PHYSIOLOGICAL INVESTIGATIONS ON LEGUMES IN TEAK BASED AGROFORESTRY SYSTEMS

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfillment of the requirements for the
Degree of

DOCTOR OF PHILOSOPHY

In

CROP PHYSIOLOGY

By

HOLALAGOUD Y. PATIL

DEPARTMENT OF CROP PHYSIOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD – 580 005

APRIL, 2010

ADVISORY COMMITTEE

DHARWAD

APRIL, 2010 **(S. J. PATIL)**
CHAIRMAN

Approved by :

Chairman : ______________________
(S. J. PATIL)

Members : **1.** ______________________
(M. B. CHETTI)

2. ______________________
(S. N. MEGERI)

3. ______________________
(S. M. MUTANAL)

4. ______________________
(ARAVINDAKUMAR B. N.)

CONTENTS

Contd…

LIST OF TABLES

Sl. No.	Title
18	Influence of teak based agroforestry system on relative growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)
19	Influence of teak based agroforestry system on net assimilation rate (g dm^{-2} day^{-1}) at different stages in legumes (pooled)
20	Influence of teak based agroforestry system on specific leaf area (dm^2 g^{-1}) at different stages in legumes (pooled)
21	Influence of teak based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes (pooled)
22	Influence of teak based agroforestry system on leaf area ratio (dm^2 g^{-1}) at different stages in legumes (pooled)
23	Influence of teak based agroforestry system on leaf area duration (Days) at different stages in legumes (pooled)
24	Influence of teak based agroforestry system on photosynthetic rate (µmol CO_2 dm^2 s^{-1}) at different stages in legumes (pooled)
25	Influence of teak based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes (pooled)
26	Influence of teak based agroforestry system on transpiration rate (mgH_2O m^{-2} s^{-1}) at different stages in legumes (pooled)
27	Influence of teak based agroforestry system on relative water content (%) at different stages in legumes (pooled)
28	Influence of teak based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)
29	Influence of teak based agroforestry system on chlorophyll “a” (mg g fresh wt^{-1}) at different stages in legumes (pooled)
30	Influence of teak based agroforestry system on chlorophyll “b” (mg g fresh wt^{-1}) at different stages in legumes (pooled)
31	Influence of teak based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes (pooled)
32	Influence of teak based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes (pooled)
33	Influence of teak based agroforestry system on nitrate reductase activity (nmol NO_2 formed g fresh wt^{-1} h^{-1}) at different stages in legumes (pooled)
34	Influence of teak based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes (pooled)

Sl. No.	Title
35	Influence of teak based agroforestry system on seed yield (kg ha^{-1}) in legumes (pooled)
36	Growth of teak trees in legumes based agroforestry systems
37	Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes (pooled)
38	Influence of teak-perennial vegetable based agroforestry system on number of leaves per plant at different stages in legumes (pooled)
39	Influence of teak-perennial vegetable based agroforestry system on number of branches per plant at different stages in legumes (pooled)
40	Influence of teak-perennial vegetable based agroforestry system on leaf area (dm^2 $plant^{-1}$) at different stages in legumes (pooled)
41	Influence of teak-perennial vegetable based agroforestry system on leaf dry weight (g $plant^{-1}$) at different stages in legumes (pooled)
42	Influence of teak-perennial vegetable based agroforestry system on stem dry weight (g $plant^{-1}$) at different stages in legumes (pooled)
43	Influence of teak-perennial vegetable based agroforestry system on pod dry weight (g $plant^{-1}$) at different stages in legumes (pooled)
44	Influence of teak-perennial vegetable based agroforestry system on total dry weight (g $plant^{-1}$) at different stages in legumes (pooled)
45	Influence of teak-perennial vegetable based agroforestry system on leaf area index (LAI) at different stages in legumes (pooled)
46	Influence of teak-perennial vegetable based agroforestry system on absolute growth rate (g $plant^{-1}$ day^{-1}) at different stages in legumes (pooled)
47	Influence of teak-perennial vegetable based agroforestry system on crop growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)
48	Influence of teak-perennial vegetable based agroforestry system on relative growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)
49	Influence of teak-perennial vegetable based agroforestry system on net assimilation rate (g dm^{-2} day^{-1}) at different stages in legumes (pooled)
50	Influence of teak-perennial vegetable based agroforestry system on specific leaf area (dm^2 g^{-1}) at different stages in legumes (pooled)

Sl. No.	Title
51	Influence of teak-perennial vegetable based agroforestry system on specific leaf weight (g $dm^{-2)}$ at different stages in legumes (pooled)
52	Influence of teak-perennial vegetable based agroforestry system on leaf area ratio (dm^2 g^{-1}) at different stages in legumes (pooled)
53	Influence of teak-perennial vegetable based agroforestry system on leaf area duration (days) at different stages in legumes (pooled)
54	Influence of teak - perennial vegetable based agroforestry system on photosynthetic rate (µmol CO_2 dm^2 s^{-1}) at different stages in legumes (pooled)
55	Influence of teak-perennial vegetable based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes (pooled)
56	Influence of teak-perennial vegetable based agroforestry system on transpiration rate (mgH_2O m^{-2} s^{-1}) at different stages in legumes (pooled)
57	Influence of teak-perennial vegetable based agroforestry system on relative water content (%) at different stages in legumes (pooled)
58	Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)
59	Influence of teak-perennial vegetable based agroforestry system on chlorophyll 'a' (mg g fresh wt^{-1}) at different stages in legumes (pooled)
60	Influence of teak-perennial vegetable based agroforestry system on chlorophyll 'b' (mg g fresh wt^{-1}) at different stages in legumes (pooled)
61	Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes (pooled)
62	Influence of teak-perennial vegetable based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes (pooled)
63	Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (nmol NO_2 formed g fresh wt^{-1} h^{-1}) at different stages in legumes (pooled)
64	Influence of teak-perennial vegetable based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes (pooled)

Sl. No.	Title
65	Influence of teak-perennial vegetable based agroforestry system on seed yield (kg ha^{-1}) in legumes (pooled)
66	Growth of teak as influenced by different components in agroforestry system
67	Growth and yield of perennial vegetables as influenced by different components in agroforestry system

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Appendix No.	Title
XVII	Influence of teak based agroforestry system on transpiration rate ($mgH_2O\ m^{-2}\ s^{-1}$) at different stages in legumes
XVIII	Influence of teak based agroforestry system on relative water content (RWC, %) at different stages in legumes
XIX	Influence of teak based agroforestry system on light transmission ratio (LTR, %) at different stages in legumes
XX	Influence of teak based agroforestry system on chlorophyll "a" (mg g fresh wt^{-1}) at different stages in legumes (pooled)
XXI	Influence of teak based agroforestry system on chlorophyll "b" (mg g fresh wt^{-1}) at different stages in legumes (pooled)
XXII	Influence of teak based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes
XXIII	Influence of teak based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes
XXIV	Influence of teak based agroforestry system nitrate reductase activity (nmol NO_2 formed g fresh $wt^{-1}\ h^{-1}$) at different stages in legumes
XXV	Influence of teak based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes
XXVI	Influence of teak based agroforestry system on seed yield (kg ha^{-1}) in legumes
XXVII	Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes
XXVIII	Influence of teak-perennial vegetable based agroforestry system on number of branches per plant at different stages in legumes
XXIX	Influence of teak-perennial vegetable based agroforestry system on number of leaves per plant at different stages in legumes
XXX	Influence of teak-perennial vegetable based agroforestry system on number of pods per plant at different stages in legumes
XXXI	Influence of teak-perennial vegetable based agroforestry system on leaf area ($dm^2\ plant^{-1}$) at different stages in legumes
XXXII	Influence of teak-perennial vegetable based agroforestry system on leaf dry weight (g $plant^{-1}$) at different stages in legumes

Appendix No.	Title
XXXIII	Influence of teak-perennial vegetable based agroforestry system on stem dry weight (g $plant^{-1}$) at different stages in legumes
XXXIV	Influence of teak-perennial vegetable based agroforestry system on pod dry weight (g $plant^{-1}$) at different stages in legumes
XXXV	Influence of teak-perennial vegetable based agroforestry system on total dry weight (g $plant^{-1}$) at different stages in legumes
XXXVI	Influence of teak-perennial vegetable based agroforestry system on leaf area index (LAI) at different stages in legumes
XXXVII	Influence of teak-perennial vegetable based agroforestry system on absolute growth rate (AGR, g $plant^{-1}$ day^{-1}) at different stages in legumes
XXXVIII	Influence of teak-perennial vegetable based agroforestry system on crop growth rate (CGR, g m^{-2} day^{-1}) at different stages in legumes
XXXIX	Influence of teak-perennial vegetable based agroforestry system on relative growth rate (RGR, g m^{-2} day^{-1}) at different stages in legumes
XXXX	Influence of teak-perennial vegetable based agroforestry system on net assimilation rate (NAR, g m^{-2} day^{-1}) at different stages in legumes
XXXXI	Influence of teak-perennial vegetable based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes
XXXXII	Influence of teak-perennial vegetable based agroforestry system on specific leaf area (g dm^{-2}) at different stages in legumes
XXXXIII	Influence of teak-perennial vegetable based agroforestry system on leaf area ratio (dm^{-2} g^{-1}) at different stages in legumes
XXXXIV	Influence of teak-perennial vegetable based agroforestry system on leaf area duration (days) at different stages in legumes
XXXXV	Influence of teak-perennial vegetable based agroforestry system on photosynthetic rate (µmol CO_2 dm^{-2} s^{-1}) at different stages in legumes
XXXXVI	Influence of teak-perennial vegetable based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes
XXXXVII	Influence of teak-perennial vegetable based agroforestry system on transpiration rate (mg H_2O m^{-2} s^{-1}) at different stages in legumes

Appendix No.	Title
XXXXVIII	Influence of teak-perennial vegetable based agroforestry system on relative water content (%) at different stages in legumes
XXXXIX	Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes
L	Influence of teak-perennial vegetable based agroforestry system on chlorophyll ‘a’ (mg g fresh wt^{-1}) at different stages in legumes
LI	Influence of teak-perennial vegetable based agroforestry system on chlorophyll ‘b’ (mg g fresh wt^{-1}) at different stages in legumes
LII	Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes
LIII	Influence of teak-perennial vegetable based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes
LIV	Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (nmol of NO_2 formed g fresh wt^{-1} h^{-1}) at different stages in legumes
LV	Influence of teak-perennial vegetable based agroforestry system on seed weight per plant (g) and 100 seed weight (g) and seed yield (kg ha^{-1}) at different stages in legumes

1. INTRODUCTION

The most serious challenge to plant physiologists involved in intercropping and agroforestry research is how to translate retrospective understanding into actual productivity increase. Physiologists and ecologists have long argued that a sound understanding of the processes and mechanisms involved in resource capture, use and their interactions with the environment is essential for the development of more reliable and productive systems (Trenbath, 1976 and Willey, 1979). It is therefore surprising that there is still considerable doubt concerning the impact of such understanding after the impressive accumulation of knowledge of intercropping in recent years (Fukai and Trenbath, 1993).

Competition between species in mixed stands differs from that between plants within monocultures in that the component species of intercrops may impose different demands on the available resources. The intensity of competition is greatest when site requirements are similar, to the point where species with over-lapping niches may be unable to co-exist within the same community. Vandermeer (1989) suggested that competition may be more severe between similar species than between species with contrasting growth habits. However, the opportunity for complementity of resource use between species is restricted by the fact that all plants are competing for the same and usually finite resources (light, CO_2, water, nutrients). Thus, there is extensive overlap between species in their resource requirements, with the partial exception of legumes which are fixing atmospheric nitrogen.

Plants growing in monoculture usually are of the same genotype and their growth and development proceeds synchronously. They are, therefore of a similar size and have equal access to available resources. Although, interplant competition is intense, this does not affect survival and reproductive success; indeed, there is good evidence that biomass accumulation and yield are unaffected by a wide range of populations above a specific threshold. Since each plant inevitably captures a decreasing proportion of the available resources as planting density increases, the initially linear relation between population and biomass become curvi-linear as competition intensifies above and below ground. The maximum attainable biomass for individual species depends primarily on the availability of light, water and nutrients. To increase productivity further, crops must either capture more of these resources or use them more efficiently.

The components of intercrops or agroforestry system often differ greatly in size, with the result that the growth of the smaller under storey species may be inhabited by shading, and possibly also by competition for water and nutrients. Competition for light is the primary limitation when water and nutrients are freely available. However, in many tropical systems, water (e.g. semi-arid regions) or nutrient availability (e.g acidic, leached or degraded soils) is the major limiting factor rather than light. It is not always straight forward to establish the primary limitation when more than one factor is marginal. For example, a species which establishes early has advantage in light capture through more rapid initial shoot growth may also exhibit greater root growth and hence resource capture because of the increased availability of photosynthates. This may in turn further improve shoot growth and light interception to the determent of the less competitive species in the mixture.

Mixed cropping systems offer considerable scope for improving seasonal water use in the semi-arid and arid tropics. For example, most annual cropping systems use only 30-35 % of the total rainfall, because much of this is lost by soil evaporation from sowing until the canopy closes, as runoff, or is left as residual moisture at final harvest. There is evidence that intercrops may make better use of available soil moisture than shorter duration sole crops and it may be postulated that agroforestry may be more effective still in increasing the proportion of rainfall used for transpiration and hence overall productivity.

The first of these is that the woody perennial component of agroforestry systems has a well established root system, at least after the initial establishment period. Thus, the woody species already has a substantial advantage in its access to below ground resources when the crop component is sown. This is also true for the capture of light unless the tree canopy is managed (e.g. by lopping or pruning) before sowing. Secondly, because of its size and age, the woody component has a considerable advantage in sequestering resources from a large area and in enhancing soil physical and chemical properties under its canopy (Kessler, 1992 and Belsky *et al.*, 1993).

In addition, organic matter content and total N, P, K and Ca concentrations were significantly higher and soil bulk density significantly lower under the tree canopies than in the open. Although several explanations have been offered for this phenomenon of micro site enrichment, the interactions involved are highly complex. There is nothing comparable in intercropping, particularly on this scale. Finally, it has been suggested that the woody species in agroforestry systems are capable of better spatial and temporal utilization of the available growth resources than annual species.

Our national goal is to have 33 per cent of land area under forest and other green cover. It is difficult for government to meet this goal due to several constraints in resource and operating systems. Therefore, there is wide scope for corporate sectors or large farmers to create commercial timber lands in order to reduce pressure on the existing natural forests. The priority is to provide a national focus on developing timber land on a large scale. The demand for timber is growing rapidly and hence commercial timber lands are imperative in order to reduce pressure on natural forests. The power of commercial forestry through application of science, technology and efficient management by farmers is well recognized. The risks are high but the rewards are much higher.

Teak is invariably raised under rainfed conditions. It is mostly confined to peninsular region below 24°latitude. The distribution is discontinuous throughout its range of natural occurrence. The natural teak forests are 8.9 m ha and new plantation are 2.8 m ha. The most important teak forests are found in Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, Kerala and parts of Uttar Pradesh, Gujarat, Orissa and Rajasthan. Farmers have choosen teak because of its higher timber value, ready market and assured returns. Hence, it is called as “Green gold”. Teak is one of the valuable species which can be successfully cultivated in agroforestry system and is considered as king of timber species. It is a deciduous tree, grows straight, and has cylindrical bole, sparse canopy and deep root system which together make it more suitable for agroforestry system. Its durability, strength properties, workability, polishing qualities and versatile utility offer a distinctive position in worldwide timber trade.

Whether the annual crops can be grown economically along with woody perennials is by and large an unsettled question. It is commonly believed that no herbaceous annual crop can successfully thrive and produce normal yield under trees, because of the so called root and shade effects. Not much research work has been done on the combination of trees and annual crops, especially under rainfed conditions. The reason for this paucity of information appears to be the dominance of entrenched notion that trees and annual crops are mutually incompatible (Nadagoud, 1990).

It is time that greater attention be devoted to economically and ecologically sustainable agricultural production systems, where present economic progress and prospects for survival will not be in conflict. Fortunately, agroforestry systems are characterized by this happy blend and help to exploit the natural resources thereby giving maximum returns to farmers from the available soil, water, nutrients and sunlight in addition to higher amounts of carbon being sequestered.

Agroforestry is a dynamic, ecologically based natural resource management system that, through integration of trees on farms and in the agricultural landscapes, diversities and sustains production to need increased social, economic and environmental demands for all land users at different levels (Anon., 2006).

Vegetables are one of the essential nutrient suppliers of our daily diet. Increasing the production of vegetables is our prior need which can be easily attained through their cultivation under different light levels permitted by the upper storey crop like trees. Multistoreyed agroforestry systems offer production of various vegetables under different shade conditions by maximum utilization of natural resources like photosynthetic active radiation (Islam *et al*., 2008). Vegetables can be integrated with forestry orchard or other agroforestry systems. Farmers use under storey crops to provide early returns diversified products and/or make more efficient use of land and labour. In general, most of the farmers have knowledge and experience to grow vegetables on the full sunlight farming system. There is an opportunity to expand vegetable production in the understory of agroforestry systems, but farmers have limited experience with such practices. Accordingly, the growth and production of vegetables would be impeded and decreased when vegetables were planted with agroforestry systems. Therefore, to prove farmers perceptions the present investigation was carried out to grow leafy perennial vegetables like curryleaf and drumstick in this study.

Legumes are large group of plants second to cereals as a source of food for man and as forage crop and the demand of legume crops is increasing rapidly due to the ever increasing population. The possible way of increasing the production of legume crops may be growing them with other crops or trees. Legumes are potential inter crops and are commonly grown with tall growing crops or trees. But legumes are sensitive to reduced light level and often suffer due to shading caused by associated crop. Growth of autotrophic plants is directly and dramatically influenced by light intensity, which is the driving force of photosynthesis and provides nearly all of the carbon and chemical energy needed for plant growth (Boardman, 1977). In any habitat, light intensity varies seasonally, diurnally and spatially. Yield reduction by shading will depend upon crop species as well as the degree of shading. The degree of shading is generally controlled by nature, age and characteristics of upper storey trees.

There is an opportunity to design more efficient and ecologically sustainable agroforestry systems to overcome physiological, biological, ecological and economic constraints, which can help to enhance production efficiency. Therefore, there is a need for research in agroforestry that is, integration of agroforestry research into the main stream of “Farming Systems Research”. The proposed technology which involves teak as a base perennial species with legume herbaceous intercrops and perennial vegetables with teak would aim to achieve the highest possible output per unit of land, water, time and labour.

Therefore, the present investigation is carried out with the following objectives:

1. To find out the influence of teak trees on growth and morphology of associated legume crops and perennial vegetables.
2. To find out the influence of teak trees on different growth parameters of associated legume crops and perennial vegetables in an agroforestry system.
3. To find out the influence of teak trees on different physiological and biochemical parameters of the associated legume crops and perennial vegetables in an agroforestry system.
4. Influence of teak trees on the yield and yield components of associated legume crops and perennial vegetables in an agroforestry system.
5. To study the compatibility of perennial vegetables in an agroforestry system.

2. REVIEW OF LITERATURE

The main aim of this literature review is to abstract and synthesize the existing knowledge on agroforestry system involving legumes and perennial vegetables particularly with regard to the physiological mechanisms associated with yield variation with potential application for integrated farming system.

This review has been organized into three main parts.The first part deals with understanding the concept of agroforestry and its components.The major focus is on the mechanisms underlying processes associated with resource sharing in both above- ground and below-ground resources.The second part deals with the influence of different tree species on the performance of inter crops.Major attention has been accorded on how various parameters are bound to get influenced, when crops are grown with tree species.The third part deals with the adverse and beneficial effects of association of various components in a agroforestry system.

2.1 Concept of agroforestry

Agroforestry is a practice of managing or using land that combines trees with agricultural or horticultural crops and livestock. It will satisfy changing human needs, to increase the living standards of rural and farming community, while maintaining the quality of environmental and conserving the natural resources. It improves soil physical and chemical properties and promotes nutrient cycling in addition to the intangible benefits.

It is felt highly essential that an integrated approach of land management to utilize the natural resources more efficiently and effectively in rainfed /dry land areas is a must to meet the requirement of the farmer and his livestock, without deteriorating the land productivity. One of the solutions to meet the basic necessities of mankind and his livestock appears to lie in agroforestry systems with judicious mix of crops, trees and grasses. Only when the natural and human resources will be efficiently utilized, productivity per unit of rain water optimized and returns per rupee invested maximized without any detrimental effects on environment (Singh and Singh, 1996).

The International Council for Research in agroforestry (ICRAF), Nairobi, Kenya which is undertaking a global inventory of existing agroforestry systems and practices defines agroforestry as an inter-disciplinary approach to systems of land use based on crop production, forestry, animal husbandry including pastures, aquaculture, land resource management and other disciplines, which all form the systematic background of land use.

According to Huxley (1983), agroforestry is a system of land use where woody perennials are grown with herbaceous crops in mixture zonally and / or sequentially with or without animals and the system provide greater benefits for the land use than agriculture or forestry alone. The agroforestry systems encompasses the related problems of soil management such as (i) sustained soil fertility, (ii) soil conservation, (iii) increased yield, (iv) diminished risk of crop failure, (v) ease of management and (vi) pest and disease control.

2.2 Choice of tree species for intercropping

Intercropping of trees help in incorporation of litter and lopped leaves every year. These act as green leaf manuring in situ and woody sticks can be used as fuel. Inclusion of top feed N–fixing genera help in mitigating the fodder scarcity and life saving of livestock in years of extreme drought. Most of the common N–fixing genera are *Acacia, Albizia, Calliandra, Hardwickia, Dalbergia, Pongamia, Prosopis, and Sesbania* etc. There are 640 species of nitrogen fixing trees known so far but their number is estimated to be around 4000 (Gerardo Budowski and Ricardo Russo, 1997).

The basic characteristics required for intercropping tree species are easy establishment, deep root system, fast growth, ability to coppice vigorously and high forage productivity. Further nitrogen fixing ability, coupled with a high foliar nitrogen content and rapid decomposition rate are other characteristics highly desirable for soil fertility maintenance (Kang *et al.,* 1984).

With livestock integration, the tree species should have fodder value and should be capable of producing good quality fodder throughout the year. Toxins and other anti–

nutritional substances should be absent or very low in foliage (Kang *et al.,* 1990). Nitrogen fixing trees in semi–arid tropics have two main roles, *viz*., productive and protective (Nair, 1984). The productive role includes the production of food, fodder, firewood and various other products; while the protective role covers soils improving and soil conserving functions.

Raising of nitrogen fixing trees (NFT's) in arable lands not only provides rich organic matter and atmospheric nitrogen, but also improves soil structure and prevents land degradation. Nitrogen fixing tree species offer immense possibility of supplementing the nitrogen requirement of crops through atmospheric nitrogen fixing and also through natural leaf fall, lopping or green leaf manuring. In semi arid tropics, it is important that organic matte supplies are to be replenished every year through leaves litter, crop residual etc. NFT's contributed to the soil fertility enrichment by the in situ fixation of N in soil and the return of nutrients to the soil through leaf fall. The contribution from 8 year old NFT was found to be 21.5 q of dry matter and 42 kg N/ha, respectively.

The intercropping of arable crops with nitrogen fixing trees viz., *F. albiza, A. ferruginea* and *P. cineraria,* increased the yield of sorghum and castor. Whereas, both the crops failed when intercropped with *L. leucocephal* mainly due to canopy cover. This shows the importance of canopy management for successful under cropping. *Faidherbia albida* is one of the best known soil improvement trees of the semiarid tropics (Vandenbett, 1992). The positive impact *of Faidherbia albida* trees are a common feature of areas with long cropping histories. Similar to other NFT's, soil properties below the crowns of *Faidherbia albida* are higher in available nutrients (Rhoades, 1995) and in total soil pools of carbon and nitrogen. The most unique feature of *Faidherbia albida* is that it exhibits reversed leaf phenology by shedding its foliage during the cropping season, its bare tree branches reduce evapotranspiration and increase relative humidity beneath the canopy without reducing crop production (Rhoades, 1997).

Hardwickia binata, nitrogen fixing tree species due to its erect growth behavior fits well in intercropping system. The tree of greater economic value for its timber has tiny leaves and the tree canopy is not dense which is quite favorable for crop production in its interspaces. *Hardwickia binata* has numerous advantages under wider spacing (Gill *et al.*, 1998).

2.3 Resource sharing in agroforestry

A mixture of herbaceous crop and tree in an agroforestry system will share resources each other (Moisture, nutrient, light and space). The resource sharing could be below ground and /or above ground. Nature of competition depends upon tree species, age and size of the tree and agricultural crops and availability of growth resources. There could be positive and /or negative interactions among trees and crops. It could be very difficult to separate resource sharing as it depends upon site, species and crops.

2.3.1 Above ground resources

Above ground resource sharing light and space depends upon the age of tree species and crops. The amount of light intercepted by trees depends on the amount of incident light and fraction of light intercepted through canopy, low light intensity is one of the important constraints for higher yield. The degree of shading to annual crops increases with an increase in the proportion of land occupied by trees in agroforestry.

The study on micro–climate variation around the tree cover by Harsha and Tewari (1988) revealed that in silvi-pastoral system of *A. tortalis*, only 14 to 30 per cent of total incident light was received around trees and were insufficient for the growth of grass. At Dharwad, highest light transmission ratio was observed in teak followed by *Eucalyptus, Leucaena* and *Casuarinas* (Chandrasekharaiah, 1986 and Bhat, 1988).

Reduced yield of cowpea adjacent to *calliandra* hedge rows was noticed due to shading (Gichuru and kang, 1989) and maize yields were reduced in the vicinity of the hedge rows of *Leucaena* (Lal, 1989)

Radiation varied form 15 to 60 per cent around *A. nilotica* trunk which interferes with the sorghum for light utilization in arid zone (Anon., 1992). On the other hand, radiation of 13 to 31 per cent variation around *A. auriculiformis* affected the blackgram yield (Anon., 1986).

Cowpea yields were higher due to better light interception under *Fatherbia albida* at Hyderabad (Anon., 1992). The maximum amount of photosysntetically active radiation (PAR) was observed under *F. albida.* Sorghum and horse gram yields were increased under trees as compared to sole cropping (Anon., 1992).

Nadagoud (1990) also observed maximum LTR in teak and minimum in *Sissoo* and *A. auriculiformis*. LTR was lowest near tree line and increased gradually with increasing distance from tree line. The reduction in LTR was 8, 33, 48 and 51 per cent under *Anjan, Eucalyptus*, *Neem* and *Sissoo*, respectively (Korwar, 1992). *A. nilotica* intercepted light probably resulting in decreased photosynthetic activities of wheat. With reduced photosynthesis, less energy is captured resulting in reduced wheat growth and yield.

Wheat grain yield decreased with increasing duration of shading (Nazir *et al.,* 1995). Maize yield decreased almost proportionately up to 50 per cent reduction in radiation (Anon., 1993). Crown shading of *Paulownia* had affected wheat grain yield and 1000 grain weight depending upon the distance from the trees as compared to control (Lang *et al.,* 1995). Maximum light intensity was recorded under open field and minimum with casuarinas (Maheta *et al.,* 1996).

Kaushal *et al.,* (2003) reported that at panicle initiation, milking and harvesting, minimum light was recorded in the close proximity of the tree at 1 m and 2 m distance. Light availability again increased with increased in distance from the tree base towards the outer side.The effect of shading, increased leaf area of an over storey, reduces the energy available for photosynthesis but also reduces the temperatures of soil and under storey leaves, this may increase or decrease productivity depending on the temperature relative to the optimum for a specific plant growth process.

Pruning, species selection, planting density and arrangement allow the agro forestry to reduce or increase tree transpiration, crop shading and shelter, which in turn influence temperature and humidity.

2.3.2 Below ground resources

Resource sharing for moisture and nutrients are relatively more important in agroforestry system. Lateral spread of roots and concentration of fine roots in soil upto 50 cm depth pose more competition for nutrients and moisture with other crops (Khan and Ehrenreich, 1994). Size of trees had less impact on yield than distance from trees. It is assumed that the reason for reduced yields may be due to competition between tree roots and wheat for moisture, nutrients and space. *A. nilotica* trees may be using/ recycling the soil resources such as water and nutrients, which were beyond the reach of wheat crops.

The soil moisture variation was due to water requirement of different tree species; soil moisture was 67, 91, 95 and 99 per cent in *eucalyptus, neem, sissoo* and *anjan,* respectively (Korwar, 1992). Soil moisture was maximum when trenched on both side of tree rows as compared to without trenching (Nisha Chopra *et al.,* 1993).

The profile of soil moisture storage decreased in cluster bean / pearl millet with *A. tortalis* as compared to sole crops (Sharma *et al.,* 1994). Trees require lesser quantity of nutrient for their growth as compared to annual crops. Trees absorb nutrients from deeper layers and pump to the surface of soil through litter fall. But, nutrient competition persists at early stage of tree growth as distribution of lateral and fine roots is within 50 cm depth.

Kaushel (2003) reported that the soil moisture and nutrients, reduced considerably at 1 and 2 m distance during all the growth stages of wheat. Available N, P and K in soil at sowing and harvesting under G*rewia* showed significant variation due to distance from the tree base. At the time of sowing, plots under the *Grewia* at 1 m and 2 m has less available 'N' as compared to 8 mtrs distance (control.)

Zegye (1999) reported that the significant soil moisture at 1 and 2 m distance at all other growth stages of wheat which can be attributed to the competition for moisture by the surfacial root systems of the tree, as most of the lateral roots spread of *Grewia* is confined within 2 m distance from the tree base. Competition for moisture in agroforestry systems is common occurring phenomenon, which can affect the systems adversely (Ong *et al.,* 1991 and Rao *et al.,* 1991). Lower content of nutrients in soil below tree is generally not accepTable hypothesis but negligible addition of leaf litter to the soil seems the reason for low nutrient content of the soil below their crown.

Monteith, *et al.* (1991) reported that removal of nutrients at 1 and 2 m distance was more as compared to other distance. Further, the majority of roots of *Grewia* generally remain in top 60 cm layer which is also nutrient sorption zone of wheat and thus might have created competition for nutrients.

The improvement of the nitrogen nutrition of the trees intercropped with a legume is a trailitation process (Vandermeer, 1989) that could compensate partially for the water competition process.

Dancette and Paulain (1969) found 40 per cent more organic carbon and nitrogen, exchangeable calcium and moderate increase in P and K in the soils under *A. albida* compared to soil away from the trees. *Subabul* recorded higher soil moisture as compared to *sissoo, casuarinas, eucalyptus, bamboo* and *teak* (Itnal, 1987 and Bhat, 1988).

2.4 Influences of different tree species on the morphological, growth, biophysical, physiological, biochemical and yield parameters of intercrops

2.4.1 Morphological characters

The plant height was significantly greater under poplars but manifested a distinct reduction in plant height due to increase in shade intensity to some level was also observed earlier in ginger and turmeric (Aclan and Quisumbing, 1976 and Lalitha Bai, 1981).

Mutanal (1998) showed that the plant height was significantly higher in sole groundnut (31.0 cm) compared to groundnut with teak + grass (27.8 cm), teak + subabul (27.7 cm) and teak (27.0 cm). Plant height was significantly lower with increased distance from 1 to 4 m from teak.

Bhatt (1988) reported that sole crop recorded maximum sorghum plant height of 111.75 cm and was significantly superior over inter crops. Further there were nonsignificant differences in plant height recorded under different tree species, except under bamboo which reduced the plant height (17.44 cm) considerably. Sole crop of sorghum recorded maximum number of leaves (22.0). At 9 m distance significantly higher number of leaves (13.91) was recorded with subabul than other tree species.

Kaushal (2003) reported that all the growth and yield attributes of wheat depicted significant reduction of varying magnitude underneath *Grewia.* Plant height and number of tiller per plants decreased significantly at 1 m distance compared to other distances. In ginger crop moderate leaves of shade exerts a positive influence on plant height (Aclan and Quisumbing, 1976; Jyachandran *et al.,* 1991). But, Lalitha Bai (1981) observed a negative effect of shadeon leaves and tillring. Jaswal *et al.,* (1993) reported a positive influence of shade on the number of leaves per plant.

Rodrigo and Adams (1972) considered leaf as an important functional unit of plant which contributed to the formation of yield in case of field bean. Kuo *et al.,* (1977) reported that the leaf number is an important parameter in the production of dry matter and yield in green gram. The leaf area index is mainly governed by the number and size of the assimilatory surface area.

A wide genotypic variability was reported among green gram genotypes with respect to number of leaves and number of nodes (Dodwad, 1997). He also found that the number of leaves varied with different stages of crop growth.

2.4.2 Dry matter accumulation

Plant growth, development and economic yield depend on dry matter accumulation and its distribution at various growth stages. Therefore, dry matter production at each growth stage and its partitioning to reproductive organs during pre flowering to maturity period has immense importance in determining the productivity.

Dry matter production in any cropping system is often linearly related to the quantity of radiation absorbed by its canopy, in the absence of other limiting factors (Monteith, 1981). This relation holds because the net photosynthetic rate of individual leaves increases linearly with irradiance up to a level where they become light saturated, whole canopy assimilation tends to exhibit a similar response, but with saturation occurring at higher irradiances because of the influence of canopy architecture and mutual shading on the irradiance incident upon individual leaves (Biscoe *et al.,* 1975).

Dry matter production is proportional to mean canopy photosynthetic rate because respiratory and photo respiratory losses of carbon generally comprise a conservative fraction of assimilation within individual species (Squire, 1990). The higher light saturated photosynthetic rates of C4 species as compared to C3 plants are reflected by differences in both conversion coefficients and maximum growth rates.

Significantly higher dry matter (33.60 g/plant) in sole cropping. Among the tree species, subabul, though resulted in higher dry matter of the crop at 3 and 9 m distances (15.37 g and 28.81 g / plant respectively), did not differ significantly with *sissoo* and *casuarinas* at 3 m distance and *sissoo* at 9 m distance. At 6 m distance, dry matter recorded under subabul (26.60 g/ plant) was significantly superior over other tree species.

Dry matter accumulation was lower due to decreased photosynthesis in paddy under shaded conditions (Hesse, 1984). Balasubramanian (1983) attributed the reduction in Yam yield in alley cropping to shade from *leucaiena* hedge rows which were managed as live stake for yam. Shading has been reported to cause loss in pastures (Sommarriba, 1988).

Total dry mater was significantly lower with association of groundnut with teak (21.9 g plant $^{-1}$), teak + grass (21.0 g plant $^{-1}$) and teak + subabul (20.6 g plant $^{-1}$) agro forestry systems compared to sole groundnut (37.1 g plant $^{-1}$).

Patro and Sahu (1986) reported that the adverse effect of low light was less with plants exposed to shade during the vegetative stage than with those exposed during the reproductive stage. Low light also significantly reduced total dry matter per plant; the reduction in total dry matter production was contributed by the reduced nitrogen metabolism as evident from the decreased nitrate reductase activity and soluble protein content.

2.4.3 Growth parameters

Growth analysis is a physiological probe on the development of the crop in chronological sequence to elucidate and account the causes for differences in yield through the events that have occurred at different stages of growth (Krishnamurthy *et al.,* 1973).

Leaf area is the major photosynthetic organ in plants, which generally expressed through the final dry matter production, under low light conditions considerable changes in leaf morphology occurred. At 25% PAR leaf area expansion was lower compared to 100% PAR condition.

Leaf area has been shown to be critical crop light interception which has substantial influence on crop yield in soybean (Sinclair and Dewitt, 1976).

Nijhawan *et al.* (1986) reported leaf area differed significantly among twenty five promising varieties of green gram. They further observed an increasing trend of leaf area up to 15 days after the initiation of buds and thereafter there was a steady decline in all the cultivars.

Total leaf area increased significantly in grasses, where as in legumes its increased slightly under shade condition (50% PAR). Increased in leaf area under reduced light level can be considered as an adaptation to compensate the total light harvest (Morita *et al.*, 1994).

Leaf area of groundnut was significantly higher in sole crop as compared to agroforestry system. The extent of reduction of leaf area was 53.46 and 56 per cent in association with teak, teak + grass and teak + subabul, respectively. Leaf area of groundnut was significantly reduced from 1, 2, 3 and 4 mts from teak row as compared to 5 m from teak row. The other interactions were not significant (Mutanal, 1998).

Bhat (1988) observed significantly higher leaf area (585.55 cm^2) in sole cropping compared to other treatments in sunflower + Pigeonpea cropping system. Among the tree species, higher leaf area was recorded under subabal at all the the distances, (216.95, 315.16 and 412.76 cm^2 at 3, 6 and 9 m distances, respectively).

Leaf area index is also known to be positively influenced by shade (Ravishankar and Muthuswamy, 1988). Lalitha Bai (1981) reported increased total content of chlorophyll, nitrogen, phosphorus and potassium percentages of green foliage with an increase in shade intensity. Crop under shade recorded more top growth and lesser nut yield (Anon., 2001).

Specific leaf weight (SLW) was lower in shaded plants than in the control plants (Rao and Mitra, 1988). The maximum specific leaf weight was obtained from 100 per cent PAR level.

The genotype showing little changes in specific leaf weight is less tolerant to low light. Because it is apparent that when light is the limiting factor for photosynthesis, then it might bring limited advantage from investing more leaf tissues in unit leaf area for photosynthesis. The plant with higher species leaf weight (thick leaf) possesses more mesophyll cells for photosynthesis.

Specific leaf weight is a sTable character and has served as important character in the selection of genotypes for higher yield in soybean (Dornhoff and Shibles, 1970). A positive association between specific leaf weight and photosynthetic rate was reported in soybean (Ford *et al.,* 1983). The specific leaf weight was initially low and improved subsequently and reached the maximum value at 42 days in green gram genotypes (Kalubarme and Pandey, 1979). Both specific leaf area and specific leaf weight made substantial contribution to seed yield and were found strongly associated with yield in greengram (Gopalsingh and Narainsingh, 1982).

Specific leaf weight of leguminous crops reduced drastically by low radiation. Singh (1997) similar observations of decreasing specific leaf weight cause of shading have been reported in tall fescue (Allard *et al*., 1991). Decrease in specific leaf weight means reduction of tissue available in a unit leaf area indicating the sensitivity of a genotype to a low light condition.

In an experiments conducted by Nag *et al.* (2000) on 3 promising black gram varieties, all the varieties showed maximum leaf area index at 52 DAE. Total dry matter per unit area at 66 DAE and crop growth rate at 59 DAE. RGR and NAR were maximum at 31 DAE. Among all the 3 varieties Barimosh –1 showed maximum LAI (4.42), CGR (0.2269 g/m^2/day), RGR (13.057 g/m^2/day), NAR and TDM (303.84 g/m^2 day).

According to Bangali and King (1987), the maximum crop growth rates of crop were 16 to 25 g/m^2/day. The average values of net assimilation rate were about 0.50 g/m^2/week. The average relative growth rate was found to be 0.59 g/g/week and the net assimilation rate (NAR). These positively correlated with bright sunshine hours.

The crop growth rate was found to be low during early vegetative phase, but increased with the advancement of growth in green gram (Kalubarme and Pandey, 1979).

The crop growth rate (CGR) was slow up to 15 days after sowing. The maximum dry matter was between 30-60 DAS. Significant genotypic and temporal differences were noticed with respect to net assimilation rate (NAR) and relative growth rate (RGR) of the crop. Yield was not limited by dry matter production but by it's partitioning to seeds (Shamboo Prasad and Srivastava, 1999).

2.4.4 Bio-physical parameters

The reduction of boundary layer conductance, increases day time temperature and daytime vapour pressure, increase in vapour pressure at the under storey surface then boundary stomatal conductance generally decreases causing a decrease in plant growth. If there is a decrease in vapor pressure then stomatal conductance increases and the amount of carbon fixed per unit of water transpired increases.

Nearly all land plants have stomata, some species have stomata on both sides and others have stomata on the lower side only. The main environmental variables to which stomata respond to photosynthetic quantum flux density, vapour pressure deficit, leaf water status, leaf temperature and internal CO_2 concentration. Shading by over storey reduces causing changes in stomatal conductance. Competition for water between over storey and undestroyed changes leaf water status. Therefore plants growing under tree may have different conductance from those grown in monoculture, changing their evaporation and photosynthetic rates. Conductance of a canopy is generally takes as average stomatal conductance multiplied by plant leaf area index.

Radke and Hagstrom (1973) also found that, while the sheltered soybeans were well watered, stomatal conductance was higher but transpiration lower than in the unsheltered plants; as water availability decreased, stomatal conductance decreased but transpiration increased in shelter compared with the unsheltered control. Shelter may bring about an increase in leaf area as well as an increase in transpiration per unit leaf area, so a sheltered crop may deplete water reserves earlier than an unsheltered crop. In a water limited environment, this may cause the sheltered crop to become stressed while unsheltered plants remain unstressed (Jensen, 1954).

Stomatal conductance in garden pea's genotypes grown with different PAR levels decreased with decreasing light intensities. The decrease of stomatal conductance in plants grown in shaded conditions was probably due to lower stomatal density (Allard *et al*., 1991). Similar results have also been reported by Allard and Nelson, 1991, Vandana and Bhatt 1999), they found that stomatal conductance was decreased mainly because of reduced number of stomata due to reduced light. Photosynthesis was reduced which was more or less coincided with mesophyll conductance reflecting the poor carbonization activity in the mesophyll. These indicate that carbonization efficiency (mesophyll conductance) decreased with decreasing light levels eventually affected the rate of photosynthesis to a greater extent than stomatal conductance.

This is clearly reflected that photosynthetic enzyme such as RUBP carboxylase might have some limitation under low light condition to fix CO_2. The photosynthetic rate decreased with decreasing light intensity or PAR levels. The rate of photosynthesis was reduced to about half of the control (100% PAR) under high shade *i.e.* at 25 per cent PAR but reduction was higher in some genotypes.

Under full sunlight larger quantity of tissue was distributed to leaves showing higher leaf weight ratio and contains more photosynthetically active cells, results in high rate of photosynthesis (Hoflacher and Bauer, 1982). The low photosynthetic rate on shade growth plants can be attributed to the lower RUBP carbaxylase activity (Ushuda *et al*., 1985) and lower stomatal conductance (Vandana and Bhatt, 1999).

Higher photosynthetic rate under normal light conditions, however under shaded conditions the rice cultivars suffered about 19 per cent reduction in Photosynthetic rate was recorded (Laza *et al.,* 2003).

Woledge (1977) suggested that the decrease in photosynthetic capacity of shade growth plants was attributed too both stomatal and mesophyll cells properties. High photosynthetic rate in high light intensity is found to depend on the higher stomatal and mesophyll conductance (Islam, 1994). Kubeta and Hamid, (1992) also reported that the reduction of photosynthesis due to low light condition in greengram and blackgram.

When a vegetation canopy is dry, evaporation comes under the physiological control of the plants, since it has to pass through the stomata or cuticle of the leaves. The rate of cuticular transpiration is usually very low, since the resistance to water, vapour transfer across the cuticle is at least an order of magnitude greater than when the stomata are open (Rutter,1975).The transpiration rate therefore depends on the bulk stomatal resistance of the entire canopy, or simply the 'surface resistance' (Monteith.,1965).

Transpiration from crops is controlled by the aerodynamic and canopy conductances. Canopy conductance takes account of both the physiological and morphological characteristics of the canopy since it is usually calculated as the sum of the product of leaf area index and leaf conductance for the various layers of foliage within the canopy. The contributions of leaf sheaths, pods and panicles must be included in such calculations since they may contribute up to 30 per cent of leaf conductance, and canopy transpiration and 15 per cent of the total water transpired between sowing and maturity (Batchelor and Roberts, 1983).

Transpiration is often controlled primarily through regulations of the transpiring area rather than leaf conductance during progressive drought (Black *et al.,* 1985). The main determinant of transpiration from open, stressed or senescent canopies is go but the aerodynamic conductance which is dependent on wind speed, may be important in tall, dense canopies, particularly at low wind speeds,. Depending on aerodynamic conductance, canopy conductance's of 1.5-2.0 cm s^{-1} are required before most crops can transpire at near the potential rate; to achieve this, a leaf area index of 3-4 and a mean leaf conductance averaged over the canopy of about 0.6 cm s^{-1} are required.

The windbreak and shading effect of the taller component of intercropping and agroforestry systems tends to reduce air temperature and wind speed and in case the atmospheric humidity experienced by the shorter component, thereby decreasing evaporative demand. The shorter component of inter crops, though not necessarily of agro forestry systems, is often a C_3 species with a low light saturated photosynthetic rate, and so the reduced PAR fluxes caused by partial shading may not reduce assimilation.

Haung shoubo (1998) reported that under shading condition the respiratory intensity and transpiration rate decreased because of the lower temperature and light intensity. Therefore under strong light conditions, proper shading was beneficial to tea plants growth due to the increase in effective photosynthetic efficiency.

Vandana and Bhatt (2009) reported decreased rate of transpiration and water use efficiency increased, while leaf diffusion resistance increased significantly with decrease light intensities. The water content in fresh tea sprouts increased under shade. The higher water content was beneficial to prevent the young sprouts from ageing (CAAS, 1986).

Chandrababu and Nagarajan (2008) studied the soybean grown under coconut garden and reported higher shoot height, internal elongation and lower leaf area index. Leaf net photosynthesis, crop growth rate and seed yield were also reduced under shade.

Light stress had an advance effect on the growth and yield of sword bean, plant height and chlorophyll content increased under low light conditions where as dry matter production, specific leaf weight and yield decreased drastically with increasing shade (Geeta *et al*., 2008).

2.4.5 Bio-chemical parameters

Chlorophyll content was positively correlated with net photosynthetic rate in cowpea (Amresh chandra and Bhatt., 1999). Decreasing the sink intensity there was a reduction in the rate of senescence as indicated by chlorophyll concentration in leaves and the rate of decline in photosynthesis was slowed down by the removal of pods in cowpea cultivars (Srivalli *et al*., 1999).

The genotypic variation in chlorophyll content has been reported in various crops (Singh *et al*., 1985). Genotypic differences in chlorophyll a, chlorophyll b and total chlorophyll contents among twenty four cultivars of soybean (different yield groups) have also been reported (Koti, 1997). There was an increasing trend of these parameters from 30 to 60 days after sowing and decreased thereafter irrespective of the cultivars.

Singh *et al.* (1994) found increasing trend of both chlorophyll 'a' and chlorophyll 'b' in green gram up to 45 days after sowing and declined significantly at 60 days after sowing.

Increase in chlorophyll is due to the tendency of the rice crop to enrich the assimilatory system to produce more photosynthesis and recommended that high total chlorophyll and low a: b ratio could be used as selection parameters to screen varieties for efficient photosynthesis at low light (Lin *et al*., 1984).

Kumar Rita (2001) reported that the total chlorophyll was higher in the leaves of the plants grown in less light intensity, whereas, the less light intensity hinders the total proteins, amino acids and total carbohydrates while it has promoting effect on the synthesis of total chlorophyll. There have been several reports of higher concentration of chlorophyll and chlorophyll a : b ratio in shade grown plants than in sun grown plants of sitka spruce (Lewandowska and Jarvis, 1977).

Synthesis of chlorophyll including Chlorophyll "a" and Chlorophyll "b" were promoted in the shade grown plants, in order to trap the available sun energy efficiently under shade condition (Muthuchelian *et al.,* 1989).

The chlorophyll content in tea leaves also increased with the shading degree. Therefore the photosynthetic efficiency and the utilization efficiency of light of tea plants under shading were relatively higher, that was particularly obvious on high temperature days (Haung shoubo *et al.,* 1998).

Total chlorophyll content was maximal under 50% light intensity in both plant species. Accumulation of chlorophyll b. increase but chlorophyll a decrease under low light intensities (Vandan and Bhatt, 2009).

Laxmi Prabha *et al.* (2004) studied that the effect of low light on various physiological attributes with reduction in light intensity. Chlorophyll content showed a progressive increase in rice cultivars.

The higher content under shade than in the open light conditions and longer exposure to shade significantly reduced chlorophyll content of the dry season adopted rice cultivars. The study shown higher SPAD values at this growth stages (Laza *et al*., 2003).

Nitrate reductase activity, the important enzyme involved in the nitrogen assimilation process and the key of metabolic regulation in crops was markedly influenced by the sources of nutrients.

Significantly less Nitrate reductase activity and soluble protein content was observed under control which might be due to reduction in enzyme level and poor nitrogen assimilation which led to less protein synthesis and also due to reduced plant growth and development (Sinha and Nicholas, 1983). Nitrate reductase activity indicator nitrate utilization was also significantly reduced under shade conditions. Both reduced enzyme activity and net photosynthetic rate could be attributed to the lowered whole plant biomass productivity.

The increased stomatal diffusive resistance in shade plants, associated with the low rate of transpiration. It is concluded that the biomass productivity of *Erythrina* species under shade condition is drastically reduced by low irradiance (Muthuchelian *et al.,* 1989). Under shade inhibition of nitrate reduction activity was associated with an increase in peroxides activity (Prakash *et al*., 1982).

2.5 Yield and yield components

In wheat, number of tillers was lowest near the trees and increased with distance from tree. The number of tillers at 1 m was significantly less than the number at any other distance. The weight /1000 grains were at a minimum at 1 m with a gradual increase up to 11 m. The grain yield was lowest near the trees and gradually increased with distance from the trees

The yield per plant and yield per hectare in ginger were maximum under 5 x 4 m spacing and minimum in pure crops (Khan and Ehrenreich, 1994 and Jaiswal *et al.,* 1993). Conversely, yield per plant and yield per hectare in turmeric were maximum under 5 m x 5 m spacing and minimum under 5 m x 3 m spacing. The data showed an increased of 145 and 199 per cent and a decline of 5 per cent in yield per hectare over control with increase in shade intensity. Mustard yield was significantly lower around unlopped trees regardless of whether the field was irrigated or not (Yadav and Blyth, 1996). The total soybean grain yield was 85, 84, 75 and 65 per cent under *Albizia, Mandarin, Alder* and *Cherry,* respectively compared to its yield as sole crop.

Maximum yield was recorded under subabul, followed by *safed Siris*, *Poplar* and *Mulberry* (Chauhan *et al.,* 1995). Mutanal (1998) observed significant difference in 100 kernel weight with sole groundnut (42.7 g) having higher values than groundnut grown with teak (32.0 g), teak + grass (32.5 g) and teak + subabul (31.5 g). Number of pods per plant was significantly higher in sole crop (8.90) and decreased in groundnut with teak (41 %), teak + grass (38%), teak + subabul (38%). Lower pod weight per plant was observed when groundnut grown with teak (11.6 g), teak + grass (11.7 g) and *teak + subabul* (11.4 g) as compared to sole crop of groundnut (20.4 g).

In about 17 years old *Acacia nilotica* based agri silvicultural system germination of soybean crop was severely decreased by 25.00 per cent to 14.28 per cent up to 6-7 m distance near the tree base compared to open plot. However, reduced to 9.37 to 3.13 per cent at a distance of 8 to 9 from the tree base. The reduction in yield was 33.13 to 23.43 per cent up to a distance of 7 to 9 m and 10.9 per cent after 9 m distance from tree base (Anon., 2000).

Arya and Rana (1999) studied 25 French bean genotypes and observed significant and positive correlations of green pod yield per plant with plant height, branches per plant and 100 seed weight.

Significant positive correlation with branches per plant and pods per plant in Frenchbean (Sahu and Das., 1996).

Leaf area and pod weight were positively correlated with green pod yield per plant and pod length had the greatest direct effect on pod yield, while direct but negative effects were observed for number of leaves per plant and average pod weight in cowpea cultivars (Mishra *et al.,* 1996).

In a field study with 430 short, medium and long duration germplasm accessions of blackgram, the seed yield was found to be positively associated with total duration of the crop (Ramaswami and Oblisami, 1984).

Total dry weight had a significant positive correlation with yield in green gram (Malik *et al.,* 1987).Total dry matter was positively correlated with yield in green gram though it was non significant (Gill *et al.,* 1992).

A positive association between CGR and yield was reported in chickpea (Prasad *et al.,* 1979). Sharma and Garg (1984) observed a significant positive association of seed yield with RGR during flowering and pod development stages in peas. The same relationship was further established by Gill *et al.,* (1992) in case of greengram.Relative growth rate at pod development stage was significantly associated with grain in gram (Prasad *et al.,* 1979).

Kaushal and Verma, (2003) reported that the grain and straw yield also depicted maximum reduction in the close proximity of the tree at 1 m distance, where about 51.9 per cent reduction was recorded as compared to control (8 m distance)

Further, yield improved linearly with increase in distance from the tree base. It was turned that growth and yield of wheat crop was influenced negatively below the tree crown, while it increased with increase in distances from the tree trunk.

The maize yield was 1280 kg/ ha in first year and 100 kg ha^{-1} in second year and in the third year it did not flower when grown with *Eucalyptus mellidora* planted with a spacing of 2.5 x 2.5 m and crops such as maize, sorghum and beans were inter planted (Redhead and Maghembe.,1982). The closer spacing of 2.5 m x 2.5 m was too close to permit sufficient light for maize and sorghum to grow after the first year. The yield of beans was extremely poor for the three year period.

Melkhania (1983) was of the opinion that the viability of tree herb associates is largely governed by physical factors viz., shade, moisture, nutrients and allelopathy.

Under Dharwad (Karnataka) condition, eucalyptus, *Tectona grandis* and *bamboo* had greater adverse effect on safflower yield in *rabi. Leucaena leucocephala* had the least adverse effect (Chandrashekharaiah, 1986).

Sheigh and Haq (1986) observed reduction of wheat yields up to 5 m distance from the tree rows in Thar Desert of Pakistan. Beyond about 30 to 35 m from the rows, there was a gradual increase in the yield of wheat. The same authors studied the effect of rows of poplar on the yield of sugarcane in Peshwar valley. They found that poplars reduced the tonnage of sugarcane crop at 0 to 10 m distance away from the study area was 75 t /ha. They opined that the trees in close vicinity to depressed agricultural crops, irrespective of the fact whether grown in rows or singly in the field. However, the effect varied from species to species and from crop to crop. For instance, *Eucalyptus camaldulensis* competed so intensively with cotton for moisture that it did not allow the seed to germinate within about 5 to 10 m distance.

Srivastava (1986) reported that the grain yield of *rabi* sorghum and safflower were reduced by 3 to 8 per cent and 13 to 18 per cent, respectively due to *Azadirachta indica* and *eucalyptus.* While *Acacia nilotica* reduced the yield by 42 and 46 per cent in *rabi* sorghum and safflower, respectively.

The experiment on Agroforestry systems in red soils of Bangalore revealed a reduction in crop yields by eucalyptus associated with agricultural crops. The effect was observed up to 3 m distance away from the tree line of eucalyptus which was closely followed by casuarinas. In another trail, it was observed that crop yield reduced from 11.6 to 58.3 per cent in different years due to subabul strips grown at 6 m. It was also noticed that the reduction in crop yield was much more when subabul was cut at 1.5 m height compared to lower cut at 0.45 m (Anon., 1987).

2.6 Beneficial effects

Agroforestry involves mixture of species with different kinds of plants, one of which at least is a woody perennial. If such associations are to be selected and managed optimally and they are to be understood properly, the success of the existing agroforestry plant associations and their effects cannot be ignored. It is often facility assumed, even by proponents of agroforestry, that the addition of tree to a field crop production, although the additional tree crop production may offset this decrease. There is a notion that the trees being the dominant partner in the association will compete with under storey crops particularly for light and that as a result of this competition; the arable crop yields are depressed. The woody perennials have deep and spreading roots and a large crown through which there is expected to be competition for soil moisture and radiant energy. The under storyed crops may suffer from lack of moisture and shade effects .The adversely and / or beneficial contribution of a given agroforestry system, therefore , depends on factors like type of genotypes involved , the proportion and arrangement of trees, the types of farming situations and climatic parameters and other environmental conditions which affect the component crops in such system.

Field crop grown in association with certain tree species are reported to have been greatly benefited. With regard to intercropping with food and fodder crops and soil fertility improvement, *Prosopis cineraria* is a more useful species than *Prosopis juliflora.* There is a long standing tradition of growing pearl millet under *Prosopis cineraria* in the arid zones of India. Results of the investigations conducted at the Central Arid Zone Research Institute (CAZRI), Jodhpur, over the past 20 years on the *Khejri* trees (Mann and Sexena, 1980). Khattack *et al.* (1980) reported higher yield of wheat under *Dalbergia sissoo* was higher (1996 kg ha^{-1}) compared to the crop grown in association with *Populus detoides*, *Eucalyptus citridora* and *Bombyx ceiba*. The yield from control plots was 2000 kg per hectare on an average.

The investigation carried out at Bellary, Karnataka revealed the adverse effect of trees on crop growth and yield of sorghum and safflower was less in the early stage of tree growth due to lesser shading and competition for moisture. The adverse effects were found increasing after three years of planting when shading was observed over a distance of 2 to 3 m by *Acacia nilotica*, 1 to 2 m in *Azadirachta indica* and *Eucalyptus* (Anon., 1984).

Interplanting of soybean with eucalyptus in a two tier system of agroforestry stated that the best soybean and wood production was obtained with five rows of soybean at 0 to 5 m apart in between two rows of *Eucalyptus grandis* in Brazil (Cauto *et al*., 1984).

An excellent advantage of agroforestry system has been given by Singh and Korawar (1986) who have suggested suiTable agro forestry systems for dry lands to augment the income and to bring in more stability in production. According to him, cropping without tree culture is incomplete.

Rhoades (1997) compared sorghum planted away and under *Acacia albida* with and without fertilizer and found that sorghum yield was double and groundnut yielded nearly 30 per cent more under the trees. Kulkarni *et al.,* (1970) found that growth and yield of *rabi* sorghum and cotton grown in association with *Prosopis cineraria* were better than crops grown away from the tree in black soils of Karnataka. Similar results were reported by Charreau (1974) for millet. Crops grown under Acacia canopies produced 150 per cent more yield than crops grown in open space. Poschen (1986) has shown yield increase of 76 per cent for maize and 36 per cent for sorghum grown under *Acacia albida*. An examination of the yield components showed higher 1000 grain weight and more grains per plant for the crops grown under *Acacia albida*. In an exhaustive study with *P. cineraria* and *Acacia albida* under semi – arid region at 3 spacings with green gram and cluster bean as intercrop indicated that seed production of green gram and cluster bean was not affected by *P. cineraria* or *Acacia albida* (Shankaranarayana and Harsh, 1986). Khydri *et al.,* (1988) observed that the crop yield was significantly affected due to distance from tree line. When trees were planted at 5 m apart, the tree species had depressing effect on crop yield.

Performance of wheat was superior with indigenous *Dalbargia sissoo* compared to the exotic *P. deltoids* (Singh *et al.*, 1999). Growth and yield of wheat was reduced more in fields shattered by the exotic *P. deltoids* compared to the indigenous *D. sissoo*.

Alley cropping, especially with *Leucaena leucocephala*, reduced the crop yield. Intercropping of annual crops with *A.albida* did not produce conclusive results after 3 years, while intercropping with *L. leucocephla* reduced crop yield. Plans for erosion control studies are outlined (Pelter *et al.,* 1988). Jha *et al.,* (1991) reported that soybean gave highest average yield (6.32 q ha^{-1}) over all tree species followed by sesame (5.67 q ha^{-1}), horsegram (4.57 q ha^{-1}) and niger (3.02 q ha^{-1}). Yield of mango was not significantly affected by intercropping, but the height and spread of trees inter planted with banana and cassava was significantly greater than those of control mono cropped trees (Bhuva *et al.,* 1989). There was a reduction in yield of all the crops inter planted in the plantations compared with the control (outside plantation), but the reduction was minimum with tamarind because of less canopy. Lentils, gram, sorghum, berseem, wheat and rice could be grown successfully with tamarind without much reduction in yield, but with teak, only berseem and gram could be grown (Dagar *et al.,* 1995).

Musvoto and Campbell (1995) managed to optimize the yields of both intercrops and mangos. Mango trees on crop lands were widely perceived as having a positive effect on soil fertility and soil moisture and a negative effect on crop yield. Total grain weights were recorded for the wheat samples and height (average 9 m), dbh (diameter at breast height) and crown diameter for the trees.

Reduction in wheat yield was found upto 18.29 m from the *sisham* rows and 19.51 m from the mango rows, but reductions were much higher with mango than *sisham* (Muhammad, Afzal and Muhammad, Hafeez, 1997).

Aerial biomass yield of sorghum was higher near the tree and decreased continuously with increasing distance. Similarly, yields become much smaller and randomly distributed beyond the distance of 2.0 m crown radia (Vercumbe, 1993). This information is important particularly in determining appropriate tree spacing for the derivation of maximum benefits in both forestry and agroforestry systems. The positive impact of *F. albida* on crop yield and soil fertility has long been recognized. Scattered and matured *F. albida* are a common feature of areas with long cropping histories. Across Africa, yields of maize, millet, groundnut and sorghum range from 30 to 200 per cent higher beneath *A. albida* canopies compared to surrounding area (Saka *et al.,* 1994).

An experiment was initiated to elucidate the influence of some ecological parameters and population density of *H. binata* on growth and yield of intercrops, viz, black gram or soybean and Indian mustard. Results revealed that the difference in crop yield was less between sole crop and a population density of 200 trees per ha at the 5th year of tree age (Bisaria *et al.,* 1995) and growing of 200 trees per hectare with arable crops as intercrop was found more advantageous than either of the sole crops.

Khan (1975) observed that the damaging effect of *D. sissoo* trees was only upto 6.0 m. The yields between 6.0 and 11.0 m were higher than in the control. *A. nilotica* showed higher damaging effect than *D. sissoo*. The higher reduction in yield might be due to an allelopathic effect, rooting habits and the size of these trees. Better yield of wheat crop was recorded when grown in close proximity to trees (Bheemaiah *et al.,* 1992).

Akbar *et al.,* (1990) reported the tree's impact on wheat yield up to 2 m distance, little impact up to 6 m and almost no impact at 8, 10 and 12 m distance from tree base.

2.7 Effects of teak on associated field crops

The compatibility of associated crops with trees in agroforestry depends upon site, soil, climatic factors, age, size and type of tree species. Crops differ in their compatibility with teak based on site conditions and availability of growth resources. Commercially regenerated teak was grown with crops, viz., corn, tapioca and tobacco (Gilbert, 1929). In taungya, dry rice, maize and peanut were grown successfully with teak plantation (Coster and Hardjowasono, 1935). In Madras state, paddy, chillies and ginger gave significantly better yields without causing any decrease in height of teak (Anon., 1947). It was reported that the crops like hill paddy, chillies, ragi, tapioca, horsegram, ginger and blackgram can be grown along with teak, without loss of height (Anon., 1949 and 1955). The better growth of maize, ragi and rice were observed in associated with *D. sissoo* and *T. grandis* (Mishra, 1979).

Food crops (rice, maize) were grown in teak planted at 4 x 2 m^2, 5 x 2 m^2 and 6 x 2 m^2 spacing for five years without reduction of yields (Arifin, 1983). Nair (1980) reported that black pepper; cocoa and medicinal plants were grown under teak without affecting the growth of teak. Maize, paddy, ginger, turmeric, pineapple, long staple cotton were grown in teak plantation during early stage without reduction in yield (Sibtain *et al.,* 1983). Maize yields were reduced when grown in teak planted at 1.8 x 1.8 m^2 due to poor light availability to maize (Vericumbe and Okali, 1985).

At Dharwad, grain yield of maize was less with teak (42%) and bamboo (51%) compared to control (Chandrasekharaih, 1986). Lowest yield reduction of *rabi* sorghum was with teak and subabul (Itnal, 1987). The yield reduction decreased with increasing distance from the tree alley and lowest run off was collected through alleys of teak, casuarinas and subabul. At Prabhunagar (Dharwad), *D. sissoo* and teak had no adverse effect on the yield of rice compared to eucalyptus, casuarinas and *Albizia molucana* (Nadagouda *et al.,* 1988). Crops like maize and cassava were grown without any loss of yield with teak Agroforestry system in Georgia, USA (Wojtkowski *et al.,* 1988). Teak growth and yields of paddy and pulse crops were not much affected by their combinations (Kapp, 1988). Early growth was not affected by crop combinations viz., rice, sorghum, groundnut and sesame (Watanade *et al.,* 1988). Crops were grown for 15-20 years in teak plantation of 8 x 8 m^2 spacing (Gajaneni and Jordan, 1989).

Teak growth was not affected when grown with turmeric or ginger in West Bengal (Lahiri, 1989). Niger yield was maximum with the combination of teak at Ranchi without affecting its growth (Jha *et al.,* 1989). Groundnut yield reduction was minimum with *D. latifolia* (18.8%) followed by *teak* (20.4%) and *eucalyptus* (41.6%) in four years of planting under irrigated conditions (Nadagoud, 1990).

Teak plantations were established by growing rice without affecting the teak growth (Chantraprapa, 1991). In taungya cultivation, combination of teak with agricultural crops or pastoral crops did not affect height, mean annual increment in height and dbh (White, 1991). In Jawa Social Forestry Programme (JSFP) degraded forest land was assigned to tribal for growing of crops and teak. The survival of teak seedlings exceeded 90 per cent and crop yields were not much affected by it (Sunderlin, 1992).

Teak is one of the deciduous tree, the leaf litter is another important factor. The leaf litter usually starts from following the monsoon rains and varies with places (Mutanal, 1998). Maximum litter fall occurs during November-December in Uttar Pradesh (Omkar Singh, *et al.,* 1993); December-February in Kerala (Sudheendra Kumar *et al..* 1993).

Leaf fall exerts an important influence on physical, chemical and biological characters of soil and thus balances the nutrients of soil resource. Tree leaves are periodically or continuously dropped on the ground to form litter, which decomposes in time to release the nutrients contained therein to the soil from where they are recirculated (Agarwal, 1987).

Pepper vine yields were highest from plants grown in teak in Kerala under rain fed conditions (Kurien *et al.,* 1994). Teak Plantations were intercropped with paddy, ground nut, pulses for the first 2-5 years without any reduction of teak growth or yield (Roder *et al.,* 1995). Teak trees were much benefited by growing of crops like berseem and greengram in the inter space of teak for the six years as additional care like water and nutrient management was given for field crops (Dagar *et al.,* 1995).

Paris *et al.,* 1995, reported that growing of perennial leguminous species as intercrops may reduce the growth of trees if compared to weeded or mulched trees.

A high nitrogen availability stimulates leaf expansion and net assimilation flux density and may reduce photosynthetic photo inhibitions in high radiance (Field *et al.,* 1983).

2.8 Effect of other trees

Two or more species when grown in agroforestry, both positive and negative interactions are expected. Competition between trees and crop depends upon site factors *viz*., climate, soil, physiographic and biotic factors. Rabi sorghum yields were considerably low upto a distance of 28 m from *P. Juliflora* in black soils of Bellary (Prajapati *et al.,* 1971). The study conducted on compatibility of crop and tree associated that the yield of wheat reduced significantly with *E. comaldulensis, P. deltoids and B. ceiba* compared to *D. sissoo* (Khattack *et al.,* 1980).

The reduction in the yield of maize was higher with *bamboo* (51%), teak (24%) followed by *eucalyptus* (28%) and *casuarinas* (23%) at Dharwad (Chandrashekharaiah, 1986). Rabi sorghum yield was low with *A. nilotica* (89.8%) followed by eucalyptus (74.3%) compared to sole crop (Itnal, 1987).

Eucalyptus trees planted on field boundaries reduced the yield of annual crops by 46 and 49 per cent in the 9^{th} and 10^{th} year of planting respectively (Ahmed, 1989). Groundnut yield reduction was maximum with eucalyptus (41.6%) and *subabul* (26.3%) after four years of tree planting (Nadagoud, 1990).

In agroforestry studies at Solan (Himachal Pradesh), significantly lower grain yield of wheat was obtained with mulberry and poplar compared to *sirsal, subabul* and sole crops (Chauhan *et al.,* 1995).

Grain yield of agricultural crops (gram, mustard and Indian bean) grown in association with trees *viz*., *Adina cordifolia* and *G. arborea* decreased as compared to sole crops (Maheta *et al.,* 1996). Sorghum fodder yield was increased with increase in the distance from tree rows (Sharma *et al.,* 1996).

Many authors have reported beneficial effect of trees on crops. Sorghum yield was doubled and groundnut yielded nearly 3 per cent more when grown with *F. albida* (Charreau, 1974). Sorghum yield increased by 76 per cent under *A. albida* (Poschen, 1986). The *P. Cineraria* and millet was best mixture in eastern Rajasthan (Manna and Saxena, 1980). The productivity of mungbean was increased with *P. cinera*ria and *A. albida* compared to sole cropping (Shankaranarayan *et al.,* 1987) at Jodhpur. Sorghum grain yield was highest (1248 kg/ha) with *A. indica* and least with *A. nilotica* at CRIDA, Hyderabad (Anon., 1990). At Kovilipattti, sorghum yield was highest with tamarind (10.32 q ha^{-1}) and reduced significantly with silk cotton (4.79 q/ha and casuarinas (3.42 q ha^{-1}) (Anon., 1995). In groundnut + Mahuwa association, groundnut recorded highest yield and lowest was in Siris and Vamkanti (Anon., 1996).

Verma *et al.,* (2004) reported that wheat variety HD–2380 produced maximum grain yield (22.17 q/ha) when grown as intercrop in peach plantation and produced grain yield of 26.00 q/ha in sole crop system. Similar results were obtained by Corlett *et al.,* (1992), Salazar *et al.,* (1993), Decosta and Chandrapala (2000).

In an experiment conducted at Raipur, Chattisgarh, India, soybean was intercropped under five poplar clones. The results revealed that shoot biomass, root biomass and nodules were highest in sole soybean. Grain yield was highest (14.5 q/ha) in sole crop and decreased under poplar clones. It reduced from 2.00 to 33.00 per cent under different clones (Mishra *et al.,* 2004).

Swamy *et al.,* (2003) observed 20.35 per cent of less photosynthetically active radiation (PAR) under high LAI stands in 2 x 2 m^2 of *Gimelian arborea,* which was responsible for 28 per cent reduction in soybean yield.

In a field experiment on rice based agri silviculture system with two tree species viz., *Acacia auriculiformis* and *Casuarina equisetifolia* planted at 2 spacings (5 x 2, 10 x 2 and 15 x 2 m^2), the yield of rice in interspaces of both the tree species reduced compared to no tree control. The reduction in yield attributes, grain yield and straw yield of rice decreased with increasing tree row spacing. At closer spacing of 5 x 2 m, the reduction in grain yield of rice was to the tune of 33.00 per cent and 26.00 per cent when grown in between two rows of *Casuarina equisetifolia* and *Acacia auriculiformis* respectively (Thaware *et al.,* 2004).

Crop distance from poplar tree line significantly affected yield of wheat and mustard crop upto 4 to 6 m from tree line, depending on the age and growth of the tree and the maximum reduction was within 3 m from tree base (Sharma *et al*., 2000).

In a field experiment on *Eucalyptus tereticornis* based agri silviculture system, five test crops viz., wheat, berseem, potato, mustard and lentil were sown as intercrops. All the test crops sown in the interspaces of eucalyptus showed reduced plant vigour interms of plant height, stem diameter, number of branches and yield attributes compared to control. The yield of lentil, berseem, wheat, potato and mustard under eucalyptus decreased to the tune of 16.3, 52.1, 62.3, 80.8 and 82.4 per cent, respectively. Lentil, recorded least reduction in yield, however, from gross income point of view, wheat was found most economical crop under eucalyptus (Kumar and Nandal, 2004).

