ha) than in pruned condition (9 kg/ha).

Essentially the underlying processes involved in the partitioning of resources (e.g. light, water and nutrients) are not well understood. A better mechanistic understanding of resource capture and utilization in agroforestry system in terms of species combination, planting arrangement and management (Howard *et al.*, 1995).

Agroforestry system that incorporate a range of tree crop species offer much more scope for useful management of light interception and distribution than do monoculture forests and agricultural crops (Miah *et al.*, 1995).

The higher amount of light transmitted through *Gliricidia sepium* species may be due to its small and thin leaf lets as well as low branching habit (Miah, 1993).

Basri *et al.* (1990) found that incorporating prunnings increased upland rice yield by 25-30% on a fill area basis. Root + shoot prunings of trees was found better in increasing crop yield compared to other pruning managements due to reduction of above ground competition (light) by shoot pruning and below ground competition (water, nutrient) by root pruning.

The potential benefits as a result of combining fields crop with trees are so obvious from consideration of the waste of light resources experienced in orchard and tree crop orientation (Jackson, 1987).

Interaction among the trees and solar geometry produce the particular solar climate of tree/crop systems. These interaction and effects include interception of radiation by tree stands of various densities, effect of canopy structure, effect of latitude and time of year on solar paths, shade from single crowns and spectral quality of sun light under partial shade (Reifsnyder, 1987).

According to Salisbury and Ross (1986), in darkness or at very low light level the green plants become etiolated with maximum elongation of internodes. The stem becomes soft and weak with degeneration of xylem and differentiation of too much parenchyma. Different spectra have different effects on plants. Plants attain maximum height under red light. In blue and violet rays, the plants become healthy in structural and functional.

Nayak and Murty (1980) observed that yield reduction of rice by 47, 57 and 74 percent in 75, 50 and 25 percent of normal light, respectively. This was mostly due to impaired dry matter production, panicle number and grains per panicle.

Nayak *et al.* (1979) reported that translocation is enhanced under slightly reduced light (70% of normal light), but further reduction in light (below 70% of normal light) affect translocation due to limitation in energy supply.

Optimal level of light is essential for normal structures and necessary physiological function of all green plant (Leopold, 1964).

2.3 Effect of shade on plant components

Studies in New Zealand have indicated that the American ginseng can be successfully grown under *Pinus radiata* with best growth under a tree stand of 130 stems/ha (Follett, 1997). In addition to providing shade, the trees may also benefit the understory component from hydraulically lifted water. Sharif (1993) reported that shading in agroforestry influences nutrient uptake.

The shading was responsible for suppression of maize yields while in the shorter second season, where rains ended abruptly, moisture competition was the main factor causing the drastically low yield (Singh *et al.*, 1989).

Rao and Mittra (1988) observed that shading by taller species usually reduces the photosynthetically active radiation. Photosynthetically active radiation regulates photosynthesis, dry matter production and yield of crop.

The partial shading (45-50% of normal light) at 15 days after transplanting reduced grain yield of rice by 73% because of reduction in number of panicles per plant (51.50%), number of grain per panicle (16.70%) and increase in number of unfilled spikelets (41.10%) in 25 rice cultivars (Jadhav, 1987).

Alley cropping agroforestry systems has been emerged as a sound technology where tree leaves are periodically pruned to prevent shading the companion crops (Kang *et al.*, 1984).

It has been reported that shading reduced leaf number, leaf area and thickness of dry bean (Crookston *et al.*, 1975). They also reported 38% decrease in photosynthesis per unit area of shaded leaves.

Some of the research suggested that yields could be increased growing Cocoa in full sun (Murray, 1953).

2.4 Economic output from agroforestry systems

2.4.1 Selection of tree species in agroforestry systems

A farmers' cooperative in the northern lowlands of Costa Rica has successfully demonstrated cultivation of the medicinal herb 'raicilla' (*Cephaelis ipecacuanha*) in natural forests for export to the Netherlands and Germany (Hager and Otterstedt, 1996).

The forest is thinned to give 30% to 40% shade and seedlings or cuttings are planted, which produce an average dried fruit yield of 375 kg/ha/annum (Zhou, 1993).

Gupta (1986) listed a number of indigenous understorey herbs and shrubs that can be produced as part of forest farming or in new forest plantations to improve economic returns from forests in India.

According to Rachie (1983), the factors to be considered during the selection of woody legumes for intercropping with annuals in the low land tropics : i) ease to establishment from seeds or seedlings, ii) rapid growth and high productivity of foliage and wood, iii) limited maximum size, iv) good coppicing ability, v) effective nutrient recycling ability especially di-nitrogen fixation, vi) multiple uses-food, fodder, firewood, construction materials and other products and services, vii) minimal competition with shallowly rooted annual crops, viii) small leaflets readily detached when dried and quickly decomposed when used as fertilizer, ix) good tolerance for draught, low fertility and other, x) freedom from pests and diseases and xi) ease of control of eventual elimination.

2.4.2 Benefits of agroforestry systems

Hossain *et al.* (2005) carried out an experiment to evaluate the performance of Indian spinach (*Basella alba*) grown under Eucalyptus (*Eucalyptus camaldulensis*) in different orientations from May to August, 2003 in the Bangladesh Agricultural University Campus, Mymensingh. The treatments involve different orientations north, south, east and west for each of the tree. The experiment was conducted in RCBD design with three replications. The fresh yield produced in south, west, east and north orientation followed by west, east and north, 56.37%, less than the open field and that of for dry yields were 52.74, 56.41, 58.14 and 59.80 less respectively.

An experiment was carried out by Ahmed (2005) to investigate the performance of the medicinal plants and spices grown under different Agroforestry system. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In open condition medicinal plants and spices received 100% sunlight; while Guava and Coconut based Agroforestry system and, Lemon and Coconut based Agroforestry system allowed, 65-70% and 34-45% sunlight respectively. The result revealed that the highest plant growth and the best yield contributing characters of *Aloe vera* was found in Guava and Coconut based Agroforestry system. But the highest dry matter of leaves was found in open condition.

Solanki (1998) stated that fruit trees and crops are grown together in various ways. In an agroforestry system where agricultural crops are normally grown between rows of fruit trees, the agricultural crops provide seasonal revenue, whereas fruit trees managed for 30-35 years giving regular returns of fruit and in some cases fuel wood from pruned wood and fodder. Several kinds of crops are also under planted to take the advantage of shade provided by the canopy of fruit trees.

The severity of competition in Agroforestry system, ultimately crop yield is dependent upon the partitioning of resources, primarily of light and water between trees and crops (Howard *et al.*, 1995).

Akter *et al.* (1990) reported that in the recent years public interest in planting of trees in croplands has increased greatly in the Southwest region of Bangladesh. In addition to planting traditional species farmer of the area have started organized planting of a fast growing species *Dalbergia sisso* in croplands. One of the reasons behind of such practice was risk of total crop failure.

Akter *et al.* (1990) reported that wheat yield under different tree species (Mulberry, siris, Ipil-ipil) did not show any significant difference as compared to control yield.

According to Kang *et al.* (1984) a substantial improvement of crop yield in agroforestry systems was reported, where tree prunings were used as mulch or green manure.

2.5 Production of green manuring crops and its impact on soil health

Parvin *et al.* (2005) was studied on decomposition pattern of two contrasting green manures viz. water hyacinth (*Eichhornia crassipes*) and mimosa (*Mimosa invisa*) in an incubation experiment at the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, during the period from May to July, 2003. The highest decomposition rate was observed in mimosa at day 2 and water hyacinth at day 10. The decomposition of mimosa was approximately two times higher than water hyacinth. After 50 days of incubation, a total of 32 and 49% of the added C were respired from water hyacinth and mimosa, respectively. Both the rate and total decomposition of the green manures were also found to be related to their nutrient status (C:N:P:S ratios).

Tilak (2004) conducted a greenhouse experiment to determine the effects of green manuring with *Sesbania aculeata* and *S. rostrata*, and mung bean residue incorporation on soil microbial population, microbial biomass, mitrogenase activity in the roots, nitrogen content in the shoot grain, and yields of straw and grain of rice and wheat. The microbial counts, namely bacteria, actinomycetes, fungi, *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria, the microbial biomass in the soil and nitrogenase activity in the roots were markedly high in soil where green manuring with *S. rostrata*, *S aculeata* and mungbean was incorporated then in fallow soil. *Sesbania rostrata* increased the microbial biomass by 148.2 and 25.8% with rice and wheat, respectively, at 0-15 cm soil depth. A similar trend was observed with the nitrogenase actively, which was 19.8 and 13.8 times higher than the fallow soil with rice and wheat, respectively, due to *S. rostrata* green manuring. The increase in shoot dry biomass and grain yield due to *S. rostrata* green manuring over no amendmet was 3.1 and 2.5 times, respectively with rice, and 1.9 and 2.4 times respectively with wheat.

A pot experiment was conducted by Fawaz-Kurdali (2004) to determine the effects of manuring with there types of plant residues (roots, shoots and roots plus shoots) of dhaincha (*Sesbania aculeata*) on growth of sorghum (Sorghum bicolor) grown on saline and non-saline soils. The objectives of this experiment were 91) to determine the effects of adding different plant residues of dhaincha on dry matter yield and nitrogen (N) uptake of sorghum; (2) to estimate the percentages and amounts of N derived from various N sources; (3) to estimate N recoveries from *Sesbania* residues; (4) to make comparison between the direct and indirect 15N tracer techniques for estimating sorghum Na uptake from *Sesbania* residues; and (5) to test feasibility of using the non-isotopic technique (N diffidence) for estimating N derived from plant residues. For measuring N uptake from various sources, two isotopic dilution techniques were utilized by adding to these soils either 15N-labelled inorganic N fertilizer (indirect method)of 15N labelled *Sesbania* leaves (direct method). For the indirect method, both soils manured with each types of *Sesbania* residue, received four split applications of 15N-labelled amlonium sulfate. Results indicated that each type of *Sesbania* residue, applied as green manure, resulted in significant increases in both dry matter yield and N uptake of sorghum compared with the unmannered control. In addition, *Sesbania* residues decreased the harmful effect of salinity on plant growth.

Sharda and Ratan-Singh (2003) reviewed that soil erosion is a major cause of land degradation in Tndia. Out of the 329 M ha geographical area of the country, 187.9 M ha is affected by various types of land degradation problems. Water erosion alone constitutes an area of 148.9 M ha resulting in an annual loss of 5333 M t of fertile soil, which is equivalent to 16.4 t ha/year. The magnitude of soil loss is much higher in Shiwalik Hills (>80 t/ha); ravine and shifting cultivation areas (>40 t/ha); and black soils and Western Ghat region (20-30 t/ha). Soil erosion depletes soil depth, fertility, organic matter, groundwater table and consequently crop productivity. The off-site effects include reduction in carrying capacity of reservoirs, meandering of rivers and drainage channels due to sedimentation, occurrence of floods, biodiversity loss and impairment of water quality. Agronomical measures such as contour farming, strip and mixed cropping, intercropping, cover management, mulching, green manure, use of crop residues, crop geometry, tillage, etc., are adequate up to 4% slope to minimize erosion losses and achieves higher productivity. However, these measures need to be supplemented with mechanical measures like levelling and bunding, bench terracing, trenching, etc. on higher slopes. Vegetative measures such as grass barriers and agroforestry are cost effective and could minimize erosion loses and enhance productivity. The input-use-efficiency of basic resources of soil, water and nutrients can be significantly improved by adopting appropriate erosion control measures for sustained productivity and farmers' profitability.

Fawaz *et al.* (2003) carried out two field experiments on Dhaincha (*Sesbaina aculeata*) and sorghum (*Sorghum bicolor*) grown in monocropping and intercropping systems was conducted under non-saline and saline conditions in Syria to evalaute dry matter production, total nitrogen (N) yield, land equivalent ratio (LER), soil N uptake and N_2-fixation using 15N isotope dilution method. The first experiment was conducted under non-saline conditions, three different combinations of *Sesbania* (ses) and sorghum (sor) were investigated in the intercropping system (2 ses : 1 sor; 1 ses : 1 sor and 1 ses : 2 sor, row ratio). Whereas, in the second experiment, only one combination (1 ses : 1 sor, row ratio) and tested under saline conditions. Results of the first experiment showed that dry matter yield of sole sorghum was higher than the sole of *Sesbania*, and was similar to that produced by the intercropping treatments. In both experiments, percentages of N_2 fixed by the *Sesbania* in the intercropping system were considerably enhanced relative to sole cropping of *Sesbania*.

Sahoo *et al.* (2002) observed that a field experiment, was conducted in an 18-year-old coconut garden at konark, Orissa, India, during kharif of 1994 and 1995 to assess the cowpea, green gram, horsegram [Macrotyloma uniflorum] and dhaincha [Sesbania], in coconut basins with littoral sandy soil. Results revealed that the plant height of different green manuring crops differed significantly in both years. Maximum plant height (63.45 cm) was observed in dhaincha followed by cowpea at 45 days after sowing. Leaf number per plant at the time of incorporation was highest (22.05) in horesgram and lowest (12.05) in dhaincha. Root nodulation also varied significantly in both years with dhaincha as the highest (139.43). Biomass production was highest in cowpea (7.23 kg) followed by green gram (6.0 kg) and horsegram (5.72 kg). Highest dry matter content in both years was found in dhaincha followed by greengram and horsegram. The results indicated that cowpea, greengram, and horsegram can be successfully grown in situ as greem manure crops in coconut basin with littoral sandy soils.

