PERFORMANCE OF COTTON (*Gossypium hirsutum* L.) IN TEAK BASED AGROFORESTRY SYSTEM

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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By

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of thesis entitled **"PERFORMANCE OF COTTON (*Gossypium hirsutum* L.) IN TEAK BASED AGROFORESTRY SYSTEM."** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis or publication of any University or Scientific Organization. The sources of material used and all assistance received during the course of investigation have been duly acknowledged.

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Date: / /2018 Enrolment No. JJ/450

CERTIFICATE

This is to certify that, the thesis entitled **"PERFORMANCE OF COTTON (*Gossypium hirsutum* L.) IN TEAK AGROFORESTRY SYSTEM"** Submitted in partial fulfilment of the requirements for the degree of **"Master of Science in Forestry (Forest Genetic Resources)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Hulke Vanashri Manikrao** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Akola
Date: / / 2018

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Abbreviations		Expanded form
%	-	Percent
@	-	at the rate of
$^{-1}$ or /	-	Per
°C		Degree Celsius
AF	-	Agro Forestry
C D	-	Critical Difference
Cm	-	Centimeter
EC	-	Electrical Conductivity
e.g.	-	Example
etc.	-	et cetera
Fig.	-	Figure
G	-	Gram
i.e.	-	that is
K	-	Potassium
K_2O	-	Potassium oxide
LAI	-	Leaf Area Index
M	-	Meter
Max	-	Maximum
Mg/g	-	Milligram per gram
min	-	Minimum
mm	-	Millimeter
MW	-	Meteorological week
N	-	Nitrogen
No	-	Number
N.S.	-	Non- Significant
OC	-	Organic Carbon
P	-	Phosphorus
P	-	Page
PAR	-	Photosynthetically ActiveRadiation
pp	-	pages

ppm	-	parts per million
R	-	Replication
RBD	-	Random Block Design
RH	-	Relative humidity
SE(m)±	-	Standard error of mean
Sig.	-	Significant
T	-	Treatment
umol $m^{-2}s^{-1}$	-	Micro mol per meter per second
viz.	-	videlicet (namely)
Wt.	-	Weight

(E) THESIS ABSTRACT

a)	**Title of the thesis**	**: "PERFORMANCE OF COTTON (*Gossypium hirsutum* L.) IN TEAK BASED AGROFORESTRY SYSTEM"**
b)	**Full name of student**	**: Hulke Vanashri Manikrao**
c)	**Name and address of Major Advisor**	**: Dr. S. S. Harne** Head, Department of Forestry, PGI, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) – 444 104.
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ABSTRACT

The present investigation entitled "Performance of Cotton (*Gossypium hirsutum* L.) in Teak based Agroforestry System" was carried out during *Kharif season*, 2017-18 on research field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The material consisted of three *Gossypium hirsutum* varieties (AKH8828, AKH09-5, AKH9916) from the Cotton Research Unit. The experiment was carried out by adopting Random Block Design with four treatments and five

replications. The observation recorded on growth, yield, microclimatic and physiological parameters of cotton sown at the distance 0-3 m (T_1), 3-6 m (T_2), 6-9 m (T_3) and control plot i.e., 12-15 m (T_4) distance from the teak row at 50% flowering, 50% boll bursting and Harvesting stage were recorded.

The growth parameters of cotton viz., plant height (cm) and leaf area index, germination percentage (%), number of sympodia and number of monopodia were observed the highest in T_4 treatment at 12-15 m distance followed byT_3 treatment at 6-9 m distance and T_2 treatment at 3-6 m distance at three different growth stages.

The yield parameters viz., number of bolls per plant, boll weight (g), seed cotton yield per plant (g), seed index (g), lint index, ginning (%) and harvest index (%) of cotton were the highest in T_4 treatment at 12-15 m distance followed by T_3 treatment at 6-9 m distance and T_2 treatment at 3-6 m distance. These yield parameters were the lowest observed in T_1 treatment at 0-3 m distance from the teak row at harvest stage.

The biochemical parameters viz., chlorophyll content (mg/g), canopy temperature (°C) at morning and afternoon were observed the highest in T_1 treatment at 0-3 m distance followed by T_2 treatment at 3-6 m distance and T_3 treatment at 6-9 m distance teak-based agroforestry systems at three different growth stages.

The relative humidity (%) at morning and afternoon was observed maximum in T_1 treatment at 0-3 m distance followed by T_2 treatment at 3-6 m distance and T_3 treatment at 6-9 m distance teak-based agroforestry systems at three different growth stages. The minimum relative humidity at morning and afternoon was observed in T_4 treatment at 12-15 m distance.

The PAR (μ $molm^{-2}$ s^{-1}) and CO_2 (ppm) were not affected significantly due to different treatments i.e., T_1 at 0-3 m, T_2 at 3-6 m, T_3 at 6-9 m and T_4 at 12-15 m distance from the teak boundary plantation.

Due to interaction of teak, cotton plants produced the lowest bolls upto distance of 6-9 m. Though the rate of production of new

vegetative leaves and new fruiting branches sites is highly depending on temperature, it is also very sensitive to water stress. For that reason, the rate of vegetative leaf growth was observed which depends on the complex soil, weather and plant interactions.

The study concludes that the effect of teak on growth and yield of cotton crop were reduced at 0-3 m and 3-6 m from the teak boundary planation and highest yield and growth of cotton at 6 m onwards.

CHAPTER I

INTRODUCTION

1.1 Background information

Forests in India are unbearable biotic pressure and deforestation is taking place at an alarming rate which is estimated to be 1.3 m. ha per year (Anon, 1984). Out of 75 m. ha of recorded forest area in the country, nearly 37 m ha (equating 49% area) is degraded resulting in less than 40 per cent crown cover density. The growing stock in India is low at 0.5 m^3/ ha/year as against world average of 2.1 m^3/ha/year.

At the present level of consumption of forest resources, the country needs a minimum of 0.47 hectare per head forest as against actual availability of 0.11 ha per head. We require more than 60 m^3 of timber, 300 m. t. of fuel by the end of 2000 (Anon, 1984). Land-use options that increase livelihood security and reduce vulnerability to climate and environmental change are necessary. Traditional resource management adaptations such as agroforestry systems may potentially provide options for improvement in livelihoods through simultaneous production of food, fodder and fuel as well as mitigation of the impact of climate change.

The degradation of forests in the form of soil erosion, degradation of watersheds, loss of biological diversity, climatic changes and reduction in economic contribution of forests of human life. The planner, foresters, scientists and environmentalists have now a challenging task to manage the resources for saving the society (Khosla and Khurana, 1987). In order to overcome the pressure on existing forests and to utilize natural resources (light, moisture, nutrient etc.) for maximum biomass production and for any other advantages, growing trees on arable lands (called agroforestry) has become necessary (Nadagoudar, 1986 and Lundgren, 1985).

Agroforestry is a collective term for all land use systems and practices in which woody plants (tree/shrubs) are deliberately combined with herbaceous crops on the same land management unit with some form of

spatial arrangement or in sequence (Anon, 1976). It provides more opportunity for efficient use of natural resources as compared to monocropping of tree or crops.

Since, agroforestry is a new branch of science which emerged during later seventies very little is known about the type of trees to be grown in combination with arable crops, although emphasis is on multipurpose trees (Burley, 1983). The tree-crop interaction influences agricultural production to varying degree depending upon species and cropping system and growing conditions. This would include managed woodlots, plantations, windbreak, and orchards.

Teak (*Tectona grandis* L.) is one of the valuable species which can be successfully cultivated in agroforestry system. It is considered as “King of Trees” species. It is deciduous tree, grows straight, 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 world-wide timber trade.

Teak is one of the most important timber species the world which belongs to the family Verbenaceae, having chromosome number 2n=36 (Kedarnath and Raizada, 1961). It is naturally distributed in parts of India, Myanmar, and Indian peninsula, Thailand, Laos and Indonesia. In India teak forests are found in Madhya Pradesh, Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu and Kerala.

Teak is a large deciduous tree that reaches maximum height of 30 to 40 m and 100 cm or more diameter at breast height with rounded crown and characteristically, quadrangular branches at early stages. Often fluted at the base with a long cylindrical bole up to 2/3rd of the height of the tree. It grows naturally over a wide range of climatic condition varying from very dry (500 mm rainfall/ year) to the very moist (up to 5,000 mm rainfall/ year) with deep, flat and well-drained alluvial soil rich calcium, and pH ranging from 6.5 to 7.5. Where maximum shade temperature is about 40°C, a mean annual temperature of 25-35°C with a marked dry season of three to five months. Studies under very dry conditions, the tree is usually

stunted and shrubby. Under very moist conditions, the tree is large and fluted and usually behaves like a semi-evergreen species; the wood quality is poor in terms of color, texture and density. For the production of high quality wood with optimal growth, moisture conditions should be between 1,200 to 2,500 mm with a marked dry season of 3-4 months. The dry season refers to period in which the cumulative rainfall is less than 50 mm per month. (Troup, 1921).

This species is pronounced as a light demander, intolerant of shade and requires complete overhead light. It is very sensitive to mutual root competition and to suppression by weeds. It is tender to frost and severe drought. The tree is wind firm and fire resistance. It has remarkable ability to regenerate by coppicing and pollarding. The leaves are non-palatable to grazers and browsers but attacked by insects and root are liked by rats and pigs. The bole is tall, straight, fairly cylindrical and with age moderately fluted and buttressed (Khanna, 1991)

Bark is thin fibrous, pale brown to grey. Flowers are small, white, sweet-scented, hermaphrodite, bracteolate, numerous borne in dichotomous cymes of erect terminal panicles. In teak the crown varies with growth condition (Gamble, 1922 and Gotwald, 1980).