The yield reduction under eucalyptus plantation was higher in low water requiring crop of mustard than in the higher water requiring crop of wheat (Malik and Sharma, 1990).

In an experiment conducted at Dharwad, Karnataka state, India, soybean was grown as intercrop with six different tree species viz., *Mangifera indica, Prosopis cineraria, Dalbergia latifolia, Ceiba pentandra, Azadiachata indica* and *Tamarindus indica*. The plant height of soybean was increased significantly under *prosops cinenaria* and *Ceiba pentandra* reduced the plant height. Leaf dry matter was highest under *Prosopis cineraria* and lowest under *Ceiba pentandra*. Maximum soybean leaf dry matter was observed in sole soybean compared to other tree species. The grain yield was reduced up to and extent of 77.00 per cent. Effect of *Prosopis cinerararia* was least in reducing the yield (Padeyannavar, 2002).

3. MATERIAL AND METHODS

The investigations of the present study were taken up on an ongoing experiment (initiated in the year 2001) of All India Coordinated Research Project on Agroforestry during *Kharif*, 2007 and 2008, to study the performance of legumes and perennial vegetables in a teak based agroforestry system. The details of the materials used and techniques adopted during the course of inv estigation are described in this chapter. The investigations involved two experiments, the first one with teak as perennial component and four pulses as arable crops. The second one consisted of teak with two pulses along with short rotation vegetables.

3.1 Experiment-I: Physiological investigation on legumes in a teak based agroforestry system

3.1.1 Experimental site

The experiment was carried out during *Kharif,* 2007-08 and 2008-09 in "I" block, agroforestry experimental fields, Main Agricultural Research Station, University of Agricultural Sciences,Dharwad which is located at 15°26' North latitude, a longitude of 75°0' east and altitude of 678m above mean sea level. It is situated in transitional tract, representing Northern transitional climatic zone (zone 8) of Karnataka.

3.1.2 Soil and its characteristics

The experimental area was medium deep black soils in nature. The composite soil sample was collected from 0-15 cm soil depth from the site before the initiation of the experiment. The soil sample was air dried, powdered and allowed to pass through 2 mm sieve and was analyzed for physical and chemical properties (Table 3).

3.1.3 Climatic conditions

The data on climatic parameters such as rainfall (mm), mean maximum and mean minimum temperature (^{0}C) and relative humidity (%) recorded at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during the experimental year and the mean of the last 57 years (1950 – 2007) are presented in Table.1 and Fig.1.

A total rainfall of 1081.10 mm was received during 2007 and was more than the average rainfall (761.98 mm) of previous 58 years by 42%. Major proportion of the rainfall was received during the months of June, July, August and September with heavy rains in June and July. The highest mean monthly maximum temperature was recorded during April (36.7 ^{0}C) which is 0.36 ^{0}C higher as compared to the average maximum temperature of 58 years for the same month. The lowest mean monthly minimum temperature was recorded in January (14^{0}C). Relative humidity was higher during July, August and September months. The total number of rainy days (67 days) was more than the average of previous 36 years (56.17 days).

Meteorological data for the year 2008 recorded at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad is given in Table 2 and Fig. 2.

A total rainfall of 956.80 mm was received during 2008 and was more than the average rainfall (777.95 mm) of previous 59 years by 23%. The onset of monsoon was regular during this year, however there was long break of 40 days from second fortnight of June and first fortnight of July. As usual major proportion of the rainfall (77%) was received during four months of monsoon i.e. June, July, August and September. The highest mean monthly maximum temperature was recorded during May (35.7 ^{0}C) which is 1.16 ^{0}C lesser as compared to the average maximum temperature of 59 years for the same month. The lowest mean monthly minimum temperature was recorded in January (12.9 ^{0}C). Relative humidity was higher during June, July, August and September months. The total number of rainy days (60 days) was more than the average of previous 37 years (56.27 days).

Table 1: Monthly meteorological data during 2007 and the average of last 57 years (1950-2007) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2007	1950-2007	2007	1950-2007	2007	1950-2007	2007	1950-2007
January	-	0.81	30.4	29.46	14.0	14.29	72	68.63
February	-	1.08	31.9	32.31	15.7	15.90	67	62.17
March	12.8	6.51	35.3	35.05	19.7	18.73	49	62.13
April	86.4	48.26	36.7	36.34	21.4	20.23	55	62.65
May	65.0	80.34	34.6	36.88	21.3	20.93	61	66.66
June	220.1	111.75	29.7	29.25	21.3	20.73	80	80.97
July	211.2	149.94	27.0	26.58	21.1	20.72	85	86.22
August	176.0	98.76	27.1	26.62	20.5	20.20	85	82.30
September	180.8	104.00	27.2	28.10	20.3	19.81	83	81.52
October	74.8	125.28	29.7	28.75	19.4	18.82	68	71.33
November	54.0	30.94	29.5	28.58	15.1	15.91	53	72.10
December	-	4.30	29.0	28.64	14.6	13.58	65	71.34
Total	**1081.1**	**761.98**	**-**	**-**	**-**	**-**	**-**	**-**
Mean	**-**	**-**	**30.68**	**30.55**	**18.70**	**18.32**	**68.58**	**72.33**

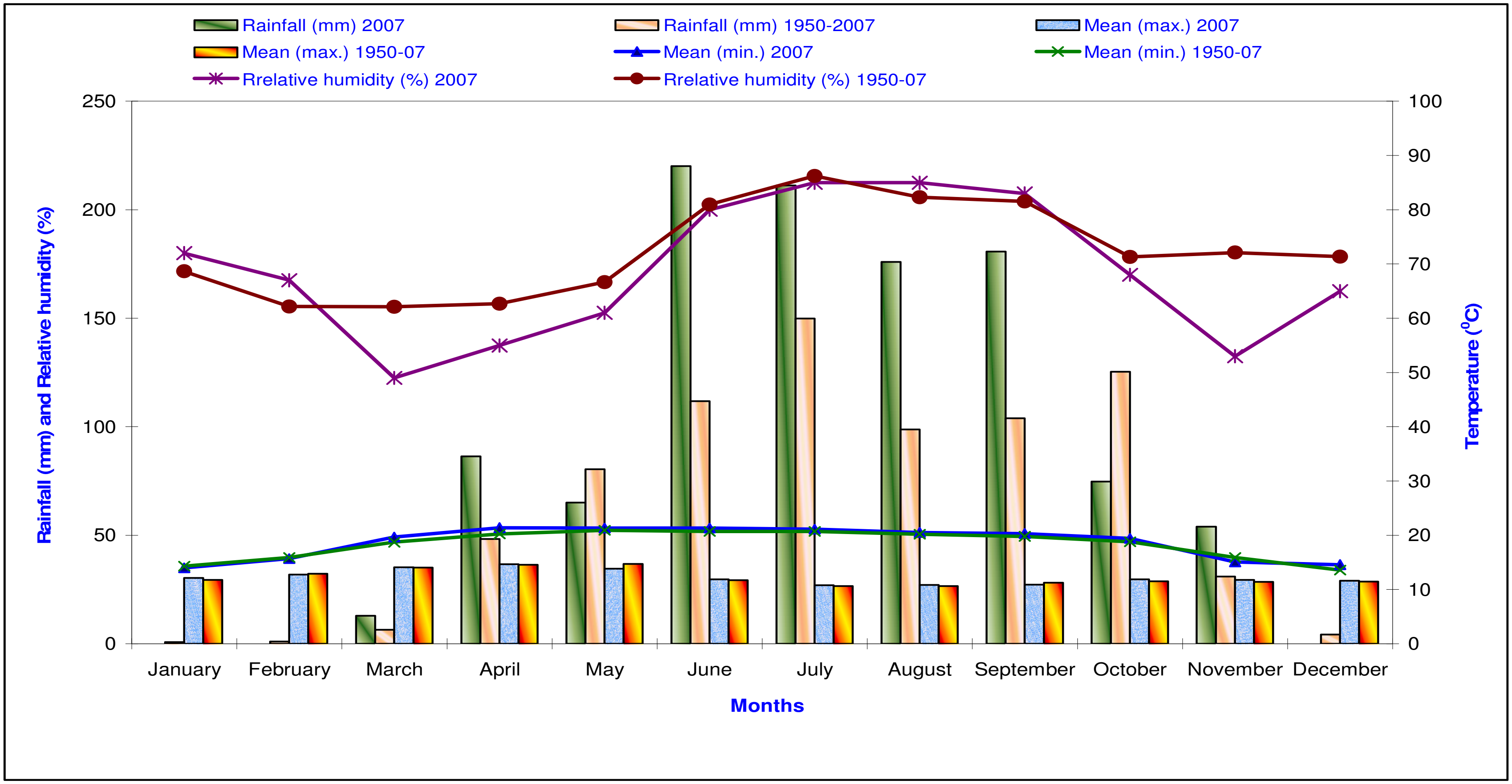


Fig. 1: Monthly meteorological data during 2007 and the average of last 57 years (1950-2007) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

3.1.4 Previous crops grown on experimental area

Safflower was grown during *rabi* season of 2006 and 2007 with recommended package of practices in the experimental site.

3.1.5 Experimental details

In an ongoing agroforestry experiment, teak was planted during the year 2001 at 8 m alleys (2 m intra row spacing). Legume crops viz., Soybean, Frenchbean, Greengram and Blackgram were grown in between teak alleys. The details of the experiment are presented in Table 4.

3.1.5.1 Design, layout and replication

The experiment was laid out in factorial randomized block design with four replications (Fig. 3 and Fig. 4).

3.1.6 Cultural operations

3.1.6.1 Legumes and teak

In this experiment, legumes were grown in teak based agroforestry system in a single unit. Following four legumes which are predominantly grown in this area are selected for the study.

3.1.6.2 Soybean (*Glycine max* L.)

Soybean (*Glycine max*. L. Merill) is known as Golden bean or Meracle crop of the 20^{th} century because it is a versatile and fascinating crop with innumerable possibilities of not only improving agriculture but also supporting industries. Soybean, besides having high yield potential (30–35q ha $^{-1}$), also provides chlotesterol free oil (20%) and high quality protein (40%). It is a rich source of amino acids, vitamins, minerals, fats and related metabolic attributes. Its edible oil contains about 1.6-3.1 per cent lecithin which is essential for building up of nerve tissue. Its oil is also used as raw material in manufacturing antibiotics, paints, varnishes, adhesives, lubricants, etc.

Soybeans are an important global crop, providing oil and protein. In the United States, the bulk of the crop has its oil solvent-extracted with hexane, then the "toasted" defatted soy meal (50% protein) makes possible the raising of farm animals (eg. chicken, hog, turkey) on an industrial scale never before seen in human history. A very small proportion of the crop is consumed directly by humans. Soybean products do appear in a large variety of processed foods.

In Karnataka, it is grown on an area of 65,000 hectares with a production of 43,000 tonnes and a productivity potential of 696 kg ha^{-1}. In addition, it is also necessary to increase the cultivable area of soybean in Karnataka. In this direction, transition tract of Karnataka with an annual rainfall of 750 to 800 mm fairly well distributed from June to October offers a good scope for the cultivation of soybean on both and black soils. Besides, farmers are interested to cultivate soybean in rabi / summer in paddy fallows and also in command areas for its increased demand by crushing industries and for its remunerative prices prevailing in the market. Soybean is also credited with the fixation of atmospheric nitrogen through symbiotic process. In addition, being monocarpic in nature, it sheds its leaves after physiological maturity and thus enhances soil fertility. Soybean is typically a sort day plant, but there can be grown in partial shaded conditions. Hence, soybean is become a sustainable crop in agroforestry systems.

Table 2: Monthly meteorological data during 2008 and the average of last 58 years (1950-2008) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2008	1950-2008	2008	1950-2008	2008	1950-2008	2008	1950-2008
January	-	0.81	29.7	29.46	12.9	14.27	46	67.82
February	-	1.08	31.1	32.29	16.3	15.91	49	61.70
March	111.0	8.42	32.4	35.01	18.9	18.73	53	61.80
April	29.2	48.76	34.7	36.31	20.4	20.23	57	62.45
May	55.8	81.30	35.7	36.86	20.6	20.92	63	66.53
June	101.6	113.50	28.6	29.24	20.9	20.73	83	81.04
July	121.0	152.03	28.2	26.61	20.7	20.72	82	86.07
August	213.2	102.44	26.9	26.62	20.1	20.20	83	82.33
September	162.4	106.80	27.7	28.09	19.8	19.81	81	81.50
October	60.4	126.32	30.3	28.78	18.6	18.82	67	71.18
November	72.2	32.18	29.3	28.59	15.9	15.91	61	71.70
December	-	-	28.6	28.64	13.8	13.58	58	70.86
Total	**956.80**	**777.95**	**-**	**-**	**-**	**-**	**-**	**-**
Mean	**-**	**-**	**30.27**	**30.54**	**18.24**	**18.32**	**65.25**	**72.08**

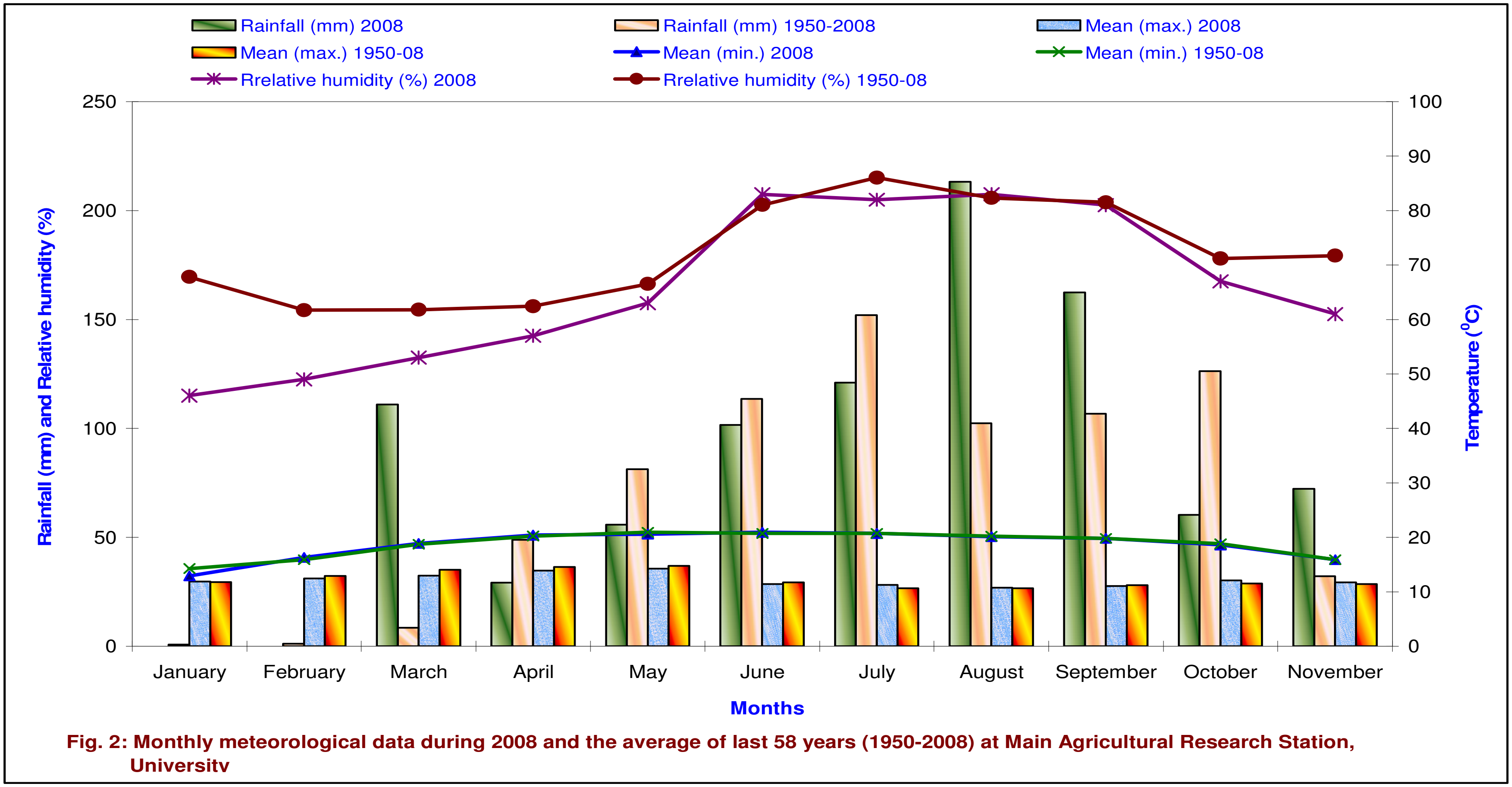


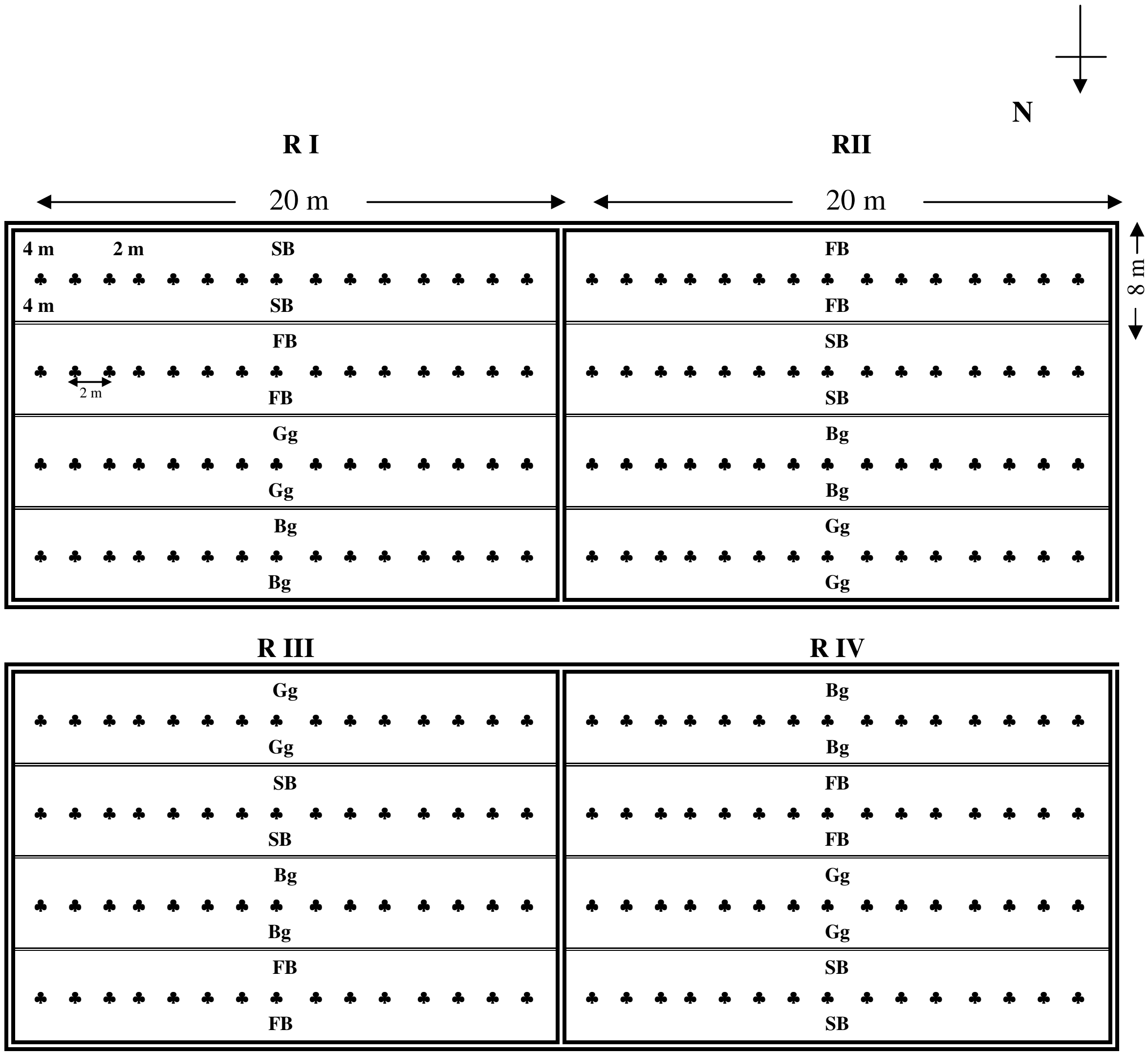
Fig. 2: Monthly meteorological data during 2008 and the average of last 58 years (1950-2008) at Main Agricultural Research Station, University

Table 3: Physical and chemical properties of the soil of experimental site

Sl. No.	Properties	Values	Method employed
I.	**Physical properties**		
1.	Coarse sand (%)	39.00	International pipette method (Piper, 1966)
2.	Fine sand (%)	29.50	International pipette method (Piper, 1966)
3.	Silt (%)	15.60	International pipette method (Piper, 1966)
4.	Clay (%)	16.80	International pipette method (Piper, 1966)
II.	**Chemical properties**		
1.	Soil pH (1:2.5 soil : water)	5.98	pH meter (Piper, 1966)
2.	Electrical conductivity (dSm^{-1})	0.54	Conductivity bridge (Jackson, 1973)
3.	Available nitrogen (kg ha^{-1})	182.40	Modified Kjeldahl method (Jackson, 1973)
4.	Available phosphorus (kg ha^{-1})	18.50	Olsen's method (Jackson, 1973)
5.	Available potassium (kg ha^{-1})	194.80	Flame photometer (Jackson, 1973)
6.	Soil organic carbon (%)	0.58	Wet oxidation method (Jackson, 1973)

Table 4: Details of teak based Agroforestry systems

Sl. No.	Particulars	Experiment
1.	Title	Physiological investigation on teak – legume based agroforestry system
2.	Crop and variety	1. Soybean (JS – 335) 2. Greengram (China mung) 3. Blackgram (TAU – 1) 4. Frenchbean (Arka Komal)
3.	Design	Factorial RBD
4.	Treatments	**A. Agroforestry systems** : T_1. Teak + Soybean T_2. Teak + Frenchbean T_3. Teak + Greengram T_4. Teak + Blackgram T_5. Soybean (sole) T_6. Frenchbean (sole) T_7. Greengram (sole) T_8. Blackgram (sole) **B. Distances from Teak row in meters** 1. 0 – 2 m 2. 2 – 4 m
5.	Replications	Four
6.	Plot size	8 m x 20 m
7.	Layout	Indicated in Fig.1
8.	Spacing	30 cm x 10 cm for Soybean / greengram/Blackgram 60 x 30 cm for Frenchbean
9.	Fertilizers (N, P_2O_5, K_2O kg ha^{-1})	Soybean 40: 80:25 Greengram / Blackgram 25:50:0 French bean 25:50:25
10.	Date of sowing	18.06.2007and 18.06.2008
11.	Date of harvesting	Frenchbean and Greengram, 25.08.2007 and 28.08.2008 and Blackgram and Soybean 20.09.2007 and 20.09.2008, respectively



Sole crop

	R-I	R-II	R-III	R-IV
Sole crop	Soybean	Blackgram	Greengram	Frenchbean
	French bean	Greengram	Soybean	Blackgram
	Greengram	Frenchbean	Blackgram	Soybean
	Blackgram	Soybean	Frenchbean	Greengram
	10 M	10 M	10 M	10 M

Legend

♣ - Teak row, SB - Soybean, Gg - Greengram, FB - Frenchbean, Bg - Blackgram;

From Teak row to row = 8 m; From Teak plant to plant = 2 m

Fig. 3: Plan of lay out of experiment I

Plate1. General view of teak legume based agroforestry system

Plate-2. Soybean in teak based agroforestry system

Plate-3. Frenchbean in teak based agroforestry system

Plate-4. Greengram in teak based agroforestry system

Plate-5. Blackgram in teak agroforestry system

3.1.6.3 Greengram (*Phaseoulus radiata* (L.) Wilczek)

Greengram is the third most important pulse crop in India, covering an area of 3.08 million hectares with a total production of 1.31 million tones. The average productivity is 425 kg ha^{-1} (Anon., 1999). The important greengram growing states are Orissa, Andhra Pradesh, Maharashtra, Karnataka and Bihar. In Karnataka, it occupies an area of 1.91 lakh hectares with a total production of 0.40 lakh tones. The average productivity is only 208 kg ha^{-1} (Anon., 1999). Which is almost half of the national productivity, thereby indicating that there is a lot of scope to improve the productivity potential.

The lower productivity of greengram could be mainly attributed to the genetic make–up of the crop, poor partitioning of assimilates, indeterminate growth habit, abscission of floral parts, canopy architecture, poor pod setting, cultivation under marginal and sub-marginal soils, particularly under rainfed conditions and non availability of photosynthates, particularly at later stages (pod development) due to leaf abscission, etc. (Alberda and Bower, 1983; Promila Kumari and Verma, 1983).

Yield is a complex character and is the resultant of interplay of different yield related morpho physiological and biochemical characters. The earlier attempts to improve the yield of green gram were mostly based on selection for morphological parameters and less importance was given to physiological parameters. Production physiology has been the recent theme in food crops, particularly in case of grain legumes. Except in soybean and groundnut, the physiological basis for yield has not been adequately explained in other legumes.

3.1.6.4. Frenchbean (*Phaseolus vulgaris* L.)

Frenchbean (P*haseolus vulgaris* L.) of the family fabaceae also known as common bean, snap bean, kidney bean, rajma, rajmash, string bean, was bean etc., is a premier short duration leguminous vegetable crop. It is consumed as green pod vegetable and as well as dry seed. It is native to Central America and evolved into an major leguminous vegetable crop of the world. It was introduced to India in 17^{th} century. Frenchbaen is an important source of carbohydrate (61.4%), proteins (17.5 to 28.5%) and mineral matter (3.2 to 5.0%). It supplies minerals like iron, potassium, phosphorus etc.

Frenchbean is one of the important pulse crops in world and grown in an area of 25.91 million hectares in the world with a total production of 18.84 million tones, in which India shares an area of 9.72 million hectares with a production of 4.34 million tones. The productivity in India is about 447 kg seeds per hectare as against world average productivity of 669 kg seeds per hectare (Anon., 2002). In India French bean is consumed as green pod and dry seeds. In Northern India, it is mainly cultivated on larger area for grain purpose (Rajmash). In India it is mainly grown in Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Bihar, Karnataka, Maharashtra, Madhya Pradesh and Andhra Pradesh. In Karnataka, it is mainly consumed as green pods and lesser extent for grains. It is grown as the green vegetable crop mainly in the district of Belgaum, Dharwad, Bangalore, Mysore and Hassan.

The physiological reasons for low productivity in frenchbean may be attributed to poor source–sink relationship, lower translocation efficiency at later stage of crop growth, shedding of floral parts, and low harvest index. Extensive studies on physiological analysis of growth and yield in several crop viz., cereals, pulses, oil seeds and vegetables have been done and emphasized the importance of growth and yield analysis (Yoshida, 1972). However, information on these aspects in Frenchbean is scanty. Hence, it is necessary to know the physiological reasons for low productivity and which helps to grow in agroforestry system for higher productivity.

3.1.6.5 Blackgram *(Vigna radiata* Roxb)

Blackgram is an important puls crop in Indian diet. It matures in 85-90 days. The plants are erect types and seeds are of medium size (40 g per 1000 seed weight) and black in colour. This variety can produce 10-12 q ha^{-1} of grain under good crop management conditions.

Blackgram was sown at 30 cm apart and provided 20 kg nitrogen and 40 kg phosphorus per hectare as basal dose. Before sowing of the crop, seed was treated with fungicide (Thirum 1.5 + Bavistin 1.5) per kg seed and Rhizobium culture @ 5g per kg of seed to avoid any seed born diseases and increases the nitrogen fixation. Thinning and weeding was done after 20 days after sowing. To control the yellow mosaic virus spraying of monocrotophos 36 per cent SL @ 500 ml ha-1 was done twice within 15 days interval.

3.1.6.6 Teak (*Tectona grandis*)

Teak is a genus of tropical hardwood trees in the mint family, Lamiaceae, native to the south and southeast of Asia, and is commonly found as a component of monsoon forest vegetation. They are large trees, growing to 30-40 m tall, deciduous in the dry season.

The yellowish brown timber with good grains and texture from teak trunk is used in the manufacture of outdoor furniture, boat decks, and other articles where weather resistance is desired. It is also used for indoor flooring and as a veneer for indoor furnishings. Teak, though easily worked, can cause severe blunting on edge tools because of the presence of silica in the wood. Teak's natural oils make it ideal for use in exposed locations and termite and pest proof, where it is durable even when not treated with oil or varnish. Timber cut from old teak trees was once believed to be more durable and harder than plantation grown.

Teak is propagated mainly from seeds. Germination of the seeds involves pretreatment to remove dormancy arising from the thick pericarp. Pretreatment involves alternate wetting and drying of the seed for three months for breaking dormancy then the seeds germinate after 15-30 days.

Teak is used extensively in India to make doors and window frames, furniture and columns and beams in old type houses. It is very resistant to termite attacks. Mature teak fetches a very good price. It is grown extensively by forest departments of different states in forest areas.

Leaves of teak wood tree are used in making Pellakai gatti (jackfruit dumpling), where batter is poured in a teak leaf and is steamed.This type of usage is found in coastal districts of Dakshina Kannada and Udupi in state of Karnataka in India. The leaves are also used in gudeg, a dish of young jackfruit made in Central Java, Indonesia, and give the dish its dark brown color.

3.1.6.7 Land preparation

After harvest of *rabi* crop, land was ploughed during summer and harrowed twice after pre monsoon rains and smoothened to prepare bring the field to fine seed tilth.

3.1.6.8 Fertilizer application and sowing

Nitrogen, phosphours and potassium were applied in the form of urea, diammonium phosphate and murriate of potash respectively as per the recommendations for legumes. Legumes seeds were treated with 150 gm of Rhizobium culture and bavistan and sown in the line opened 5 cm away from fertilizer line.

Soil working was carried out for teak, drumstick and curry leaf. Fertilizers were applied by opening a ring around teak at 30 cm away and 10 cm deep.

3.1.6.9 After care

After harvesting was carried out in both experiments as mentioned below. Plots were kept weed free by regular inter cultivations and hand weeding. Soil workings and hand weeding were done for teak. Plant protection measures were taken up at early symptoms of pest and diseases as per package of practices.

3.1.6.10 Harvesting

Harvesting of the legume was carried out at physiological maturity on dates indicated in Table 3. Legumes were harvested by picking the pods and dried in the yard for two days and then pods were separated by haulm. The pods were cleaned and weight was recorded after drying.

3.1.7 Collection of experimental data

The similar observations were recorded in both the experiments of legumes. In this experiment, five plants were randomly selected from each subplot at 2 m and 4 m distance from tree base on both sides of teak alleys. The methods and procedures followed in recording observations for different parameters on legumes are as followed.

3.1.8 Morphological parameters

3.1.8.1 Plant height (cm)

The height of the plant was measured in centimeter (cm) from the base of the plant to the tip of the main shoot at 20, 40, 60 days after sowing and at harvest, and the mean height was worked out.

3.1.8.2 Number of branches per plant

The number of branches borne on the main shoot of plant were counted from 5 plants at 20, 40, 60 days after sowing and mean branches was worked out.

3.1.8.3 Leaf area per plant (dm^2 $plant^{-1}$)

Leaf area was measured by disc method as suggested by Vivekanandan *et al*.. (1972). Fifty leaf discs of known size were taken using a cork borer from randomly selected fifty leaves from five plants. Both discs and remaining leaf blades were oven dried at 65 to 70^0C and leaf area was calculated by the following formula at all the stages of crop growth was expressed as dm^2 $plant^{-1}$.

$$LA = \frac{Wa \times A}{Wd}$$

Where,

LA = Leaf area (dm^2 $plant^{-1}$)

Wa = Weight of all leaves (including 50 discs weight in g)

Wd = Weight of 50 discs (g)

A = Area of the disc (dm^2)

3.1.8.4 Dry matter production

Five plants were randomly selected at different growth stages and were partitioned into different plant parts viz. partitioned the whole plant into leaf, stem and pods. Then kept for oven drying at 70 ^{0}C to a constant weight was recorded. Average dry matter per plant was recorded at 20,40,60 DAS and at harvest and expressed as gm per plant.

3.1.9 Growth parameters

3.1.9.1 Absolute growth rate (g $plant^{-1}$ day^{-1})

Absolute growth rate (AGR) is the dry matter production per unit time (g $plant^{-1}$ day^{-1}), which was calculated by using the formula as given by Radford (1967).

$$\text{AGR (g plant}^{-1}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Dry weight of the plants in grams at time t_1

W_2 = Dry weight of the plants in grams at time t_2

3.1.9.2 Relative growth rate (g g^{-1} day $^{-1}$)

Relative growth rate is the rate of increase in the dry weight per unit dry weight (g day^{-1}) already accumulated and was calculated by using the formula of Blackman (1919).

$$\text{RGR (g g}^{-1}\text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

Log_e = Logarithm to the base e (Neperian constant)

W_1 = Dry weight of plant in grams at time t_1

W_2 = Dry weight of plant in grams at time t_2

3.1.9.3 Net assimilation rate (g dm^{-2} day^{-1})

Net assimilation rate (NAR) is the rate of dry weight increase per unit leaf area per unit time, which was calculated by the formula as adopted by Gregory (1926) and expressed as g dm^{-2} day $^{-1}$.

$$\text{NAR (g dm}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{\log_e L_2 - \log_e L_1}{(L_2 - L_1)}$$

Where,

Log_e = Logarithm to the base e (Neperian constant)

L_1 and W_1 = Leaf area (dm^2) and dry weight of the plant (g) at time t_1

L_2 and W_2 = Leaf area (dm^2) and dry weight of the plant (g) at time t_2

3.1.9.4 Crop growth rate (g m^{-2} day^{-1})

Crop growth rate (CGR) is the rate of dry matter production per unit ground area per unit time. CGR was calculated by adopting the formula as suggested by watson *et al.*. (1952) and expressed as g m^{-2} day^{-1}.

$$\text{CGR (g. m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{A}$$

Where,

W_1 = Dry weight of the plant in grams at time t_1.

W_2 = Dry weight of the plant in grams at time t_2.

A = Unit land area occupied by the plant (m^2).

3.1.9.5 Leaf area index

The leaf area index (LAI) is the ratio of leaf area per plant to the land area occupied by the plant and was calculated by using the formula as suggested by Sestak *et al.* (1971).

$$LAI = \frac{\text{Leaf area per plant (dm}^2\text{)}}{\text{Land area occupied by a plant (dm}^2\text{)}}$$

3.1.9.6 Leaf area duration (days)

Leaf area duration (LAD) is nothing but relation of potential green leaf area for a particular period was worked out by the formula as suggested by Power *et al.*. (1967) and expressed in days.

$$\text{LAD (days)} = \frac{L_i + L_{(i+1)}}{2} \times (t_2 - t_1)$$

Where,

L_i = LAI at time t_1

$L_{(i+1)}$ = LAI at time t_2

$t_2 - t_1$ = time interval in days

3.1.9.7 Leaf area ratio ($dm^2\ g^{-1}$)

Leaf area ratio (LAR) is the ratio of leaf area to the total dry matter which was calculated by using the formula given below and expressed as dm^2 per gram.

$$\text{LAR } (dm^2\ g^{-1}) = \frac{LA}{TDM}$$

Where,

LA = Leaf area (dm^2)   TDM = Total dry matter (g)

3.1.9.8 Specific leaf weight ($g\ dm^{-2}$)

The specific leaf weight (SLW) indicates the average leaf thickness and was determined by the method suggested by Radford (1967). Specific leaf weight was expressed as g per dm^2.

Growth efficiency is associated with leaf area and its weight that mostly reflects leaf thickness. Thickness is now an important character in relation to the boundary layer and aerodynamic resistances. This parameter is equally involved in adaptation of a species to an environment such as temperature tolerance, drought resistance *etc.* thus, it seems desirable to distinguish the correlation mechanism determining dry weight distribution between various organs, from the mechanism governing leaf expansion. Thus mechanism governing leaf expansions consider the analysis of specific leaf weight.

Fourty leaf discs measuring each one cm^2 were made from the leaves of selected plants, and these discs were dried in oven for 72 hours until constant weight is attained and then weight of the leaf discs were taken. SLW was calculated using the formula

$$\text{SLW (mg/ cm}^2\text{)} = \text{Leaf weight (mg) / Leaf area (cm}^2\text{)}$$

3.1.10 Yield and yield components

3.1.10.1 Number of pods per plant

The total number of pods plucked and number of developed pods per plant was recorded at harvest.

3.1.10.2 Seed weight (g plant $^{-1}$)

Dry weight of seeds per plant was recorded at harvest and expressed in g per plant.

3.1.10.3 Pod yield (kg ha^{-1})

Pods from net plot (cm^2) were harvested, dried and weight was recorded and pod yield in kg per hectare was calculated.

3.1.10.4 100- seed weight (g)

The dry weight of 100 seeds drawn randomly from net plot was recorded and expressed in gram.

3.1.11 Biophysical parameters

Observations for the following bio physical parameters were recorded -

1. Relative Water Content 2. Light Transmission Ratio 3. Rate of photosynthesis
4. Stomatal conductance 5. Transpiration rate

3.1.11.1 Determination of Relative Water Content (RWC) in leaf tissue

Relative water content (RWC) in leaves of legumes was determined by the method of Barrs and Weatherly (1962). Ten leaf discs were collected randomly in each treatment and weighed accurately up to third decimal on a single pan analytical balance. This was considered as fresh weight. The weighed leaf discs were allowed to float on distilled water in a Petri dish and allowed to absorb water for four hours. After four hours, the leaf discs were taken out and their surface was blotted gently and weighed. This was referred to turgid weight. After drying in hot air oven at 72ºC for 48 hours, the dry weight was recorded and RWC was calculated by using the following formula and expressed in percent.

$$\text{RWC (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Turgid weight - Dry weight}} \times 100$$

3.1.11.2 Light transmission ratio (%)

Light transmission ratio (LTR) is the ratio between the light intensity under tree canopy but above the field crop and light intensity over field crop in the absence of trees and expressed as percentage. Light intensity was measured at noon using lux meter at 20,30, 50 DAS and at harvest and worked by using the formula as suggested by Yoshida *et al.*, (1972).

$$\text{LTR (\%)} = \frac{\text{Light intensity under tree canopy but above legumes}}{\text{Light intensity over legume in the absence of teak}} \times 100$$

3.1.11.3 SPAD meter (Single Photoelectric Analyzing Diode)

Chlorophyll meter developed by Minolta (SPAD 502) gives an indication of the relative amount of chlorophyll pigment present in the leaves based on leaf transmittance principle. SPAD reading could also be a reflection of leaf thickness or structural and non structural constituents of leaf other than pigments. Chlorophyll content was estimated and expressed in terms of SCMR absolute values (SPAD Chlorophyll Meter Reading) at regular intervals in the crops of the field experiment.

3.1.11.4 Measurement of biophysical parameters *viz.,* rate of photosynthesis, stomatal conductance and transpiration rate

Measurement of various biophysical parameters viz., Rate of photosynthesis, stomatal conductance and transpiration rate were made on the adaxial surface of the third fully expanded leaf from the top at 20 and 40 days after sowing in experiment I and II ,using Infra Red Gas Analyzer (IRGA,Model,CI-301). These measurements were made between 9.30 am to 12.30 noon at all the sampling dates. Stomatal conductance was expressed as cm sec^{-1} , where as ,transpiration rate and photosynthetic rate were expressed in terms of mg of H_2O cm^{-2} sec^{-1}, μ mol of CO_2 dm^{-2} sec^{-1} respectively.

3.1.12 Biochemical studies

3.1.12.1 Estimation of chlorophyll (mg.g fresh $weight^{-1}$)

Chlorophyll content in the leaves of the all legumes under study was determined calorimetrically as per the DMSO (Dimethyl sulphoxide) method of Shoaf and Lium (1976).

Procedure:

Fresh leaf tissue of 100 mg was cut into small pieces and incubated in 7 ml DMSO at 65ºC for 45 minutes at the end of the incubation period supernatant was decanted and leaf tissue was discarded and volume was made upto 10 ml with DMSO. Absorbance of the extract was read at 645 nm, 652 nm and 663 nm using DMSO as blank (Systronics, UV – VIS Spectrophotometer 108). The chlorophyll 'a' and chlorophyll 'b' and total chlorophyll contents were calculated using the below formulae and expressed as $mg.g^{-1}$ fresh weight.

$$\text{Chlorophyll 'a' (mg/g fr. wt)} = 12.7 (A_{663}) - 2.69 (A_{645}) \times \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll 'b' (mg/g fr. wt)} = 22.9 (A_{645}) - 4.68 (A_{663}) \times \frac{V}{1000 \times W \times a}$$

$$\text{Total chlorophyll (mg/g fr. wt)} = 27.8 (A_{652}) \times \frac{V}{1000 \times W \times a}$$

Where,

A = Absorbance at specific wave length (645, 663 and 652 nm)

V = Final volume of the chlorophyll extract (ml)

W = Fresh weight of the sample (g)

a = Path length of light (1cm)

3.1.12.2 Estimation of nitrate reductase `activity (nmol of NO_2 g fresh wt^{-1} hr^{-1})

The nitrate reductase activity (NRA) determines the nitrogen utilization efficiency in plants. NRA in leaves was measured by the method of Saradhambal *et al.* (1978) at 20, 40 and 60 DAS.

Fresh, 200 mg of leaf sample weighed and suspended in 25 ml flasks containing 5 ml of solution having 0.1 M phosphate buffer (pH 7.6), 0.02 M KNO_3, 5 per cent propanil and to that 2 drops of chloromphenicol (0.5 mg ml^{-1}) was added. The flasks were incubated at 30^0C for 30 minutes, after which, the reaction was stopped by adding 0.1 ml of 1.0 m zinc acetate and 1.9 ml of ethanol (70%). The contents were centrifuged at 3000 rpm for 10 minutes and the supernatant was collected. The supernatant was transferred to test tubes and 1 ml of 1 per cent sulphonilamide and 1 ml of 0.02 per cent N–1, Naphthyl ethylene diamine dihydrochloric acid were added. The absorbance of the pink colour developed was measured at 540 nm after incubating the contents of the tube at room temperature for 20 minutes. The activity of nitrate reductase was determined from a standard curve of KNO_2 and expressed as n mol of NO_2 formed g fresh $weight^{-1}$ $hour^{-1}$

3.1.13 Observations on teak

In the experiment, five trees were selected for the observations. The following observations were recorded from each treatment at end of each experiment.

3.1.13.1 Height of the tree (m)

The total height of the tree was measured by using marked pole as suggested by Bell and Gourlay (1980) and expressed in meters. During closure of experimentation, clean bole height was measured and expressed in meters.

3.1.13.2 Diameter at breast height (cm)

Diameter at breast height (DBH) was measured by extending a diameter type around the tree at 1.37 m from ground level and expressed in cm.

3.1.13.3 Crown Area (m^2 $plant^{-1}$)

Crown Area (CA) was calculated by using the following formula

$$CA = \frac{CD^2 \pi}{4}$$

Where,

CD = Crown diameter in m.

CA = Crown Area (m^2 $plant^{-1}$)

3.2 Experiment–II: Physiological investigations on legumes in teak-perennial vegetable based agroforestry system

3.2.1 Experimental site

The experiment was carried out during *Kharif,* 2007-08 and 2008-09 in "I" block of agroforestry experimental block, Main Agricultural Research Station, University of Agricultural Sciences,Dharwad which is located at 15°26' North latitude, a longitude of 75°0' East and altitude of 678 m above mean sea level. It is situated in transitional tract, representing Northern transitional climatic zone (zone 8) of Karnataka.

3.2.2 Soil and its characteristics

The experiment was conducted on medium deep black soils of Main Agricultural Research Station, Dharwad. The composite soil sample was collected from 0-15 cm soil depth from the site before the initiation of the experiment. The soil sample was air dried, powdered and allowed to pass through 2 mm sieve and was analyzed for physical and chemical properties (Table 5).

3.2.3 Climatic conditions

The data on climatic parameters such as rainfall (mm), mean maximum and mean minimum temperature (^{O}C) and relative humidity (%) recorded at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during the experimental year and the mean of the last 58 years (1950 - 2008) are presented in Table 1, 2 and Fig.1 and Fig. 2.

3.2.4 Previous crops grown on experimental area

Safflower was grown during *rabi* season of 2006 and 2007 with recommended package of practices in the experimental site.

3.2.5 Collection of experimental data

After the imposition of treatments, plants were sampled for morphological, biophysical, biochemical, growth parameters and yield and yield analysis were recorded at 20, 40 60 DAS and at harvest (Table 6 and Fig. 4).

3.2.6 Biochemical parameters

The procedure adopted for estimating the above listed biophysical and biochemical parameters viz., chlorophyll content and Nitrate reductase activity are same as given in 3.1.12, 3.1.12.1, and 3.1.12.2

3.2.7 Biophysical parameters

Various biophysical parameters viz., Relative Water Content, Transpiration rate, Stomatal conductance, Photosynthetic rate and LTR were measured at 20 ,30 and 50 days after sowing the details of which are described as in 3.1.11, 3.1.11.1, 3.1.11.2, 3.1.11.3 and 3.1.11.4

3.2.8 Observations in perennial vegetables

3.2.8.1 Curryleaf (*Murrya koengii*)

The curryleaf tree is a fast-growing deciduous shrub with deep root and aromatic leaves. It can be grown either in pots or outside. It is successful to grow in hot and dry conditions. You can try to grow from cuttings, which are neither too tender nor very hard and woody and remove the lower leaves. Cut the stems cleanly at a node, and push the cutting a few centimeters into a prepared pot or ground. Keep the pot away from direct sunlight. Rooting will take about 3 weeks. Alternatively, you can get a sapling from the nursery and plant it directly in the desired place or pot.

The tree grows 4 – 6 m. tall, with a trunk upto 40 cm diameter. The leaves are dark green in color, small, shiny and have pointed leaflets that grow closely along a central stem. The flowers of the tree are small white, and fragrant. The small black and red, shiny berries are edible, but their seeds are poisonous. The trees need to be pruned regularly for new shoots to grow. Water regularly and manure during the growing season. In winter, keep the pot in a warm, frost-free place (minimum temperature 12 ^{O}C). In April, water generously and repot if needed, and move the plants to a warm light place (around 18-20 degrees C).Watch out for scale insects, which might infest the tree. An organic insecticide like Neem Oil diluted in water can be sprayed to control the insects.

3.2.8.2 Drumstick (*Moringa indica*)

Drumstick is a native of India. The vegetable drumstick plant is also named as "ben oil tree" after commercial oil extracted from the seeds. The root of the drumstick tree is sometimes used as a substitute for horseradish and hence it is also called the "horseradish tree." The drumstick leaves fruits and flowers are edible and a common vegetable in India. It is generally believed in South Asia that drumstick trees planted on graves are will keep away the ghosts and evil spirits and hence its branches are used as charms against witchcraft.

The drumstick tree can be propagated using seeds or cuttings. Seeds may be sown directly in the field or in seedbeds and the seedlings transplanted to the field after 2 to 3 months. Mature stem cuttings 3 to 5 ft (1-1.5 m) long can also be used for planting. The tree grows rapidly, producing the first fruits within 6-12 months of planting, depending on the cultivar.

The flowers are consumed either mixed and cooked with other foods or fried in batter. Tender leaves are used to flavor ghee and to enhance the shelf-life of ghee. Traditionally the drumstick seeds have been used to purify domestic household water in rural areas in Sudan. Women collecting water would tie the ground seeds and suspend in the turbid water overnight. The oil extracted from the seeds (ben oil) was used for culinary purposes, a practice that has now been long discontinued. Almost all parts of the tree have been utilized in Indian Ayurvedic traditional medicine and other folk remedies. The drumstick flowers, leaves, seeds and roots are used for tumors. Roots are bitter, act as a tonic to the body and lungs, and are expectorant, diuretic and stimulant in paralytic afflictions, epilepsy and hysteria. The juice prepared from root is applied externally to heal irritation of skin. The leaves have purgative properties and are applied as poultice to sores, rubbed on the temples for headaches and used for piles. The bark, leaves and roots of the drumstick tree are used as a digestive aid.

Drumstick tree is a perennial, evergreen tree that grows up to 20 ft (6.1 m) tall, with a straight trunk with corky, whitish bark. It grows well in hot, semi-arid and humid regions and in well-drained sandy or loamy soils. The tree has tuberous taproot and brittle stem is with corky bark. The leaves are pale green, compound, tripinnate, 30-60 cm (11.8 to 23.6 in) in length, with many small leaflets. The lateral leaflets are elliptic in shape while the terminal one is obovate and slightly larger than the lateral ones. The fruit pods are pendulous, green turning greenish brown, triangular and split lengthwise into 3 parts when dry. The pods are 1 to 4 ft (30-120 cm) long and 1.8 cm (0.7 in) wide and tapering at both ends. The pods contain about 10 to 20 seeds embedded in the fleshy pith. The seeds are dark brown and the kernel is surrounded by a lightly wooded shell with three papery wings. The main varieties of drumstick in India are Coimbatore 1, Coimbatore 2, PKM 1, PKM 2 and Dhanaraj.

3.2.8.3 Height (m)

The total height of the perennial vegetable was measured by using marked pole as suggested by Bell and Gourlay (1980) and expressed in meters. During closure of experimentation, clean bole height was measured and expressed in meters.

3.2.8.4 Collar Diameter (cm)

Collar diameter of perennial vegetable was measured with help of vernier calipers at 10 cm above ground and expressed in cm.

3.2.8.5 Crown area (m^2 plant $^{-1}$)

Crown diameter of the perennial vegetable was measured with the help of measuring tape .the spread of crown taken in east-west and north-south direction and mean crown diameter was worked out and it was calculated by using the following formula

$$CA = \frac{CD^2 \pi}{4}$$

Where,

CD = Crown diameter in m.

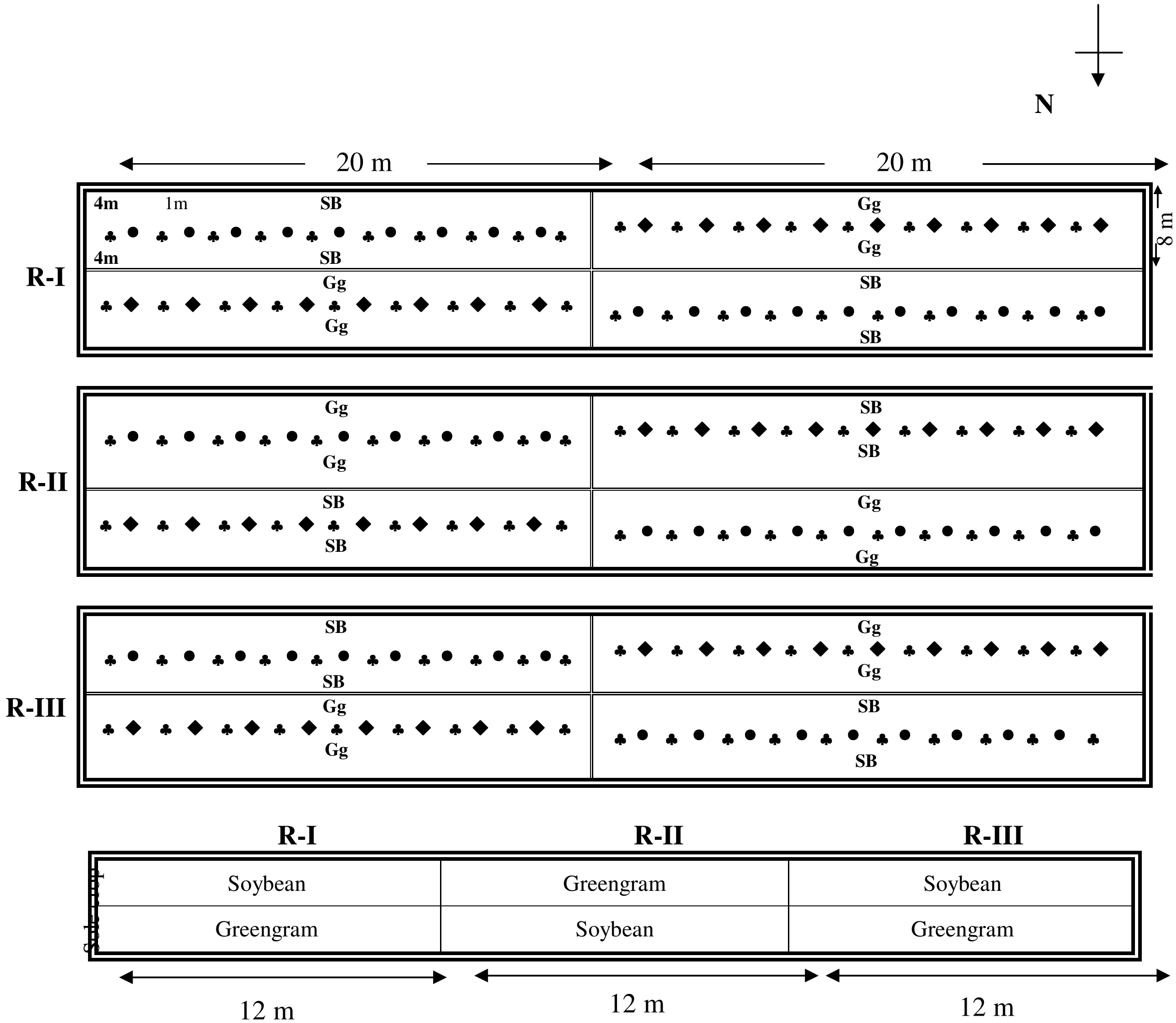
CS = Crown spread (m^2 plant^{-1})

Table 5: Physical and chemical properties of the soil of experimental site

Sl. No.	Properties	Values	Method employed
I.	**Physical properties**		
1.	Coarse sand (%)	36.20	International pipette method (Piper, 1966)
2.	Fine sand (%)	28.40	International pipette method (Piper, 1966)
3.	Silt (%)	14.80	International pipette method (Piper, 1966)
4.	Clay (%)	15.90	International pipette method (Piper, 1966)
II.	**Chemical properties**		
1.	Soil pH (1:2.5 soil : water)	5.96	pH meter (Piper, 1966)
2.	Electrical conductivity (dSm^{-1})	0.50	Conductivity bridge (Jackson, 1973)
3.	Available nitrogen ($kg\ ha^{-1}$)	184.40	Modified Kjeldahl method (Jackson, 1973)
4.	Available phosphorus ($kg\ ha^{-1}$)	18.30	Olsen's method (Jackson, 1973)
5.	Available potassium ($kg\ ha^{-1}$)	195.90	Flame photometer (Jackson, 1973)
6.	Soil organic carbon (%)	0.56	Wet oxidation method (Jackson, 1973)

Table 6: Details of Integration of teak–perennial vegetable and based agroforestry systems

Sl. No.	Particulars	Experiment
1.	Title	Physiological investigation on integration of teak perennial vegetable in legume based agroforestry system
2.	Crop and variety	1. Soybean (JS – 335) 2. Greengram (China mung)
3.	Design	Factonrial RBD
4.	Treatments	**A. Agroforestry systems** : T_1. Teak + Curryleaf + Soybean T_2. Teak + Curryleaf + Greengram T_3. Teak + Drumstick + Soybean T_4. Teak + Drumstick + Greengram T_5. Soybean (sole) T_6. Greengram (sole) **B. Distances from Teak row in meters** 1. 0 - 2 m 2. 2 - 4 m
5.	Replications	Four
6.	Plot size	8 m x 20 m
7.	Layout	Indicated in Fig.2
8.	Spacing	30 cm x 10 cm
9.	Fertilizers (N, P_2O_5, K_2O kg ha $^{-1}$)	Soybean 40: 80:25 Greengram 25:50:0 Curryleaf 300:150:150 N: $P_2O_{5:}$ K_2O gm/plant Drumstick 50:125:0 N: $P_2O_{5:}$ K_2O gm/plant
10.	Date of sowing	18.06.2007 and 18.06.2008
11.	Date of harvesting	Greengram and Soybean, 25.08.2007, 20.09.2007 and 25.08.2008, 20.09.2008 Curryleaf: Harvesting was done at 3 months interval Drumstick: fruits were harvested during Sept. to Nov. every year.



Legend

♣ - Teak row, SB- Soybean, ●-Curryleaf, ◆-Drumstick, Gg-Greengram;

Fig. 4: Plan of lay out of experiment II

Plate-6. Soybean in teak perimnial vegetable based agroforestry system

Plate-7. Greegram in teak perennial vegetable based agroforestry system

Soybean

Frenchbean

Greengram

Blackgram

Plate-8. General view of sole legumes

3.2.9 Yield of perennial vegetables

3.2.9.1 Leaf yield

Leaf yield of Curryleaf harvested from five plants in each treatment at interval of three months and green leaf yield per plant was worked out and it was expressed in kgs.

3.2.9.2 Fruit yield

Fruits of drumstick were harvested at a regular interval and total fruit yield per plant was worked out.

3.3 Statistical analysis

The data of the field experiment was analyzed by MSTATC programme. Standard anylysis of variance procedures for a two – way ANOVA in randomized blocks were used to calculate treatments means, standard errors and significant differences between treatment means. Treatment means were compared using the least significant differences of the means of Fisher calculated from standerd errors of the difference of the means using appropriate degrees of freedom, when the ANOVA indicated significant differences. Pooled analysis of data across site / seasons was carriedout whereever it was appropriate. Level of significance in 'F' and't' test at five per cent for field experiment and respective critical difference was calculated whenever the 'F' test was significant.

4. EXPERIMENTAL RESULTS

The results of the field experiments conducted to study the effect of teak legume based agroforestry systems and integration of perennial vegetables based agroforestry system and distances on the growth and yield of legumes under rainfed situations are presented in this chapter. The effect of eight main treatments in the first experiment viz., teak + soybean, teak + greengram, teak + frenchbean, teak + blackgram, sole soybean, sole frenchbean, sole greengram, sole blackgram in the first experiment and the second experiment consisted of teak with two pulses along with two short rotation vegetables viz., teak + curryleaf + soybean, teak + drumstick + greengram, teak + drumstick + soybean, teak + curryleaf + greengram, sole soybean and sole greengram, two sub plot treatments viz.,0-2 m and 2-4 m distance from teak row were conducted during *kharif* 2007 and 2008 for morphological, physiological, biophysical, biochemical and yield parameters of legumes and growth parameters of trees are presented in this chapter

4.1 Experiment–I: Physiological investigation on legumes in teak based agroforestry system

4.1.1 Morphological characters

4. 1.1.1 Plant height (cm)

The plant height of legumes was recorded at 20 DAS, 40 DAS and at harvest and is presented in the Table 7 and Fig.5. The data revealed that the treatments varied significantly among agroforestry systems and distances at 20 DAS. At 40 DAS the treatment varied significantly between the agroforestry systems only. While, the agroforestry systems, distance and their interaction were insignificant at harvest.

The height recorded was less in agroforestry systems as compared to sole crop treatment. At 20 DAS the total mean height was 14.76 cms. It ranged from 14.34 cm in 2 m distance and 15.25 cm at 4 m distance varied significantly. The treatment teak + greengram (7.81) were statistically inferior. In 2 m distance also the similar trend was noticed. Among agroforestry systems the highest height was recorded in teak + frenchbean (17.26) and lowest was in teak + greengram (8.50).

At 40 DAS, also the trend noticed at 20 DAS was observed. Among the agroforestry systems, the treatment teak + frenchbean was having highest plant height (18.91) and was on par with teak + soybean (17.66) and teak + blackgram(18.38).

However, the interaction effect between the agroforestry system and distances from tree base was varying. The treatment teak + greengram recorded significantly lowest height at 2 m distance from tree base (15.77). Where as, teak + blackgram noticed significantly highest plant height at 4 m distance (19.51)

At harvest, teak + greengram recorded significantly highest plant height (22.64) which is followed by the treatment teak + soybean (22.25). The height reduction was noticed in teak + blackgram (21.17) followed by teak + frenchbean (22.06).

However, the interaction in this stage significantly differs and the maximum plant height was noticed in teak + greengram at 4 m distances (23.35). In case of teak + blackgram recorded significantly minimum plant height at 2 m distance away from tree base. The others interaction were insignificant.

4.1.1.2 Number of leaves per plant

The number of leaves per plant was recorded at 20 DAS, 40 DAS and at harvest and is presented in the Table 8.

The data revealed that the treatments varied significantly among the agroforestry systems and distances from tree base at 20 DAS and 40 DAS while it varied significantly only with the agroforestry systems.

The number of leaves per plant was significantly influenced by agroforestry systems and distances from teak, while their interactions at all the growth stages.

Table 7: Influence of teak based agroforestry system on plant height (cm) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	15.2	16.6	**15.9**	17.3	18.0	**17.7**	21.4	23.2	**22.3**
T_2-Teak + Greengram	7.8	8.5	**8.2**	15.8	16.4	**16.1**	21.9	23.4	**22.6**
T_3-Teak + Frenchbean	16.3	17.3	**16.8**	18.4	19.5	**18.9**	21.4	22.7	**22.1**
T_4-Teak + Blackgram	15.5	17.3	**16.4**	17.3	19.5	**18.4**	20.0	22.4	**21.2**
T_5-Soybean (sole)	16.8	17.5	**17.2**	18.5	18.9	**18.7**	23.6	24.1	**23.9**
T_6-Greengram (sole)	8.6	9.5	**9.0**	17.0	18.4	**17.7**	22.4	23.3	**22.8**
T_7-Frenchbean (sole)	17.4	17.6	**17.5**	20.0	20.4	**20.2**	23.5	24.1	**23.8**
T_8-Blackgram (sole)	17.2	17.8	**17.5**	20.5	21.0	**22.7**	20.9	23.5	**22.2**
Mean	**14.3**	**15.3**	**14.8**	**18.1**	**19.01**	**18.5**	**21.9**	**23.3**	**22.6**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.26	0.75	0.32	0.93	0.38	1.08
Distance (D)	0.13	0.37	0.16	0.47	0.19	0.54
Interaction (AF X D)	0.37	NS	0.49	NS	0.59	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

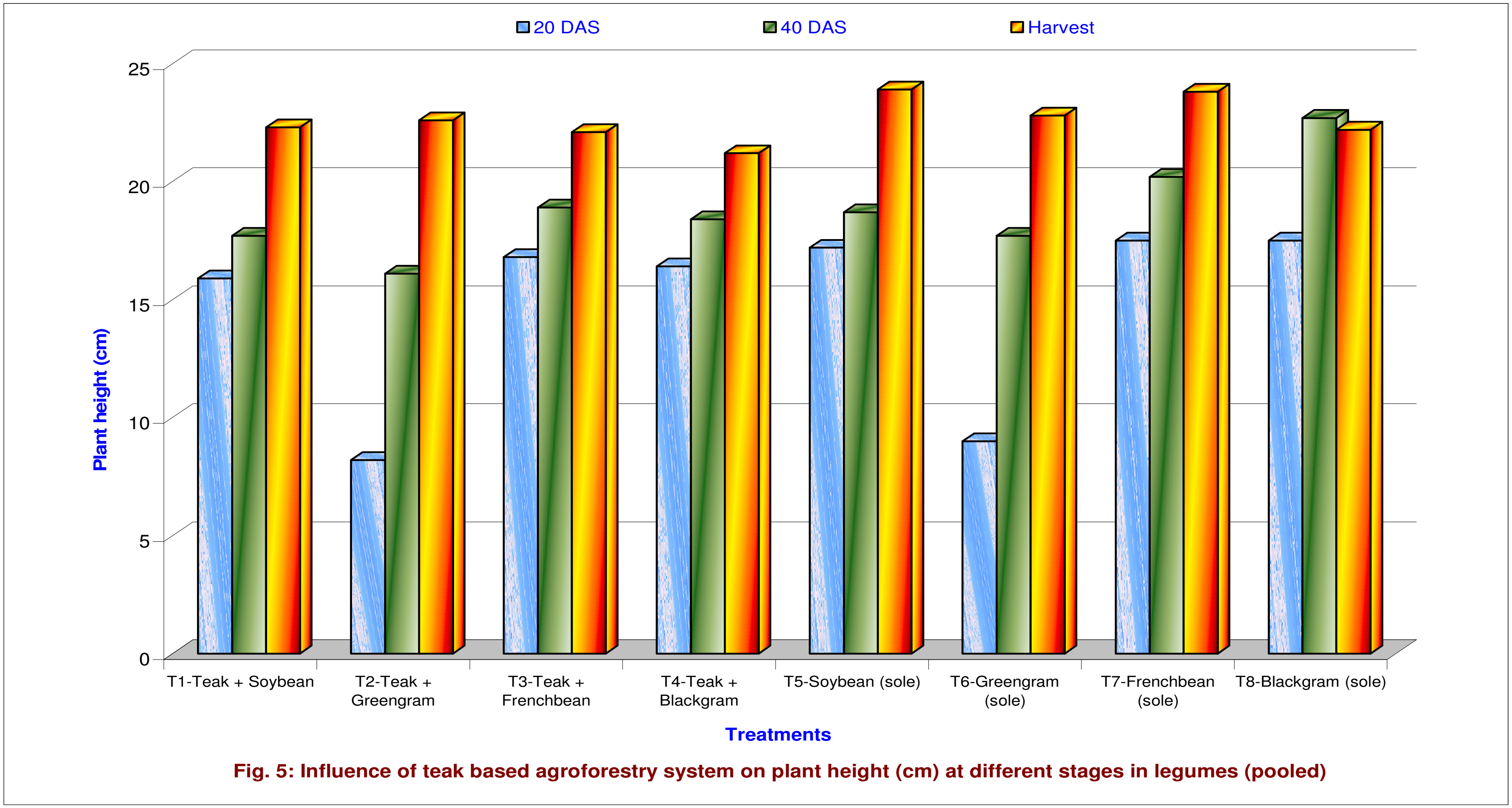


Fig. 5: Influence of teak based agroforestry system on plant height (cm) at different stages in legumes (pooled)

At 20 DAS, the number of leaves per plant was significantly higher in sole legumes as compared to agroforestry systems, the total mean number of leaves per plant was 9.03, it ranged from 8.76 at 2 m distance and 9.31 in 4 m distances from tree base.

At 2 m distance, among the treatments, the highest number of leaves per plant was recorded was teak + soybean (9.85) and the lowest number of leaves per plant was teak + greengram (7.10). The treatment teak + frenchbean (7.73) and teak + blackgram (7.93) were inferior and on par with each other. At 4 m distance also similar trend was noticed. Among agroforestry systems the highest number of leaves was recorded in teak + soybean (10.73) and lowest was in teak + greengram (7.50).

At 40 DAS, also the same trend was noticed. Among agroforestry systems the treatment teak + soybean was having highest number of leaves per plant (26.51). The treatment teak + greengram and teak + frenchbean were on par with each other.

However, the interaction effect is significantly differ in this stage. The treatment teak + frenchbean recorded significantly lowest number of leaves (17.36) at 2 m distances away from tree base. Where as, the number of leaves significantly highest was noticed in teak + soybean at 4 m distances (26.83)

At harvest, the same trend was noticed. Among agroforestry systems the treatment teak + soybean (26.51) was having highest number of leaves per plant, teak + greengram and the treatment teak + frenchbean where on par. While the treatment teak + frenchbean recorded the lowest value (17.78) and was on par with teak + green gram (19.21)

4.1.1.3 Number of branches per plant

The number of branches per plant of legumes was recorded at 20, 40 and at harvest and is presented in Table.9. The number of branches per plant was significantly influenced by agroforestry systems and distances from teak row and as well as by their interactions at all the growth stages. While the interaction effects were insignificant. The number of branches per plant was less in agroforestry systems as compared to sole crops.

At 20 DAS, the number of branches per plant was significantly higher in sole legume crops as compared with agroforestry systems, the total mean number of branches per plant was less in 2 m distance (3.46), while it was maximum in 4 m distances (4.04).

In 2 m distances (D1) from the teak rows, among the agroforestry systems, the highest number of branches per plant was recorded in teak + frenchbean(3.02) and the lowest number of branches per plant was in teak + soybean (2.62).The treatment teak + greengram (2.80) and teak + blackgram (2.86) were inferior and were on par with each other. Among agroforestry systems the highest number of branches was recorded in teak + frenchbean (3.61) and lowest was in teak + blackgram (3.21) at 4 m distances from teak alley.

At 40 DAS, the number of branches per plant was significantly higher in sole legumes crops as compared to agroforestry system. Among the agroforestry systems, the treatment in teak + frenchbean was having highest number of branches (7.98) and was on par with teak + soybean(7.48), teak + greengram (7.31) and teak + blackgram(7.48).

At harvest, the same trend was noticed, the treatment teak + soybean (9.07) and teak + frenchbean (9.07) were having highest number of branches per plant as compared to teak + greengram (8.35) and teak + blackgram (8.65)

4.1.1.4 Leaf Area (dm^2 $plant^{-1}$)

Leaf area was recorded at 20, 40 DAS and at harvest and is presented in the Table 10.

Leaf area of legumes was significantly influenced by agroforestry systems and distances from teak row at 20 DAS and 40 DAS while their interactions was insignificant at all growth stages. It varied significantly among agroforestry system at 60 DAS.In general, the leaf area was increased up to 40 DAS and decreased there after. The average leaf area ranged from 3.67 dm^2 $plant^{-1}$ (20 DAS) to 8.18 dm^2 .$plant^{-1}$ (60 DAS).