Casavajda (2002) a field experiment was conducted during 1998-99 in Mosonmagyarovar, Hungary, to determine the total biomass production (tonnes/ha), dry matter content (%) and dry matter yield (tonnes/ha) of some spring sown green manure crops such as Phacelia, oilradish, fenugreek and the mixtue of these species (Phacelia/oilradish and Phacelia/fenugreek). The highest biomass production values of 34.60-41.30 tonnes/ha were obtained under Phacelia/oilradish mixture. Statistical analysis proved significant crop year effects in all cases except in the Phacelia/oilradish mixture. The dry matter content of purely sown Phacelia showed the highest values during the entire experiment period. The total dry yield matter at harvest was found highest in the phacelia/oilradish mixture.

Aher *et al.* (2000) studied heterosis in 21 different hybrids of mungbean resulting from 7 × 7 diallel, excluding reciprocals and indicated pronounced hybrid vigour for yield and most of the yield components. Heterosis to the extent of 63.45 and 61.69% over the mid-parent and better parent, respectively was recorded for grain yield per plant. Heterosis for yield was generally accompanied by heterosis for yield components. Seven hybrids were identified as promising for many desirable traits and they may be of much use in exploiting hybrid vigour in mungbean.

resulted in a decrease in plant height, root-shoot ratio, dry weight and nodule number per plant. Protein content of leaves, stem and roots decreased under the influence pb in soil, with most pronounced reduction in roots. A gradual decline in the nitrate reductase activity was observed in treated plants. Seed germination remained unaffected at low concentrations, but was completely inhibited at higher concentration of lead.

Singh and Singh (1999) simulated differential salt profiles in potted soil to study their effects on root growth and grain yield of wheat cv K8804. The root length, root volume and root surface area greatly decreased under saline (ECe 15.2 ds/m) as well as sodic (ESP55, pH 9.6) soil conditions. In a vertically variable profile with top soil normal and lower one saline, the root penetration was poor as compared to the one having top soil normal with lower one sodic. However, root growth differences were not so prominent when normal/saline or normal/sodic soil variations were in lateral plane. The biomass was positively correlated with root dry weight which in turn, was dependent upon soil chemical environment. The yield loss under entirely saline or sodic soil was nearly 70% of the normal. It is concluded that the salinity of simulated sub-soil was more detrimental to plant growth that the sodicity of similar zone.

Madanpal *et al.* (1999) conducted a field experiment with mungbean (*Vigan radiata* L. Wilczek, cv. PS-16) grown under ambient and supplementary UV-B radiation (-UV-B, 11.02 kJm^{-2} UV-B_{BE}) at 15% ozone depletion, and determined the differences in plant height, leaf area, total biomass accumulation, photosynthetic activity, stomatal conductance, photosynthetic pigments, anthocyanin, flavonoids, carbohydrates, soluble proteins and phenylalanine ammonia-lyase (PAL) activity.

Haris *et al.* (1999) carried out in a 2 – year field experiment in New Delhi, India, green manure crops of sunnhemp [*Crotalaria juncea*], dhaincha [*Sesbania aculeata*] and cowpeas [*Vigna unguiculata*] were grown in kaharif and given 0 or 60 kg P/ha, and were followed by rabi crops of w3heat, cv. Kundan, gram [*Cicer arietinum*] cv. BG-209 or mustard [*Brassica juncea*] cv.Bio-727 given 0 or 30 kg P/ha. Soil available N was greatest following sunnhemp, followed by dhaincha, and after gram, followed by mustard. P decreased available N.

Das *et al.* (1999) studied the effect of elevated CO_2 ($600\pm50\mu l l^{-1}$) on growth, rate of photosynthesis, respiration and yield parameters of mungbean after 25 and 50 days of CO_2 exposure (25 and 50 DAT). Increasing atmospheric CO_2 directly stimulated photosynthesis and plant growth. High CO_2 treatment caused increase in leaf number leaf area and dry weight of mungbean plants at both stages similarly plant height and shoot dry weight also showed significant increase due to elevated CO_2. The enhancement in all the morphological parameters was more at 25 DAT as compared to later stage. It shows that early vegetative stages of mungbean is more responsive to high CO_2. The rate of photosynthesis was higher at both the stages but rate of respiration reduced due to elevated CO_2. Mungbean plants grown under elevated also produced significantly higher yield than ambient plants.

Turkhede *et al.* (1998) found in a trial at Akola, Maharashtra in the 1991-92 to 1995-96 kharif [monsoon] seasons, the effects of NPK fertilizer and application of 5 t glyricidia [gliricidia sp.] green manure/ha on rice cv. SKL-7 yield and soil fertility were determined. Averaged rice yield was 2.84 and 3.04 t/ha without and with green manure, respectively, while recommended NPK (100:50:50 kg N:P:K/ha) gave a yield of 3.52t. Green manuring decreased soil bulk density, and increased water holding capacity, pH, organic carbon content, and available N, P and K.

Rao and Ito (1998) carried out a comparative study of the root system morphology and of some physiological parameters at initial growth stages of 3 legumes : pigeon pea, chickpea and groundnut and 3 cereals : sorghum, pearl millet and maize. Considerable differences were observed for all the root morphological traits among the species. The root respiration rate was significantly correlated with the N uptake activity. The legumes showed a higher efficiency of N uptake in terms of respiratory requirement. The transpiration rate showed a significant correlation with total N concentration shoot, indicating the transpiration may be partly related to nitrogen flow and accumulation in shoot in case of nitrate nitrogen as a sole nitrogen source. Morphological and physiological characters of the root system using rather simple indices were found to be better criteria for describing functional differences among crop species.

Fakir *et al.* (1998) gave an information on dry matter (DM) partitioning into root system in pigeonpea. This study was conducted to compare DM production and partitioning in four contrasting pigeon pea genotypes.

Fakir (1997) observed that two contrasting rooting patterns in pigeonpea were stable over several seasons and generations which suggested that the rooting patterns might be heritable.

Saneoka *et al.* (1995) stated that for elucidation of the effects of salt stress on whole plant growth and crop productivity the knowledge of root characteristics with respect to soil physical and chemical environment is essential. Additionally, specific informations on the variation in root distribution both in space and time have been sought as an input information in computer simulation models for the reclamation of salt-affected soil (Wagenet *et al.* 1980).

Rahman *et al.* (1995) conducted a field experiment with a newly released variety of mungbean (Kanti) grown under varying population densities at different dates of sowing was evaluated for yield performance in relation to various growth parameters. There is scope to increase the grain yield of mungbean for September sown crop with higher population density. Although the crop growth rate (CGR) and total dry matter per plant was higher with lowest population density, but the leaf area index (LAI) was higher with the highest population density in case of August sown crop. Total dry matter per unit area and leaf area indices showed a strong positive significant correlation with grain yield. while crop growth rate showed inverse relationship irrespective of spacing and dates of sowing. Relative growth rate (RGR) and net assimilation rates were maximum at 20 and 40 days after emergence of the crop in all the treatments.

Sharma and Das (1994) observed that intermediate deepwater conditions (0-50cm) at Cuttack, Orissa during 1990-91, rice cv. Gayatri and dhaincha (*S. aculeata*) were either mixed-sown in different arrangements (parallel lines and mixed broadcasting) in dry soil by the end of May or rice seedlings were transplanted in plots grown with pure dhaincha after the accumulation of water in the field by mid-July. Incorporation of dhaincha in situ after 48 and 54 d of growth added 60.8-65.2 and 72.9-76.9 kg N/ha in the mixed stands compared with 81.3 and 85.1 kg N/ha in the pure stand in 1990 and 1991, respectively. Although the growth of rice when sown simultaneously with dhaincha was affected initially due to the more after the incorporation of green manure following an increase in inter-row spacings.

Xiong and Chen (1993) concluded that in a pot trial 15N tracing was used to investigate the dynamics of N in a grain-grain-green manure rotation, a forming system widely practiced in recent years in Ningxia. Spring wheat was intercropped with maize, and Vicia sativa grown as a green manure crop after wheat was harvested. The amount of N taken up by theplants when spring wheat and maize grew together in the same pot accounted for 15.88% (0.716 g/pot) of the applied fertilizer N whereas N uptake by *V. Sativa* was only 0.009 g/pot. The beneficial effects of green manure cropping after wheat and the problems involving 15N labelling by biological methods are discussed.

Sharma *et al.* (1995) stated that sesbania green manuring and mungbean residue increased grain yield of rice by 0.4 and 0.3 t/ha, respectively and of spring wheat by 0.6 and 0.6 t/ha, basally to wheat. Sesbania green manure and mungbean residue substituted for 43 and 30 kg N/ha in rice and subsequently gave a beneficial effect in spring wheat equal to the residual effect of 89 and 112 kg N/ha applied to rice, respectively. Mungbean residue remaining after the picking of pods, contributed similar amount of N as *Sesbenia* green manuring to rice-wheat cropping system but, additionally gave seed yield of 0.5 – 1.3 t/ha.

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18.1.07

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3: MATERIALS AND METHODS

This chapter deals with the materials used and methodology in conducting the experiment. The location of the experiment, materials used, and methods followed in different operations during the experiment as well as in data collection are described in the following subheads:

3.1 Location of the study

The experiments were conducted in the Agroforestry Farm Hajee Mohammed Danish Science and Technology University, Dinajpur. This site was located between $25^0 13'$latitude and $88^0 23'$ longitude and about 37.5m above the sea level.

3.2 Soil characteristics

The experimental site is situated in a medium high land belonging to the Old Himalayan Piedmont Plain area AEZ 01. The rain water did not stay there. Irrigation facilities and drain out system of excess water was well developed. The soil texture was sandy loam with sand 65%, silt 30%, clay 5%. pH of the soil 5.1 and CEC 8.07 me/100g soil. The structure of the soil was fine and the organic matter content was 1.06%. The soil posses the following amount of other element i.e. Na 0.06 me /100 g, Ca 1.30 me /100 g, Mg o.40 me /100 g, K 0.26me/100 g, total N 0.103%, P 24.0µg/g soil, S 3.2 µg/g soil, Bo 0.27µg/g soil, Cu 1.00µg/g soil, Fe 5.30µg/g soil, Mn 0.70µg/g soil, Zn 0.90µg/g soil. CEC of the soil 8.07 me/100 g.

3.3 Climate and weather

The experimental site is situated under tropical climate characterized by heavy rainfall during the months from April to July and then scanty rainfall during the rest period of the year. Information regarding monthly maximum and minimum temperature, rainfall and relative humidity recorded during the period of experiment collected from 29.04.2005 to 14.07.2005 are included in Appendix I.

3.4 Test green manuring crops

Mungbean (*Vigna radiata*) varieties are

BARI Mug-3

BARI Mug-4

BARI Mug-5

BARI Mug-6

Local variety

3.5 Trees in agroforestry system

Mango (*Mangifera indica*)

Ghoraneem (*Melia azadirach*)

Ipil-Ipil (*Leucaena leucocephala*)

3.6 Treatments of the study

Treatments of the study are given below:

Factor A: Green manuring crops (mungbean)

V_1 = BARI Mug-3

V_2 = BARI Mug-4

V_3 = BARI Mug-5

V_4 = BARI Mug-6

V_5 = Local variety

Factor B: Agroforestry species

T_1 = Open field (control).

T_2 = Mango

T_3 = Ghoraneem

T_4 = Ipil-ipil

Combination of the treatments

i) V_1T_1 = BARI Mug-3 + Open field

ii) V_1T_2 = BARI Mug-3+ Mango

iii) V_1T_3 = BARI Mug-3 + Ghoraneem

iv) V_1T_4 = BARI Mug-3 + Ipil-ipil

v) V_2T1 = BARI Mug-4 +Open field

vi) V_2T_2 = BARI Mug-4 + Mango

vii) V_2T_3 = BARI Mug-4 + Ghoraneem

viii) V_2T_4 = BARI Mug-4 + Ipil-ipil

ix) V_3T_1 = BARI Mug-5 +Open field

x) V_3T_2 = BARI Mug-5 + Mango

xi) V_3T_3 = BARI Mug-5 + Ghoraneem

xii) V_3T_4 = BARI Mug-5 + Ipil-ipil

xiii) V_4T_1 = BARI Mug-6 + Open field

xiv) V_4T_2 = BARI Mug-6 + Mango

xv) V_4T_3 = BARI Mug-6 + Ghoraneem

xvi) V_4T_4 = BARI Mug-6 + Ipil-ipil

xvii) V_5T_1 = Local variety +Open field

xviii) V_5T_2 = Local variety + Mango

xix) V_5T_3 = Local variety + Ghoraneem

xx) V_5T_4 = Local variety + Ipil-ipil

3.7 Design of the experiment

The experiment was laid out in Factorial Randomized Complete Block Design (RCBD) with four replications for each treatment. The plot size for each treatment was 2.5m × 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 m and 3.0 m respectively.