India has the distinction of growing all the four cultivated cotton species viz*. Gossypium arboreum* L., *G. herbaceum*. (both diploids), *G. hirsutum* and *G. barbadence* (both tetraploids). Globally, 90% cotton area is under *G. hirsutum*, 8% is under *G. barbadense* and just 2% is under *G. arboreum* and *G. herbaceum. G. hirsutum* is also known as American cotton or Upland cotton. To meet the domestic requirement and to exploit potential of course lint especially due to its surgical use, development of cotton varieties with higher productivity and ginning out turn is utmost importance.

Cotton is the “King of Fiber” being most important cash crop having profound influence on economics and social affairs of world. Cotton belong to Genus Gossypium of Family Malvaceae. Cotton is used as fabric in India from time immoral. Cotton occupies a place of pride in Indian economy by earning valuable foreign exchange. It is one of the important

sources of providing employment to millions of peoples. It's one among the crop species having great importance as multipurpose crop that supplies five basic products: lint, oil, seed, meal, and hull.

Cotton is a fiber, oil and protein yielding crop of global significance. It is cultivated in more than 80 countries of tropical and sub-tropical regions of the world. The major cotton producing countries are USA, China, India, Pakistan, Uzbekistan, Turkey, Brazil, Greece, Argentina and Egypt. These countries contribute about 85% to the global cotton production. India stand first I area and second for production with productivity.

In India, there are nine major cotton growing states which are divided into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana, Rajasthan, and Western Uttar Pradesh. Central zone includes Madhya Pradesh, Maharashtra, Gujrat and Orissa. South zone comprises Andhra Pradesh, Karnataka and Tamilnadu. These states cover about 95% of cotton area and also contribute about 95% of total cotton production in India.

The performance of trees and crops in an agroforestry system primarily depends upon their relative ability to tap the resource pools of light, temperature and humidity. Resilience of a component to respond to sub-optimal level of resources at any growth stage in a tree-crop system will stabilize or destabilase the tree-crop association which ultimately will influence the yield advantage of an agroforestry system. Understanding the way, system components respond to optimal or sub-optimal level of resources, forms the basis for selection of compatible and suitable components (Kumar, 1999)

Similarly, tree-crop combination competes for available moisture in the soil, more severely under rainfed agroforestry system. So inadequate moisture will become the limiting factor which will deleteriously affect the growth and yield of the components (Singh *et al.,* 1989; Corlett *et al.,* 1989).

Ecological interaction between trees and crops are examined in terms of above and below ground utilizations of physical resources. Above ground interaction such as light, temperature and humidity are analyzed in terms of possible effect on understory crops. The analysis atmospheric interaction in alley cropping in the semi-arid tropics were from positive but of minor importance compared with below ground interactions. An important effect of trees in agroforestry system is for the modification of the microclimate of annual crops and reduction in wind speed are directly beneficial to crops because they reduce the mechanical damage to crops, such as leaf tearing and crop lodging.

1.2 Importance and need of study

In tree-crop system tree species are grown and managed in the farmland\cropland and roadside fallows lands, along with agricultural crops. The main aim is to increase the overall yield of the land. This system is also based on the principle of sustainable yield of woody plants and crops which interact both ecologically and economically; the interaction may be negative or positive. This system can be of great value if trees and crops are appropriately managed according to their requirement (Rehaman, 2006).

The practice of agroforestry can meet all the multiple demands of growing population. Agroforestry provides an inexpensive means of afforestation and satisfactory returns to the farmers by arable crops (Lundgren, 1985). Tree-crop interactions play a vital role in successful adoption of an agroforestry system by maintaining economic and ecological interactions between trees and crops. There are mutual or positive benefits among the components.

The competitive effects of trees on crop are not consistent due to various reasons. These effects may be complimentary or competitive depending upon the level of competition for growth resources between woody component and crops and also due to site conditions. Under some conditions productivity of agricultural crop is reported to be lower (Puri *et al*.1994), whereas (Puri and Kumar, 1992) several workers reported higher productivity of crops in different trees.

The potential productivity of field crops in an agroforestry system depend on the amount of photosynthetically active radiation (PAR) falling on the ground. It has generally been observed that trees and crops both complete strongly for light where as shade effect resulting from the tree crown detrimentally influence the productivity potential of annual crop. Production of allelochemicals from trees further interfere with the growth and yield of associated crops. There are several difficulties associate crop. So, there is need to screen commonly grown tree species in agroforestry for their influences. (Hazara and Tripathi, 1986) (Srinivasan *et al*. 1990) (Willamson, 1990).

Tectona grandis is an important tree species in agroforestry system, it is used to grow on farm boundaries and is being preferred by the farmer to meet for timber and furniture. It needs to identify performance of suitable crops to be grown under teak.

It is time that greater attention be devoted to economically and ecologically sustainable agricultural production system, 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 amount of carbon being sequestered (Venkatarao, 2005)

It is essential to find out how the tree species influence the growth and yield of cotton grown in agroforestry system. Therefore, the present investigation on “Performance of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.” is undertaken with following objective

1.3 Objectives

Keeping in view above the facts, the present investigation was carried out in teak based agroforestry system with the following objectives:

1. To study the growth performance of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.
2. To study the yield of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.

1.4 Scope and Limitations

Tree species are adopted in a large hectare of boundaries, bunds, wastelands area and permits in the field where most annual crops are growing well. Agroforestry has many potential, such as enhance the overall (biomass) productivity, soil fertility improvement, soil conservation, nutrient cycling, micro-climate improvement etc. Recently many farmers are adopting Teak on their farmland as boundary plantations, block plantations with agriculture crops. Teak (*Tectona grandis*) is one of the most popular and highly valued timber trees. Attracted by the economic advantages of teak culture, many private companies in India had ventured into establishing commercial plantations of teak. Teak is one such species that can be used in agroforestry in view of its importance (Peddappaiah *et al.,* 2001).

In developing countries forests and agroforestry provide substantial benefits to rural dwellers, national economies, and the environment. Therefore, Agroforestry system gives diversification, creates green cover for carbon sequestration and increases the nutrient uptake and their utilization management practices that lead to improved organic matter status of the soil will lead inevitably to improved nutrient cycling and better soil productivity.

Under the agroforestry system the interaction between tree and crop are studied in positive, negative and neutral way. This interaction is depending the type of model including varying species, their nature and composition. Further, interaction is defined as the effect of one component of a system on the performance of another component and/or the overall system (Nair, 1993).

Various interactions take place between the tree and herbaceous plants (crops and pasture), which are referred to as the tree-

crop interface. Studying tree-crop interaction in agroforestry would help to devise appropriate ways to increase overall productivity of land. Increased productivity, improved soil fertility, nutrient cycling, soli conservation are the major positive effects of interactions.

Competition is the main negative effects of interaction, which substantially reduces the crop yield. It may be for space, light, nutrient and moisture. Ecological sustainability and success of any agroforestry system depends on the inter-play and complementarily between negative and positive interactions. It can yield positive result only if positive interaction outweighs the negative interactions (Singh, 2013).

Tree is the one that they may compete with the companion crop. A shade loving crop such as cocoa, etc. fits more easily in a mixed cropping system with trees than a sun-loving crop like maize, cotton, etc. Potential of trees is serving as hosts to insects and birds. Rapid regeneration of profile trees may displace food crops and take over entire fields. Through skilled management practices any or all these aspects can be controlled. For example, once it is known that trees complete with food crops and may reduce food yields, it is easy to adopt some of the following strategies.

1. Select legume trees that have small or light crowns so that sunlight will reach the food crops.
2. Select trees that are deep-rooted so that they will also absorb moisture and nutrient from the deeper subsoil.
3. Space the trees further apart to reduce their competitive effect on the food crop.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the literature on different aspects of the study. The main emphasis has been given on the "**Performance of cotton (*Gossypium hirsutum*L) in teak based agroforestry systems."** The literature is broadly reviewed under the following aspects.

2.1 Concept of agroforestry

2.2 Performance of agricultural crop in agroforestry system

2.3 Effect on microclimate in agroforestry system

2.4 Yield and growth influence between agri-tree species

2.1 Concept of agroforestry

Nair (1993) stated that the term 'Agroforestry' describes integrated land use system or practices of growing crops in association with the tree species. Site conservation and optimal productivity are cordinal aspects of all agroforestry land management system around the world. They also classified the various agroforestry system around the world, based on structural, functional, socio-economic and ecological attributes. Such a classification is perhaps necessary, to evaluate the existing agroforestry system and to develop action plans for their improvement. Based on structural component, agroforestry is divided into agrisilviculture (crops, pasture/animal and tree), silvipastoral (pasture/animal and tree) and agro-silvipostral (crop, pasture/animal and trees).

Makundi and Sathaye (2004) studied the planting of trees along with crops improves soil fertility, controls and prevent soil erosion, controls water logging, checks acidification and eutrophication of stream and rivers, increase local biodiversity, decrease pressure on natural forests for fuel and provide fodder for livestock.