Table 8: Influence of teak based agroforestry system on number of leaves at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	9.9	10.7	**10.3**	26.2	26.8	**26.5**	20.3	21.8	**21.1**
T_2-Teak + Greengram	7.1	7.5	**7.3**	18.7	19.7	**19.2**	15.4	17.2	**16.3**
T_3-Teak + Frenchbean	7.7	9.2	**8.5**	17.4	18.2	**17.8**	15.6	16.7	**16.2**
T_4-Teak + Blackgram	7.9	8.2	**8.1**	20.5	22.4	**21.5**	16.7	19.5	**18.1**
T_5-Soybean (sole)	12.0	12.5	**12.3**	28.4	28.5	**28.5**	24.1	25.4	**24.8**
T_6-Greengram (sole)	7.7	7.8	**7.7**	18.9	19.9	**19.4**	18.6	19.2	**18.9**
T_7-Frenchbean (sole)	9.4	9.8	**9.6**	18.0	18.6	**18.3**	16.5	18.3	**17.4**
T_8-Blackgram (sole)	8.4	8.8	**8.6**	23.5	24.3	**23.9**	20.8	22.2	**21.5**
Mean	**8.8**	**9.3**	**9.0**	**21.5**	**22.3**	**21.9**	**18.5**	**20.04**	**19.3**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.16	0.46	0.36	1.03	0.29	0.83
Distance (D)	0.08	0.23	0.18	0.53	0.14	0.41
Interaction (AF X D)	0.22	NS	0.56	NS	0.41	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 9: Influence of teak based agroforestry system on number of branches per plant at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2.6	3.5	**3.1**	6.7	8.3	**7.5**	8.8	9.4	**9.1**
T_2-Teak + Greengram	2.8	3.6	**3.2**	6.9	7.7	**7.3**	8.1	8.6	**8.4**
T_3-Teak + Frenchbean	3.0	3.6	**3.3**	7.7	8.3	**8.0**	8.7	9.5	**9.1**
T_4-Teak + Blackgram	2.9	3.2	**3.0**	6.9	8.1	**7.5**	8.4	8.9	**8.7**
T_5-Soybean (sole)	5.6	6.3	**5.9**	9.2	9.7	**9.4**	10.5	11.1	**10.8**
T_6-Greengram (sole)	3.9	4.2	**4.0**	8.8	9.2	**9.0**	9.1	9.5	**9.3**
T_7-Frenchbean (sole)	3.7	4.0	**3.9**	8.2	8.9	**8.6**	10.0	9.7	**9.8**
T_8-Blackgram (sole)	3.2	4.0	**3.6**	9.3	9.6	**9.5**	9.4	9.6	**9.5**
Mean	**3.5**	**4.0**	**3.8**	**8.0**	**8.7**	**8.3**	**9.1**	**9.5**	**9.3**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.15	0.43	0.12	0.35	0.14	0.39
Distance (D)	0.075	0.21	0.06	0.17	0.07	0.19
Interaction (AF X D)	0.215	NS	0.17	NS	0.19	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 10: Influence of teak based agroforestry system on leaf area ($dm^2 plant^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	4.39	4.75	**4.57**	7.63	8.44	**8.04**	5.60	5.51	**5.55**
T_2-Teak + Greengram	1.04	1.38	**1.21**	5.23	5.24	**5.23**	4.21	4.22	**4.21**
T_3-Teak + Frenchbean	5.48	5.82	**5.65**	7.92	8.83	**8.38**	4.99	5.43	**5.21**
T_4-Teak + Blackgram	1.19	1.24	**1.21**	5.25	5.27	**5.26**	4.22	4.24	**4.23**
T_5-Soybean (sole)	7.86	8.30	**8.08**	12.76	14.10	**13.43**	6.20	6.31	**6.25**
T_6-Greengram (sole)	1.26	1.27	**1.26**	7.23	7.25	**7.24**	5.21	5.22	**5.21**
T_7-Frenchbean (sole)	5.93	6.42	**6.17**	8.90	9.09	**8.99**	5.43	5.82	**5.62**
T_8-Blackgram (sole)	1.21	1.22	**1.22**	7.27	7.28	**7.27**	5.17	5.58	**5.38**
Mean	**3.54**	**3.80**	**3.67**	**7.77**	**8.18**	**7.98**	**5.12**	**5.29**	**5.20**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.126	0.362	0.193	0.555	0.134	0.385
Distance (D)	0.063	0.181	0.096	0.276	0.072	NS
Interaction (AF X D)	0.178	NS	0.273	NS	0.203	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

At 20 DAS, leaf area was significantly maximum in the treatment teak+frenchbean (5.65) the next best treatment was teak + soybean (4.57), when compared to other agroforestry systems. The minimum leaf area was recorded in the treatment teak + greengram (1.21) and teak + blackgram (1.21) which were on par with each other.

Among the distances, 2 m away from the tree base was recorded lowest leaf area when compared to 4 m distance at all the stages.

At 40 DAS, also the same trend was noticed at 20 DAS was observed. Among the agroforestry systems the treatment teak + frenchbean (8.38) was having maximum leaf area and the next best treatment was teak + soybean (8.04).The treatment teak + green gram (5.23) and teak + blackgram (5.26) were an par with each other.

At 60 DAS, among the agroforestry systems the leaf area was significantly highest in the treatment teak + soybean (5.55) and the next best treatment was teak + frenchbean (5.21). Whereas the treatment teak + greengram (4.21) and teak + blackgram (4.23) were on par with each other. The treatment did not vary, among the distances and interactions were also insignificant.

4.1.2 Dry matter production and partioning

4.1.2.1 Leaf dry matter (g plant^{-1})

Leaf dry matter production (g plant^{-1}) of legumes was recorded at 20 DAS, 40 DAS and at harvest and is presented in the Table 11.

The leaf dry matter of legumes was significantly influenced by the agroforestry systems and the distances from the tree base at all stages. While their interaction were insignificant.

At 20 DAS, among the agroforestry systems the leaf dry matter was significantly higher in teak + frenchbean (1.33) followed by the treatment teak + blackgram (1.28) as compared to other treatments. The leaf dry matter was lowest in teak + greengram (0.88) which was followed by the treatment teak + soybean (1.22)

The average leaf dry matter ranged from 1.22 to 4.21 g plant^{-1} (40 DAS).

At 40 DAS, among the agroforestry treatments teak + soybean recorded significantly maximum leaf dry matter (5.02) and which was followed by the treatment teak + frenchbean (4.95) both are on par. Whereas, the treatment teak + greengram recorded significantly minimum leaf dry matter (2.81) and followed by teak + blackgram as compared to sole crops.

However, the interaction affect between agroforestry system and distances from base of tree were insignificant.

At harvest, the treatment teak + soybean noticed significantly increased leaf dry matter (2.35) and followed by treatment teak + frenchbean (2.24). Whereas, teak + blackgram recorded significantly decreased leaf dry matter (1.39) and the treatment followed by teak + greengram (1.53) when compared to the sole legume treatment.

The interaction effect between agroforestry system and distances were insignificant.

4.1.2.3 Stem dry matter (g plant^{-1})

The data on stem dry matter of legumes were significantly influenced by the agroforestry system and the distances from the base of tree at all the stages. While the interaction effect was insignificant at all stages (Table 12).

The average stem dry matter of legume ranged from 1.30 g (20 DAS) to 2.89 g (harvest) stem dry matter production was higher to sole crops as compared to agroforestry system.

At 20 DAS, the stem dry matter was significantly highest in teak + frenchbean (1.71) and teak + soybean (1.23) when compared to rest of the agroforestry systems. The treatment teak + greengram recorded significantly lowest stem dry matter (0.88) followed by the treatment teak + blackgram. (1.12).

Table 11: Influence of teak based agroforestry system on leaf dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.21	1.23	**1.22**	4.78	5.62	**5.02**	2.23	2.47	**2.35**
T_2-Teak + Greengram	0.85	0.91	**0.88**	2.68	2.94	**2.81**	1.44	1.63	**1.53**
T_3-Teak + Frenchbean	1.28	1.39	**1.33**	4.63	5.27	**4.95**	2.02	2.46	**2.24**
T_4-Teak + Blackgram	1.21	1.35	**1.28**	2.75	2.93	**2.84**	1.32	1.46	**1.39**
T_5-Soybean (sole)	1.26	1.40	**1.33**	5.92	5.74	**5.83**	2.56	3.05	**2.80**
T_6-Greengram (sole)	0.94	0.96	**0.95**	3.27	3.37	**3.32**	1.48	1.68	**1.58**
T_7-Frenchbean (sole)	1.39	1.48	**1.43**	5.83	6.02	**5.93**	2.72	3.00	**2.86**
T_8-Blackgram (sole)	1.36	1.39	**1.38**	3.00	3.02	**3.01**	1.64	1.78	**1.71**
Mean	**1.18**	**1.26**	**1.22**	**4.10**	**4.35**	**4.21**	**1.93**	**2.19**	**2.06**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.046	0.132	0.166	0.478	0.146	0.420
Distance (D)	0.023	0.066	0.083	0.239	0.044	0.126
Interaction (AF X D)	0.065	NS	0.235	NS	0.198	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 12: Influence of teak based agroforestry system on stem dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.21	1.24	**1.23**	4.27	4.40	**4.33**	3.54	3.82	**3.68**
T_2-Teak + Greengram	0.78	0.98	**0.88**	2.04	2.40	**2.22**	2.02	2.16	**2.09**
T_3-Teak + Frenchbean	1.62	1.79	**1.71**	3.01	3.43	**3.22**	2.82	3.20	**3.01**
T_4-Teak + Blackgram	1.04	1.20	**1.12**	2.34	2.57	**2.46**	2.16	2.36	**2.26**
T_5-Soybean (sole)	1.31	1.35	**1.33**	4.40	4.92	**4.66**	3.89	4.09	**3.99**
T_6-Greengram (sole)	0.99	1.17	**1.08**	2.28	2.64	**2.46**	2.10	2.42	**2.26**
T_7-Frenchbean (sole)	1.71	1.83	**1.77**	3.43	3.74	**3.58**	3.20	3.40	**3.30**
T_8-Blackgram (sole)	1.22	1.30	**1.26**	2.52	2.74	**2.63**	2.27	2.45	**2.36**
Mean	**1.23**	**1.35**	**1.30**	**3.04**	**3.36**	**3.20**	**2.77**	**3.02**	**2.89**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.065	0.187	0.082	0.236	0.093	0.267
Distance (D)	0.032	1.092	0.042	0.120	0.046	0.132
Interaction (AF X D)	0.100	NS	0.121	NS	0.131	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Among the distances, 2 m from the tree base recorded significantly lowest stem dry matter when compared to 4 m distances, which recorded significantly highest stem dry matter at all the stages.

At 40 DAS, the treatment teak + soybean noticed significantly maximum stem dry matter (4.33) and it was followed by teak + frenchbean (3.22) whereas, the treatment teak + greengram noticed significantly lowest stem dry matter (2.22) and next best treatment was teak + blackgram (2.46).

Sole legume crops recorded maximum stem dry matter as compared to agroforestry systems at all the stages.

However, the interaction effects were insignificant.

At harvest, among the agroforestry treatments teak + soybean noticed significantly maximum stem dry matter (3.68) and the next best treatments teak + frenchbean (3.01), where as the teak + greengram recorded minimum stem dry matter (2.09) which was followed by teak + blackgram(2.26).

The interaction effects between agroforestry systems and distances were non significant.

4.1.2.4 Pod dry matter (g plant^{-1})

The pod dry matter was recorded at 40 DAS and at harvest and the data is presented in Table 13. The statistical analysis of the data revealed that the treatment varied significantly any agroforestry system, distances and among their interaction also at both the stages. The mean value ranged from 1.04 gm plant^{-1} (40 DAS) to 11.32 gm plant^{-1}(harvest).

At 40 DAS, the value was 0.93 and 1.16 in 2 m and 4 m respectively, among the 2 m distances treatment teak + frenchbean was higher value and it was 1.25 and the lowest value was noticed in teak + blackgram (0.62). The treatment teak + frenchbean were significantly superior while the treatment teak + blackgram were significantly inferior. The treatments teak + soybean and teak + greengram were on par. At 2 m distances the same trend was noticed but the treatment teak + soybean and teak + greengram were statistically varying. The higher value was in teak + french bean and the lowest was in teak + blackgram.

The data on interaction revealed that the heighest value was noticed in teak + french bean at 4 m distance (1.75) and the lowest were in teak + blackgram (0.74) at 2 m distance teak + greengram at 2 m distance which were on par with each other.

At harvest, the mean value ranged from 10.59 in 2 m distances to 12.06 in 4 m distances. In 2 m distances the higher value was in teak + soybean (15.00) and the lowest was in teak + blackgram (5.24). The treatment teak + blackgram and teak + greengram were on par with each other. In 4 m distances similar trend was noticed.

Among the agroforestry system, it ranged from 6.28 (teak + greengram) to 16.44 (teak + soybean). The treatment teak + soybean were significantly superior over other treatments. The treatment teak + greengram and teak + blackgram were on par with each other. The data on interaction revealed that the treatment teak + soybean at 2 m distance with 17.88 values were significantly superior over others. While teak + blackgram (5.24) and teak + greengram (5.32) at 2 m distance were significantly inferior and were also on par with each other.

Pod dry matter production was significantly higher in sole crops as compared agroforestry systems.

4.1.2.5 Total dry matter (g plant^{-1})

The data pertaining to total dry matter of legume crops was significantly influenced by the agroforestry systems and distances from the tree base at 20 DAS and 40 DAS (Table 14). At harvest the treatments varied significantly among agroforestry systems only. The interactions were insignificant at all stages.

The average total dry matter ranged from 2.66 g plant^{-1} (20 DAS) to 22.77 g plant^{-1} (harvest). The total dry matter production was significantly higher is sole legume crops as compared to agroforestry systems.

Table 13: Influence of teak based agroforestry system on pod dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.80	1.12	**0.96**	15.00	17.88	**16.44**
T_2-Teak + Greengram	0.70	0.90	**0.80**	5.32	7.22	**6.28**
T_3-Teak + Frenchbean	1.25	1.75	**1.50**	9.62	11.68	**10.65**
T_4-Teak + Blackgram	0.62	0.74	**0.68**	5.24	7.68	**6.46**
T_5-Soybean (sole)	1.00	1.18	**1.09**	18.94	19.98	**19.46**
T_6-Greengram (sole)	0.86	0.98	**0.92**	8.80	9.12	**8.96**
T_7-Frenchbean (sole)	1.43	1.85	**1.64**	12.82	13.12	**12.97**
T_8-Blackgram (sole)	0.77	0.79	**0.78**	9.00	9.82	**9.41**
Mean	**0.93**	**1.16**	**1.04**	**10.59**	**12.06**	**11.32**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.038	0.103	0.193	0.555
Distance (D)	0.019	0.054	0.096	0.276
Interaction (AF X D)	0.054	0.155	0.273	0.786

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 14: Influence of teak based agroforestry system on total dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2.45	2.44	**2.45**	9.95	10.88	**10.41**	21.07	24.47	**22.77**
T_2-Teak + Greengram	1.63	1.89	**1.76**	5.42	6.24	**5.83**	8.78	11.01	**9.90**
T_3-Teak + Frenchbean	2.90	3.18	**3.04**	8.89	10.45	**9.67**	14.56	17.50	**16.03**
T_4-Teak + Blackgram	2.64	2.95	**3.00**	5.71	6.25	**5.98**	8.72	11.50	**10.11**
T_5-Soybean (sole)	2.54	2.75	**2.64**	10.32	11.84	**11.08**	25.29	27.02	**26.15**
T_6-Greengram (sole)	1.93	2.13	**2.03**	6.41	6.99	**6.70**	12.38	13.22	**12.80**
T_7-Frenchbean (sole)	3.10	3.31	**3.20**	10.69	11.61	**11.15**	18.74	19.52	**18.86**
T_8-Blackgram (sole)	3.31	3.13	**3.22**	6.29	6.55	**6.42**	12.91	14.05	**13.48**
Mean	**2.56**	**2.72**	**2.66**	**9.95**	**10.88**	**10.41**	**21.07**	**24.47**	**22.77**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.101	0.290	0.289	0.832	0.891	2.566
Distance (D)	0.049	0.141	0.144	0.414	0.445	1.281
Interaction (AF X D)	0.152	NS	0.409	NS	1.261	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

As 20 DAS, the treatment teak + frenchbean recorded significantly increased total dry matter (3.04) the next best value is teak + blackgram (3.00) when compared to rest of the agroforestry systems. Whereas, it was significantly lowest in the treatment teak + greengram (1.76) followed by the treatment teak + soybean (2.45).Total dry matter production was low at 0 to 2 m distance from teak row (2.44) as compared to 2 to 4 m distances (2.45).

At 40 DAS, total dry matter production in legume crops was significantly reduced when legumes grown with teak based agroforestry systems as compared to sole crop.

The total dry matter recorded was significantly higher in the treatment teak + soybean (10.41) which was followed by teak + frenchbean (9.67) when compared to other agroforestry systems. Reduction was highest in the treatment teak + greengram (5.83) and teak + blackgram (5.98).

The treatment 2 m distance away from tree base noticed significantly lowest total dry matter while the treatment 4 m distance recorded significantly highest total dry matter this trend was followed at all stages.

At harvest, among the agroforestry treatment teak + soybean showed significantly maximum total dry matter (22.77) followed by teak + frenchbean (16.03). However, when compared to other agroforestry system, the treatment teak + greengram had significantly minimum total dry matter (9.90) and was followed by teak + blackgram (10.11).

However, the interaction effect between the tree species and distances were significant at this stage.

The treatment teak + soybean recorded significantly increased total dry matter at 4 m distance (24.47) whereas, at 2 m distance from the base of the tree (21.07) recorded.

4.1.3 Growth and growth parameters

4.1.3.1 Leaf Area Index

The data on leaf area index of legumes is presented in the Table 15. It was significantly influenced by the agroforestry systems and distances from tree base at 20 and 40 DAS while it was only among agroforestry systems at harvest.

The interaction insignificant at all the stages of growth. The leaf area index of legumes was significantly increased with increased in distance from teak alley. In general the leaf area index increased up to 40 DAS and decreased thereafter. The average leaf area index of legumes ranged from 1.21 to 2.66 (40 DAS).

At 20 DAS, among the agroforestry systems leaf area index was significantly higher in the treatment teak + frenchbean (1.88) and followed by teak +soybean (1.50). While, it was lowest in the treatment teak + greengram (0.37) and teak + blackgram (0.38) and both were on par with each other.

The distances 2 m away from the tree base showed lowest leaf avea index of legumes. It was highest at 4 m distances. This trend was followed at all the stages.

At 40 DAS, leaf area index was significantly maximum in teak + frenchbean (2.79) and the next best treatment was teak + soybean (2.67) but the lowest leaf area index was found in teak + greengram (1.74) and teak + blackgram(1.75) and both were on par with each other.

However, the interaction effect between agroforestry systems and distances with respect to distance from tree base was varying significantly. Leaf area index was lowest in teak + greengram at 2 m distance from tree base (1.74). Whereas, at 4 m distance showed highest leaf area index in teak + frenchbean (2.94)

At harvest, drastic reduction was observed in all the agroforestry systems. The values were highest in the treatment teak + frenchbean (1.73) followed by teak + soybean (1.85) and the lowest leaf area index was observed in the treatment teak + greengram (1.40), the interaction effect was non significant.

Table 15: Influence of teak based agroforestry system on leaf area index (LAI) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.46	1.54	**1.50**	2.54	2.81	**2.67**	1.83	1.86	**1.85**
T_2-Teak + Greengram	0.34	0.41	**0.37**	1.74	1.74	**1.74**	1.40	1.41	**1.40**
T_3-Teak + Frenchbean	1.83	1.94	**1.88**	2.64	2.94	**2.79**	1.66	1.81	**1.73**
T_4-Teak + Blackgram	0.36	0.39	**0.38**	1.74	1.75	**1.75**	1.41	1.41	**1.41**
T_5-Soybean (sole)	2.62	2.76	**2.69**	4.25	4.70	**4.47**	2.06	2.10	**2.08**
T_6-Greengram (sole)	0.42	0.42	**0.42**	2.41	2.41	**2.41**	1.73	1.74	**1.74**
T_7-Frenchbean (sole)	1.97	2.14	**2.05**	3.00	3.02	**3.01**	1.81	1.94	**1.87**
T_8-Blackgram (sole)	0.40	0.41	**0.40**	2.42	2.45	**2.42**	1.72	1.86	**1.79**
Mean	**1.18**	**1.26**	**1.22**	**2.59**	**2.73**	**2.66**	**1.70**	**1.76**	**1.73**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.041	0.118	0.064	0.184	0.048	0.138
Distance (D)	0.020	0.057	0.032	0.092	0.024	NS
Interaction (AF X D)	0.058	NS	0.090	NS	0.068	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

4.1.3.2 Absolute Growth Rate (AGR, g $plant^{-1}$ day^{-1})

The data on absolute growth rate (AGR) of agroforestry systems and distances from the tree base at all stages is presented in Table 16. It varied significantly among agroforestry system, distances and also with interaction effects at all the stages.

The average AGR, ranged from 0.295 g (20-40 DAS) to 0.399 g (40-60 DAS).

At 20-40 DAS, among the agroforestry systems teak + soybean recorded significantly maximum AGR (0.404) followed by teak + frenchbean (0.331). Absolute growth rate was minimum in teak + blackgram (0.179) and teak + greengram agroforestry system (0.204).

Among the distances, the values at 2 m distances from tree base had lowest absolute growth rate. Whereas, at 4 m distance highest absolute growth rate was recorded. This trend was noticed even at 40-60 DAS and 60 DAS to harvest.

At 40-60 DAS, the treatment teak + soybean showed significantly highest absolute growth rate (0.612), the next best treatment was teak + frenchbean (0.318) when compared to other agroforestry systems. It was lowest in the treatment teak + greengram (0.254) followed by the treatment teak + blackgram (0.207) as compared to other agroforestry system.

At 60 DAS to harvest, the absolute growth rate was higher in the treatment teak + soybean (0.413) followed by in teak + frenchbean (0.212) as compared to other agroforestry systems, whereas the treatment teak + greengram (0.136) had the least absolute growth rate and was followed by treatment teak + blackgram (0.138).

Interaction effect between the agroforestry system and distance from tree base differed significantly. The treatment teak + soybean at 2 m distance recorded highest value at all the stages and was significantly superior over others. However, the treatment teak + blackgram at 2 m had the lowest value at all the stages.

4.1.3.3 Crop Growth Rate (CGR, g m^{-2} day^{-1})

The data on crop growth rate of legumes differed significantly among the agroforestry systems, distance from tree base and their interactions 20-40 DAS and 40–60 DAS stages. While it was significantly varied among the agroforestry systems and distances only at 60 to harvest stages.

The average crop growth rate of legumes ranged from 0.009 to 0.012 g m^{-2} day^{-1} (40-60 DAS) (Table 17).

At 20–40 DAS, teak + soybean had significantly highest crop growth rate (0.012) and was followed by teak + frenchbean (0.010) when compared to other agroforestry systems. The lowest value of crop growth rate was noticed in teak + greengram (0.006) and teak + blackgram (0.006) and these were on par with each other.

Among the distances, 2 m distances from the tree base recorded minimum crop growth rate. The treatment 4 m distance recorded maximum crop growth rate. The same trend was observed at all the stages.

The interaction effects between agroforestry systems and distances from base of the tree varied significantly at 20 – 40 DAS and 40 – 60 DAS. The lowest crop growth rate during 20 – 40 DAS period at 2 m distances from tree base was noticed in teak + blackgram (0.005) and teak + greengram (0.005). It was highest in 4 m. distance in the teak + soybean (0.013).

At 40 – 60 DAS, the treatment teak + soybean showed maximum crop growth rate (0.018) and was followed by teak + frenchbean (0.010) when compared to other treatment. It was lowest in the teak + blackgram (0.006) and teak + greengram (0.007) which were on par with each other.

At 60 DAS – harvest, the crop growth rate was drastically reduced.The treatment teak + soybean (0.012) had the highest value and was followed by teak + frenchbean (0.006). It was minimum in teak + greengram (0.004 g) and teak + blackgram (0.004). In general, the crop growth rate was minimum in agroforestry systems as compared to sole crop treatment. The average crop growth rate of legumes ranged from 0.008 to 0.012.

Table 16: Influence of teak based agroforestry system on absolute growth rate (g plant^{-1} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.368	0.440	**0.404**	0.563	0.662	**0.612**	0.384	0.442	**0.413**
T_2-Teak + Greengram	0.190	0.217	**0.204**	0.218	0.290	**0.254**	0.112	0.160	**0.136**
T_3-Teak + Frenchbean	0.299	0.363	**0.331**	0.284	0.352	**0.318**	0.189	0.235	**0.212**
T_4-Teak + Blackgram	0.173	0.185	**0.179**	0.151	0.263	**0.207**	0.100	0.175	**0.138**
T_5-Soybean (sole)	0.377	0.455	**0.416**	0.747	0.758	**0.752**	0.498	0.505	**0.502**
T_6-Greengram (sole)	0.224	0.228	**0.226**	0.295	0.311	**0.303**	0.196	0.208	**0.202**
T_7-Frenchbean (sole)	0.380	0.422	**0.401**	0.402	0.389	**0.396**	0.268	0.259	**0.264**
T_8-Blackgram (sole)	0.198	0.203	**0.200**	0.334	0.375	**0.354**	0.223	0.250	**0.236**
Mean	**0.276**	**0.314**	**0.295**	**0.374**	**0.425**	**0.399**	**0.246**	**0.279**	**0.262**

For comparing the means of	20 - 40 DAS SEm ±	20 - 40 DAS CD (0.05)	40 - 60 DAS SEm ±	40 - 60 DAS CD (0.05)	60 - Harvest SEm ±	60 - Harvest CD (0.05)
Agroforestry system (AF)	0.007	0.020	0.013	0.037	0.008	0.023
Distance (D)	0.003	0.008	0.006	0.017	0.004	0.011
Interaction (AF X D)	0.102	0.293	0.018	0.051	0.011	0.031

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 17: Influence of teak based agroforestry system on crop growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Soybean	0.011	0.013	**0.012**	0.017	0.020	**0.018**	0.011	0.013	**0.012**
T_2-Teak + Greengram	0.005	0.007	**0.006**	0.007	0.007	**0.007**	0.003	0.005	**0.004**
T_3-Teak + Frenchbean	0.009	0.011	**0.010**	0.008	0.011	**0.010**	0.005	0.007	**0.006**
T_4-Teak + Blackgram	0.005	0.006	**0.006**	0.005	0.008	**0.006**	0.003	0.005	**0.004**
T_5-Soybean (sole)	0.014	0.015	**0.015**	0.022	0.023	**0.022**	0.015	0.015	**0.015**
T_6-Greengram (sole)	0.007	0.007	**0.007**	0.009	0.009	**0.009**	0.006	0.006	**0.006**
T_7-Frenchbean (sole)	0.012	0.013	**0.012**	0.012	0.012	**0.012**	0.008	0.007	**0.008**
T_8-Blackgram (sole)	0.007	0.008	**0.008**	0.010	0.011	**0.011**	0.006	0.007	**0.007**
Mean	**0.008**	**0.010**	**0.009**	**0.011**	**0.013**	**0.012**	**0.007**	**0.008**	0.007

For comparing the means of	20 - 40 DAS SEm ±	20 - 40 DAS CD (0.05)	40 - 60 DAS SEm ±	40 - 60 DAS CD (0.05)	60 - Harvest SEm ±	60 - Harvest CD (0.05)
Agroforestry system (AF)	0.0002	0.0005	0.0005	0.0001	0.0003	0.0008
Distance (D)	0.0001	0.0002	0.0003	0.0008	0.0001	0.0002
Interaction (AF X D)	0.0003	0.0008	0.0007	NS	0.0004	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

4.1.3.4 Relative Growth Rate (RGR, g g^{-1} day^{-1})

The data on relative growth rate of agroforestry systems and distance from tree base at (20-40) DAS, (40– 60) DAS and (60 DAS – harvest) is presented in the Table18. The average RGR of legumes ranged from 0.059 to 0.031 g g^{-1} day^{-1} (40-60 DAS).

At 20–40 DAS RGR was significantly maximum in teak + soybean (0.069) followed by in teak + frenchbean (0.060) when compared to other agroforestry systems.The reduction was highest in teak + blackgram (0.044) followed by teak + greengram (0.058).

Among the distances, 2 m distance from tree base recorded lowest relative growth rate where as 4 m distance showed highest relative growth rate at all the stages.

Interaction effect between agroforestry system and base of the tree at 20 – 40 DAS period varied significantly. The minimum relative growth rate at 2 m distance from tree base in teak + blackgram (0.044). It was maximum at 4 m distance in teak + soybean based agroforestry system (0.073).

At 40 – 60 DAS, the treatment teak +soybean recorded significantly maximum relative growth rate (0.039) followed by teak + frenchbean (0.026). It was minimum in teak + greengram (0.025) and teak + blackgram (0.026) which were on par with each other.

In general, RGR was maximum at 4 m distance to compared 2 m distance from tree base.

The interaction effect between the agroforestry systems and distance from teak alley differed significantly. The treatment teak + blackgram (0.021) at 2 m distance registered the lowest relative growth rate. It was highest at 4 m distance in the teak + soybean (0.039). The maximum relative growth rate was observed in sole legumes as compared to agroforestry systems.

At 60 DAS–harvest period, the same trend was observed in the treatment teak + soybean(0.026), followed by teak + frenchbean (0.017) and teak + blackgram(0.017) and teak + greengram (0.017) which were on par with each other.

There was no significant interaction between agroforestry systems and distances at 60 DAS – harvest stage.

4.1.3.5 Net Assimilation Rate (NAR, g dm^{-2} day^{-1})

The data on net assimilation rate (NAR) of legumes was significantly influenced by the agroforestry systems at both stages among the distances from tree base. While, the interaction effects were insignificant at both stages (Table 19).

The average NAR of legumes ranged from 0.023 g dm^{-2} day^{-1} (20 – 40 DAS) to 0.029 g dm^{-2} day^{-1} (40 – 60 DAS).

At 20 – 40 DAS, among the agroforestry systems, the treatments teak + soybean (0.028) and teak + blackgram (0.025) recorded the maximum NAR and both were on par. It was lowest in teak + greengram (0.016) followed by in teak + frenchbean (0.023).

The distance at 2 m from tree base recorded lowest net assimilation rate, when compared to 4 m distance at both the stages (20 – 40 DAS) and (40 – 60 DAS) and were on par with each other.

However, the interaction effect between tree species and base of tree was significantly differ. The treatment teak + greengram noticed lowest NAR at 2 m distance from tree base (0.016). It was highest at 4 m distance in teak + soybean (0.029).

At 40 - 60 DAS, also the same trend was noticed, the treatment teak + soybean (0.034) followed by teak + blackgram (0.029) were having highest NAR values as compared to other agroforestry system. The treatment teak + greengram (0. 026), teak + frenchbean (0.026), teak + blackgram (0.029) were on par with each other.

Table 18: Influence of teak based agroforestry system on relative growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.066	0.073	**0.069**	0.038	0.039	**0.039**	0.026	0.026	**0.026**
T_2-Teak + Greengram	0.056	0.060	**0.058**	0.025	0.026	**0.025**	0.016	0.019	**0.017**
T_3-Teak + Frenchbean	0.060	0.060	**0.060**	0.024	0.029	**0.026**	0.016	0.017	**0.017**
T_4-Teak + Blackgram	0.044	0.045	**0.044**	0.021	0.030	**0.025**	0.014	0.020	**0.017**
T_5-Soybean (sole)	0.069	0.077	**0.073**	0.041	0.045	**0.043**	0.027	0.030	**0.029**
T_6-Greengram (sole)	0.060	0.060	**0.060**	0.032	0.033	**0.032**	0.021	0.022	**0.021**
T_7-Frenchbean (sole)	0.062	0.063	**0.062**	0.025	0.028	**0.027**	0.017	0.019	**0.018**
T_8-Blackgram (sole)	0.045	0.047	**0.046**	0.037	0.038	**0.037**	0.024	0.025	**0.025**
Mean	**0.058**	**0.060**	**0.059**	**0.031**	**0.032**	**0.031**	**0.021**	**0.022**	**0.021**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.0010	0.0028	0.0008	0.0023	0.0005	0.0014
Distance (D)	0.0005	0.0014	0.0004	0.0011	0.0003	0.0008
Interaction (AF X D)	0.0015	0.0043	0.0012	NS	0.0008	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 19: Influence of teak based agroforestry system on net assimilation rate (g dm^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.028	0.029	**0.028**	0.033	0.035	**0.034**
T_2-Teak + Greengram	0.016	0.017	**0.016**	0.026	0.027	**0.026**
T_3-Teak + Frenchbean	0.022	0.024	**0.023**	0.026	0.027	**0.026**
T_4-Teak + Blackgram	0.025	0.026	**0.025**	0.028	0.030	**0.029**
T_5-Soybean (sole)	0.029	0.030	**0.029**	0.035	0.036	**0.035**
T_6-Greengram (sole)	0.018	0.020	**0.019**	0.027	0.029	**00.028**
T_7-Frenchbean (sole)	0.023	0.025	**0.024**	0.027	0.029	**0.028**
T_8-Blackgram (sole)	0.026	0.028	**0.027**	0.030	0.032	**0.031**
Mean	**0.023**	**0.024**	**0.023**	**0.029**	**0.030**	**0.029**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.0013	0.0037	0.0005	0.0014
Distance (D)	0.0008	0.0023	0.0003	0.0008
Interaction (AF X D)	0.0020	NS	0.0009	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

4.1.3.6 Specific Leaf Area (SLA, $dm^2 g^{-1}$)

The data on specific leaf area (SLA) of legumes was significantly influenced by the agroforestry systems. The data is presented the Table 20. It varied significantly among the agroforestry systems and among the distances at harvest.

The average of specific leaf area of legumes ranged from 2.90 to 2.67 $dm^2 g^{-1}$ (20- 40 DAS).

At 20 DAS, the treatment teak + frenchbean showed significantly highest specific leaf area (5.61) followed by teak + soybean (4.29), when compared to other agroforestry systems. It was lowest in teak + blackgram (0.95) followed by teak + greengram (1.36).

The distance 4 m from the tree base recorded lowest specific leaf area, where as 2 m distance showed highest specific leaf area. This trend was observed at both stages. The interaction effects were non significant.

Interaction effect between agroforestry and distances from tree base was non significant.

At 40 DAS, the treatment teak + greengram showed highest specific leaf area (2.77) followed by teak + blackgram (2.34) when compared to other agroforestry systems. It was lowest in teak + frenchbean (1.82) followed by teak + soybean (2.18).

At harvest, the similar trend was noticed. The specific leaf area noticed significantly maximum in teak + greengram (1.88) and teak + blackgram (1.87). A drastic reduction of specific leaf area in the treatment teak + soybean (1.57) and teak + frenchbean (1.47) was noticed. However, there was increased in specific leaf area in sole legumes as compared to agroforestry systems.

4.1.3.7 Specific Leaf Weight (SLW, $g\ dm^{-2}$)

The data on specific leaf weight (SLW) of legumes were significantly influenced by the agroforestry systems at all stages. While the interaction effect was non significant at all the stages. The data is presented in the Table 21.

The average specific leaf weight of legumes ranged from 0.440 $g\ dm^{-2}$ to 0.616 $g\ dm^{-2}$ (harvest).

At 20 DAS, the treatment teak + greengram recorded maximum specific leaf weight (0.467) followed by teak + blackgram (0.411) when compared to other agroforestry systems. A decreased specific leaf weight was noticed in teak + soybean (0.276) followed by teak + frenchbean (0.393) and both were on par with each other.

At 40 DAS, specific leaf weight of legume recorded maximum in teak + greengram (0.630) followed by teak + blackgram (0.616) when compared to other agroforestry systems. It was minimum in teak +soybean (0.462) followed by teak + frenchbean (0.593).

Interaction effects between among the distances from the base of the tree, the treatment teak + soybean at 2 m distance recorded lower specific leaf weight (0.436) whereas, 4 m distance from base of the tree the treatment teak + greengram recorded significantly increased specific leaf weight (0.638).

At harvest, among the agroforestry systems the treatment teak + frenchbean (0.403) registered significantly highest SLW followed by teak + soybean (0.398). It was lowest in the treatment teak + greengram (0.300) followed by teak + blackgram (0.307).

Interaction effect between agroforestry systems and distances from tree base was insignificant.

The treatment teak + greengram (0.274) showed reduced specific leaf weight at 2 m distance from tree base. Whereas, at 4 m distance recorded increase specific leaf weight in teak + frenchbean (0.454).

4.1.3.8 Leaf Area Ratio (LAR, $dm^2 g^{-1}$)

The data on leaf area ratio (LAR) of legume was significantly influenced by the agroforestry systems at all stages between the distances from tree base at 20 DAS and harvest stages. While the interaction effects significantly differ at all the stages except at 40 DAS (Table 22).The average LAR of legumes ranged from 1.29 $dm^2 g^{-1}$ to 0.61 $dm^2 g^{-1}$ (20 DAS- harvest).

At 20 DAS, the treatment teak + frenchbean noticed significantly maximum leaf area ratio (1.88) followed by teak + soybean (1.76). It was minimum in teak + blackgram (0.34) and was followed by teak + greengram (0.63).

Among the distances, 2 m from tree base showed significantly highest leaf area ratio, while 4 m distance recorded lowest leaf area ratio. This trend was noticed at all stages.

The interaction effect between agroforestry systems and distances from tree base differed significantly. The treatment teak + frenchbean recorded maximum leaf area ratio at 2 m distances from tree base (1.90) and the same treatment teak + frenchbean noticed maximum leaf area ratio (1.86) at 4 m distance also.

At 40 DAS, among the agroforestry systems, the treatment teak + greengram recorded significantly increased leaf area ratio (0.88) and the next best value was in teak + blackgram (0.83). LAR reduction was highest in teak + frenchbean (0.71) followed by teak + soybean (0.76)

However, interaction effect between agroforestry systems and distances from teak alley was significantly varying. The distances 4 m from base of tree recorded decreased leaf area ratio in teak + frenchbean (0.71).It was increased in teak + green gram at 2 m away from the tree.

At harvest, the treatment teak + blackgram noticed maximum leaf area ratio (0.68) followed by in teak + greengram (0.65). It was minimum is teak + frenchbean (0.40) and teak + soybean (0.49).

The interaction between agroforestry systems and distances was significant. The distance from base of tree was recorded decreased leaf area ratio (0.40) in teak + frenchbean. It increased in teak + blackgram (0.70) at 2 m away from the tree base.

4.1.3.9 Leaf Area Duration (Days)

The data on leaf area duration of legumes was significantly influenced by the agroforestry systems and the distances from base of tree at both stages. (Table 23). While the interaction were insignificant at both stages.

The average leaf area duration of legumes ranged from 38.71 days (20-40 DAS) to 48.99 days (40 - 60 DAS).

At 20 – 40 DAS, among the agroforestry treatments, the treatment teak + frenchbean noticed significantly maximum leaf area duration (46.77) followed by teak + soybean (41.80). Reduction of leaf area duration was highest in teak + green gram (21.48) and teak + blackgram (21.59) both were on par with each other.

Among the distances effect, 2 m distances from tree base showed decreased leaf area duration, where as 4 m distance recorded increased leaf area duration. This trend was followed at 40 – 60 DAS period also.

However, interaction effect between agroforestry systems and distances from tree base was insignificant.

At 40 – 60 DAS, the treatment teak + soybean recorded maximum leaf area duration (51.17) and followed by teak + frenchbean (46.07). It was minimum in teak + greengram (35.40) and next best value was in teak + blackgram (36.16).

Among the interaction effect between agroforestry systems and distances from base of tree was varied significantly. At 2 m distance from base of tree was observed decreased leaf area duration in teak + greengram (34.90) and it was increased at 4 m distances in teak + soybean (52.37).

Table 20: Influence of teak based agroforestry system on specific leaf area ($dm^2\ g^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	3.86	3.62	**3.74**	2.30	2.06	**2.18**	1.61	1.52	**1.57**
T_2-Teak + Greengram	1.34	1.34	**1.34**	2.95	2.59	**2.77**	1.96	1.80	**1.88**
T_3-Teak + Frenchbean	4.27	4.19	**4.23**	1.83	1.81	**1.82**	1.48	1.46	**1.47**
T_4-Teak + Blackgram	0.89	0.88	**0.88**	2.58	2.10	**2.34**	1.95	1.80	**1.87**
T_5-Soybean (sole)	5.93	5.29	**5.61**	3.21	3.06	**3.14**	2.60	2.45	**2.52**
T_6-Greengram (sole)	1.51	1.22	**1.36**	3.67	3.22	**3.44**	2.25	2.16	**2.21**
T_7-Frenchbean (sole)	4.33	4.25	**4.29**	2.89	2.20	**2.55**	1.72	1.67	**1.70**
T_8-Blackgram (sole)	0.99	0.92	**0.95**	3.16	3.13	**3.15**	2.00	2.41	**2.21**
Mean	**2.89**	**2.71**	**2.90**	**2.82**	**2.52**	**2.67**	**1.95**	**1.90**	**1.95**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.116	0.334	0.098	0.259	0.083	0.239
Distance (D)	0.058	NS	0.031	0.089	0.041	0.118
Interaction (AF X D)	0.164	NS	0.177	NS	0.117	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 21: Influence of teak based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.275	0.278	**0.276**	0.436	0.488	**0.462**	0.387	0.409	**0.398**
T_2-Teak + Greengram	0.461	0.473	**0.467**	0.623	0.638	**0.630**	0.274	0.326	**0.300**
T_3-Teak + Frenchbean	0.390	0.397	**0.393**	0.588	0.598	**0.593**	0.352	0.454	**0.403**
T_4-Teak + Blackgram	0.406	0.415	**0.411**	0.608	0.623	**0.616**	0.300	0.314	**0.307**
T_5-Soybean (sole)	0.444	0.463	**0.454**	0.633	0.670	**0.651**	0.387	0.475	**0.431**
T_6-Greengram (sole)	0.523	0.563	**0.543**	0.618	0.688	**0.653**	0.351	0.387	**0.369**
T_7-Frenchbean (sole)	0.427	0.440	**0.434**	0.677	0.710	**0.693**	0.545	0.553	**0.549**
T_8-Blackgram (sole)	0.532	0.555	**0.544**	0.6 10	0.651	**0.630**	0.321	0.324	**0.322**
Mean	**0.432**	**0.448**	**0.440**	**0.599**	**0.633**	**0.616**	**0.364**	**0.405**	**0.384**

For comparing the means of	20 - 40 DAS SEm ±	20 - 40 DAS CD (0.05)	40 - 60 DAS SEm ±	40 - 60 DAS CD (0.05)	60 - Harvest SEm ±	60 - Harvest CD (0.05)
Agroforestry system (AF)	0.018	0.051	0.022	0.063	0.014	0.040
Distance (D)	0.039	NS	0.011	0.031	0.007	0.020
Interaction (AF X D)	0.111	NS	0.032	NS	0.019	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 22: Influence of teak based agroforestry system on leaf area ratio ($dm^2 g^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.82	1.71	**1.76**	0.77	0.74	**0.76**	0.52	0.45	**0.49**
T_2-Teak + Greengram	0.63	0.63	**0.63**	0.92	0.84	**0.88**	0.69	0.62	**0.65**
T_3-Teak + Frenchbean	1.90	1.86	**1.88**	0.80	0.71	**0.71**	0.40	0.40	**0.40**
T_4-Teak + Blackgram	0.42	0.27	**0.34**	0.87	0.80	**0.83**	0.70	0.66	**0.68**
T_5-Soybean (sole)	2.80	2.49	**2.64**	1.22	1.19	**1.20**	0.60	0.58	**0.59**
T_6-Greengram (sole)	0.71	0.58	**0.64**	1.07	1.02	**1.04**	0.76	0.70	**0.73**
T_7-Frenchbean (sole)	2.04	2.00	**2.02**	0.82	0.80	**0.81**	0.60	0.48	**0.54**
T_8-Blackgram (sole)	0.46	0.43	**0.45**	1.10	1.05	**1.07**	0.87	0.75	**0.81**
Mean	**1.34**	**1.24**	**1.29**	**0.93**	**0.89**	**0.91**	**0.64**	**0.58**	**0.61**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.045	0.130	0.027	0.077	0.022	0.060
Distance (D)	0.022	0.065	0.013	0.037	0.011	0.030
Interaction (AF X D)	0.064	0.184	0.041	NS	0.031	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 23: Influence of teak based agroforestry system on leaf area duration (Days) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	40.06	43.53	**41.80**	49.96	52.37	**51.17**
T_2-Teak + Greengram	20.90	22.06	**21.48**	34.90	35.89	**35.40**
T_3-Teak + Frenchbean	44.68	48.85	**46.77**	45.69	46.45	**46.07**
T_4-Teak + Blackgram	21.46	21.72	**21.59**	35.92	36.39	**36.16**
T_5-Soybean (sole)	68.73	74.66	**71.70**	69.08	73.98	**71.53**
T_6-Greengram (sole)	28.27	28.41	**28.34**	52.21	53.28	**52.75**
T_7-Frenchbean (sole)	47.76	51.70	**49.73**	49.52	53.65	**51.58**
T_8-Blackgram (sole)	28.27	28.35	**28.31**	46.61	47.94	**47.27**
Mean	**37.52**	**39.91**	**38.71**	**47.99**	**49.99**	**48.99**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.967	2.784	0.959	2.761
Distance (D)	0.483	1.391	0.479	1.379
Interaction (AF X D)	1.367	NS	1.357	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

4.1.4 Biophysical parameters

4.1.4.1 Photosynthetic rate (µmol CO_2 dm^{-2} s^{-1})

The effect of agroforestry systems and distances from the tree base on photosynthetic rate in legume crops at different stages is presented in the Table 24.

The rate of photosynthesis decreased from 20 DAS to 40 DAS. It was more in sole crops as compared to in agroforestry systems.

At 20 DAS, among the agroforestry system the rate of photosynthesis was significantly more in the treatment teak + soybean (12.27) followed by in teak + frenchbean(12.10). The lowest photosynthetic rate was recorded in the treatment teak + blackgram (10.99) and followed by teak + greengram (11.14) which were on par with each other.

Among the distances 2 m distance from the tree base recorded minimum photosynthetic rate. The treatment teak + blackgram (10.73) had the lowest value and it was followed by teak + greengram (10.83). At 4 m distance, the rate of photosynthesis was significantly higher than over 2 m distances. At distance 4 m from tree base the treatment teak + soybean (12.82) followed by teak + frenchbean (12.78) were significantly superior over other treatments.

In general the rate of photosynthesis increased significantly with increased in distance from teak alley.

A reduction in the rate of photosynthesis was noticed at 40 DAS as compared to 20 DAS. Among the agroforestry systems, the highest rate of photosynthesis was recorded in the treatment teak + soybean (10.80) followed by in teak + frenchbean (10.15). The minimum photosynthetic rate was found in the treatment teak + blackgram (9.05) followed by teak + greengram (9.22)

Interaction effect between the agroforestry systems and distances was non significant.

4.1.4.2 Stomatal conductance (cm s^{-1})

The effect of agroforestry systems and distances on stomotal conductance in legume crops presented in the Table 25 indicated that it increased from 20 DAS to 40 DAS.

In general, the stomatal conductance of legumes was more in sole crop treatments as compared to agroforestry systems. At 20 DAS, the stomatal conductance was lower in the treatment teak + greengram (3.25) followed by teak + blackgram (3.37). The higher stomatal conductance was found in the treatment teak + frenchbean (4.21) followed by teak + soybean (4.01).

As the distance increased from teak alley the stomatal conductance increased in legume crops. The same trend was observed in 40 DAS also.

At 40 DAS, the stomatal conductance significantly increased in the treatment teak + frenchbean (5.36) followed by teak + soybean (4.89) and the minimum stomatal conductance was noticed in the treatment teak + blackgram (3.29) followed by teak + greengram (3.60).

Among the distances effect, 2 m distance from teak alley showed decreased stomatal conductance where as 4 m distance recorded significantly increased stomatal conductance.

4.1.4.3 Transpiration rate (mgH_2O m^{-2} s^{-1})

The data on transpiration rate of legume was significantly influenced by agroforestry systems and distances. It is presented in the Table 26.

The rate of transpiration decreased from 20 DAS to 40 DAS. In general the transpiration rate was more in sole crops treatment as compared to agroforestry systems.

At 20 DAS, among the agroforestry systems the rate of transpiration was significantly high in teak + frenchbean (4.58) followed by teak + soybean (4.47). The lowest transpiration rate was observed in the treatment teak + blackgram (3.66) followed by in teak + greengram (3.92).

Table 24: Influence of teak based agroforestry system on photosynthetic rate (µmol CO_2 dm^{-2} s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Soybean	11.73	12.82	**12.27**	10.70	10.91	**10.80**
T_2-Teak + Greengram	10.83	11.45	**11.14**	8.90	9.55	**9.22**
T_3-Teak + Frenchbean	11.43	12.78	**12.10**	9.77	10.53	**10.15**
T_4-Teak + Blackgram	10.73	11.25	**10.99**	8.90	9.21	**9.05**
T_5-Soybean (sole)	12.55	13.00	**12.77**	11.63	12.08	**11.85**
T_6-Greengram (sole)	10.95	11.98	**11.46**	9.13	9.70	**9.41**
T_7-Frenchbean (sole)	13.20	13.09	**13.14**	11.18	11.76	**11.47**
T_8-Blackgram (sole)	11.36	11.93	**11.65**	9.25	9.95	**9.60**
Mean	**11.60**	**12.29**	**11.94**	**9.93**	**10.46**	**10.19**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.13	0.37	0.15	0.43
Distance (D)	0.06	0.17	0.07	0.20
Interaction (AF X D)	0.19	NS	0.21	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 25: Influence of teak based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	3.92	4.11	**4.01**	4.73	5.06	**4.89**
T_2-Teak + Greengram	3.16	3.34	**3.25**	3.34	3.86	**3.60**
T_3-Teak + Frenchbean	4.13	4.29	**4.21**	5.18	5.55	**5.36**
T_4-Teak + Blackgram	3.31	3.43	**3.37**	3.46	3.53	**3.29**
T_5-Soybean (sole)	4.38	4.56	**4.47**	6.00	6.23	**6.11**
T_6-Greengram (sole)	3.45	3.63	**3.54**	3.78	4.10	**3.94**
T_7-Frenchbean (sole)	4.52	4.70	**4.61**	5.86	6.21	**6.03**
T_8-Blackgram (sole)	3.32	3.75	**3.53**	3.65	3.75	**3.70**
Mean	**3.77**	**3.98**	**3.87**	**4.50**	**4.78**	**4.64**

For comparing the means of	SEm ± (20 DAS)	CD (0.05) (20 DAS)	SEm ± (40 DAS)	CD (0.05) (40 DAS)
Agroforestry system (AF)	0.08	0.23	0.12	0.34
Distance (D)	0.04	0.11	0.06	0.17
Interaction (AF X D)	0.12	NS	0.17	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

The rate of transpiration at 4 m distances was 4.41 and was significantly superior over 2 m distances.

At 40 DAS, the rate of transpiration drastically reduced as compared to 20 DAS. Among the agroforestry systems, the rate of transpiration was more in the treatment teak + soybean (3.75) followed by teak + frenchbean (3.52) and lower transpiration values were found in teak + blackgram (3.20) and by teak + greengram (3.29).

Among the distances 2 m distance from the teak alley recorded minimum transpiration rate (3.45) as compared to 4 m distances (3.68)

4.1.4.4 Relative Water Content (RWC, %)

Relative water content of legumes as influenced by agroforestry systems and distances from tree base different growth stages is presented in the Table 27.

The relative water content of legumes decreased gradually from 20 DAS to harvest. The data varied significantly among agroforestry systems at all stages. Among distances at 20 DAS and at harvest while interaction effect was insignificant.

Among agroforestry systems significantly increased RWC was noticed and it was highest in teak + soybean (91.33) followed by teak + frenchbean (87.18). The lowest RWC was observed in teak + greengram (81.24) followed by teak + blackgram (85.67).

The relative water content was more in agroforestry system as compared to sole crop treatments. The RWC was more in 2 m distance (85.29) as compared to 4 m distance (82.65).

Among the distances, 2 m distance from teak alley was recorded significantly maximum RWC in teak + soybean (79.78). Whereas, at 4 m distance the treatment teak + blackgram minimum relative water content (72.63).

At harvest, the same trend was noticed. Among to agroforestry systems the treatment teak + soybean (70.22) registered significantly higher relative water content followed by teak + greengram (69.58). Whereas, lower relative water content was observed in the treatment teak + frenchbean (55.16) followed by in teak + blackgram (66.03). The relative water content was higher 2 m distance as compared to 4 m distances from teak alley.

4.1.4.5 Light Transmission Ratio (LTR, %)

The data on light transmission ratio (LTR) of legumes was significantly influenced by the agroforestry systems the distances from base of tree and due to their interaction effect all the stages (Table 28 and Fig.6).

The averages light transmission ratio of legumes ranged from 88.89 to 82.06 per cent (harvest).

At 20 DAS, among the agroforestry systems, the highest light transmission ratio (LTR) was observed in teak + soybean 80.35 it was significantly superior over other. The LTR was significantly more in 4 m distance (93.79) as compared to 2 m distances (83.99).

At 40 DAS, among the agroforestry system, the treatment teak + frenchbean noticed significantly maximum light transmission ratio (74.69) and was followed by teak + blackgram (70.22) as compared to other agroforestry systems. Reduction of light transmission ratio was highest in teak + greengram (69.10) and was closely followed by treatment teak + soybean (69.32) both were on par with each other.

Interaction effect between the agroforestry systems and distances from tree base was significantly varying at 4 m distance from tree base. Higher light transmission ratio was noticed in teak + frenchbean (80.23). While it was significantly low in teak + blackgram (62.26) at 2 m distance from tree base.

At harvest, agroforestry system recorded significantly lower light transmission ratio as compared to previous stages. Significantly high light transmission ratio was noticed in teak + frenchbean (69.53) followed by teak + soybean (67.01) and teak + greengram (60.70 %) and teak + blackgram (59.25) recorded lowest values. The light transmission ratio was 84.50 per cent at 2 m distance and was varying significantly over 4 m distance (79.61).

Table 26: Influence of teak based agroforestry system on transpiration rate (mgH_2O m^{-2} s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	4.39	4.54	**4.47**	3.71	3.79	**3.75**
T_2-Teak + Greengram	3.78	4.07	**3.92**	3.21	3.37	**3.29**
T_3-Teak + Frenchbean	4.35	4.82	**4.58**	3.39	3.65	**3.52**
T_4-Teak + Blackgram	3.67	3.65	**3.66**	3.05	3.35	**3.20**
T_5-Soybean (sole)	4.53	5.03	**4.78**	4.06	4.30	**4.18**
T_6-Greengram (sole)	4.12	4.25	**4.18**	3.32	3.74	**3.53**
T_7-Frenchbean (sole)	4.73	4.90	**4.82**	3.72	3.79	**3.75**
T_8-Blackgram (sole)	3.82	4.03	**3.92**	3.25	3.47	**3.36**
Mean	**4.17**	**4.41**	**4.29**	**3.45**	**3.68**	**3.56**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)
Agroforestry system (AF)	0.068	0.195	0.061	0.175
Distance (D)	0.034	0.097	0.030	0.086
Interaction (AF X D)	0.102	NS	0.090	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 27: Influence of teak based agroforestry system on relative water content (%) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	91.8	90.9	**91.3**	79.8	77.6	**78.7**	72.8	67.76	**70.2**
T_2-Teak + Greengram	82.1	80.4	**81.2**	73.9	73.7	**73.8**	70.6	68.6	**69.3**
T_3-Teak + Frenchbean	88.2	86.7	**87.2**	75.2	74.8	**75.0**	58.7	51.6	**55.2**
T_4-Teak + Blackgram	86.7	84.7	**85.7**	69.3	67.4	**68.3**	67.9	64.2	**66.0**
T_5-Soybean (sole)	90.7	86.3	**88.5**	79.8	77.6	**78.7**	70.5	64.7	**67.6**
T_6-Greengram (sole)	79.6	78.1	**78.8**	73.9	73.7	**73.8**	68.8	63.0	**65.9**
T_7-Frenchbean (sole)	82.7	78.0	**80.2**	75.2	74.8	**75.0**	50.2	50.4	**50.3**
T_8-Blackgram (sole)	80.9	76.9	**78.9**	73.9	72.6	**73.3**	65.4	60.1	**62.7**
Mean	**85.3**	**82.65**	**84.0**	**75.0**	**72.9**	**74.0**	**65.6**	**61.3**	**63.4**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.69	1.99	0.56	1.61	0.92	2.64
Distance (D)	0.34	0.98	0.28	0.81	0.47	1.35
Interaction (AF X D)	0.98	NS	0.84	NS	1.75	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 28: Influence of teak based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	71.2	89.6	**80.4**	63.8	74.9	**69.3**	61.3	72.7	**67.0**
T_2-Teak + Greengram	65.5	84.9	**75.2**	63.1	75.1	**69.1**	57.2	64.2	**60.7**
T_3-Teak + Frenchbean	68.2	91.7	**80.0**	69.2	80.2	**74.7**	62.9	76.2	**69.5**
T_4-Teak + Blackgram	67.1	84.3	**75.7**	62.3	78.2	**70.2**	55.6	62.9	**59.3**
T_5-Soybean (sole)	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
T_6-Greengram (sole)	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
T_7-Frenchbean (sole)	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
T_8-Blackgram (sole)	100.00	100.0	**100.0**	100.0	100.00	**100.0**	100.0	100.0	**100.0**
Mean	**84.0**	**93.8**	**89.0**	**82.3**	**88.5**	**85.4**	**79.6**	**84.5**	**82.1**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.71	2.04	1.01	2.911	0.92	2.66
Distance (D)	0.35	1.02	0.51	1.451	0.46	1.33
Interaction (AF X D)	1.00	2.89	1.431	4.12	1.31	3.76

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

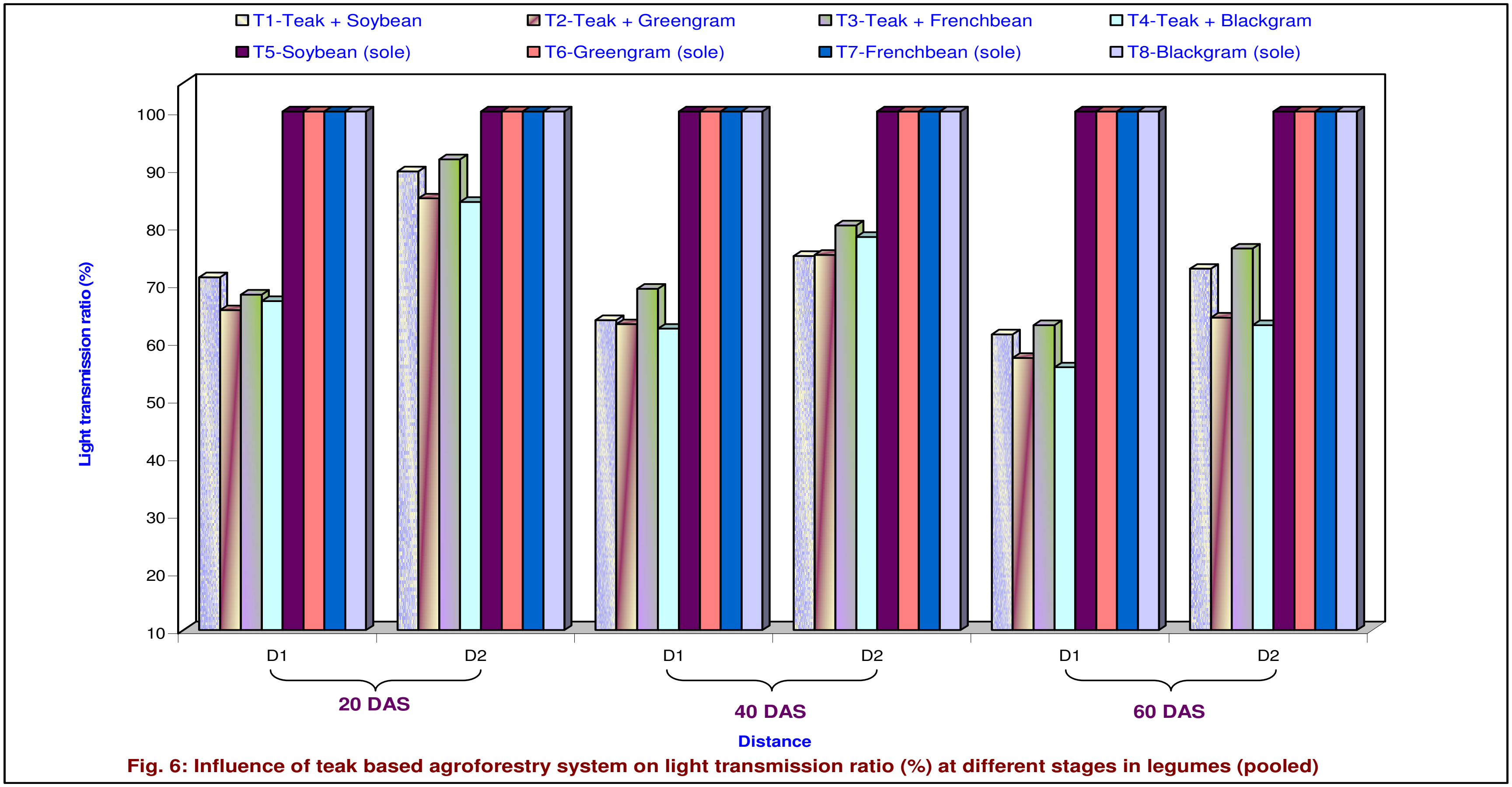


Fig. 6: Influence of teak based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)

4.1.5 Biochemical parameters

4.1.5.1 Chlorophyll ‘a’ content (mg g fresh wt^{-1})

The data of chlorophyll ‘a’ content of legume crops was significantly influenced by the agroforestry systems and the distances at all the stages while the interaction was non significant (Table 29).

The average chlorophyll ‘a’ content ranged from 1.24 mg. g fresh wt^{-1} (20 DAS) to 1.36 mg. g fresh wt^{-1} (40 DAS).

At 20 DAS, the treatment of teak + soybean noticed significantly maximum chlorophyll ‘a’ content (1.84) followed by teak + frenchbean (1.66) and it was lowest in teak + greengram (0.90) followed by teak + blackgram (1.13).

The distance 4 m from tree base recorded lowest chlorophyll ‘a’ content in agroforestry system, whereas, at 2 m distance from tree base showed significantly highest chlorophyll content at all the stages.

At 40 DAS, the treatment of teak + frenchbean showed lowest chlorophyll ‘a’ content (0.96) followed by teak + blackgram(1.34) whereas, significantly highest value was obtained in teak + soybean(1.70) followed by teak + greengram (1.54).

Among the distances effect, 2 m distance tree base showed increased chlorophyll ‘a’ content, whereas 4 m distance recorded decreased chlorophyll content. This trend was followed by 60 DAS period also.

At 60 DAS, among the agroforestry system, the treatment of teak + soybean recorded significantly maximum chlorophyll ‘a’ content (0.78) followed by teak + blackgram (0.71). The lower chlorophyll ‘a’ content was found in the treatment teak + greengram (0.66) followed by teak + frenchbean (0.67) both are on par.

4.1.5.2 Chlorophyll ‘b’ content (mg g fresh wt^{-1})

The data on chlorophyll ‘b’ content of legume crops was significantly influenced by the agroforestry systems and distance from base of tree at all stages, while interaction effect was significant at all stages. The data presented in the Table 30.

The average of chlorophyll ‘b’ ontent in legumes ranged from 0.49 to 0.29 mg, g fr.wt^{-1} (60 DAS).

At 20 DAS, among the agroforestry treatments, the treatment teak + frenchbean had significantly highest chlorophyll ‘b’ content (0.73) followed by teak + soybean(0.53). It was lowest in teak + greengram (0.42).

The distance 4 m from teak alley was noticed minimum chlorophyll ‘b’ content among all the agroforestry treatments. Whereas, at 2 m distance from tree base recorded maximum chlorophyll ‘b’ content. This was followed at 40 DAS and 60 DAS period also.

At 40 DAS, teak + frenchbean recorded minimum chlorophyll ‘b’ content (0.48) followed by teak + greengram (0.50). The maximum chlorophyll ‘b’ content was noticed in the treatment of teak + blackgram (0.66) followed by teak + soybean (0.63).

At 60 DAS, the treatment of teak + frenchbean registered lowest chlorophyll ‘b’ content (0.25) followed by teak + greengram (0.29). Whereas, significantly highest value of chlorophyll ‘b’ was noticed in teak + soybean (0.41) followed by teak + blackgram (0.36).

Among the distances effect, at 2 m distance from tree base showed increased chlorophyll ‘b’ content. Whereas, 4 m distance from teak alley recorded decreased chlorophyll ‘b’ content.

4.1.5.3 Total chlorophyll content (mg g fresh wt^{-1})

The data on total chlorophyll content of legume crops was significantly influenced by the agroforestry systems and the distances from base of the teak, at all the stages. While, the interaction effect was significantly varying at all stages except 60 DAS (Table 31, Fig. 7).

The average total chlorophyll content of legume crops ranged from 1.80 (20 DAS) to 0.95 mg. g fresh wt^{-1} (60 DAS).

Table 29: Influence of teak based agroforestry system on chlorophyll "a" (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.86	1.83	**1.84**	1.75	1.64	**1.70**	0.78	0.77	**0.78**
T_2-Teak + Greengram	0.91	0.89	**0.90**	1.58	1.51	**1.54**	0.66	0.66	**0.66**
T_3-Teak + Frenchbean	1.68	1.65	**1.66**	0.97	0.94	**0.96**	0.71	0.63	**0.67**
T_4-Teak + Blackgram	1.13	1.12	**1.13**	1.37	1.32	**1.34**	0.72	0.69	**0.71**
T_5-Soybean (sole)	1.84	1.63	**1.84**	1.74	1.63	**1.68**	0.70	0.58	**0.64**
T_6-Greengram (sole)	0.89	0.87	**0.88**	1.54	1.44	**1.49**	0.58	0.56	**0.57**
T_7-Frenchbean (sole)	1.21	1.06	**1.13**	0.96	0.89	**0.93**	0.54	0.46	**0.50**
T_8-Blackgram (sole)	1.13	1.12	**1.13**	1.38	1.16	**1.27**	0.70	0.62	**0.66**
Mean	**1.33**	**1.27**	**1.30**	**1.41**	**1.32**	**1.36**	**0.67**	**0.62**	**0.64**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.020	0.057	0.019	0.054	0.016	0.046
Distance (D)	0.010	0.028	0.009	0.025	0.010	0.028
Interaction (AF X D)	0.030	NS	0.028	NS	0.023	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 30: Influence of teak based agroforestry system on chlorophyll "b" (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	0.55	0.50	**0.53**	0.71	0.56	**0.63**	0.42	0.40	**0.41**
T_2-Teak + Greengram	0.43	0.41	**0.42**	0.53	0.48	**0.50**	0.32	0.26	**0.29**
T_3-Teak + Frenchbean	0.74	0.72	**0.73**	0.49	0.47	**0.48**	0.26	0.24	**0.25**
T_4-Teak + Blackgram	0.46	0.41	**0.43**	0.66	0.66	**0.66**	0.38	0.34	**0.36**
T_5-Soybean (sole)	0.49	0.47	**0.48**	0.57	0.49	**0.53**	0.33	0.30	**0.31**
T_6-Greengram (sole)	0.40	0.33	**0.37**	0.43	0.38	**0.40**	0.26	0.22	**0.24**
T_7-Frenchbean (sole)	0.74	0.66	**0.70**	0.38	0.35	**0.36**	0.22	0.20	**0.21**
T_8-Blackgram (sole)	0.37	0.33	**0.35**	0.48	0.44	**0.46**	0.32	0.28	**0.30**
Mean	**0.52**	**0.47**	**0.49**	**0.50**	**0.45**	**0.47**	**0.31**	**0.28**	**0.29**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.009	0.025	0.018	0.051	0.009	0.024
Distance (D)	0.004	0.011	0.009	0.025	0.004	0.011
Interaction (AF X D)	0.012	NS	0.026	NS	0.014	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 31: Influence of teak based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2.41	2.34	**2.37**	2.46	2.20	**2.33**	1.20	1.17	**1.18**
T_2-Teak + Greengram	1.34	1.31	**1.32**	2.11	1.99	**1.97**	0.98	0.91	**0.94**
T_3-Teak + Frenchbean	2.42	2.37	**2.39**	1.46	1.41	**1.43**	0.97	0.87	**0.92**
T_4-Teak + Blackgram	1.59	1.53	**1.56**	2.04	1.99	**2.02**	1.10	1.03	**1.06**
T_5-Soybean (sole)	2.33	2.10	**2.22**	2.31	2.16	**2.23**	1.03	0.88	**0.95**
T_6-Greengram (sole)	1.29	1.20	**1.25**	1.95	1.81	**1.88**	0.84	0.78	**0.81**
T_7-Frenchbean (sole)	1.95	1.73	**1.84**	1.34	1.24	**1.29**	0.76	0.86	**0.80**
T_8-Blackgram (sole)	1.52	1.44	**1.48**	1.73	1.64	**1.68**	1.02	0.90	**0.96**
Mean	**1.85**	**1.75**	**1.80**	**1.92**	**1.80**	**1.86**	**0.98**	**0.92**	**0.95**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.0291	0.083	0.0250	0.007	0.0183	0.052
Distance (D)	0.0146	0.042	0.0288	0.082	0.0091	0.026
Interaction (AF X D)	0.0412	0.118	0.0144	0.041	0.0258	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

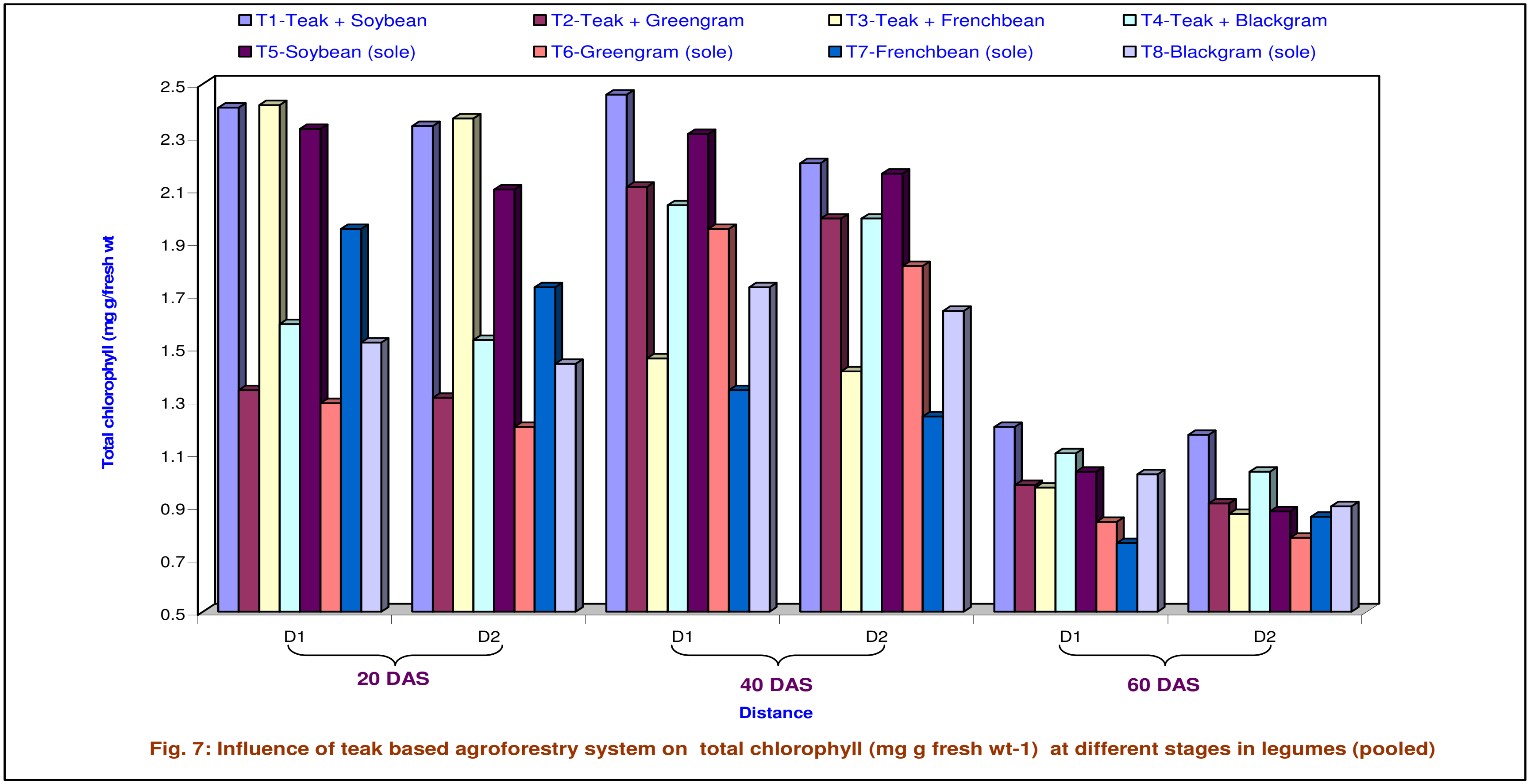


Fig. 7: Influence of teak based agroforestry system on total chlorophyll (mg g fresh wt-1) at different stages in legumes (pooled)

At 20 DAS, among the agroforestry systems teak + frenchbean showed significantly highest total chlorophyll content (2.39) followed by teak + soybean (2.37). It was lowest in teak + greengram (1.32).