3.8 Layout of the experiment

Replication-1

$T_1 V_2$	$T_1 V_3$	$T_1 V_1$	$T_1 V_5$	$T_1 V_4$
$T_2 V_1$	$T_2 V_4$	$T_2 V_5$	$T_2 V_3$	$T_2 V_2$
$T_3 V_!$	$T_3 V_5$	$T_3 V_4$	$T_3 V_2$	$T_3 V_3$
$T_4 V_3$	$T_4 V_2$	$T_4 V_1$	$T_4 V_4$	$T_4 V_5$

Replication-2

$T_1 V_1$	$T_1 V_5$	$T_1 V_3$	$T_1 V_4$	$T_1 V_2$
$T_2 V_4$	$T_2 V_1$	$T_2 V_5$	$T_2 V_2$	$T_2 V_3$
$T_3 V_1$	$T_3 V_2$	$T_3 V_4$	$T_3 V_3$	$T_3 V_5$
$T_4 V_2$	$T_4 V_4$	$T_4 V_5$	$T_4 V_1$	$T_4 V_3$

Replication-3

$T_1 V_1$	$T_1 V_5$	$T_1 V_3$	$T_1 V_4$	$T_1 V_2$
$T_2 V_2$	$T_2 V_1$	$T_2 V_4$	$T_2 V_3$	$T_2 V_5$
$T_3 V_2$	$T_3 V_5$	$T_3 V_1$	$T_3 V_4$	$T_3 V_3$
$T_4 V_5$	$T_4 V_4$	$T_4 V_3$	$T_4 V_2$	$T_4 V_1$

Replication-4

$T_1 V_5$	$T_1 V_4$	$T_1 V_2$	$T_1 V_1$	$T_1 V_3$
$T_2 V_2$	$T_2 V_3$	$T_2 V_5$	$T_2 V_4$	$T_2 V_1$
$T_3 V_3$	$T_3 V_4$	$T_3 V_2$	$T_3 V_1$	$T_3 V_5$
$T_4 V_5$	$T_4 V_2$	$T_4 V_4$	$T_4 V_3$	$T_4 V_1$

3.9 Duration of the experiment

The duration of the experiments was 29 April 2005 to 14 July 2005.

3.10 Land preparation

The land was opened in the early of April, 2005 and then prepared throughly by spading to obtain a good tilth. The weeds and stubbles were removed from the field and bigger clods were broken into smaller pieces. We make 2.5 m×2.5 m size plot between the tree rows. The edge of the plot was 25 cm apart from the base of the trees as 3mX3m spacing were maintained for tree plantation. The age of the trees was only one year although the growth was notable.

3.11 Description of agroforestry species

There are three tree species selected for the experiment. Brief description of the present status of the species and the reasons of their selection is given bellow:

Mango: Mango is one of the major fruit of Bangladesh. Ripen mango consists of a lot of vitamin A. We can get fruit within only one year after plantation of one year aged grafted mango sapling. The height, base diameter, dbh and canopy diameter of mango were 2.23 m, 5.69 cm, 3.71 cm and 115.60 cm respectively at the sowing time of mungbean.

Ghora neem: Ghoraneem is short durated tree species. It can be harvested with 6-8 years. It is fast growing and complete deciduous tree species. The height, base diameter, dbh and canopy diameter of ghoraneem of the experiment were 3.28 m, 4.07 cm, 3.02 cm and 140.50 cm respectively at the sowing time of Mungbean varieties.

Ipil-ipil: It is fast growing deciduous tree species. Its leaves and pods are widely used as palatable fodder as it is grown for protein bank. It is a member of leguminosae family and can fixes nitrogen. Its deep root system helps in nutrient recycling, leaflets of the tree are small and easily decomposable. The height, base diameter, dbh and canopy diameter of ipil-ipil were 4.49 m, 4.00 cm, 3.37 cm and 150.75 cm respectively.

3.12 Establishment of the Mungbean varieties

The seeds of different Mungbean varieties were sown on 29 April 2005. Placement of Mungbean varieties in each replication of the treatment were randomly selected 30 cm line to line distance was maintained and seeds were sown continuously in the furrow of line by hand. Each plot contained 9 lines and plant population 225. Mature pods were plucked by hand time to time and final plucking was done at 75 DAS. After final plucking total biomass was incorporated in the soil (except pod).

3.13 Management practices

3.13.1 Fertilizer application

Recommended doses of fertilizers for Mungbean were used for all varieties of mungbean, 10 ton cow dung, 20 kg N, 60 kg P and 40 kg K per hectare were applied. (BARC, 1997). All cowdung and fertilizers were applied during the final land preparation.

3.13.2 Intercultural operation

Weeding was done periodically whenever necessary. Thinning was done twice once just after emergence and another at 20 DAS. Finally 5 cm plant to plant distance was maintained. The additional rain water was drained out through side canal from the plot.

3.13.3 Pest and disease control

No pesticides were used to control the insect pest and diseases as there were no out break of pest and diseases.

3.14 Harvesting

At 75 days after sowing we plucked all the pods finally by hand. At the time of maturity the pods were turned black in colour. Some pods were opened to see the hardiness of seed. The seeds were quite hard. After final harvesting the rest of the biomass (roots and shoots) were incorporated in the soil.

3.15 Data collection

The data were collected at two times, First one was at 50 Days After Sowing (DAS) and last one was at 75 DAS (at the time of final harvest of Mungbean).At 50 DAS, The following parameters were recorded weight/plant (above ground), root weight/plant, nodule weight/plant, total weight/plant i.e. biomass/plant, total biomass/ha, At 75 DAS, weight/plant (above ground), root weight/plant, nodule weight/plant, total weight/plant i.e. biomass/plant, total biomass/ha, incorporate biomass/ha, pod length, number of pod/plant, number of seed/pod, number of seed/plant, 1000-seed weight, yield/plant and yield/ha were recorded from Mungbean varieties.

3.16 Data collection procedure

For data collection 10 representative sample plants were selected and dugout carefully with parts of their root systems which was washed with a jet of water to remove adhering soil particles keeping the root portion of each individual plant in a sieve. The plants were divided into root, shoot and root nodule and the said data were collected at 50 DAS. The similar procedure was followed at 75 DAS except yield contributing characters. For yield parameter, mature pods were collected time to time from the plants which were selected previously.

The mean value of each parameter was calculated manually. Multiplying the mean value by plant population of plot and hectare. The value of each parameter was obtained as per plot and per hectare.

3.17 Data analyses

The data on various growth and yield contributing characters of mungbean varieties were statistically analyzed to determine the significant variation of the results due to different agroforestry system. The analysis of variance for each of the studied character was done by F (variance ratio) test following Randomized Complete Block Design (RCBD). These data were analyzed statistically following ANOVA technique and means separations were adjusted by DMRT test at 1% and 5% level of significance.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4: RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results from the experiment carried out to study the performance of mungbean varieties as green manuring crop in agroforestry system. The data have been presented in table(s), Figure(s) and a summary of the analysis of variance in respect of all the parameter. The result of each parameter has been discussed and possible interpretation where ever necessary has been given under the following headings.

4.1 Biomass contribution of Mungbean varieties

4.1.1 Plant weight (above ground)

Significantly the highest weight/plant at 50 and 75 DAS were recorded 16.56 g and 30.12 g respectively in V_4 which followed by V_3, V_2 (at 50 DAS 13.56 g and 12.99 g produced by V_3, V_2 and 22.46 g, 22.00 g were produce by V_3, V_2 at 75 DAS respectively) although the value of weight/plant in V_3 and V_2 was statistically identical (Table 1). Significantly the lowest weight/plant was found in both 50 and 75 DAS in V_5.

4.1.2 Root weight

At 50 DAS, significantly the highest root weight/plant (6.44 g) was recorded in V_2 that was followed by V_4 (5.67 g) and the lowest value was found in V_5 (3.54 g). 0n the other hand, V_4 produced significantly the highest root weight/plant (6.85 g) at 75 DAS that was followed by V_2 (6.29 g). Significantly poor performance was found in V_5 (4.81 g) at 75 DAS (Table 1).

4.1.3 Nodule weight

Significantly the highest nodule weight/plant was produced by V_4 (0.38 g) and the lowest value was found in V_5 (0.22 g) at 50 DAS.The trend of variation in nodule weight/plant at 50 DAS was similar to root weight/plant at 75 DAS. At 75 DAS, maximum nodule weight/plant was found in V_4 (0.27 g) that was followed by V_3 (0.18 g) and V_1 (0.18 g).The lowest value was found in V_2 (0.13 g) (Table 1).

4.1.4 Total weight i.e. biomass per plant

Significantly the highest biomass/plant at 50 DAS and 75 DAS were recorded 22.62 g and 45.26 g respectively in V_4 which followed by V_3, V_2 (Table 1) although the value of biomass/plant in V_3 (18.67 g at 50 DAS, 39.37 g at 75 DAS) and V_2 (18.37 g at 50 DAS and 40.14 g at 75 DAS) was statistically identical. Significantly the lowest biomass/plant was found in both 50 DAS and 75 DAS in V_5.

4.1.5 Total biomass per hectare

Significantly the highest total biomass/ha at 50 DAS and 75 DAS were found 814.4 kg and 1629.65 kg respectively in V_4 which followed by V_3, V_2 (Table 1) although the value of total biomass/ha in V_3 (672.2 kg at 50 DAS and 1413.09 kg at 75 DAS) and V_2 (673.7 kg at 50 DAS and 1445.23 kg at 75 DAS) was statistically identical. The significantly the lowest total biomass/ha was found in both 50 DAS and 75 DAS in V_5.

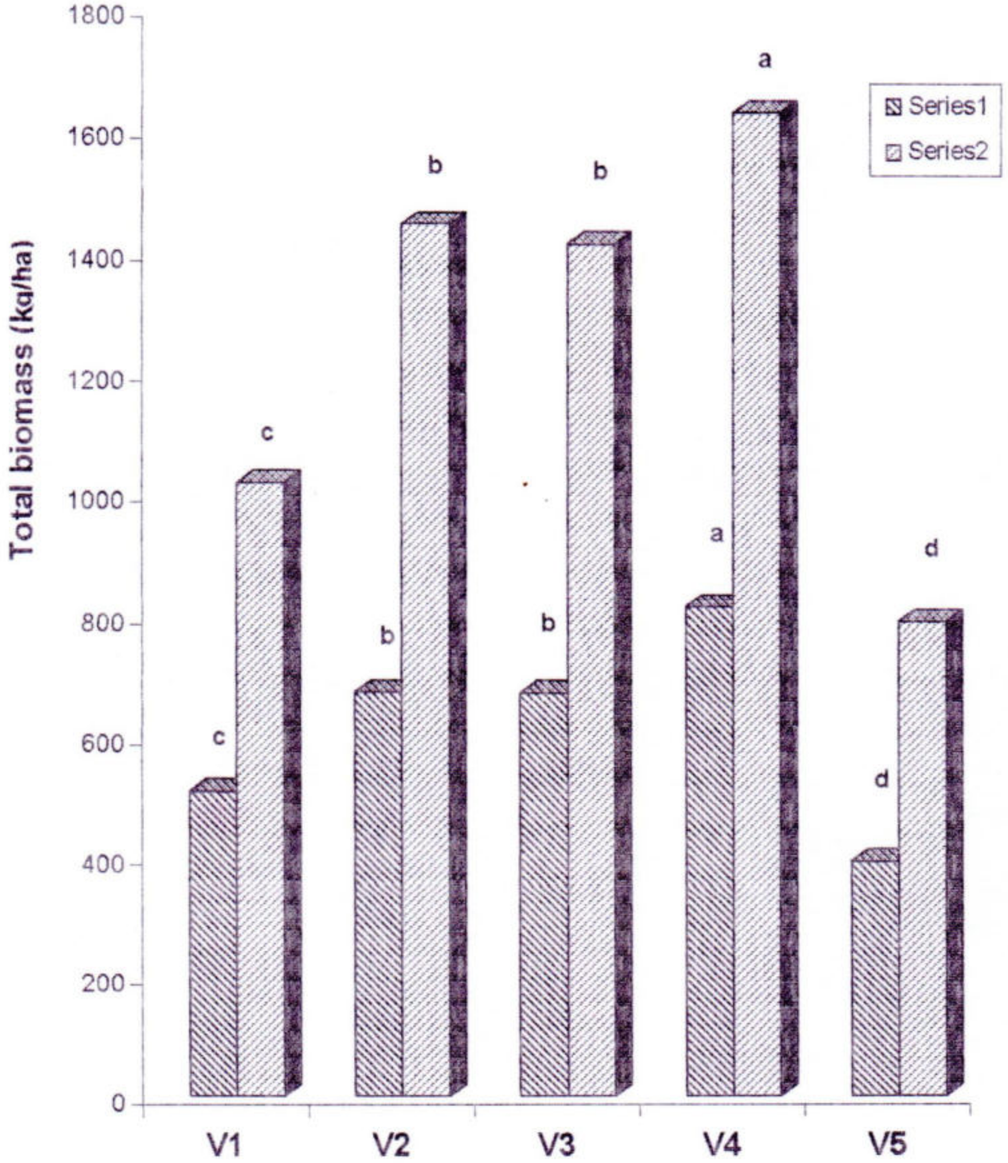

Fig.1 Total biomass production (kg/ha) of mumgbean varieties at 50 DAS and 75 DAS

Table 1-Biomass contribution of mungbean varieties as green manuring crop in agroforestry system.