Rao *et al.* (2007) noticed the important elements of agroforestry system that can play a significant role in the adaptation to

climate change include changes in the microclimate, protection through provision of permanent cover, opportunities for diversification of the agricultural systems, improving efficiency of use of soil, water and climatic resources, contribution to soil fertility improvement, reducing carbon emissions and increasing sequestration, and promoting gender equity.

Singh *et al.* (2013) found that in the agroforestry, ecological sustainability and success of any agroforestry system depends on the inter-play and complementarily between negative and positive interaction. It can yield positive results only if positive interactions outweigh the negative interactions.

Evans and Rombold (1985) reported that *Melia azadirach* can be used effectively as a tree component in agroforestry systems. The fast growth habit, deep root system, addition of large quantities of organic matter through leaf and titter fall, compatibility with agricultural crops and production of poles and fire wood make Melia an excellent species for agroforestry combination.

Vandenbett (1992) studied the intercropping of arable crops with nitrogen fixing trees viz., *F. albida, A. ferruginea*, *P. cineraria,* increased the yield of sorghum and castor. Whereas, both the crops failed when intercropped with *L. leucocephela* mainly due to canopy cover. This shows the importance of canopy management for successful under cropping.

Rhoades (1997) stated that 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.

Kumar *et al.* (2011) confirmed that neem (*Azadirachta indica*) can be effectively used as a tree component in agroforestry system. Crops like barley and oats can be grown as inter crops in early years of neem tree without affecting the yield. There was no incidence of stem borer and termite in barley in oat due to the insecticidal property of neem plant.

2.2 Performance of agricultural crop in agroforestry system

Khan and Aslam (1974) studied the effect of single tree of *Dalbergia sissoo* on the yield of Wheat crop and reported that the grain yield showed a decrease of 30, 88, 23.6 and 12.7 % at the distance of 3, 4, 5 and 6 m, respectively as compared to the open field.

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.

Bhat (1988) reported that significantly higher dry matter (33.60 g) was produced in control treatment. Among the tree species, Subabul, though resulted in higher dry matter of the crop at 3 m and 9 m distances (15.37 g and 28.81 g respectively), did not differ significantly with Sissoo and Casuarina at 3 m distance and Sissoo at 9 m distance. At 6 m distance, dry matter recorded under Subabul (26.60 g) was significantly superior over other tree species.

Akbar *et al.* (1990) studied the effect of trees on the yield of Wheat crop and recommended that the tree's impact was on Wheat yield up to 2 m distance, while little was seen up to 6 m and almost there was no impact at 8,10 and 12 m distance from the tree base.

Ralhan *et al*. (1992) studied on performance of Wheat as intercrop under Poplar and reported that 23.3 per cent decline in Wheat grain yield (Variety HD 2329) with Poplar (clone G-s) at three-year age whereas reduction in grain yield during first year was nine per cent only.

Khan and Ehrenreich (1994) studied on effect of increasing distance from *Acacia nilotica* trees on Wheat yield and suggested that in Wheat crops the number of tillers/m^2 was lowest near the trees and increased with increasing distance from tree. The number of tillers at 1 m was significantly less than the number at any other distance. The test weight (1000 grains) was recorded minimum at 1 m with a gradual increase

up to 11 m. Similarly, the grain yield was lowest near the trees and gradually increased with increasing the distance from the trees.

Mutanal (1998) showed that the plant height was significantly higher in sole Groundnut (31.0 cm) as compared to Groundnut with Teak + Grass (27.8 cm), Teak + Subabul (27.7 cm) and Teak (27.0 cm). Plant height was significantly lower in 1 to 4 m. from Teak, Teak + Subabul and Teak + Grass as compared to sole Groundnut.

Nandal *et al*. (1999) investigated the performance of 5 Wheat cultivars under Sissoo trees and found that, dry matter yield, leaf area index, spikelets m^{-1} and grains spike $^{-1}$ and grain yield were reduced under tree canopy when compared to crops growing in the open field.

Mutunal *et al.* (2001) conducted experiment to study the compatibility of sorghum in Teak based agroforestry system. Studies revealed that grain and straw yield of Sorghum was highest with sole Sorghum as compared to sorghum with Teak, Teak + Grass and Teak + Subabul. Grain and straw yield of Sorghum was reduced significantly near the teal alley compared to 5 m from the Teak alley.

Venkatarao (2005) reported that the influence of Teak on the performance of Groundnut was severe nearer to tree species compared to away from the tree species. Yield reduction in Groundnut was 53.85 per cent at 0-1 m distance as compared to 4 - 5 m distance from the tree base. among the biochemical parameter chlorophyll content was highest in 0-1 m distance from the teak alley.

Reddy *et al.* (2006) studied the effect of eucalyptus tree on growth and yield of American cotton. Plant height, root length, and weight per plant increased with increase in distance from eucalyptus trees. However, due to adverse effect of eucalyptus tree cotton plant did not produce any bolls up to distance of 6-7 m. Allelopathic effect of eucalyptus tree reduced the cotton yield to 92% in plants at 7-8 m away compared to 22-23 m. Available nitrogen and phosphorous in soil increased as the distance from eucalyptus trees increased both in 0-30 and 30-60 cm soil

depth. Similarly, moisture content of surface soil (0-15 cm) also increased as the distance increased from the eucalyptus trees up to 12-14 m.

Burman *et al*. (2009) studied the green fodder yield of Sorghum and grain yield of Barley was lesser nearer to trees and yield increased with distance from the tree line. The yield of crops under the influence of trees was lower than control (without trees). The association of trees with the crops resulted in higher reduction in yield on northern side of tree belt as compared to southern side.

Peng *et al.* (2009) reported that yield of Maize growing nearer to tree rows of Walnut and Plum (1 m near to tree rows) was lower than sole crop yield. This was because of competition of trees with crops. The effect of tree competition significantly reduced the photosynthetically active radiation (PAR), net assimilation and growth. Maize crop was severely affected as Plants with C4 pathway are less adaptable to shade.

Ding and Su (2010) studied the effect of tree shading on Maize crop within poplar-maize agroforestry system. The results revealed that tree shading reduced the crop yield by 27 and 22 per cent in western and eastern regions respectively. Mean crop yield on western side was 23 per cent lower than eastern side.

Fadl and Sheikh (2010) studied the effect of *Acacia senegal* on growth and yield of Groundnut in agroforestry system. Their study revealed that yield of Groundnut was reduced by 35 and 17 per cent in the first season and 37 and 39 per cent in the second season. Combined analysis indicated that intercropping reduced groundnut yield by 26 per cent.

Osman *et al.* (2011) studied the performance of Cowpea and Pearl millet intercropped under *Parkia biglobosa* in an agroforestry system. Their studies revealed that *Parkia biglobosa* reduced yield and flowering of Cowpea and Pearl millet. The reduction in yield was up to 21 per cent for sole cowpea and 67 per cent for sole pearl millet under trees. Intercrops yield were less affected by growth under trees.

Pandey *et al.* (2011) investigated the performance of Gram (*Cicer arietinum)* under neem (*Azadirachta indica*) based agroforestry system. Their studies indicated that there was 29 to 40 per cent reduction in Gram yield in two years. The availability of photosynthetically active radiation (PAR) is highly correlated with vegetative and yield attributes of the crop. PAR decreased with increase in the age of trees as reduction was 33 per cent in 1998 and 48 per cent in 1999 as compared to open. Soil water and nutrients were not limiting factors for crop performance. Crop growth and yield was lowest under the base of the tree.

Panwar and Chakravarthy (2011) studied the performance of Paddy under agrisilviculture system found that plant height, number of panicles and straw and grain yield increased as the distance from the tree increased. The availability of sufficient amount of light in the middle of plant rows has attributed to further the increase in growth and yield parameters.

Gnangle *et al.* (2013) studied the productivity of cotton and sorghum in a shea-tree based agroforestry system in northern Benin. Within each parkland and village, three classes of tree crown diameter for shea tree (4-8 m, 8-10 m, <10 m), were defined after the inventory phase. The data was collected for sorghum and cotton on 1 m area under the crown and outside the crown, in the four cardinal directions of each sample tree: crop height, fresh biomass per crop and buds per cotton plant. Data analysis revealed a very significant difference in the variables (height of sorghum and cotton, biomass of cotton and sorghum, number of cotton buds) between the areas under the crown and those outside the crown ($P < 0.01$). The productivity variables for sorghum, i.e., average plant height and average biomass, dropped by 9.75% and 29.31%, respectively, when planted under the crown. Cotton under the crown was 6.58% shorter compared to plants outside the crown. Average bud production and average fresh biomass for cotton plants was 13.06% and 36.06% less, respectively, when planted under the crown of shea trees.

Kaur and Puri (2013) reported that sole crop had more biomass in comparison to crop grown under trees. They reported that total biomass of crop with trees was 33.34 Mg/ha in *Vigna mungo* and also

Triticum aestivum the total biomass for sole crop was 79.25 Mg/ha whereas crop with trees showed 74.63Mg/ha biomass.