Among the distances, the distance at 4 m away from tree base had minimum total chlorophyll as compared to 2 m distance. This trend was followed at all the stages.

However, the interaction effects between agroforestry system and distances from tree base differed significantly. The treatment of teak + greengram noticed least total chlorophyll content (1.31) at 4 m distance. Whereas, at 2 m distance away from tree base recorded highest total chlorophyll content in teak + frenchbean (2.42).

At 40 DAS, the treatment teak + frenchbean were noticed minimum total chlorophyll content (1.43). Whereas, significantly maximum total chlorophyll was registered in teak + soybean (2.33) and teak + blackgram (2.02).

The interaction effect between agroforestry systems and distance from base of tree was varying significant. Total chlorophyll content was least at 4 m distance in teak + frenchbean (1.41), and it was highest at 2 m distance away from tree base in teak + soybean (2.46).

At 60 DAS, there was drastic reduction in the total chlorophyll content among the agroforestry system and distances. The treatment of teak + frenchbean showed lowest total chlorophyll content (0.92) followed by teak + blackgram (0.94). Whereas, significantly highest value of total chlorophyll was observed in teak + soybean (1.18).

Among the distances from the tree base, 2 m distance from teak alley showed maximum total chlorophyll content. whereas, 4 m distance from tree base recorded minimum total chlorophyll content.

4.1.5.4 SPAD values (Single Photoelectric Analyzing Diode, %)

The data on SPAD values of legume crops was significantly influenced by the agroforestry system and the distances (Table 32).

The average of Single Photoelectric Analyzing Diode (SPAD) readings of legumes ranged from 27.39 (20 DAS) to 22.31 (60 DAS).

In general the SPAD readings indicated that the amount of chlorophyll content in the leaves, higher the SPAD values the higher amount of chlorophyll content in the legume crops.

At 20 DAS, the treatment of teak + soybean was noticed significantly higher values of SPAD (33.20) followed by teak + frenchbean (33.17) and it was lowest in teak + blackgram (21.41).

The distance 4 m from teak alley recorded lowest SPAD readings in agroforestry system, whereas, at 2 m distance from teak base showed significantly highest SPAD readings. The same trend was observed in all the stages.

At 40 DAS, among the agroforestry system and distances the treatment teak + soybean showed highest SPAD readings (30.92) followed by teak + frenchbean (30.14) both were on par with each other, whereas the treatment of teak + blackgram (24.20) recorded lowest Single Photoelectric Analyzing Diode readings.

At 60 DAS, teak + blackgram recorded minimum Single Photoelectric Analyzing Diode value (19.73) followed by teak + greengram (21.26), significantly higher SPAD values was found in the treatment of teak + soybean (26.31).

4.1.5.5 Nitrate reductase activity (nmol of NO_2 formed g fresh wt^{-1} h^{-1})

The data on nitrate reductase activity of legumes was significantly influenced by the agroforestry systems from the tree base and among their interaction (Table 33).

The nitrate reductase activity decreased from 20 DAS to 60 DAS, among all the agroforestry system and the distances.

Table 32: Influence of teak based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Soybean	33.6	32.8	**33.2**	31.5	30.4	**30.9**	26.8	25.9	**26.3**
T_2-Teak + Greengram	23.9	22.8	**23.4**	27.3	25.9	**26.6**	22.0	20.6	**21.3**
T_3-Teak + Frenchbean	33.6	32.8	**33.17**	30.6	29.7	**30.1**	25.0	24.0	**24.5**
T_4-Teak + Blackgram	21.7	21.2	**21.4**	24.8	23.7	**24.2**	20.3	19.2	**19.7**
T_5-Soybean (sole)	33.3	32.5	**32.9**	29.3	27.8	**28.5**	26.1	24.7	**25.4**
T_6-Greengram (sole)	23.1	22.3	**22.7**	26.0	25.6	**25.8**	21.1	19.7	**20.4**
T_7-Frenchbean (sole)	32.1	31.2	**31.7**	28.9	28.3	**28.6**	24.5	21.2	**22.9**
T_8-Blackgram (sole)	21.2	20.3	**20.7**	23.4	22.6	**23.0**	18.8	17.3	**18.1**
Mean	**27.8**	**27.0**	**27.4**	**27.7**	**26.7**	**27.2**	**23.1**	**21.6**	**22.3**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.21	0.61	0.27	0.78	0.27	0.77
Distance (D)	0.11	0.30	0.14	0.39	0.13	0.39
Interaction (AF X D)	0.30	NS	0.39	NS	0.38	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 33: Influence of teak based agroforestry system on nitrate reductase activity (nmol NO_2 formed g fresh wt^{-1} hr^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	38.70	42.15	**40.42**	26.56	30.57	**28.56**	19.15	20.90	**20.02**
T_2-Teak + Greengram	15.47	17.04	**16.25**	12.33	12.50	**12.42**	10.65	11.09	**10.87**
T_3-Teak + Frenchbean	67.00	80.30	**73.65**	53.67	65.28	**59.47**	39.70	43.16	**41.43**
T_4-Teak + Blackgram	17.68	19.58	**18.63**	15.47	17.55	**16.51**	15.41	15.81	**15.61**
T_5-Soybean (sole)	42.13	44.83	**43.48**	30.35	31.29	**30.82**	20.55	21.58	**21.06**
T_6-Greengram (sole)	17.95	19.57	**18.76**	15.65	16.15	**15.90**	11.30	11.63	**11.46**
T_7-Frenchbean (sole)	81.11	81.41	**81.26**	64.81	6729	**66.05**	41.46	46.18	**43.82**
T_8-Blackgram (sole)	20.28	21.82	**21.05**	18.55	19.35	**18.95**	16.93	18.16	**17.55**
Mean	**37.54**	**42.08**	**39.81**	**29.67**	**32.49**	**31.08**	**21.89**	**23.56**	**22.72**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.744	2.140	0.513	1.477	0.411	1.183
Distance (D)	0.372	1.070	0.256	0.737	0.205	0.590
Interaction (AF X D)	1.052	3.020	0.725	2.088	0.582	1.676

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

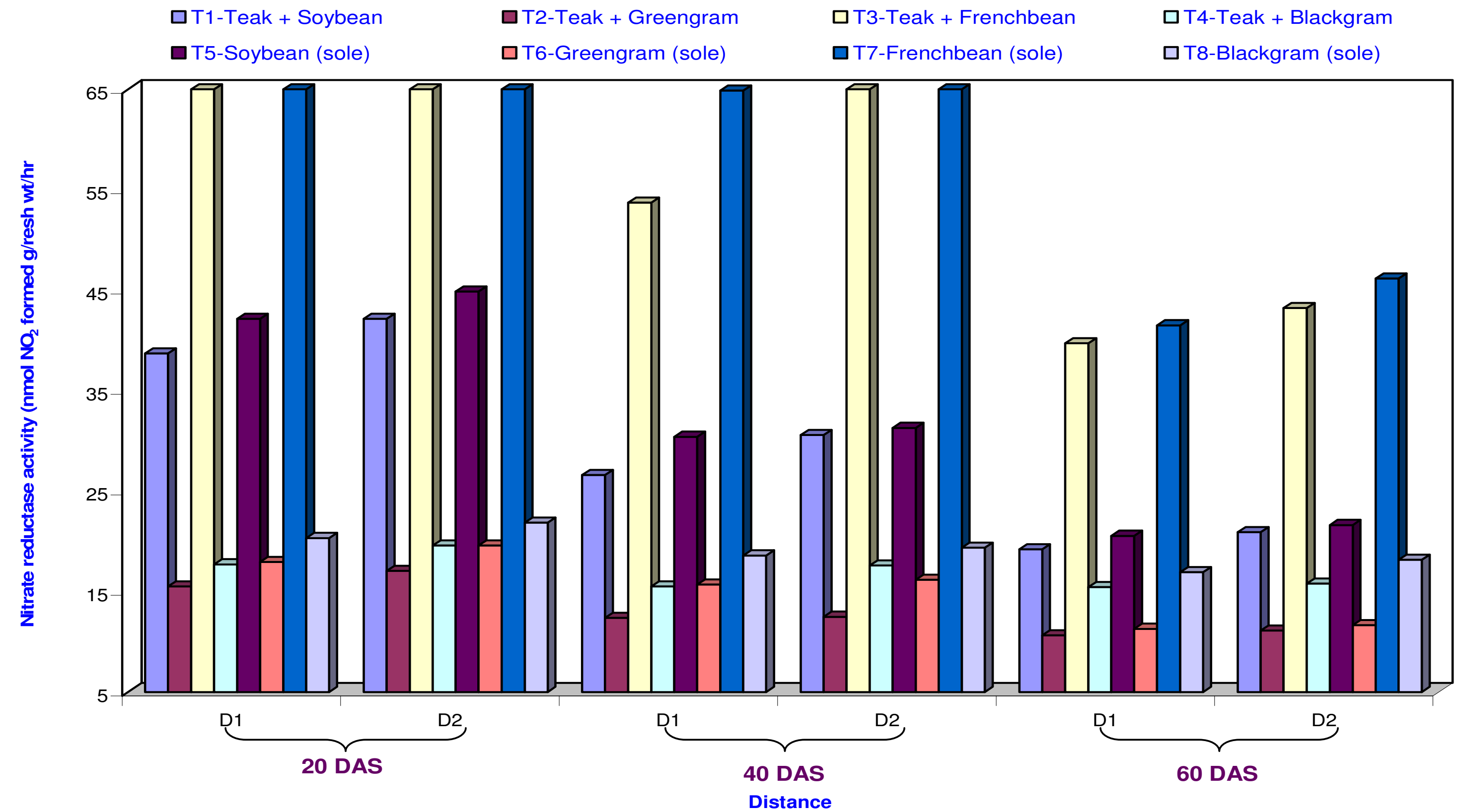


Fig. 8 : Influence of teak based agroforestry system on nitrate reductase activity (nmol NO2 formed g fresh wt-1 hr-1) at different stages in legumes (pooled)

Fig. 8 : Influence of teak based agroforestry system on nitrate reductase activity (nmol NO2 formed g fresh wt-1 hr-1) at different stages in legumes (pooled)

At 20 DAS, among the agroforestry system and distance the treatment of teak + frenchbean was noticed significantly maximum nitrate reductase activity content (73.65) and it was lowest in teak + greengram (16.25).

The distance 2 m from tree base was recorded in lowest nitrate reductase activity and where as at 4 m distance from teak alley showed significantly higher amount of nitrate reductase activity content. This trend was observed at both the stages.

The interaction effect between the agroforestry system and distances from tree base was significantly differ.The treatment of teak + frenchbean was recorded significantly higher values of nitrate reductase activity (80.30) at 4 m distance where as, at 2 m distance away from teak alley was noticed in lower values of nitrate reductase activity in teak + greengram (15.47).

At 40 DAS, the treatment of teak + frenchbean had significantly maximum nitrate reductase activity content (59.47) and whereas, significantly lower nitrate reductase activity was found in teak + greengram (12.42).

The interaction effect between agroforestry systems and distance from base of tree varied significantly. The maximum nitrate reductase activity was found at 4 m distance from tree base in teak + frenchbean (65.28) and minimum was at 2 m distance from teak alley in the treatment of teak + greengram (12.33).

At 60 DAS, the treatment of teak + frenchbean was recorded significantly maximum nitrate reductase activity (41.43). Minimum nitrate reductase activity value was found in teak + greengram (10.87) and the next best treatment was teak + blackgram (15.61).

In general the nitrate reductase activity was maximum at 4 m distance from teak alley as compared to 2 m distance from teak base.

The interaction effect between the agroforestry system and distances from teak alley was significantly varying. The treatment of teak + frenchbean (43.16) at 4 m distance was noticed in higher nitrate reductase activity content. It was lowest at 2 m distance in teak + greengram (10.65).

4.1.6 Yield and yield components

4.1.6.1 Number of pods per plant

The number of pods in legume crops was significantly influenced by agroforestry systems and distances from base of tree is presented in the Table 34.

The number of pods significantly maximum in the treatment teak + soybean (51.76) followed by teak + greengram (19.18) and teak + frenchbean (18.90) and it was minimum in teak + blackgram (15.73).

The number of pods decreased significantly at 2 m distance from teak alley as compared to 4 m distance.

Interaction between agroforestry systems and distances from tree base was significant. The treatment teak + blackgram showed lowest number of pods (14.95) at 2 m distance from base of tree. At 4 m distance noticed highest number of pods in teak + soybean (54.85).

4.1.6.2 Seed weight per plant (g)

Seed weight of legumes was significantly influenced by the agroforestry system and distances from teak alley (Table 34).The seed weight was significantly higher in the treatment teak + frenchbean (9.04) followed by teak +soybean(9.03) both were on par. Reduction of seed weight was highest in teak + blackgram (2.73) followed by teak + greengram (2.95).

Among the distances, 2 m from tree base noticed minimum seed weight, whereas, at 4 m distances from tree base recorded maximum seed weight.

Interaction effect between the agroforestry system and distances from tree base was varied significantly. Seed weight was decreased at 2 m distances from tree base in teak + blackgram (2.76). Whereas, 4 m distance recorded increased seed weight is teak + soybean (10.35).

Table 34: Influence of teak based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes (pooled)

Agroforestry system	Number of pods per plant			Seed weight per plant (g)			100 seed weight (g)		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	48.7	54.9	**51.8**	7.7	10.4	**9.0**	9.4	10.3	**9.9**
T_2-Teak + Greengram	17.4	20.9	**19.2**	2.6	3.3	**3.0**	3.5	4.5	**4.0**
T_3-Teak + Frenchbean	16.9	20.9	**18.9**	8.1	10.0	**9.0**	16.8	21.6	**19.2**
T_4-Teak + Blackgram	15.0	16.5	**15.7**	2.7	2.8	**2.7**	3.7	4.2	**4.0**
T_5-Soybean (sole)	48.2	65.5	**56.8**	10.5	11.9	**11.2**	14.0	15.3	**14.6**
T_6-Greengram (sole)	18.5	23.0	**20.7**	3.4	3.9	**3.6**	5.7	6.9	**6.3**
T_7-Frenchbean (sole)	22.6	24.4	**23.5**	9.1	10.0	**9.6**	21.6	24.6	**23.1**
T_8-Blackgram (sole)	17.9	20.2	**19.0**	3.3	3.4	**3.4**	5.7	6.4	**6.0**
Mean	**25.6**	**30.8**	**28.2**	**5.9**	**7.0**	**6.4**	**9.3**	**10.9**	**10.1**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	1.62	4.66	0.16	0.46	0.77	2.21
Distance (D)	0.81	2.33	0.08	0.23	0.38	1.09
Interaction (AF X D)	2.30	6.62	0.22	0.63	1.09	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Plate-9. Performance of Soybean from different distances of teak rows

Plate-10. Performance of Frenchbean from different distances of teak rows

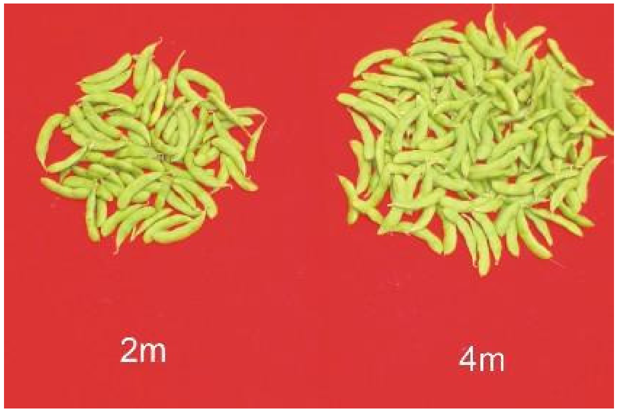


Plate-11. Soybean pods at different distances of teak rows

Plate-12. Frenchbean pods at different distances of teak rows

Table 35: Influence of teak based agroforestry system on seed yield (kg ha^{-1}) in legumes (pooled)

Agroforestry system	Seed yield (kg ha^{-1})		
	D_1	D_2	Mean
T_1-Teak + Soybean	798.4	953.3	**875.8**
T_2-Teak + Greengram	377.4	438.9	**408.1**
T_3-Teak + Frenchbean	902.3	1183.5	**1042.9**
T_4-Teak + Black gram	392.0	438.9	**415.5**
T_5-Soybean (sole)	944.6	1001.7	**973.1**
T_6-Greengram (sole)	532.6	611.0	**571.8**
T_7-Frenchbean (sole)	1110.4	1197.5	**1157.9**
T_8-Blackgram (sole)	552.0	459.0	**505.5**
Mean	**736.2**	**790.7**	**763.5**

For comparing the means of	SEm ±	CD (0.05)
Agroforestry system (AF)	15.62	44.98
Distance (D)	7.82	22.52
Interaction (AF X D)	24.18	NS

D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 36: Growth of teak trees in legumes based agroforestry systems

Agroforestry systems	Height (m)		DBH (cm)		Crown area ($m^2\ pl^{-1}$)	
	2007	2008	2007	2008	2007	2008
T_1-Teak + Soybean	7.39	8.19	10.81	14.67	6.97	11.07
T_2-Teak + Greengram	6.87	7.62	8.59	12.62	6.69	11.64
T_3-Teak + Frenchbean	8.02	8.11	11.95	14.05	7.59	10.62
T_4-Teak + Blackgram	7.41	7.78	11.44	13.47	4.92	9.28
T_5-Soybean (sole)	-	-	-	-	-	-
T_6-Greengram (sole)	-	-	-	-	-	-
T_7-Frenchbean (sole)	-	-	-	-	-	-
T_8-Blackgram (sole)	-	-	-	-	-	-
Mean	-	-	-	-	-	-
SEm ±	0.18	0.13	0.51	0.43	1.12	0.83
CD 5%	0.57	0.41	1.62	1.36	NS	NS

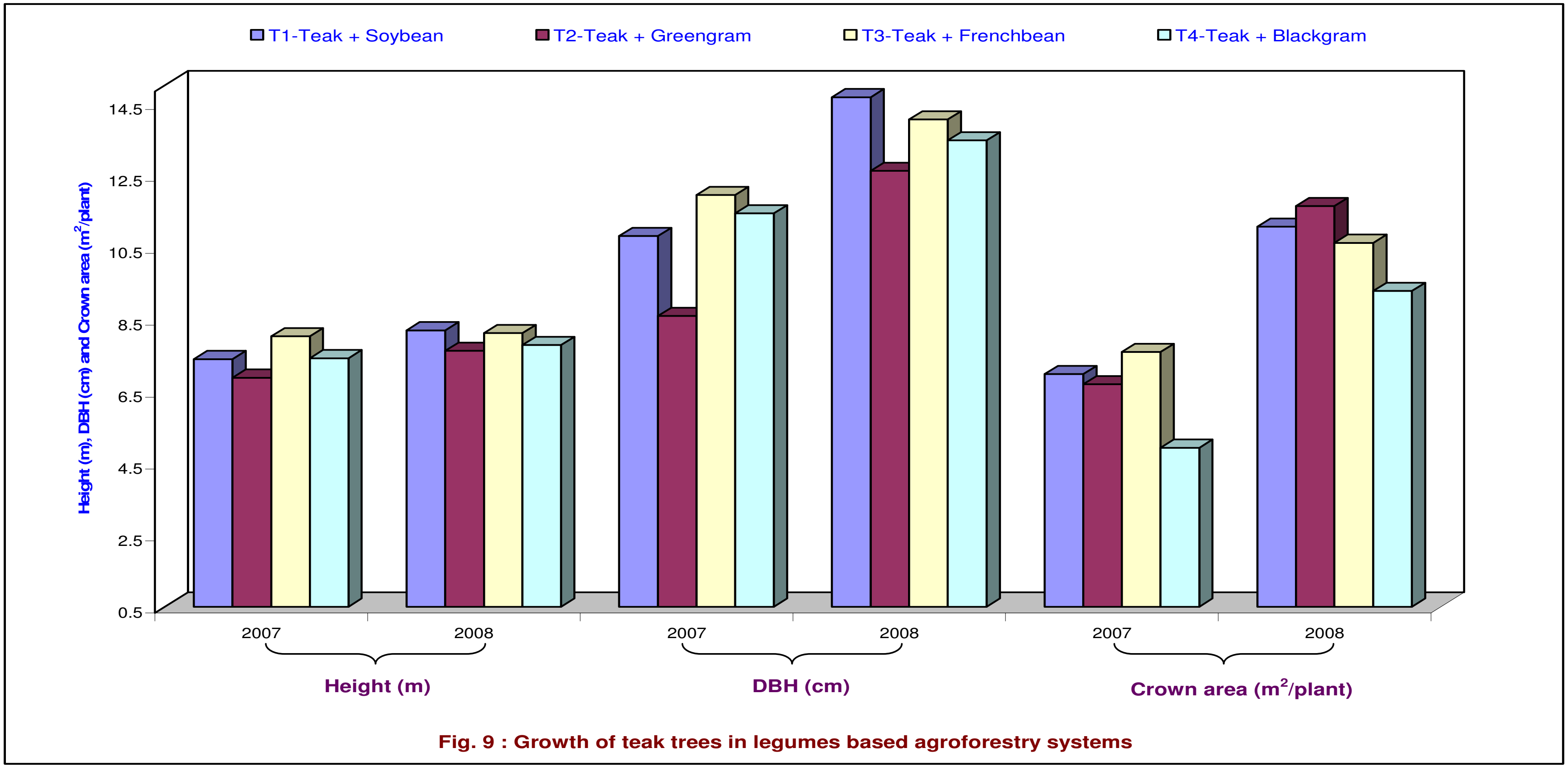


Fig. 9 : Growth of teak trees in legumes based agroforestry systems

4.1.6.3 Hundred seed weight (g)

The data on hundred seed weight in legumes was significantly influenced by the different agroforestry systems and distances from base of tree(Table 34).

The treatment teak + frenchbean recorded significantly increased hundred seed weight (19.20) followed by the treatment teak + soybean (9.87). Reduction of hundred seed weight was highest in teak + blackgram (3.95) followed by teak + greengram (4.00).

Among the distances, minimum hundred seed weight was noticed at 2 m distance from the tree base whereas, at 4 m distances recorded the maximum hundred seed weight.

The other interactions were non significant.

4.1.6.4 Seed yield (kg ha^{-1})

Seed yield of legumes was significantly influenced by the agroforestry systems and distances from tree base (Table 35).

The seed yield was significantly higher in the treatment teak + frenchbean (1042.92 kg ha^{-1}) followed by teak + soybean (875.84 kg ha^{-1}). Seed yield was lowest in teak + greengram (408.11 kg ha^{-1}) followed by teak + blackgram (415.45 kg ha^{-1}).

Among the distances, the distance 2 m from tree base recorded minimum seed yield whereas, at 4 m distance noticed maximum seed yield.

4.1.7 Performance of teak with legumes

4.1.7.1 Height of teak (m)

During the year 2007 teak height was significantly higher when growth with teak + frenchbean (8.02) followed by teak + blackgram (7.41) and was lowest in teak + greengram (6.87) (Table 36 and Fig. 9).

During 2008, significantly higher height (8.19) was teak with frenchbean followed by teak with soybean (8.19) both are on par with each other and the lowest teak height was found in the treatment teak with greengram (7.62) followed by teak with blackgram (7.78).

4.1.7.2 Diameter at Breast Height (cm)

Diameter at breast height (2007) was significantly higher in teak with frenchbean (11.95) which were on par with teak + blackgram (11.44) as compared to other treatments and lowest diameter at breast height was found in teak + greengram (8.59) (Table 36, Fig. 9).

Teak grown with soybean and frenchbean recorded significantly higher diameter at breast height 14.67 and 14.05 cm respectively as compared to teak + blackgram and teak + greengram (13.47), (12.62) respectively.

4.1.7.3 Crown area (m^2 $plant^{-1}$)

During the year 2007 the teak crown area was higher in the treatment teak + frenchbean (7.59) followed by teak + soybean (6.97) and lowest crown area was observed in the treatment teak + blackgram (4.92).

In 2008, teak + greengram had higher crown area (11.64) followed by teak + soybean (11.07) and lower crown area was observed in teak + blackgram (9.28) as compared to other agroforestry systems (Table 36, Fig. 9).

4.2 Experiment–II: Physiological investigations on legume in teak-perennial vegetables based agroforestry systems

The results of the field experiments conducted to study the effect of teak legume based agroforestry systems and integration of perennial vegetables on the growth and yield of legumes under rainfed situations are presented in the following paragraphs.

4.2.1 Morphological characters

4.2.1.1 Plant height (cm)

The data on plant height of legumes was significantly influenced by tree species and the distances from tree base at all stages. Whereas, interaction was insignificant (Table 37 and Fig. 10). The average plant height ranged from 10.58 to 19.61 cm (harvest).

At 20 DAS, among the agroforestry system the plant height was significantly more in teak + curryleaf + soybean (13.91 cm) followed by teak + drumstick + soybean (13.11) as compared to other agroforestry systems whereas, the lowest plant height was observed is teak + drumstick + greengram (6.36).

Generally the sole legume was more plant height as compared to agroforestry systems. Among the distances, plant height of legumes 2 m from the base of tree was recorded lowest when compared to 4 m distances at 20, 40 DAS and harvest.

At 40 DAS, the plant height recorded was significantly highest in teak + curry leaf + soybean (16.05) treatment followed by teak + drumstick + soybean (15.20). The lowest plant height was noticed in teak + drumstick + greengram (13.01) followed by teak + curryleaf + greengram (13.91). The interaction effect between the agroforestry systems and distances was insignificant.

At harvest, the same trend was observed. The treatment teak + curryleaf + soybean was noticed highest plant height (20.29) followed by the treatment teak + drumstick + soybean (19.47) and the lowest plant height was noticed in teak + drumstick + greengram (17.59) followed by teak + curryleaf + greengram (18.00). At 2 m distance the lowest plant height was recorded as compared to 4 m distance from base of tree.

4.2.1.2 Number of leaves per plant

The number of leaves per plant was recorded at 20 DAS, 40 DAS and at harvest and is presented is the Table 38.

At 20 DAS, the number of leaves per plant was significantly higher in sole crops as compared to agroforestry systems. The average number of leaves ranged from 7.64 to 15.97. The number of leaves increased up to 40 DAS and there after the number of leaves gets reduced at harvest.

At 20 DAS, the number of leaves was significantly maximum in teak + curry leaf + soybean (8.78) which is followed by the treatment teak + drumstick + soybean (7.46). The treatment teak + drumstick + greengram recorded significantly minimum number of leaves (5.30) and teak + curryleaf + greengram (6.24) when compared to sole legumes.

Among the distances, the distance 2 m from base of tree recorded significantly lowest number of leaves and 4 m distance recorded significantly highest number of leaves this trend was follows at all the stages.

At 40 DAS, among the treatment, the number of leaves increased significantly in teak + curryleaf + soybean (22.99) and was followed by teak + drumstick + soybean (19.54). Whereas, it significantly decreased in teak + curryleaf + greengram (16.42) and next value was in teak + drumstick + greengram (14.77) when compared to sole legumes.

At harvest, the treatment teak + curryleaf + soybean recorded significantly maximum number of leaves (18.00) and the next best values is in teak + drumstick + soybean (15.30). The treatment teak + drumstick + greengram recorded significantly lowest number of leaves which was followed by teak + curryleaf + greengram (13.94) when compared to sole legumes.

4.2.1.3 Number of branches per plant

The data on number of branches of legumes was significantly influenced by the tree species and the distance from teak alley at all stages. The data is presented is the Table 39.The average number of branches of legumes ranged from 3.07 to 8.48 (harvest).

Table 37: Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	13.4	14.4	**13.9**	15.5	16.6	**16.1**	19.9	20.7	**20.3**
T_2-Teak + Curryleaf + Greengram	6.6	7.4	**7.0**	13.5	14.3	**13.9**	17.7	18.3	**18.0**
T_3-Teak + Drumstick + Soybean	12.9	13.3	**13.1**	14.4	16.0	**15.2**	19.2	19.8	**19.5**
T_4-Teak + Drumstick + Greengram	6.2	6.6	**6.4**	12.4	13.6	**13.0**	17.2	18.0	**17.6**
T_5-Soybean (sole)	14.4	15.3	**14.9**	17.4	18.0	**17.7**	21.1	21.9	**21.5**
T_6-Greengram (sole)	8.1	8.5	**8.3**	16.1	16.5	**16.3**	20.5	21.2	**20.9**
Mean	**10.3**	**10.9**	**10.6**	**14.9**	**15.8**	**15.4**	**19.3**	**20.0**	**19.6**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.19	0.56	0.26	0.77	0.25	0.72
Distance (D)	0.11	0.32	0.15	0.44	0.14	0.41
Interaction (AF X D)	0.27	NS	0.37	1.08	0.35	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

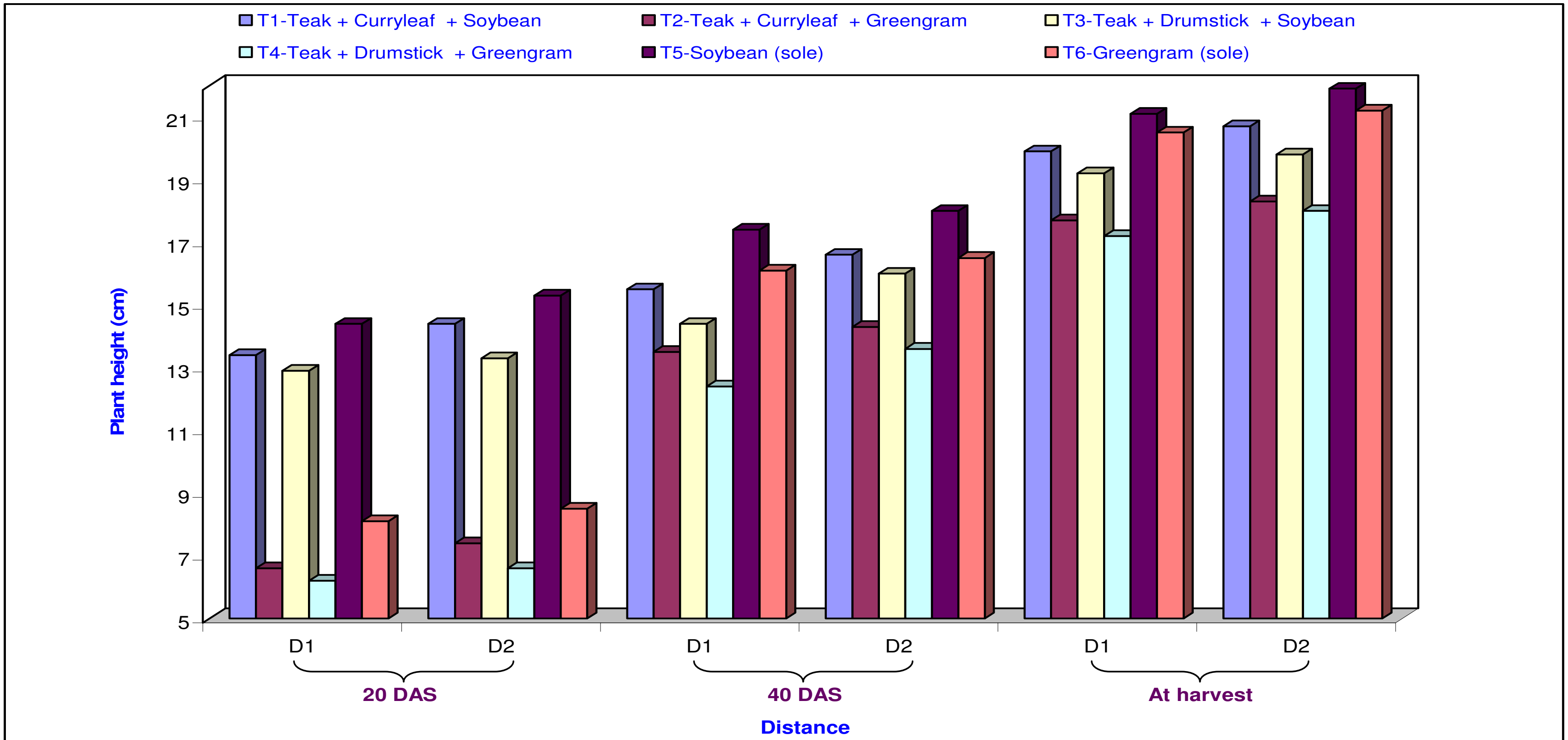


Fig. 10 : Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes (pooled)

Fig. 10 : Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes (pooled)

Table 38: Influence of teak-perennial vegetable based agroforestry system on number of leaves per plant at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	8.4	9.2	**8.8**	22.4	23.6	**23.0**	17.4	18.7	**18.0**
T_2-Teak + Curryleaf + Greengram	6.1	6.4	**6.2**	16.0	16.8	**16.4**	13.2	14.7	**13.9**
T_3-Teak + Drumstick + Soybean	7.1	7.8	**7.5**	19.0	20.0	**19.5**	14.7	15.9	**15.3**
T_4-Teak + Drumstick + Greengram	5.2	5.4	**5.3**	14.4	15.2	**14.8**	11.2	12.5	**11.9**
T_5-Soybean (sole)	9.7	10.5	**10.1**	25.1	27.1	**26.4**	20.0	21.5	**20.7**
T_6-Greengram (sole)	8.0	8.1	**8.0**	18.4	19.4	**18.9**	15.1	16.9	**16.0**
Mean	**7.4**	**7.9**	**7.6**	**19.3**	**20.4**	**19.8**	**15.3**	**16.7**	**16.0**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.18	0.53	0.49	1.44	0.64	1.86
Distance (D)	0.10	0.30	0.29	0.83	0.37	1.07
Interaction (AF X D)	0.26	NS	0.70	NS	0.90	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 39: Influence of teak-perennial vegetable based agroforestry system on number of branches per plant at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	2.4	3.3	**2.9**	5.8	7.7	**6.7**	8.2	8.7	**8.5**
T_2-Teak + Curryleaf + Greengram	2.5	2.9	**2.7**	5.7	7.1	**6.4**	7.7	8.5	**8.1**
T_3-Teak + Drumstick + Soybean	2.0	2.9	**2.5**	5.3	6.6	**5.9**	7.4	8.2	**7.8**
T_4-Teak + Drumstick + Greengram	2.5	2.9	**2.7**	5.0	5.9	**5.5**	7.4	7.5	**7.5**
T_5-Soybean (sole)	3.9	4.8	**4.4**	8.5	8.6	**8.6**	9.6	9.9	**9.7**
T_6-Greengram (sole)	3.3	3.4	**3.4**	8.1	8.5	**8.3**	9.1	9.7	**9.4**
Mean	**2.7**	**3.4**	**3.1**	**6.4**	**7.4**	**6.9**	**8.2**	**8.7**	**8.5**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.12	0.34	0.21	0.60	0.17	0.48
Distance (D)	0.07	0.20	0.12	0.35	0.10	0.28
Interaction (AF X D)	0.17	NS	0.29	NS	0.23	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

At 20 DAS, the treatment teak + curryleaf + soybean recorded significantly higher number of branches per plant (2.85) and was on par with teak + curryleaf + greengram (2.70) were on par. In case of teak + drumstick + soybean recorded significantly minimum number of branches per plant (2.47) followed by teak + drumstick + greengram (2.66) as compared to sole legumes.

Among the distances, the distances 2 m away from tree base recorded significantly lowest number of branches per plant as compared to 4 m distances, this trend was followed at all stages.

At 40 DAS, the treatment teak + curryleaf + soybean recorded significantly highest number of branches per plant (6.74), followed by teak + curryleaf + green gram (6.41) both were on par. Whereas, significantly lowest number of branches per plant were recorded in the treatment teak + drumstick + greengram (5.46) followed by teak + drumstick + soy bean (5.93) when compared to sole legumes.

At harvest, the treatment teak + curryleaf + soybean recorded significantly highest number of branches (8.45) followed by teak + curryleaf + greengram (8.07) whereas, significantly lowest number of branches per plant was noticed in teak + drumstick + greengram (7.45) and teak + drumstick + soybean (7.81).

4.2.1.4 Leaf area (dm^2 $plant^{-1}$)

The data on leaf area of legumes was significantly influenced by the agroforestry system and distances from tree base at all stages. The results were presented in the Table 40.

In general leaf area increased up to 40 DAS and decreased thereafter, while the interaction effects between the agroforestry system was insignificant. The average leaf area ranged from 2.66 dm^2 $plant^{-1}$ to 5.86 dm^2 $plant^{-1}$ (40 DAS).

At 20 DAS, leaf area was significantly maximum in the treatment teak + curry leaf + soybean (3.90) the next best treatment was teak + drumstick + soybean (3.68), when compared to other agroforestry systems. Whereas, the minimum leaf area was recorded in the treatment teak + drumstick + greengram (0.97) followed by teak + curryleaf + greengram (1.03).

Among the distances, 2 m away from the tree base was having lowest leaf area of legumes when compared 4 m distance at all the stages.

At 40 DAS, leaf area was significantly highest in teak + curryleaf + soybean (6.84). The next best treatment was teak + drumstick + soybean (6.57), when compared to other agroforestry systems. Leaf area was lowest in teak + drumstick + greengram (4.23) followed by teak + curryleaf + greengram (4.48) as compared to sole legumes.

At harvest, among the agroforestry a system, the leaf area was significantly highest in teak + curryleaf + soybean (4.76) and teak + drumstick + soybean (4.26). It was lowest in teak + curryleaf + greengram (3.61) which was followed by teak + drumstick + greengram (3.77) and when compared to sole legumes.

The other interactions were non significant.

4.2.2 Dry matter production and partitioning

4.2.2.1 Leaf dry matter (g $plant^{-1}$)

The leaf dry matter of legumes was significantly influenced by the tree species and the distances from the tree base at all stages. However, the interaction was significantly varying only at 20 DAS. The data is presented in the Table 41.

The average leaf dry matter ranged from 0.91 to 3.47 (40 DAS).

At 20 DAS, among the treatments, leaf dry matter significantly high in teak + curryleaf + soybean (1.03) followed by the treatment teak + drumstick + soybean (0.97) as compared to other agroforestry systems. Leaf dry matter was lowest in teak + drumstick + greengram (0.62) which was followed by the treatment teak + curryleaf + greengram (0.73) when compared to sole crops.

Table 40: Influence of teak-perennial vegetable based agroforestry system on leaf area (dm^2 $plant^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	3.75	4.06	**3.90**	6.48	7.21	**6.84**	4.74	4.78	**4.76**
T_2-Teak + Curryleaf + Greengram	0.88	1.17	**1.03**	4.46	4.51	**4.48**	3.60	3.62	**3.61**
T_3-Teak + Drumstick + Soybean	3.54	3.83	**3.68**	6.34	6.81	**6.57**	4.06	4.46	**4.26**
T_4-Teak + Drumstick + Greengram	0.83	1.11	**0.97**	4.21	4.24	**4.23**	3.39	4.15	**3.77**
T_5-Soybean (sole)	4.78	5.18	**4.98**	7.45	8.28	**7.87**	5.44	5.50	**5.47**
T_6-Greengram (sole)	1.37	1.38	**1.37**	5.13	5.18	**5.15**	4.13	4.16	**4.14**
Mean	**2.52**	**2.79**	**2.66**	**5.68**	**6.04**	**5.86**	**4.22**	**4.44**	**4.33**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.039	0.11	0.077	0.23	0.11	0.32
Distance (D)	0.022	0.06	0.047	0.13	0.06	0.18
Interaction (AF X D)	0.055	NS	0.109	NS	0.15	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 41: Influence of teak-perennial vegetable based agroforestry system on leaf dry weight (g $plant^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	1.02	1.04	**1.03**	4.08	4.79	**4.44**	2.07	2.28	**2.17**
T_2-Teak + Curryleaf + Greengram	0.71	0.75	**0.73**	2.29	2.65	**2.47**	1.22	1.38	**1.30**
T_3-Teak + Drumstick + Soybean	0.96	0.97	**0.97**	3.46	4.07	**3.77**	1.75	1.93	**1.84**
T_4-Teak + Drumstick + Greengram	0.60	0.64	**0.62**	2.05	2.12	**2.09**	1.03	1.17	**1.10**
T_5-Soybean (sole)	1.17	1.19	**1.18**	4.69	5.51	**5.10**	2.37	2.62	**2.49**
T_6-Greengram (sole)	0.94	1.02	**0.98**	2.87	3.11	**2.99**	1.70	1.88	**1.79**
Mean	**0.90**	**0.93**	**0.91**	**3.24**	**3.70**	**3.47**	**1.69**	**1.88**	**1.78**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.084	0.246	0.176	0.515	0.167	0.489
Distance (D)	0.048	0.140	0.101	0.295	0.096	0.281
Interaction (AF X D)	0.119	0.348	0.249	NS	0.237	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Among the distances, 2 m away from the base of tree had lowest leaf dry matter, whereas 4 m distances recorded significantly highest leaf dry matter of legumes. This trend was same at 40 DAS and harvest also.

The interaction effect between agroforestry systems and distances varied significantly. The treatment teak + drumstick + greengram noticed significantly lowest leaf dry matter (0.60) at 2 m distance from tree base. Whereas, at 4 m distance recorded significantly highest leaf dry matter in teak + curryleaf + soybean (1.04).

At 40 DAS, among the agroforestry treatments, teak + curryleaf + soybean recorded significantly maximum leaf dry matter (4.44) and was followed by the treatment teak + drumstick + soybean (3.77) whereas, the treatment teak + drumstick + greengram recorded significantly minimum leaf dry matter (2.09) and was followed by teak + curryleaf + greengram (2.47) as compared to sole legumes.

At harvest, the treatment teak + curryleaf + soybean noticed significantly increased leaf dry matter (2.17) and followed by teak + drumstick + soybean (1.84).Whereas, teak + drumstick + greengram recorded significantly decreased leaf dry mater (1.10) followed by teak + curryleaf + greengram (1.30), when compared to the sole legumes.

4.2.2.2 Stem dry matter (g plant $^{-1}$)

The data on stem dry matter of legume crops were significantly influenced by the agroforestry systems and the distances from base of the tree at all stages. The results are presented in the Table 42.The average stem dry matter of legumes ranged from 0.92 to 2.50 g plant $^{-1}$ (harvest).

At 20 DAS, the stem dry matter was significantly highest in teak + curryleaf + soybean (1.06) and teak + drumstick + soybean (0.90) when compared to other treatments. The treatment teak + drumstick + greengram recorded significantly lowest stem dry matter (0.62) followed by the treatment teak + curryleaf + greengram (0.71), when compared to sole legume crops.

Among the distances, 2 m from the teak and perennial vegetable recorded significantly lowest stem dry matter, when compared to 4 m distances which recorded significantly highest stem dry matter at all the stages.

However, the interaction effect between the agroforestry systems, perennial vegetable and distances, the treatment teak + drumstick + greengram recorded significantly lowest stem dry matter (0.57) at 2 m distances from tree base, whereas, at 4 m distance in teak + curryleaf + soybean noticed significantly highest stem dry matter (1.07).

At 40 DAS, the treatment teak + curryleaf + soybean noticed significantly maximum stem dry matter (3.79) and it was followed by teak + drumstick + soybean (3.22). Whereas, the treatment teak + drumstick + greengram noticed significantly lowest stem dry matter (1.60) and best next treatment was teak + curryleaf + green gram (1.89) when compared to sole legume crops.

At harvest, teak + curryleaf + soybean noticed significantly highest stem dry matter (3.22) which was followed by teak + drumstick + soybean recorded (2.73), when compared to other agroforestry system. Whereas, the significantly lowest stem dry matter was noticed in the treatment teak + drumstick + greengram (1.50) followed by the treatment teak + curryleaf + greengram (1.78), compared to other sole crops.

The interactions effects were non significant.

4.2.2.3 Pod dry matter (g plant $^{-1}$)

The data on pod dry matter in legume crops showed significant variation at all stages. The development of pods was started from 40 DAS onwards, it was significantly influenced by the teak, perennial vegetables and the distances from tree base at all stages. The results are presented in the Table 43.

The average pod dry matter of legume crops ranged from 0.82 (40 DAS) to 9.69 g. plant $^{-1}$(Harvest).

Table 42: Influence of teak-perennial vegetable based agroforestry system on stem dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	1.05	1.07	**1.06**	3.73	3.84	**3.79**	3.10	3.34	**3.22**
T_2-Teak + Curryleaf + Greengram	0.66	0.76	**0.71**	1.73	2.05	**1.89**	1.71	1.84	**1.78**
T_3-Teak + Drumstick + Soybean	0.89	0.91	**0.90**	3.17	3.26	**3.22**	2.63	2.84	**2.73**
T_4-Teak + Drumstick + Greengram	0.57	0.68	**0.62**	1.47	1.73	**1.60**	1.45	1.55	**1.50**
T_5-Soybean (sole)	1.31	1.33	**1.32**	4.28	4.41	**4.35**	3.62	3.83	**3.73**
T_6-Greengram (sole)	0.90	1.02	**0.96**	2.29	2.65	**2.47**	2.20	2.34	**2.27**
Mean	**0.89**	**0.96**	**0.92**	**2.78**	**2.99**	**2.88**	**2.44**	**2.62**	**2.53**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.064	0.187	0.116	0.339	0.108	0.316
Distance (D)	0.037	0.108	0.062	0.181	0.058	0.169
Interaction (AF X D)	0.079	0.231	0.144	NS	0.134	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 43: Influence of teak-perennial vegetable based agroforestry system on pod dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.68	0.95	**0.82**	12.79	15.29	**14.04**
T_2-Teak + Curryleaf + Greengram	0.59	0.76	**0.68**	4.54	6.17	**5.35**
T_3-Teak + Drumstick + Soybean	0.58	0.80	**0.69**	10.83	12.92	**11.87**
T_4-Teak + Drumstick + Greengram	0.50	0.64	**0.57**	3.85	5.24	**4.55**
T_5-Soybean (sole)	0.99	1.32	**1.16**	14.72	17.54	**16.33**
T_6-Greengram (sole)	0.92	1.12	**1.02**	5.41	6.99	**6.20**
Mean	**0.71**	**0.93**	**0.82**	**8.69**	**10.69**	**9.69**

For comparing the means of	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.115	0.33	0.261	0.76
Distance (D)	0.066	0.19	0.151	0.44
Interaction (AF X D)	0.163	NS	0.370	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

At 40 DAS, the data on pod dry matter in the treatment teak + curryleaf + soybean showed significantly highest pod dry matter (0.82) and next best treatment was teak + drumstick + soybean (0.69) where as, the treatment teak + drumstick + greengram noticed significantly lowest stem dry matter (0.57) which was followed by (0.68) when compared to sole legume crops.

Among the distances, 2 m distance away from tree and perennial vegetable base recorded significantly decreased pod dry matter, whereas at 4 m distance recorded significantly increased pod dry matter. This was noticed at both the stages (40 DAS and Harvest).

At harvest, pod dry matter in the treatment teak + curryleaf + soybean recorded significantly maximum pod dry matter (14.04) which was followed by teak + drumstick + soybean (11.87). The treatment teak + drumstick + greengram noticed significantly minimum pod dry matter (4.55) followed by teak + curryleaf + green gram (5.35) when compared to sole legume crops.

The other interactions were non significant.

4.2.2.4 Total dry matter (g plant $^{-1}$)

The data pertaining to total dry matter of legume crops was significantly influenced by the teak with integration of perennial vegetables and distances from the base of the tree at all stages. The results are presented in the Table 44. The average total dry matter ranged from 1.89 to 13.91 g. plant $^{-1}$ (harvest).

At 20 DAS, the treatment teak + curryleaf + soybean recorded significantly increased total dry matter (2.10) and the next best value was teak + drumstick + soybean (1.89) when compared to rest of the treatments.

Whereas, it was significantly decreased in the treatment teak+ drumstick + greengram (1.25) followed by the treatment teak + curryleaf + greengram (1.46) both are on par, when compared to the sole crops.

The distance 2 m away from teak alley noticed significantly lowest total dry matter, whereas at 4 m distance recorded significantly highest total dry matter, this trend was at other stages also (40 DAS and harvest).

At 40 DAS, the total dry matter was significantly maximum in the treatment teak + curryleaf + soybean (9.05) which is followed by teak + drumstick + soybean (7.68) when compared to agroforestry systems. It was lowest in teak + drumstick + greengram (4.27) and (4.97) when compared to sole crops.

At harvest, among the agroforestry systems and distances, the treatment teak+ curryleaf + soybean showed significantly maximum total dry matter (19.46) followed by teak + drumstick + soybean (16.53) when compared to other systems. Whereas, it was significantly minimum in the treatment teak + drumstick + greengram (7.16) and teak+ curryleaf + greengram (8.44) when compared to sole legumes.

4.2.3 Growth and growth parameters

4.2.3.1. Leaf area index

The data on leaf area index is presented in the Table 45. It was significantly influenced by the teak perennial vegetables and distances from tree base at all stages. The interaction effects were significant at 20 DAS.

In general, the leaf area index increased up to 40 DAS and decreased thereafter. The average of leaf area index of legume crops ranged from 0.88 to 1.96 (40 DAS).

At 20 DAS, leaf area index of the legumes was significantly highest in the treatment of teak + curryleaf + soybean (1.30) which was followed by teak + drumstick + soybean (1.22) when compared to other agroforestry systems. It was lowest in the treatment of teak + drumstick + greengram (0.32) and followed by teak + curryleaf + greengram (0.34) both were on par as compared to sole legume crops.

Table 44: Influence of teak-perennial vegetable based agroforestry system on total dry weight (g plant^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	2.08	2.11	**2.10**	8.50	9.60	**9.05**	18.03	20.91	**19.46**
T_2-Teak + Curryleaf + Greengram	1.38	1.53	**1.46**	4.62	5.33	**4.97**	7.48	9.40	**8.44**
T_3-Teak + Drumstick + Soybean	1.86	1.91	**1.89**	7.22	8.15	**7.68**	15.28	17.77	**16.53**
T_4-Teak + Drumstick + Greengram	1.17	1.33	**1.25**	4.02	4.51	**4.27**	6.34	7.98	**7.16**
T_5-Soybean (sole)	2.48	2.83	**2.65**	9.75	11.02	**10.39**	20.69	24.04	**22.36**
T_6-Greengram (sole)	1.78	2.26	**2.02**	5.51	6.31	**5.91**	8.59	10.49	**9.54**
Mean	**1.79**	**1.99**	**1.89**	**6.60**	**7.48**	**7.04**	**12.73**	**15.10**	**13.91**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.068	0.199	0.304	0.890	0.356	1.043
Distance (D)	0.036	0.105	0.175	0.512	0.205	0.600
Interaction (AF X D)	0.096	NS	0.430	NS	0.504	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 45: Influence of teak-perennial vegetable based agroforestry system on leaf area index (LAI) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	1.25	1.35	**1.30**	2.16	2.40	**2.28**	1.58	1.59	**1.58**
T_2-Teak + Curryleaf + Greengram	0.29	0.39	**0.34**	1.44	1.50	**1.49**	1.13	1.38	**1.25**
T_3-Teak + Drumstick + Soybean	1.18	1.27	**1.22**	2.11	2.27	**2.19**	1.35	1.48	**1.42**
T_4-Teak + Drumstick + Greengram	0.27	0.37	**0.32**	1.40	1.41	**1.41**	1.20	1.20	**1.20**
T_5-Soybean (sole)	1.59	1.72	**1.66**	2.48	2.76	**2.62**	1.81	1.83	**1.82**
T_6-Greengram (sole)	0.45	0.46	**0.45**	1.71	1.72	**1.71**	1.37	1.38	**1.38**
Mean	**0.84**	**0.93**	**0.88**	**1.89**	**2.01**	**1.95**	**1.41**	**1.48**	**1.44**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.013	0.038	0.025	0.073	0.036	0.105
Distance (D)	0.007	0.020	0.014	0.040	0.021	0.061
Interaction (AF X D)	0.018	0.052	0.036	NS	0.052	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

The distance 2 m away from the tree base showed lowest leaf area index of legumes. It was highest at 4 m distance. This trend was noticed at all the stages.

The interaction effect between the teak perennial vegetables and distances from tree base was varying significantly. Leaf area index was lowest in teak + drumstick + greengram at 2 m distance from tree base (0.27) where as at 4m distance showed highest leaf area index in teak + curryleaf + soybean (1.35).

The leaf area index of legumes increased significantly with increase in distance from tree base.

At 40 DAS, leaf area index was significantly maximum in teak + curryleaf + soybean (2.28) as compared to other agroforestry system. Leaf area index of legumes reduced significantly when grown in association with teak + drumstick + greengram (1.41) and teak + curryleaf + greengram (1.49) as compared to sole crop.

At 60 DAS, significantly more leaf area index was observed in teak + curryleaf + soybean (1.58) followed by teak + drumstick + soybean (1.42 g) and the least leaf area index was observed in teak + drumstick + greengram (1.20) followed by teak + drumstick + greengram (1.25) as compared to sole crops.

The interactions were non significant.

4.2.3.2 Absolute Growth Rate (AGR, g plant^{-1} day^{-1})

The data on absolute growth rate of legumes was significantly influenced by the teak, perennial vegetables and distances from tree at all stages. The data are presented in the Table 46. The average absolute growth rate ranged from 0.264 to 0.253 g plant^{-1} day^{-1} (40 – 60 DAS).

At 20 – 40 DAS, among the treatments, the treatment of teak + curryleaf + soybean was having significantly maximum AGR (0.348) followed by teak + drumstick + soybean (0.290) whereas, it was minimum in the treatment teak + drumstick + greengram (0.145) and teak + curryleaf + greengram (0.173).

Among the distances, 2 m distance from tree base showed lowest AGR, whereas, 4 m distance recorded highest absolute growth rate, this trend was noticed at 40-60 DAS and 60 DAS - harvest.

At 40-60 DAS, the treatment of teak + curryleaf + soybean showed significantly highest absolute growth rate (0.520), the next best value followed by this was teak + drumstick + soybean (0.442) when compared to other agroforestry systems. It was minimum in the treatment teak + drumstick + greengram (0.151) and teak + curryleaf + greengram (0.176) as compared to sole legume crops.

At 60 DAS - harvest, the absolute growth rate was higher in the treatment teak + curryleaf + soybean (0.347) followed by in teak + drumstick + soybean (0.295) as compared to other agroforestry system. Whereas, the treatment teak + drumstick + greengram (0.096) was having lowest absolute growth rate and it was followed by teak + curryleaf + greengram (0.116).

4.2.3.3 Crop Growth Rate (CGR, g m^{-2} day^{-1})

The data on crop growth rate of legumes as influenced by interaction of perennial vegetables, teak and distances at different growth stages is presented in Table 47.

The data on crop growth rate varied significantly among agroforestry systems and distances from the tree base. While, interaction effects were insignificant. The average crop growth rate ranged from 0.088 to 0.116 g m^{-2} day^{-1} (40-60 DAS).

At 20-40 DAS, the treatment teak + curryleaf + soybean was having significantly highest crop growth rate (0.116) and was followed by teak + drumstick + soybean (0.097), when compared to other agroforestry systems. The lowest value of crop growth rate was noticed in teak + drumstick + greengram (0.050) and teak + curryleaf + greengram (0.059) and were on par, when compared to other sole crop treatment.

Table 46: Influence of teak-perennial vegetable based agroforestry system on absolute growth rate (g $plant^{-1}$ day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.321	0.374	**0.348**	0.475	0.566	**0.520**	0.317	0.377	**0.347**
T_2-Teak + Curryleaf + Greengram	0.143	0.204	**0.173**	0.162	0.190	**0.176**	0.095	0.136	**0.116**
T_3-Teak + Drumstick + Soybean	0.268	0.312	**0.290**	0.403	0.481	**0.442**	0.269	0.321	**0.295**
T_4-Teak + Drumstick + Greengram	0.116	0.173	**0.145**	0.143	0.159	**0.151**	0.077	0.116	**0.096**
T_5-Soybean (sole)	0.369	0.430	**0.399**	0.547	0.651	**0.599**	0.364	0.434	**0.399**
T_6-Greengram (sole)	0.210	0.242	**0.226**	0.214	0.269	**0.241**	0.130	0.166	**0.148**
Mean	**0.237**	**0.289**	**0.263**	**0.324**	**0.386**	**0.355**	**0.208**	**0.258**	**0.233**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.0159	0.046	0.0110	0.032	0.0100	0.028
Distance (D)	0.0092	0.026	0.0150	0.043	0.0061	0.017
Interaction (AF X D)	0.0224	NS	0.0090	NS	0.0140	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 47: Influence of teak-perennial vegetable based agroforestry system on crop growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.107	0.125	**0.116**	0.158	0.189	**0.173**	0.106	0.126	**0.116**
T_2-Teak + Curryleaf + Greengram	0.054	0.063	**0.059**	0.048	0.068	**0.058**	0.032	0.045	**0.039**
T_3-Teak + Drumstick + Soybean	0.089	0.104	**0.097**	0.134	0.160	**0.147**	0.090	0.107	**0.098**
T_4-Teak + Drumstick + Greengram	0.048	0.053	**0.050**	0.039	0.058	**0.048**	0.026	0.039	**0.032**
T_5-Soybean (sole)	0.123	0.143	**0.133**	0.182	0.217	**0.200**	0.121	0.145	**0.133**
T_6-Greengram (sole)	0.072	0.083	**0.077**	0.065	0.083	**0.074**	0.047	0.059	**0.053**
Mean	**0.082**	**0.095**	**0.088**	**0.104**	**0.129**	**0.116**	**0.070**	**0.087**	**0.078**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.0050	0.0144	0.0052	0.0152	0.0034	0.0097
Distance (D)	0.0030	0.0086	0.0030	0.0086	0.0020	0.0058
Interaction (AF X D)	0.0070	NS	0.0073	NS	0.0049	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Among the distances, 2 m distance from the tree base recorded minimum crop growth rate. The treatments 4 m distance recorded maximum crop growth rate. This trend was observed at all the stages.

At 40 – 60 DAS, among the agroforestry systems and distances, the treatment teak + curryleaf + soybean showed maximum crop growth rate (0.173) and it was followed by teak + drumstick + soybean (0.147) when compared to other agroforestry systems whereas, it was minimum in teak + drumstick + greengram (0.048) followed by teak + curryleaf + greengram (0.058) as compared to sole crop treatment.

At 60 DAS – harvest, reduced crop growth rate was noticed. The treatment teak + curryleaf + soybean (0.116) has the highest value and was followed by teak + drumstick + soybean (0.098). It was minimum in teak + drumstick + greengram (0.032) and was followed by teak + curryleaf + greengram (0.039) which were on par with each other.

In general, the average crop growth rate was minimum in agroforestry system as compared to sole crop treatment.

4.2.3.4 Relative Growth Rate (RGR, g g^{-1} day^{-1})

The data on relative growth rate of legume was significantly influenced by teak, perennial vegetables and distances at all the growth stages, while the interaction effects were insignificant (Table 48).

The average relative growth rate of legume crops ranged from 0.029 g to 0.016 (g g^{-2} day^{-1}) at 60 DAS.

At 20-40 DAS, relative growth rate was significantly maximum in teak + curryleaf + soybean (0.030) followed by in teak + drumstick + soybean (0.029) when compared to other agroforestry systems. The reduction in relative growth rate was more in teak + drumstick + greengram (0.017) followed by teak + curryleaf + green gram (0.025) when compared with other sole crop treatments.

Among the distances, 2 m distance from teak and perennial vegetable alley recorded lowest relative growth rate, whereas at 4 m distance showed highest relative growth rate at all stages.

At 40-60 DAS, the treatment teak + curryleaf + soybean recorded significantly maximum relative growth rate (0.018) followed by teak + drumstick + soybean (0.016). It was minimum in teak + drumstick + greengram (0.009) followed by teak + curry leaf + greengram (0.011) as compared to sole crop treatment.

At 60 DAS - harvest period, also the same trend was observed and the treatment teak + curryleaf + soybean (0.013) had maximum relative growth rate and it was followed by teak + drumstick + soybean (0.011). The treatment teak + drumstick + greengram (0.007) was having the minimum relative growth rate and was followed by teak + curryleaf + greengram (0.008) which were on par with each other.

4.2.3.5 Net assimilation rate (NAR, g dm^{-2} day^{-1})

The data on net assimilation rate of legume crops was significantly influenced by teak, perennial vegetable and distances from tree base at both, while the interaction effect were insignificant (Table 49).The average net assimilation rate of legumes ranged from 0.028 to 0.035 g dm^{-2} day^{-1}(40-60 DAS).

At 20-40 DAS, treatment teak + curryleaf + greengram was recorded the maximum net assimilation rate (0.028) and was followed by teak + drumstick + greengram (0.027) and teak + curryleaf + soybean (0.027) both were on par and it was lowest net assimilation rate was observed in teak + drumstick + soybean (0.024) as compared to sole crop treatment. The interactions were in significant.

At 40-60 DAS, teak + curryleaf + soybean recorded significantly increased net assimilation rate (0.036) followed by the treatment of teak + drumstick + soybean (0.034) as compared to other treatments. Whereas the treatment of teak + drumstick + greengram showed decreased net assimilation rate (0.029) followed by teak + curry leaf + greengram (0.033) when compared to sole crop treatments.

Table 48: Influence of teak-perennial vegetable based agroforestry system on relative growth rate (g m^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.029	0.031	**0.030**	0.018	0.019	**0.018**	0.012	0.014	**0.013**
T_2-Teak + Curryleaf + Greengram	0.025	0.026	**0.025**	0.010	0.012	**0.011**	0.008	0.009	**0.008**
T_3-Teak + Drumstick + Soybean	0.029	0.030	**0.029**	0.016	0.016	**0.016**	0.010	0.011	**0.011**
T_4-Teak + Drumstick + Greengram	0.015	0.020	**0.017**	0.008	0.010	**0.009**	0.006	0.008	**0.007**
T_5-Soybean (sole)	0.039	0.041	**0.040**	0.026	0.026	**0.026**	0.013	0.017	**0.015**
T_6-Greengram (sole)	0.035	0.036	**0.035**	0.020	0.021	**0.021**	0.009	0.020	**0.014**
Mean	**0.028**	**0.030**	**0.029**	**0.016**	**0.017**	**0.016**	**0.009**	**0.013**	**0.011**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.0014	0.0040	0.0006	0.0017	0.0004	0.0011
Distance (D)	0.0008	0.0020	0.0004	0.0011	0.0002	0.0005
Interaction (AF X D)	0.0020	NS	0.0009	NS	0.0006	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 49: Influence of teak-perennial vegetable based agroforestry system on net assimilation rate (g dm^{-2} day^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
1. Teak+Curryleaf+Soybean	0.028	0.027	**0.027**	0.031	0.042	**0.036**
2. Teak+Curryleaf+Greengram	0.027	0.029	**0.028**	0.031	0.035	**0.033**
3. Teak+Drumstick+Soybean	0.025	0.023	**0.024**	0.032	0.037	**0.034**
4. Teak+Drumstick+ Greengram	0.026	0.028	**0.027**	0.028	0.030	**0.029**
5. Sole Soybean	0.030	0.034	**0.032**	0.040	0.044	**0.042**
6. Sole Greengram	0.032	0.034	**0.033**	0.039	0.041	**0.040**
Mean	**0.028**	**0.029**	**0.028**	**0.033**	**0.038**	**0.035**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)
1. Agroforestry system (AF)	0.0012	0.0035	0.0006	0.0017
2. Distance (D)	0.0008	NS	0.0004	0.0011
3. Interaction (AF X D)	0.0020	NS	0.0009	NS

DAS – Days after sowing; D_1 – 2m distance from teak alleys; D_2 – 4m distance from teak alleys

Among the distances 2 m distance from tree base were recorded in lowest net assimilation. The interactions were insignificant at both the stages.

4.2.3.6 Specific Leaf Area (SLA, $dm^2\ g^{-1}$)

The data on specific leaf area of legumes as influenced by integration of teak-perennial vegetables and distances at all stages is presented in Table 50. It varied significantly among the agroforestry systems and distance from the base at all stages while the interactions were insignificant. The average specific leaf area of legume crops ranged from 2.67 to 3.57 $dm^2\ g^{-1}$ (40 DAS).

At 20 DAS, the treatment of teak + curryleaf + soybean showed significantly highest specific leaf area (4.02) followed by teak + drumstick + soybean (3.88), when compared to other agroforestry systems. It was lowest in teak + drumstick + green gram (1.19) followed by teak + curryleaf + greengram (1.32) as compared to sole crop treatments.

The distance 4 m from tree base recorded the lowest specific leaf area of legumes, whereas at 2 m distance showed highest specific leaf area. This trend was followed at 40 and 60 DAS. The interaction effects were non significant.

At 40 DAS, specific leaf area of legumes was significantly maximum in teak + curryleaf + soybean (4.11) and followed by teak + drumstick + soybean (3.92). Where as the treatment teak + drumstick + greengram noticed in lowest specific leaf area (2.33) and it was followed by teak + curryleaf + greengram (2.90) as compared to sole crop treatment.

In general, the specific leaf area observed was more in sole crop treatment as compared to agroforestry system.

At 60 DAS, the treatment of teak + curryleaf + soybean showed highest specific leaf area (1.87) and was followed by the treatment teak + curryleaf + greengram (1.81) when compared to other agroforestry system. It was lowest in teak + drumstick + soybean (1.64) followed by teak + drumstick + greengram (1.80).

4.2.3.7 Specific Leaf Weight ($g\ dm^{-2}$)

The data on specific leaf weight of legumes varied significantly among the agroforestry systems at all the growth stages among the distances from the tree base at 20 and 60 DAS only, while the interactions were insignificant (Table 51).

The average specific leaf weight of legumes ranged from 0.404 $g\ dm^{-2}$ to 0.593 $g\ dm^{-2}$ (40 DAS).

At 20 DAS, the treatment teak + curryleaf + greengram recorded maximum specific leaf weight (0.484) followed by teak + drumstick + greengram (0.460) when compared to other to other agroforestry systems. A decreased specific leaf weight was noticed in teak + drumstick + soybean (0.227) as followed by teak + curryleaf + soybean (0.274) as compared to sole crop treatment.

Among the distances, the distance 2 m from base of tree recorded decreased specific leaf weight as compared to 4 m distance. This trend was noticed at 40 DAS also.

At 40 DAS, maximum specific weight was recorded in teak + curryleaf + soybean (0.580) as followed by teak + drumstick + soybean (0.572) and teak + curryleaf + greengram (0.572) both are on par. It was minimum in teak + drumstick + greengram (0.510) as compared to sole crop treatments.

There was no significant difference between agroforestry systems and distances.

At harvest, teak + curryleaf + soybean (0.330) was having significantly highest specific leaf weight followed by teak + drumstick + soybean (0.310). It was lowest in the treatment teak + drumstick + greengram (0.229) followed by teak+ curryleaf + greengram (0.236) as compared to sole crop treatment.

4.2.3.8 Leaf Area Ratio ($dm^2\ g^{-1}$)

The data on leaf area ratio of legumes as influenced by integration of perennial vegetables, teak and distances at different growth stages is presented in the Table 52.

Table 50: Influence of teak-perennial vegetable based agroforestry system on specific leaf area ($dm^2\ g^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	4.04	4.00	**4.02**	4.22	3.99	**4.11**	1.92	1.82	**1.87**
T_2-Teak + Curryleaf + Greengram	1.45	1.20	**1.32**	3.82	2.48	**2.90**	1.91	1.72	**1.81**
T_3-Teak + Drumstick + Soybean	4.11	3.66	**3.88**	4.14	3.72	**3.92**	1.68	1.60	**1.64**
T_4-Teak + Drumstick + Greengram	1.14	1.24	**1.19**	2.48	2.18	**2.33**	1.85	1.74	**1.80**
T_5-Soybean (sole)	4.11	3.86	**3.99**	4.46	4.86	**4.66**	3.00	2.62	**2.81**
T_6-Greengram (sole)	1.69	1.59	**1.64**	3.42	3.20	**3.31**	2.17	2.05	**2.11**
Mean	**2.75**	**2.59**	**2.67**	**3.75**	**3.40**	**3.57**	**2.08**	**1.92**	**1.94**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.108	0.316	0.132	0.386	0.082	0.240
Distance (D)	0.052	0.152	0.071	0.208	0.047	0.137
Interaction (AF X D)	0.153	NS	0.187	NS	0.116	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 51: Influence of teak-perennial vegetable based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.242	0.307	**0.274**	0.562	0.598	**0.580**	0.314	0.346	**0.330**
T_2-Teak + Curryleaf + Greengram	0.454	0.515	**0.484**	0.502	0.642	**0.572**	0.214	0.258	**0.236**
T_3-Teak + Drumstick + Soybean	0.219	0.234	**0.227**	0.547	0.597	**0.572**	0.417	0.424	**0.310**
T_4-Teak + Drumstick + Greengram	0.458	0.474	**0.466**	0.493	0.506	**0.510**	0.221	0.238	**0.229**
T_5-Soybean (sole)	0.382	0.499	**0.440**	0.630	0.665	**0.648**	0.437	0.475	**0.456**
T_6-Greengram (sole)	0.513	0.559	**0.536**	0.662	0.776	**0.699**	0.339	0.382	**0.360**
Mean	**0.378**	**0.431**	**0.404**	**0.566**	**0.630**	**0.593**	**0.323**	**0.353**	**0.320**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.043	0.126	0.020	0.060	0.043	0.123
Distance (D)	0.024	0.072	0.011	0.034	0.024	NS
Interaction (AF X D)	0.060	NS	0.029	NS	0.060	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 52: Influence of teak-perennial vegetable based agroforestry system on leaf area ratio ($dm^2\ g^{-1}$) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	1.82	1.71	**1.77**	0.85	0.81	**0.83**	0.35	0.31	**0.33**
T_2-Teak + Curryleaf + Greengram	0.54	0.42	**0.48**	0.85	0.78	**0.81**	0.35	0.26	**0.31**
T_3-Teak + Drumstick + Soybean	1.80	1.60	**1.70**	0.81	0.79	**0.80**	0.25	0.23	**0.24**
T_4-Teak + Drumstick + Greengram	0.49	0.38	**0.44**	0.79	0.70	**0.74**	0.26	0.24	**0.25**
T_5-Soybean (sole)	2.73	2.07	**2.40**	0.95	0.94	**0.95**	0.65	0.61	**0.63**
T_6-Greengram (sole)	0.75	0.86	**0.80**	0.99	0.90	**0.94**	0.62	0.54	**0.58**
Mean	**1.35**	**1.17**	**1.21**	**0.87**	**0.82**	**0.84**	**0.41**	**0.36**	**0.39**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.105	0.307	0.035	0.102	0.092	0.269
Distance (D)	0.060	0.175	0.020	0.058	0.005	0.014
Interaction (AF X D)	0.148	NS	0.050	NS	0.013	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

The data varied significantly among the agroforestry systems and distances from the base while the interaction effects were insignificant.