Variety	(Above ground) Weight/plant (g)		Root weight/plant (g)		Nodule weight/plant (g)		Total wt/plant i.e.biomass/plant (g)		Incorporated biomass/ha (kg)
	50DAS	75DAS	50DAS	75DAS	50DAS	75DAS	50DAS	75DAS	75DAS
V_1	10.47 c	16.21 c	3.58 d	4.88 c	0.24 c	0.18 b	14.10c	28.28c	747.18c
V_2	12.99 b	22.00 b	6.44 a	6.29 b	0.28 b	0.13 c	18.67b	40.14b	1022.58b
V_3	13.56 b	22.46 b	4.80 c	6.18 b	0.29 b	0.18 b	18.67b	39.37b	1038.06b
V_4	16.56 a	30.12 a	5.67 b	6.85 a	0.38 a	0.27 a	22.62a	45.26a	1341.02a
V_5	7.07 d	9.72 d	3.54 d	4.81 c	0.22 c	0.15 c	10.91d	21.96d	529.74d
Level of significance	**	**	**	**	**	**	**	**	**
LSD 0.05%	0.5987	0.5303	0.3118	0.1977	0.03166	.00708	0.8226	1.014	26.59

4.1.6 Biomass added to the soil

Significantly the highest incorporated biomass/ha at 75 DAS was recorded 1341.02 kg in V_4 that was followed by V_3 (1038.06 kg), V_2 (1022.58 kg). Although the value of incorporated biomass/ha in V_3, V_2 was statistically identical. Significantly the lowest incorporated biomass/ha were found in V_5 (Table 1).

The study revealed that V_4 performed the best in all growth parameter except root weight/plant at 50 DAS.

4.2 Effect of trees on biomass contribution of mungbean varieties.

4.2.1 Plant weight (above ground)

At 50 DAS, effect of trees on weight/plant of mungbean was insignificant (Table 2). Although numerically the highest weight/plant was obtained in T_1 (open field) that was followed by T_3 (ghoraneem). The lowest value was found in T_4 (Ipil-ipil). At 75 DAS, significantly the lowest weight/plant (18.03g) was found under ghoraneem (T_3) and the highest value of weight/plant obtained from open field (T_1).The second highest weight/plant (19.89g) was recorded under mango (T_2). At 75 DAS significant effect was found due to various shade created by different canopy of MPTs.

4.2.2 **Root weight**

The effect of trees on root weight/plant was found similar to that of weight/plant. At 50 DAS, effect of trees on root weight/plant of mungbean was insignificant (Table 2). Although numerically the highest root weight/plant was obtained in T_1 (open field) that was followed by T_3 (ghoraneem). The lowest value was found in T_4 (Ipil-ipil).At 75 DAS, significantly the lowest root weight/plant (4.88g) was found under ghoraneem (T_3) and the highest value of root weight/plant obtained from open field (T_1).The second highest root weight/plant (6.12g) was recorded under mango (T_2).At 75 DAS, significant effect was found due to various shade created by different canopy of MPTs.

4.2.3 Nodule weight

At 50 DAS, effect of trees on nodule weight/plant of mungbean was insignificant (Table 2). Although numerically the highest nodule weight/plant was obtained in T_1 (open field) that was followed by T_3 (ghoraneem). The lowest value was found in T_4 (Ipil-ipil). At 75 DAS, significantly the lowest nodule weight/plant (0.15g) was found under ghoraneem (T_3) and highest value of nodule weight/plant obtained from open field (T_1).The second highest nodule weight/plant (0.19g) was recorded under mango (T_2). At 75 DAS significant effect was found due to various shade created by different canopy of MPTs.

4.2.4 Total biomass per plant

At 50 DAS, effect of trees on total biomass/plant of mungbean was insignificant (Table 2). Although numerically the highest total biomass/plant was obtained in T_1 (open field) that was followed by T_3 (ghoraneem).The lowest value was found in T_4 (Ipil-ipil). At 75 DAS, significantly the lowest total biomass/plant (30.88g) was found under ghoraneem (T_3) and the highest value of total biomass/plant obtained from open field (T_1).The second highest total biomass/plant (35.40g) was recorded under mango (T_2). At 75 DAS, significant effect was found due to various shade created by different canopy of MPTs.

4.2.5 Total biomass per hectare

Significantly the highest total biomass/ha at 50 DAS and 75 DAS were recorded as 689.86 kg and 1441.23 kg respectively in T_1 which was followed by T_2 (at 50 DAS 618.42 kg and at 75 DAS 1274.56 kg). Significantly the lowest value was measured as 569.57 kg at 50 DAS and 1111.68 kg at 75 DAS in T_4 and T_3 respectively (Table 2).

Table-2 Effect of trees on biomass contribution of mungbean varieties as green manuring crop in agroforestry system.

Tree species	Weight/plant (g)		Root weight/plant (g)		Nodule weight/plant (g)		Total wt/plant i.e.biomass/plant (g)		Incorporated biomass/ha (kg)
	50DAS	75DAS	50DAS	75DAS	50DAS	75dAS	50DAS	75DAS	75 DAS
T_1	13.12	22.57a	5.7	6.93a	0.32	0.22a	19.16	40.13a	1070.35a
T_2	11.86	19.89b	5.03	6.12b	0.27	0.19b	17.17	35.40b	943.65b
T_3	11.89	18.03d	5.71	4.88d	0.25	0.15d	15.86	30.88d	830.80d
T_4	11.2	19.09c	4.29	5.67c	0.29	0.17c	15.82	33.60c	898.06c
Level of significance	NS	**	NS	**	NS	**	NS	**	**
LSD 0.05%	-	0.4743	-	0.1769	-	0.006332	-	0.9069	23.78

4.2.6 Biomass added to the soil

Significantly the highest incorporated biomass/ha at 75 DAS was measured by T_2 943.65 kg. Significantly the lowest incorporated biomass/ha was (830.80 kg) measured at 75 DAS in T_3 (Table 2).

The study revealed that T_1 performed the best (1070.35 kg) in all growth parameter

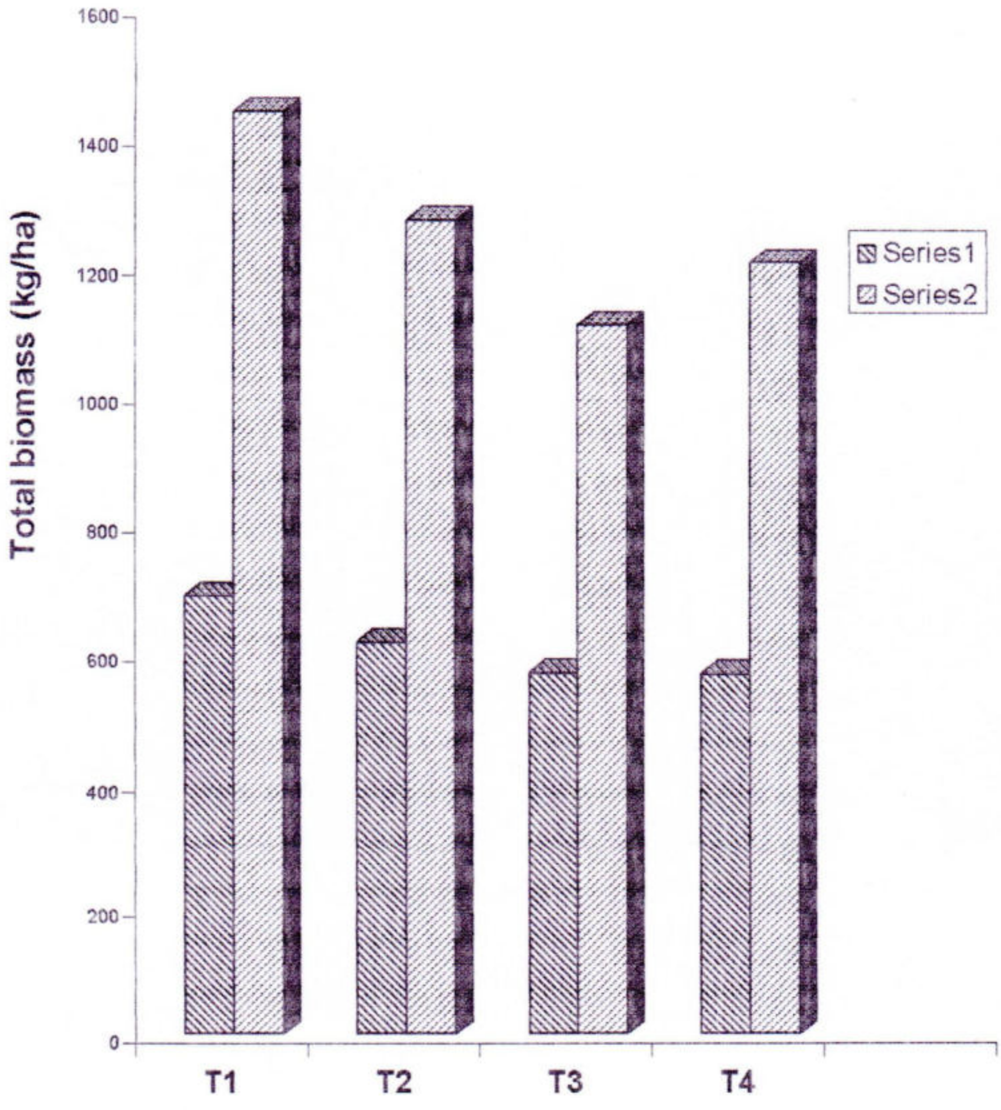

Fig.2 Effect of trees on total biomass production (kg/ha) at 50 DAS and 75 DAS

4.3 Interaction effect of trees and mungbean varieties on biomass contribution

4.3.1 Plant weight (above ground)

From the interaction effect, significantly the highest weight/plant at 50 DAS and 75 DAS were recorded 17.76g and 32.67g respectively in V_4T_1. Significantly the lowest weight/plant was recorded in both 50 DAS (6.39 g) and 75 DAS (8.55 g) in V_5T_3 (Table 3).

4.3.2 Root weight

From the combined effect, the highest root weight/plant at 50 DAS and 75 DAS was produced 7.72g & 8.78g respectively in V_2T_1. Significantly the lowest root weight/plant was produced in V_5T_3 (2.37 g) at 50 DAS and in V_1T_3 (3.15) at 75 DAS (Table 3).

4.3.3 Nodule weight

According to combined effect, the highest nodule weight/plant at 50 DAS was 0.43 g in V_4T_1which was followed by V_3T_4 (0.34 g). The lowest value of nodule weight/plant at 50 DAS was 0.14 g in V_2T_3. The highest nodule weight/plant at 75 DAS was found in V_4T_1 (0.34g) which was followed by V_4T_2 (0.29 g). The lowest value of nodule weight/plant was 0.10 g at 75 DAS in V_2T_3 (Table 3).

4.3.4 Total weight i.e. biomass per plant

Significantly the highest biomass/plant at 50 DAS was found 24.85 g in V_4T_1 that was followed by V_4T_4 (23.64 g). Significantly the lowest biomass/plant at 50 DAS was found in V_5T_3 (9.00 g). Significantly the highest biomass/plant at 75 DAS was found 50.00 g in V_4T_1 that was followed by V_4T_2 (45.91 g). Significantly the lowest biomass/plant at 75 DAS recorded in V_5T_3 (19.22 g) (Table 3).

4.3.5 Total biomass per hectare

Significantly the highest total biomass/ha at 50 DAS was measured as 894.85 kg in V_4T_1 that was followed by V_4T_2 and V_4T_3. Although the value of total biomass/ha in V_4T_2 (813.00 kg) and V_4T_3 (806.60 kg) was statistically identical. At 75 DAS, the highest value was measured as 1800.00 kg in V_4T_1that was followed by V_4T_2 (1652.85 kg). Although the value of total biomass/ha in V_4T_2 (1652.85 kg) and V_2T_1 (1689.86 kg) was statistically identical. The significantly lowest total biomass/ha was measured in both 50 DAS (328.15 kg) and 75 DAS (691.92 kg) in V_5T_3 (Table 3).

4.3.6 Biomass added to the Soil

Significantly the highest incorporated biomass/ha at 75 DAS was shown 1473.48 kg in V_4T_1 that was followed by V_4T_2 (1346.85 kg) and V_4T_4 (1308.60 kg).Although the value of incorporated biomass/ha in V_4T_2 and V_4T_4 was statistically identical. Significant the lowest value was shown in V_4T_3 (457.92 kg) (Table 3).