Kumar *et al.* (2015) studied growth and yield of *Vigna radiate* L. under *Terminalia arjuna* and *Mitragyna parvifolia* based agrisilvicultural system. With treatment involving silvicultural components of 20 years old *Terminalia arjuna Bedd.* (Arjun) and *Mitragyna parvifolia Korth* (Kalam) intercropped with agricultural components of four varieties of green gram (*Vigna radiate* L.) viz. Pusa Vishal, GM-3. GM-4, and K-851. All the varieties of green gram were compared for growth and yield parameter like plant height (cm), number of leaves, number of branches per plants as well as per plot at harvestable stage under Arjuna and Kalam trees. All the varieties of green gram performed superior in terms of number of leaves, number of branches, grain yield (per plant and per plot basis) under open condition as compared to crops under Arjun and Kalam. However, only the plant height was highest under Arjun, followed by Kalam trees. Among all the varieties tested, K-851 variety showed superiority for number of leaves (12.31) and number of branches per plant (3.96) and grain yield (2.66 gm per plant and 0.80 kg per plot) as compared to other varieties (at P=0.05) comparatively lower yield of crop under tree cover could be due to shade effect.

Kumar *et al*. (2015) reported that higher harvest index in sole cotton crop (44.24 %) as compared to others.

Kaur *et al*. (2017) studied the to evaluate the production behaviour of *Zea mays* as intercrop in an agri-silviculture system located in Sultanpur village of Solan District (Himachal Pradesh). The trees present were *Grewia optiva, Bauhinia variegate and Toona ciliate*. Plant height, number of leaves, number of cobs, number of grains, grain yield, straw yield and harvest index were evaluated during the year 2010 and 2011. Grain yield and harvest index was 1.21 and 1.13times more in the year 2011 in comparison to year 2010. Average straw yield for the two years of study varied from 1208.5 to 1541.0 Mg/ha. Grain yield reduced near the tree base and it gradually increased with an increased in distance from the tree.

Bhardwaj *et al.* (2017) study the effect of *Eucalyptus tereticornis* bund plantation on the yield of agricultural crops and soil properties in Haryana. Total biomass yield of dhaincha was significantly affected up to 3 m distance from tree line both of east-west and north-south planted rows of eucalyptus. Different aspects have no significant effect on total biomass yield of dhaincha. The reduction in total biomass yield of dhaincha was 27.2 % at 0-3 m distance from tree line over 15-18 m distance under both the south-north and east-west planted row of eucalyptus. The grain yield of Barley was significant less than other distance in both east-west and north-south planted eucalyptus. The soil organic carbon and available N, P and K content were significantly highest in the western in the aspect in 0-3 m distance and these decreased with increase in the distance from the tree in different aspects.

2.3. Effect on microclimate in agroforestry systems

Monteith *et al.* (1991) reported that tree on form bring about favourable changes in the microclimatic conditions by influencing radiation flux, air temperature, wind speed, saturation deficit of understory crops all of which will have a significant impact on modifying the rate and duration of photosynthesis and subsequent plant growth, transpiration, and soil water use.

Niwas and Sastri (1997) studied the stomatal response to radiation and temperature, Photosynthetically active radiation (PAR), leaf temperature, humidity and diffusion resistance for both abaxial and adaxial leaf surfaces of Pearl millet. An inverse relationship was found between stomatal diffusion resistance and PAR while a direct relationship was observed between diffusion resistance and leaf temperature.

Zhao and Oosterhuis (1997) reported that to determine the effects of an 8-d period of shade (63% reduction in photosynthetic photon flux density) at four growth stage of cotton (*Gossypium hirsutum* L.) [i.e., pinhead square (PHS), first flower (FF), peak flower (PF), and boll development (BD)] leaf photosynthesis, chlorophyll concentration, and nonstructural carbohydrate (hexose, sucrose and starch) concentrations in leaves, floral bracts, and floral buds of field-grown cotton plants. At all four

growth stages, shade caused a 43 to 55% decrease in leaf photosynthetic rate, and a 14 (on a leaf area basis) or 73% (on a dry weight basis) increase in total chlorophyll concentration but did not affect leaf dark respiration rate. Starch concentration in leaves and floral bracts decreased sharply under shade, whereas only minor changes in hexose concentration occurred. Shade at FF and PF stage did not, whereas shade at the BD stage did decreases, the concentration of total nonstructural carbohydrate (TNC) in 20-d-old floral buds.

Muthunal *et al.* (1998) Studies conducted by revealed that Groundnut pod yield was higher in pure stand (1149 kg ha-1) as compared to743 kg ha^{-1} in agroforestry system. This was due to decreased light transmission ratio in agroforestry system.

Steffan-Dewenter *et al.* (2007) studied the removal of shade trees increased soil surface temperature by about 4°C and reduced relatively air humidity at 2 m above ground by about 12%.

Mukherjee *et al.* (2008) reported that tea under plantation of alley of seven shade tree species including *Accacia auriculiformis, Casuarina equisetifolia, Dalbergia sisso, Gliricidia sepium, albizzia lebbeck, Gmelina arborea, and Eucalyptus hybrid* and reported that both atmospheric temperature and soil temperature were lowered by 2-3°C compared to a non-shade open condition, where as relative humidity valves increased by 3-9%within shade.

Nair *et al.* (2009) under the agroforestry system carbon sequestration has potential to mitigate the greenhouse gases because of greater efficiency of resources (nutrients, light and water) capture and utilization. Moreover, reforestation and agroforestry system offer perhaps the greatest potential to remove large quantities of carbon from the atmosphere.

Verma and Rana (2014) study the light intensity recorded was maximum in open crop than tree under tree canopy. The result indicate that paddy grain yield was 14.7- -1-1 19.7% less under tree canopy (1.99 t ha)

than open area (2.34 t ha). However, under tree canopy, the wheat grain yield (1.49 t ha) was 26.4-34.6 % lower than that of open cultivation.

Hosur and Dasog (1995) studied the effect of tree species on soil properties. They noticed that organic carbon was more under tree plantations compared to control site.

Moreno *et al.* (2007) studied on the impact of evergreen oaks *(Quercu silex* L.) on soil fertility and crop production of intercropped oats (*Avena sativa*). Soil fertility increased near the trees, with increase in soil organic matter. In unfertilized plots, trees had a positive effect on crop production, with higher crop production occurring beneath trees. In fertilized plots crop production was reduced near the trees because fertilizers outweighed the positive effect of trees.

Burman *et al.* (2009) reported that organic carbon decreased with increasing distance from the trees. Organic carbon status of the soil was higher on northern side of the tree as compared to southern side. This was due to more shading effect of trees on northern side.

Reis *et al.* (2010) assessed the contribution of silvipastural systems on soil fertility. Results indicated that N, P, K and micronutrients were higher in silvipastoral systems compared to control.

2.4 Effect on yield of agri-tree species system

Kermani *et al.* (1980) studied the economics evaluation is an important tool to assess the technology. For a successful adoption of a system, it should be economically viable. In Pakistan, eucalyptus + cotton combination was best for higher monetary returns.

Mathur *et al.* (1984) reported that the loss in grain yield of paddy was from 38 to 40quintals per hector and for wheat it was from 33 to 35 quintals per hector when grown with eucalyptus and the economic return from eucalyptus was Rs. 15,300/-. Hence, reduction in crop yield of paddy and wheat were compensated by the value of eucalyptus.

Anon (1984) studied the alley cropping of leucaena + sorghum had higher returns (Rs 14,000/ha) as compared to sole sorghum (Rs. 2,700/ha).

Reddy *et al.* (1992) studied that the agroforestry system was more profitable than tree farming, profits from arable crops like sorghum, sorghum + pigeon pea and castor worked out to be 40, 72 and 25 percent with casuarina as compared to growing of sole crops.

Subramanyam *et al.* (1996) found that the gross returns were found higher in sunflower (Rs. 2851/ha) and castor (Rs. 3159/ha) in association with *D.* sissoo as compared to sole crops at Rajendranagar.

CHAPTER III

MATERIALS AND METHODS

A study entitled “Performance of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.” was undertaken at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during 2017-2018.

3.1 MATERIALS

The seed material and field facilities at Cotton Research Unit were used and instruments were made from Department of Forestry and Department of Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

3.2 EXPERIMENTAL SITE

The experiment was carried out during *Kharif*, 2017 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

3.3 SOIL AND ITS CHARACTERISTICS

The experiment was conducted on black cotton soil of main Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The composite soil sample was collected from 0-25 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 NPK content.

3.4 CLIMATIC AND WEATHER CONDITIONS

The data on climatic parameters such as rainfall (mm), mean maximum and mean minimum temperature (°C) and relativity humidity (%) recorded at meteorological observatory, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Akola is situated in sub-tropical region between 22^0 42’ N latitude and 77^0 02’ E longitudes. The altitude of the place is 304.42 m above mean sea level. The climate of Akola is semi-arid and characterized by three distinct seasons *viz.*, hot and dry summer from March to May, warm humid rainy season from June to October and mild cold winter from

November to February. Average annual precipitation on the basis of last fifteen years is 515.8 mm. The experimental rainfed cotton crop was sown in the 25 MW (20 June, 2017) and harvested in 51MW (Last picking). The total rainfall received during the crop growth period was 591.3 mm in 26 rainy days. The temperature data reported maximum (day) temperature 38^0C in 41 MW during the crop growth period and minimum temperature during (night) time was ranged from 12.1^0Cin 49 MW. Dry spell was in 39 MW which hampered the growth of the crop during flowering stage and thereafter it was well distributed up to 51MW, which ultimately reflected on the significant improvement in the yields of the rainfed cotton under the various manurial treatments.

3.5 PREVIOUS CROPS GROWN ON EXPERIMENTAL AREA

Cotton was grown during kharif season of 2016 with recommended package of practices in the experimental site.