At 20 DAS, the treatment of teak + curryleaf + soybean was noticed significantly maximum leaf area ratio (1.77) followed by teak + drumstick + soybean ((1.70) and both were on par. It was minimum in teak + drumstick + greengram (0.44) and was followed by teak + curryleaf + greengram (0.48) when compared to other sole treatments.

Among the distances, 2 m from tree base showed significantly highest leaf area ratio, while 4 m distance recorded lowest leaf area ratio. This trend was noticed at all stages.

At 40 DAS, among the agroforestry systems, the treatment teak + curryleaf + soybean recorded significantly increased leaf area ratio (0.83) and the next best value was in teak + drumstick + soybean (0.80). Leaf area ratio reduction was highest in teak + drumstick + greengram (0.74) followed by teak + curryleaf + greengram (0.81).

At harvest, the treatment teak + curryleaf + soybean was having maximum leaf area ratio (0.32) followed by in teak + curryleaf + greengram (0.31). It was minimum in teak + drumstick + soybean (0.24) and teak + drumstick + greengram (0.25) when compare to other sole crop treatments.

4.2.3.9 Leaf Area Duration (days)

The leaf area duration of legumes was significantly influenced by the agroforestry systems and the distances from base tree at both stages. While the interactions were significant only at 20-40 DAS period (Table 53).

The average leaf area duration of legumes ranged from 37.24 to 53.44 days.

At 20-40 DAS, among the agroforestry systems, the treatment teak + curryleaf + soybean was noticed significantly maximum leaf area duration (48.87) followed by teak + curryleaf + soybean (46.21). Reduction in leaf area duration was highest in teak + drumstick + greengram (20.62) followed by in teak + curryleaf + greengram (21.86) and both are on par with each other.

Among the distances, the leaf area duration was minimum effect at 2 m distance from tree base duration, where as 4 m distance recorded increased leaf area duration. This trend was followed at 40-60 DAS period.

However, interaction effect between agroforestry system and distance from base of tree was significantly varying. The treatment teak + drumstick + greengram observed in lowest leaf area duration at 2 m distance from tree base (19.65) while, 4 m distance recorded highest leaf area duration in teak + curryleaf + soybean (51.09).

At 40 – 60 DAS, the treatment teak + curryleaf + soybean maximum leaf area duration (61.64) and followed by teak + drumstick + soybean (57.44) as compared to other treatments. It was minimum in teak + drumstick + greengram (40.78) and next best value was in teak + curryleaf + greengram (41.96), when compared to sole soybean. The interaction effects were non significant.

4.2.4 Biophysical parameters

4.2.4.1 Photosynthetic rate (µmol CO_2 dm^{-2} s^{-1})

The effect of agroforestry systems and distances from teak and perennial vegetable alley on photosynthetic rate in legume crops at different stages is presented in the Table 54.

The observations varied significantly among agroforestry systems and distances from the tree base, while the interactions were insignificant.

The photosynthetic rate decreased from 20 DAS to 40 DAS. It was more in sole crops as compared to agroforestry systems.

At 20 DAS, among the agroforestry systems the rate of photosynthesis was significantly more in the treatment teak + curryleaf + soybean (11.09) followed by in treatment teak + curryleaf + greengram (10.33), the lowest photosynthetic rate was recorded in the treatment teak + drumstick + greengram (9.28).

Table 53: Influence of teak-perennial vegetable based agroforestry system on leaf area duration (days) at different stages in legumes (pooled)

Agroforestry system	20 - 40 DAS			40 - 60 DAS		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Curryleaf + Soybean	46.65	51.09	**48.87**	59.06	64.03	**61.54**
T_2-Teak + Curryleaf + Greengram	20.81	22.91	**21.86**	41.76	42.16	**41.96**
T_3-Teak + Drumstick + Soybean	44.15	48.27	**46.21**	54.59	60.30	**57.44**
T_4-Teak + Drumstick + Greengram	19.65	21.59	**20.62**	39.42	42.14	**40.78**
T_5-Soybean (sole)	56.78	62.19	**59.49**	67.86	73.56	**70.71**
T_6-Greengram (sole)	26.27	26.53	**26.40**	47.97	48.45	**48.21**
Mean	**35.72**	**38.76**	**37.24**	**51.78**	**55.10**	**53.44**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.335	0.981	0.803	2.352
Distance (D)	0.193	0.565	0.463	1.356
Interaction (AF X D)	0.473	1.385	1.135	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 54: Influence of teak - perennial vegetable based agroforestry system on photosynthetic rate (µmol CO_2 dm^{-2} s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	10.57	11.62	**11.09**	9.56	10.09	**9.82**
T_2-Teak + Curryleaf + Greengram	10.07	10.59	**10.33**	7.81	8.10	**7.76**
T_3-Teak + Drumstick + Soybean	10.00	10.10	**10.05**	7.75	8.79	**8.27**
T_4-Teak + Drumstick + Greengram	8.93	9.63	**9.28**	6.99	7.15	**7.07**
T_5-Soybean (sole)	12.03	12.58	**12.31**	10.24	10.70	**10.47**
T_6-Greengram (sole)	10.26	11.30	**10.78**	8.28	8.90	**8.59**
Mean	**10.31**	**10.97**	**10.64**	**8.43**	**8.95**	**8.69**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)
Agroforestry system (AF)	0.14	0.40	0.22	0.63
Distance (D)	0.08	0.23	0.12	0.36
Interaction (AF X D)	0.20	NS	0.31	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Among the distances, 2 m away from the tree base recorded significantly lowest photosynthetic rate when compared to 4 m distance which recorded significantly highest photosynthetic rate. The same trend was noticed at 40 DAS also.

A reduction in the rate of photosynthesis was noticed at 40 DAS as compared to 20 DAS. Among the agroforestsry systems the highest rate of photosynthesis was registered in teak + curryleaf + soybean (9.82) followed by in teak + drumstick + soybean (8.27), the minimum photosynthetic rate was found in the treatment teak + drumstsick + greengram (7.07) followed by teak + curryleaf + greengram (7.76).

In general, the rate of photosynthesis increased significantly with increase in distance from teak with perennial vegetable alley.

4.2.4.2 Stomatal conductance (cm s^{-1})

Stomatal conductance of legumes as influenced by integration of perennial vegetables teak based agroforestry systems is presented in the Table 55.

The observations varied significantly among the agroforestsry systems and distances from the tree base. While, the interactions were insignificant. The stomatal conductance increased from 20 DAS to 40 DAS.

At 20 DAS, the stomatal conductance was lower in the agroforestry system as compared to sole crop. Treatment teak + drumstick + greengram had minimum conductance (2.47) followed by teak + curryleaf + greengram (2.53). Highest stomatal conductance was observed in the treatment teak + drumstick + soybean (4.38) followed by teak + curryleaf + soybean (2.53).

As the distance increased from teak perennial vegetable alley the stomatal conductance increased in legume crops.

At 40 DAS, the stomatal conductance increased significantly in the treatment teak + curryleaf + soybean (4.38) followed by teak + drumstick + soybean (4.05) and the lowest values of the stomatal conductance were observed in teak + drumstick + greengram (3.49) followed by teak + curryleaf + greengram (3.61) which were on par with each other.

Among the distances effect, 2 m distance from teak perennial vegetable alley showed decreased stomatal conductance, where as 4 m distance recorded significantly increased stomatal conductance.

4.2.4.3 Transpiration rate (mg H_2O $m^{-2}s^{-1}$)

The data on transpiration rate of legumes as influenced by integration of perennial vegetables teak based agroforestry systems and distances is presented in the Table 56.

The observations varied significantly among agroforestry systems and distances from the tree base while the interactions were insignificant.The transpiration rate decreased from 20 DAS to 40 DAS. It was more in sole crops as compared to agroforestry systems.

The rate of transpiration decreased from 20 DAS to 40 DAS. In general the transpiration rate was more in sole crop treatment as compared to agroforestsry systems.

At 20 DAS, among the agroforestry systems the rate of transpiration was significantly higher in the treatment teak + curryleaf + soybean (4.32) followed by teak + drumstick + soybean (4.21), the lower transpiration rate was observed in the treatment teak + drumstick + greengram (3.40) followed by in teak + curryleaf + greengram (3.57).

The rate of transpiration at 4 m distance was 4.40 and was significantly superior over 2 m distance.

At 40 DAS, the rate of transpiration reduced significantly as compared to 20 DAS. Among the agroforestry systems, the rate of transpiration was lower in teak + drumstick + greengram (3.01) followed by teak + curryleaf + greengram (3.15), and higher transpiration rate was observed in teak + curryleaf + soybean (3.45) followed by teak + drumstick + soybean (3.28).

Among the distances 2 m distance from teak perennial vegetable alley recorded lower transpiration rate (2.96) as compared to 4 m distance (3.54).

Table 55: Influence of teak-perennial vegetable based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	3.80	3.98	**3.89**	4.23	4.54	**4.38**
T_2-Teak + Curryleaf + Greengram	2.56	2.59	**2.53**	3.50	3.73	**3.61**
T_3-Teak + Drumstick + Soybean	3.34	5.42	**4.38**	3.99	4.11	**4.05**
T_4-Teak + Drumstick + Greengram	2.45	2.49	**2.47**	3.46	3.53	**3.49**
T_5-Soybean (sole)	4.13	4.24	**4.18**	4.60	4.78	**4.69**
T_6-Greengram (sole)	2.63	2.85	**2.74**	3.75	3.82	**3.78**
Mean	**3.15**	**3.59**	**3.37**	**3.92**	**4.08**	**4.00**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)
Agroforestry system (AF)	0.04	0.11	0.06	0.18
Distance (D)	0.02	0.06	0.04	0.11
Interaction (AF X D)	0.06	NS	0.09	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 56: Influence of teak-perennial vegetable based agroforestry system on transpiration rate (mgH_2O m^{-2} s^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	4.24	4.40	**4.32**	3.35	3.54	**3.45**
T_2-Teak + Curryleaf + Greengram	3.53	3.62	**3.57**	3.07	3.23	**3.15**
T_3-Teak + Drumstick + Soybean	4.11	4.31	**4.21**	3.26	3.30	**3.28**
T_4-Teak + Drumstick + Greengram	3.38	3.42	**3.40**	2.96	3.07	**3.01**
T_5-Soybean (sole)	4.57	4.65	**4.61**	3.78	4.06	**3.92**
T_6-Greengram (sole)	3.99	4.05	**4.02**	3.24	3.33	**3.29**
Mean	**3.97**	**4.08**	**4.02**	**3.28**	**3.42**	**3.35**

For comparing the means of	SEm ± (20 DAS)	CD (0.05) (20 DAS)	SEm ± (40 DAS)	CD (0.05) (40 DAS)
Agroforestry system (AF)	0.05	0.13	0.04	0.11
Distance (D)	0.03	0.08	0.02	0.06
Interaction (AF X D)	0.06	NS	0.05	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

4.2.4.4 Relative Water Content (RWC, %)

Relative water content (RWC) of legumes as influenced by agroforestry system and distances from tree base at different growth stages is presented in the Table 57. The observations varied significantly among agroforestry systems and distances from the tree base, while the interactions were insignificant.

The relative water content of legumes decreased gradually from 20 DAS to 60 DAS. At 20 DAS, among the agroforestry systems significantly increased RWC was noticed as compared to sole crop and was highest with teak + drumstick + soybean (87.21) followed by teak + curryleaf + soybean (85.11). The lowest relative water content was observed in teak + curryleaf + greengram (76.33) followed by teak + drumstick + greengram (77.25).

The relative water content was more in 2 m distance (87.71) as compared to 4 m distance from teak perennial vegetable alley (75.43).

At 40 DAS, among the agroforestry systems, the RWC was significantly more in teak + drumstick + soybean (80.49) followed by teak + curryleaf + soybean (80.40) and lower relative water content was observed in the treatment teak + drumstick + greengram (72.69) followed by teak + curryleaf + greengram (73.59).

Among the distances 2 m away from tree base recorded significantly higher relative water content (81.76) when compared to 4 m distance (72.48).

At 60 DAS, the same trend was noticed among the agroforestry systems the treatment teak+ curryleaf + greengram (69.42) was having significantly higher amount of relative water content and it was followed by teak + curryleaf + soyobean (70.63). The lower relative water content was observed in teak + drumstick + greengram (66.86) followed by teak + drumstick + soybean (67.08).

4.2.4.5 Light Transmission Ratio (LTR, %)

The data on light transmission ratio of legumes was significantly influenced by the teak perennial vegetable based agroforestry systems and distances from base of tree and also due to their interaction effect at all stages (Table 58 and Fig 11).

The average light transmission ratio of legumes ranged from 76.98 to 60.96 per cent (60 DAS).

At 20 DAS, among the agroforestry the treatment teak + curryleaf + soybean (72.59) having higher LTR followed by the treatment teak + drumstick + soybean (66.50) and minimum LTR was observed in the treatment teak + curryleaf + greengram (58.26) followed by teak + drumstick + greengram (64.56).

The light transmission ratio was significantly more in 4 m distance (80.94) as compared to 2 m distance (54.02).

The interaction effect between agroforestry system and distance was significant, light transmission ratio was significantly higher in 0-2 m distance from teak perennial vegetable alley as compared to 2-4 m distances.

At 40 DAS, among the agroforestry system the treatment teak + curryleaf + soybean was noticed significantly maximum light transmission ratio (60.48) while other agroforestry systems had low light transmission ratio.

Reduction of light transmission ratio was highest in teak + drumstick + greengram (45.14) followed by teak + drumstick + soybean (47.16) as compared to sole crop treatment.

An interaction effect between the agroforestry systems and distances from tree base was significantly varying at 2 m distance from tree base. The higher light transmission ratio was noticed in teak + curryleaf + soybean (65.89) at 4 m distance. While it was significantly low in teak + drumstick + greengram (42.49) at 2 m distance from tree base.

Table 57: Influence of teak-perennial vegetable based agroforestry system on relative water content (%) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	86.6	83.8	**85.1**	81.8	79.0	**80.4**	72.8	68.4	**70.6**
T_2-Teak + Curryleaf + Greengram	77.2	75.4	**76.3**	74.2	73.0	**73.6**	69.8	69.1	**69.4**
T_3-Teak + Drumstick + Soybean	87.7	86.7	**87.2**	80.8	80.2	**80.5**	67.2	67.0	**67.1**
T_4-Teak + Drumstick + Greengram	77.8	76.7	**77.3**	72.9	72.5	**72.7**	68.4	65.3	**66.9**
T_5-Soybean (sole)	77.2	75.4	**76.3**	78.9	78.6	**78.8**	66.5	64.6	**65.6**
T_6-Greengram (sole)	73.6	73.0	**73.3**	71.5	70.8	**71.1**	59.6	59.4	**59.5**
Mean	**80.0**	**78.5**	**79.3**	**76.7**	**75.7**	**76.2**	**67.4**	**65.6**	**66.5**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	0.44	1.29	0.53	1.54	0.52	1.51
Distance (D)	0.26	0.74	0.30	0.89	0.30	0.87
Interaction (AF X D)	0.62	NS	0.74	NS	0.73	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 58: Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	64.3	80.9	**72.6**	55.1	65.9	**60.5**	40.5	49.2	**44.9**
T_2-Teak + Curryleaf + Greengram	58.5	70.7	**64.6**	48.0	51.3	**48.7**	38.2	45.7	**41.9**
T_3-Teak + Drumstick + Soybean	61.0	72.0	**66.5**	45.3	49.0	**47.2**	34.2	39.3	**36.7**
T_4-Teak + Drumstick + Greengram	54.0	62.5	**58.3**	42.5	47.8	**45.1**	38.3	46.3	**42.3**
T_5-Soybean (sole)	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
T_6-Greengram (sole)	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
Mean	**72.9**	**81.0**	**77.0**	**65.1**	**69.0**	**66.9**	**58.51**	**63.4**	**61.0**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	Harvest SEm ±	Harvest CD (0.05)
Agroforestry system (AF)	1.07	3.13	0.51	1.50	1.09	3.22
Distance (D)	0.61	1.81	0.29	0.86	0.63	1.86
Interaction (AF X D)	1.51	4.43	0.72	2.12	1.55	4.55

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

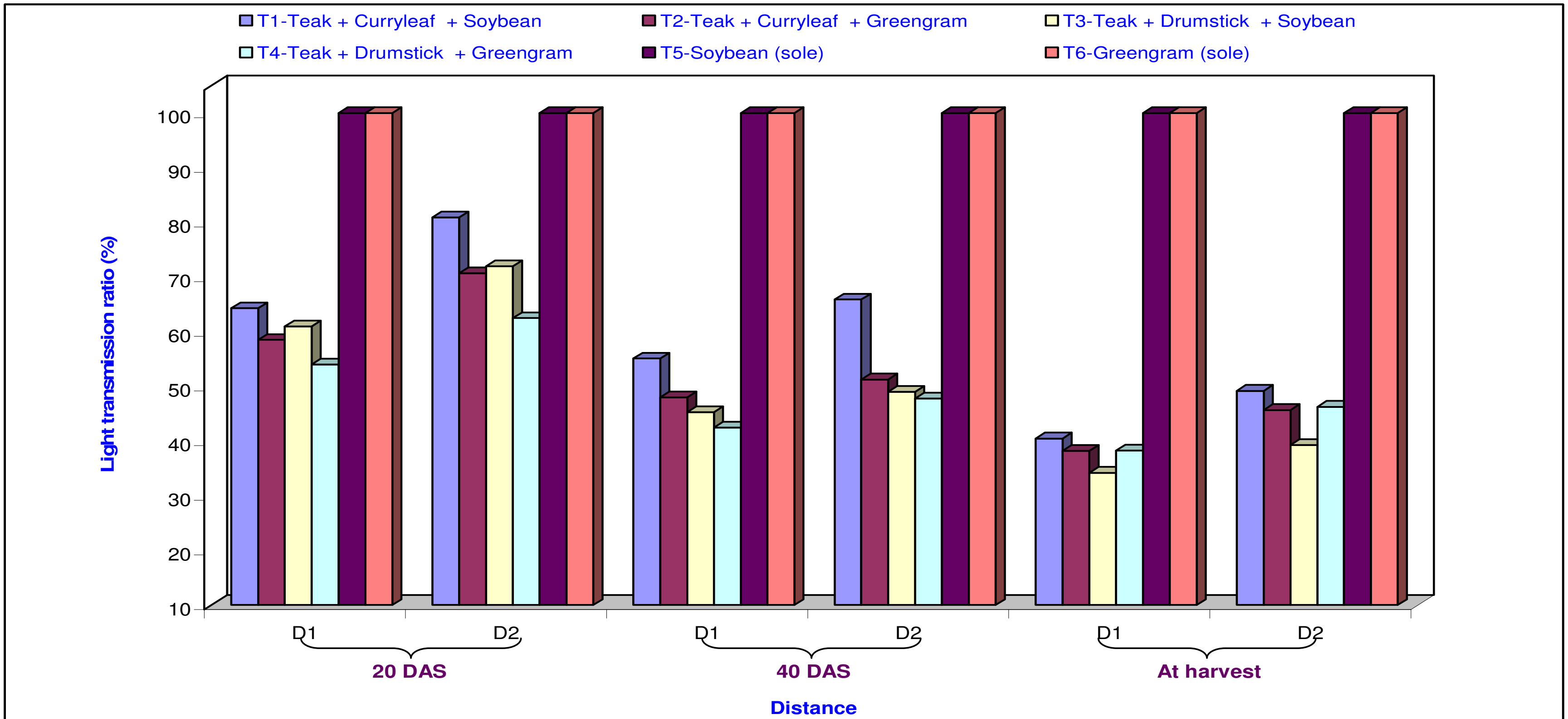


Fig. 11 : Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)

Fig. 11 : Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes (pooled)

At 60 DAS, agroforestry systems recorded significantly lower light transmission ratio as compared to 20 DAS and 40 DAS. Significantly higher light transmission ratio was noticed in teak + curryleaf + soybean (44.87) followed by teak + drumstick + greengram (42.27). The lowest light transmission ratio value was found in the treatment teak + drumstick + soybean (36.23).

Among the distances, light transmission ratio was 63.41 at 4 m distance and was significantly superior over 2 m distance (58.51).The treatment teak + drumstick + soybean were recorded lowest light transmission ratio and at 2 m distance from teak perennial vegetable alley (34.20) where as teak + curryleaf + soybean at 4 m distance recorded highest light transmission ratio (49.24).

4.2.5 Biochemical parameters

4.2.5.1 Chlorophyll 'a' content (mg g fr.wt^{-1})

The data on chlorophyll 'a' content of legume crops was significantly influenced by the teak perennial vegetables based agroforestry system and the distances at all the stages (Table 59).

The average chlorophyll content ranged from 1.27 mg g fr.wt^{-1} (20DAS) to 0.57 mg g fr.wt^{-1} (60 DAS).

At 20 DAS, the treatment of teak + drumstick + soybean noticed significantly maximum chlorophyll 'a' content (1.80) followed by teak + curryleaf + soybean (1.67) as compared to agroforestry systems and it was lowest in teak + curryleaf + greengram (0.87) followed by teak + drumstick + greengram (0.93) when compared to sole crop treatment.

The distance 4 m from tree base recorded lowest chlorophyll 'a' content in agroforestry system, whereas, at 2 m distance from tree base showed significantly highest chlorophyll 'a' content at all the stages.

Interaction effect between agroforestry system and distances from tree base was significantly varying. The treatment teak + curryleaf + greengram observed least chlorophyll 'a' content at 4 m distance away from tree base (0.86). It was more at 2m distance away from tree base in teak + drumstick + soy bean (1.82).

At 40 DAS, the treatment of teak + curryleaf + greengram registered lowest chlorophyll 'a' content (1.36) followed by teak + curryleaf + soybean (1.44). Whereas, significantly highest chlorophyll 'a' value was observed in teak + drumstick + soybean (1.54) followed by teak + drumstick + greengram (1.46) when compared to sole crop.

Among the distances effect, 2 m distance from tree base showed increased chlorophyll 'a' content, whereas, 4 m distance recorded decreased chlorophyll 'a' content. The same trend was followed at 60 DAS period also.

At 60 DAS, among the agroforestry systems, the treatment teak + drumstick + soybean recorded significantly maximum chlorophyll 'a' content (0.78) followed by teak + curryleaf + soybean (0.70). The lower chlorophyll 'a' content was found in the treatment teak + drumstick + greengram (0.57) followed by teak + curryleaf + green gram (0.65) as compared to sole crop treatment.

4.2.5.2 Chlorophyll 'b' content (mg g fr.wt^{-1})

The data on chlorophyll 'b' content of legumes was significantly influenced by the agroforestry systems and distances from base of tree at all stages. While, interaction effect was insignificant at all stages except 40 DAS. The data is presented in the Table 60. The average of chlorophyll 'b' content in legumes ranged from 0.40 to 0.31 mg g fresh wt^{-1}.

At 20 DAS, among the agroforestry systems the treatment teak + drumstick + greengram had significantly highest chlorophyll 'b' content (0.47) followed by teak + drumstick + soybean (0.46). It was lowest in teak + curryleaf + greengram (0.38) followed by teak + curryleaf + soybean (0.46), when compared to sole crop treatment.

Among all the agroforestry systems treatments, the distance 4 m from teak perennial vegetable alley registered minimum chlorophyll 'b' content. Whereas, at 2 m distance from tree base recorded maximum chlorophyll ‘b’ content. This trend was followed at 40 DAS and 60 DAS period also.

At 40 DAS, the treatment teak + curryleaf + greengram showed lowest chlorophyll ‘b’ content (0.43) followed by teak + drumstick + greengram (0.45) when compared to agroforstry systems, the maximum chlorophyll ‘b’ content was noticed in the treatment teak + drumstick + soybean (0.64) followed by teak + curryleaf + soybean (0.59) as compared to sole crop treatments.

However, the interactions effect between agroforestry system and distances from tree base differed significantly. The treatment teak + curryleaf + greengram noticed least chlorophyll ‘b’ content (0.42) at 4 m distance. whereas, at 2 m distance away from tree base recorded highest chlorophyll ‘b’ content in teak + drumstick + soybean (0.71).

At 60 DAS, there was reduction in chlorophyll ‘b’ content among the agroforestry systems and distances. The treatment teak + curryleaf + greengram showed lowest chlorophyll ‘b’ content (0.28) followed by teak + drumstick + green gram (0.28) both on par with each other. Whereas, significantly highest chlorophyll ‘b’ content was observed in teak + curryleaf + soybean (0.39) followed by teak + drumstick + soybean (0.38). The other interactions were insignificant.

4.2.5.3 Total chlorophyll content (mg g fr.wt^{-1})

The data on total chlorophyll content of legume crops was significantly influenced by the teak perennial vegetable based agroforestry systems and the distances from base of the tree at all stages, is presented in the Table 61 and Fig. 12. While the interaction effect varying significantly at 20 DAS only.

The average total chlorophyll content of legume crops ranged from 1.67 (20 DAS) to 0.98 mg. g fr.wt^{-1} (60 DAS).

At 20 DAS, among the agroforestry systems teak + drumstick + soybean significantly higher total chlorophyll content (2.26) followed by teak + curryleaf + soybean (2.13), when compared to other agroforestry systems. whereas, it was lowest total chlorophyll content teak + curryleaf + greengram (1.25) as compared to sole crop treatments.

Among the distances, the distances at 4 m away from the tree base had minimum total chlorophyll content as compared to 2 m distances. This trend was followed at 40 DAS and 60 DAS period also.

However, the interaction effects between agroforestry systems and distances from teak perennial vegetable alley differed significantly. The treatment teak + curry leaf + greengram noticed least total chlorophyll content at 4 m distance from tree base (1.24). Whereas, at 2 m distance recorded highest total chlorophyll content in teak + drumstick + soybean (2.21) at 4 m distances from tree base.

At 40 DAS, the treatment teak + curryleaf + greengram noticed minimum total chlorophyll content (1.79). Whereas, significantly maximum total chlorophyll content was noticed in teak + drumstick + soybean (2.18).

At 60 DAS, there was reduction is total chlorophyll content among the agroforestry systems and distances. The treatment teak + curryleaf + greengram (0.93) showed least total chlorophyll content followed by teak + drumstick + greengram (0.96), whereas, significantly higher amount of total chlorophyll content was observed in teak + drumstick + soybean (1.16) followed by teak + curryleaf + soybean (1.09).

Among the distance from the tree base, 2 m distance from teak perennial vegetable alley recorded maximum total chlorophyll content, whereas, 4 m distance noticed minimum total chlorophyll content.

4.2.5.4 SPAD values (Single Photoelectric Analyzing Diode)

The data on Single Photoelectric Analyzing Diode of legume crops was significantly influenced by the teak perennial vegetable based agroforestry systems and distances (Table 62).

Table 59: Influence of teak-perennial vegetable based agroforestry system on chlorophyll 'a' (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Curryleaf + Soybean	1.79	1.54	**1.67**	1.47	1.42	**1.44**	0.75	0.65	**0.70**
T_2-Teak + Curryleaf + Greengram	0.88	0.86	**0.87**	1.40	1.32	**1.36**	0.66	0.64	**0.65**
T_3-Teak + Drumstick + Soybean	1.82	1.78	**1.80**	1.57	1.51	**1.54**	0.79	0.77	**0.78**
T_4-Teak + Drumstick + Greengram	0.93	0.93	**0.93**	1.47	1.45	**1.46**	0.60	0.55	**0.57**
T_5-Soybean (sole)	1.67	1.34	**1.51**	1.39	1.38	**1.38**	0.69	0.68	**0.68**
T_6-Greengram (sole)	0.86	0.84	**0.85**	1.28	1.25	**1.27**	0.67	0.61	**0.64**
Mean	**1.33**	**1.22**	**1.27**	**1.43**	**1.38**	**1.40**	**0.60**	**0.55**	**0.57**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.029	0.084	0.018	0.052	0.015	0.043
Distance (D)	0.017	0.049	0.010	0.029	0.008	0.023
Interaction (AF X D)	0.029	0.084	0.026	NS	0.021	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 60: Influence of teak-perennial vegetable based agroforestry system on chlorophyll 'b' (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	0.47	0.45	**0.46**	0.66	0.52	**0.59**	0.39	0.39	**0.39**
T_2-Teak + Curryleaf + Greengram	0.39	0.38	**0.38**	0.45	0.42	**0.43**	0.28	0.27	**0.28**
T_3-Teak + Drumstick + Soybean	0.49	0.43	**0.46**	0.71	0.56	**0.64**	0.39	0.37	**0.38**
T_4-Teak + Drumstick + Greengram	0.49	0.46	**0.47**	0.46	0.45	**0.45**	0.29	0.28	**0.28**
T_5-Soybean (sole)	0.33	0.30	**0.31**	0.58	0.50	**0.54**	0.32	0.32	**0.32**
T_6-Greengram (sole)	0.33	0.32	**0.33**	0.41	0.37	**0.39**	0.25	0.23	**0.24**
Mean	**0.41**	**0.39**	**0.40**	**0.54**	**0.47**	**0.50**	**0.32**	**0.31**	**0.31**

For comparing the means of	SEm ± (20 DAS)	CD (0.05) (20 DAS)	SEm ± (40 DAS)	CD (0.05) (40 DAS)	SEm ± (60 DAS)	CD (0.05) (60 DAS)
Agroforestry system (AF)	0.006	0.017	0.011	0.032	0.007	0.020
Distance (D)	0.003	0.008	0.006	0.017	0.004	NS
Interaction (AF X D)	0.009	NS	0.016	0.046	0.010	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 61: Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	2.26	1.99	**2.13**	2.13	1.94	**2.03**	1.14	1.04	**1.09**
T_2-Teak + Curryleaf + Greengram	1.27	1.24	**1.25**	1.85	1.74	**1.79**	0.94	0.91	**0.93**
T_3-Teak + Drumstick + Soybean	2.31	2.21	**2.26**	2.28	2.07	**2.18**	1.18	1.14	**1.16**
T_4-Teak + Drumstick + Greengram	1.42	1.39	**1.40**	1.93	1.90	**1.91**	0.98	0.96	**0.96**
T_5-Soybean (sole)	2.00	1.64	**1.82**	1.97	1.88	**1.92**	0.99	0.93	**0.96**
T_6-Greengram (sole)	1.19	1.16	**1.18**	1.69	1.62	**1.66**	0.85	0.78	**0.81**
Mean	**1.74**	**1.60**	**1.67**	**1.97**	**1.85**	**1.91**	**1.01**	**0.95**	**0.98**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.031	0.090	0.022	0.064	0.019	0.055
Distance (D)	0.018	0.052	0.013	0.038	0.011	0.032
Interaction (AF X D)	0.044	0.128	0.031	NS	0.028	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

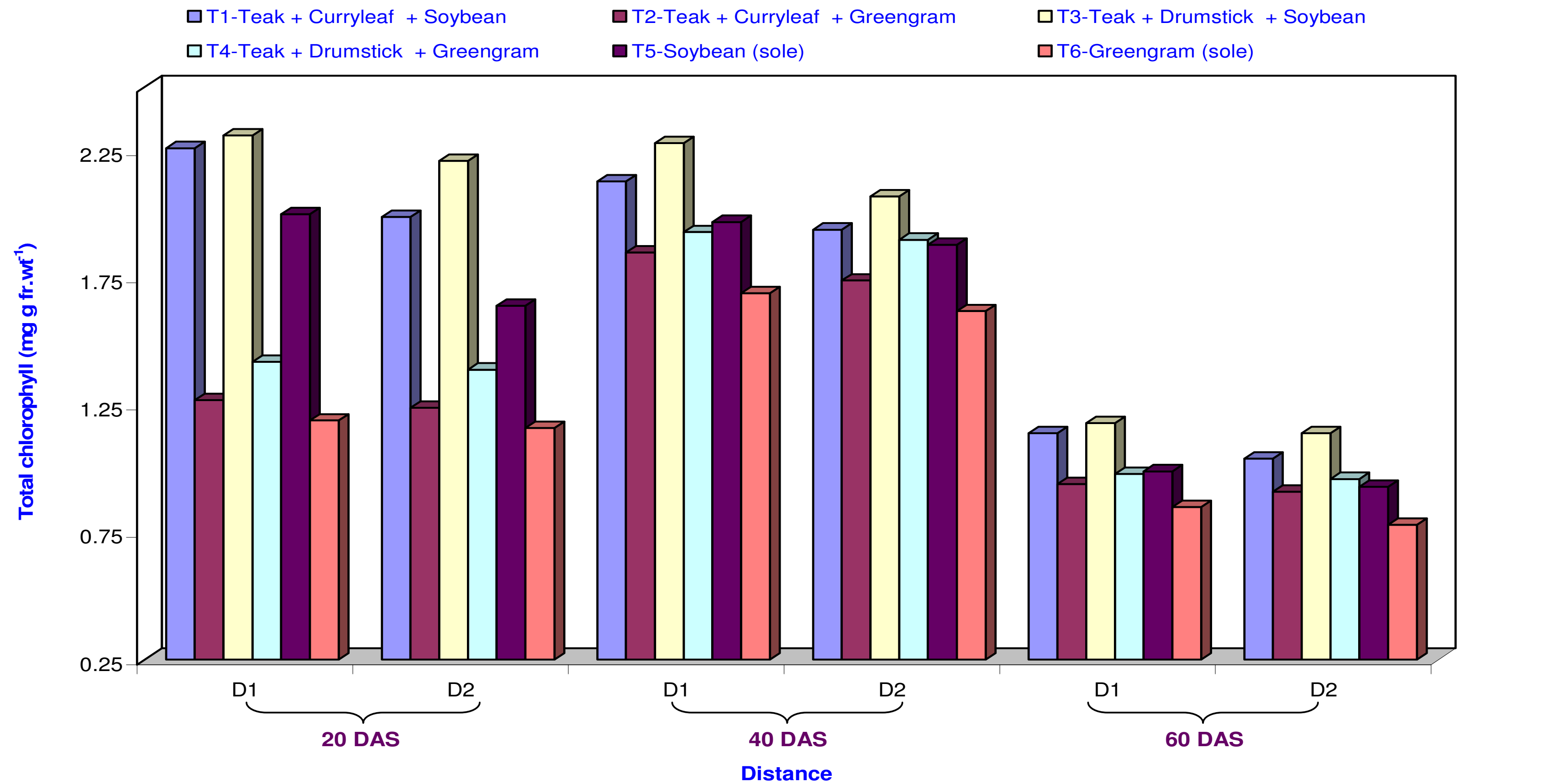


Fig. 12 : Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fr.wt-1) at different stages in legumes (pooled)

Fig. 12 : Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fr.wt-1) at different stages in legumes (pooled)

Table 62: Influence of teak-perennial vegetable based agroforestry system on single photoelectric analyzing diode (SPAD, %) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	26.0	24.7	**25.4**	34.2	33.4	**33.8**	23.5	22.9	**23.2**
T_2-Teak + Curryleaf + Greengram	21.1	19.7	**20.4**	24.5	24.0	**24.3**	18.9	17.9	**18.4**
T_3-Teak + Drumstick + Soybean	29.8	28.8	**29.3**	36.2	34.9	**35.5**	25.0	24.5	**24.8**
T_4-Teak + Drumstick + Greengram	21.2	21.2	**21.2**	25.9	24.7	**25.3**	19.2	19.0	**19.1**
T_5-Soybean (sole)	23.3	21.9	**22.6**	33.3	31.5	**32.4**	21.9	21.5	**21.6**
T_6-Greengram (sole)	19.1	18.6	**18.8**	23.6	22.3	**22.9**	17.4	17.2	**17.3**
Mean	**23.4**	**22.5**	**23.0**	**29.6**	**28.5**	**29.1**	**20.9**	**20.5**	**20.7**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.34	0.99	0.41	1.20	0.26	0.77
Distance (D)	0.19	0.57	0.23	0.69	0.15	0.44
Interaction (AF X D)	0.48	NS	0.58	NS	0.37	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 63: Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (nmol NO_2 formed g fresh wt^{-1} h^{-1}) at different stages in legumes (pooled)

Agroforestry system	20 DAS			40 DAS			60 DAS		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Curryleaf + Soybean	36.73	39.09	**37.91**	22.48	23.18	**22.83**	18.36	19.38	**18.87**
T_2-Teak + Curryleaf + Greengram	16.46	16.62	**16.54**	13.45	13.68	**13.56**	9.26	9.52	**9.39**
T_3-Teak + Drumstick + Soybean	35.75	38.34	**37.05**	22.00	22.95	**22.48**	17.35	17.74	**17.55**
T_4-Teak + Drumstick + Greengram	15.96	16.38	**16.17**	13.03	13.25	**13.14**	9.12	10.13	**9.62**
T_5-Soybean (sole)	39.27	40.12	**39.69**	23.75	24.51	**24.13**	19.45	20.53	**19.99**
T_6-Greengram (sole)	16.99	17.87	**17.43**	14.83	15.01	**14.92**	10.43	10.52	**10.48**
Mean	**26.86**	**28.07**	**27.46**	**18.25**	**18.76**	**18.51**	**13.99**	**14.63**	**14.31**

For comparing the means of	20 DAS SEm ±	20 DAS CD (0.05)	40 DAS SEm ±	40 DAS CD (0.05)	60 DAS SEm ±	60 DAS CD (0.05)
Agroforestry system (AF)	0.25	0.75	0.21	0.63	0.25	0.75
Distance (D)	0.14	0.43	0.12	0.36	0.14	0.43
Interaction (AF X D)	0.36	1.06	0.30	NS	0.36	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

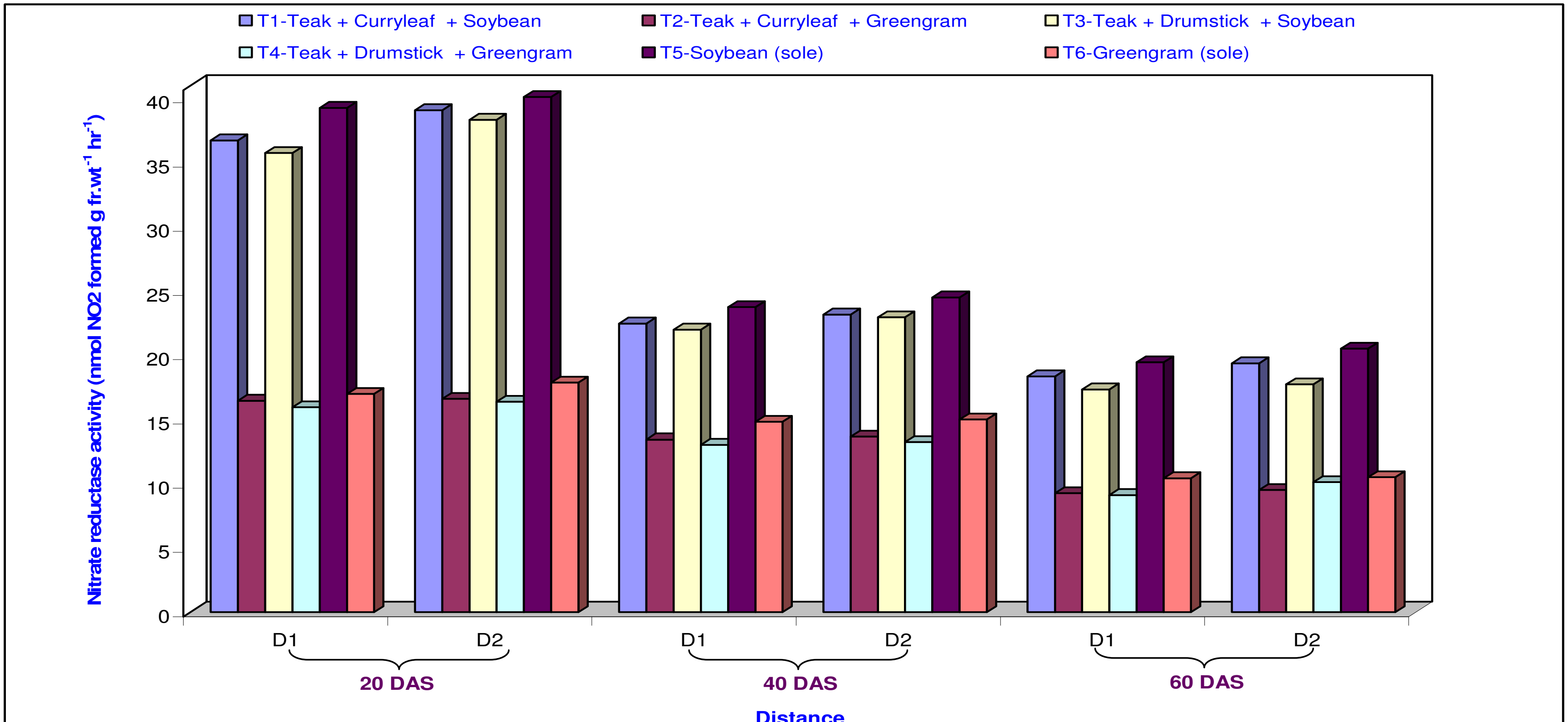


Fig. 13 : Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (nmol NO2 formed g fr.wt-1 hr-1) at different stages in legumes (pooled)

Fig. 13 : Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (nmol NO2 formed g fr.wt-1 hr-1) at different stages in legumes (pooled)

The average of Single Photoelectric Analyzing Diode (SPAD) readings of legumes ranged from 22.95 (20 DAS) to 29.05 (40 DAS).

In general the Single Photoelectric Analyzing Diode readings of indicated that the amount of chlorophyll content in the leaves, higher the SPAD values, the higher amount of chlorophyll content in the leaves of legume crops.

At 20 DAS, the treatment teak + drumstick + soybean noticed significantly higher values of SPAD (29.27) followed by teak + curryleaf + soybean (25.36). It was lowest in teak + curryleaf + greengram (20.42) followed by teak + drumstick + greengram (21.22).

The distance 4 m from tree base from teak perennial vegetable alley recorded lowest SPAD values. Whereas, 2 m distance from teak base showed significantly higher Single Photoelectric Analyzing Diode values. The same trend was followed at 40 DAS and 60 DAS period also.

At 40 DAS, among the agroforestry systems and distances the treatment teak + drumstick + soybean showed highest SPAD values (35.32) followed by teak + curryleaf + soybean (33.81). Whereas, the treatment teak + curryleaf + greengram (24.28) recorded lowest Single Photoelectric Analyzing Diode values.

At 60 DAS, teak + curryleaf + greengram recorded minimum SPAD values (18.39) followed by teak + drumstick + greengram (19.07). Significantly higher single photoelectric analyzing diode values were found in the treatment teak + drumstick + soybean (24.76).

4.2.5.5 Nitrate reductase activity (nmol of NO_2 formed g fresh wt^{-1} h^{-1})

The data on nitrate reductase activity of legumes was significantly influenced by the teak perennial vegetable based agroforestry systems and distances from the tree base and their interactions (Table 63). The nitrate reductase activity was significantly higher in sole crop of legumes (39.69) as compared to legumes grown with teak perennial vegetables.

At 20 DAS, among the agroforestry systems, the treatment teak + curryleaf + soybean noticed significantly maximum nitrate reductase activity content (37.91) and it was lowest in teak + drumstick + greengram (16.17).

The distance 2 m from tree base recorded lowest nitrate reductase activity content and whereas, at 4 m distance from teak perennial vegetable alley showed significantly higher amount of nitrate reductase activity content. This trend was observed at 40 DAS and 60 DAS period also.

The interaction effect between the agroforestry system and distances from tree base was significantly differ. The treatment teak + curryleaf + soybean recorded significantly higher values of nitrate reductase activity at 4 m distance (39.09). whereas, at 2 m distance away from teak perennial vegetable alley was noticed lower values of nitrate reductase activity in teak + drumstick + greengram (16.17).

At 40 DAS, the treatment teak + curryleaf + soybean had significantly maximum nitrate reductase activity content (22.83) whereas, significantly lower nitrate reductase activity was found in teak + drumstick + greengram (13.14)

At 60 DAS, among the agroforestry system, the treatment teak + curryleaf + greengram recorded significantly maximum nitrate reductase activity content (18.87) and it was minimum nitrate reductase activity value was found in teak + curryleaf + greengram (9.39) and the next best treatment was teak + drumstick + greengram (9.62).

In general the nitrate reductase activity was maximum at 4 m distance from teak– perennial vegetable alley as compared to 2 m distance from tree base. The maximum nitrate reductase activity value was found in sole crops as compared to agroforestry systems.

4.2.6 Yield and yield components

4.2.6.1 Number of pods per plant

The number of pods in legumes was significantly higher in sole crop treatment and decreased in agroforestry systems teak + curryleaf + soybean (15.0),teak+ drumstick +

soybean (24.8), teak + curryleaf + greengram (15.3), teak+ drumstick + greengram (19.4) (Table 64).

Higher number of pods per plant was recorded in teak + curryleaf + soybean (42.74) and less number of pods observed in teak + drumstick + greengram (17.83). The number of pods per plant was increased significantly from 2 - 4 m distance from the tree base.

Interaction effect between agroforestry system and distances from teak vegetable alley was significant. The treatment teak + curryleaf + soybean showed highest number of pods per plant (48.94) at 4 m distance from tree base of tree. At 2 m distance noticed lowest number of pods in teak + drumstick + greengram (16.73).

4.2.6.2 Seed weight per plant (g)

Seed weight of legumes was significantly influenced by the agroforestry systems and distances from teak-perennial vegetable alley (Table 64).

The seed weight was significantly higher in the treatment teak + curryleaf + soybean (6.22) and lowest seed weight was observed in the treatment teak + drumstick + greengram (1.99).

Among the distances 2 m from tree base was noticed minimum seed weight, where as 4 m distance from teak alley recorded maximum seed weight.

4.2.6.3 Hundred seed weight (g)

The data on hundred seed weight legumes was significantly influenced by different agroforestry systems and distances from base of tree (Table 64).

The treatment teak + curryleaf + soybean recorded significantly increased hundred seed weight (8.24) followed by the treatment teak + drumstick + soybean (6.72). Reduction of hundred seed weight was highest teak + drumstick + greengram (2.47) followed by teak + curryleaf + greengram (2.77).

Among the distances, minimum hundred seed weight was noticed at 2 m distance from the tree base, where as 4 m distance recorded the maximum hundred seed weight.

Hundred seed weight was more in sole crops as compared to agroforestry systems.

4.2.6.4 Seed Yield (kg ha^{-1})

Higher seed yield was observed in sole legume crops treatment of soybean and greengram (820.10) and (313.50) respectively (Table 65).

The extent of reduction seed yield was 22.14, 30.06, 40.60 and 38.37 per cent in association with teak + curryleaf + soybean, teak + curryleaf + greengram, teak+ drumstick + soybean, teak + drumstick + greengram as compared to sole legume crops respectively.

Among the distances, the distances of 2 m from tree base recorded minimum seed yield. Whereas, 4 m distance noticed maximum seed yield.

The other interactions was non significant.

4.2.7 Performance of teak

4.2.7.1 Height of teak (m)

During the year 2007, teak height was significantly higher when grown with teak + curryleaf + soybean legumes (8.09) followed by teak + curryleaf + greengram (8.05) both are on par with each other and lowest teak height was observed in the treatment teak + drumstick + greengram (6.71) followed by teak + drumstick + soybean (7.25) (Table 66).

In the year 2008, the teak height was significantly increased in the teak + curryleaf + soybean legumes (8.25) followed by the treatment teak + curryleaf + greengram (8.13) and lowest height was found in teak + drumstick + greengram (7.10).

Table 64: Influence of teak-perennial vegetable based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes (pooled)

Agroforestry system	Number of pods per plant			Seed weight per plant (g)			100 seed weight (g)		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	36.5	48.9	**42.7**	6.08	6.36	**6.22**	8.00	8.48	**8.24**
T_2-Teak + Curryleaf + Greengram	18.7	20.9	**19.8**	2.40	2.78	**2.59**	2.62	2.91	**2.77**
T_3-Teak + Drumstick + Soybean	34.7	40.8	**37.7**	5.81	6.16	**5.98**	6.30	7.15	**6.72**
T_4-Teak + Drumstick +Greengram	16.7	18.9	**17.8**	1.93	2.05	**1.99**	2.37	2.56	**2.47**
T_5-Soybean (sole)	49.1	51.2	**50.2**	9.01	10.63	**9.82**	12.00	12.54	**12.27**
T_6-Greengram (sole)	23.3	23.5	**23.4**	3.32	3.35	**3.33**	5.13	5.32	**5.23**
Mean	**29.8**	**34.0**	**31.9**	**4.75**	**5.22**	**4.98**	**6.07**	**6.49**	**6.28**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	1.05	3.09	0.22	0.64	0.47	1.38
Distance (D)	0.61	1.78	0.13	0.37	0.27	NS
Interaction (AF X D)	1.49	4.36	0.31	NS	0.67	NS

D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Table 65: Influence of teak-perennial vegetable based agroforestry system on seed yield (kg ha^{-1}) in legumes (pooled)

Agroforestry system	Seed Yield (kg/ha.)		
	D_1	D_2	Mean
T_1-Teak + Curryleaf + Soybean	741.1	791.6	766.3
T_2-Teak + Curryleaf + Greengram	300.8	313.5	307.1
T_3-Teak + Drumstick + Soybean	589.0	680.8	634.9
T_4-Teak + Drumstick + Greengram	247.0	261.2	254.1
T_5-Soybean (sole)	823.3	817.0	820.1
T_6-Greengram (sole)	310.3	316.6	313.5
Mean	**501.9**	**530.1**	**516.0**

For comparing the means of	SEm ±	CD (0.05)
Agroforestry system (AF)	17.14	50.22
Distance (D)	9.89	28.97
Interaction (AF X D)	24.24	NS

D_1 – 2m distance from teak alleys; D_2 – 4m distance from teak alleys

Table 66: Growth of teak as influenced by different components in agroforestry system

Agroforestry systems	Height (m)		DBH (cm)		Crown area (m^2/ pl)	
	2007	2008	2007	2008	2007	2008
T_1-Teak + Curryleaf + Soybean	8.09	8.25	11.86	14.35	5.25	12.44
T_2-Teak + Curryleaf + Greengram	8.05	8.13	12.08	14.50	5.32	12.24
T_3-Teak + Drumstick + Soybean	7.25	7.70	10.23	13.39	5.37	11.06
T_4-Teak + Drumstick + Greengram	6.71	7.10	8.60	12.78	4.77	11.59
T_5-Soybean (sole)	7.89	8.09	10.62	12.20	5.10	12.12
T_6-Greengram (sole)	-	-	-	-	-	-
Mean	-	-	-	-	-	-
SEm ±	0.29	0.08	0.32	0.30	0.44	0.50
CD 5%	0.96	0.26	1.06	0.98	NS	NS

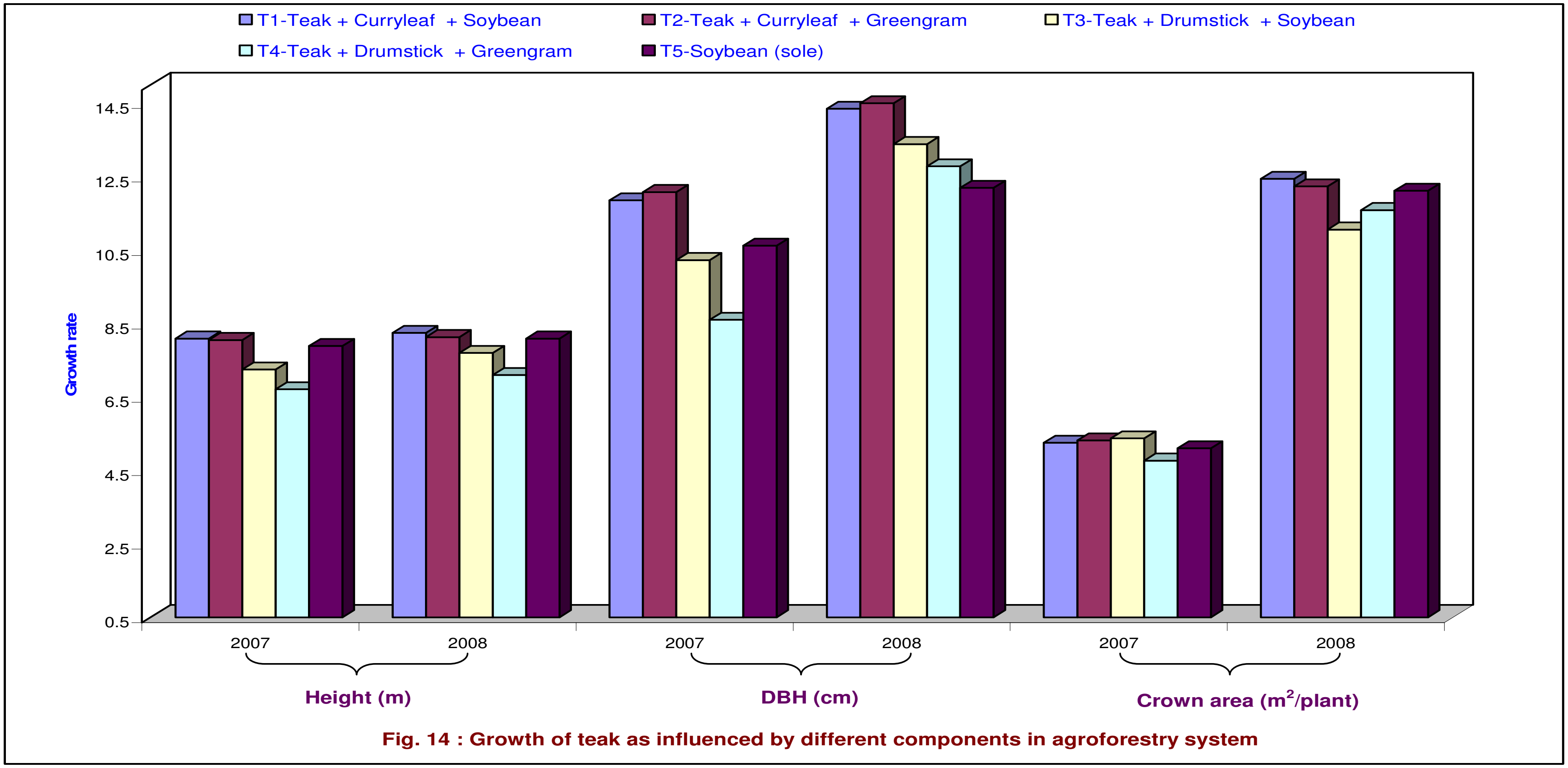


Fig. 14 : Growth of teak as influenced by different components in agroforestry system

4.2.7.2 Diameter at breast height (dbh, cm)

Diameter at breast height (2007) was significantly higher in teak + curryleaf + greengram (12.08) which was on par with teak + curryleaf + soybean (11.86) as compared to teak + drumstick + soybean (10.23) and lowest diameter at breast height was found in teak + drumstick + greengram (8.60) as compared teak alone only (Table 66).

In the year 2008, the teak diameter was increased in the treatment teak + curry leaf + greengram (14.50) followed by the treatment teak + curryleaf + soybean (14.35) and lowest diameter was found in teak + drumstick + greengram (12.20)

4.2.7.3 Crown area (m^2 $plant^{-1}$)

During 2007, among the agroforestry systems, higher teak crown area was found in the treatment teak + drumstick + soybean (5.37) and less crown area was observed in teak + drumstick + greengram (4.77) (Table 66).

In 2008, teak + curry leaf + soybean (12.44) followed by teak + curryleaf + greengram (12.24) and lowest crown area was found in teak + drumstick + soybean (11.06) as compared to other agroforestry systems.

4.2.8 Performance of perennial vegetables

4.2.8.1 Height of drumstick and curryleaf (m)

Among the perennial vegetable studied the growth of drumstick was more as compared to curryleaf (Table 67).

In the year 2007, the drumstick height was more in the treatment teak + drumstick + greengram (5.81) as compared to teak + drumstick + soybean (5.33) whereas, the curryleaf height was more in the teak + curryleaf + soybean (1.16) followed by teak + curryleaf + greengram (1.15) both are on par with each other.

During 2008, the treatment teak + drumstick + greengram (4.35) had more height as compared to other agroforestry systems followed by teak + drumstick + soybean (4.07), where as lowest height was found in teak + curryleaf + soybean (0.98)

4.2.8.2 Collar diameter of drumstick and curryleaf (cm)

Collar diameter of drumstick was significantly higher in teak + drumstick + soybean (11.16) followed by teak + greengram (9.82).Whereas, the curryleaf collar diameter was more in teak + greengram (3.90) as compared to teak + soybean (3.35) (Table 67).

In 2008, drumstick collar diameter was higher as compared to other agroforestry systems, the treatment teak + greengram (13.14) and lowest collar diameter was found in teak + soybean (11.08). Whereas, the curryleaf diameter low in teak + greengram (8.73) and the treatment teak + soybean (8.92) both are on par.

4.2.8.3 Crown area of drumstick and curryleaf (m^2 $plant^{-1}$.)

Among the agroforestry systems, in the year 2007, drumstick crown area was more in the treatment teak + greengram (11.45) followed by the treatment teak+ soybean (7.25), where as the treatment teak + soybean (0.32) had lower curryleaf crown area as compared to teak + greengram (0.35) as compared to other agroforestry systems (Table 67).

In the year 2008, the drumstick crown area was higher in teak + drumstick + greengram (7.91) followed by teak + drumstick + soybean (6.92).Whereas, the treatment teak + curryleaf + soybean (0.50) had higher crown area as compared to other agroforestry systems, and lower crown area was found in teak + curryleaf + greengram (0.19).

4.2.8.4 Fruit yield (number of fruits per plant) and curry leaf yield (kg/plant)

Average fruit yield of drumstick was higher in teak + greengram (69) followed by teak + soybean (59.00) ,where as the average green curryleaf yield was more in teak + greengram (1.41 kg $plant^{-1}$) as compared to teak + soybean (1.16 kg $plant^{-1}$) (Table 67).

Table 67: Growth and yield of perennial vegetables as influenced by different components in agroforestry system

Agroforestry systems	Height (m)		Collar Diameter (cm)		Crown area (m^2/ pl)		Green leaf yield (kg/plant) and number of fruits per plant		
	2007	2008	2007	2007	2008	2008	2007	2008	Mean
Teak+Curryleaf+Soybean	1.16	0.98	3.35	8.92	0.32	0.50	1.64	1.19	1.41
Teak+Curryleaf+Greengram	1.15	1.02	3.90	8.73	0.35	0.19	1.27	1.06	1.16
Teak+Drumstick+Soybean	5.33	4.07	11.16	11.08	7.25	6.92	81.0	38.00	59.50
Teak+Drumstick+ Greengram	5.81	4.35	9.82	13.14	11.45	7.91	90.00	48.00	69.00
Teak only	-	-	-	-	-	-	-	-	
Soybean (sole)	-	-	-	-	-	-	-	-	
Greengram (sole)	-	-	-	-	-	-	-	-	

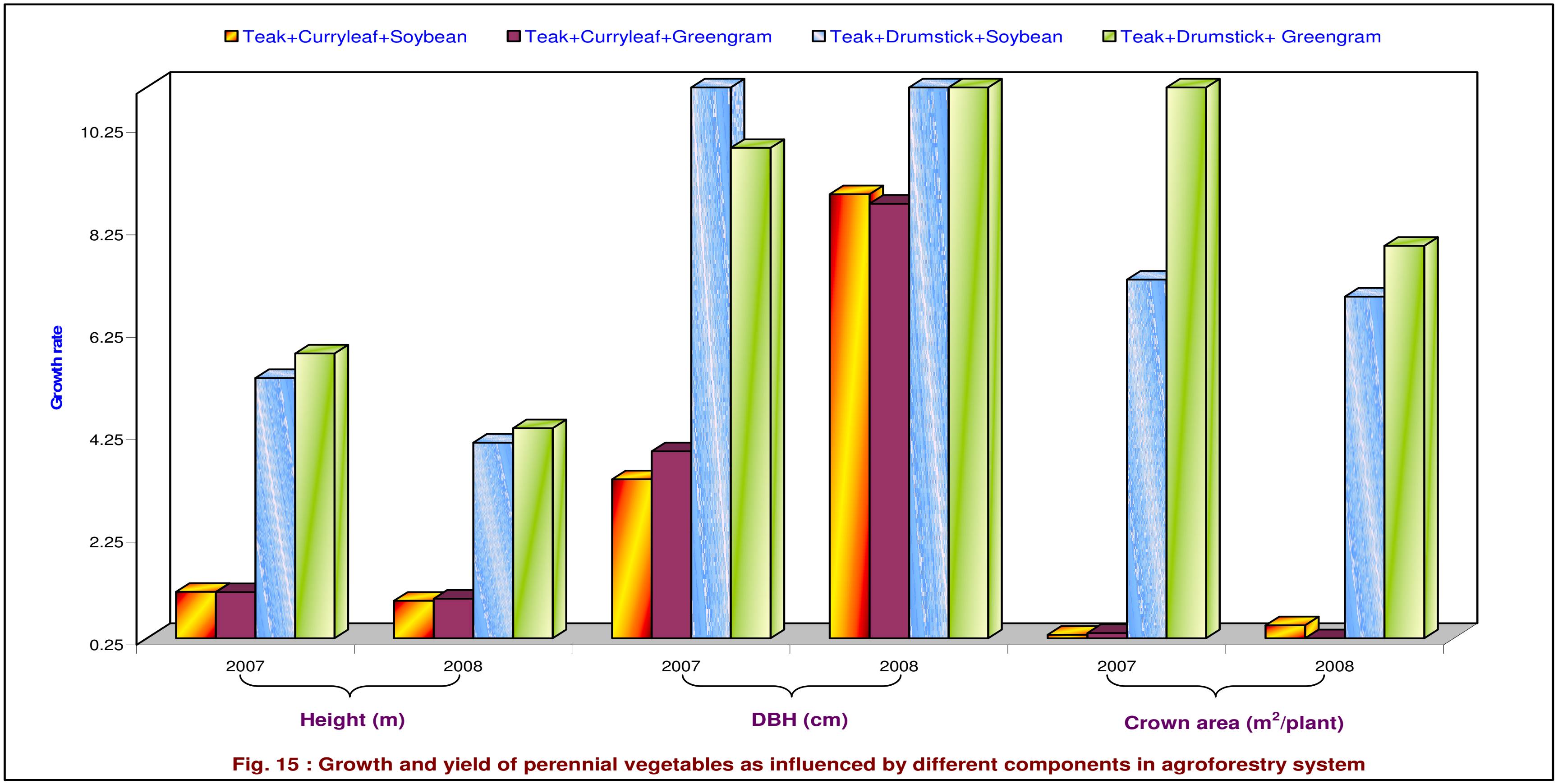


Fig. 15 : Growth and yield of perennial vegetables as influenced by different components in agroforestry system

5. DISCUSSION

A sound understanding of the processes and mechanisms involved in resource capture and use and mechanisms with environment is essential for the development of more reliable and productive systems. Competition between species in mixed stands (interspecific competition) differs from that between plants within monocultures in that the component species of intercrops may impose different demands on the available resources.The components of intercrops or agroforestry systems often differ greatly in size, with the result that the growth of smaller understorey species may be inhabited by shading, and possibly also by competition for water and nutrients.When resources are not limiting, densely planted monocultures usually provide the most efficient resource capture systems. However, where one or more resources are limiting, it may be possible to improve productivity by using species mixtures if the component species capture more of available resources or use them more efficiently for growth.

Keeping this in view, experiments were designed to study the influence of teak-legume based agroforestry systems on growth, physiology and productivity of the component legumes during kharif 2007 and 2008 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Results obtained from the investigations are discussed experiment wise in this chapter.

5.1 Weather conditions

Dharwad is located in the transitional agroclimatic zone of north Karnataka. The meteorological data for 2007, 2008 and average for the past 57 years (1950 - 2007) was collected from the Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The data indicated that the total rainfall received was 1081 and 957 mm respectively during 2007 and 2008 indicating a 68.5 and 18.4 per cent higher rainfall compared to average values. The total rainfall received during cropping period (June - August) was 607 and 436 mm, respectively during 2007 and 2008, which was 68 and 18 per cent more compared to average of past 57 years.

The mean maximum and minimum temperatures did not vary much during both the years and with the mean over the past 57 years. However, the year 2007 was slightly warmer than 2008. The warmest month during the crop growth period was June and the coolest month was August in both the years.

The relative humidity during the cropping period ranged from 80 to 85 per cent during 2007 and 82 to 83 per cent during 2008. The mean relative humidity was however 2 percent more in 2007 and 5 per cent less in 2008 as compared to the past 57 and 58 years, respectively.

5.2 Experiment–I: Physiological investigations on legumes in teak based agroforestry system

Legumes are large group of plants second to cereals, protenaceous source of food for human and as a forage crop for cattle. The demand of legume crops is increasing rapidly due to the ever increasing population. Hence, it is necessary to increase the production and productivity of legumes. One of the possible ways of increasing the production of legume crops is growing them in association with trees as legumes are potential intercrops when grown with tall trees.

Legumes when grown in association with teak or perennial vegetables will interact with them for different resources. The interaction may be positive or negative or complex. The competition would be mostly for light, moisture, nutrients and space. Teak and perennial vegetables being perennial in nature and with well established deep root systems have upper hand over other crops, especially under rainfed situations. The interaction effects could be due to different components in the agroforestry system, proximity to tree line and their interactions for various resources. The interaction between the field crops (legumes) and perennial component is ineviTable when they are grown in a agroforestry systems. The results of the present investigations involving teak as a base crop and four legumes as intercrops in one experiment and teak and perennial vegetables as base crops along with two legumes in the second experiment are discussed hereunder.

5.2.1 Morphological characteristics

Number of leaves per plant at different growth stages will determine the plant architecture and contribute to the total dry weight produced per plant. Increased number of leaves also contribute to the total photosynthates produced vis-à-vis increase in the dry matter produced per plant. It is observed that the number of leaves was greatly influenced by intercropping with teak trees indicating beneficial effects of complementing with teak.

The plant height increased steadily from 20 to 40 DAS (26 %) and further upto harvest (53 %); while, the increase in number of leaves and number of branches was at much higher rate. It was 242 and 222 per cent at 40 DAS and 213 and 248 per cent at 40 DAS and at harvest over 40 DAS, respectively in number of leaves and number of branches. However, the leaf area per plant enhanced by 117 per cent at 40 DAS compared to 20 DAS and it reduced there after. Though there was a reduction in leaf area after 40 DAS compared to 20 DAS, but it was still higher by 42 per cent at harvest compared to 20 DAS.This indicates that there is no adverse effect of intercropping of legumes with teak with respect to assimilatory surface area which is most important for contributing to total dry matter production.

There was a reduction in plant height among the agroforestry systems compared to control because of competition for resources. The reduction in height was 7 and 5 per cent respectively at 40 DAS and harvest over control. However, the increase in plant height was steady in soybean, frenchbean and blackgram at all growth stages compared to greengram, which exhibited sudden increase by 97 and 178 per cent at 40 DAS and at harvest, respectively. Similar trend was also noticed in sole crops. The proximity to tree line caused about 5 per cent reduction in plant height at 2 m compared to 4 m.

The number of leaves per plant increased by 142 and 113 per cent, respectively at 40 DAS and at harvest compared to 20 DAS. The per cent decrease in leaf number at harvest could be attributed to natural senescence. The number of leaves per plant was reduced in agroforestry systems compared to sole crop at all the stages to on extent of 6 –13 per cent. The reduction in leaf number was to the extent of 3-8 per cent only at 2 m compared to 4 m from tree base. Due to incorporation of these legumes in agroforestry systems, there was a decline in leaf number per plant and it ranged from 6 –13 per cent. The soybean sole crop recorded 132 per cent increase in leaf number at 40 over 20 DAS and the same trend was also noticed under agroforestry systems. However, there was a reduction by 7 per cent in agroforestry over sole crop.

The number of branches per plant increased by 122 per cent at 40 DAS and by 148 per cent at harvest reflecting an increasing trend during the growth period. The closer distances from the tree base had negative effect on number of branches. The reduction in the number of branches was to an extent of 5 –14 per cent over the stages compared to longer distance. The incorporation of legumes in agroforestry systems reduced the branch number by 28, 17 and 11 per cent, respectively at 20, 40 and at harvest compared to sole crop. Among the agroforestry systems, the teak + soybean at harvest was having maximum per cent increase of branches at 20 DAS and it was however, less by 16 per cent over its control. While, greengram was having 162 per cent more branches at harvest and it was the lowest among the legumes tried and there was 10 per cent reduction in this crop under agroforestry systems compared to sole crop. The soybean crop maintained more branches both under agroforestry system and control, while other legumes had the lowest. This clearly indicates that soybean is better compared to other legumes viz., greengram, frenchbean and blackgram to be intercropped with soybean. This could also be due to least allelopathic influence of teak plant on growth and development of soybean.

Leaf area increased with the advancement in age upto 40 DAS and it was higher by 117 per cent over 20 DAS. Among the agroforestry system, however, there was a decline thereafter and it was more by only 42 per cent over control. Closer the proximity to the tree base more was the reduction in leaf area. It was 93, 95 and 97 per cent, only at 2 m distance compared to 4 m distance. The maximum leaf area was at 40 DAS coinciding with peak flowering and reducing thereafter with senescence. At 40 DAS, the maximum leaf area was noticed in soybean and was 66 per cent more than at 20 DAS. However, it was highest with frenchbean among the agroforestry systems thereby reflecting the superiority of this legume compared to greengram and blackgram. Frenchbean recorded only 7 per cent reduction in leaf area under agroforestry, while there was more than 27 per cent reduction in other species.

Reduced plant height in agroforestry system compared to sole crop could be attributed to reduction in cell turgidity as a result of stress imposed due to competition for water which led to decrease in cell elongation and decreased plant height.The observations of the present study are in line with those of Kramer (1959) who observed reduced cell elongation due to reduced cell turgidity which decreased not only the size of the plants but also the yield. The decrease in number of leaves in intercrops compared to sole crops could also be attributed to the moisture stress created due to the competition between the tree species and crop and may also be due to the reduced light intencity. Since sole crop had a competition free environment, it had highest number of leaves. Not only the leaf number, but also the number of branches and leaf area per plant which affect the dry matter production per plant also got reduced due to intercropping. In the present investigation, leaf area was significantly higher under sole crop. It was significantly lower when legumes were grown with teak. In the present study, both soybean and frenchbean had significantly higher plant height, number of branches, number of leaves and leaf area compared to other legumes.

More moisture depletion at 0 – 2 m and 2 – 4 m distance under teak + legume was the main cause for reduction in leaf area per plant. Since the competition for the moisture, nutrient and the solar radiation was low with teak, the leaf area produced was higher when legumes were grown with teak. Kramer (1959) reported that water stress caused decrease in enlargement of leaves due to reduced cell elongation and earlier cell maturation as these processes depend upon cell turgidity. This reduction in leaf size is especially serious, because it decreases the photosynthetic surface and finally affects the yield (Khan and Ehrenreich, 1994; Lalitha Bai, 1981; Mutanal, 1998; Bhat, 1988; Padeyannavar, 2002 and Venkata Rao, 2006).