The study revealed that interaction effect of V_4T_1 combination performed the best in all growth parameter except root weight/plant in both 50 DAS and 75 DAS

Table-3 Interaction effect of trees and mungbean varieties for biomass contribution as green manuring crop in agroforestry system

Interaction	Weight/plant (g)		Root weight/plant (g)		Nodule weight/plant (g)		Total biomass/plant (g)	
	50 DAS	75DAS	50DAS	75DAS	50 DAS	75DAS	50DAS	75DAS
V_1T_1	10.71 ij	18.39 h	4.20 hi	5.24 fg	0.27c-g	0.20 e	15.19fg	32.58 g
V_1T_2	9.93 j	17.00 I	4.01 hi	4.90 gh	0.25fgh	0.16 gh	14.19gh	30.06 h
V_1T3	11.76hi	14.30 j	2.28k	3.15 k	0.21 gh	0.14 ij	14.26gh	23.86jk
V_1T_4	9.50 j	15.15 j	3.04j	4.25 ij	0.22 gh	0.13ij	12.75hi	26.65 I
V_2T_1	14.15ef	24.80 e	7.72 a	8.78 a	0.30 c-f	0.16 gh	22.18bc	46.94 b
V_2T_2	11.92hi	20.00 g	5.95 c	7.10 c	0.18 hi	0.14 ij	18.06de	39.35e
V_2T3	11.57hi	19.11gh	4.92efg	6.30 de	0.14 I	0.10 k	16.64fe	35.66 f
V_2T_4	12.13 h	20.00 g	5.59cde	7.00 c	0.25fgh	0.13 j	17.98de	38.63 e
V_3T_1	15.42cd	26.01 d	5.57cde	7.22 c	0.34 fgh	0.22 d	21.33bc	46.26 b
V_3T_2	13.45fg	22.25 f	5.16def	6.50 d	0.24bcd	0.20 e	18.86d	39.10 e
V_3T3	12.77 gh	20.11 g	3.87 I	5.00 gh	0.23 bc	0.15 hi	16.89ef	34.37fg
V_3T_4	12.61gh	21.50 f	4.62fgh	6.00 e	0.34 b	0.18 f	17.60de	37.78 e
V_4T_1	17.74 a	32.67 a	6.68 b	7.92 b	0.43 a	0.34 a	24.85a	50.00 a
V_4T_2	16.42bc	30.12 b	5.73 cd	7.00 c	0.41 a	0.29 b	22.58bc	45.91 b
V_4T3	16.97 ab	28.12 c	5.10def	5.99 e	0.32 ab	0.20 e	22.40bc	41.31 d
V_4T_4	15.11dc	29.59 b	5.15def	6.50 d	0.38 d-g	0.26 c	23.64b	43.85 c
V_5T_1	7.58 k	10.98 k	4.39ghi	5.53 f	0.26 efg	0.20 e	12.24i	24.89 ij
V_5T_2	7.58 k	10.11kl	4.32ghi	5.11g	0.27 efg	0.18 f	12.18i	22.60kl
V_5T3	6.39 k	8.55 m	2.37 k	4.00 j	0.34bcd	0.17 fg	9.11j	19.22m
V_5T_4	6.73k	9.25 ml	3.08 j	4.60 hi	0.27defg	0.18 f	10.11j	21.13lm
Level of significance	**	**	*	**	**	**	*	**
LSD 0.05%	1.197	1.061	0.6237	0.3955	0.06332	0.01516	1.645	2.028

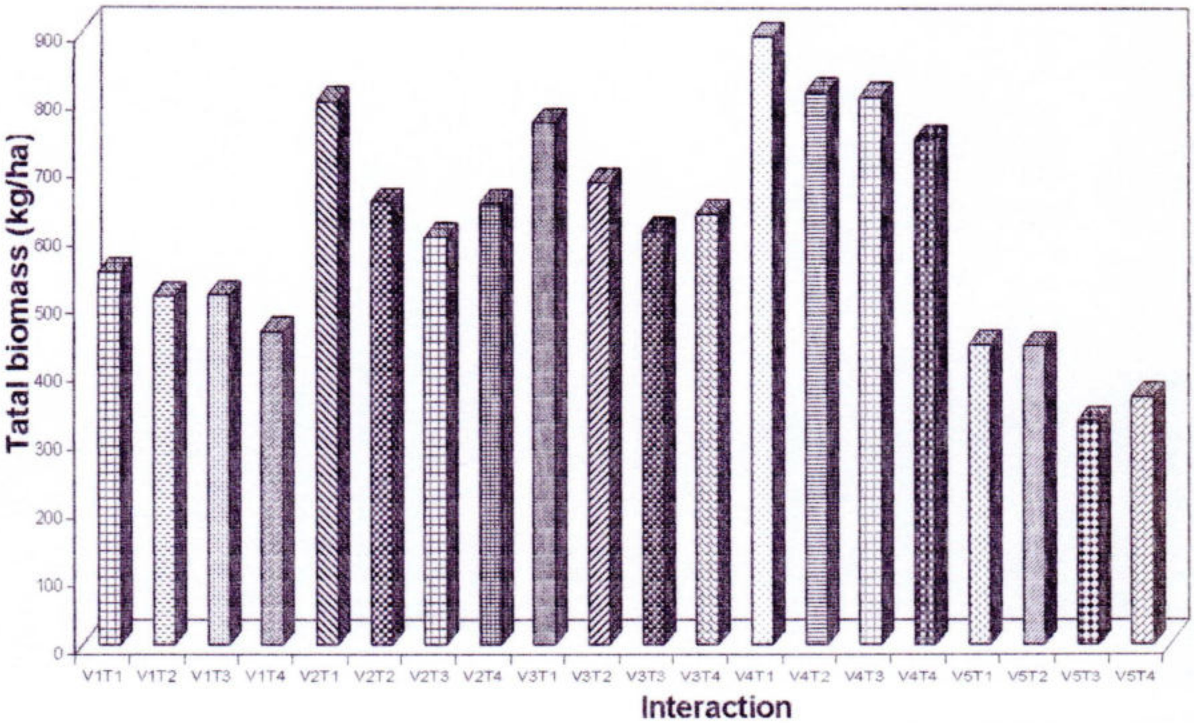

Fig. 3 Interaction effect of trees and mungbean varieties on total biomass production (kg/hs) at 50 DAS

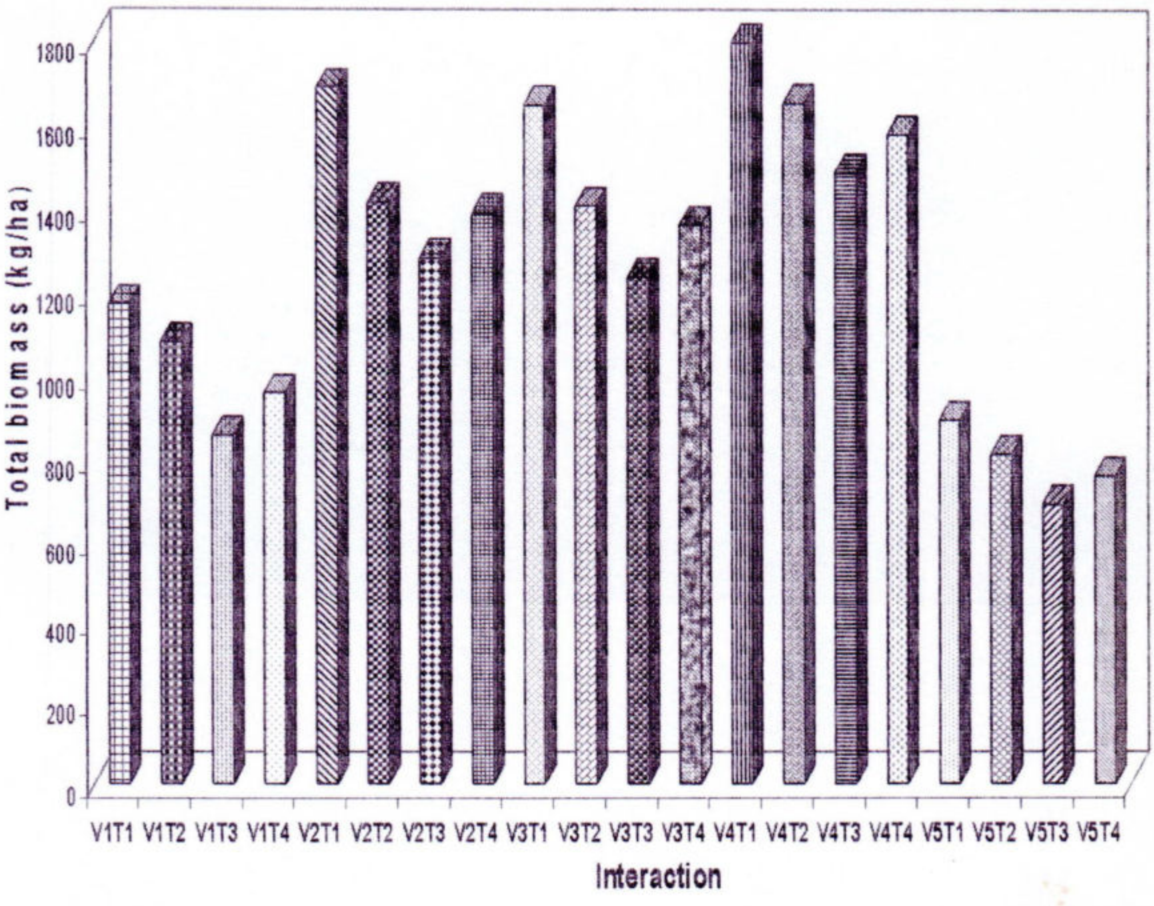

Fig.4 Interaction effect of trees and mungbean varieties on total biomass production (kg/ha) at 75 DAS

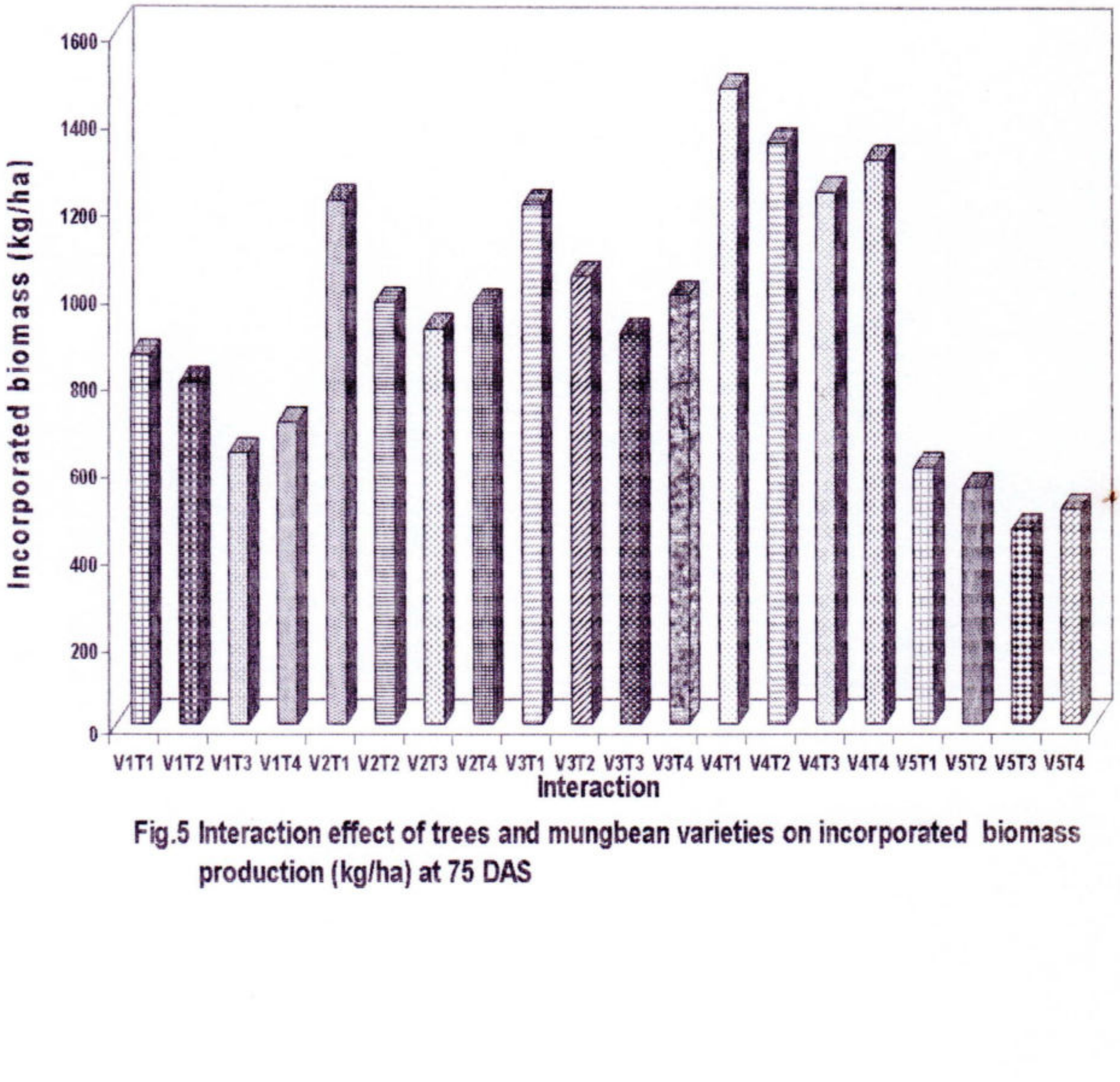

Fig.5 Interaction effect of trees and mungbean varieties on incorporated biomass production (kg/ha) at 75 DAS

4.4 Yield contribution of mungbean varieties

4.4.1 Pod length

Significantly the highest pod length was recorded 6.91cm in V_3 that was followed by V_4 (6.13cm). Significantly the lowest pod length was found in V_5 (5.08cm) (Table 4).