3.6 DESIGN, LAYOUT AND REPLICATION

The experiment was laid out in Random Block Design with five replications and four Treatments indicated in (Fig. 1)

3.7 CULTURAL OPERATIONS

3.7.1 Land preparation

Land was ploughed during summer and harrowed twice after pre-monsoon rains and smoothened to prepare fine seed bed.

3.7.2 Sowing

Cotton seeds were hand dibbled in the line opened 3 m away from the teak plantation along with 60 cm to 60 cm plant to plant spacing.

3.7.3 After care

Gap filling was carried out for crops after 15 days of sowing to maintain optimum plant population. Plots were kept weed free by regular intercultivations and hand weeding. Plant protection measures were taken up at early symptoms of pest and diseases as per package of practices.

3.7.4 Harvesting

Harvesting of the crop was carried out at physiological maturity. Cotton was harvested by uprooting the plants, for measured the dry weight and root length.

Table 1. Details of teak based agroforestry system.

Particulars	Experiment
Title	Performance of cotton (Gossypium *hirsutum* L.) under teak based agroforestry system.
Tree	Teak (King of Timber) 30 years old boundary plantation.
Botanical Name	*Tectona grandis* L.
Family	Verbenaceae
Crop	Cotton (American cotton) (King of fiber)
Botanical Name	*Gossypium hirsutum* L.
Family	Malvaceae
Spacing of cotton crop	60 × 60 cm^2
Method of sowing of cotton	Dibbling
Variety	- AKH9916 - AKH09-5 - AKH8828
Treatments details	T_1 = Cotton plot at 3m. distance from teak row plantation. T_2 = Cotton plot at 6 m. distance from teak row plantation. T_3 = Cotton plot at 9m. distance from teak row plantation. T_4 = Control plot without tree
Design	Randomized Block Design (RBD)
Treatments	Four (4)
Replication	Five (5)
Plot Size	13 m × 9 m for shaded plot 13 m × 5.5 m for control plot
Fertilizers (N, P_2O_5, K_2O kg ha $^{-1}$)	25:50:25
Date of sowing	7 July 2017

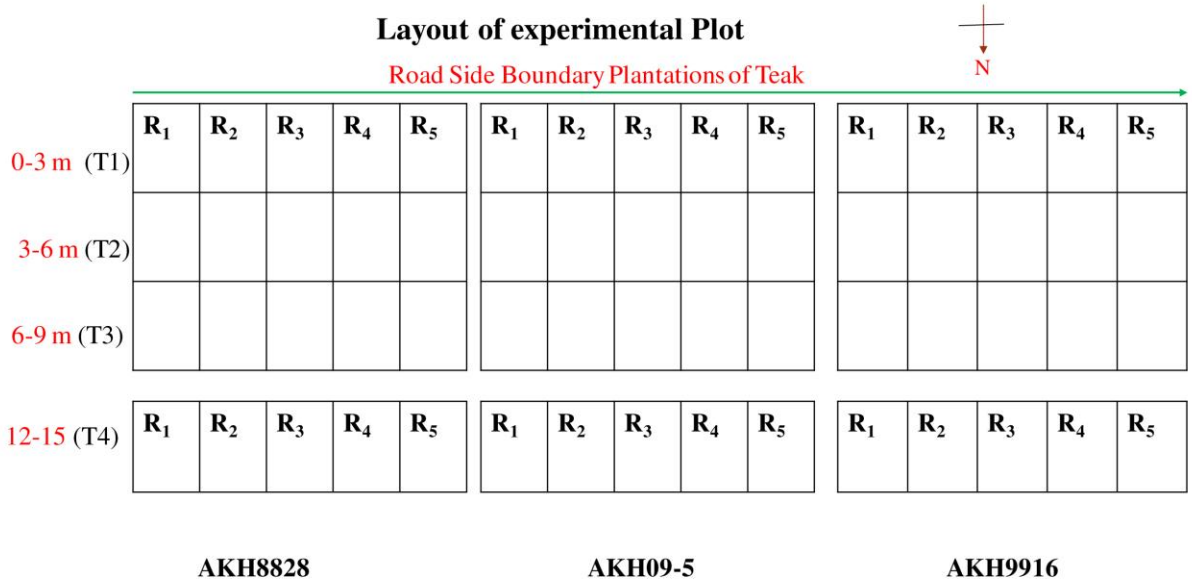

Fig. 1 Plan of layout

Plate 1. View of teak boundary plantation at beginning the start of research work.

Plate 2. View of T_1, T_2, T_3 plot of cotton at first flowering stage.

Plate 3. View of T_4 plot of cotton at first flowering stage.

3.8 Observations recorded

In the experiment, five plants were randomly selected from each plot per replication per treatment. The methods and procedure followed in recording observations for different parameters in cotton are as followed.

A. Tree Growth Parameter

1) Height (m)
2) Diameter at breast height (cm)
3) Crown spread (m)

B. Crop Growth and Yield Parameter

1) Germination / Field Emergence (%)
2) Plant Height (cm)
3) Days to First Flowering
4) Days to 50% Flowering
5) Days to 50% Boll Bursting
6) Number of Monopodial per Plant
7) Number of Sympodial per Plant
8) Number of Bolls per Plant
9) Boll Weight (g)
10) Seed Cotton Yield per Plant (g)
11) Seed Index (g)
12) Lint Index
13) Ginning Percentage (%)

C. Microclimatic Observation

1) Photosynthetically Active Radiation (µmol m^{-2} s^{-1})
2) Relative Humidity (%)
3) Temperature (°C)
4) CO_2 (ppm)

D. Physiological Observation

1) Leaf Area Index
2) Harvest Index (%)
3) Chlorophyll Content (mg/g)

Recording the Observation

A. Tree Growth Parameters

Tree growth parameters were recorded at start of experiment.

1) Height (m): -

Tree height was measured in meter with the help of Ravi altimeter.

2) Diameter at breast height (cm): -

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

3) Crown spread (E-W and N-S) (m): -

Tree crown spread was recorded by measured spread of tree in east-west and north-south direction.

B. Crop Growth and Yield Parameter

1) Germination/ field Emergence (%): -

Number of initial plants per plot was recorded twenty days after date of sowing.

2) Plant Height (cm): -

The height of five selected plants in each plot was measured in centimeter from cotyledonary node up to the growing point at maturity.

3) Days to First Flowering: -

The days required to 1st flowering of plant from the date of sowing was recorded.

Plate 4. Measurement of height (m) of boundary plantation of teak tree

Plate 5. Measurement of diameter at breast height (cm) of boundary plantation of teak tree

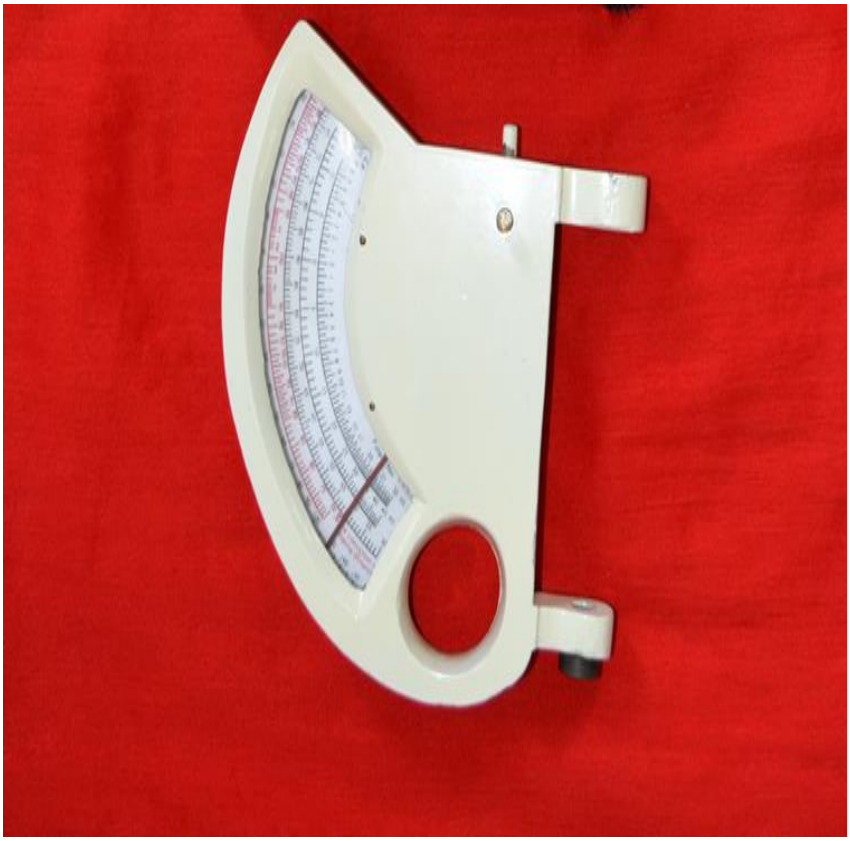

Plate 6. Ravi Altimeter

Plate 7. Measuring tape

4) Days to 50% Flowering: -

Data on number of days required for initiation flowering of 50% of plants in each plot from date of sowing was recorded for replication and average was calculated.

5) Days to 50% Boll Bursting: -

The days required to boll burst of 50% of plants per replication was recorded.

6) Number of monopodia per Plant: -

Total number of vegetative growing branches was counted on main stem of selected plants in each plot at maturity.

7) Number of sympodia per plant: -

Total number of fruits bearing branches per selected plant was counted at maturity.