5.2.2 Growth and growth parameters

Difference in yield components and ultimately the yield in the component legumes is attributed to the differences in dry matter production and its distribution at different growth stages. Therefore, dry matter accumulation at each growth stage and its partitioning to reproductive organs during pre-flowering to maturity period has more importance in determining the productivity.

Building up of efficient photosynthetic structure in the early phase of the plant growth is possible for the synthesis, accumulation and translocation of photosynthates. Rapid early growth helps to produce more canopies to harvest the solar energy to a maximum extent and leads to build up of good plant stand at later stages.In the present investigation, legumes raised at 2 m from tree base suffered due to non availability of soil moisture, solar energy and nutrients during early stages and thus failed to build up adequate plant structure which resulted in lower dry matter production at 20 DAS during crop growth.

Dry matter production is greatly influenced by the growth of the crop right from the beginning and is indicated in plant height, number of leaves, leaf area, leaf area index and other growth parameters like AGR, CGR and NAR. These growth parameters were affected mainly due to lack of soil moisture, solar radiation and nutrient availability. Korawar (1992), Jaswal *et al.,* (1993), Iang *et al.,* (1995), Mutanal (1998), Bhat (1988), Chauhan *et al.,* (1990), Padeyannavar (2002) and Venkata Rao (2005), Patro and Sahu (1986) also reported the adverse effect of low light intencity on growth and dry matter production.

Growth analysis is a physiological probe on the development of the crop in chronological sequence to elucidate and account the causes for differences in yields through the events that have occured at different growth stages. In the present investigation LAI in legumes was affected greatly by teak. It was lowest with teak + greengram both at 2 and 4 m distance from tree base followed by blackgram + teak. Sole legume treatments recorded maximum leaf area index (17.5%). The lower leaf area index is also known to be positively influenced by shade. As the distance increased from 1 to 5 m from teak row in a agroforestry systems, there was a gradual increase in leaf area index of groundnut (Mutanal, 1998).

Similar results were also obtained by Padeyannavar (2002), Venkata Rao (2005), Ravishankar and Muthuswamy (1988).

Absolute growth rate in legumes was affected greatly by different agroforestry systems and distances. It was lowest when teak + blackgram at 0 – 2 m and 2 – 4 m distance from tree base followed by teak + greengram at all the stages. Sole legumes recorded maximum AGR. Crop growth rate and net assimilation rate were also found to have high significant positive correlation with seed yield. Both the parameters were lower at early stage of the crop growth and increased with advancement in crop growth thereby, indicating an increase in the accumulation of dry matter. CGR and NAR were more in sole legumes as compared to legumes grown with teak and thus explain the reasons for higher yield in sole legumes. The crop growth rate was slow up to 20 days after sowing and the maximum was between 20–40 DAS. Significant genotypic and temporal differences were noticed with respect to net assimilation rate and relative growth rate of the crop.

Kalubourne and Pandey (1979) noticed low crop growth rate during early vegetative phase, but increased with the advancement of growth of greengram. The average values of net assimilation rate were about 0.50 g/m^2 /week. The average relative growth rate was found to be positively correlated with bright sunshine hours (Shamboo Prasad and Srivastava, 1999 and Naga *et al*., 2000).

Specific leaf weight was affected negatively when teak was grown with other legumes. It was lowest with teak + soybean followed by teak + frenchbean at 20 DAS and 40 DAS. At 60 DAS, the SLW was higher in teak + frenchbean followed by teak + soybean.

The specific leaf weight was initially low and improved subsequently and reached the maximum value at 40 DAS. The decrease in the SLW at early stages could be due to low light intencity compared to later stage. The plant with higher specific leaf weight possesses more mesophyll cells for photosynthesis. Singh (1997) reported that SLW of leguminous crops reduced drastically by low radiation. Similar observation of decrease in SLW because of shading have been reported in tact fescue (Naird *et al.,* 1991). Both specific leaf area and specific leaf weight made substantial contribution to seed yield and were found strongly associated with yield in greengram (Gopalsingh and Nariansingh, 1982). Decrease in SLW indicates that the leaves are thinner which is an indicative of the exposure of leaves to low light intencity. The increase in SLW is because of the stacking of mesophyll cells which is more important since mesophyll cells contain chloroplast. More the number of mesophyll cells means more number of chloroplasts, which are essential for light harvesting and hence increased photosynthetic efficiency.

Geeta *et al.,* (2008) reported that an adverse effect of light systems on growth and yield of the crop and plant height. While, dry matter production and specific leaf weight decreased drastically with increasing shade. However, chlorophyll content increased under low light conditions. LAR at 2 m distance from teak alley was more as compared to 4 m distance from the tree base. LAR was also more in sole legume crop treatment as compared to legumes with teak. LAR was more in teak + frenchbean followed by teak + soybean and minimum leaf area ratio was observed in teak + blackgram and teak + greengram. It is evident that leaf area ratio increased slightly in shade tolerant species, while it decreased in shade susceptible species with decreasing light intensity. These results are in confirmity with those reported for greengram and groundnut (Singh, 1977).

Under reduced light levels, the genotypes which maintain higher LAR are considered to be tolerant. If plants allocate more tissue for producing larger leaf area and harvest more light and resources only in that case the plant may resist to reduction of total dry matter.

The leaf area duration is the total amount of leaf area present over a particular period of growth and is an important growth parameter that influences productivity potential. It was less at early stage of crop growth and increased thereafter due to enhanced leaf area. Further, leaf area duration was maximum in sole legume crops followed by teak + soybean, teak + frenchbean and lowest in teak + greengram and teak + blackgram. The leaf area duration increased rapidly from 20 – 30 DAS and it was slow towards harvesting (Aher *et al.,* 2006).

5.2.3 Biophysical parameters

The biophysical parameters like photosynthetic rate, stomatal conductance, transpiration rate and light transmission ratio were less in agroforestry system as compared to sole crop treatments; whereas, the relative water content was more in agroforestry system or in shaded condition.

Leaf photosynthesis and transpiration rate of legumes was more at 20 DAS and decreased at 40 DAS; whereas, the stomatal conductance increased from 20 to 40 DAS. Light transmission ratio was more in the initial crop growth period and declined after 40 DAS. Chandrababu and Nagarjun (2009) also reported that the net photosynthesis reduced under shade. The photosynthetic efficiency of teak plants decreased under the shaded condition mainly due to reduction in light intencity. Under shaded conditions, there was also a decrease in respiration and transpiration mainly because of the lower temperature and light intensity. On the contrary, the relative water content increased under shade, which was beneficial to prevent the young sprouts from ageing (Haung, 1983).

The results also showed that the relative water content was more in shade conditions as compared to open conditions. At 2 m distance from teak alley, higher relative water content was noticed as compared to the 4 m distances. And also, relative water content was more in agroforestry systems as compared to sole crop treatments. Vandan and Bhatt (2001) reported that the rate of transpiration and water use efficiency decreased, while leaf diffusion resistance increased significantly with decreased light intensity. The overall rate of photosynthesis, stomatal conductance, carboxylation efficiency and water use efficiency was higher in teak + soybean and teak + frenchbean as compared to other agroforestry systems. It may indicate the better adoptability under shade condition and that these may be suitable to grow under agroforestry systems. Similar results have also been reported by Allard and Nelson (1991). Vandana and Bhatt (1999) found that decreased stomatal conductance was mainly because of reduced number of stomata in reduced light.

Reduced photosynthesis coincided with reduced mesophyll conductance and thereby reflecting the poor carboxylation activity in the mesophyll cells. These indicate that carboxylation efficiency decreased with decreasing light intensity eventually affecting the rate of photosynthesis to a greater extent than stomatal conductance. This clearly indicates that the principal photosynthetic enzyme, RuBp carboxylase might have some limitation under low light condition to fix carbon dioxide.

5.2.4 Biochemical parameters

Chlorophyll content is one of the important biochemical parameters which is used as the index of production capacity. The chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents were estimated at 20, 40 and 60 DAS in the component crops and the data revealed significant differences due to intercropping with teak and distances from the tree base. There was an increase in chlorophyll 'b' and total chlorophyll contents between 20 and 40 DAS. The difference in the chlorophyll content between the agroforestry treatments and distances at all growth stages of the crops, was mainly because of shade effect of trees. Significantly lower chlorophyll content and (a + b + total) were noticed in sole crop treatment. It was highest in agroforestry systems and was more at 2 m distance from the teak alley. The findings are in support of the results obtained by Lalithabai *et al.,* (1981) and Geeta *et al.,* (2008). The chlorophyll content noticed in tea leaves also increased with the shading (Haung, 1983). Kumar Rita *et al*., (2008) reported that the total chlorophyll content was found to be higher in the leaves of the plants grown in less light intensity and it had promoting effect on the synthesis of total chlorophyll. John and Murrayo (1982) also reported increase in the chlorophyll a/b ratio of the crop plants with increasing shade intensity but leaf weight per unit area decreased because of thinner leaves. SPAD values indicated the amount of chlorophyll content in the legume leaves. Higher the Single Photoelectric Analyzing Diode values (SPAD) higher will be amount of chlorophyll content.

The legumes at 4 m distance from teak alley recorded lower chlorophyll values under open condition (sole legume crops) compared to 2 m distance from the teak alley. The agroforestry systems had higher amount of chlorophyll content. The study of Laza *et al.,* (2003) indicated higher SPAD values in the crops grown under shade.

The nitrate reducatase, which is the key enzyme in nitrogen metabolism is known to be regulated by various environmental factors apart form its own substrate, nitrate. It is also believed that the reduction of nitrate to nitrite by nitrate reducatase is the rate limiting step for the utilization of nitrogen in the form of nitrate. The peak activity of nitrate reducatase coincided with the maximum chlorophyll content, thereby complementing the carbon-nitrogen balance in plants. Nitrate reductase activity, which is an indicator of nitrate utilization also reduced significantly under shaded condition. Reduced enzyme activity could be attributed to low light intencity under shade and is one of the important factors for the activation of the enzyme. In addition it could also be due to lower availability of nitrogen due to decreased transpiration under shaded condition.

Prakash *et al.,* (1982) also suggested that under shade condition nitrate reductase activity was reduced, while, there was an increase in peroxidase activity. Vandana and Bhatt (2001) reported that the total protein content and nitrate reductase activity reduced under low light conditions. Rodriguez *et al.,* (2006) also reported that the activity of nitrate reductase was higher under open ligh and it was affected by decrease in soil moisture, mainly under shaded condition.

5.2.5 Yield and yield components

Yield is the ultimate manifestation of morphological, physiological, biochemical processes and growth parameters and is considered to result from trapping and the conversion of solar energy efficiently. Improvement in yield can be realized in two ways i.e., by adopting the existing varieties to grow better in their environment or by altering the relative proportion of different plant parts so as to increase the yield of economically important parts (Humphries, 1969).

The highest grain yield was obtained in sole legume crops of frenchbean (1157 kg ha^{-1}) followed by teak + frenchbean based agroforestry system (1042 kg ha^{-1}). It was interesting to note that teak + frenchbean based agroforestry system was better than the sole cropping of soybean and its agroforestry system. The lowest yield was recorded in teak + greengram (408 kg ha^{-1}). Among different agroforestry systems, the performance of teak + frenchbean was superior followed by teak + soybean. The increase in yield was attributed to increased number of pods per plant, seed weight and 100 seed weight, which inturn depended on total dry matter accumulation, CGR, RGR, NAR and AGR.

Among the distances, the legumes grown at 4 m distance away from base of teak recorded significantly higher grain yield (790 kg ha^{-1}) compared to 2 m distance (736 kg ha^{-1}). The significantly lower soil moisture at 1 m and 2 m distances at all the growth stages of legumes due to competition for moisture by the surfacial root system of the tree; as most of the lateral root spread of teak is confined to 2 m distance from the tree base was attributed for lower yield. Competition for moisture in agroforestry systems is a common phenomenon, which can affect the system adversely (Ong *et al.,* 1991 and Rao *et al.,* 1999).

There was a maximum reduction in grain yield in the close proximity of the tree base. Further, the yield improved in a linear fashion with an increase in distance from the tree base. More negative effect in close vicinity of trees can be ascribed to more competition for soil moisture, nutrients and light, which is also evident in the present study. Reductions in yield of wheat below the tree crown due to resource competition were also reported by Puri and Bangrwa (1992) and Dhillon *et al.* (1998).

The number of pods per plant was lowest in the teak + blackgram (14.9, 16.5) followed by teak + frenchbean (16.8, 20.9) compared to teak + greengram (17.4, 20.9) and teak + soybean (48.6, 54.8) respectively at 2 and 4 m distances as compared to sole legume crops. Reduction in seed weight per plant was highest when legumes were grown with teak + blackgram (18.50 %) followed by teak + greengram (18.73 %) and teak + frenchbean (5.34 %) compared to sole legumes.

Hundred seed weight was lowest when blackgram was grown with teak in both distances 0 – 2 m and 2 – 4 m distances (3.73, 4.18 g) followed by teak + greengram (3.50, 4.50 g) and teak + soybean (9.40, 10.33 g), teak + frenchbean (16.83, 21.56 g) compared to sole legume crops. A positive correlation between seed yield and other components has also been reported by several workers (Potadar *et al.,* (1977), Siddhu and Bains (1980), Dagar *et al.,* (1995), Vericumber (1993), Padeyannavar (2002), Venkata Rao (2005), Kushal and

Verma (2003) who also reported that the growth and yield of crop was influenced negatively below the tree crown, while it increased with increase in distance from the tree trunk. Soil moisture, nutrients and temperature were reduced considerably at 1 and 2 m distances from the tree base.

Seed yield of sole legumes was highest and was 973, 571, 1157 and 505 in soybean, greengram, frenchbean and blackgram respectively. The extent of reduction of seed yields was 9.7, 28.6, 9.9 and 17.8 per cent with teak + soybean, teak + greengram, teak + frenchbean and teak + blackgram, respectively as compared to their sole legumes.

Among agroforestry systems, the seed yield was maximum in frenchbean + teak followed by soybean + teak, blackgram + teak and greengram + teak. The main reasons for decreased yield of legumes in agroforestry systems were due to severe competition for moisture, light and nutrients by teak. Patro and Salier (1986) reported that detrimental effect of agroforestry system on physiology and yield of component crops was mainly because of the exposure of the crops to low light intencity. The shading effect was more conspicuous during vegetative stage compared to reproductive stage due to the growth of the component crops.

Venkata Rao *et al.* (2006) reported that the extent of reduction in pod yield was 5.5 and 3.1 per cent in groundnut with teak and teak + subabul as compared to groundnut grown with teak + grass. Similarly, reduction in yields of maize, sorghum, sunflower and groundnut adjoining tree lines were reported by Mutanal (1998), Chandrashekharaih (1986), Itnal (1987), Bhat (1988) and Nadagoud (1990), respectively. The reduction in seed yield of legumes in adjoining tree line was due to the effect of shade from the tree and their root competition with crops for moisture and nutrients. Low light intensity and soil moisture have adverse effects on crop growth resulting in reduction of yield in legumes.

Among the legumes, the extent of reduction in seed yield under agroforestry system was in the order of greengram > blackgram> soybean> frenchbean. While, in sole crop, reduction in seed yield was in the order of frenchbean (1042. 9) > soybean (875.8) > blackgram (415.4) and greengram (408.1).

A significantly low seed yield of legumes was recorded at 2 m distance from teak row as compared to 4 m distances. The extent of reduction in pod yield was 18.1 per cent at 2 m distance from teak row as compared to 4 m distance, which may be due to lower soil moisture and low light transmission ratio (59.2 to 79.6%) as compared to 2 – 4 m (69.1 to 84.5 %) from teak row. This may also be due to shading effect of trees, and also adverse effect of these factors was reflected in the reduction of leaf area, dry matter production of legumes near the teak row. Similarly, reduction in yields of maize, sorghum, sunflower and groundnut adjoining tree lines were reported by Chandrasekharaiah (1986), Itnal (1987), Bhatt (1988), Nadagoud (1990), Anon (1990), Anon (1996) and Venkata Rao (2005).

Low light intensity and soil moisture also had adverse effect on crop growth resulting in reduction of legume yields nearer the tree line. Yield reduction was decreased with increase in distance from teak row. The stress resulting from competition throughout the crop growth resulted in primitive closure of stomata to reduce transpiration loss. In addition it also decreased carbon dioxide diffusion into the leaves thereby affecting photosynthesis. Shading reduced photosynthesis, transpiration rate, partitioning of biomass from vegetative parts to economic parts and increased stomatal and mesophyll resistance in crop plants (Nygren and Killomaki, 1993).

Moisture stress also caused dehydration of protoplasm thereby decreasing photosynthetic rate which inturn resulted in reduced yield (Kramer, 1963). Similar results have been obtained by Sale (1976), Dhillon *et al.,* (1982). Shankaranarayan *et al.* (1987) noticed that lopping of the trees is known to reduce the effect of shade and increased the grain yield of intercrops. Similar results were obtained by Miller and Pallaray (2001), Corlett *et al.,* (1992) and Marshall (1995).

The interaction effects of agroforestry systems and distances were significant. Seed yield decreased significantly nearer to teak row in all agroforestry systems except in sole crop treatment. But they did not differ significantly within distances among different agroforestry systems. The probable reasons for differences is soil moisture content and light transmission ratio at various distances are tree crown size and root spread which in turn affected the total dry matter production, leaf area, plant height, pod weight and number of pods per plant; similar observations were made by Nadagoud (1990) and Venkata Rao (2005).

5.2.6 Performance of teak

Height of teak was significantly higher (5.00%) in teak + frenchbean as compared to teak + blackgram (2.6 %) and teak + greengram. Diameter at breast height was significantly higher in teak + soybean which was on par with teak + frenchbean. DBH was 4.22 and 4.12 per cent higher in teak + soybean and teak + frenchbean, respectively as compared to teak + blackgram. Crown spread was 4.89 and 4.06 per cent higher in teak + greengram as compared teak + soybean and teak + frenchbean, respectively.

Due to shallow root system legumes did not compete much with teak. Moreover, teak trees were grown up (10 years old) and had well established root system, were able to utilize the resources efficiently. The study by Lahiri (1989) and Jha *et al.,* (1989) also reported that growth of teak was not affected when they were intercropped with legumes. Similarly, teak growth was better with groundnut at Raichur under irrigated conditions (Nadagouda, 1990). In taungya cultivation of teak with agricultural crops/ pastoral crops, mean annual increment and diameter at breast height were not affected (White, 1991). Teak plantation inter-planted with paddy, groundnut and pulse crops for the first 2-5 years had no reduction in the growth of teak (Roder *et al.*, 1995). Groundnut due to its shallow root system did not compete much with teak (Venkata Rao, 2005).

5.3 Experiment II: Physiological investigation on legumes in teak perennial vegetables based agroforestry system

5.3.1 Morphological characters

In the present study, the growth parameters viz., the plant height, number of leaves and number of branches were maximum in sole legumes compared to agroforestry system. Among the agroforestry systems, the soybean with teak recorded significantly higher plant height at all the growth stages compared to greengram with teak + curryleaf and teak + drumstick agroforestry systems. Legumes recorded lower plant height at 2 m distance from the teak perennial vegetable alley, compared to 4 m distance from the tree base at all stages. The performance of growth parameters of soybean was better than the greengram.

More number of leaves per plant in soybean based agroforestry system might have increased the photosynthesis, which inturn, resulted in higher accumulation of dry matter (19.46 g/plant) at all growth stages. With a decrease in distance from the tree base, the number of leaves and plant height also reduced which could be because of competition for water, light and nutrients which was further indicated by reduction in relative water content.

The Changes in leaf number and leaf area were responsible for differences in yield potential in soybean. There was a linear increase in number of leaves, leaf area and leaf area index from 20 to 40 DAS and was rapid between 20 to 40 DAS and was less afterwards towards pod development. The decline towards harvest was due to senescence and defoliation of older leaves.

5.3.2 Growth and growth parameters

Growth analysis is a physiological probe in order to explain and account cause and effect relationship for yield differences (Krishnamurthy *et al.,* 1973). Dry matter accumulation recorded at different growth stages revealed that soybean recorded significantly higher total dry matter compared to greengram under different agroforestry systems. Partitioning of dry matter in to leaf, stem and pods also revealed significantly higher dry matter in pods of soybean compared to greengram. This increased total dry matter of soybean was attributed to significantly higher growth parameters caused by higher soil moisture content and light transmission ratio.

Growth analysis of legumes in agroforestry systems revealed that the leaf area index was higher in soybean compared to greengram because of more leaf area at all stages of crop. However, sole crops recorded significantly higher leaf area index compared to their respective agroforestry systems. Similarly, other growth indices viz., absolute growth rate, crop growth rate, relative growth rate and net assimilation rate were significantly higher in soybean based agroforestry systems, because of higher assimilatory surface area, which in turn, resulted in significantly higher total dry mater accumulation. Among the sole crops, soybean recorded higher AGR, CGR, RGR, and NAR at all growth stages compared to greengram. However, the sole crops recorded higher leaf area, leaf area index, AGR, CGR, RGR and NAR due to higher photosynthetic area and high light interception compared to agroforestry system.

Among the distances of legume inter crops, 4 m distance recorded higher leaf area, leaf area index, AGR, CGR, RGR, NAR and LAD mainly because of less competition for light,water,nutrients and higher light transmission ratio. Similarly, specific leaf weight was maximum in sole crop treatments compared to corresponding agroforestry systems due to higher light transmission ratio. Similar observations were made by Rao and Mitra (1988) and Singh (1997). The reduced specific leaf weight of legumes under shade was attributed to a reduction in tissue available per unit leaf area. A positive association between specific leaf weight and photosynthetic rate was reported in soybean (Ford *et al.,* 1983).

In both the crops, specific leaf weight increased with increase in duration up to 40 DAS and declined thereafter and this decrease was more in greengram compared to soybean, causing the greater differences in dry matter accumulation and yield attributes. A positive significant association was found between these growth indices and yield attributes which reveal greater importance of crop growth rate and net assimilation rate towards yield contribution.

5.3.3 Biophysical parameters

Sole crop treatments recorded significantly higher photosynthetic rate, stomatal conductance and transpiration rate compared to their respective agroforestry systems. Among the sole crops, soybean based agroforestry system recorded higher rate of photosynthesis, stomatal conductance and transpiration rate compared to green gram. This was further expressed in growth and yield parameters. Even in different agroforestry systems, soybean exhibited higher rate of photosynthesis, stomatal conductance and transpiration rate compared to greengram perennial vegetable based agroforestry systems, which was mainly because of higher chlorophyll content, nitrate redcutase activity, light interception and leaf area duration. Similar results were also reported by Allard Nelson, (1991) and Vandan and Bhatt (1999) who noticed decreased stomotal conductance due to reduced number of stomata as a result of reduced light intensity. Photosynthetic rate was reduced under shade which coincided with mesophyll conductance reflecting the poor carbonization activity in the mesophyll. It clearly indicated that the photosynthetic enzyme RuBp carboxylase might have some limitation under shade to fix carbon dioxide. Lower photosynthetic rate (19% reduction) in rice cultivars under shaded conditions has been reported (Laza *et al.,* 2003). Kubeta and Hamid (1992) also reported similar results in greengram and blackgram.

5.3.4 Biochemical parameters

Among different photosynthetic pigments, chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll have greater influence on photosynthesis and productivity of crop plants. The average chlorophyll content of legume crops of greengram and soybean in different agroforestry system ranged from 1.25 to1.4 and 2.13 to 2.26 mg g fr.wt^{-1}, respectively. It increased from 1.79 to 1.91 in greengram and from 2.03 to 2.18 in soybean at 40 DAS.

There was a reduction in chlorophyll ‘a’, chlorophyll ‘b’, and total chlorophyll contents at 40 DAS, probably due to leaf senescence in legumes. Among the two legumes studied, greater reduction in chlorophyll content was noticed in greengram compared to soybean. Further, with increase in distance from 2 m to 4 m from the teak alley, decrease in chlorophyll ‘a’, chlorophyll ‘b’, and total chlorophyll content was noticed due to shading effect and reduced light interception.

Lower light transmission ratio increased with thickness of leaf due to increased upper cuticular layer, palisade and spongy tissue there by increased chlorophyll content. Venkata Rao (2005), Padeyannavar (2002), Lalitha bai *et al.,* (1981) also reported reduced chlorophyll content with increase in distance from tree base. Increased synthesis of chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll were promoted under shade, with increased shade in order to trap the available photosynthetic active radiation effectively (Muktuchellian *et al.,* 1989). Vandana and Bhatt (2009) also noticed maximum chlorophyll under 50 per cent light intensity and decreased chlorophyll 'b' with increased light intensity.

Nitrate reductase activity enzyme catalyzes the reduction of nitrate to nitrite which is the rate limiting step in nitrogen metabolism. It was observed that nitrate reductase activity was maximum at initial stage and decreased thereafter gradually due to leaf senescence and declining root nodule activity. Similar results were also noticed by Ashwini (2005). On the contarary, nitrate reductase activity increased with increased age of the crop up to 60 DAS with the foliar spray of $MnSO_4$ and growth regulators (Jamakhandi, 2004). In the present study, soybean both under agroforestry system and sole cropping recorded significantly higher nitrate reductase activity at all the growth stages compared to greengram resulting in significantly higher grain yield. There was a positive and significant correlation between yield and nitrate reductase activity. Higher nitrate reductase activity in soybean may be due to the availability of assimilates and the substrates for its activity.

Among the distances, 2 m distance recorded lower nitrate reductase activity compared to 4 m distance at all the growth stages due to prevalence of higher shade, low light interception and greater soil moisture depletion. Similar results were obtained by Venkata Rao (2005) and Padeyannavar (2002).

5.3.5 Yield and yield components

Among the sole crops, the highest seed yield was obtained in soybean (820 kg ha^{-1}) compared to greengram (313 kg ha^{-1}). Increased yield of soybean was mainly due to more number of seeds per plant, number of pods per plant and test weight. And these yield attributes had positive correlation with all growth indices like AGR, RGR, CGR and NAR which were significantly higher due to more dry matter accumulation in sole crops compared to agroforestry systems. Different agroforestry systems involving soybean as a inter crop recorded significantly higher seed yield compared to greengram. However, seed yield was affected in teak + curryleaf with soybean.

The lowest legume yield was recorded in teak + drumstick + greengram and the extent of reduction of legumes yield was 22, 30, 40, 38 per cent in teak + curry leaf + soybean, teak + curryleaf + greengram, teak + drumstick + soybean, teak + drumstick + greengram, respectively compared to sole legumes. Reduction in yield in inter cropping systems was maximum in greengram compared to soybean. This indicates that the soybean is adopTable to shaded condition and is having shade tolerance capacity. The synergistic effect of agroforestry trees with soybean was also recorded by Cauto *et al.,* (1984). Different workers reported yield reduction of arable crops under agroforestry system to a greater extent after 4–5 years of planting (Singh and Korwar 1986; Kulkarni *et al.,* 1970).

Reduction of legume yield under agroforestry systems was attributed to low light interception which could be attributed to reduction in photosynthetic rate, transpiration rate and stomatal conductance. Radake and Hagstroan (1973) reported that soybean recorded lower transpiration rate under shelter plant compared to unsheltered plant. The biophysical parameters like stomatal conductance, transpiration rate and photosynthetic rate have greater influence in dry matter accumulation and growth indices which were significantly lower in greengram based agroforestry systems compared to soybean + teak based agroforestry systems.The yield attributes viz., seed yield per plant, numbers of pods per plant and test weight were significantly higher in soybean based agroforestry system compared to greengram + teak - perennial vegetables based agroforestry system.

Pelter *et al.,* (1988) and Jha *et al.,* (1999) reported higher soybean yield under tree species followed by sesame, horsegram and niger. Reduction in soybean yield was minimum in teak + curryleaf agroforestry system compared to teak + drumstick agroforestry system. Due to lower canopy and regular harvest of curryleaf, there was more light interception which inturn had less competition with arable crops. With increased distance from the base of teak, there was a significant increase in grain yield of legumes. A similar result of increased yield of many crops with increased distance was noticed by several workers (Padeyannavar, 2002; Venkata Rao, 2005; Mutanal, 1998 and Itnal 1990).

The extent of reduction in grain yield of legumes was 8 per cent in 2 m distance compared to 4 m distances from tree alley. This decreased yield due to closer distance was attributed to greater competition between trees and arable crops as evidenced by lower soil moisture and nutrients depletion. Low light transmission ratio affected all the biophysical and growth indices, which inturn affected dry matter accumulation.

Lower nutrient content of nutrients in the soil below trees is generally not accepTable hypothesis but, negligible addition of leaf litter to the soil (as teak leaves drop in winter season) seems the reason for low nutrient content in the soil below their crown. This is evident from the present study, where removal of nutrients at 1 and 2 m distance was more as compared to 4 m distances. Further, majority of roots of teak and perennial vegetables remain up to 60 cm layer, which is also nutrient sorption zone of legumes and thus might have created competition for nutrients. Similar results were obtained by Vanderbelt and Williams (1992), Zegye (1999), Mutanal (1998) and Chandrashekharaiah (1986) also noticed reduction in sorghum and maize yield at closer spacing. The direction of teak row has significant effect on yield of sorghum (Mutanal, 1998). Wheat grain yield reduced due to crown shading on eastern side of *Paulownia sps* rows (Iang *et al.,* 1990).

In a multistoreyed agroforestry system with coconut as a perennial component, Islam *et al*., (2008) noticed that carrot and chilli were economically profiTable than sole production system. In another study on cinnamum based agroforestry system under homestead garden, curryleaf was found to be more popular and economical (Singh *et al.,* 2008).

Future line of work

1. There is need to study eco–physiological interactions in different agroforestry systems.
2. There is a need to standardize silvicultural techniques to restrict root growth and canopy management of perennial components to enhance light interception in field crops.
3. The shade loving field crops like turmeric, zinger etc., need to be evaluated with teak in order to find out the compatibility.
4. It is necessary to workout suiTable teak alley spacing for sustainable production of both herbaceous and woody perennials for different soil types and agroclimatic situations.
5. Studies on nutrient dynamics need to be worked out for the agroforestry systems at different stages.
6. There is a need for intensive study on carbon sequestration in the agroforestry systems as a whole.
7. There is need to to quantify the tree crop interactions for different resources viz., moisture, light and nutrients.

Practical applications of the results

From the present investigation, following results of practical importance have been obtained.

1. Among the legumes, reduction in seed yield was minimum in soybean and frenchbean when grown with teak as they are shade tolerant, while greengram and blackgram are highly susceptible.
2. Yield reduction was more at 0 – 2 m distance from teak row and the effect decreased at 3 – 4 m distance. The crop interaction was more intense at tree base.
3. The demand for food, fuel and timber of the growing population can be met through agroforestry system involving teak and legumes.
4. Integration of perennial vegetables viz., curryleaf and drumstick with teak is more economical and sustainable to the small and marginal farmers as they generate income in the initial year by exploiting the excess resources than existing.

6. SUMMARY AND CONCLUSIONS

Agroforestry plays a vital role in sustainable production in rainfed agriculture. Teak is the king of timber and can be integrated with perennial vegetables and field crops to meet the ever increasing demand for wood, vegetables and the grain. Investigations were carried out to study the influence of teak and perennial vegetables on legumes raised in medium deep black soils at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2007 and 2008. The experiments were laid out in factorial randomized block design with four replications. There were 16 treatment combinations in teak + legume based agroforestry system and 12 treatment combinations in teak + perennial vegetables + legumes based agroforestry systems in the investigation.

The observations on morphological, physiological, biophysical, biochemical, growth and yield parameters on legumes at 2 and 4 m distances from tree and perennial vegetables base were recorded at 20, 40, 60 DAS and at harvest. The results obtained are summarized below:

1. The plant height of legumes was less in agroforestry system and was more in sole crop treatment. Among the agroforestry systems, the maximum plant height was recorded in teak + frenchbean followed by teak + blackgram. In perennial vegetables with legume based agroforestry system, the maximum plant height was recorded in teak + curryleaf + soybean followed by teak + curryleaf + greengram.
2. In general, maximum leaf dry weight was observed in sole legumes of soybean when compared to other agroforestry systems. Leaf dry weight was maximum at 40 DAS and it decreased thereafter. It was maximum in teak + soybean and lowest in teak + greengram. In perennial vegetables with legume based agroforestry system, the maximum leaf dry weight was observed in teak + curryleaf + soybean and minimum in teak + drumstick + greengram. The leaf dry weight was more at 4 m distance from tree based compared to 2 m distance.
3. Maximum stem dry weight was recorded in teak + soybean at 40 DAS. The teak + greengram treatment had the lowest stem dry weight at 2 and 4 m distances from tree base. In perennial vegetable based agroforestry system, the stem dry weight was maximum in teak + curryleaf + soybean and was minimum in teak + drumstick + greengram based agroforestry systems.
4. The pod dry weight in legumes increased significantly in all agroforestry systems at harvest from 2 and 4 m distance from teak perennial vegetable row.
5. The total dry weight increased significantly under sole crops and it was minimum under the teak + greengram followed by teak + blackgram. In teak perennial vegetables agroforestry system, maximum total dry weight was observed in soybean followed by greengram.
6. The leaf area of legumes increased up to 40 DAS and decreased thereafter. At 2 m distance, teak + greengram recorded lowest leaf area as compared to other agroforestry systems. In teak perennial vegetable based agroforestry system, the lowest leaf area was noticed in teak + drumstick + greengram compared to other agroforestry systems.
7. The growth analysis parameters *viz.*, LAI, LAD, AGR, CGR, NAR and SLW of legumes in both teak + legumes and teak + perennial vegetables differed significantly due to influence of teak and perennial vegetables on legumes. The parameters like AGR, CGR, RGR, LAD and NAR increased significantly under teak + soybean and teak + curryleaf + soybean based agroforestry systems.
8. Grain yield of legumes was maximum in teak + frenchbean (1042.9 kg ha^{-1}) followed by teak + soybean (875.8 kg ha^{-1}). In teak perennial vegetable based agroforestry system, teak + curryleaf + soybean (766.3 kg ha^{-1}) followed by teak + curryleaf + greengram (307.1 kg ha^{-1}) had higher grain yield as compared to other agroforestry systems. Growing of legumes in association with teak + greengram and teak + perennial vegetables with greengram resulted in decreased yield due to lower growth and yield components.

9. Among the agroforestry systems, the yield of legumes was affected more than that of sole crops. The yield reduction was to the extent of 10 per cent in teak + soybean, 9.93 per cent in teak + frenchbean, 17.82 per cent in teak + blackgram and 28.54 per cent in teak + greengram compared to sole legumes. Under teak perennial vegetables agroforestry system, the legume yield was affected more than that of sole crops. The yield reduction was to the extent of 6.5 per cent in teak + curryleaf + soybean, 2.0 per cent in teak + curryleaf + greengram, 22.68 per cent in teak + drumstick + soybean and 18.94 per cent in teak + drumstick + greengram, compared to sole legume crops.

10. In general, the influence of teak and perennial vegetables on the performance of legumes was severe nearer to tree base compared to further from the tree. Yield reduction in teak + legumes was 18.06 per cent and teak + perennial vegetable with legumes was 8.20 per cent at 2 m distance compared to 4 m distance from tree base.

11. Biophysical parameters viz., photosynthetic rate, transpiration rate and relative water content decreased from 20 to 40 DAS. Whereas, the stomatal conductance increased from 20 to 40 DAS in both teak + legume and teak + perennial vegetables with legume based agroforestry system. Among the distances, the photosynthetic rate, transpiration rate and stomatal conductance were lower at 2 m distance compared to 4 m distance. Relative water content was more in agroforestry system as compared to sole crops. However, relative water content was more at 2 m distance compared to 4 m distance from tree base.

12. The biochemical parameters like chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll and SPAD values were found to be maximum in 2 m distance away from the tree base compared to 4 m distance in teak with legume and teak + perennial vegetables with legume based agroforestry systems.

13. Nitrate reductase activity was found to be higher at 4 m distance from tree base compared to 2 m distance in teak + legumes and teak + perennial vegetable with legume based agroforestry system. The nitrate reductase activity increased from 20 to 40 DAS in both agroforestry systems.

14. Light transmission ratio (LTR) was lower in teak + legume and teak - perennial vegetable with legume based agroforestry system. Light transmission ratio was lower in near teak + perennial vegetable row and increased with increase in distance from tree base.

15. Number of pods per plant, seed weight per plant and 100 - seed weight were lower in agroforestry systems of teak with legume and teak + perennial vegetables with legume based agroforestry systems compared to sole legumes. These parameters were lower near teak with perennial vegetable row at 2 m distance compared to 4 m distance from tree base.

16. Height, diameter at breast height and crown area of teak was more in teak + soybean and teak with curryleaf and soybean based agroforestry system.

17. Number of drumstick fruits and curryleaf yield were more in teak with drumstick + soybean and teak with curryleaf + soybean based agroforestry system.

In the present study, efforts were made to evaluate the performance of legumes and perennial vegetables in a teak based agroforestry systems. Identification of legumes and perennial vegetables attain importance, in view of the demand for enhanced legumes and miniral rich vegetables.

From the results, it can be concluded that soybean and frenchbean perform better in a teak based agroforestry system sustaining both above and below ground competitions. Integration of curryleaf along with teak in the initial 6-8 years is still more profitable as it assuares additional income along with legumes.

This technology has dual role in supporting the socioeconomic status of the farmers on one hand and mitigating adverse climatic effects of deforestratoin to a greater extent by increasing green cover index on the other hand. It also generates additional income and improves productivity per unit area per volume as a result of efficient utilization of natural resources.

REFERENCES

Aclan, P. and Quisumbing, E. C., 1976, Fertilizer requirement, mulch and light attenuation on the yield and quality of ginger. *Philippines Agri.*, 60 (5/6): 183-191.

Aher S. R., Mate S. N. and Tigadi L. N., 2006, Leaf growth in relation to crop yield of black gram. *New Bot. Int. J. Plant Scie. Res.,* 33 : 1- 4.

Ahmed, P., 1989, Eucalyptus in agroforestry : its effects on agricultural production and economics, *Agrofor. System.* 8 : 31-38.

Akbar, G., Ahmed M., Raeique, S. and Babar, K. N., 1990, Effect of trees on the yield of wheat crop. *Agrofor. System*, 11 : 1-10.

Akhter, N. Rahman, M.M., Mirza Hasanuzzaman.and Kamrun Nahar., 2009, Physiolgical response of garden pea (*Pisum sativum* L.) growth under different light environment. *Bot. Res. Int.* 2 (4): 304-309.

Alberda, T. H. and Bower, J. M. W., 1983, Distribution of dry matter and nitrogen between different plant parts in intact and depoded soybean plants after flowering. *The Netharlands J. Agri Sci.*, 31: 171 – 179.

Allard, G., Nelson C. J. and Pallardy, S. G., 1991, Shade effects on growth of all fescue: 1. Leaf anatomy and dry matter partitioning. *Crop Sci.*, 31: 63 – 167.

Anonymous, 1947, The effect of different Kumari crops on *Teak. For. Res. India*, Burma, Pt. II, 1946-47, p. 53.

Anonymous, 1949, Effect of different Kumari crops on teak raised with them. *For. Res. India*, Pt II, 1948-49, p. 37.

Anonymous, 1955, Teak plantations with Kumari crops. *For. Res. India*, Pt II, 1954-55, p. 74.

Anonymous, 1976, *Ann. Rep.*, International Centre for Research on Agroforestry, Nairobi, Kenya, pp. 22-25.

Anonymous, 1984, *Ann. Rep.*, All India Co-ordinated Research Project on Dryland Agriculture, Bellary Centre.

Anonymous, 1984, *Ann. Rep.*, All India Co-ordinated Research Project on Dryland Agriculture, Kovilapatti Centre, p. 24.

Anonymous, 1986, *Ann. Rep.*, Central Research Institute for Dryland Agriculture, Hyderabad, pp. 44-55.

Anonymous, 1986, *Ann. Rep.*, Central Research Institute for Dryland Agriculture,. Anantapur, p. 19.

Anonymous, 1987, *Ann. Rep.*, All India Co-ordinated Research Project on Dryland Agriculture, Bangalore Centre.

Anonymous, 1988, *Ann. Rep.*, Central Research Institute for Dryland Agriculture, Hyderabad, pp. 29-30.

Anonymous, 1990, *Ann. Rep.*, Central Research Institute for Dryland Agriculture, Hyderabad, pp, 36-38.

Anonymous, 1992, *Ann. Rep.*, Central Research Institute for Dryland Agriculture, Hyderabad, pp. 34-35.

Anonymous, 1993. *Ann. Rep.*, International Centre for Research on Agroforestry, Nairobi, Kenya, pp. 72-76.

Anonymous, 1995, *Ann. Rep.*, Central Research Institute for Dryland Agriculture, Hyderabad, pp, 82-85.

Anonymous, 1996, *Ann. Rep.*, National Research Centre for Agroforestry, Jhansi, pp. 17-24.

Anonymous, 2000, *Ann. Rep.*, National Research Centre for Agroforestsry, Jhansi, pp.55.

Anonymous, 2001, *Ann. Rep.*, Central Research Institute for Dry land Agriculture, Hyderabad, pp. 29-33.

Anonymous, 2006, World Agroforestry Centre, Kenya, Nairobi. pp.13

Anonymous.,1999, Survey of Indian Agricultural, *The Hindu*, pp. 61-65

Arifin, M., 1983, Enlargement of teak planting space in intercropping system. *Duta Rimba*, 9 : 57-59.

Arnon, D.I., 1949, Copper enzyme in isolated chloroplasts polyphenol oxidase in *Beta vulgaris. Pl. Physio*, 24: 1-15.

Ashwini. G.M., 2005, Effect of organics, nutrients and plant growth regulators on physiology and yield in Frenchbean (*Phaseoulus vulagaris* L.) *M. Sc. (Agri.) Thesis,* Univ. Agri. Sci., Dharwad.

Asthan, A. N. 1998, Pulse crop research in India. *Ind. J. Agric. Sci*, 68 (8) : 448– 452.

Azam-Ali, S.N. 1983, Seasonal estimates of transpiration from a millet crop using a (*Manihot esculenta Crantz*). 2. Fibrous root length. *Field Crops Res.,* 9, 361-371.

Azam-Ali, S.N., 1995, Assessing the efficiency of radiation use by intercrops. In; Sinoquet, H. and Cruz, P. (eds). *The Ecophysio. Trop. Intercropping.,* INRA Editions, Paris, pp. 305-318.

Balasubramanian, V., 1983, Alley cropping: cannot be alternative to chemical fertilizers in Ghana?. An invited paper presented at the 3rd *National Maize Workshop* held at Kwadeso Agricultural College, Kumasi, Ghana, February, pp. 1-3.

Bangall, D. J.and King, R. W., 1987, Temperature and irradiance effects on yield in cow pea. *Field Crops Res.,* 16 : 217-229.

Barrs, H. D. and Weatherly, P. E., 1962, A re-examination pf relative turgidly for estimating water deficit in leaves. *Aus. J. Biol. Sci.*, 15: 413-428.

Batchelor, C. H and Roberts, J. M., 1983, Evaporation from the irrigation water, foliage and panicles of paddy rice in north-east Srilanka. *Agri. Meteo.,* 29 : 11-26.

Bates, L. S., Waldern, R. D. and Teare, J. D., 1973, Rapid determination of free proline in water stresses studies. *Plant and Soil*, 38: 205-208.

Bell, C. J. and Squire, G. R., 1981, Comparative measurements with two water vapour diffusion porometers (dynamic and steady state). *J. Exp Bot.* 32 : 1143-1156.

Bell, J. F. and Courley, R., 1980, Assessing the accuracy of a sectional pole. Haga altimeter and altilevel for determining total height of young coniferous stands. *South J. App .For.*, 4 : 136-138.

Belskyo, A. J., Mwonga, S. M. and Duxbury, J .M., 1993, Effects of widely spaced trees and livestock grazing on understorey environments in tropical savannas. *Agrofor. Systems* 24, 1-20.

Bhat, R., 1988, Influence of some tree species on sunflower + pigeonpea cropping system. *M.Sc. (Agri) Thesis*, Uni. Agri. Sci., Dharwad.

Bheemaiah, G., Subrahmanyam, M. V. R. and Ismail, S., 1992, Performance of arable crops with *Acacia albid*a under different alley width in dry lands. In : *Pro. the First Nat. Sym. On Allelopathy in Agrosystems* (Agricultural and Forestry), February 12-14 (1992), pp. 120-122.

Bheemaiah, G., Subrahmanyam, M.V.R. and Ismail, S., 1995, Intercropping in *Faidherbia albida* with arable crops under different tree spacings in Alfisols. *Ind. J. Dryland Agri. Res. and Deve.*, 10 (1) : 9-39.

Bhuva, H. P., Katrodia, J. S., Patel, G. L. and Chundawaat, B. S., 1989, Second International Symposium on mango, Bangalore, India, 20-24 May, 1984, *Acta Horti.,* 231 : 316-320.

Bisaria, A. K., Ramnewaj and Ajit, 1995, Integrated response of intercrops to ecophysiological parameter and population density of trees in relation to productivity in agroforestry system. *Ann. Rep.*, 1994-95, National Research Centre for Agroforestry, Jhansi.

Biscoe, P. V., Scott, R. K. and Monteith, J. L., 1975, Barley and its environment. III. Carbon budget of the stand. *J. App. Eco.,* 12, 269-291.

Black, C. R., Tang, D. Y., Ong, C. K, Solon, A. and Simmonds, L. P., 1985, Effects of soil moisture stress on the water relations and water use of groundnut stands. *New Phyto.,* 100 : 312-328.

Blackman, V. H., 1919, *Soil Plant Relationships*, 2nd ed., John Wiley and Sons, Inc., New York, pp, 230-234.

Boardman, N. K., 1977, Comparative photosynthesis of sun and shade plants. *Ann. Rev. Plant Physiol.,* 28; 355 – 377.

Burley, J., 1983, Global needs and problems of collection, storage and distribution of multipurpose tree germplasm – A background document, In : I Burley and P. Van Carlowity (Eds.) Multipurpose Tree Germination, ICRAF, Nairobi, Kenya, p. 298.

Cauto, L., Barros, N. P. and Rezende, G. C., 1984, Interplanting soybean with eucalyptus in a 2-tier agroforestsry venture in south-eastern Brazil. *For. Abst.*, 45 : 218.

Chandrababu R. and Nagarajan, M., 2008, Growth and development of soybean (*Glycine max* (L)) Cultivars under shade in coconut garden. *Madras Agri. J.,* 171 : 279-283.

Chandrashekaraiah, A. M., 1986, Investigation on agroforestry in the transitional tract of Dharwad. *Ph.D. Thesis*, Uni. Agri. Sci., Bangalore.

Chantraprapa, S., 1991, Agroforestry of Lkalg Dong forest station, International Workshop on conservation and sustainable development, 22-26 April, Bangkok, Thailand.

Chantraprapa, S., 1991. Agroforestry of Lkalg Dong forest station, International Workshop on conservation and sustainable development, 22-26 April, Bangkok, Thailand.

Charreau, C., 1974, Soils of tropical drylands wet climate areas fo west Africa and their use and management. A series of lectures at the department of Agronomy, Cornell University, Agronomy Department. Mimeo, 74-76 Ithaca, New York.

Chauhan, V. K., Sood, S. K., Bhargava, J. N. and Mishra, V. K., 1995, Effect of different trees on the yield of rainfed wheat crop. *Ann. of For.*, 3 (2): 147-151.

Cooper, P. J. M., Gregory, P .J., Tully, D. and Harris, H. C., 1987, Improving water use of efficiency of annual crops in rainfed farming systems of West Asia and North Africa, *Experimental Agri.,* 23 : 113-158.

Corlett, J. E., Black, C. R., Ong, C. K. and Monteith, J. L., 1992, Above and below ground interactions in a *leucaen*a /mill*et* alle*y* cropping system II. Light interception and dry matter production. *Agri. For. Meteoro.*, 60 : 73-91.

Corre, W. J., 1983, Growth and morphogenesis of sun and shade plants. *Acta Bot. Neerl.*, 32: 49 – 62.

Coster, I. C. and Hardjowasono, M. S., 1935, The influence of agricultural crops in taungya plantations of the growth of teak. *Tectona*, 28: 464-473.

Dagar, J. C., Gurbachan Singh, N. T. and Singh, G., 1995, Evaluation of crops in agroforestry with teak (*Tectona grandis*) Maharukh (*Alianthus excelca*) and Tamarind (*Tamarindus indica*) on reclaimed salt affected soils. *J. Trop. For. Sci.*, 7 (4) : 623-634.

Dancette, C. and Paulain, J. F., 1969, Influence of *Acacia albida* on pedo-climatic factors and crop yields. *Soils Africians*, 14: 143-181.

Decosta, W. A. J. M. and Chandrapala, A.G., 2000, Effect of different tree species on growth and yield of mungbean (*Vigna radiata* (L.) Wilczek) growth in hedge row intercropping systems in Sri Lanka. *J. Agron. Crop Sci.*, 174 : 43-48.

Dhillon, G. S., Dhanda, R. S. and Dhillon, M. S., 1998, Performance of wheat under scattered trees of kikar (*Acacia nilotica*) under rainfed condition in Punjab (India*). Ind. For.,* 48:53-56.

Dhillon, G. S., Surjit Singh, Dillon, M. S. and Atwal, A. S., 1982, Developing agri-silviculture practices: Studies on the shading effect of eucalyptus on the yield of adjoining crops. *Ind.J. Eco.*, 9: 228-236.

Dhillon, M. S., Surjit Singh, Atwal, A. S. and Dhillon, G. S., 1984, Developing agri-silviculture practices : effect of *Dalbergia sissoo* and *Acacia nilotica* on the yield of adjoining crops. *Indian J. Ecol.*, 11: 249-253.

Dodwad. I. S., 1997, Genetic variation for morpho physiological traits influencing seed yield in greengram (*Vigna radiata* L) *M.Sc (Agri) Thesis,* Univ. Agri.Sci., Dharwad.

Field C., Merino, J. and Mooney, H. A., 1983, Compromises between water-use efficiency and nitrogen–use efficiency in five species of California evergreens*. Oecologia,* 60: 384-389.

Fukai, S. and Trenbath, B. R., 1993, Processes determining intercrop productivity and yields of component crops. *Field Crops Res.,* 34: 247-271.

Gajaneni, J. and Jordan, D. F., 1989, Diversified agroforestry system. *Symp. Agrofor. System and Technol..* Bogor Indonesia, 19-21 September.

Gallo, K. P. and Daughty, C. S. T., 1986, Technique for measuring intercepted and absorbed photosynthetically active radiation in corn canopies. *Agron. J.*, 78: 752-756.

Geeta V., Pushpakumari R. and Krishnaprasad B. T., 2008, Response of sword bean (*Canavallia sp.*) to different intensities of light stress. *Acta Hort.,* 752: 153-157.

Gerardo Budowski and Ricardo Russo, 1997, Nitrogen fixing trees and nitrogen fixation in sustainable agriculture: Research challenges. *Soil Bio. Biochem.,* 29 (5&6) : 767-771.

Gichuru, M. P. and Kang, B. T., 1989, *Callindra calothyrus* Gneiss in an alley cropping system with sequentially cropped maize and cowpea in south western Nigeria. *Agrofor. Systems*, 9 : 191-203.

Gilbert, G., 1929, La sylviculture aux index, Netherlandaises. *Bulletin Agriculture*, *Congo Belge*, 20 (4) : 479-500.

Gill, A. S., Deb Roy, R. and Chaudhary, P. L., 1988, Effect of multipurpose tree species on pulse production under semi-arid conditions. *Ind. J. Agron*., 43 (3): 560-565.

Gill, D. S., Verma, M. M and Brar, G. S., 1992, Physiological parameters determining yield in mungbean. C*rop Improv.,* 19 (1): 29 – 33.

Gomez, A. K. and Gomez, A. A., 1984. *Stat. Proc. Agri. Res*., 2nd Edition; A Wiley-Inter Science Publication, New York, pp. 187-241.

Gopal Singh, B. and Narain Singh, J., 1982, Effect of seasonal changes on growth parameters of greengram (*Vigna radiata*). *Ind. J. Plant Physiol*., 25: 328 – 389.

Grantz, D. A., 1990 Plant response to atmospheric humidity. *Plant, Cell and Env.,*13: 667-679.

Gregory, F. G., 1926, The effect of climate conditions on the growth of barley. *Ann. Bot*., 40: 1-26.

Harsha, L. N. and Tewari, J. C., 1988, Tree crop interaction in agroforestry systems, in: *Workshop Proc.Agrofor. Rural Needs*, 6: 535-541.

Hazra, C. R. and Patil, B. D., 1986. Forage production under Silvi pastoral system, light and temperature relation. *Ind. J. Range Mangt.*, 7 (1):33-36.

Hesse, P. R., 1984, In "*Organic Matter and Rice*". International Rice Research Institute, Los Banos, Laguna, Phillippines, pp. 35-42.

Hoflacher, H. and Bauer, H., 1982, Light acclimation in leaves of the juvenile and adult phase of ivy (*Header helix*). *Physiol. Plant.,* 56: 177 – 182.

Huang Shoubo, 1976, Study on the relationship between climate factors and tea growth. *Tea Res.*, 4: 8-9.

Huang Shoubo, Pan Genshen and Gao Renjun.,1983, Microclimate characteristics of tea garden. *Agrometeo.,* 4 (4): 35 – 39.

Huxley, P. A., Oinney, A., Akunda, E and Murarji, 1994, A tree-crop interface orientation experiment with *Grevellia robusta* hedge row. *Agrofor. System,* 26: 23-45.

Iang, J. P., Jhu, J. and Liu, T. Z., 1955, Related changes of wheat yield and photosynthetically radiation in *paulownia*-wheat intercropping. *Field Crop Abst.*, 48 (4): 23.

Islam, K. K., Pervin, M. J., Rashid, M. A., Mondol, M. A. and Rahim, M. A., 2008, Per formance of winter vegetable sgrown under coconut-lemon based multistrata agroforestry system. *Trop. Subtrop. Agroecosystem*, 8: 165-170.

Islam, M. T., 1994, Eco-physiological studies on photosynthesis and dry matter production in mungbean. Ph.D. Diss. Kyushu Univ. Japan.

Islam, M. T., Kubota F. and Agata, W., 1993, Photosynthetic response of mungbean (*Vigna radiata,* L) leaves to different shading conditions. *Bull. Ins. Trop. Agric. Kyushu.Univ*., 16 : 81-89.

Itnal, C. J., 1987, Investigation on agroforestry in northern dry zone of Karnataka. *Ph.D. Thesis*, Univ. Agri.Sci., Dharwad.

Jackson, M. L., 1973, *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi, pp. 183-192.

Jaswal, S. C., Mishra, V. K. and Verma, K. C., 1993, Intercropping ginger and turmeric with *Populus deltoids* G-E Marsh, *Agrofor. Systems*, 22 (2) : 111-117.

Jayachandran, B. K., Meerabi, M., Abdul Salam, M., Mammen, M.K. and Mathew Kunjamma, P., 1991. Performance of ginger under shade and open conditions. *Ind. Cocoa Arecanut Species J*., 15 (2): 40-41.

Jenson, M., 1954, Shelter effect, investigation into the Aerodynamics of shelter and its effects on climate and crops. *The Danish Tech. press, Copenhagen*, pp.185.

Jha, L. K, Jha, G. and Srivastava, K. K., 1989, Selection and evaluation of suiTable tree species and food crops under agroforestry systems in: *Proc. 3rd Conf. Mendelian Soc. India* held at Birsa, Ranchi, 4-7 April.pp 362-365

Jha, L. K, Jha, G., Srivastava, K. K., Trivedi, R. N., Sharma, P. K. S. and Singh, M. P., 1991, Environmental assessment and management, social forestry in tribal regions.In: *Procee. 3rd Conference, Mendelian Soc. India* held at Birsa, Ranchi, 4-7 April, pp. 389-394.

Kalubarme, M.H .and Pandey, R. K., 1979, Note on the growth analysis of greengram genotypes. *Ind. J. Agri. Sci*, 49: 975 – 977.

Kang, B. T., Reynold, L. and Atta-Krah, A. N., 1990, Alley farming, *Adv. Agron.*, 43: 315-355.

Kang, B. T., Wilson, G. F. and Spikens, L., 1981, Alley cropping OF maize and leucaenain Southoern Nigeria, *Plant and Soil*, 63 : 165-179.

Kang, B.T., Wilson, G.F. and Lawson, T.L., 1984, Alley cropping: A sTable alternative to shifting cultivation. *Int. Institute Trop. Agri.*, Ibadan, Nigeria.

Kapp, G., 1988, The forest-village of the Thai state. *Plant Res. and Development*, 27: 8-11.

Kaushal, R. and Verma, K. S., 2003, Tree-Crop interaction studies in natural agroforestry system: A case study from western Himalayas in India. Published in: *Proc. of XII world For. Congress*, Quebec city pp: 234-236.

Kermani, W.A., 1980, Developing multiple use silvicultural practices for forestry of arid regions. Proc. *IUFRO MAB Conf*. Research on multiple use of forest resources. Flag Staff, Arizona, pp. 39-45.

Kessler, J. J., 1992, The influence of karate (*Vitellaria paradox*) and nere (*Parkia biglobosa*) trees on sorghum production in Burkina Faso. *Agrofor. Systems,* 17: 97-134.

Khaja Mohinuddin, A. Jamkhandi, 2004, Effect of nutrients on powdery mildew disease resistance and yield in Blackgram (*Vigna munga* L.)*. M. Sc. (Agri.) Thesis,* Uni. Agri.Sci., Dharwad.

Khan, G. S. and Ehrenreich, J. H., 1994, Effect of increasing difference from *Acacia niotica* trees on wheat yield. *Agrofor. Systems*, 25 : 23-29.

Khan, G. S., 1975, A study of the shading effects of shisham trees on wheat crop. *Pak. J. Agri. Sci.,* 12: 281-284.

Khattack, G. M., Sheikh, M. I. and Khaljique, A., 1980, Growing trees with agricultural crops. *Pak. J. For.,* 31: 95-97.

Khosla, P. K. and Khurana, D. K., 1987, Agroforestry for Rural Needs (Vol.I). *Ind. Soc. Tree Sci*., Solan, pp. 7-8.

Khydri, M. I, Gupta, R. K. and Sewaram, 1988, Effect of *Grewia optiva, Morus alba* and Eucalyptus hybrid on the yield of crops under rainfed conditions (in) *Ann.Report 1987-88*, Central Soil and Water Conservation Research and Training Institute, Dehra Dun, pp. 12-14.

Korwar, G. R., 1992, Studies on alley cropping and agrisilviculture system in black soils under dry land agricultural conditions. *Ph.D. Thesis*, Univ. Agri. Sci., Dharwad.

Koti, R. V., 1997, influence of seasons on phenology, reproductive efficiency and physiological indices in soybean genotypes. *Ph.D Thesis,* Univ. Agri. Sci., Dharwad.

Kramer, P .J., 1963, Water stress and plant growth. *Agron. J.,* 55 : 31-55.

Kramer, P. J., 1959, The role of water in physiology of plants. *Adv. Agron*., 11: 51-70.

Krishnamurthy, K., Bommegouda. A., Venugopal N., Jagannath M. K., Raghunath, C. and Rajeshekar, B. G., 1973, Investigations of the varietal difference in the growth components of sorghum. *Mysore J. Agri. Sci*., 8:52-59.

Kubota, F. and Hamid, A., 1992, Comparative analysis of dry matter production and photosynthesis between mungbean (*Vigna radiata (*L.) Herpper) in different light intensities. *J. Fac. Agr. Kyushu Univ*., 37 (1-2): 71-80.

Kulkarni, R. V., Perur, N. G. and Shastsry, K. S., 1970, “BANNI TREE” (*Prosopis spicegera*). *Proc. of seminar on Soil Conser*., held at Rural Development Training Centre, Dharwad.

Kumar Rita, N., Chakraborty Sudeshna, Kumar, J. I. and Nirmal, 2008, Biochemical constituents under different light intensities in *Andrographis paniculata*. *Ind. J. Plant Physiol*., 13 : 2 : 13-15.

Kumar, A. and Nandal, D. P. S., 2004, Performance of winter crops under Eucalyptus tereticornis based agrisilviculture system. *Ind. J. Agrofor*., 6 (2) : 97-98.

Kuo, C. G., Wang, L. J., Cheng, A. C. and Chou, M. H., 1977, physiological basis for mung bean yield improvement. *In : Procee. the First Intenat. Symp. Mungbean, Uni. Phillippines*, Los Banos, 16-19, August, 1977, pp; 205-213.

Kurien, S, Cheeeran, A. and Babu, N. M., 1984, Major pepper varieties on *Erythrina indica*, Live-standard competition under different spacing. *Ind. Cocoa-Areacanut and Spices J.,* 18 (3) : 75-78.

Lahiri, A. K., 1989, Taungya based agroforestry trials in West Bengal. *Ind. For.,* 115 (3) : 127-132.

Lal, R., 1989, Agroforestry systems and soil surface management of a trial alfisol : 1 : Soil moisture and crop yields. *Agrofor. Systems*, 8: 7-29.

Lalitha Bai, E. K., 1981, Shade response of common rainfed intercrops of coconut. *M. Sc. (Agri.) Thesis*, Kerala Agri. Uni. Thrissur, Kerala, India.

Laxmi Praba., Vanangamudi, M. and Thandapani V., 2004, Effect of low light on yield and physiological attributes of rice. *IRRN,* 29 (2) : 71-73.

Lewandowska, M. and Jarvis, P. G., 1977, Changes in Chlorophyll and Carotenoid content, Specific leaf area and dry weight fraction in Sitka spruce, in response to shading and season. *New Phyto.*, 79 : 247-256.

Liu, Naizhung., 1998, A preliminary study on the shading model of field windbreak, Collected papers of forest meteorology. International Development Research Center, Ottawa, Canada. reference@idrc.ca

Lundgren, B., 1985, Global deforestation, its causes and suggested remedies. *Agrofor. Systems*, 3 (2) : 91-95.

Maheta, K. B., Kukadia, M.U., Vashi, B.G. and Jadeja, D. B., 1996, Effects of forest tree species on the yield potentials of intercrops. *Ind. For.*, 122 : 651-653.

Malik, R. S. and Sharma, S. K., 1990, Moisture extraction and crop yield as a function of distance from a row of *Eucalyptus tereticornis*. *Agrofor. Systems*, 12 : 187-195.

Mann, H. S. and Saxena, S. K., 1980, Khejri (*Prosopis cineraria*). In: The Indian Desert, its role in agroforestry, CAZRI, Monograph, 11: Jodhpur, India.

Marshall, B. and Willey, R.W., 1983, Radiation interception and growth in an intercrop, of pearl millet / groundnut. *Field Crops Res.,* 7:141-160.

Marshall, F. M., 1995, Resource partitioning and productivity of perennial pigeonpea /groundnut agroforestry system in India, *Ph. D. Thesis,* Uni. Nottingham, UK.

Mathur, M. N., Sharma, S. K. and Ansari, M. N., 1984, Economics of eucalyptus under agroforestry. *Ind. For.*, 110: 191-201.

Mehta, K. K. and Mandal., R. C., 1988, Operational research on reclamation of alkali soil tree planting ICAR No.12 Central Soil Salinity Research Institute, Karnal pp. 44-52.

Melkhania, N. P., 1983, Influence of certain selected tree species on ground flora. *Ph. D. Thesis*, Kumawan Uni. Nainital, p. 442.

Miller, A. W. and Pallardy, S.G., 2001, Resource competition across the tree-crop interface in a maize silver maple temperate alley cropping stand in Missouri. *Agrofor. system*, 53: 247-259.

Mishra, A., Swamy, S. L. and Sunilpuri, 2004, Growth and productivity of soybean under five promising clones of populus deltoids in agrisilviculture system. *Ind. J. Agrofor.*, 6 (2) : 9-13.

Mishra, L. C., 1979, Nitrogen cycling in greenlands at Kanpur. *Plant and Soil*, 53 : 361-371.

Mitra, S. and Ghildiyal, M. C., 1988, Photosynthesis and assimilate partitioning in mungbean in response to source sink alteration. *J. Agron. Crop Sci.,*160 : 303-308.

Monteith, J. L., Ong, C. K. and Corlett, J. E., 1991, Microclimate interactions in agroforestry systems. *For. Eco. Mangt.*, 45: 31-44.

Monteith, J. L., Szeicz, G. and Waggoner, P. E., 1965, The measurement and control of stomatal resistance in the field. *J. App. Eco.,* 2, 345-355.

Monteith, J. L.1981a, Does light limit crop production. In: Johnson, C. B. (eds). *Physiological Processes Limiting Plant Productivity*. Butterworths, London, pp 23-39.

Morita, O., Goto, M. and Ehara, H.,1994, Growth and dry matter production of pasture plant grown under reduced light conditions of summer season. *Bull. Fac. Bio-resources, Mie – Univ*., 12:11-20.

Muhammad, Afzal and Muhammad, H., 1997, Effect of forest vs. fruit trees on wheat crop. *Pak. J. For*., 47: 47-52.

Musvoto, C. and Campbell, B. M., 1995, Mango tree as components of agroforestry systems in Mangwende, *Agrofor. Systems*, 32 (3):247-260.

Mutanal, S. M., 1998, Studies on teak (*Tectona grandis* Linn.F.) based agroforestry system and fertigation. *Ph.D. Thesis*, Uni. Agri. Sci., Dharwad.

Muthuchelian, K. Kailash Paliwala. and Gnanam, A., 1989, Influence of shading on net photosynthesis and transpiration rates, stomatal diffusive resistance, nitrate reductase and biomass productivity of woody legume tree species. *Proc. Plant Sci.,* 99 (6): 539 – 546.

Nadagoud, V. B., 1990, Performance of tree species and their influence on seasonal crops in agroforestry systems under irrigation. *Ph. D. Thesis*, Univ. Agri. Sci., Dharwad.

Nadagoudar, B. S., 1986, Agroforestry Research Mamal. Oxford Forestry Institute, Oxford University, Oxford, p.28.

Nadagoudar, B. S., Hanumasheetty, S. I. and Devaranavadagi, S. B., 1988, *Eucalyptus*, *Acacia* and *Casuarina* in agroforestry system. Paper presented in *Int. For. Conf. for the Aust. Bicentenary*, 1988 held at Albury, Australia.

Nag, B. L, Rahman, M. A., Talukaderm, M. R., Hossainm, H. and Alam, M. S., 2005, Growth analysis and dry matter parttioning of Mungabean (*Vigna radiata*) under variable seed rates. *Leg. Res*., 28 (3):157-165.

Nair, P. K. V., 1984, Soil productivity of agroforestry, science and practice of agroforestry series No.1. ICRAF, Nairobi.

Nair, P. K. V., 1993, *An Introduction to Agroforestry*, Kluwer Academic Publishers, Dordrecht, Netherlands.

Nair, P. N., 1980, Vanalakshmi, an agroforestry project in Kerala. *Ind. For*., 106 (12): 829-836.

Nazir, M. S., Ahmed, R. and Cheema, S. A., 1995, Quantitative analysis effects of shasham tree shade in wheat. *Pak. J. Agri. Res*., 14 (1): 12-17.

Nijhawan, C. C., 1986, Assimilation rate and growth analysis of yielding ability in 25 cultivars of mungbean (*Vigna radiata*). *Leg. Res*., 9 (1) : 29-53.

Nijhawan, D. C. and Chandra, S., 1980, The physiology of plant growth with parameter reference to the concept of photosynthetic efficiency in mungbean (*Vigna radiata*). *Ind. J. Plant Physiol*., 23:40-46.

Nisha Chopra, Neelam, K. C. and Harh, L. N., 1993, Root trenching of *Acacia tortalis* can increase the yield of intercrops. *Ind. Farming*, 43 (7) : 25-27.

Ong, C. K, Corlett, J. E, Singh, R. P. and Black, C. R., 1991, Above and below ground interactions in agroforestry systems. *For. Eco. and Mangt.,* 45: 45-47.

Ong, C. K., 1996, A frame work for quantifying the various effects of tree-crop interactions. In: Ong, C.K and Huxley, P (Eds), *Tree crop interactions: A Physiological Approach.* pp.1-23,CAB International,Wallingford,UK

Ong, C. K., Odongo, J. C. W., Marshall, F. and Black, C. R., 1992, Water use of agroforestry systems in semi arid India. In: Calder, I.R, Hall, R.L. and Adlard, P.G. (eds). *Growth and water use of forest plantations*. Wiley, Chichester, pp. 347-358.

Ong. C. K., 1994, Alley farming: pies in the sky?. *Agrofor. Today,* 6 (3) : 8 – 11.

Padeyannavar, K. R., 2002, Physiological investigation on soybean (*Glycine max* (L.) Merrill) in agroforestry system. *M.Sc. (Agri) Thesis*, Uni. Agri.Sci., Dharwad.

Paris, P., Cannata, F. and Olimpieri, G., 1995, Influence of alfalfa (*Medicago sativa* L) Intercropping and polyethylene mulching on early growth of walnut (*Juglans spp*). *Agrofor. systems,* 31: 169 – 180.

Parvez, Ahmed, 1989, Eucalyptus in agroforestry its effects on agricultural production and economics. *Agrofor. Systems*, 8 : 31-38.

Patra, B. and Sahu. G., 1986, Effect of low light at different stages of the crop on sink size. *Oryza,* 23:123-125.

Patru, G. J. and Sahu, B. C., 1997, Evaluation of quantitative characteristics in some mutant lines of greengram (*Phaseoulus radiata*). *Ind. J. Agri. Sci.,* 67 (11): 533-535.

Peltier, R. and Eyog, M. O., 1988, Agroforestry traits in northern Camaroon. Bios-et-Forest-des-Tropiques, 1988, Publ. 1990, 217 : 3-31.

Piper, C.S., 1966, *Soil and Plant Analysis*, Academic Press, New York, pp. 47-77.

Poschen, P., 1986, An evaluation of the *Acacia albida* based agroforestry practices in the Hararghe high lands of eastern Ethopia. *Agrofor. Syst.*, 4 : 129-143.

Potdar, M. V., Pawar, K. R. and Sreenivas, L., 1977, Simple correlation and regression studies between grain yield and yield attributing character in sunflower. *Ind. J. Agron.*, 28: 115-116.

Powar, J. F., Willis, W. O., Grunen, D. L. and Reichmen, G. A., 1967, Effect of soil temperature, phosphorus and plant age on growth analysis of barley. *Agron. J.*, 59:231-234.

Prajapati, M. C., Verma, B., Mittal, S. P., Nambiar, K. T. N. and Tippannavar, B. S., 1971, Effect of lateral development of *Prosopis juliflora* DC roots on agricultural crops. *My For.*, 20: 186-193.

Prakash V., 1982, Effect of genotypes, moisture stress and shading on the effectives of nitrate reductase and peroxidase in wheat leaves. *Plant Physiol., Biochem.,* 9 (1) 41– 47.

Prakash, M., Siddeshkumar, J., Kannan, K., Senthilkumar, M. and Ganeshan, J., 2003, Effect of plant growth regulators on growth physiology and yield of black gram. *Legume Res.,* 26 (3):183-187.