4.4.2 Number of pod

Significantly the highest number of pod/plant was measured as 14.90 in V_1 followed by V_2 (12.35). Although V_3 (10.75) and V_4 (10.86) statistically identical. Significantly the lowest number of pod/plant was shown in V_5 (6.77) (Table 4).

4.4.3 Number of seed

Significantly the highest seed/pod was produced 5.53 in V_3 that was followed by V_2 (5.15) and V_4 (5.24) although the value of number of seed/pod in V_2 and V_4 was statistically identical. Significantly the lowest no. of seed/pod was found in V_5 (3.39) (Table 4).

4.4.4 1000 seed weight

Significantly the highest value of 1000 seed weight was recorded 36.91g in V_3 that was followed by V_1 (30.32g) and V_4 (30.63g). Although the value of 1000 seed weight in V_1 and V_4 was statistically identical. Significantly the lowest value of 1000 seed weight was found in V_5 (11.16g) (Table 4).

4.4.5 Grain yield per plant

The highest yield/plant was given 2.41g by V_3 which was followed by V_1 (2.33g) and V_2 (2.17g).Although the value of V_3 and V_1 was statistically identical. The significantly lowest value of yield/plant was shown in V_5 (0.78g) (Table 4).

Table-4 Yield contribution of mungbean varieties as green manuring crop in agroforestry system

Variety	Pod length (cm)	No of pod/plant	No. of seed/pod	1000 seed weight (gm)	Grain yield/plant (gm)
V_1	5.99 bc	14.90 a	4.49 c	30.32 b	2.33 a
V_2	5.87 c	12.35 b	5.15 b	29.03 c	2.17 b
V_3	6.91 a	10.75 c	5.53 a	36.91 a	2.41 a
V_4	6.13 b	10.86 c	5.24 b	30.63 b	2.05 c
V_5	5.08 d	6.77 d	3.39 d	11.16 d	0.78 d
Level of significance	**	**	**	**	**
LSD 0.05%	0.2015	0.5982	0.2182	0.6144	0.08955

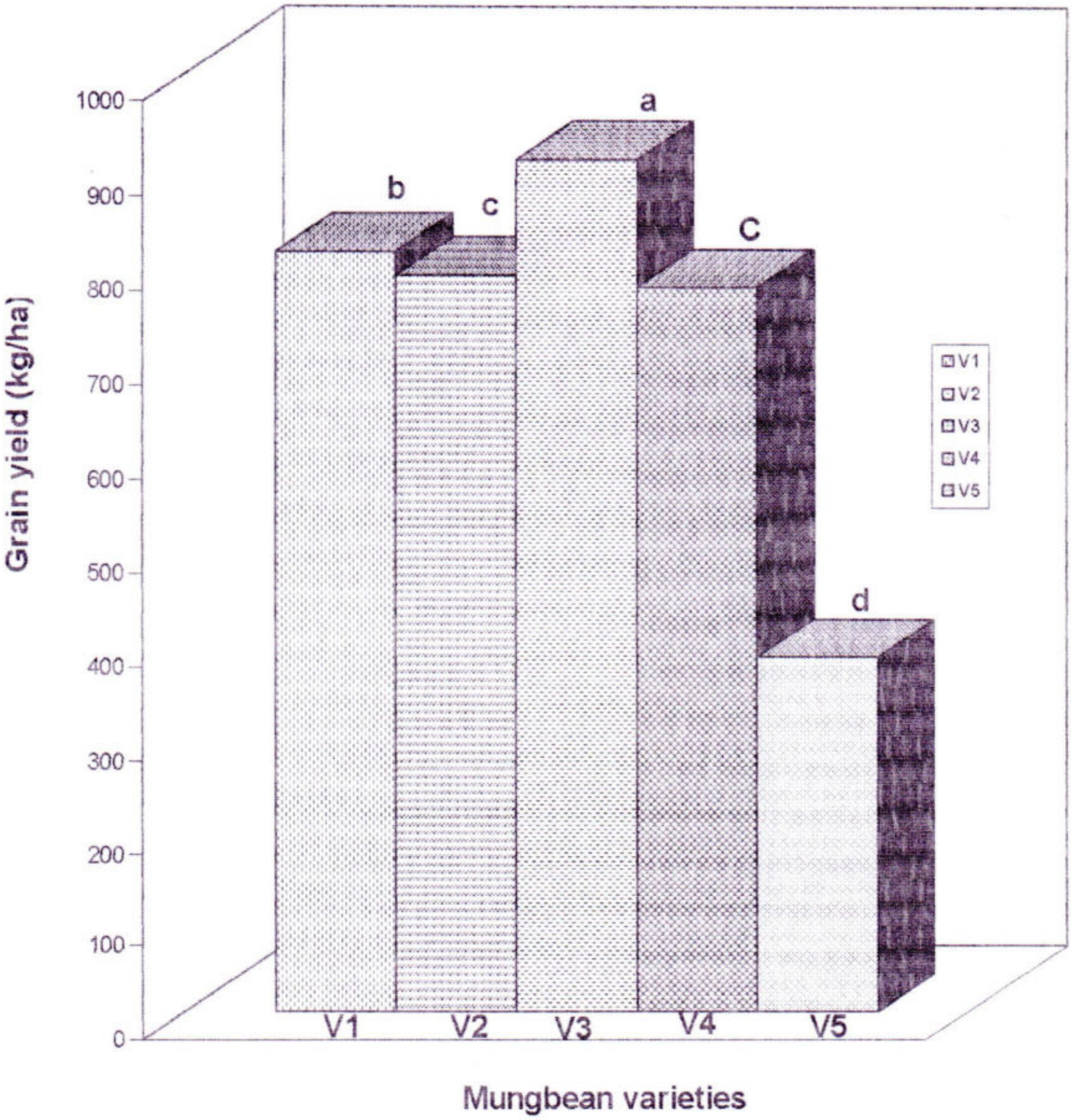

Fig.6 Grain yield (kg/ha) of mungbean varieties

4.4.6 Grain yield per hectare

Significantly the highest yield/ha was measured as 910.50 kg in V_3 that was followed by V_1 (812.40kg). The value of yield/ha in V_2 (787.50kg) and V_4 (774.80kg) was statistically identical. Significantly the lowest value of yield/ha was given by V_5 (382.00kg) (Table 4).

The study revealed that V_3 performed the best in all yield parameter except number of pod/plant.

4.5 Effect of trees on yield contribution of mungbean varieties

4.5.1 Pod length

The effects of trees on pod length of mungbean varieties were insignificant. Although numerically the highest pod length was recorded 6.11cm in T_1 that was followed by T_2 and T_4. Although the value of T_2 (6.03cm) and T_4 (5.94cm) was statistically identical. Significantly the lowest pod length was found in T_3 (5.89cm) (Table 5).

4.5.2 Number of pod

Significantly the highest number of pod/plant was produced 12.58 in T_1 that was followed by T_2 (11.81). The value of number of pod/plant in T_3 (9.97) and T_4 (10.15) was statistically identical. Significantly the lowest number of pod/plant was found in T_3 (9.97(Table 5)).

4.5.3 Number of seed

Significantly the highest number of seed/pod was shown 5.26 in T_1 that was followed by T_2 (5.01). The value of number of seed/pod in T_3 (4.29) and T_4

(4.47) statistically identical. Significantly the lowest no.of seed/pod was recorded in T_3 (4.29) (Table 5).

4.5.4 1000 seed weight

Significantly the highest 1000 seed weight was measured as 28.50g in T_1 that was followed by T_2 (27.81g) (Table 5). The value of 1000 seed weight in T_3 (26.94g) and T_4 (27.19g) was statistically identical. Significantly the lowest 1000 seed weight was produced in T_3 (26.94g).

4.5.5 Grain yield per plant

Significantly the highest yield/plant was recorded 2.20g in T_1 that was followed by T_2 (2.05g) (Table 5). Significantly the lowest yield/plant was found in T_3 (1.70g)

Table-5 Effect of trees on yield contribution of mungbean varieties as green manuring crop in agroforestry system

Tree species	Pod length (cm)	No of pod/plant	No. of seed/pod	1000 seed weight (gm)	Grain yield/plant (gm)
T_1	6.11	12.58 a	5.26 a	28.50 a	2.20 a
T_2	6.03	11.81 b	5.01 b	27.81 b	2.05 b
T_3	5.89	9.97 c	4.29 c	26.94 c	1.70 d
T_4	5.94	10.15 c	4.47 c	27.19 c	1.84 c
Level of significance	NS	**	**	**	**
LSD 0.05%	-	0.5351	0.1952	0.5495	0.08010

4.5.6 Grain yield per hectare

Significantly the highest yield/ha was measured as 806.70kg in T_1 that was followed by T_2 (754.80kg). Significantly the lowest yield/ha was found in T_3 (669.10kg) (Table 5).

The study revealed that T_1 (open field) performed the best in all yield parameter.

4.6 Interaction effect of trees and mungbean varieties on grain yield of mungbean

4.6.1 Pod length

The interaction effects on pod length of mungbean were insignificant. Although numerically the highest pod length was recorded 7.00cm in V_3T_1. The lowest pod length was found in V_5T_4 (5.00cm) and V_5 T_3 (5.00cm) (Table 6).

4.6.2 Number of pod

The interaction effects on no. pod of mungbean were insignificant. Although numerically the highest number of pod/plant was produced 16.48 in V_1T_1 that was followed by V_1T_2 (15.00). The number of pod/plant in V_1T_3 (14.00) and V_1T_4 (14.10) was statistically identical. Significantly the lowest number of pod/plant was recorded in V_5T_3 (5.39) (Table 6).

4.6.3 Number of seed

Interaction effect showed the highest number of seed/pod 6.21 in V_2T_1 was statistically identical with V_3T_1 (6.12). The lowest number of seed/pod was obtained at V_5T_4 (3.30) (Table 6).

4.6.4. 1000 seed weight

Effect of interaction gives the highest 1000 seed weight 38.25g in V_3T_1 followed by V_3T_2 (37.50g). The value of 1000 seed weight in V_3T_1 and V_3T_2 was statistically identical. The lowest 1000 seed weight was found in V_5T_3 (11.00g) and V_5T_4 (11.00g) (Table 6).

4.6.5 Grain yield per plant

The highest yield/plant were produced 2.82g by V_3T_1which was followed by V_3T_2 (2.70g). The value of yield/plant in V_3T_1 and V_3T_2 was statistically identical. The significantly lowest yield/plant was recorded in V_5T_3 (0.50g) (Table6).

4.6.6 Grain yield per hectare

Interaction effect provides significantly the highest yield/ha 1019.00kg in V_3T_1 that was followed by V_3T_2 (966.00kg). The value of yield/ha in V_2T_1 (856.00kg) and V_3T_4 (851.60kg) was statistically identical. Significantly the lowest yield/ha was recorded in V_5T_3 (320.00kg) (Table 6).

Considering the effects of interaction, the study revealed that V_3T_1 combination performed the best in all yield parameter except number of pod/plant and number of seed/pod.