8) Number of bolls per plant: -

Number of bolls per plant from which seed cotton was picked during each picking and mean number of bolls per plant was calculated.

9) Boll weight (g): -

After final picking seed cotton of five representative bolls from each plant of each treatment was weighed and average was worked out and recorded.

10) Seed cotton yield per plant (g): -

Seed cotton obtained from five randomly selected plants was weighed separately and mean seed cotton yield was computed.

11) Seed Index (g):-

Seed index was recorded by weighing 100 seeds of each selected plant per replication.

12) Lint Index: -

It is an absolute weight of lint borne on 100 g seed of cotton.

Plate 8. To separate the lint from the seed cotton yield by using ginning hand machine

Plate 9. Measured the seed index with the help of Digital weighing balance

$$\text{Lint index} = \frac{\text{Weight of 100 seeds} \times \text{Ginning \%}}{100 - (\text{Ginning \%})}$$

13)Ginning Percentage (%): -

It is a ratio of lint to seed cotton. The seed cotton was ginned by hand. Ginn weight of lint was recorded and ginning percentage calculated by using formulae,

$$\text{Ginning \%} = \frac{\text{Weight of lint (g)}}{\text{Weight of seed cotton (g)}} \times 100$$

Microclimatic Observation: -

The microclimatic observations PAR, RH and Air Temperature was recorded at two different time i.e., 8 am and 4 pm above cotton (*Gossypium hirsutum* L.) crop in each treatment during the course of cotton crop cultivation at different growth stages i.e., 50% flowering, 50% boll bursting and harvesting.

1) Photosynthetically Active Radiation (PAR): -

Photosynthetically Active Radiation was measured with the help of External Solar Electronic Quantum Meter and recorded in µmol m^{-2} s^{-1} for each treatment at different growth stages.

2) Relative Humidity (%): -

Relative humidity was measured with the help of Digital Hygrometer and recorded in percentage at different growth stages.

3) Temperature (°C): -

Air temperature was measured with the help of Digital Thermometer and recorded in °C at different growth stages.

4) CO_2 (ppm): -

CO_2 was measured with the help of CO_2 meter and recorded in ppm at different growth stages.

Plate 10. Measured the PAR of cotton plant at field

Plate 11. Measured the Chlorophyll content and CO_2 of cotton plant at field

Plate 12. Chlorophyll spad meter

Plate 13. External Solar Quantum Meter

Plate 14. CO_2 Meter

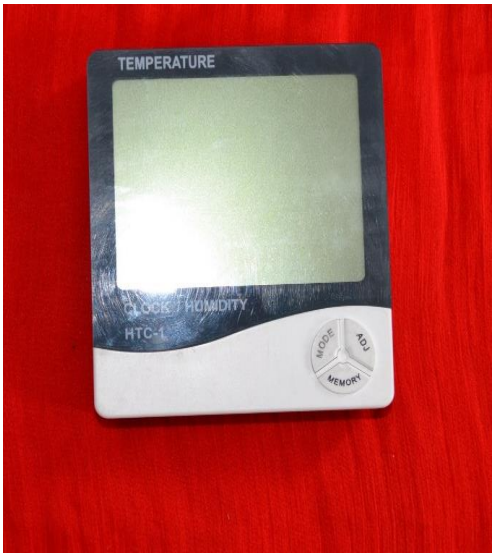

Plate 15. Digital Hygrometer and Thermometer

Physiological Observation: -

The physiological observation LAI, HI and chlorophyll content was recorded.

1) Leaf Area Index (LAI): -

Leaf area index represents the ratio of leaf area per plant to the land area occupied by the plant. LAI was calculated from data on leaf area per plant by following formula given by Watson (1947) at three growth stages i.e., 50% flowering, 50% boll bursting and harvesting.

$$LAI = \frac{\text{Leaf area per plant } (cm^2)}{\text{Ground area per plant } (cm^2)}$$

2) Harvest Index (HI) (%): -

Harvest index was computed by dividing the seed cotton yield per plant total biological yield per plant and expressed in percentage at harvest.

$$\text{Harvest Index (\%)} = \frac{\text{Seed cotton yield per plant}}{\text{Biological yield per plant}} \times 100$$

3) Chlorophyll Content (mg/g): -

Chlorophyll content was measured with the help of chlorophyll spado meter at three different growth stages i.e., 50% flowering, 50% boll bursting and Harvesting

CHAPTER IV

RESULTS AND DISCUSSION

An experiment entitled "**Performance of Cotton (*Gossypium hirsutum* L.) in Teak based Agroforestry System."** was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2017 - 2018. The experiment was laid out in Random Block Design, which contained five replications with four treatments. The summarized data, statistical parameters and result obtained are presented in this chapter at three different growth stages with following objectives.

1. To study the growth performance of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.
2. To study the yield of cotton (*Gossypium hirsutum* L) in teak based agroforestry system.

During the course of field experimentation, the observations recorded on growth and yield attributes of cotton as influenced by teak-based agroforestry systems were presented, tabulated and discussed in this chapter under appropriate heading and sub heading.

4.1 RESULT

4.1.1 Growth Performance of cotton in teak

4.1.1.1 Germination Percentage (%)

The seed germination percentage of *Gossypium hirsutum* L as influenced by teak with different treatments is presented in Table 2 and graphically shown in Fig. 2 Germination percentage of the crop differs in all the treatment and the germination percentage was progressively increased with increased in distance from the teak boundary plantation.

The mean performance of the character germination percentage (%) was ranged from 76.8 per cent to 97.2 per cent with mean 89.75 per cent of variety AKH09-5. The highest germination percentage was observed significantly in T_4 treatment (97.2%) at 12-15 m distance

followed by T_3 treatment (93.8%) at 6-9 m distance and T_2 treatment (91.2%) at 3-6 m distance from the teak boundary plantation as at par with T_4 plot.

The highest germination percentage of AKH8828 was observed significantly in T_4 treatment (98.6%) at 12-15 m distance followed by T_3 treatment (93.8%) at 6-9 m distance and T_2 treatment (87.4%) at 3-6 m distance as at par with T_4 treatment. The ranged of germination percentage from 64.8 per cent to 98.6 per cent with mean 86.15 per cent.

The lowest germination percentage of AKH9916 was observed in T_1 treatment (73.8%) at 0-3 m distance. The mean performance of the germination percentage was ranged from 73.8 per cent to 97.8 per cent with mean 99.75 per cent. The highest germination percentage was significantly observed in T_4 treatment at 12-15 m distance followed by T_3 treatment (94.4%) at 6-9 m distance and T_2 treatment (89.0%) at 3-6 m distance as at par.

As the germination percentage for T_3 andT_4 treatment in each replication was above 90 per cent was the highest as compared to T_1 and T_2 treatment above 80 per cent.

Table 2. Germination percentage of cotton as influenced by different distance from the teak tree

Treatments	**Germination Percentage (%)**		
Varieties	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	64.8	76.8	73.8
T_2	87.4	91.2	89.0
T_3	93.8	93.8	94.4
T_4	98.6	97.2	97.8
Mean	86.15	89.75	88.75
Range	64.8 -98.6	76.8 - 97.2	73.8 -97.8
SE (m)±	3.20	1.61	1.85
CD (5%)	9.87	4.95	5.71
C. V.	8.32	4.00	4.67
‘F’ Test	Sig	Sig	Sig