Promila Kumari and Verma, S. K., 1983, Genotypic differences in flower production, shedding and yield in mungbean (*Vigna radiata* L. wile zek). *Ind. J. Plant Physiol.*, 27: 402 – 405.

Puri, S. and Bangarwa, K. S., 1992, Effects of trees on the yield of irrigated wheat crop in semi–arid regions. *Agrofor. Systems*, 20: 229 – 241.

Radford, P.J., 1967, Growth analysis formulae, their use and abuse. *Crop Sci.*, 7 : 171-175.

Radke, J. K and Hagstrom, R. T., 1973, Plant water measurements on soybeans sheltered by temparory corn windbreaks. C*rop Sci.*,13: 543 – 548.

Rai, P., Solanki, K. R. and Rao, G. R., 1999, Silvipasture research in India – A Review. *Ind. J. Agrofor.*, 1: 107-120.

Rao, L. J. and B. N. Mittra, 1988, Growth and yield of peanut as influenced by degree and duration of shading. *J. Agron. Crop Sci.*, 160: 260 – 265.

Ravishankar, C. and Muthuswamy, S., 1988, Influence of light and temperature on leaf area index chlorophyll content and yield of ginger, *J. Maharashtra Agri. Uni.,* 13 (2) : 216-217.

Reddy, Y. V. R., Katyal, J. C. and Das, S. K., 1992, Economics of agroforestry system. *Ind. J. Dryland Agri. Res. Develop.*, 7 (1): 19-25.

Redhead, J. F. and Maghembe, J.A., 1982, Effect of food crops on the trees growth in Tanzania. Agroforestry in African Humid Tropics (Ed. Lh, McDonald). *Proceedings of Workshop held at Nigeria*, Ibadian, 27April 1st May, 1981, The United Nations University, pp. 115-120.

Rhoades, C. C., 1995, Seasonal patterns of nitrogen mineralization and soil moisture beneath. *Faidherbia albida* in central Malawi. *Agrofor. Systems*, 29: 133-145.

Rhodes, C. C., 1997, Single tree influences on soil properties on agroforestry : lessons from natural forest and savanna eco-systems, *Agrofor. Systems*, 35: 71-94

Rodder, W., Keooboualapha, B. and Manivanh, V., 1995, Teak fruit, trees and other perennials used by hill farmers of Northern Laos. *Agrofor. Systems*, 29 : 47-60.

Rodrigo, A. D. and Adams, M. W., 1972, A path coefficient analysis of some yield component interaction in field beans (*Phaseolus vulgaries* L.). *Crop Sci.*, 12: 579-582.

Rutter, A. J., 1975, The hydrological cycle in vegetation. In; *Vegetation and the Atmosphere, Vol*. I. Academic Press, London, pp. 111-154.

Saka, A. R., Eunderson, W. T., Itimu, O. A., Phombeeya, H. S. K. and Meekeani, Y., 1994, The effects of *Acacia albida* on soils an maize grain yields under small holder farm conditions. *Agrofor. Systems*, 64: 217-230.

Salazar, A., Scott, L.T. and Palm, C.A., 1993, Crop tree interactions in alley cropping systems on alluvial soils on the upper Arizon basin. *Agrofor. Systems*, 22: 67-82.

Sale, P. J. M., 1976, Effect of shading at different time on the growth and yield of Potato. *Aust. J. Agri. Res.*, 27 : 557-566.

Sardhambal, K.V., Singh, S.P., Prakash, J. and Naik, M.S., 1978, Effect of bacterial blight on the activities of nitrate reductase and peroxidase in rice plants. *Ind.J. Biochem. And Biophy.,* 15 : 105-107.

Sekhavat, J. S., Sen, N. L. and Sornan, L. L., 1988, Evaluation of agroforestry system under rainfed conditions of Rajasthan, *Ind. For.*, 114 : 98-101.

Sestak, Z., Catask and Jarvis, P.G., 1971, Plant Photosynthetic Production : *Manual of Methods*, Ed., Junk, N.V. The Hague Publishers, p. 818.

Shankaranarayan, K. A., Harsh, L. N. and Kathju, S., 1987, Agroforestry in arid zones of India. *Agrofor. Systems*, 5: 69-88.

Shankaranarayan, K. A.and Harsh, L. N., 1987, Agroforestry in arid zones of India. Agroforestry Systems description under ICRAF's agroforestry inventory project (USAID), 22 : 1-22.

Sharma, B. N., Rathore, S. S. and Gupta, J. P., 1994, Compatibility studies on *Acacia tortilis* and *Zizyphus rotundifolia* with field crops under arid conditions. *Ind. For.*, 12: 423-430.

Sharma, K. K., 1996, Agroforestry in farming systems development. *Ind. For.*, 127: 547-551.

Sharma, K. K., Pradeep Khanna and Ajay Gulati, 1996, Influence of eucalyptus shelter belts on fodder crop. *Ind. For.*, 122: 655-664.

Sharma, N. K., Singh, H. P. and Dadhwal, K. S., 2000, Effect of poplar (*Populus deltoides*) on wheat growth at an ear stage, *J. Soil Conse.*, 28: 221-225.

Sheikh, M. I. and Razaul HaQ, 1986, Study of size placement and composition of wind breaks for optimum production of annual crops and wood. *Final Technical Report*, December, 1979 to November, 1986, FI, Peshawar, p.125.

Shoaf, T. W. and Lium, B. W., 1976, Improved extraction of chlorophyll a and b from algae using dimethyl sulphoxide. *Limol Occa,* 21:926-928.

Shyamsunder, S., 1996, Commercial teak growing in India for the 21st century, *Commonwealth For. Rev.*, 74 (4) : 273-275.

Sibtain, S. M., Natah, B., Saxena, H. O., Rao, A. L., Ghosh, R. C. and Joshi, M. D., 1983, Cultivation of plants yielding minor forest products including medicinal plans and their economic cultivation and marketing. *Pro. Eleventh Silv.Conf.*, Dehradun May 15 to 25th 1967, Volume III 1983 p.361-395.

Sidhu, B. S. and Bains, D. S., 1980, Effect of planting techniques on growth and seed yield of sunflower. *J. Res. Punjab Agri. Uni.*, 17 : 148-151.

Sinclair, T. R. and Dewitt, C. T., 1976, Analysis of the carbon and nitrogen limitations to soybean yields. *Agron. J.,* 68: 319 – 324.

Singh V. P., Dey, S. K., Murthy, K. S. and Nicholas, J. C., 1988, Effect of low light stress on growth and yield of rice. *Ind. J. Plant Physiol.,* 31 (1): 84-91.

Singh, B. B, Srivastava, M. K. and Lalchand, 1985, Relationship among leaf chlorophyll, yield & other characters in field grown soybean cultivars, *Photosynthetica*, 19: 240 – 243.

Singh, H. P., Kohli, R. K. and Daizy, R. B., 1999, Impact of *Populas delitoides* and *Dalbergia sissoo*. Shelter belts on wheat – A *Comparative study. Int. Tree Crops J.*, 10: 51-60.

Singh, N. P., Shankaran, M. and Jai Prakash., 2008, Tree spices as component in home gardens of Tripura.Tree spice cultivation and sustainable development of home gardens for decent livelihood and environmental protection in Andaman and Nicobar Islands*: Nat. workshop cum Sym. Pro. workshop,* held in CARI Port Blair,4-6,February, 2008 p. 1.

Singh, R. P., Ong, C. K. and Sahran, N., 1989, Above and below ground interactions in alley cropping in semiarid India. *Agrofor. System*, 9: 259-274.

Singh, S .P. and Singh, G. S., 1996, Genetic variability heritability, expected genetic advance and correlation studies on physiological parameters in mungbean (*vigna radiata). Ind. J. Plant Physiol.*, 1 (1): 68-69.

Singh, S., 1994, Physiological response of different crop species to low light stress. *Ind. J. Plant Physiol.*, 37 (3): 147 – 151.

Singh, S., 1997, Growth and yield response of different crop species to low light and high temperature – humidity stress. *Ind. J. Plant Physiol.*, 2: 151 – 155.

Singh, U. and Yadav, D. S., 1997, Studies on sulphur and zinc nutrition on greengram (*Phaseoulus radiata*. L.) in relation to growth attributes seed protein yield and S, Zn uptake. *Leg. Rese.*, 20: 224 – 226.

Singh. R. P. and Korwar, G.R., 1986, Agroforestry option for dry lands in India. *Ind. J. Dryland Agri. Res. Develop.*, 1: 1 -10.

Sommarriba, E., 1988, Pasture growth and floristic composition under the shade of guava (*Psidium guajava* L.) trees in costa Rica. *Agrofor. systems*, 6 : 113 – 162.

Squire, G. R., 1990, *The Physiology of Tropical Crop Production*. CAB International, Wallingford, Oxford, UK, 236 pp.

Sunderlin, W., 1982, Benefits, costs and equity analysis of social forestry site in central jawa, *Financial and economical analysis of agroforestry systems Pro.* workshop*, held in Honolalu Hawaii, USA*, pp 261 – 270.

Swamy, S. L., Mishra, A. and Puri, S., 2003, Biomass production and root distribution of *Gemelina arborea* under an agrisilviculture system in subhumid tropics of central India. *New Forests*, 26 : 167 – 186.

Thaware, S. L., Bhagat, S. B., Khatdar, B. S., Jadhav, B. B., Dhonukhe, B. L. and Jambhale, N. D., 2004, Effect of tree species on growth and yield at rice (*Oryza sativa* L.) in Konkan region. *Ind. J. of Agrofor.*, 6 (2) : 15-18.

Thind, H. S. and Dhillon, M. S., 1994, Degraded lands of Punjab and their development through agroforestry, In : *Agroforestry Systems for Degraded Lands* (Eds. Punjab

Singh, P.S. Pathak and M.M. Roy) Oxford and IBH Publishing Co.Pvt.Ltd., New Delhi, 1 : 1-12.

Thind, H. S., 1996, Agroforestry inventions for sustaining agricultural productivity and environment. In : *Resource Inventory Techniques to Support Agroforestry and Environment* (Eds., R.K. Kohli and K.S. Arya) pp. 25-100. *Pro. of Int. Sym., Chandigarh*, October 1996, IURO/DNAES, Chandigarh.

Thornton. R. K. and Wampie, R. L., 1980, Changes in sunflower response to water stress conditions. *Plant Physiol*., 65: 1-7.

Trenbath, B. R., 1976, Light use efficiency of crops and the potential for improvement through intercropping. In: Willey, R.W. (eds), *Proce. of Int. Workshop on Intercropping*. ICRISAT, Hyderbad, India, pp 141-154.

Ushuda, H. S., Ku, B.M. and Edwards, G. E., 1985, Influence of light intensity during growth on photosynthesis and activity of several key photosynthetic enzymes in a C_4 plant (Zea mays). *Plant Physiol*., 63: 65 – 67.

Vandana and Bhatt R. K., 2001, Physiological changes in Sesbnia species to reducing light intensities. *J. Agron. Crop Sci*., 182: 43 – 47.

Vandenbett, R.J., 1992, *Faiderbia albida* in the West-African semi arid tropics. ICRISAST, Patancheru, India, p. 206.

Vanderbelt, R. J. and Williams, J. H., 1992, The effect of soil temperature on the growth of millet in relation to the effect of *Faidherbia albida* trees. *Agric. Forest. Meteo*. 60 : 93 -150.

Vandermeeer, J., 1989, *The Ecology of Intercropping*. Cambridge University Press, Cambridge, UK, p. 237.

Vandermeer J., 1989, The Ecology of Intercropping. Cambridge University Press, 237 p Warembourg FR (1995) Isotopic methods in intercropping studies. In: Sinoquet H and Cruz (eds) *Ecophysio. Trop. Intercrop*., pp. 213-228. INRA Editions, Paris.

Venkata Rao, M., Patil, S. J. and Chetti, M. B., 2006, Influence of teak based agroforestry systems on the yield and yield components of groundnut. *The Andhra Agril. J.,* 53 (1&2): 90-92.

Venkata Rao, M., Patil, S. J.and Chetti, M.B., 2006, Morphological parameters and total biomass of groundnut as influenced by teak based agroforestry system. *The Andhra Agril. J.,* 53 (3&4): 224-227.

Vergera, N., 1982, Selection of Legumes tree for agroforestry, in : *New Direction of Agroforestry*. The potential of tropical legume trees. East-West Centre Honolulu, Hawaii.

Vericumbe, I. and Okali, D. U., 1984, The effect of coppiced teak regrowth on soil in teak maize agroforest. *For. Eco. Manag*., 12 : (1) : 37-41.

Verinumbe, I., 1993, Soil and *Leucaena leucocephala* growth variability under *Fardhera albida* and *Ziziphus spina-chrissi*, *Agrofor. System*, 22 : 287-292.

Verma, K. S., Zegaya, M. W. and Kaushal., R., 2002, Growth and yield performance of wheat in agri-horti-silviculture systems of agroforestry in the mid-hills of Himachal Himalayas. *Ind.J Agrofor*., 4 (1) : 1-7.

Verma, K.S., Sood, R. and Kaushal, R., 2004, Varietals response of wheat to different levels of nitrogen in agri-silviculture system under rainfed hill farming system. *Ind. J Agrofor*., 6 (2) : 1-7.

Vivekanandan, A. S., Gunasena, H. P. M. and Shivanayagan, T., 1972, Statistical evaluation of accuracy of three techniques used in the estimation of leaf area of crop plants. *Ind. J Agrofor*., 42 : 857-860.

Watanabe, H., Sahunalu, P. and Khemnark, C., 1988, Combination of trees and crops in the taungya method as applied in Thailand. *Agrofor. Systems*, 6 (2):169-177.

Watsosn, D. J., Thorn, G. W. and French, S. A. W., 1952, Physiological causes of different in grain yield between varieties in barley. *Ann. Bot.*, 22 : 321-352.

White, K. J., 1991, Teak some aspect of research and development RAPA Publication, FAO, Bangkok, 17 : 70.

Willey, R. W., 1979, Intercropping – its importance and research needs. Competition and yield advantages, *Field Crops Abst,* 32: 1-10.

Wojtkowski, P. A., Brister, G. H. and Cubbage, F. W., 1988, Using multiple objective linear programming to evaluate multi participant agroforestry systems. *Agrofor. Systems*, 7 (2) : 185-195.

Woledge, J., 1977, The effect of shading and cutting treatments on the photosynthesis rate of ryegrass leaves. *Ann. Bot.*, 41 : 1279 – 1286.

Yadav, I. P. and Blyth, J. B., 1996, Combined productivity of *Prosopis cineraria* mustard agro silviculture practice. *Internat. Tree Crop J.*, 88 : 47-58.

Yoshida, S., Forno, D. A., Cock, J. H. and Gomez, K. A., 1972, Laboratory manual for physiological studies of rice. *Internat. Rice Research Inst.*, Manila, Philippines, pp. 9-18.

Zegeye, M. W., 1999, Tree crop interaction studies in agri horti silviculture system. *M. Sc. (Agri.) Thesis,* Dr.Y.S.Parmer Uni. of Horti. and For., Solan, H.P.,India.

Appendix-I: Influence of teak based agroforestry system on plant height (cm) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	17.3	18.7	**18.0**	18.5	19.4	**19.0**	22.4	25.3	**23.9**	14.2	14.6	**14.4**	16.2	16.6	**16.4**	20.2	20.9	**20.5**
T_2-Teak + Greengram	7.7	9.50	**8.6**	22.1	22.0	**22.0**	31.0	33.4	**32.2**	6.6	7.5	**7.1**	8.6	9.5	**9.04**	13.0	14.1	**13.5**
T_3-Teak + Frenchbean	18.4	19.4	**18.9**	20.4	21.8	**22.1**	22.6	24.3	**23.4**	14.2	15.1	**14.7**	16.3	17.2	**16.71**	20.3	21.1	**20.7**
T_4-Teak + Black gram	16.9	19.2	**18.0**	18.2	23.8	**21.0**	20.4	26.9	**23.6**	14.2	15.4	**14.8**	16.4	17.8	**17.1**	20.0	21.0	**20.5**
T_5-Soybean (sole)	18.3	18.8	**18.5**	19.5	19.7	**19.6**	26.4	26.7	**26.5**	15.3	16.2	**15.8**	17.5	18.1	**17.8**	20.4	21.6	**21.0**
T_6-Greengram (sole)	9.4	10.0	**9.7**	24.2	25.1	**24.7**	31.9	31.8	**31.9**	7.7	8.9	**8.3**	9.6	11.3	**10.5**	13.6	14.5	**14.1**
T_7-French bean (sole)	19.5	19.6	**19.6**	22.9	22.8	**22.8**	27.5	26.61	**27.1**	15.3	15.5	**15.4**	17.4	17.8	**17.6**	21.2	21.6	**21.4**
T_8-Black gram (sole)	19.4	20.3	**19.8**	24.4	24.6	**24.5**	29.4	29.9	**29.6**	15.1	15.3	**15.2**	16.6	17.3	**17.0**	19.5	21.3	**20.4**
Mean	**15.9**	**16.9**	**16.4**	**21.2**	**22.4**	**21.8**	**26.4**	**28.1**	**27.2**	**12.8**	**13.6**	**13.2**	**14.8**	**15.7**	**15.2**	**18.5**	**19.5**	**19.0**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	**0.29**	**0.85**	**0.30**	**0.86**	**0.86**	**2.49**	**0.30**	**0.30**	**0.30**	**0.86**	**0.37**	**1.06**
Distance (D)	0.15	0.42	0.15	0.43	0.43	1.24	0.15	0.15	0.15	6.43	0.18	0.53
Interaction (AF X D)	0.42	NS	0.42	1.22	1.22	NS	0.43	0.43	0.42	NS	0.520	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-II: Influence of teak based agroforestry system on number of branches at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2.51	3.46	**2.48**	6.56	8.11	**7.34**	8.45	9.40	**8.92**	2.73	3.50	**3.11**	6.83	8.41	**7.62**	9.06	9.36	9.21
T_2-Teak + Greengram	2.64	3.46	**3.05**	6.83	7.65	**7.24**	8.11	0.30	**8.20**	2.96	3.70	**3.33**	7.00	7.78	**7.39**	8.03	8.90	**8.46**
T_3-Teak + Frenchbean	2.78	3.40	**3.09**	7.83	8.51	**8.17**	8.86	9.18	**9.02**	3.26	3.83	**3.55**	7.48	8.13	**7.80**	8.50	9.76	**9.13**
T_4-Teak + Black gram	2.93	3.43	**3.18**	6.80	7.96	**7.36**	8.52	9.20	**8.86**	2.80	3.00	**2.90**	7.00	8.16	**7.58**	8.33	8.36	**8.45**
T_5-Soybean (sole)	6.27	6.68	**6.48**	9.20	9.56	**9.38**	10.28	10.71	**10.49**	4.93	5.83	**5.38**	9.16	9.75	**9.45**	10.63	11.46	**11.05**
T_6-Greengram (sole)	3.88	3.90	**3.89**	8.46	8.88	**8.67**	9.42	9.60	**9.51**	3.90	4.48	**4.19**	9.20	9.53	**9.36**	8.76	9.43	**9.10**
T_7-French bean (sole)	3.51	3.80	**3.65**	8.23	9.01	**8.62**	8.58	9.28	**8.98**	3.88	4.16	**4.02**	8.20	8.75	**8.47**	9.36	10.10	**9.73**
T_8-Black gram (sole)	3.20	4.01	**3.60**	9.53	9.06	**9.30**	9.55	9.71	**9.63**	3.25	4.43	**3.84**	9.13	10.06	**9.60**	9.16	9.56	**9.36**
Mean	**3.46**	**4.01**	**3.73**	**7.93**	**8.59**	**8.26**	**8.97**	**9.42**	**9.19**	**3.46**	**4.11**	**3.78**	**8.00**	**8.82**	**8.41**	**8.98**	**9.04**	**9.01**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.0696	0.2004	0.123	0.352	0.064	0.1842	0.255	0.734	**0.195**	**0.561**	**0.232**	**0.668**
Distance (D)	0.0348	0.1002	0.061	0.176	0.032	0.0924	0.127	0.365	**0.097**	0.279	0.116	0.334
Interaction (AF X D)	0.0984	0.2843	0.175	0.505	0.091	0.262	0.361	NS	0.276	NS	0.328	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-III: Influence of teak based agroforestry system on leaf area (dm^2 $plant^{-1}$) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	4.29	4.34	**7.71**	9.43	10.03	**9.73**	10.20	10.86	**10.53**	4.48	4.90	**4.69**	9.16	10.53	**9.85**	11.00	12.13	**11.56**
T_2-Teak + Greengram	18.20	18.75	**18.47**	26.33	27.13	**26.73**	21.43	22.76	**22.10**	17.4	18.70	**18.06**	26.76	28.16	**27.46**	21.66	22.86	**22.26**
T_3-Teak + Frenchbean	5.35	5.43	**5.39**	9.08	9.31	**9.20**	8.46	8.58	**8.52**	5.63	6.18	**5.90**	9.33	10.73	**10.03**	7.18	8.03	**7.60**
T_4-Teak + Black gram	20.01	20.78	**20.40**	33.33	34.96	**34.15**	22.96	25.90	**24.43**	19.33	21.63	**20.48**	28.06	31.90	**29.98**	20.93	22.20	**21.56**
T_5-Soybean (sole)	7.58	7.85	**4.32**	13.06	15.55	**15.30**	9.86	10.83	**10.35**	8.10	8.71	**8.40**	15.21	17.66	**16.44**	12.63	13.07	**12.85**
T_6-Greengram (sole)	18.11	19.45	**18.78**	24.56	25.43	**25.09**	20.06	21.50	**20.78**	18.20	20.30	**19.25**	27.16	29.30	**28.23**	22.83	24.33	**23.58**
T_7-French bean (sole)	5.53	5.58	**5.55**	9.18	9.33	**9.25**	8.25	8.35	**8.30**	5.93	7.16	**6.55**	10.13	11.33	**10.73**	8.23	9.26	**8.75**
T_8-Black gram (sole)	21.33	21.88	**21.60**	32.26	33.10	**32.68**	24.70	25.96	**25.33**	20.86	22.53	**21.70**	30.26	32.34	**31.31**	22.66	23.53	**23.10**
Mean	12.55	13.01	**12.78**	19.90	20.60	**20.25**	15.74	16.84	**16.29**	12.49	13.76	**13.12**	19.51	21.50	**20.50**	15.89	16.93	**16.41**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.186	0.5371	0.714	2.0619	0.617	1.7818	0.315	0.907	0.522	4.503	0.387	1.114
Distance (D)	0.093	0.2685	0.352	NS	0.308	NS	0.157	0.452	0.261	0.751	0.193	0.555
Interaction (AF X D)	0.263	NS	1.010	NS	0.873	NS	0.445	NS	0.738	NS	0.547	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-IV: Influence of teak based agroforestry system on leaf dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.15	1.27	**1.21**	4.36	4.69	**4.53**	2.06	2.71	**2.35**	1.28	1.20	**1.24**	5.20	5.83	**551**	2.86	3.20	**3.03**
T_2-Teak + Greengram	0.06	0.08	**0.07**	0.66	0.71	**0.69**	2.38	2.45	**2.41**	0.56	0.70	**0.63**	1.90	2.03	**1.96**	0.50	0.81	**0.65**
T_3-Teak + Frenchbean	1.29	1.40	**1.34**	4.73	5.29	**5.01**	4.32	5.14	**4.73**	1.26	1.38	**1.32**	4.53	5.26	**4.90**	3.80	4.43	**4.11**
T_4-Teak + Black gram	1.23	1.33	**1.28**	1.73	1.90	**1.81**	1.86	1.94	**1.90**	1.20	1.36	**1.28**	1.76	1.96	**1.86**	1.43	1.63	**1.53**
T_5-Soybean (sole)	1.07	1.26	**1.16**	4.18	4.44	**4.33**	1.93	1.98	**2.25**	1.45	1.55	**1.50**	5.66	7.00	**6.33**	2.93	3.76	**3.15**
T_6-Greengram (sole)	0.06	0.08	**0.06**	0.64	0.71	**0.67**	2.30	2.61	**2.45**	0.45	0.55	**0.50**	1.40	1.53	**1.56**	0.66	0.76	**0.71**
T_7-French bean (sole)	1.43	1.47	**1.45**	5.47	5.48	**5.47**	4.99	4.96	**4.98**	1.35	1.48	**1.41**	6.20	6.56	**6.38**	4.46	5.03	**4.758**
T_8-Black gram (sole)	1.38	1.40	**1.24**	2.05	2.03	**2.04**	1.94	1.97	**1.95**	1.35	1.38	**1.36**	1.96	2.01	**1.99**	0.70	0.96	**0.83**
Mean	0.96	1.04	**1.00**	2.98	3.16	**3.07**	2.72	2.92	**2.82**	1.11	1.20	**1.15**	3.60	4.02	**3.81**	2.17	2.56	**2.36**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.030	0.0866	0.088	0.2541	0.687	1.9839	0.049	0.141	0.248	0.714	0.136	0.391
Distance (D)	0.015	0.0433	0.044	0.1270	0.034	0.0981	0.024	0.069	0.124	0.357	0.068	0.195
Interaction (AF X D)	0.043	NS	0.125	NS	0.097	0.2801	0.070	NS	0.351	NS	0.192	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-V: Influence of teak based agroforestry system on stem dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.24	1.22	**1.23**	4.31	4.66	**4.59**	4.15	4.28	**4.21**	1.25	1.20	**1.22**	4.23	4.33	**4.28**	3.63	3.90	**3.76**
T_2-Teak + Greengram	0.11	0.13	**0.12**	1.48	1.55	**1.51**	3.61	4.56	**4.08**	0.16	0.30	**0.23**	1.10	1.45	**1.27**	0.63	0.76	**0.70**
T_3-Teak + Frenchbean	1.88	1.93	**1.90**	3.09	3.36	**3.22**	3.56	4.17	**3.86**	1.36	1.66	**1.51**	2.93	3.50	**3.21**	2.50	2.96	**2.73**
T_4-Teak + Black gram	1.85	1.92	**1.88**	2.46	2.49	**2.47**	2.26	2.21	**2.23**	1.06	1.56	**1.31**	2.40	2.80	**2.60**	1.73	2.06	**1.90**
T_5-Soybean (sole)	1.27	1.36	**1.22**	4.68	3.01	**4.84**	4.68	4.73	**4.70**	1.28	1.35	**1.31**	4.13	4.83	**4.48**	3.06	3.46	**3.26**
T_6-Greengram (sole)	0.14	0.13	**0.13**	1.41	1.47	**1.44**	3.98	4.45	**4.21**	0.26	0.41	**0.34**	1.41	1.53	**1.47**	0.63	0.80	**0.71**
T_7-French bean (sole)	1.92	2.10	**2.01**	3.60	3.71	**3.65**	4.21	4.27	**4.24**	1.50	1.56	**1.53**	3.26	3.76	**3.51**	2.20	2.93	**2.56**
T_8-Black gram (sole)	1.89	5.68	**1.92**	2.22	2.15	**2.18**	2.19	2.08	**2.13**	0.96	1.26	**1.11**	2.46	3.00	**2.73**	1.96	2.43	**2.20**
Mean	**1.29**	**1.34**	**1.31**	**2.93**	**3.05**	**2.99**	**3.58**	**3.84**	**3.71**	**0.98**	**1.16**	**1.07**	**2.74**	**3.15**	**2.94**	**2.04**	**2.41**	**2.22**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.026	0.0750	0.060	0.1732	0.084	0.2425	0.085	0.244	0.160	0.460	0.103	0.296
Distance (D)	0.013	0.0375	0.030	0.0866	0.042	0.1212	0.042	0.120	0.080	6.230	0.051	0.146
Interaction (AF X D)	0.037	NS	0.085	NS	0.120	0.5465	0.121	NS	0.226	NS	0.146	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-VI: Influence of teak based agroforestry system on total dry weight (g $plant^{-1}$) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2.38	3.10	**2.74**	7.14	8.33	**7.87**	24.83	27.66	**26.25**	2.53	2.70	**2.61**	9.43	10.16	**9.80**	6.53	7.16	**6.85**
T_2-Teak + Greengram	0.16	0.18	**0.17**	2.05	2.15	**2.10**	13.17	13.55	**13.36**	1.25	1.76	**1.50**	3.18	3.41	**3.30**	1.16	1.58	**1.37**
T_3-Teak + Frenchbean	3.14	3.20	**3.17**	8.79	9.32	**9.06**	19.39	21.42	**20.41**	2.63	2.98	**2.80**	7.46	8.70	**8.08**	6.23	7.3	**6.76**
T_4-Teak + Black gram	3.37	3.36	**3.37**	6.17	6.30	**6.23**	8.12	8.28	**8.20**	2.21	2.85	**2.53**	4.20	4.68	**4.44**	3.23	3.80	**3.51**
T_5-Soybean (sole)	2.53	3.40	**2.96**	7.81	9.11	**8.46**	25.46	27.55	**26.50**	2.71	2.91	**2.81**	10.16	10.56	**10.36**	6.16	6.63	**6.40**
T_6-Greengram (sole)	0.15	0.17	**0.16**	2.05	2.10	**2.07**	12.53	12.35	**12.44**	1.66	1.90	**1.78**	3.01	2.66	**2.94**	1.36	1.60	**1.48**
T_7-French bean (sole)	3.27	3.51	**3.29**	10.59	10.71	**10.65**	22.68	23.26	**22.97**	2.80	2.95	**2.87**	9.06	10.20	**9.63**	6.56	7.93	**7.25**
T_8-Black gram (sole)	3.38	3.61	**3.49**	6.15	6.58	**63.36**	8.15	9.02	**8.38**	2.35	2.70	**2.52**	4.50	4.98	**4.74**	2.23	3.06	**2.65**
Mean	2.30	2.57	**2.43**	6.38	6.83	**6.60**	16.79	17.89	**17.34**	**2.27**	2.59	2.43	**6.37**	6.94	**6.65**	4.18	4.88	**4.53**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.069	0.199	0.080	0.231	0.420	1.212	0.096	0.276	0.079	0.227	0.584	1.681
Distance (D)	0.034	0.09	0.040	0.115	0.210	0.606	0.048	0.138	0.039	0.113	0.290	0.835
Interaction (AF X D)	0.097	0.280	0.114	0.329	0.594	NS	0.136	NS	0.111	0.319	0.826	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-VII: Influence of teak based agroforestry system on leaf area index (LAI) at different stages in legumes

Agroforestry system	2007									2008								
	D_1			D_2			Mean			D_1			D_2			Mean		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.38	1.91	**1.64**	3.26	3.51	**3.38**	2.22	3.16	**2.69**	1.41	1.96	**1.68**	3.96	4.66	**4.31**	2.06	3.16	**2.61**
T_2-Teak + Greengram	3.51	3.57	**3.54**	6.46	7.46	**6.96**	6.20	6.53	**6.36**	3.60	3.96	**3.78**	4.93	5.63	**5.28**	2.76	3.26	**3.01**
T_3-Teak + Frenchbean	3.52	3.61	**3.57**	6.21	6.42	**6.32**	5.16	5.70	**5.43**	3.43	3.88	**3.65**	6.20	6.83	**6.51**	5.36	6.00	**5.68**
T_4-Teak + Black gram	1.36	1.45	**1.40**	1.64	1.80	**1.75**	1.99	2.16	**2.08**	1.45	1.66	**1.55**	1.68	1.85	**1.76**	1.80	2.20	**2.00**
T_5-Soybean (sole)	2.61	2.85	**2.73**	5.28	5.26	**5.27**	3.53	3.65	**3.59**	2.40	2.86	**2.63**	3.00	5.63	**5.31**	3.30	3.45	**3.37**
T_6-Greengram (sole)	3.40	3.61	**3.50**	7.48	7.65	**7.56**	6.30	6.11	**6.20**	3.76	4.16	**3.96**	5.93	6.16	**6.05**	3.78	4.10	**3.94**
T_7-French bean (sole)	3.61	3.65	**3.63**	7.92	8.00	**7.96**	6.60	6.46	**6.53**	3.83	4.06	**3.95**	6.60	6.86	**6.73**	5.33	5.80	**5.56**
T_8-Black gram (sole)	1.43	1.46	**1.44**	1.71	1.74	**1.72**	2.32	2.41	**2.36**	2.21	2.06	**1.89**	1.93	2.83	**2.13**	2.80	3.26	**3.03**
Mean	**2.60**	**3.08**	**2.84**	**4.99**	**5.23**	**5.11**	**4.29**	**4.52**	**4.40**	**2.70**	**3.08**	**2.89**	**4.53**	**4.99**	**4.76**	**3.40**	**3.90**	**3.65**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.019	0.054	0.038	0.081	0.233	0.116	0.096	0.137	0.394	0.676	0.235	0.676
Distance (D)	0.009	0.025	0.019	0.040	0.115	0.058	0.334	0.068	0.195	0.336	0.117	0.336
Interaction (AF X D)	0.027	0.779	0.054	0.115	0.331	0.164	0.167	0.194	NS	NS	0.332	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-VIII: Influence of teak based agroforestry system on absolute growth rate (g plant^{-1} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 - Harvest			20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Soybean	0.172	0.356	**0.264**	0.362	0.932	**0.650**	0.417	0.477	**0.447**	0.247	0.347	**0.297**	0.420	0.780	**0.600**	0.483	0.960	**0.722**
T_2-Teak + Greengram	0.105	0.114	**0.110**	0.355	0.368	**0.362**	0.370	0.390	**0.380**	0.146	0.170	**0.158**	0.317	0.407	**0.362**	0.383	0.437	**0.410**
T_3-Teak + Frenchbean	0.285	0.350	**0.317**	0.519	0.556	**0.543**	0.562	0.587	**0.574**	0.287	0.350	**0.318**	0.507	0.670	**0.588**	0.505	0.643	**0.574**
T_4-Teak + Black gram	0.228	0.250	**0.239**	0.184	0.196	**0.190**	0.193	0.227	**0.210**	0.250	0.317	**0.283**	0.333	0.483	**0.408**	0.333	0.470	**0.402**
T_5-Soybean (sole)	0.521	0.436	**0.478**	1.052	1.059	1.056	**1.073**	1.077	**1.075**	0.477	0.577	**0.527**	0.930	1.023	**0.974**	1.050	1.080	**1.065**
T_6-Greengram (sole)	0.120	0.132	**0.126**	0.363	0.375	**0.369**	0.383	0.387	**0.385**	0.180	0.230	**0.205**	0.383	0.473	**0.428**	0.450	0.540	**0.495**
T_7-French bean (sole)	0.370	0.376	**0.373**	0.618	0.621	**0.619**	0.690	0.700	**0.695**	0.380	0.453	**0.417**	0.633	0.703	**0.668**	0.697	0.790	**0.743**
T_8-Black gram (sole)	0.218	0.224	**0.221**	0.122	0.133	**0.127**	0.143	0.167	**0.155**	0.320	0.400	**0.360**	0.450	0.540	**0.495**	0.820	0.863	**0.842**
Mean	**0.252**	**0.280**	**0.266**	**0.447**	**0.532**	**0.489**	**0.479**	**0.501**	**0.490**	**0.286**	**0.355**	**0.320**	**0.497**	**0.635**	**0.566**	**0.590**	**0.723**	**0.656**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.016	0.046	0.005	0.0144	0.009	0.0259	0.016	0.0460	0.0050	0.0144	0.003	0.0920
Distance (D)	0.008	0.023	0.002	0.0057	0.004	0.0115	0.008	0.0230	0.0025	0.0071	0.016	0.0460
Interaction (AF X D)	0.006	0.0172	0.008	0.0230	0.013	NS	0.023	0.0662	0.0070	NS	0.045	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-IX: Influence of teak based agroforestry system on crop growth rate (g m^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 - Harvest			20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Soybean	8.40	15.95	**12.17**	15.22	20.23	**17.73**	13.40	20.96	**18.18**	8.30	12.50	**10.40**	16.96	20.60	**18.78**	18.36	21.96	**20.16**
T_2-Teak + Greengram	3.39	3.51	**3.45**	11.85	13.98	**12.92**	12.20	14.40	**13.30**	3.51	4.33	**3.92**	12.50	14.90	**13.70**	15.13	15.06	**13.10**
T_3-Teak + Frenchbean	0.19	0.21	**0.20**	0.34	0.40	**0.37**	0.33	0.61	**0.57**	1.56	2.26	**1.91**	2.96	3.93	**3.45**	3.50	4.13	**3.81**
T_4-Teak + Black gram	6.43	9.43	**7.93**	3.41	5.26	**4.34**	3.63	5.56	**4.60**	6.50	9.20	**7.85**	9.40	13.46	**11.43**	13.93	14.36	**14.15**
T_5-Soybean (sole)	17.26	17.35	**17.30**	34.76	34.73	**34.75**	35.60	37.26	**36.48**	15.53	17.30	**16.41**	23.10	26.26	**24.68**	23.73	27.56	**25.65**
T_6-Greengram (sole)	3.63	3.76	**3.69**	13.95	14.33	**14.14**	15.73	16.73	**16.23**	4.23	5.43	**4.83**	14.36	15.89	**15.08**	14.86	15.70	**15.28**
T_7-French bean (sole)	0.22	0.23	**0.22**	0.41	0.42	**0.41**	0.50	0.51	**0.50**	1.86	2.66	**2.26**	3.73	4.43	**4.08**	3.96	4.73	**4.35**
T_8-Black gram (sole)	9.18	9.35	**9.26**	4.86	4.96	**4.91**	5.78	5.83	**5.80**	8.26	8.76	**8.51**	9.70	11.40	**10.35**	15.23	15.50	**15.36**
Mean	**6.09**	**7.47**	**6.78**	**10.60**	**11.79**	**11.19**	**11.17**	**12.74**	**11.95**	**6.22**	**7.80**	**7.01**	**11.59**	**13.85**	**12.72**	**13.59**	**14.37**	**13.98**

For comparing the means of	SEm ±	CD (0.05)	Sem ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.261	0.751	0.180	0.518	0.219	0.630	0.394	1.134	0.441	1.270	0.526	1.514
Distance (D)	0.130	0.374	0.090	0.259	0.109	0.313	0.197	0.567	0.220	0.633	0.263	0.757
Interaction (AF X D)	0.369	1.062	0.255	0.737	0.310	0.892	0.557	1.604	0.624	NS	0.744	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-X: Influence of teak based agroforestry system on relative growth rate (g m^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 - Harvest			20 - 40 DAS			40 - 60 DAS			60 - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Soybean	0.056	0.076	**0.066**	0.038	0.036	**0.037**	0.017	0.020	**0.018**	0.056	0.063	**0.060**	0.030	0.037	**0.033**	0.029	0.043	**0.036**
T_2-Teak + Greengram	0.142	0.151	**0.142**	0.092	0.087	**0.089**	0.052	0.062	**0.057**	0.142	0.152	**0.147**	0.077	0.080	**0.078**	0.057	0.024	**0.041**
T_3-Teak + Frenchbean	0.021	0.023	**0.022**	0.016	0.017	**0.016**	0.070	0.070	**0.070**	0.024	0.032	**0.028**	0.012	0.018	**0.015**	0.012	0.040	**0.026**
T_4-Teak + Black gram	0.138	0.147	**0.143**	0.080	0.089	**0.084**	**0.055**	0.055	0.0550	0.142	0.158	**0.150**	0.075	0.090	**0.083**	0.060	0.032	**0.046**
T_5-Soybean (sole)	0.058	0.054	**0.056**	0.038	0.043	0.040	**0.023**	0.018	0.020	0.060	0.068	**0.064**	0.031	0.042	**0.037**	0.020	0.042	**0.031**
T_6-Greengram (sole)	0.145	0.155	**0.150**	0.091	0.095	**0.093**	0.043	0.053	**0.048**	0.144	0.158	**0.151**	0.088	0.094	**0.094**	0.048	0.023	**0.036**
T_7-French bean (sole)	0.023	0.024	**0.024**	0.017	0.018	**0.017**	0.083	0.090	**0.087**	0.085	0.043	**0.064**	0.014	0.019	**0.016**	0.015	0.033	**0.024**
T_8-Black gram (sole)	0.145	0.149	**0.147**	0.088	0.089	**0.088**	0.053	0.060	**0.057**	0.153	0.167	**0.160**	0.072	0.083	**0.078**	0.055	0.047	**0.051**
Mean	0.091	0.097	**0.094**	0.058	0.059	**0.058**	0.050	0.054	**0.052**	**0.101**	**0.105**	**0.103**	0.050	0.058	0.054	0.017	0.035	**0.026**

For comparing the means of	SEm ±	CD (0.05)	Sem ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.001	0.00028	0.001	0.00028	0.004	0.01152	0.010	0.028	0.002	0.005	0.006	0.017
Distance (D)	0.001	0.00028	0.001	NS	0.002	NS	0.005	NS	0.001	0.002	0.003	NS
Interaction (AF X D)	0.002	NS	0.002	NS	0.005	NS	0.015	NS	0.004	NS	0.009	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XI: Influence of teak based agroforestry system on net assimilation rate (g dm^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Soybean	0.055	0.065	**0.060**	0.064	0.067	**0.066**	0.085	0.092	**0.088**	0.053	0.062	**0.057**	0.075	0.085	**0.080**	0.081	0.085	**0.083**
T_2-Teak + Greengram	0.165	0.175	**0.170**	0.096	0.101	**0.098**	0.108	0.110	**0.109**	0.159	0.175	**0.167**	0.196	0.270	**0.233**	0.103	0.117	**0.110**
T_3-Teak + Frenchbean	0.016	0.018	**0.017**	0.023	0.024	**0.024**	0.046	0.055	**0.051**	0.015	0.021	**0.018**	0.033	0.045	**0.039**	0.048	0.057	**0.052**
T_4-Teak + Black gram	0.410	0.514	**0.462**	0.229	0.287	**0.258**	0.383	0.543	**0.463**	0.380	0.390	**0.385**	0.450	0.560	**0.505**	0.453	0.603	**0.528**
T_5-Soybean (sole)	0.046	0.046	**0.046**	0.078	0.082	**0.080**	0.085	0.095	**0.090**	0.060	0.087	**0.073**	0.072	0.087	**0.079**	0.083	0.110	**0.097**
T_6-Greengram (sole)	0.173	0.182	**0.177**	0.098	0.104	**0.101**	0.104	0.122	**0.113**	0.170	0.183	**0.177**	0.240	0.298	**0.269**	0.263	0.387	**0.325**
T_7-French bean (sole)	0.019	0.020	**0.020**	0.024	0.025	**0.025**	0.192	0.053	**0.123**	0.022	0.032	**0.027**	0.047	0.063	**0.055**	0.055	0.072	**0.063**
T_8-Black gram (sole)	0.519	0.523	**0.521**	0.295	0.348	**0.322**	0.292	0.308	**0.320**	0.510	0.617	**0.563**	0.607	0.640	**0.623**	0.603	0.693	**0.648**
Mean	0.175	0.193	**0.184**	0.114	0.130	**0.122**	0.162	0.177	**0.169**	**0.171**	**0.195**	**0.183**	0.215	0.256	**0.212**	0.211	0.265	**0.238**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.0057	0.01611	0.0046	0.0132	00.028	0.08064	0.014	0.040	0.021	0.060	0.026	0.074
Distance (D)	0.0029	0.00083	0.0023	0.0006	0.014	NS	0.007	0.020	0.010	0.028	0.013	0.037
Interaction (AF X D)	0.0081	0.02332	0.0066	0.01900	0.040	NS	0.020	NS	0.029	NS	0.037	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XII: Influence of teak based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Soybean	0.32	0.38	**0.35**	0.43	0.48	**0.45**	0.43	0.46	**0.45**	0.70	1.00	**0.85**	0.78	1.40	**1.09**	0.50	0.93	**0.71**
T_2-Teak + Greengram	4.30	4.55	**4.42**	6.80	6.92	**6.86**	4.65	5.08	**4.86**	3.66	4.33	**4.00**	6.13	6.76	**6.45**	4.00	4.40	**4.23**
T_3-Teak + Frenchbean	2.18	2.51	**2.35**	4.27	4.46	**4.37**	4.40	4.56	**4.48**	2.16	2.83	**2.50**	4.20	4.75	**4.47**	3.63	3.76	**3.70**
T_4-Teak + Black gram	4.50	4.61	**4.35**	6.43	6.83	**6.63**	4.45	4.26	**4.35**	4.13	4.26	**4.20**	6.26	6.33	**6.30**	3.9	4.06	**3.98**
T_5-Soybean (sole)	0.41	0.44	**0.42**	0.38	0.44	**0.41**	0.57	0.62	**0.60**	0.90	1.15	**1.02**	1.46	1.60	**1.53**	0.56	0.93	**0.75**
T_6-Greengram (sole)	4.43	4.70	**4.56**	6.93	7.05	**6.99**	5.08	5.41	**5.25**	4.00	4.41	**4.20**	6.40	6.83	**6.61**	4.53	4.60	**4.56**
T_7-French bean (sole)	2.48	2.60	**2.54**	4.50	4.60	**4.55**	4.60	4.73	**4.66**	2.36	2.71	**2.54**	5.06	5.53	**5.30**	4.00	4.58	**4.29**
T_8-Black gram (sole)	4.58	4.66	**4.62**	6.71	6.96	**6.84**	4.31	4.53	**4.42**	3.73	4.76	**4.25**	6.05	6.70	**6.37**	3.78	4.23	**4.00**
Mean	**2.90**	**3.03**	**2.96**	**4.55**	**4.72**	**4.63**	**3.56**	**3.71**	**3.63**	**2.70**	**3.18**	**2.94**	**4.54**	**4.99**	**4.76**	**3.12**	**3.41**	**3.26**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.035	0.1008	0.038	0.1094	0.089	0.2563	0.127	0.365	0.167	0.480	0.171	0.492
Distance (D)	0.017	0.0489	0.019	0.0547	0.044	0.1267	0.063	0.181	0.083	0.239	0.085	0.244
Interaction (AF X D)	0.049	0.1411	0.054	NS	0.125	NS	0.180	NS	0.236	NS	0.242	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XIII: Influence of teak based agroforestry system on Leaf Area Ratio (dm^{2} g^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
1. Teak+ Soybean	1.92	1.89	**1.90**	0.80	0.73	**0.76**	0.56	0.47	**0.51**	1.75	1.50	**1.62**	0.74	0.75	**0.74**	**0.48**	0.43	**0.45**
2. Teak+ Greengram	0.72	0.71	**0.71**	0.94	0.86	**0.90**	0.71	0.63	**0.67**	1.54	0.55	**0.54**	0.90	0.82	**0.86**	0.67	0.61	**0.64**
3.Teak+Frenchbean	1.94	1.80	**1.87**	0.84	0.73	**0.78**	0.42	0.40	0.41	1.92	1.86	**1.89**	0.76	0.69	**0.72**	0.40	0.38	**0.39**
Teak+ Blackgram	0.43	0.28	**0.35**	0.90	0.83	**0.86**	0.76	0.67	0.71	0.41	0.26	**0.33**	0.84	0.77	**0.80**	0.65	0.64	**0.64**
5. Sole Soybean	2.89	2.52	**2.70**	1.32	1.20	**1.26**	0.61	0.60	0.60	2.71	2.46	**2.58**	1.18	1.12	**1.15**	0.59	0.56	**0.57**
06. Sole Greengram	0.72	0.59	**0.65**	1.10	1.12	**1.11**	0.77	0.72	**0.74**	0.70	0.57	**0.63**	1.04	0.92	**0.98**	0.75	0.68	**0.71**
7. Sole Frenchbean	2.15	2.10	**2.12**	0.86	0.83	**0.84**	0.63	0.49	**0.56**	1.93	1.90	**1.91**	0.78	0.77	**0.75**	0.57	0.47	**0.52**
8. Sole Blackgram	0.52	0.46	**0.49**	1.12	1.09	**1.10**	0.88	0.77	**0.82**	0.40	0.40	**0.40**	1.08	1.01	**1.04**	0.86	0.73	**0.79**
Mean	**1.41**	**1.29**	**1.35**	**0.98**	**0.92**	**0.95**	**0.66**	**0.59**	**0.62**	**1.29**	**1.18**	**1.23**	**0.91**	**0.85**	**0.88**	**0.62**	**0.56**	**0.59**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
1.Agroforestry system(AF)	0.042	0.120	**0.021**	0.060	0.018	0.051	0.038	0.109	0.023	0.066	0.016	0.046
2. Distance (D)	0.021	0.060	0.010	0.028	0.009	0.025	0.019	0.054	0.011	0.031	0.008	0.023
3. Interaction (AFX D)	0.059	0.16	0.029	NS	0.031	NS	0.055	0.158	0.032	NS	0.022	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XIV: Influence of teak based agroforestry system on Leaf Area Duration (Days) at different stages in legumes

Agroforestry system	2007						2008					
	20 - 40 DAS			40 - 60 DAS			20 - 40 DAS			40 - 60 DAS		
	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
1. Teak+ Soybean	42.83	45.10	**43.96**	51.08	53.25	**51.16**	37.29	41.96	**39.62**	48.84	51.49	**50.16**
2. Teak+ Greengram	23.08	24.27	**23.67**	36.70	37.62	**37.16**	18.72	19.85	**19.28**	33.70	34.16	**33.93**
3. Teak+ Frenchbean	47.40	49.21	**48.30**	46.16	47.23	**46.69**	41.96	48.49	**45.22**	45.22	45.67	45.44
4 Teak+ Blackgram	22.19	23.38	**22.73**	36.93	37.52	**37.22**	19.54	21.25	**20.39**	34.91	35.26	**35.08**
5. Sole Soybean	70.15	74.46	**72.30**	71.16	74.96	**73.06**	67.31	74.86	**71..08**	67.00	73.00	**70.00**
6. Sole Greengram	29.15	30.26	**29.70**	53.26	54.45	**53.85**	26.28	27.67	**26.96**	51.16	52.11	**51.63**
7. Sole Frenchbean	48.26	53.96	**51.11**	50.76	54.66	**52.71**	48.26	49.44	**48.85**	48.28	52.64	**50.46**
8. Sole Blackgram	31.26	31.96	**31.58**	47.84	48.21	**48.02**	24.75	25.34	**25.04**	45.38	47.67	**46.52**
Mean	39.29	41.57	**40.43**	49.23	50.98	**50.10**	**35.51**	**38.60**	**37.05**	**46.81**	**49.00**	**47.90**

For comparing the means of	2007 20 - 40 DAS SEm ±	2007 20 - 40 DAS CD (0.05)	2007 40 - 60 DAS SEm ±	2007 40 - 60 DAS CD (0.05)	2008 20 - 40 DAS Sem ±	2008 20 - 40 DAS CD (0.05)	2008 40 - 60 DAS SEm ±	2008 40 - 60 DAS CD (0.05)
1. Agroforestry system (AF)	0.986	2.839	0.897	2.583	0.846	2.436	0.782	2.252
2. Distance (D)	0.493	1.419	0.448	1.290	0.423	1.218	0.391	1.126
3. Interaction (AFX D)	1.368	NS	1.269	NS	1.197	NS	1.106	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XV: Influence of teak based agroforestry system on photosynthetic rate (µmol CO_2 dm^{-2} s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	11.46	12.47	**11.97**	10.86	11.26	**11.06**	12.00	13.06	**12.58**	10.53	10.56	**10.55**
T_2-Teak + Greengram	10.95	11.57	**11.26**	8.86	9.50	**9.18**	10.95	12.40	**11.67**	9.40	9.90	**9.65**
T_3-Teak + Frenchbean	12.33	12.73	**12.53**	10.02	10.40	**10.21**	12.06	13.46	**12.76**	9.53	**10.66**	**10.10**
T_4-Teak + Black gram	10.50	10.88	**10.69**	8.80	9.20	**9.00**	10.96	11.63	**11.30**	9.00	9.23	**9.11**
T_5-Soybean (sole)	12.76	13.03	**12.90**	10.93.	11.33	11.13	12.33	12.96	**12.65**	10.33	10.83	**10.58**
T_6-Greengram (sole)	10.73	11.30	**11.01**	**9.46**	9.90	9.68	10.93	11.60	**11.26**	8.35	9.20	**8.77**
T_7-French bean (sole)	12.33	12.83	**12.58**	10.20	10.66	**10.43**	12.53	12.73	**12.63**	10.16	10.86	**10.51**
T_8-Black gram (sole)	11.07	11.76	**11.41**	9.20	9.56	**9.38**	11.66	12.10	**11.88**	9.30	10.33	**9.81**
Mean	11.52	12.07	**11.79**	9.79	10.22	**10.00**	**11.68**	**12.50**	**12.09**	**9.57**	**10.20**	9.88
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**Sem ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.085	0.2448		**0.139**	0.4003		0.258	0.743		**0.255**	**0.734**	
Distance (D)	0.042	0.1209		0.069	0.1987		0.129	0.371		0.127	0.365	
Interaction (AF X D)	0.120	NS		0.196	NS		0.365	NS		0.360	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XVI: Influence of teak based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	4.07	4.20	**4.14**	5.14	5.26	**5.20**	3.76	4.01	**3.89**	5.33	5.86	**5.60**
T_2-Teak + Greengram	3.82	3.91	**3.87**	3.26	3.43	**3.35**	3.10	3.36	**3.23**	4.30	4.76	**4.53**
T_3-Teak + Frenchbean	4.21	4.35	**4.28**	5.46	5.60	**3.53**	4.05	4.23	**4.14**	5.66	**6.23**	5.95
T_4-Teak + Black gram	3.43	3.52	**3.48**	2.91	3.63	**3.27**	3.20	3.35	**3.27**	3.40	3.86	**3.63**
T_5-Soybean (sole)	4.36	4.51	**4.43**	5.35.	5.61	5.48	4.40	4.61	**4.50**	5.65	5.85	**5.75**
T_6-Greengram (sole)	3.85	4.00	**3.92**	**3.28**	3.51	3.40	3.06	3.26	**3.16**	3.40	3.61	**3.50**
T_7-French bean (sole)	4.28	4.41	**4.35**	5.50	5.95	**5.72**	4.16	4.40	**4.28**	5.46	5.75	**5.60**
T_8-Black gram (sole)	3.55	3.66	**3.60**	3.06	3.35	**3.20**	3.10	3.83	**3.46**	3.46	3.60	**3.53**
Mean	3.94	4.07	**4.00**	4.24	4.54	**4.39**	**3.00**	**3.88**	**3.44**	**4.58**	**4.94**	4.76

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.027	0.077	**0.041**	0.118	0.166	0.478	**0.238**	**0.685**
Distance (D)	0.013	0.037	0.020	0. 058	0.083	0.239	0.119	0.342
Interaction (AF X D)	0.038	NS	0.058	0.167	0.236	NS	0.337	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XVII: Influence of teak based agroforestry system on transpiration rate (mg H_2O m^{-2} s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	3.58	3.75	**3.66**	4.28	4.36	**4.32**	3.85	3.83	**3.84**	4.50	4.73	**4.61**
T_2-Teak + Greengram	3.30	3.45	**3.37**	3.67	3.81	**3.74**	3.13	3.30	**3.21**	3.88	4.33	**4.10**
T_3-Teak + Frenchbean	3.56	3.76	**3.66**	4.43	4.46	**4.45**	3.21	3.53	**3.37**	4.26	**5.18**	4.72
T_4-Teak + Black gram	3.15	3.36	**3.25**	3.58	3.70	**3.64**	2.96	3.33	**3.15**	3.76	3.60	**3.68**
T_5-Soybean (sole)	4.08	4.28	**4.18**	4.63	4.69	4.66	4.05	4.33	**4.19**	4.43	5.36	**4.90**
T_6-Greengram (sole)	3.44	3.61	**3.53**	**4.18**	4.30	4.24	3.20	3.86	**3.53**	4.06	4.20	**4.13**
T_7-French bean (sole)	3.76	3.91	**3.84**	4.46	4.65	**4.55**	3.21	3.53	**3.32**	5.00	5.16	**5.08**
T_8-Black gram (sole)	3.25	3.40	**3.32**	3.73	3.85	**3.79**	3.25	3.55	**3.40**	3.71	4.21	**4.06**
Mean	3.51	3.69	**3.60**	4.12	4.23	**4.17**	**3.36**	**3.64**	**3.50**	**4.22**	**4.60**	4.41
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**Sem ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.036	0.10368		**0.038**	0.10944		0.120	0.345		**0.208**	**0.599**	
Distance (D)	0.018	0.05184		0.019	0.05447		0.060	0.172		0.104	0.299	
Interaction (AF X D)	0.051	NS		0.054	NS		0.169	NS		0.294	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XVIII: Influence of teak based agroforestry system on relative water content (RWC, %) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	89.40	91.01	**90.20**	85.36	86.90	**86.13**	77.63	80.06	**78.85**	83.16	90.43	**86.80**	69.86	72.66	**71.26**	53.70	61.50	**57.60**
T_2-Teak + Greengram	79.03	81.10	**80.06**	76.73	77.90	**77.31**	73.23	74.46	**73.85**	77.13	78.00	**77.56**	69.90	70.50	**70.23**	63.96	66.66	**65.31**
T_3-Teak + Frenchbean	86.43	86.33	**86.38**	84.90	85.40	**85.15**	80.02	81.33	**80.68**	82.80	87.13	**84.96**	57.20	65.36	**61.28**	52.80	59.10	**55.95**
T_4-Teak + Black gram	78.16	79.26	**78.17**	76.00	76.73	**76.36**	72.56	72.93	**72.95**	75.13	82.46	**79.00**	58.00	62.63	**60.31**	51.56	61.86	**56.71**
T_5-Soybean (sole)	90.65	91.96	**91.30**	86.03	86.63	**86.33**	78.46	80.60	**79.53**	91.06	91.66	**91.36**	67.10	68.76	**67.93**	50.93	60.30	**55.61**
T_6-Greengram (sole)	80.43	81.43	**80.93**	76.96	78.20	**77.58**	73.63	74.83	**74.23**	80.33	82.66	**81.55**	60.10	73.90	**67.00**	52.33	62.70	**57.51**
T_7-French bean (sole)	87.20	88.63	**87.91**	85.19	85.86	**85.53**	80.56	81.63	**81.10**	85.13	87.76	**86.45**	70.50	70.55	**70.52**	56.83	61.63	**59.23**
T_8-Black gram (sole)	80.16	80.90	**80.53**	76.93	77.63	**77.28**	73.70	74.40	**74.05**	85.86	83.83	**79.85**	67.63	70.83	**69.23**	54.60	61.43	**58.01**
Mean	**83.93**	**85.08**	**84.50**	**81.01**	**81.90**	**81.45**	**76.22**	**77.53**	**81.37**	**85.50**	**85.49**	**85.49**	**69.05**	**69.39**	**69.22**	**54.59**	**61.90**	**58.24**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.433	1..2470	**0.199**	0.5731	0.257	0.7401	1.195	3.441	**2.468**	**7.107**	1.693	4.875
Distance (D)	0.216	0.6220	0.099	0.2851	0.128	0..3686	0.597	1.719	1.234	3.553	0.846	2.436
Interaction (AF X D)	0.612	NS	0.282	NS	0.363	NS	1.690	NS	3.490	NS	2.395	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XIX: Influence of teak based agroforestry system on light transmission ratio (LTR, %) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	67.96	90.56	79.26	64.53	82.00	73.26	60.43	77.70	69.06	74.33	88.53	81.43	63.06	67.70	65.38	62.16	67.76	64.96
T_2-Teak + Greengram	64.53	88.00	76.26	63.21	81.31	72.26	57.36	64.86	61.11	66.40	81.72	74.06	63.06	68.83	65.95	56.96	63.60	60.28
T_3-Teak + Frenchbean	68.40	92.73	80.56	68.54	84.46	76.50	65.16	79.66	72.41	68.06	90.60	79.33	69.76	76.00	72.88	60.60	72.70	66.65
T_4-Teak + Black gram	67.36	83.46	75.41	62.20	81.86	72.03	54.83	59.63	57.23	66.86	85.10	75.96	62.33	74.50	68.41	56.33	66.20	61.26
T_5-Soybean (sole)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
T_6-Greengram (sole)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
T_7-French bean (sole)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
T_8-Black gram (sole)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mean	83.53	94.34	**88.93**	82.31	91.20	**86.75**	79.72	85.23	**82.47**	84.45	93.24	**88.84**	82.27	85.87	**84.07**	79.50	83.78	**81.64**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.939	2.7043	**1.004**	2.8915	0.799	2.30112	0.919	2.646	**0.990**	**2.851**	1.378	3.968
Distance (D)	0.469	1.3607	0.502	1.4457	0.399	1.14912	0.459	1.321	0.495	1.425	0.689	1.984
Interaction (AF X D)	1.327	3.8217	1.421	4.0924	1.129	3.2615	1.300	3.744	1.400	NS	1.949	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XX: Influence of teak based agroforestry system on chlorophyll "a" (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	1.878	1.627	**1.753**	1.642	1.593	**1.612**	0.863	0.697	**0.790**	1.80	1.64	**1.72**	1.84	1.67	**1.76**	0.73	0.66	0.69
T_2-Teak + Greengram	0.935	0.916	**0.926**	1.508	1.448	**1.478**	0.710	0.687	**0.698**	0.85	0.82	**0.84**	1.57	1.45	**1.51**	0.65	0.64	**0.64**
T_3-Teak + Frenchbean	1.218	1.064	**1.141**	1.013	0.904	**0.959**	0.687	0.610	**0.648**	1.20	1.06	**1.13**	0.92	0.88	**0.90**	0.60	0.51	**0.56**
T_4-Teak + Black gram	1.170	1.117	**1.143**	1.367	1.332	**1.350**	0.725	**0.632**	**0.678**	1.13	1.10	**1.12**	1.38	1.31	**1.34**	0.68	0.61	**0.65**
T_5-Soybean (sole)	1.823	1.815	**1.819**	1.655	1.644	**1.649**	0.818	**0.779**	**0.798**	1.89	1.85	**1.87**	1.85	1.64	**1.75**	0.76	0.77	**0.76**
T_6-Greengram (sole)	0.933	0.912	**0.923**	1.590	1.532	**1.561**	0.738	**0.695**	**0.717**	0.89.	0.88	**0.88**	1.57	1.50	**1.53**	0.58	0.62	0.60
T_7-French bean (sole)	1.178	1.170	**0.174**	1.018	0.955	**0.982**	0.630	**0.575**	**0.602**	1.19	1.14	**1.16**	0.96	0.90	**0.93**	0.60	0.50	**0.35**
T_8-Black gram (sole)	1.167	1.122	**1.144**	1.370	0.968	**1.169**	0.745	**0.690**	**0.718**	1.11	1.12	**1.11**	1.40	1.35	**1.38**	0.72	0.68	**0.70**
Mean	**1.288**	**1.218**	**1.253**	**1.395**	**1.297**	**1.346**	**0.742**	**0.670**	**1.20**	**1.25**	**1.20**	**1.34**	**1.43**	**1.33**	**1.38**	**0.66**	**0.62**	**0.64**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.021	0.040	**0.059**	0.164	0.016	0.046	0.038	0.109	**0.023**	**0.066**	0.027	0.077
Distance (D)	0.010	0.028	0.029	0.083	0.008	0.023	0.019	0.054	0.011	0.031	0.013	NS
Interaction (AF X D)	0.029	0.083	0.083	NS	0.023	NS	0.054	NS	0.032	NS	0.039	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXI: Influence of teak based agroforestry system on chlorophyll "b" (mg g fresh wt^{-1}) at different stages in legumes (pooled)

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	**Mean**	D_1	D_2	**Mean**	D_1	D_2	**Mean**	D_1	D_2	**Mean**	D_1	D_2	**Mean**	D_1	D_2	**Mean**
T_1-Teak + Soybean	0.503	0.478	**0.491**	0.678	0.442	**0.560**	0.323	0.303	**0.313**	0.49	0.46	0.48	0.54	0.48	0.51	3.34	0.30	**0.32**
T_2-Teak + Greengram	0.407	0.342	**0.374**	0.460	0.393	**0.426**	0.320	0.291	**0.305**	0.40	0.32	**0.36**	0.36	0.35	**0.36**	0.33	0.24	**0.28**
T_3-Teak + Frenchbean	0.752	0.683	**0.718**	0.354	0.338	**0.346**	0.222	0.208	**0.215**	0.74	0.64	**0.69**	0..40	0.37	0.39	0.22	0.20	**0.21**
T_4-Teak + Black gram	0.774	0.733	**0.754**	0.688	0.680	**0.684**	0.263	0.282	**0.272**	0.78	0.73	**0.75**	0.67	0.61	**0.64**	0.27	0.22	**0.25**
T_5-Soybean (sole)	0.523	0.500	**0.512**	0.348	0.308	**0.328**	0.302	0.287	**0.294**	0.58	0.51	**0.54**	0.60	0.48	**0.54**	0.33	0.31	**0.32**
T_6-Greengram (sole)	0.428	0.415	**0.421**	0.477	0.322	**0.429**	0.307	0.280	**0.293**	0.44	0.41	**0.43**	0.40	0.36	0.38	0.34	0.25	**0.29**
T_7-French bean (sole)	0.717	0.708	**0.712**	0.352	0.342	**0.347**	0.198	0.190	**0.194**	0.77	0.74	**0.76**	0.43	0.41	**0.42**	0.28	0.25	**0.26**
T_8-Black gram (sole)	0.772	0.733	**0.753**	0.678	0.658	**0.668**	0.228	0.183	**0.205**	0.76	0.74	**0.75**	0.66	0.64	**0.65**	0.22	0.20	**0.21**
Mean	**0.610**	**0.574**	**0.592**	**0.504**	**0.443**	**0.473**	**0.271**	**0.254**	**0.262**	**0.62**	**0.57**	**0.59**	**0.50**	**0.47**	**0.49**	**0.29**	**0.25**	**0.27**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.003	0.0008	0.009	0.0259	0.008	0.0230	0.017	0.048	0.008	0.0230	0.015	0.043
Distance (D)	0.001	0.0002	0.004	0.0115	0.004	0.0115	0.008	0.023	0.004	0.0115	0.007	0.030
Interaction (AF X D)	0.005	0.0144	0.013	0.0374	0.011	NS	0.024	NS	0.012	0.034	0.021	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXII: Influence of teak based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	2..382	2.105	**2.243**	2.352	2.034	**2.193**	1.206	1.000	**1.103**	2..298	2.107	**2.203**	2.390	2.158	**2.274**	1.077	0.963	**1.020**
T_2-Teak + Greengram	1.342	1.258	**1.300**	1.968	1.835	**1.902**	1.023	0.988	**1.006**	1..248	1.152	**1.200**	1.940	1.803	**1.872**	0.953	0.933	**0.943**
T_3-Teak + Frenchbean	1.970	1.747	**1.859**	1.367	1.242	**1.304**	0.895	0.832	**0.863**	1..943	1.717	**1.830**	1.330	1.257	**1.293**	0.800	0.770	**0.785**
T_4-Teak + Black gram	1.944	1.850	**1.897**	2.046	2.009	**2.028**	0.987	0.913	**0.950**	1..915	1.840	**1.878**	2.035	1.817	**1.926**	0.917	0.833	**0.875**
T_5-Soybean (sole)	2.167	2.315	**2.241**	2.000	1.952	**1.976**	1.105	1.063	**1.084**	2.480	2..372	**2.426**	2.453	2.135	**2.294**	1.163	1.053	**1.108**
T_6-Greengram (sole)	1.358	1.324	**1.341**	2.068	1.915	**1.991**	1.048	0.975	**1.012**	1..325	1.297	**1.311**	1.947	1.890	**1.918**	0.987	**0.863**	**0.925**
T_7-French bean (sole)	1.895	1.878	**1.886**	1.276	1.325	**1.300**	**0.827**	0.768	**0.798**	1.970	1.888	**1.929**	1.367	1.346	**1.356**	0.813	0.770	**0.792**
T_8-Black gram (sole)	1.941	1.854	**1.897**	2.049	1.960	**2.004**	0.952	0.895	**0.923**	1.800	1.863	**1.832**	2.050	2.020	**2.035**	0.923	0.890	**0.907**
Mean	**1.875**	**1.791**	**1.833**	**1.891**	**1.784**	**1.837**	**1.005**	**0.929**	**0.967**	**1.872**	**1.779**	**1.826**	**1.939**	**1.803**	**1.871**	**0.954**	**0.885**	**0.919**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.0304	0.0875	0.0167	0.0480	0.0199	0.0573	0.0447	0.1287	**0.0365**	**0.1051**	0.0314	0.0904
Distance (D)	0.0152	0.0437	0.0083	0.0239	0.0100	0.0288	0.0224	0.0645	0.0183	0.0527	0.0157	0.0452
Interaction (AF X D)	0.0430	0.1238	0.0236	0.0679	0.0282	0.0812	0.0633	0.1823	0.0516	0.1486	0.0444	0.1278