Table-6 Interaction effect of trees and mungbean varieties for yield contribution as green manuring crop in agroforestry system

Interaction	Pod length (cm)	No of pod/plant	No. of seed/pod	1000 seed weight (gm)	Grain yield/plant (gm)
V_1T_1	6.13	16.48	4.89 e	31.32 cd	2.52 b
V_1T_2	6.00	15.00	4.72 ef	30.11 def	2.45 bc
V_1T_3	5.88	14.00	4.00 g	29.90 ef	2.10 ef
V_1T_4	5.95	14.10	4.35 fg	29.95 ef	2.25 de
V_2T_1	6.03	13.17	6.21 a	29.16 f	2.38 bcd
V_2T_2	5.90	13.00	5.90 ab	29.00 f	2.18 ef
V_2T_3	5.78	12.00	4.20 g	28.95 f	2.00 fg
V_2T_4	5.75	11.25	4.30 fg	29.00 f	2.10 ef
V_3T_1	7.00	12.07	6.12 a	38.25 a	2.82 a
V_3T_2	6.95	11.59	5.59 bc	37.50 a	2.70 a
V_3T_3	6.78	9.35	5.00 de	35.90 b	2.00 fg
V_3T_4	6.89	10.00	5.39 cd	36.00 b	2.11 ef
V_4T_1	6.23	12.67	5.60 bc	32.40 c	2.29 cde
V_4T_2	6.20	12.35	5.45 bcd	31.15 cde	2.00 fg
V_4T_3	6.00	9.10	4.90 e	28.95 f	1.89 g
V_4T_4	6.10	9.31	5.00 de	30.00 def	2.00 fg
V_5T_1	5.20	8.50	3.50 h	11.35 g	1.00 h
V_5T_2	5.10	7.01	3.40 h	11.30 g	0.90 hi
V_5T_3	5.00	5.39	3.35 h	11.00 g	0.50 j
V_5T_4	5.00	6.10	3.30 h	11.00 g	0.75 i
Level of significance	NS	NS	**	**	**
LSD 0.05%	-	-	0.4364	1.229	0.1791

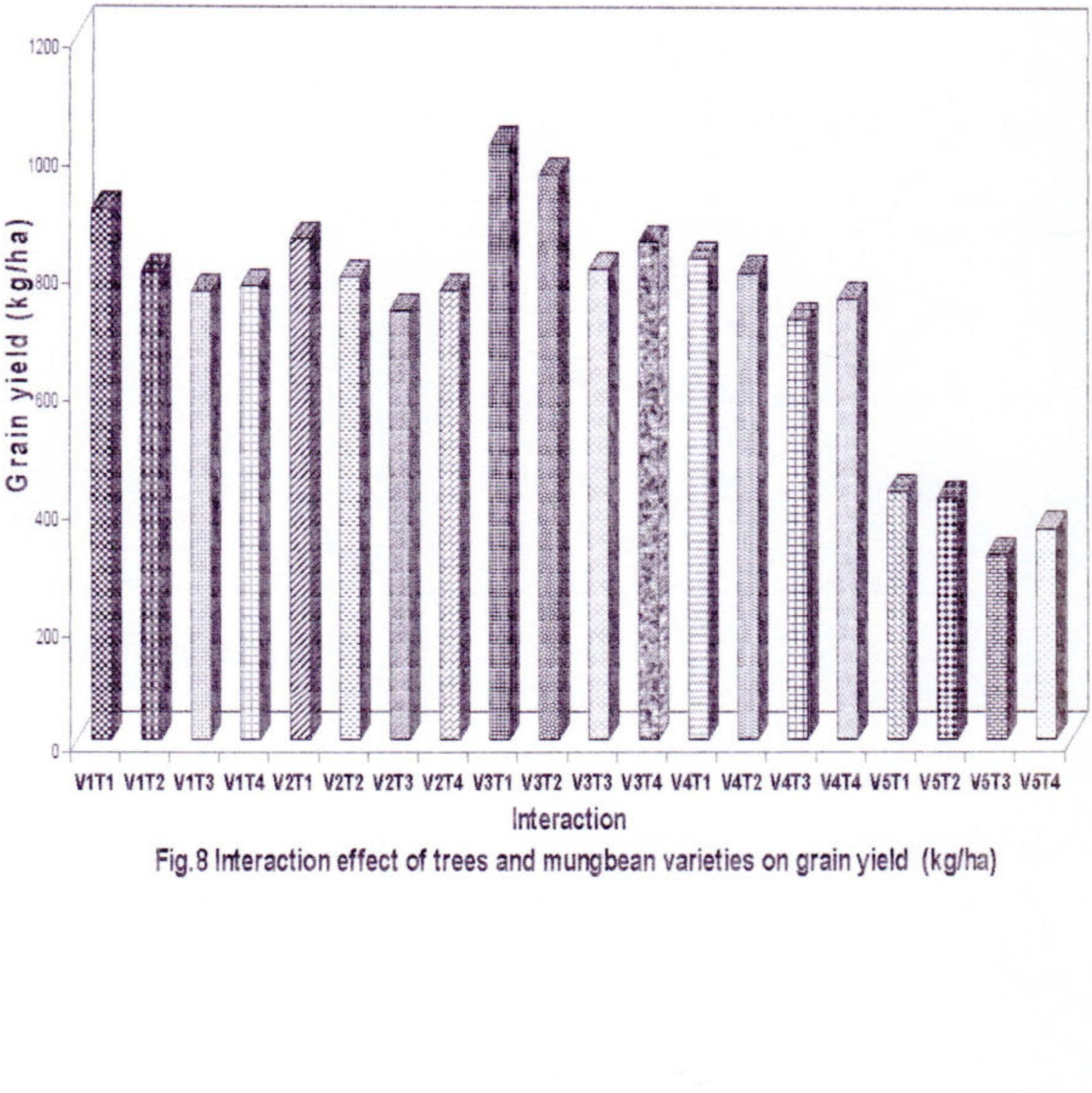

Fig.8 Interaction effect of trees and mungbean varieties on grain yield (kg/ha)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

The result of the present studies showed that performance of mungbean varieties grown under tree species varied significantly. Among the five varieties of Mungbean, BARI Mug-6 significantly contributes the highest biomass that was followed by BARI Mug-3 and then BARI Mug-4, for yield contribution BARI Mug-5 was found superior. Local variety was not suitable at all.

Therefore, it may be predicted that most of the varieties of mungbean are suitable for green manuring in agroforestry system, but their degree of suitability may be ranked as BARI Mug-6>BARI Mug-5>BARI Mug-4>BARI Mug-3>Local variety for biomass production and BARI Mug-5>BARI Mug-3>BARI Mug-4>BARI Mug-6>Local variety for yield contribution.

On the other hand, T_1 produce the highest biomass (V_4) and yield (V_3) which was followed by T_2 (mango). The results revealed that the production of mungbean may be ranked as open field > mango >ipil-ipil > ghoraneem. So the suitability of the best combination for biomass production is V_4T_1 where V_3T_1 is better for yield contribution.

In conclusion, it can be predicted that only for green manuring crop (considering biomass contribution at 50 DAS) for soil health development V_4 (BARI Mug-6) is the best among the above varieties. If grain yield is desirable then V_3 (BARI Mug-5) will be superior variety. It can also contribute 2nd highest biomass.

However the result of the present studies were achieved based on one season trial and specific tree species which were early aged may not be sufficient to asses the sustainability of the results and for all agroforestry practices. Similar experiments should be repeated at least in another season with the same tree of different ages and also with different tree species.

REFERENCES

REFERENCES

Abedin, M.Z. and Quddus, M.A. 1990. Household fuel situation, home garden and agroforestry practices at six-agroecologically different locations of Bangladesh. In : Abedin *et al.*(ed). *Homestead plantation and agroforestry in Bangladesh.* BARI, Winrock International and BARC. pp. 19-53.

Abedin, M.Z., Akter, M.S. and Alam, M.S. 1988. Multipurpose trees and their uses on the small farmers of low rainfall Ganges Floodplain Soils of Bangladesh. *Proceeding on an International Workshop on multipurpose tree species for small farm use;* held on November 2-5, 1987 at Patty, Thailand.

Aher, R. P., Sonawane, V. P. and Dahat, D. V. 200. Heterosis in mungbean (*Vigna radiata* L> Wilczek). *Indian J. Agric. Res.,* 34(2): 134-137.

Ahmed, F. 2005. Performance of medicinal plants and spices in coconut based agroforestry system. *MS Thesis*, Department of Agroforestry, Bangladesh Agricultural Univversity, Mymensing. p . 1.

Akter, M.S., Abedin, M.Z. and Quddus, M.A. 1989. Why farmers grow trees in agricultural fields: some thoughts, some results, *Research Report*, 1988-89. On Farm Research Division, Joydebpur.

Akter, M.S., Abedin, M.Z. and Quddus, M.A. 1990. Why farmer grow trees in agricultural fields; some results. *Proc. Regional Symposium on Tree Plantation in the Humid/Sub-humid Tropics in Asia;* held on May 5-9, 1988 in University Partanian, Malaysia.

BARC. 1997. *Fertilizer recommendation guide*. BARC, Farmgate, Dhaka.

Basri, I.H., Mercado, A.R. and Gamity, D.P. 1990. Upland rice cultivation using leguminous tree hedgerows on strongly acid soils. Paper presented at the IRRI Saturday seminar, 31 March 1990. p. 14.

BBS. 1996. *Statistical Year Book of Bangladesh.* Bangladesh Bureau of Statistics. Ministry of Planning Government of the People Republic of Bangladesh, Dhaka, Bangladesh.

.Bhatia, K.S. and Singh, R.P. 1994. Trees for sustainable agriculture production. *Agroforestry Abstract* 7(3): 125.

Casavajda, E. 2002. Productivity investigations of some green manure crops as valuable factors in the maintenance of soil fertility *I. Acta Agronomica Ovariensis.* 44(2): 121-133.

Chowdhury, R.A. and Hossain, H. 1990. *Participation Planting and Extension Strategies.* BARI, Gazipur, Bangladesh. p. 101, pp. 23-56.

Crookston, R.K., Trehame, K.J., Ludford, P. and Ozbun, J.I. 1975. Response of beans to shading. *Crop Sci.* 15: 412-416.

Das, M., Pal, M., Zaidi, P. H., Raj, A. and Sengupta, U. K. 1999. Growth response of mungbean to elevated level of carbon dioxide. *Indian J. Plant. Physiol.,* 5(2): 132-135.

Fakir, M. S. A. 1997. A study of morphophysiological selection criteria related to yield in pigeonpea (*Cajanus cajan* (L.) Millsp.). *Ph. D. Thesis,* Department of Life Sciences. The University of West Indies. St. Augustine, Trinidad. p. 8-29.

Fakir, M. S. A., Umaharan, P. and McDavid, C. R. 1998. A modified method for estimating floral abscission in pigeonpea. Trop. Agric. (Trinidad), 75(3): 393-395.

FAO. 1988. *Agro-ecological region of Bangladesh.* Land resources appraisal of Bangladesh for Agricultural Department. BDG 81/35: Tech. Rep. 2 FAO and UNDP, Rome. Italy p. 107.

Fawaz, K., Mussaddak, J. and Khalaf, K. 2003. Growth and nitrogen fixation and uptake in dhaincha/sorghum intercropping system under saline and non-saline conditions. *Communications in Soil Science and Plant Analysis.* 34(17/18).

Fawaz-Jurdali, 2004. Estimates of dry matter yield and nitrogen uptake in sorghum grown on saline and non-saline soils manured with dhaincha plant residues. *Journal of Plant Nutrition.* 27(9): 1611-1633.

Follett J. 1997. Ginseng production in New Zealand forests: experiences from Tiketere. *New Zealand Tree Grower* 18(3): 19-21.

Groot, J.J.R. and Sourmare, A. 1995. The roots of the matter: Soil quality and tree in the Sahel. *Agroforestry Today* 7(1): 9-11.

Gupta R. 1986. Integration of medicinal plants cultivation in forest and forest plantations of northwestern Himalaya. pp. 59-67. *In: Agroforestry Systems: A New Challenge.* Indian Society of Tree Scientists, Solan, India.

Hager N. and Otterstedt J. 1996. Coope San Juan, a farmers' cooperative. Sustainable use of the natural forest-past and future: a minor field study. *Working Paper No. 302.* International Rural Development Centre, Swedish University of Agricultural Sciences, Uppsala, Sweden. p.59.

Haris, A., Rai, R.K., Safeena, A.N., Mukherjee, P.K. and Haris, A. 1999. Available 'N' status of the soil as influenced by phosphorus application and some kharif green manure crops grown in succession with some rabi crops. *Annals of Agricultural Research.* 20(4): 522-523.

Harou, 1983. Economic principles of appraise agroforestry project. *Agricultural Administration* 12: 127-139.

Hill, D.B. and Buck, L.E. 2000. Forest farming practices. pp.283-320. In : Garrett H.E., Rietveld W.J. and Fisher R.F. (eds.), *North American Agroforestry: An Integrated Science and Practice.* American Society of Agronomy Inc., Madison, W.I., USA.

Hossain, K. L., Wadud, M. A., Hossain, K. S. and Abdullah, M. R. 2005. Performance of Indian spinach in association with Eucalyptus for agroforestry system. *J. Bangladesh Agril. Univ*. 3(1): 29-35.

Hossain, S. M. A., Salam, M. U., Alam, A. B. M. M. and Kashem, M. A. 1997. Declining soil organic matter Farmers management and strategies for improvement. *J. Rural Dev*. 27(1): 1-18.

Hossain, S.M.A. and Bari, M.N. 1993. Agroforestry farming system. In: Haque, M.A. (ed). *Agroforestry in Bangladesh*. Swiss Development Corporation (SDC), Dhaka and Bangladesh Agricultural University (BAU), Mymensingh, pp. 21-28.

Howard, S.B., Ong, C.K., Rao, M.R., Mathuva, M. and Black, C.R. 1995. The partitioning of light and water in *Leucaena*-maize agroforestry systems. In : Sinoquet, H. and Cruz P. (ed.). *Ecophysiology of tropical intercropping* IRNA Edition, Paris, France.

Islam, M.J, 2005. Performance of lemon and guava grown under coconut based multistoried agroforestry system. *M. S. Thesis*, Dept. of Agroforestry, Bangladesh Agricultural University, Mymensingh.