4.1.1.2 Plant height (cm)

Data on plant height recorded at various stages of crop

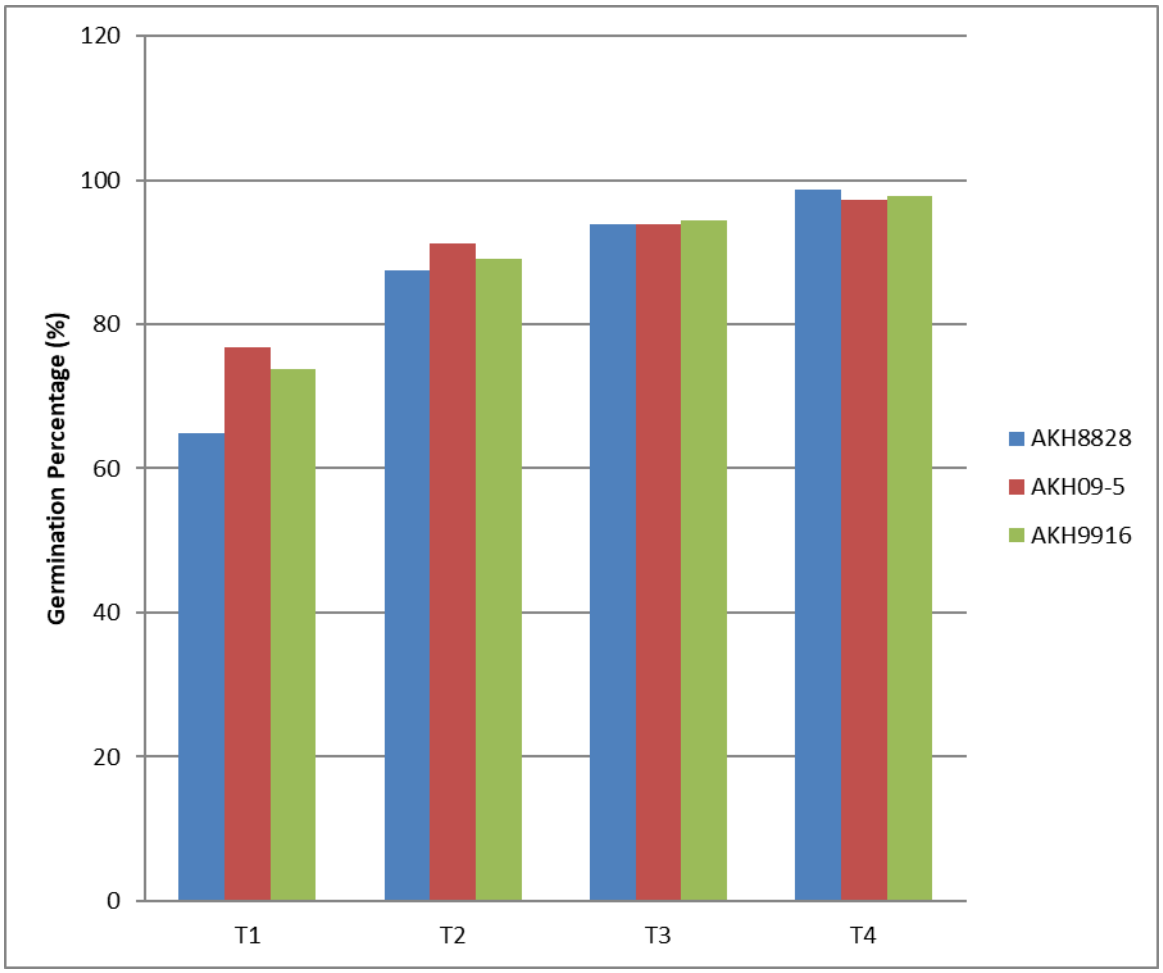

Fig. 2. Germination percentage of cotton as influenced by different distance from the teak tree

growth (i.e. 50% flowering, 50% boll bursting and harvesting) as affected by different treatments are presented in Table 3 and graphically shown in Fig. 3. Plant height as the crop advanced in age attaining its maximum values of 96.7 cm, 108.6 cm and 84.3 cm of variety i.e., AKH8828, AKH09-5 and AKH9916 respectively at harvest.

At 50 % Flowering Stage

The highest plant height of cotton AKH8828 was observed significantly in T_4 treatment (75.5 cm) at 12-15 m distance followed by T_3 treatment (59.9 cm) at 6-9 m distance and T_2 treatment (46.0 cm) at 3-6 m distance as at par with T_4 treatment. The mean performance of plant height ranged from 37.8 cm to 75.5 cm with mean 52.55 cm.

The mean performance of plant height of cotton AKH09-5 was ranged from 41.1 cm to 71.0 cm with mean 59.90 cm. The lowest plant height was observed in T_1 treatment (41.1 cm) at 0-3 m distance followed by T_2 treatment (56.8 cm) at 3-6 m distance and T_3 treatment (67.3 cm) at 6-9 m distance as at par with T_4 treatment.

In AKH9916 variety of cotton, the highest plant height was observed significantly in T_4 treatment (72.9 cm) at distance 12-15 m distance followed by T_3 treatment (70.0 cm) at 6-9 m distance and T_2 treatment (62.0 cm) at 3-6 m distance from the teak boundary plantation as at par. The ranged of plant height from 43.3 cm to 72.9 cm with mean 62.10 cm.

At 50% Boll Bursting Stage

The plant height of cotton AKH8828 was observed significantly the highest in T_4 treatment (83.7 cm) at 12-15 m distance. The mean performance of plant height ranged was 43.0 cm to 83.7 cm with mean 62.52 cm. The lowest plant height was found in T1 treatment (43.0 cm) at 0-3 m distance followed by T_2 treatment (54.3cm) at 3-6 m distance and T_3 treatment (61.1 cm) at 6-9 m distance as at par with T_4 treatment.

At T_4 treatment (85.3 cm) was significantly the highest plant height of cotton AKH09-5 as compared to T_3 treatment (73.6cm) and T_2

treatment (60.0cm) as at par with T_4 treatment. The lowest plant height was observed inT_1 treatment (46.3cm) at 0-3 m distance from the teak boundary plantation. The ranged of plant height was 46.3 cm to 85.3 cm with mean 66.30 cm.

The ranged of cotton AKH9916 was 47.1 cm to 81.0 cm with mean 66.30 cm. The highest plant height was significantly found in T_4 treatment (85.3 cm) at 12-15 m distance followed by T_3 treatment (71.8 cm) at 6-9 m distance and T_1 treatment (64.4cm) at 3-6 m distance as at par with T_4 treatment.

Table 3. Plant height of cotton as influenced by different distance from the tree

Treatment	Plant Height (cm)								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	37.8	41.1	43.3	43.0	46.3	47.1	54.9	51.6	50.1
T_2	46.0	56.8	62.0	54.3	60.0	64.4	64.8	64.8	66.3
T_3	50.9	67.3	70.0	61.1	73.6	71.8	76.3	84.9	78.1
T_4	75.5	71.0	72.9	83.7	85.3	81.0	96.7	108.6	84.3
Mean	52.55	59.90	62.10	62.52	66.30	66.30	73.17	77.47	69.70
Range	37.8 - 75.5	41.1 - 71.0	43.3 - 72.9	43.0 - 83.7	46.3 - 85.3	47.1 - 81.0	54.9 - 96.7	51.6 - 108.6	50.1 - 84.3
SE (m)±	2.94	1.80	2.49	2.82	2.12	1.19	0.72	3.06	1.55
CD (5%)	9.07	5.53	7.67	8.69	6.52	3.66	2.23	9.44	4.77
C. V.	12.52	6.80	8.97	10.4	7.14	4.02	2.21	8.84	4.97
'F' Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

At Harvesting Stage

The mean performance of cotton AKH8828 was significantly the highest in T_4 treatment (96.7 cm) at 12-15 m distance from the teak row. The ranged of the plant height from 54.9 cm to 96.7 cm with mean 73.17 cm. The lowest plant height was observed in T_1 treatment (54.9 cm) at 0-3 m distance followed by T_2 treatment (64.8cm) at 3-6 m distance and T_3 treatment (76.3 cm) at 6-9 m distance from the teak boundary plantation.

At this stage, variety AKH09-5 was significantly the highest

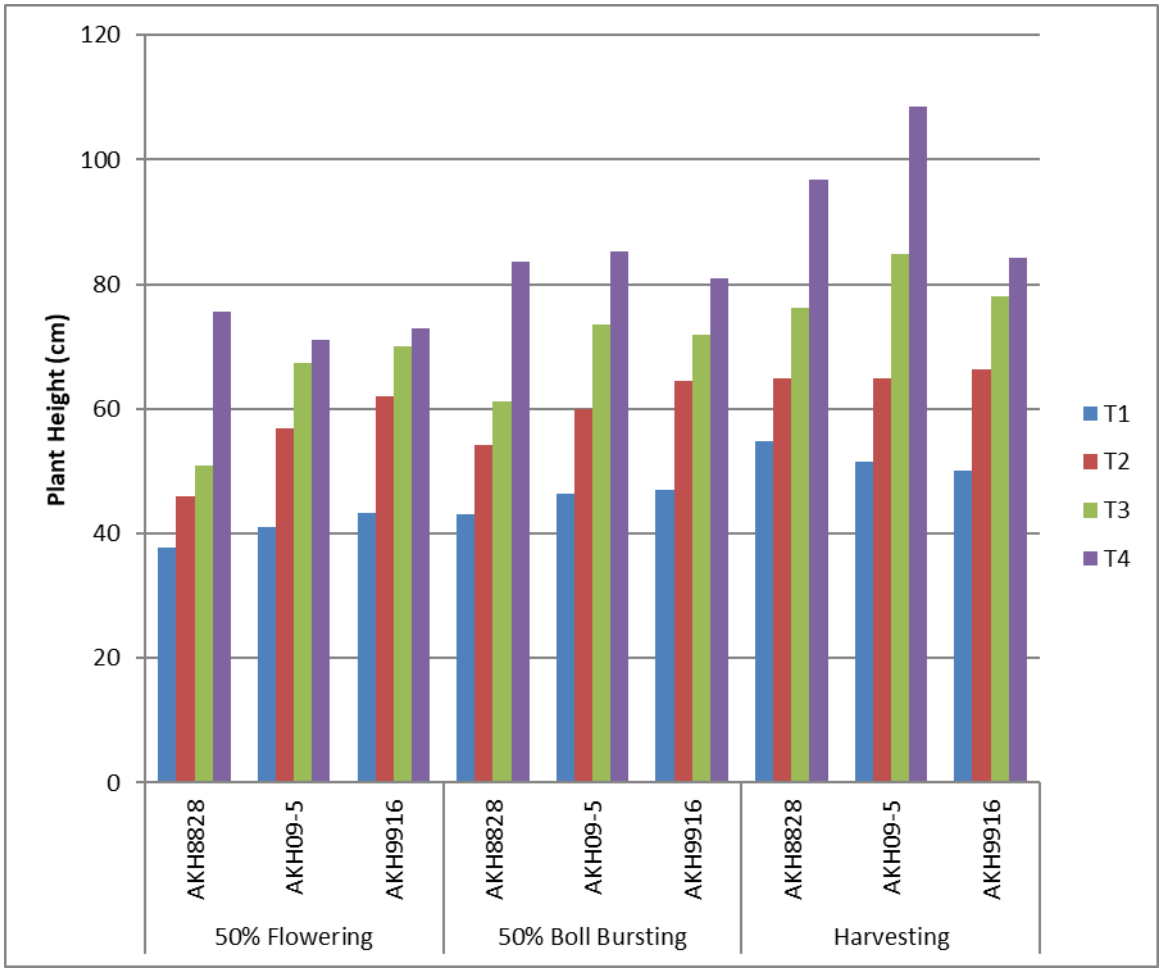

Fig. 3. Plant height of cotton as influenced by different distance from the tree

plant height in T_4 treatment (108.6cm) at 12-15 m distance followed by T_3 treatment (84.9cm) at 6-9 m distance and T_2 treatment (64.8 cm) at 3-6 m distance as at par with T_4 treatment. The ranged was observed from 51.6 cm to 108.6 cm with mean 77.47 cm.