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXIII: Influence of teak based agroforestry system on Single Photoelectric Analyzing Diode (SPAD, %) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	29.10	28.26	**28.68**	33.53	32.83	**33.18**	27.00	26.43	**26.71**	29.53	27.26	**28.40**	32.73	32.73	**33.23**	**26.56**	**25.26**	**25.91**
T_2-Teak + Greengram	23.40	22.43	**22.91**	26.46	25.73	**26.10**	21.56	20.70	**21.13**	23.63	22.43	**23.03**	25.60	25.46	**25.53**	22.40	20.40	**21.40**
T_3-Teak + Frenchbean	29.43	28.73	**29.08**	32.03	31.50	**31.76**	25.70	20.56	**23.13**	28.43	27.83	**28.13**	**32.20**	30.93	**31.56**	**23.36**	21.9	**22.63**
T_4-Teak + Black gram	21.30	20.53	**20.96**	23.46	22.73	**23.09**	20.73	19.66	**20.20**	21.40	20.53	**20.96**	23.30	32.50	**22.90**	19.86	18.66	**19.26**
T_5-Soybean (sole)	31.83	30.60	**31.21**	33.46	33.06	**33.26**	27.06	25.96	**26.51**	31.16	30.10	**30.63**	33.20	31.9	**32.55**	27.16	25.31	**26.34**
T_6-Greengram (sole)	23.46	22.63	**23.00**	27.26	26.06	**26.66**	21.93	21.00	**21.46**	23.13	22.40	**22.76**	27.26	25.66	**26.46**	22.16	**20.36**	**21.26**
T_7-French bean (sole)	29.63	28.83	**29.23**	32.33	31.56	**31.95**	**26.46**	25.53	**24.00**	31.50	30.60	**31.05**	34.83	33.96	**34.40**	23.43	22.50	**22.96**
T_8-Black gram (sole)	21.43	20.86	**21.15**	23.50	22.66	**23.08**	21.16	19.66	**20.41**	21.86	21.50	**21.68**	24.06	22.66	**23.36**	20.50	19.00	**19.75**
Mean	**26.20**	**25.35**	**25.77**	**29.00**	**28.27**	**28.63**	**23.95**	**22.44**	**25.33**	**26.33**	**26.33**	**38.22**	**-**	**29.27**	**21.70**	**-**	**23.18**	**-**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.173	**0.4982**	0.179	**0.5155**	0.210	0.6048	0.310	0.915	**0.462**	**1.330**	0.365	1.051
Distance (D)	0.086	0.2476	**0.089**	0.2563	0.105	0.8024	0.159	0.457	0.231	0.665	0.112	0.524
Interaction (AF X D)	0.244	NS	0.254	0.73152	0.297	0.8553	0.450	NS	0.653	NS	0.517	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXIV: Influence of teak based agroforestry system nitrate reductase activity (nmol NO_2 formed g fresh wt^{-1} h^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	38.13	41.16	**39.68**	22.53	24.08	23.30	19.40	20.95	**20.17**	**39.26**	43.13	**41.20**	22.60	25.06	**23.83**	18.90	20.86	**19.88**
T_2-Teak + Greengram	17.31	17.41	**17.36**	14.22	14.31	**14.27**	11.28	11.71	**11.50**	17.63	20.66	**19.15**	14.45	14.70	**14.57**	11.31	11.55	**11.43**
T_3-Teak + Frenchbean	69.20	80.26	**74.75**	53.83	67.00	**60.41**	41.50	45.9	**43.70**	64.80	80.33	**72.56**	53.51	63.56	**58.54**	41.43	46.46	**43.95**
T_4-Teak + Black gram	19.63	20.70	**20.16**	20.95	22.45	**21.70**	18.60	19.20	**18.9**	19.73	22.46	**21.10**	18.00	20.66	**19.33**	16.23	16.43	**16.33**
T_5-Soybean (sole)	41.60	42.90	**42.25**	24.66	24.98	24.82	21.26	21.90	**21.58**	42.66	46.76	**44.71**	24.03	25.60	**24.81**	19.83	21.26	**20.55**
T_6-Greengram (sole)	17.18	17.48	**17.33**	13.66	13.96	13.81	10.86	11.09	**10.98**	18.73	21.66	**20.20**	13.63	14.33	**13.98**	10.43	11.10	**10.76**
T_7-French bean (sole)	80.93	81.30	**81.11**	68.10	69.16	68.63	37.41	42.26	**39.84**	81.30	81.53	**81.43**	61.53	65.41	**63.47**	42.00	44.06	**43.03**
T_8-Black gram (sole)	19.06	20.31	**19.69**	20.91	22.38	21.65	18.36	19.86	**19.11**	21.50	23.34	**22.42**	21.76	22.73	**22.25**	17.50	18.46	**17.98**
Mean	**37.88**	**40.19**	**39.03**	**29.86**	**33.29**	**31.57**	**22.83**	**24.11**	**23.47**	**38.20**	**42.48**	**40.34**	**28.68**	**31.50**	**30.09**	**22.20**	**23.77**	**22.98**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	Sem ±	CD (0.05)	Sem ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.759	**2.185**	0.544	**1.566**	0.562	1.618	1.29	3.715	**0.67**	**1.929**	0.41	1.180
Distance (D)	0.379	1.091	**0.72**	0.783	0.281	0.809	0.64	1.843	0.33	0.950	0.20	0.576
Interaction (AF X D)	1.073	3.090	0.769	2.214	0.795	2.289	1.82	5.241	0.94	2.707	0.59	1.699

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXV: Influence of teak based agroforestry system on number of pods per plant, seed weight per plant (g) and 100 seed weight (g) at different stages in legumes

Agroforestry system	**2007**									**2008**								
	Number of pod per plant			**Seed weight per plant (g)**			**100 seed weight (g)**			**Number of pod per plant**			**Seed weight per plant (g)**			**100 seed weight (g)**		
	D_1	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**	**D_1**	**D_2**	**Mean**
T_1-Teak + Soybean	51.86	58.76	**55.31**	7.79	10.90	9.34	**14.36**	15.96	15.16	51.50	58.93	56.21	**7.63**	9.80	8.71	**13.66**	**14.53**	14.10
T_2-Teak + Greengram	17.00	20.20	**18.60**	2.71	3.48	**3.09**	3.53	4.66	**4.10**	17.86	21.66	**19.76**	2.86	3.55	**3.20**	3.46	4.33	**3.90**
T_3-Teak + Frenchbean	19.83	27.00	**23.41**	8.25	10.66	**9.46**	16.16	**23.96**	20.06	13.90	14.87	**14.38**	7.91	**9.33**	8.62	17.50	**19.16**	**18.33**
T_4-Teak + Black gram	15.56	17.63	**16.60**	2.40	3.40	**2.90**	**2.69**	3.56	3.03	14.33	15.40	**14.86**	2.46	3.46	**2.96**	2.76	3.00	**2.88**
T_5-Soybean (sole)	53.41	62.46	**57.94**	10.73	12.46	11.60	**3.75**	4.90	4.32	43.06	68..43	**33.75**	10.26	11.33	**10.80**	13.06	13.76	**13.41**
T_6-Greengram (sole)	17.56	21.93	**19.75**	3.21	3.80	3.51	**3.73**	4.84	4.28	15.43	20.03	**17.73**	**3.18**	3.53	3.35	**3.63**	4.01	3.82
T_7-French bean (sole)	29.96	32.30	**31.13**	9.10	10.40	9.75	23.93	**29.16**	26.55	15.20	16.56	**15.88**	9.03	9.66	**9.35**	19.26	20.10	**19.68**
T_8-Black gram (sole)	16.53	19.26	**17.90**	2.53	3.45	2.99	**3.20**	3.76	3.48	15.33	17.03	**16.18**	2.60	3.16	**2.88**	2.76	4.66	**4.21**
Mean	27.71	32.46	**30.08**	5.84	7.32	6.58	**8.92**	11.33	10.12	23.57	29.11	26.34	**5.74**	6.73	6.23	**9.64**	10.44	**10.04**
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**Sem ±**	**CD (0.05)**		**Sem ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.639	**1.8403**		0.239	**0.688**		0.676	1.946		2.809	8.089		**0.211**	**0.607**		0.267	0.768	
Distance (D)	0.319	0.918		**0.119**	0.342		0.338	0.9734		1.404	4.043		0.105	0.302		0.133	0.383	
Interaction (AF X D)	0.904	2.603		0.338	0.973		0.957	2.736		3.972	NS		0.299	NS		0.378	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXVI: Influence of teak based agroforestry system on seed yield (kg ha^{-1}) in legumes

Agroforestry system	Seed yield (kg ha^{-1})					
	2007			2008		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Teak + Soybean	943.40	1047.11	**995.25**	813.33	883.50	**848.41**
T_2-Teak + Greengram	394.53	492.23	**443.38**	360.20	385.50	**372.85**
T_3-Teak + Frenchbean	1154.66	1263.66	**1209.16**	1050.00	1163.33	**1106.66**
T_4-Teak + Black gram	417.13	496.46	**456.80**	366.96	381.23	**374.10**
T_5-Soybean (sole)	950.60	1061.75	**1006.17**	938.50	941.73	**940.11**
T_6-Greengram (sole)	698.75	841.70	**770.22**	366.36	380.36	**373.36**
T_7-French bean (sole)	1205.50	1270.00	**1237.75**	1015.20	1125.00	**1070.10**
T_8-Black gram (sole)	725.36	535.43	**630.40**	378.53	382.53	**380.53**
Mean	**811.24**	**876.04**	**843.64**	**661.13**	**705.39**	**683.26**

For comparing the means of	**SEm ±**	**CD (0.05)**	**Sem ±**	**CD (0.05)**
Agroforestry system (AF)	14.94	48.02	21.82	62.84
Distance (D)	7.47	21.51	10.91	31.42
Interaction (AF X D)	21.13	60.85	30.86	NS

Appendix-XXVII: Influence of teak-perennial vegetable based agroforestry system on plant height (cm) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	14.10	15.20	**14.65**	16.30	17.50	**16.90**	20.90	21.80	**21.35**	12.69	13.68	**13.18**	14.67	15.70	**15.21**	18.84	19.62	**19.23**
T_2-Teak + Curryleaf + Greengram	6.90	7.80	**7.35**	14.20	15.10	**14.65**	20.20	20.80	**20.50**	6.21	7.02	**6.61**	12.78	13.59	**13.18**	18.18	18.72	**18.45**
T_3-Teak + Drumstick + Soybean	13.60	14.00	**13.80**	15.20	16.80	**16.00**	18.60	19.90	**19.25**	12.24	12.60	**12.42**	13.68	15.12	**14.40**	16.74	17.37	**17.05**
T_4-Teak + Drumstick + Greengram	6.50	6.90	**6.70**	13.10	14.30	**13.70**	18.10	18.95	**18.52**	5.85	6.21	**6.03**	11.79	12.87	**12.33**	16.29	17.05	**16.67**
T_5-Soybean (sole)	15.20	16.10	**15.65**	18.30	18.90	**18.60**	22.20	23.10	**22.65**	13.68	14.49	**14.08**	16.47	17.01	**16.74**	19.98	20.79	**20.38**
T_6-Greengram (sole)	8.50	8.90	**8.70**	16.90	17.40	**17.15**	21.60	22.30	**21.95**	7.65	8.01	**7.83**	15.21	15.66	**15.43**	19.44	20.07	**19.75**
Mean	**10.26**	**10.90**	**10.58**	**15.66**	**16.66**	**16.16**	**20.26**	**21.14**	**20.70**	**9.72**	**10.33**	**10.02**	**14.10**	**15.00**	**14.55**	**18.24**	**18.93**	**18.58**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.020	0.591	0.277	0.811	0.259	0.758	0.182	0.533	0.249	0.729	0.233	0.682
Distance (D)	0.117	0.342	0.160	0.468	0.149	0.436	0.105	0.307	0.144	0.421	0.134	0.392
Interaction (AF X D)	0.287	NS	0.392	NS	0.366	NS	0.258	NS	0.352	NS	0.330	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXVIII: Influence of teak-perennial vegetable based agroforestry system on number of branches per plant at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	2.50	3.50	**3.00**	6.10	8.10	**7.10**	8.60	9.20	**8.90**	2.25	3.15	**2.70**	5.49	7.29	**6.39**	7.74	8.28	**8.01**
T_2-Teak + Curryleaf + Greengram	2.60	3.10	**2.85**	6.00	7.50	**6.75**	8.10	8.90	**8.50**	2.34	2.79	**2.56**	5.40	6.75	**6.07**	7.29	8.01	**7.65**
T_3-Teak + Drumstick + Soybean	2.10	3.10	**2.60**	5.60	6.90	**6.25**	7.80	8.65	**8.22**	1.89	2.79	**2.34**	5.04	6.21	**5.62**	7.02	7.78	**7.40**
T_4-Teak + Drumstick + Greengram	2.60	3.00	**2.80**	5.30	6.20	**5.75**	7.80	7.90	**7.85**	2.34	2.70	**2.52**	4.77	5.58	**5.17**	7.02	7.11	**7.06**
T_5-Soybean (sole)	4.10	5.10	**4.60**	8.90	9.10	**9.00**	10.10	10.40	**10.25**	3.69	4.59	**4.14**	8.01	8.19	**8.10**	9.09	9.36	**9.22**
T_6-Greengram (sole)	3.50	3.60	**3.55**	8.50	8.90	**8.70**	9.60	10.20	**9.90**	3.15	3.24	**3.19**	7.65	8.01	**7.83**	8.64	9.15	**8.89**
Mean	**2.9**	**3.6**	**3.2**	**6.7**	**7.8**	**7.3**	**8.7**	**9.2**	**8.9**	**2.61**	**3.21**	**2.91**	**6.06**	**7.00**	**6.53**	**7.80**	**8.28**	**8.04**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.123	0.360	0.217	0.635	0.174	0.509	0.111	0.325	0.195	0.571	0.157	0.460
Distance (D)	0.071	0.208	0.125	0.336	1.100	0.293	0.064	0.187	0.113	0.331	0.090	0.263
Interaction (AF X D)	0.174	NS	0.307	NS	0.246	NS	0.157	NS	0.277	NS	0.222	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXIX: Influence of teak-perennial vegetable based agroforestry system on number of leaves per plant at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	8.85	9.65	**9.25**	18.27	19.64	**18.95**	23.58	24.83	**24.20**	7.96	8.68	**8.32**	16.44	17.67	**17.06**	21.22	22.34	**21.78**
T_2-Teak + Curryleaf + Greengram	6.39	6.75	**6.82**	13.86	15.50	**14.68**	16.85	17.73	**17.29**	5.75	6.07	**5.91**	12.47	13.95	**13.21**	15.16	15.95	**15.56**
T_3-Teak + Drumstick + Soybean	7.52	8.20	**7.86**	15.52	16.69	**16.10**	21.04	21.10	**20.57**	6.76	7.38	**7.70**	13.96	15.02	**14.49**	18.03	18.99	**18.51**
T_4-Teak + Drumstick + Greengram	5.43	5.73	**5.58**	11.78	13.17	**12.47**	15.16	15.95	**15.55**	4.88	5.15	**5.02**	10.60	11.85	**11.22**	13.64	14.35	**13.99**
T_5-Soybean (sole)	10.17	11.09	**10.63**	21.01	22.58	**21.79**	27.11	28.55	**27.83**	9.15	9.98	**9.56**	18.90	20.32	**19.61**	24.39	25.69	**25.04**
T_6-Greengram (sole)	7.34	7.76	**7.55**	15.93	17.82	**16.87**	19.37	20.38	**19.87**	6.60	6.98	**6.79**	14.33	16.03	**15.18**	17.43	18.34	**17.88**
Mean	**7.61**	**8.19**	**7.90**	**16.06**	**17.56**	**16.81**	**20.35**	**21.42**	**20.88**	**6.85**	**7.37**	**7.11**	**14.45**	**15.81**	**15.13**	**18.31**	**19.28**	**18.79**
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.181	0.530		0.638	1.869		4.943	14.482		**0.171**	**0.501**		**0.604**	**1.769**		**0.468**	**1.371**	
Distance (D)	0.104	0.304		0.368	1.078		0.285	0.835		0.099	0.290		0.349	1.022		0.270	0.791	
Interaction (AF X D)	0.256	NS		0.902	NS		0.699	NS		0.242	NS		0.855	NS		0.662	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXX: Influence of teak-perennial vegetable based agroforestry system on number of pods per plant at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	10.98	11.39	**11.18**	23.94	26.87	**25.40**	32.06	33.90	**32.98**	9.88	10.25	**10.06**	21.54	24.18	**22.86**	28.85	30.51	**29.68**
T_2-Teak + Curryleaf + Greengram	10.19	10.67	**10.43**	14.81	17.90	**16.35**	23.49	24.32	**23.90**	9.17	9.60	**9.38**	13.32	16.11	**14.72**	21.11	21.88	**21.50**
T_3-Teak + Drumstick + Soybean	9.33	9.68	**9.50**	20.34	22.83	**21.58**	27.25	28.81	**28.03**	8.39	8.70	**8.55**	18.30	20.54	**19.42**	24.52	25.92	**25.22**
T_4-Teak + Drumstick + Greengram	8.66	9.06	**8.86**	12.58	15.21	**13.89**	19.96	20.67	**20.31**	7.79	8.15	**7.97**	11.32	13.68	**12.50**	17.96	18.60	**18.28**
T_5-Soybean (sole)	12.62	13.09	**12.85**	27.53	30.90	**29.21**	36.86	38.98	**37.92**	11.35	11.78	**11.56**	24.77	27.81	**26.29**	33.17	35.08	**34.12**
T_6-Greengram (sole)	11.71	12.27	**11.99**	17.03	20.58	**18.80**	27.01	27.96	**27.48**	10.53	11.04	**10.79**	15.32	18.52	**16.92**	24.30	25.16	**24.73**
Mean	**10.58**	**11.02**	**11.80**	**19.37**	**22.38**	**20.87**	**21.62**	**29.10**	**25.36**	**9.52**	**9.92**	**9.72**	**17.43**	**20.14**	**18.78**	**24.99**	**26.19**	**25.59**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.159	0.465	0.405	1.186	0.304	0.890	**0.150**	**0.439**	**0.384**	**1.125**	**0.288**	**0.843**
Distance (D)	0.091	0.266	0.234	0.685	0.175	0.512	0.087	0.254	0.222	0.650	0.166	0.486
Interaction (AF X D)	0.225	NS	0.574	NS	0.430	NS	0.213	NS	0.543	NS	0.407	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXI: Influence of teak-perennial vegetable based agroforestry system on leaf area (dm^2 $plant^{-1}$) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	3.95	4.27	**4.10**	6.83	7.59	**7.21**	4.99	5.04	**5.01**	3.55	3.84	**3.70**	6.14	6.83	**6.48**	4.49	4.53	**4.51**
T_2-Teak + Curryleaf + Greengram	0.93	1.24	**1.08**	4.70	4.75	**4.72**	3.79	3.81	**3.80**	0.84	1.11	**0.97**	4.23	4.27	**4.25**	3.41	3.42	**3.42**
T_3-Teak + Drumstick + Soybean	3.73	4.03	**3.88**	6.48	7.17	**6.82**	4.28	4.70	**4.49**	3.35	3.63	**3.49**	6.01	6.45	**6.23**	3.85	4.23	**4.04**
T_4-Teak + Drumstick + Greengram	0.88	1.17	**2.05**	4.44	4.47	**4.45**	3.57	4.37	**3.97**	0.79	1.05	**0.92**	3.99	4.02	**4.01**	3.21	3.93	**3.57**
T_5-Soybean (sole)	5.04	5.46	**5.25**	7.85	8.72	**8.28**	5.73	5.79	**5.76**	4.53	4.91	**4.72**	7.06	7.84	**7.45**	5.15	5.21	**5.18**
T_6-Greengram (sole)	1.44	1.46	**1.45**	5.40	5.46	**5.43**	4.35	4.38	**4.36**	1.29	1.31	**1.30**	4.86	4.91	**4.88**	3.91	3.94	**3.92**
Mean	**2.66**	**2.93**	**2.79**	**5.95**	**6.36**	**6.15**	**4.45**	**4.68**	**4.56**	**2.39**	**2.64**	**2.51**	**5.38**	**5.72**	**5.55**	**4.00**	**4.21**	**4.10**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.395	1.157	0.077	0.225	0.110	0.322	0.037	0.108	0.073	0.213	0.104	0.304
Distance (D)	0.228	0.668	0.044	0.128	0.063	0.184	0.021	0.061	0.042	0.123	0.060	0.175
Interaction (AF X D)	0.055	NS	0.109	NS	0.156	NS	0.052	NS	0.103	NS	0.148	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXII: Influence of teak-perennial vegetable based agroforestry system on leaf dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	1.08	1.10	**1.09**	4.30	5.05	**4.67**	2.18	2.40	**2.29**	0.97	0.99	**0.98**	3.87	4.54	**4.20**	1.96	2.16	**2.06**
T_2-Teak + Curryleaf + Greengram	0.76	0.81	**0.78**	2.41	2.64	**2.52**	1.29	1.46	**1.37**	0.68	0.72	**0.70**	2.16	2.51	**2.34**	1.16	1.31	**1.23**
T_3-Teak + Drumstick + Soybean	1.02	1.06	**1.04**	3.65	4.29	**3.97**	1.85	2.04	**1.94**	0.91	0.92	**0.92**	3.28	3.86	**3.57**	1.66	1.83	**1.75**
T_4-Teak + Drumstick + Greengram	0.64	0.68	**0.66**	2.16	2.24	**2.20**	1.09	1.24	**1.16**	0.57	0.61	**0.59**	1.94	2.01	**1.98**	0.98	1.11	**1.04**
T_5-Soybean (sole)	1.24	1.26	**1.25**	4.94	5.80	**5.37**	2.50	2.76	**2.63**	1.11	1.13	**1.12**	4.44	5.22	**4.83**	2.25	2.48	**2.36**
T_6-Greengram (sole)	0.87	0.93	**0.90**	2.77	3.03	**2.90**	1.48	1.67	**1.57**	0.78	0.83	**0.81**	2.49	2.72	**2.61**	1.33	1.50	**1.41**
Mean	**0.93**	**0.97**	**0.95**	**3.37**	**3.84**	**3.60**	**1.73**	**1.92**	**1.82**	**0.84**	**0.87**	**0.85**	**3.03**	**3.48**	**3.25**	**1.55**	**1.73**	**1.64**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.043	0.125	0.176	0.515	0.167	0.489	0.079	0.231	0.106	0.310	0.158	0.462
Distance (D)	0.487	0.426	0.101	0.295	0.096	0.281	0.046	0.134	0.061	0.178	0.091	0.266
Interaction (AF X D)	0.119	NS	0.249	NS	0.237	NS	0.113	NS	0.150	NS	0.224	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXIII: Influence of teak-perennial vegetable based agroforestry system on stem dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	1.11	1.13	**1.12**	3.93	4.05	**3.99**	3.27	3.52	**3.39**	0.99	1.01	**1.00**	3.53	3.64	**3.59**	2.94	3.16	**3.05**
T_2-Teak + Curryleaf + Greengram	0.70	0.81	**0.75**	1.83	2.16	**1.99**	1.81	1.94	**1.87**	0.63	0.72	**0.67**	1.64	1.94	**1.79**	1.62	1.74	**1.68**
T_3-Teak + Drumstick + Soybean	0.94	0.96	**0.95**	3.34	3.44	**3.39**	2.77	2.99	**2.88**	0.84	0.86	**0.85**	3.00	3.09	**3.05**	2.49	2.69	**2.59**
T_4-Teak + Drumstick + Greengram	0.60	0.72	**0.66**	1.55	1.83	**1.69**	1.53	1.64	**1.58**	0.54	0.64	**0.59**	1.39	1.64	**1.52**	1.37	1.47	**1.42**
T_5-Soybean (sole)	1.27	1.30	**1.28**	4.51	4.65	**4.58**	3.76	4.04	**3.90**	1.14	1.17	**1.15**	4.05	4.18	**4.12**	3.43	3.63	**3.53**
T_6-Greengram (sole)	0.80	0.93	**0.86**	2.10	2.48	**2.29**	2.08	2.23	**2.15**	0.72	0.84	**0.78**	1.89	2.23	**2.06**	1.87	2.00	**1.93**
Mean	**0.90**	**0.97**	**0.93**	**2.87**	**3.10**	**2.98**	**2.53**	**2.72**	**2.62**	**0.81**	**0.87**	**0.84**	**2.58**	**2.79**	**2.68**	**2.29**	**2.45**	**2.37**
For comparing the means of	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**
Agroforestry system (AF)	0.108		0.316	0.125		0.366	0.047		0.137	0.103		0.301	0.118		0.345	0.044		0.128
Distance (D)	0.062		0.181	0.072		0.210	0.027		0.079	0.059		0.172	0.068		0.199	0.025		0.073
Interaction (AF X D)	0.153		NS	0.176		NS	0.066		NS	0.145		NS	0.167		NS	0.063		NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXIV: Influence of teak-perennial vegetable based agroforestry system on pod dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	40 DAS			Harvest			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.72	0.01	**0.86**	13.50	16.10	**14.80**	0.64	0.90	**0.77**	12.12	14.49	**13.30**
T_2-Teak + Curryleaf + Greengram	0.63	0.81	**0.72**	4.78	6.50	**5.64**	0.56	0.72	**0.64**	4.30	5.85	**5.07**
T_3-Teak + Drumstick + Soybean	0.61	0.85	**0.73**	11.47	13.68	**12.57**	0.54	0.76	**0.65**	10.26	12.24	**11.25**
T_4-Teak + Drumstick + Greengram	0.53	0.68	**0.60**	4.06	5.52	**4.79**	0.47	0.61	**0.54**	3.65	4.96	**4.31**
T_5-Soybean (sole)	0.82	0.16	**0.99**	15.52	18.51	**17.01**	0.73	1.04	**0.89**	13.95	16.62	**15.28**
T_6-Greengram (sole)	0.72	0.93	**0.82**	5.49	7.15	**6.32**	0.64	0.83	**0.74**	4.94	6.43	**5.68**
Mean	**0.67**	**0.90**	**0.78**	**9.13**	**11.24**	**10.18**	**0.60**	**0.81**	**0.70**	**8.20**	**10.10**	**9.15**

For comparing the means of	2007 40 DAS SEm ±	2007 40 DAS CD (0.05)	2007 Harvest SEm ±	2007 Harvest CD (0.05)	2008 40 DAS SEm ±	2008 40 DAS CD (0.05)	2008 Harvest SEm ±	2008 Harvest CD (0.05)
Agroforestry system (AF)	0.055	0.161	0.261	0.764	0.052	0.152	0.248	0.726
Distance (D)	0.032	0.093	0.151	0.442	0.030	0.087	0.143	0.418
Interaction (AF X D)	0.078	NS	0.370	NS	0.074	NS	0.350	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXV: Influence of teak-perennial vegetable based agroforestry system on total dry weight (g plant^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	2.19	2.23	**4.42**	8.95	10.11	**9.53**	18.95	22.02	**20.48**	1.97	2.00	**1.98**	8.05	9.09	**8.57**	17.05	19.81	**18.43**
T_2-Teak + Curryleaf + Greengram	1.46	1.62	**1.54**	4.87	5.61	**5.24**	7.88	9.90	**8.89**	1.31	1.45	**1.38**	4.38	5.04	**4.71**	7.09	8.91	**8.00**
T_3-Teak + Drumstick + Soybean	1.96	2.02	**1.99**	7.60	8.58	**8.09**	16.09	18.71	**17.40**	1.76	1.81	**1.79**	6.84	7.72	**7.28**	14.48	16.83	**15.66**
T_4-Teak + Drumstick + Greengram	1.24	1.40	**1.32**	4.4	4.75	**4.49**	6.68	8.40	**7.54**	1.11	1.26	**1.18**	3.81	4.27	**4.04**	6.01	7.56	**6.78**
T_5-Soybean (sole)	2.51	2.56	**2.53**	10.27	11.61	**10.94**	21.78	25.31	**23.54**	2.25	2.30	**2.28**	9.24	10.44	**9.84**	19.60	22.77	**21.19**
T_6-Greengram (sole)	1.67	1.86	**1.76**	5.59	6.44	**6.01**	9.05	11.05	**10.05**	1.50	1.67	**1.58**	5.03	5.79	**5.41**	8.14	9.94	**9.04**
Mean	**1.83**	**1.94**	**1.88**	**6.92**	**7.85**	**7.38**	**13.40**	**15.89**	**14.64**	**1.65**	**1.75**	**1.70**	**6.22**	**7.06**	**6.64**	**12.06**	**14.30**	**13.18**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.115	0.336	0.304	0.890	0.356	1.043	0.109	0.319	0.288	0.843	0.337	0.987
Distance (D)	0.066	0.193	0.175	0.512	0.205	0.600	0.063	0.184	0.166	0.486	0.195	0.571
Interaction (AF X D)	0.163	NS	0.430	NS	0.504	NS	0.155	NS	0.407	NS	0.477	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXVI: Influence of teak-perennial vegetable based agroforestry system on leaf area index (LAI) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			Harvest			20 DAS			40 DAS			Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	1.31	1.42	**1.37**	2.27	2.53	**2.40**	1.66	1.6	**1.67**	1.18	1.28	**1.23**	2.04	2.27	**2.16**	1.49	1.51	**1.50**
T_2-Teak + Curryleaf + Greengram	0.31	0.41	**0.36**	1.56	1.58	**1.57**	1.26	1.27	**1.26**	0.28	0.37	**0.32**	1.41	1.42	**1.41**	1.13	1.14	**1.14**
T_3-Teak + Drumstick + Soybean	1.24	1.34	**1.29**	2.16	2.39	**2.27**	1.42	1.56	**1.49**	1.11	1.21	**1.16**	1.94	2.15	**2.04**	1.28	1.41	**1.34**
T_4-Teak + Drumstick + Greengram	0.29	0.39	**0.34**	1.48	1.49	**1.48**	1.19	1.45	**1.32**	0.26	0.35	**0.30**	1.33	1.34	**1.33**	1.07	1.31	**1.19**
T_5-Soybean (sole)	1.68	1.82	**1.75**	2.61	2.90	**2.76**	1.91	1.93	**1.92**	1.51	1.63	**1.57**	2.35	2.61	**2.48**	1.71	1.73	**1.72**
T_6-Greengram (sole)	0.48	0.48	**0.48**	1.80	1.82	**1.81**	1.450	1.46	**1.45**	0.43	0.44	**0.43**	1.62	1.63	**1.62**	1.30	1.31	**1.30**
Mean	**0.88**	**0.98**	**0.93**	**1.98**	**2.120**	**2.05**	**1.48**	**1.56**	**1.52**	**0.80**	**0.88**	**0.84**	**1.78**	**1.90**	**1.84**	**1.33**	**1.40**	**1.36**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.014	0.041	0.031	0.090	0.038	0.111	0.012	0.035	0.028	0. 082	0.034	0.099
Distance (D)	0.008	0.023	0.018	0.052	0.022	0.064	0.007	0.020	0.016	0.046	0.020	0.058
Interaction (AF X D)	0.019	NS	0.044	NS	0.054	NS	0.017	NS	0.040	NS	0.049	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXVII: Influence of teak-perennial vegetable based agroforestry system on absolute growth rate (AGR, g plant^{-1} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest			20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.338	0.394	**0.366**	0.500	0.596	**0.548**	0.333	0.397	**0.365**	0.304	0.355	**0.329**	0.450	0.536	**0.493**	0.300	0.357	**0.329**
T_2-Teak + Curryleaf + Greengram	0.171	0.200	**0.185**	0.151	0.215	**0.183**	0.100	0.143	**0.122**	0.153	0.180	**0.166**	0.135	0.193	**0.164**	0.090	0.129	**0.110**
T_3-Teak + Drumstick + Soybean	0.282	0.328	**0.305**	0.424	0.506	**0.465**	0.283	0.338	**0.310**	0.254	0.295	**0.275**	0.382	0.456	**0.419**	0.255	0.304	**0.279**
T_4-Teak + Drumstick + Greengram	0.150	0.167	**0.159**	0.122	0.182	**0.152**	0.081	0.122	**0.101**	0.135	0.151	**0.143**	0.110	0.164	**0.137**	0.073	0.109	**0.091**
T_5-Soybean (sole)	0.388	0.452	**0.420**	0.575	0.685	**0.630**	0.384	0.456	**0.420**	0.349	0.407	**0.378**	0.518	0.616	**0.567**	0.345	0.411	**0.378**
T_6-Greengram (sole)	0.196	0.229	**0.213**	0.173	0.231	**0.202**	0.115	0.154	**0.135**	0.176	0.208	**0.191**	0.156	0.207	**0.182**	0.104	0.138	**0.121**
Mean	**0.254**	**0.295**	**0.275**	**0.324**	**0.402**	**0.363**	**0.216**	**0.268**	**0.242**	**0.229**	**0.266**	**0.247**	**0.292**	**0.362**	**0.327**	**0.195**	**0.241**	**0.218**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.0160	0.046	0.0163	0.047	0.0109	0.031	0.0150	0.043	0.0147	0.043	0.0098	0.028
Distance (D)	0.0096	0.028	0.0094	0.027	0.0063	0.018	0.0087	0.025	0.0085	0.024	0.0056	0.016
Interaction (AF X D)	0.0236	NS	0.0231	NS	0.0154	NS	0.0212	NS	0.0208	NS	0.0138	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXVIII: Influence of teak-perennial vegetable based agroforestry system on crop growth rate (CGR, g m^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest			20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.113	0.131	**0.122**	0.167	0.199	**0.183**	0.111	0.132	**0.122**	0.101	0.110	**0.110**	0.150	0.170	**0.164**	0.100	0.119	**0.110**
T_2-Teak + Curryleaf + Greengram	0.057	0.067	**0.062**	0.050	0.072	**0.061**	0.033	0.048	**0.041**	0.050	0.060	**0.055**	0.040	0.060	**0.055**	0.030	0.043	**0.037**
T_3-Teak + Drumstick + Soybean	0.094	0.109	**0.102**	0.141	0.169	**0.155**	0.094	0.113	**0.103**	0.080	0.090	**0.092**	0.120	0.150	**0.140**	0.085	0.101	**0.093**
T_4-Teak + Drumstick + Greengram	0.050	0.056	**0.053**	0.041	0.016	**0.051**	0.027	0.041	**0.034**	0.041	0.050	**0.048**	0.030	0.050	**0.046**	0.024	0.036	**0.030**
T_5-Soybean (sole)	0.129	0.151	**0.140**	0.192	0.228	**0.210**	0.128	0.152	**0.140**	0.110	0.130	**0.126**	0.170	0.200	**0.189**	0.115	0.137	**0.126**
T_6-Greengram (sole)	0.065	0.076	**0.071**	0.058	0.077	**0.067**	0.038	0.051	**0.045**	0.050	0.060	**0.064**	0.050	0.060	**0.061**	0.035	0.046	**0.040**
Mean	**0.085**	**0.098**	**0.092**	**0.108**	**0.134**	**0.121**	**0.072**	**0.089**	**0.081**	**0.072**	**0.089**	**0.082**	**0.097**	**0.121**	**0.109**	**0.065**	**0.080**	**0.073**
For comparing the means of	**SEm ±**	**CD(0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.0053	0.014		0.0050	0.014		0.0031	0.008		0.0050	0.0146		0.0049	0.0143		0.0033	0.0096	
Distance (D)	0.0036	0.008		0.0030	0.008		0.0023	0.005		0.0029	0.0084		0.0028	0.0082		0.0019	0.0055	
Interaction (AF X D)	0.0071	NS		0.0070	NS		0.0052	NS		0.0071	NS		0.0069	NS		0.0046	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXIX: Influence of teak-perennial vegetable based agroforestry system on relative growth rate (RGR, g m^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest			20 - 40 DAS			40 - 60 DAS			60 DAS - Harvest		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.030	0.033	**0.032**	0.017	0.017	**0.017**	0.011	0.011	**0.011**	0.027	0.030	**0.028**	0.015	0.015	**0.015**	0.010	0.010	**0.010**
T_2-Teak + Curryleaf + Greengram	0.026	0.27	**0.027**	0.011	0.012	**0.011**	0.007	0.008	**0.008**	0.024	0.024	**0.024**	0.009	0.011	**0.010**	0.006	0.007	**0.007**
T_3-Teak + Drumstick + Soybean	0.303	0.031	**0.031**	0.016	0.017	**0.017**	0.011	0.011	**0.011**	0.027	0.028	**0.028**	0.015	0.015	**0.015**	0.010	0.010	**0.010**
T_4-Teak + Drumstick + Greengram	0.027	0.027	**0.027**	0.101	0.012	**0.011**	0.007	0.008	**0.007**	0.024	0.024	**0.024**	0.009	0.011	**0.010**	0.006	0.007	**0.007**
T_5-Soybean (sole)	0.031	0.033	**0.032**	0.016	0.017	**0.017**	0.011	0.011	**0.011**	0.028	0.030	**0.029**	0.015	0.015	**0.015**	0.010	0.010	**0.010**
T_6-Greengram (sole)	0.027	0.027	**0.027**	0.010	0.012	**0.011**	0.007	0.008	**0.007**	0.024	0.024	**0.024**	0.009	0.011	**0.010**	0.006	0.007	**0.007**
Mean	**0.029**	**0.030**	**0.029**	**0.013**	**0.015**	**0.014**	**0.009**	**0.010**	**0.009**	**0.026**	**0.027**	**0.026**	**0.012**	**0.013**	**0.013**	**0.008**	**0.009**	**0.008**

For comparing the means of	SEm ±	CD(0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.0015	0.0042	0.0006	0.0017	0.0004	0.0011	0.0014	0.0041	0.0006	0.0017	0.0004	0.0011
Distance (D)	0.0009	0.0026	0.0004	0.0011	0.0002	0.0058	0.0008	0.0023	0.0003	0.0087	0.0002	0.0058
Interaction (AF X D)	0.0021	NS	0.0009	NS	0.0006	NS	0.0019	NS	0.0008	NS	0.0005	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXX: Influence of teak-perennial vegetable based agroforestry system on net assimilation rate (NAR, g m^{-2} day^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 - 40 DAS			40 - 60 DAS			20 - 40 DAS			40 - 60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.028	0.030	**0.029**	0.037	0.042	**0.039**	0.025	0.027	**0.026**	0.033	0.037	**0.035**
T_2-Teak + Curryleaf + Greengram	0.032	0.033	**0.032**	0.015	0.022	**0.019**	0.029	0.030	**0.029**	0.014	0.020	**0.017**
T_3-Teak + Drumstick + Soybean	0.025	0.026	**0.025**	0.035	0.038	**0.036**	0.022	0.024	**0.023**	0.031	0.034	**0.033**
T_4-Teak + Drumstick + Greengram	0.030	0.030	**0.030**	0.013	0.108	**0.016**	0.027	0.027	**0.027**	0.012	0.016	**0.014**
T_5-Soybean (sole)	0.027	0.028	**0.027**	0.037	0.041	**0.039**	0.024	0.025	**0.025**	0.033	0.037	**0.035**
T_6-Greengram (sole)	0.028	0.033	**0.031**	0.015	0.020	**0.018**	0.026	0.030	**0.028**	0.014	0.018	**0.016**
Mean	**0.028**	**0.030**	**0.029**	**0.026**	**0.030**	**0.028**	**0.025**	**0.027**	**0.026**	**0.023**	**0.027**	**0.025**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.0015	0.0042	0.0010	0.0029	0.0014	0.0041	0.0011	0.0032
Distance (D)	0.0009	0.0026	0.0006	0.0017	0.0008	0.0023	0.0006	0.0017
Interaction (AF X D)	0.0022	NS	0.0015	NS	0.0020	NS	0.0015	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXI: Influence of teak-perennial vegetable based agroforestry system on specific leaf weight (g dm^{-2}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.271	0.255	**0.263**	0.630	0.666	**0.648**	0.444	0.476	**0.460**	0.244	0.229	**0.236**	0.567	0.599	**0.583**	0.399	0.428	**0.414**
T_2-Teak + Curryleaf + Greengram	0.816	0.654	**0.735**	0.516	0.587	**0.552**	0.340	0.384	**0.362**	0.735	0.589	**0.662**	0.465	0.529	**0.497**	0.306	0.346	**0.326**
T_3-Teak + Drumstick + Soybean	0.273	0.255	**0.264**	0.547	0.597	**0.572**	0.447	0.437	**0.442**	0.245	0.229	**0.237**	0.492	0.537	**0.514**	0.402	0.394	**0.398**
T_4-Teak + Drumstick + Greengram	0.728	0.581	**0.655**	0.485	0.501	**0.493**	0.298	0.281	**0.289**	0.656	0.523	**0.589**	0.437	0.451	**0.444**	0.268	0.253	**0.260**
T_5-Soybean (sole)	0.246	0.231	**0.239**	0.630	0.665	**0.648**	0.437	0.475	**0.456**	0.222	0.208	**0.215**	0.567	0.599	**0.583**	0.393	0.427	**0.410**
T_6-Greengram (sole)	0.603	0.638	**0.621**	0.513	0.559	**0.536**	0.339	0.382	**0.360**	0.543	0.575	**0.559**	0.462	0.503	**0.482**	0.305	0.343	**0.324**
Mean	**0.490**	**0.436**	**0.463**	**0.554**	**0.596**	**0.575**	**0.384**	**0.406**	**0.395**	**0.441**	**0.392**	**0.416**	**0.498**	**0.536**	**0.517**	**0.346**	**0.365**	**0.355**

For comparing the means of	SEm ±	CD(0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.045	0.131	0.023	0.067	0.043	0.125	0.040	0.117	0.021	0.061	0.038	0.111
Distance (D)	0.026	0.076	0.013	0.038	0.024	0.070	0.023	0.067	0.012	0.035	0.022	0.064
Interaction (AF X D)	0.064	NS	0.033	NS	0.060	NS	0.057	NS	0.029	NS	0.054	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXII: Influence of teak-perennial vegetable based agroforestry system on specific leaf area (g dm^{-2}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	4.043	4.039	**4.041**	1.596	1.504	**1.550**	2.346	2.102	**2.224**	3.63	3.63	**3.63**	1.43	1.35	**1.39**	2.11	1.89	**2.00**
T_2-Teak + Curryleaf + Greengram	1.283	1.636	**1.461**	2.018	1.810	**1.914**	3.499	2.614	**3.056**	1.15	1.47	**1.31**	1.81	1.62	**1.72**	3.14	2.35	**2.75**
T_3-Teak + Drumstick + Soybean	4.333	3.855	**4.094**	1.774	1.687	**1.730**	2.414	2.402	**2.408**	3.46	3.89	**3.68**	1.59	1.51	**1.55**	2.17	2.16	**2.16**
T_4-Teak + Drumstick + Greengram	1.417	1.728	**1.572**	2.181	2.052	**2.116**	4.725	4.401	**4.563**	1.27	1.55	**1.41**	1.96	1.84	**1.90**	4.25	3.96	**4.10**
T_5-Soybean (sole)	4.072	4.336	**4.204**	1.589	1.503	**1.546**	2.335	2.134	**2.235**	3.66	3.90	**3.78**	1.43	1.35	**1.39**	2.10	1.92	**2.01**
T_6-Greengram (sole)	1.678	1.574	**1.626**	1.956	1.841	**1.898**	2.977	2.628	**2.803**	1.51	1.41	**1.46**	1.76	1.65	**1.70**	2.67	2.36	**2.52**
Mean	**2.804**	**2.862**	**2.833**	**1.852**	**1.733**	**1.792**	**3.049**	**2.713**	**2.881**	**2.52**	**2.57**	**2.55**	**1.66**	**1.56**	**1.61**	**2.74**	**2.44**	**2.59**
For comparing the means of	**SEm ±**	**CD(0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.324	0.949		0.097	0.284		0.542	1.588		0.291	0.852		0.087	0.254		0.488	1.429	
Distance (D)	0.187	0.547		0.056	0.164		0.313	NS		0.168	0.492		0.050	0.146		0.282	NS	
Interaction (AF X D)	0.458	NS		0.138	NS		0.767	NS		0.412	NS		0.124	NS		0.691	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXIII: Influence of teak-perennial vegetable based agroforestry system on leaf area ratio ($dm^{-2}\ g^{-1}$) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	1.807	1.922	**1.865**	0.715	0.676	**0.695**	0.264	0.229	**0.247**	1.62	1.73	**1.67**	0.71	0.67	**0.69**	0.23	0.20	**0.22**
T_2-Teak + Curryleaf + Greengram	0.662	0.779	**0.720**	0.882	0.763	**0.822**	0.482	0.385	**0.433**	0.59	0.70	**0.64**	0.88	0.76	**0.82**	0.43	0.34	**0.39**
T_3-Teak + Drumstick + Soybean	2.122	2.000	**2.061**	0.774	0.752	**0.763**	0.266	0.252	**0.259**	1.91	1.80	**1.85**	0.77	0.75	**0.76**	0.24	0.22	**0.23**
T_4-Teak + Drumstick + Greengram	0.716	0.841	**0.778**	0.944	0.852	**0.898**	0.535	0.523	**0.529**	0.64	0.75	**0.70**	0.94	0.85	**0.89**	0.48	0.47	**0.47**
T_5-Soybean (sole)	2.028	2.142	**2.085**	0.688	0.680	**0.684**	0.263	0.229	**0.246**	1.82	1.92	**1.87**	0.69	0.68	**0.68**	0.23	0.20	**0.22**
T_6-Greengram (sole)	0.908	0.790	**0.849**	0.872	0.764	**0.818**	0.481	0.396	**0.438**	0.81	0.71	**0.76**	0.87	0.76	**0.81**	0.43	0.35	**0.39**
Mean	**1.374**	**1.412**	**1.393**	**0.813**	**0.748**	**0.780**	**0.382**	**0.336**	**0.359**	**1.23**	**1.27**	**1.25**	**0.81**	**0.74**	**0.78**	**0.34**	**0.30**	**0.32**

For comparing the means of	2007 20 DAS SEm ±	2007 20 DAS CD(0.05)	2007 40 DAS SEm ±	2007 40 DAS CD (0.05)	2007 60 DAS SEm ±	2007 60 DAS CD (0.05)	2008 20 DAS SEm ±	2008 20 DAS CD (0.05)	2008 40 DAS SEm ±	2008 40 DAS CD (0.05)	2008 60 DAS SEm ±	2008 60 DAS CD (0.05)
Agroforestry system (AF)	0.110	0.322	0.035	0.102	0.008	0.023	0.099	0.290	0.035	0.102	0.008	0.023
Distance (D)	0.063	0.184	0.020	0.058	0.005	0.014	0.057	0.167	0.020	0.058	0.005	0.014
Interaction (AF X D)	0.156	NS	0.050	NS	0.012	NS	0.140	NS	0.050	NS	0.012	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXIV: Influence of teak-perennial vegetable based agroforestry system on leaf area duration (days) at different stages in legumes

Agroforestry system	2007						2008					
	20 - 40 DAS			40 - 60 DAS			20 - 40 DAS			40 - 60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	49.11	53.78	**54.45**	62.17	67.40	**64.78**	44.20	48.41	**46.30**	55.95	60.66	**58.30**
T_2-Teak + Curryleaf + Greengram	21.90	24.12	**23.01**	43.96	44.38	**44.17**	19.71	21.70	**20.71**	39.57	39.94	**39.75**
T_3-Teak + Drumstick + Soybean	46.47	50.81	**48.64**	57.46	63.47	**60.47**	41.82	45.73	**43.78**	51.72	57.12	**54.42**
T_4-Teak + Drumstick + Greengram	20.69	22.72	**21.71**	41.50	44.36	**42.93**	18.62	20.45	**19.53**	37.35	39.93	**38.64**
T_5-Soybean (sole)	59.77	65.46	**62.62**	71.43	77.43	**74.43**	53.80	58.92	**56.36**	64.29	69.69	**66.99**
T_6-Greengram (sole)	27.66	27.93	**27.79**	50.50	51.00	**50.75**	24.89	25.14	**25.01**	45.45	45.40	**45.67**
Mean	**37.60**	**40.80**	**39.20**	**54.50**	**58.00**	**56.25**	**33.84**	**36.72**	**35.28**	**49.05**	**52.20**	**50.62**
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.352	1.031		0.845	2.475		0.317	0.928		0.760	2.226	
Distance (D)	0.203	0.594		0.488	1.429		0.183	0.536		0.439	1.286	
Interaction (AF X D)	0.498	NS		1.195	NS		0.449	NS		1.075	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXV: Influence of teak-perennial vegetable based agroforestry system on photosynthetic rate (µmol CO_2 dm^{-2} s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	11.13	12.23	**11.68**	11.00	11.47	**11.23**	10.02	11.01	**10.51**	9.90	10.41	**10.15**
T_2-Teak + Curryleaf + Greengram	10.92	11.47	**11.19**	9.38	9.62	**9.50**	9.82	10.32	**10.07**	8.35	8.62	**8.49**
T_3-Teak + Drumstick + Soybean	10.53	10.63	**10.56**	10.27	11.37	**10.82**	9.48	9.57	**9.52**	9.24	10.23	**9.73**
T_4-Teak + Drumstick + Greengram	9.40	10.14	**9.76**	9.43	9.47	**9.45**	8.46	9.12	**8.79**	8.67	8.52	**8.59**
T_5-Soybean (sole)	12.65	13.42	**13.04**	11.08	11.60	**11.34**	11.40	11.92	**11.66**	9.70	10.14	**9.92**
T_6-Greengram (sole)	10.80	11.90	**11.35**	9.72	9.82	**9.77**	9.72	10.71	**10.21**	7.84	8.43	**8.14**
Mean	**10.90**	**11.63**	**11.26**	**10.14**	**10.55**	**10.34**	**9.81**	**10.44**	**10.13**	**8.95**	**9.39**	**9.17**

For comparing the means of	2007 20 DAS SEm ±	2007 20 DAS CD(0.05)	2007 40 DAS SEm ±	2007 40 DAS CD (0.05)	2008 20 DAS SEm ±	2008 20 DAS CD (0.05)	2008 40 DAS SEm ±	2008 40 DAS CD (0.05)
Agroforestry system (AF)	0.15	0.433	0.22	0.635	0.131	0.383	0.204	0.597
Distance (D)	0.08	0.231	0.13	0.375	0.075	0.219	0.118	0.345
Interaction (AF X D)	0.20	NS	0.31	NS	0.185	NS	0.289	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXVI: Influence of teak-perennial vegetable based agroforestry system on stomatal conductance (cm s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	4.00	4.19	**4.10**	5.20	5.22	**5.20**	3.60	3.77	**3.68**	4.21	4.19	**4.20**
T_2-Teak + Curryleaf + Greengram	3.75	3.78	**3.76**	3.17	3.60	**3.38**	3.37	3.40	**3.39**	2.56	2.78	**2.67**
T_3-Teak + Drumstick + Soybean	3.52	3.60	**3.55**	4.67	4.88	**4.78**	3.16	3.24	**3.20**	3.78	3.90	**3.84**
T_4-Teak + Drumstick + Greengram	3.68	3.63	**3.65**	3.23	3.47	**3.35**	3.31	3.27	**3.29**	2.61	2.97	**2.79**
T_5-Soybean (sole)	4.35	4.53	**4.44**	5.45	5.67	**5.56**	3.91	4.02	**3.96**	4.14	4.53	**4.47**
T_6-Greengram (sole)	3.82	4.07	**3.95**	3.36	3.48	**3.42**	3.44	3.64	**3.54**	2.60	2.67	**2.63**
Mean	**3.85**	**3.96**	**3.90**	**4.18**	**4.38**	**4.28**	**3.46**	**3.55**	**3.51**	**3.36**	**3.51**	**3.43**

For comparing the means of	**SEm ±**	**CD(0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.040	0.115	0.063	0.191	0.037	0.108	0.059	0.172
Distance (D)	0.023	0.066	0.036	0.103	0.021	0.061	0.034	0.099
Interaction (AF X D)	4.00	4.19	4.10	5.20	0.052	0.152	0.083	3.60

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXVII: Influence of teak-perennial vegetable based agroforestry system on transpiration rate (mg H_2O m^{-2} s^{-1}) at different stages in legumes

Agroforestry system	2007						2008					
	20 DAS			40 DAS			20 DAS			40 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	3.53	3.73	**3.63**	4.48	4.63	**4.55**	3.18	3.36	**3.27**	4.02	4.17	**4.09**
T_2-Teak + Curryleaf + Greengram	3.23	3.40	**3.32**	3.72	3.82	**3.77**	2.91	3.06	**2.98**	3.34	3.43	**3.39**
T_3-Teak + Drumstick + Soybean	3..43	3.48	**3.45**	4.33	4.55	**4.44**	3.09	3.13	**3.11**	3.89	4.09	**3.99**
T_4-Teak + Drumstick + Greengram	3.12	3.23	**3.18**	3.57	3.68	**3.62**	2.80	2.90	**2.85**	3.21	3.24	**3.22**
T_5-Soybean (sole)	4.02	4.28	**4.15**	4.82	4.93	**4.87**	3.58	3.85	**3.72**	4.33	4.41	**4.37**
T_6-Greengram (sole)	3.42	3.51	**3.46**	4.20	4.30	**4.25**	3.07	3.15	**3.11**	3.78	3.84	**3.81**
Mean	**3.45**	**3.60**	**3.52**	**4.18**	**4.32**	**4.25**	**3.10**	**3.24**	**3.17**	**3.76**	**3.86**	**3.81**

For comparing the means of	SEm ±	CD(0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.039	0.112	0.046	0.132	0.035	0.102	0.043	0.125
Distance (D)	0.022	0.063	0.026	0.075	0.020	0.058	0.024	0.070
Interaction (AF X D)	0.056	NS	0.065	NS	0.050	NS	0.060	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXVIII: Influence of teak-perennial vegetable based agroforestry system on relative water content (%) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	88.20	91.17	**89.68**	83.20	86.06	**84.63**	72.03	76.67	**74.35**	79.38	82.05	**80.71**	74.88	77.46	**76.17**	64.83	69.00	**66.91**
T_2-Teak + Curryleaf + Greengram	79.40	81.30	**80.35**	76.03	76.73	**76.38**	73.00	73.73	**73.36**	71.46	73.17	**72.31**	69.15	70.29	**69.72**	65.43	66.12	**65.77**
T_3-Teak + Drumstick + Soybean	85.53	87.83	**86.68**	82.20	84.17	**83.18**	70.53	71.46	**71.00**	76.98	78.75	**77.86**	74.49	74.76	**74.62**	63.48	63.63	**63.55**
T_4-Teak + Drumstick + Greengram	76.83	77.50	**77.17**	74.50	75.87	**75.18**	72.00	71.56	**71.78**	69.15	69.72	**69.43**	67.05	67.74	**67.39**	64.80	61.89	**63.34**
T_5-Soybean (sole)	91.28	92.30	**91.79**	84.27	85.10	**84.68**	78.53	80.56	**79.55**	82.15	83.09	**82.62**	76.02	76.50	**76.26**	70.68	72.51	**71.59**
T_6-Greengram (sole)	80.75	82.33	**81.54**	76.83	78.10	**77.47**	73.66	74.13	**73.89**	72.67	73.71	**73.19**	68.67	69.06	**68.86**	65.79	65.85	**65.82**
Mean	**83.67**	**85.40**	**84.53**	**79.50**	**81.00**	**80.25**	**73.29**	**74.68**	**73.98**	**75.30**	**76.74**	**70.02**	**71.71**	**72.63**	**72.17**	**65.83**	**66.50**	**66.16**
For comparing the means of	**SEm ±**	**CD(0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.48	1.38		0.49	1.39		0.57	1.64		0.418	1.224		0.499	1.462		0.488	1.429	
Distance (D)	0.27	0.77		0.28	0.80		0.33	0.95		0.241	0.706		0.288	0.843		0.281	0.638	
Interaction (AF X D)	0.68	NS		0.69	NS		0.81	NS		0.591	NS		0.705	NS		0.690	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-XXXXIX: Influence of teak-perennial vegetable based agroforestry system on light transmission ratio (%) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	67.63	85.20	**76.41**	57.96	69.36	**63.66**	42.80	51.83	**47.31**	60.87	76.68	**68.77**	52.17	62.43	**57.30**	38.37	46.65	**42.51**
T_2-Teak + Curryleaf + Greengram	61.53	74.40	**67.96**	50.56	54.00	**52.28**	40.26	48.73	**44.50**	55.38	66.96	**61.17**	45.51	48.60	**47.05**	36.15	43.29	**39.72**
T_3-Teak + Drumstick + Soybean	64.16	75.83	**70.00**	47.70	51.60	**49.65**	36.10	41.33	**38.81**	57.75	68.25	**63.00**	42.93	46.44	**44.68**	32.40	37.20	**34.80**
T_4-Teak + Drumstick + Greengram	56.86	67.46	**62.16**	44.73	50.30	**47.51**	40.06	48.10	**44.08**	51.18	59.22	**55.20**	40.26	45.27	**42.76**	36.24	43.86	**40.05**
T_5-Soybean (sole)	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**
T_6-Greengram (sole)	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**	100.00	100.00	**100.00**
Mean	**75.03**	**83.81**	**79.42**	**66.82**	**70.87**	**68.84**	**59.90**	**63.00**	**62.45**	**67.53**	**75.18**	**71.35**	**60.14**	**63.79**	**61.96**	**53.86**	**58.50**	**56.18**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	1.231	3.556	0.540	1.559	1.155	3.335	1.071	3.138	0.486	1.423	1.041	3.050
Distance (D)	0.711	2.053	0.311	0.898	0.667	1.926	0.618	1.810	0.280	0.820	0.601	1.760
Interaction (AF X D)	1.741	5.027	0.764	2.206	0.634	1.857	1.515	NS	0.687	NS	1.473	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-L: Influence of teak-perennial vegetable based agroforestry system on chlorophyll ‘a’ (mg g fresh wt^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	1.89	1.63	**1.75**	1.55	1.50	**1.52**	0.80	0.69	**0.74**	1.70	1.46	**1.58**	1.39	1.34	**1.37**	0.71	0.61	**0.66**
T_2-Teak + Curryleaf + Greengram	0.93	0.92	**0.92**	1.48	1.40	**1.44**	0.70	0.68	**0.69**	0.83	0.82	**0.83**	1.32	1.25	**1.29**	0.63	0.61	**0.62**
T_3-Teak + Drumstick + Soybean	1.76	1.52	**1.64**	1.45	1.42	**1.43**	0.72	0.64	**0.68**	1.58	1.27	**1.43**	1.49	1.43	**1.46**	0.64	0.57	**0.61**
T_4-Teak + Drumstick + Greengram	0.91	0.89	**0.90**	1.36	1.32	**1.34**	0.64	0.59	**0.61**	0.81	0.80	**0.81**	1.22	1.18	**1.20**	0.56	0.52	**0.54**
T_5-Soybean (sole)	1.92	1.88	**1.89**	1.68	1.67	**1.67**	0.84	0.81	**0.83**	1.72	1.68	**1.70**	1.51	1.49	**1.50**	0.75	0.73	**0.74**
T_6-Greengram (sole)	0.98	0.98	**0.98**	1.55	1.53	**1.54**	0.73	0.72	**0.72**	0.88	0.88	**0.88**	1.39	1.38	**1.38**	0.65	0.64	**0.65**
Mean	**1.40**	**1.30**	**1.35**	**1.54**	**1.50**	**1.52**	**0.74**	**0.69**	**0.71**	**1.26**	**1.15**	**1.20**	**1.39**	**1.35**	**1.37**	**0.66**	**0.61**	**0.63**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.016	0.046	0.019	0.054	0.015	0.043	0.028	0.820	0.017	0.049	0.014	0.041
Distance (D)	0.009	0.025	0.011	0.031	0.008	0.025	0.016	0.046	0.010	0.029	0.008	0.023
Interaction (AF X D)	0.023	0.066	0.027	NS	0.012	NS	0.040	NS	0.025	NS	0.020	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-LI: Influence of teak-perennial vegetable based agroforestry system on chlorophyll 'b' (mg g fresh wt^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	0.50	0.48	**0.49**	0.65	0.49	**0.57**	0.31	0.31	**0.31**	0.45	0.42	**0.43**	0.58	0.44	**0.51**	0.28	0.27	**0.28**
T_2-Teak + Curryleaf + Greengram	0.36	0.36	**0.36**	0.45	0.41	**0.43**	0.21	0.30	**0.30**	0.31	0.32	**0.32**	0.40	0.37	**0.38**	0.27	0.26	**0.26**
T_3-Teak + Drumstick + Soybean	0.42	0.40	**0.41**	0.58	0.42	**0.50**	0.26	0.28	**0.27**	0.47	0.40	**0.43**	0.58	0.43	**0.51**	0.27	0.26	**0.27**
T_4-Teak + Drumstick + Greengram	0.35	0.32	**0.34**	0.42	0.40	**0.41**	0.24	0.27	**0.26**	0.31	0.29	**0.30**	0.39	0.35	**0.37**	0.24	0.22	**0.23**
T_5-Soybean (sole)	0.56	0.52	**0.54**	0.61	0.58	**0.59**	0.34	0.34	**0.34**	0.50	0.47	**0.48**	0.55	0.47	**0.51**	0.30	0.30	**0.30**
T_6-Greengram (sole)	0.52	0.49	**0.50**	0.45	0.43	**0.44**	0.32	0.32	**0.32**	0.46	0.43	**0.45**	0.40	0.39	**0.39**	0.27	0.26	**0.26**
Mean	**0.45**	**0.42**	**0.43**	**0.52**	**0.45**	**0.48**	**0.29**	**0.30**	**0.29**	**0.42**	**0.39**	**0.40**	**0.48**	**0.41**	**0.44**	**0.27**	**0.26**	**0.26**
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.006	0.017		0.012	0.034		0.007	0.020		0.006	0.017		0.011	0.032		0.007	0.020	
Distance (D)	0.003	0.008		0.007	0.020		0.004	NS		0.003	0.008		0.006	0.017		0.004	0.011	
Interaction (AF X D)	0.009	0.025		0.018	0.051		0.011	NS		0.008	NS		0.015	NS		0.010	NS	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-LII: Influence of teak-perennial vegetable based agroforestry system on total chlorophyll (mg g fresh wt^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	2.27	1.99	**2.13**	2.09	1.89	**1.99**	1.05	0.94	**1.00**	3.59	3.09	**3.34**	1.98	1.79	**1.88**	1.00	0.89	**0.94**
T_2-Teak + Curryleaf + Greengram	1.22	1.20	**1.21**	1.82	1.71	**1.77**	0.95	0.92	**0.93**	1.76	1.73	**1.75**	1.72	1.62	**1.67**	0.90	0.87	**0.88**
T_3-Teak + Drumstick + Soybean	2.17	1.77	**1.97**	2.19	1.97	**2.08**	0.96	0.89	**0.92**	3.35	2.69	**3.02**	2.07	1.87	**1.97**	0.91	0.84	**0.88**
T_4-Teak + Drumstick + Greengram	1.20	2.15	**1.17**	1.70	1.62	**1.66**	0.85	0.79	**0.82**	1.72	1.69	**1.71**	1.61	1.54	**1.57**	0.81	0.74	**0.78**
T_5-Soybean (sole)	2.35	2.28	**1.31**	2.17	2.08	**2.13**	1.12	1.10	**1.11**	3.64	3.56	**3.60**	2.06	1.97	**2.02**	1.06	1.04	**1.05**
T_6-Greengram (sole)	1.43	1.39	**1.41**	1.89	1.86	**1.88**	0.98	0.96	**0.97**	1.86	1.86	**1.86**	1.79	1.77	**1.78**	0.92	0.91	**0.92**
Mean	**1.77**	**1.63**	**1.705**	**1.98**	**1.86**	**1.92**	**0.99**	**0.94**	**0.96**	**2.65**	**2.44**	**2.25**	**1.87**	**1.76**	**1.82**	**0.93**	**0.88**	**0.91**
For comparing the means of	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**	**SEm ±**		**CD (0.05)**
Agroforestry system (AF)	0.013		0.090	0.022		0.064	0.019		0.055	0.059		0.172	0.021		0.063	0.018		0.052
Distance (D)	0.018		0.052	0.013		0.038	0.011		0.032	0.034		0.099	0.012		0.035	0.010		0.029
Interaction (AF X D)	0.044		NS	0.031		NS	0.028		NS	0.084		NS	0.030		NS	0.026		NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-LIII: Influence of teak-perennial vegetable based agroforestry system on Single Photoelectric Analyzing Diode (SPAD, %) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	27.36	26.00	**26.68**	33.40	32.20	**32.80**	23.06	23.53	**23.30**	24.66	23.40	**24.03**	30.06	29.28	**29.67**	21.27	20.76	**21.01**
T_2-Teak + Curryleaf + Greengram	22.23	20.76	**21.50**	25.83	25.30	**25.56**	18.83	19.90	**19.36**	20.01	18.69	**19.35**	23.25	22.77	**23.01**	17.91	16.95	**17.43**
T_3-Teak + Drumstick + Soybean	24.56	23.06	**23.81**	27.53	26.20	**26.86**	19.96	20.60	**20.28**	22.11	20.76	**21.43**	24.78	23.58	**24.18**	20.64	20.34	**20.49**
T_4-Teak + Drumstick + Greengram	21.10	19.40	**20.25**	24.87	23.43	**24.15**	18.06	18.56	**18.31**	18.09	17.58	**17.83**	22.38	21.09	**21.73**	16.45	16.26	**16.35**
T_5-Soybean (sole)	31.30	30.30	**30.80**	33.43	33.16	**33.30**	25.83	26.30	**26.06**	28.20	27.27	**27.73**	31.59	29.85	**30.72**	23.67	23.25	**23.46**
T_6-Greengram (sole)	22.16	22.20	**22.18**	26.16	26.03	**26.10**	22.30	22.93	**22.61**	20.11	20.10	**20.10**	24.57	23.43	**24.00**	18.18	17.97	**18.07**
Mean	**24.78**	**23.62**	**24.20**	**28.53**	**27.72**	**28.12**	**21.34**	**21.92**	**21.63**	**22.19**	**21.30**	**21.74**	**26.10**	**25.00**	**25.55**	**19.68**	**19.22**	**19.47**

For comparing the means of	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**	**SEm ±**	**CD (0.05)**
Agroforestry system (AF)	0.336	0.970	0.285	0.823	0.282	0.814	0.322	0.943	0.390	1.142	0.250	0.732
Distance (D)	0.194	0.560	0.164	0.473	0.162	0.467	0.186	0.544	0.225	0.659	0.144	0.421
Interaction (AF X D)	0.476	NS	0.403	NS	0.399	NS	0.456	NS	0.552	NS	0.352	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-LIV: Influence of teak-perennial vegetable based agroforestry system on nitrate reductase activity (n mol of NO_2 formed g fr.wt^{-1} h^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	20 DAS			40 DAS			60 DAS			20 DAS			40 DAS			60 DAS		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	38.66	41.15	**39.90**	23.66	24.40	**24.03**	19.33	20.40	**19.86**	34.80	37.03	**35.91**	21.30	21.96	**21.63**	17.40	18.36	**17.88**
T_2-Teak + Curryleaf + Greengram	16.83	17.63	**17.23**	41.16	14.40	**14.28**	10.83	11.10	**10.96**	15.60	15.75	**15.67**	12.75	12.96	**12.85**	9.72	9.97	**9.84**
T_3-Teak + Drumstick + Soybean	37.63	40.36	**39.00**	23.16	24.16	**23.66**	18.26	18.75	**18.50**	33.87	36.33	**35.10**	20.85	21.75	**21.30**	16.44	16.81	**16.62**
T_4-Teak + Drumstick + Greengram	16.80	17.25	**17.03**	13.71	13.95	**13.83**	9.60	10.76	**10.18**	15.12	15.52	**15.32**	12.34	12.55	**12.45**	8.64	9.60	**9.12**
T_5-Soybean (sole)	41.33	42.23	**41.78**	25.00	25.83	**25.41**	20.48	21.61	**21.05**	37.20	38.01	**37.61**	22.50	23.22	**22.86**	18.43	19.45	**18.94**
T_6-Greengram (sole)	17.33	17.50	**17.42**	14.56	14.88	**14.75**	10.96	11.55	**11.25**	15.15	15.99	**15.57**	13.11	13.28	**13.19**	9.88	9.97	**9.93**
Mean	**28.10**	**29.35**	**28.72**	**19.04**	**19.60**	**19.32**	**14.91**	**15.69**	**15.30**	**25.29**	**26.44**	**25.86**	**17.14**	**17.62**	**17.38**	**13.42**	**14.03**	**13.72**

For comparing the means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Agroforestry system (AF)	0.270	0.779	0.230	0.664	0.306	0.883	0.244	0.714	0.204	0.597	0.243	0.711
Distance (D)	0.156	0.450	0.133	0.384	0.176	0.508	0.141	0.413	0.118	0.345	0.140	0.410
Interaction (AF X D)	0.382	0.103	0.325	NS	0.432	NS	0.345	NS	0.289	NS	0.344	NS

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

Appendix-LV: Influence of teak-perennial vegetable based agroforestry system on seed weight per plant (g) and 100 seed weight (g) and seed yield (kg ha^{-1}) at different stages in legumes

Agroforestry system	2007									2008								
	Seed weight / plant (g)			100 seed weight (g)			Seed yield(kg/ha)			Seed weight/plant (g)			100 seed weight (g)			Seed yield(kg/ha)		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D1	D2	Mean	D1	D2	Mean	D1	D2	Mean
T_1-Teak + Curryleaf + Soybean	6.40	6.70	**6.55**	10.53	11.03	**10.783**	780.0	833.3	**806.6**	5.76	6.03	**5.89**	9.48	9.93	**9.70**	702.0	750.0	**726.0**
T_2-Teak + Curryleaf + Greengram	2.53	2.93	**2.73**	2.76	3.06	**2.91**	326.6	333.3	**330.0**	2.28	2.64	**2.46**	2.49	2.76	**2.62**	294.0.	300.0	**297.0**
T_3-Teak + Drumstick + Soybean	5.06	5.43	**5.25**	6.63	7.53	**7.08**	620.0	716.6	**668.3**	4.56	4.89	**4.72**	5.97	6.78	**6.37**	558.0	645.0	**601.0**
T_4-Teak + Drumstick + Greengram	2.03	2.16	**2.10**	2.50	2.70	**2.60**	260.0	275.0	**267.5**	1.83	1.95	**1.89**	2.25	2.43	**2.34**	234.0	247.0	**240.0**
T_5-Soybean (sole)	8.03	6.33	**7.18**	10.53	11.10	**10.81**	866.6	860.0	**863.3**	7.23	5.70	**6.46**	9.48	9.99	**9.73**	780.0	774.0	**777.0**
T_6-Greengram (sole)	2.90	2.86	**2.88**	3.30	3.50	**3.40**	316.6	330.0	**232.3**	2.61	2.58	**2.59**	2.97	3.15	**3.06**	285.0	297.0	**291.0**
Mean	**4.49**	**4.40**	**4.45**	**6.04**	**6.48**	**6.26**	**528.3**	**558.0**	**543.1**	**4.04**	**3.96**	**4.00**	**5.44**	**5.84**	**5.64**	**475.0**	**502.0**	**488.0**
For comparing the means of	**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**		**SEm ±**	**CD (0.05)**	
Agroforestry system (AF)	0.230	0.673		0.496	1.453		18.04	52.86		0.207	0.606		0.446	1.306		16.23	45.57	
Distance (D)	0.132	0.386		0.286	0.837		10.41	30.52		0.119	0.348		0.258	0.755		9.37	27.46	
Interaction (AF X D)	0.325	0.952		0.702	NS		25.51	74.76		0.293	0.858		0.631	Ns		22.96	67.28	

DAS =Days after sowing; D_1 = 2.0 m distance from teak alleys; D_2 = 4.0 m distance from teak alleys

PHYSIOLOGICAL INVESTIGATIONS ON LEGUMES IN TEAK BASED AGROFORESTRY SYSTEM

H. Y. PATIL **2010** **Dr. S. J. PATIL**
MAJOR ADVISOR

ABSTRACT

A field experiment was conducted during *kharif,* 2007 and 2008 at Main Agricultural Research Station (MARS), UAS, Dharwad to study the performance of legumes and perennial vegetables in a teak based agroforestry systems, the experiment was laid out in factorial randomized block design with four replications. The investigations involved two experiments, the first one with teak as perennial component and four pulses as arable crops. The second one consisted of teak with two pulses along with two short rotation vegetables.

The plant height, leaf, stem, pod and total dry matter in legumes were highest in sole crop treatment as compared to legume with teak and teak+perennial vegetable based agroforestry system and were superior in 2-4m distance from teak row. The growth parameters of legumes in both teak+legumes and teak with perennial vegetables, *viz*., LAI, LAD, AGR, CGR, NAR and SLW differed significantly due to influence of teak and perennial vegetables.

Grain yield of legume was higher in teak+frenchbean (1042 kg ha^{-1}) followed by teak+soybean (875 kg ha^{-1}). In teak perennial vegetable based agroforestry systems teak+curryleaf+soybean (766 kg ha^{-1}) followed by teak+curryleaf+greengram (307 kg ha^{-1}) had higher grain yield as compared to other agroforestry systems.

The values of biochemical parameters (chlorophyll 'a', 'b', total chlorophyll and SPAD) were found to be higher in 2m distance from the tree base compared to 4m distance in teak+legumes and teak perennial vegetables in legume based agroforestry systems. Nitrate reductase activity was found to be higher at 4m distance from tree base compared to 2m distance in teak+legumes and teak+perennial vegetables based agroforestry systems.

The biophysical parameters (photosynthetic rate, transpiration rate and relative water content) were decreased from 20 to 40 DAS, whereas, the stomatal conductance increased from 20 to 40 DAS in both teak+legumes and teak + perennial vegetables with legume based agroforestry systems.