Jackson 1987. Stated that the potential benefits of combining field crops with trees are so obvious from consideration of waste of light resources experienced in orchard and tree crop combination.

Jadhav, B.B. 1987. Effect of partial shading on the yield of rice. *Indian J. Agric. Sci.* 57(7): 193-205.

Kang, B.T., Wilson, G.F. and Lawson, T.L. 1984. *Alley cropping a stable alternative to shifting cultivation.* IITA, Ibadan, Nigeria.

Leopold, A.C. 1964. *Plant growth and Development.* McGraw-Hill, New York.

Lundgreen, B.O. and J.B. Raintree. 1982. Sustained Agroforestry. In: *Agricultural Research for Development-Potentials and Challenges in Asia (Ed.* B. Nestel). IS NAR, pp. 37-49.

MacDicken, K.G. and Vergara, N. 1990. Agroforestry : Classification and Management. John Willey, New York, USA.

Madanpal, Sengupta, U. K., Srivastava, A. C., Vanita Jain and Meena, R. C. 1999. Changes in growth and photosynthesis of mungbean induced by UV-B radiation. *Indian J. Pl. Physiol.*, 4(2): 79-84.

Miah, M.G. 1993. Performance of selected multipurpose tree species and field crops grown in associations as affected by tree branch pruning. A *Ph.D. Dissertation*, Crop Science. Agronomy. CLSU, Philippines.

Miah, M.G., Garrity, D.Y. and Agron, M.L. 1995. Light availability, to the understorey annual crops in an Agroforestry system. In Sinoquet, H.

and Cruz, P. (ed) *Ecophysiology of tropical inter cropping.* IRNA Editions, Paris, France.

Millate-e-Mostofa, 1997. Floristics and Indigenous Management Techniques of Home garden in Bangladesh. Alam, M.K., Ahmed, F.U. and Amin, (eds). *Agroforestry Bangladesh Perspective.* APAN, NAWG and BARC, Dhaka, Bangladesh.

Murray, D.B. 1953. *A Shade Fertilizer Experiment with Cocoa 11 Research* Institute. Imperial College of Tropical Agriculture (ICTA), Trinidad, pp. 11-24.

Nadeau L., Oliver A., Semard R.R., Coulobe J. and Yelle S. 1999. Growing american ginseng in maple forests as an alternative land use system in Quebec, Canada. *Agroforestry System* 44: 345-353.

Nair, P.K.R. 1985. Agroforestry in the context of land clearing and development in the tropics. *Working paper no. 33.* ICRAF, Nairobi, Kenya.

Nair, P.K.R. 1987. Agroforestry in the context of land clearing and development in the tropics. In : Lal, R. *et al.* (eds) *Tropical land clearing for sustainable agriculture.* IBSRAM. Proc. Series No. 3, Bangkok, Thailand: pp. 29-44.

Nayak, S.K. and Murty, K.S. 1980. Effect varying light intensities on yield and growth parameters in rice. *Indian J. Plant Physiology* 23: 309-316.

Nayak, S.K., Murty, P.S.S. and Murty, K.S. 1979. Photosynthesis and translocation in rice during ripening as influenced by different light intensities. J. *Nuclear Agric. Biol.* 8(1): 23-25.

Ong, C.K. 1988. The interaction light, water and nutrients in Agroforestry system. Chapter for book on "*Application of Biological Research on Asian Agroforestry system*". J.A. 885.

Parvin, N., Chowdhury, M. A. H. and Ferdous, H. S. J. 2005. Decomposition pattern of two green manures in BAU farm soil. *J. Bangladesh Agril. Univ.* 3(1): 37-42.

Pierre, C.S. 1991. Evolution of agroforestry in the Xinshuangbanna region of tropical China. Agroforestry system 13: 159-176.

Pieters, A.J. 2004. Green Manuring *Principle and Practices.* Agobios (India). pp. 09-194.

Rachie, K. 0. 1983. Intercropping tree legume with annual crops. *Plant Research and Agroforestry,* ICRAF.

Rahman, M. M. and Miah, A. A. 1988. *Mungbean in bangladesh problems and prospects.* In mungbean: Asian Vegetable Research Development Centre, Shanlua, Taiwan.

Rahman, M. M., Miah, A. A., Maniruzzaman, A. F. M., Rahman, A. K. M. M. and Khan, K. 1995. Growth analysis of mungbean (*Vigna radiata* (L.) Wilczek) under variable population densities a different dates of sowing. *Bangladesh J. Bot*. 24(1): 53-59.

Rang, A. Bhat, M.L., Makaya, A.S., Masoodi, N.A., Anani, A.Z. and Sharma, D.P. 1990. Agroforestry Research in India. *Indian J. Agril*. 68(8): 559-566.

Rao, L.G. and Mittra, B.N. 1988. Growth and yield of pea nut as influenced by degree and duration of shading. J. Agronomy and Crop Science 160 : 260-265.

Rao, T. P. and Ito, O. 1998. *Japanese Agricultural Research Quarterly* (JARC), 32: 97-103.

Reifsnyder, W.E. 1987. Control of solar radiation in Agroforestry practices. *Meteorology and Agroforestry*. ICRAF, WHO and UNEP.

Sahoo, S.C., Lenka, P.C. and Dash, D.K. 2002. A note on the performance of in situ green manuring crops in palm basins in littoral sandy soil of Orissa. *Orrisa Journal of Horticulture*. 30(1): 130-132.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology* Crop Botany, Pub. Bholanath Nagor, Shahdara, Delhi.

Saneoka, H., Nagasaka, C., Hahn, D. T., Yang, W. J., Premchandra, G. S., Joly, R. J. and Rhodes, D. 1995. Salt tolerance of glycinebetaine-deficient and containing maize lines. *Plant Physiol.*, 107-: 631-638.

Sattar, M. A. and Ahmed, S. U. 1992. Response of mungbean (*Vigna radiata* L. Wilczek) to nodulation with *Bradyrhizobium* as affected by phosphorus levels. *Proc. Commi. IV Conf. Bangladesh. pp.* 419-423.

Saxena, M.B.L. 1984. Improved crop variety in agroforestry. Agroforestry in Arid and Semi-Arid Zones, Central Arid Zone Research Institute, Jodhpur, India.

Shankarnarya, K.A. 1984. Agroforestry, its concept and implication for a sound land use goal. *Agroforestry in Arid and Semi-Arid Zones.* Central Arid Zone Research Institute, Jodhpur, India.

Sharda, V.N. and Ratan, S. 2003. Erosion control measures for improving productivity and farmers' profitability. Fertilizer News. 48(12): 71-78.

Sharif, M. 1993. Effect of shade on plant nutrient uptake. *Research Report*, 1994. On Farm Research Division, Gazipur.

Sharma, A.R. and Das, K.C. 1994. Effect of green manuring with dhaincha (*Sesbania aculeata*) on growth and yield of direct sown and transplanted rice under intermediate deepwater conditions (0-50cm). *Journal of Agricultural Science*. 122(3): 359-364.

Sharma, S.N., Prasad, R. and Singh, S. 1995. The role of mungbean residues and Sesbania aculeata green manure in the nitrogen economy of rice-wheat cropping system. *Plant and Soil*. 1995; 172: 1, 123-129; 13 ref.

Singh, R.P., Ong, C.K. and Sharma, W. 1989. Above and below ground interaction in alley cropping in semi-arid India. *Agroforestry System* 9: 259-274.

Singh, S. and Singh, T. N. 1999. Root growth of wheat in simulated vertical and lateral splits of layered salt profiles in soil. *Indian J. Plant Physiol.* 4(2): 73-78.

Solanki, K.H. 1998. Agroforestry Research in India. *India J. Agril. Sci.* 68(8): 559-566.

Teel, W.S. and Buck, L.E. 2002. Between wild crafting and monocultures: agroforestry options. pp. 199-222. In: Jones E.T., McLain R.J. and Weigand J. (eds), *Non-Timber Forest Products in the United States.* University Press of Kansas, Lawrence, KS. USA.

Tilak, R.V.B.R. 2004. Response of Sesbania green manuring and mungbean residue incorporation on microbial activities for sustainability of a rice-wheat cropping system. *Journal of Agricultureand Rural Development in the Tropics and Subtropics.* 105(2): 189-196.

Walt, H.R. 1989. We need agroforestry in a big way, Workshop on *agroforestry in California: planning for the twenty-first century,* Deptt. of Forestry and Resources Management University of California, Berkeley, pp. 1-3.

Xiong, Z.X. and Chen, M.H. 1993. A preliminary report on tracing the dynamics of N uptake by labelled 15N in "grain-grain-green manure" rotation. Ningxia Journal of Agro-Forestry Sciences and Technology. 2:43-46.

Yantasath, K., Buranasilpin, P., Sapatanakul, W., Tanpanich, S., Chantrasiri, S., Patanawible, S. and Jitanawasan, S. 1992. Research on acacias and their potential. In : Awang, K. and Tailor, D.A. (eds.) Tropical Acacias in East and the Pacific. *Proc. First meeting of a Consultative Group for Research and Development of Acacias,* COGREDA. June 1-3, 1992. Phuket, Thailand.

Young, A. 1984. Impact of trials on soil in experimental plots, In : Huxley, P. A. (ed.) *Methodology for Exploration and Assessment of Multipurpose Trees. Section,* 3 (3): 70-74.

Zhou S.Q. 1993. Cultivation of Amomum villosum in tropical forests. *Forest Ecol. Manag.* 60: 157-162.

Zou, X. and Sanford, R.L. 1990. Agroforestry systems in China: a survey and classification. *Agroforestry system* 11: 85-94.

APPENDICES

Appendix 1.Distribution of monthly temperature, relative humidity and rainfall of the experimental site during the period from April to July 2005. Wheat Research Centre, Dinajpur (2005).

Month	Humidity	Temperature DC		Total rainfall
	%	Minimum	Maximum	
April	83	21.1	32.8	54.0
May	77	21.5	31.9	213.0
June	82	23.2	33.2	333.0
July	85	25.8	32.0	369.0

Appendix 2.Biomass contribution of Mungbean varieties as green manuring crop in agroforestry system

Variety	**Total biomass/ha (kg)**	
	50DAS	**75DAS**
V_1	507.7c	1018.17c
V_2	673.7b	1445.23b
V_3	672.2b	1413.09b
V_4	814.4a	1629.65a
V_5	392.9d	790.56d
Level of significance	**	**
LSD 0.05%	25.79	33.02

Appendix 3. Effect of trees on biomass contribution of mungbean varieties as green manuring crop in agroforestry system.

Tree species	Total biomass/ha (kg)	
	50 DAS	**75DAS**
T_1	689.86a	1441.23a
T_2	618.42b	1274.56b
T_3	571.03c	1111.68c
T_4	569.57c	1209.89b
Level of significance	**	*
LSD 0.05%	23.07	35.54

Appendix 4.Interaction effect of trees and mungbean varieties for biomass contribution as green manuring crop in agroforestry system

Interaction	**Total biomass/ha (Kg)**		**Incorporated biomass/ha (kg)**
	50 DAS	75DAS	75DAS
V_1T_1	547.03f	1172.88g	857.88g
V_1T_2	511.13fg	1082.16h	794.16h
V_1T3	513.35fg	858.24jk	633.24j
V_1T_4	459.55gh	959.40i	703.44i
V_2T_1	798.60b	1689.86b	1214.64c
V_2T_2	650.23de	1416.6e0	980.64e
V_2T3	599.03e	1283.76e	918.36f
V_2T_4	647.30de	1390.68e	976.68e
V_3T_1	767.97bc	1647.36b	1204.20c
V_3T_2	679.15d	1407.60e	1042.20d
V_3T3	608.03e	1237.32fg	909.36fg
V_3T_4	633.70de	1360.08e	996.48de
V_4T_1	894.85a	1800.00a	1473.48a
V_4T_2	813.00b	1652.85b	1346.85b
V_4T3	806.60b	1487.16d	12.35.16c
V_4T_4	743.22c	1578.60c	1308.60b
V_5T_1	440.83h	896.04ij	601.56jk
V_5T_2	438.60h	813.60kl	554.40kl
V_5T3	328.15i	691.92m	457.92m
V_5T_4	364.08i	760.68l	505.08lm
Level of significance	**	**	**
LSD 0.05%	51.58	66.04	53.18

Appendix 5. Yield contribution of mungbean varieties as green manuring crop in agroforestry system

Variety	**Grain yield/ha (kg)**
V_1	812.40 b
V_2	787.50 c
V_3	910.50 a
V_4	774.80 c
V_5	382.00 d
Level of significance	**
LSD 0.05%	18.52

Appendix 6. Effects of trees on yield contribution of mungbean varieties as green manuring crop in agroforestry system

Tree species	Grain yield/ha (kg)
T_1	806.70 a
T_2	754.80 b
T_3	669.10 d
T_4	703.10 c
Level of significance	**
LSD 0.05%	16.56

[illegible]	[illegible]
V_5T_1	427.20 j
V_5T_2	416.00 j
V_5T_3	320.00 l
V_5T_4	365.00 k
Level of significance	**
LSD 0.05%	37.04