The lowest plant height of cotton AKH9916 variety was observed in T_1 treatment (50.1 cm) at 0-3 m distance followed by T_2 treatment (66.3 cm) at 3-6 m distance and T_3 treatment (78.1cm) at 6-9 m distance. The ranged from 50.1 cm to 84.3 cm with mean 69.70 cm.

4.1.1.3 Days to First Flowering

Data on days to first flowering recorded at three different varieties of crop (AKH8828, AKH09-5, AKH9916) as affected by different treatments are presented in Table 4. and graphically shown in Fig. 4. The days to first flowering was maximum in treatment T_1 and minimum in T_4.

Table 4. Days to First Flowering required to cotton as influenced by different distance from teak tree

Treatment	**Days to First Flowering**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	52.4	51.8	51.8
T_2	50.4	50.2	50.0
T_3	48.2	48.2	48.0
T_4	45.8	45.0	45.2
Mean	49.20	48.80	48.70
Range	45.8 - 52.4	45.0 - 51.8	45.2 - 51.8
SE (m)±	0.27	0.29	0.26
CD (5%)	0.82	0.91	0.81
C. V.	1.22	1.35	1.20
‘F’ Test	Sig	Sig	Sig

Maximum day required significantly in T_1 treatment (52.4) at 0-3 m distance in cotton variety AKH8828 followed by T_2 treatment (50.4) at 3-6 m distance and T_3 Treatment at 6-9 m distance from the teak boundary plantation. The ranged observed from 45.8 to 52.4 with mean 49.20.

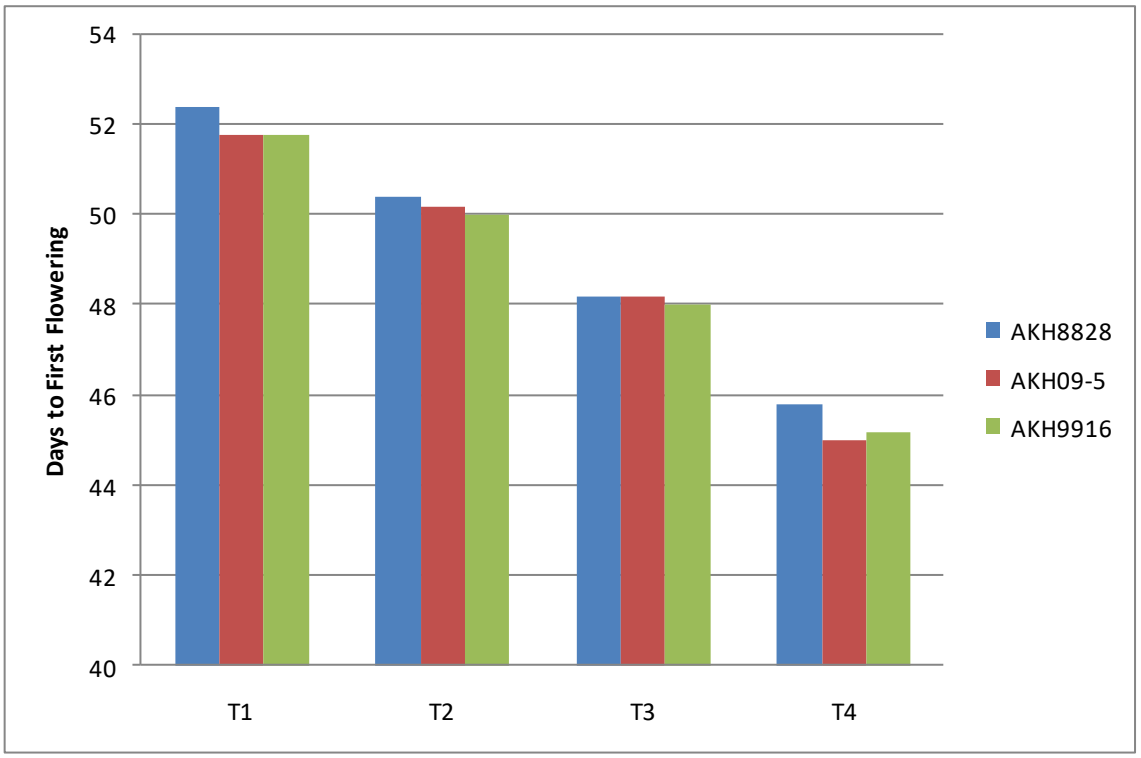

Fig. 4. Days to First Flowering required to cotton as influenced by different distance from teak tree

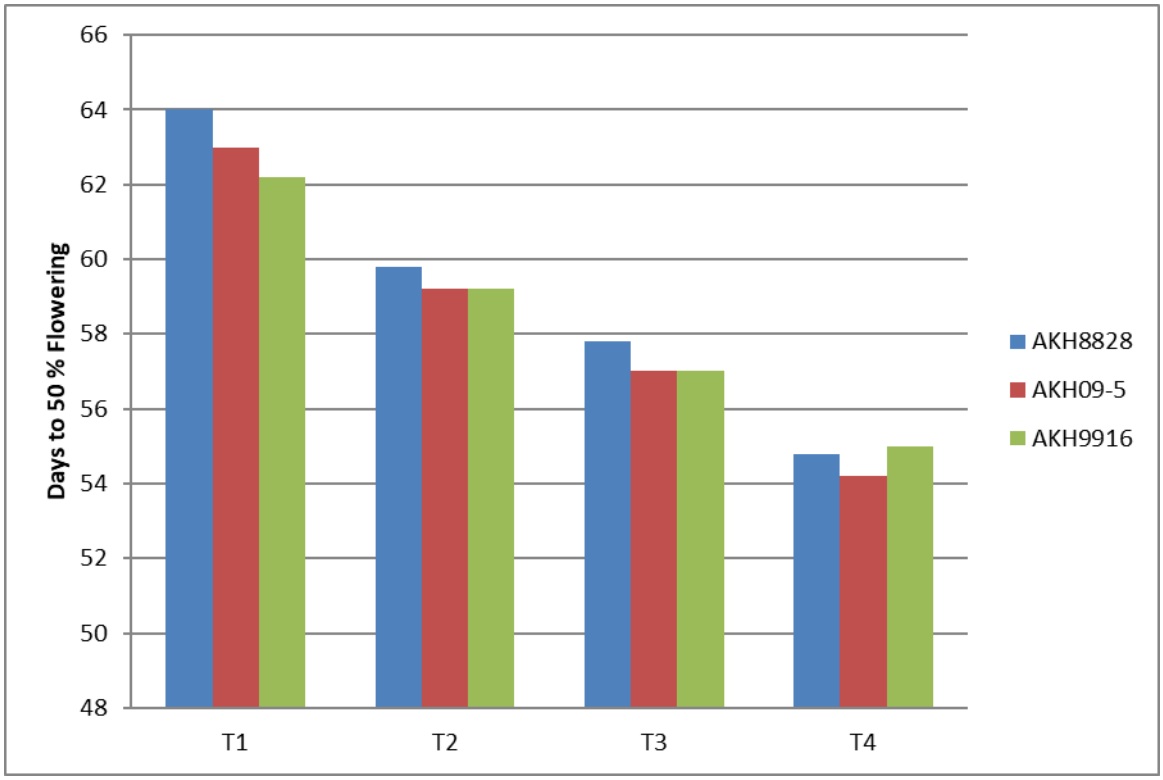

Fig. 5. Days to 50% Flowering required to cotton as influenced by different distance from teak tree

The mean performance of cotton variety AKH09-5 was significantly minimum days required to T_4 treatment at 12-15 m distance. The ranged from 45.0 to 51.8 with mean 48.80 whereas the maximum days required to first flowering in T_1 treatment (51.8) at 0-3 m distance followed by T_2 treatment (50.2) at 3-6 m distance and T_3 treatment (48.2) at 6-9 m distance from the teak row.

The days to first flowering of cotton variety (AKH9916) was maximum significantly required to T_1 treatment (51.8) at 0-3 m distance followed T_2 treatment (50.0) at 3-6 m distance and T_3 treatment (48.0) at 6-9 m distance. The ranged of days required to first flowering from 45.2 to 51.8 with mean 48.70.

4.1.1.4 Days to 50% Flowering

The data on days to 50% flowering recorded at three different cotton varieties (AKH8828, AKH09-5 and AKH9916) as affected by different treatment are presented in Table 5 and graphically shown in Fig. 5.

The days to 50 % flowering required to cotton (AKH8828) was significantly maximum days observed in T_1 treatment (64.0) at 0-3 m distance followed by T_2 treatment (59.8) at 3-6 m distance and T_3 treatment (57.8) at 6-9 m distance. The ranged observed from 54.8 to 64.0 with mean 59.10.

The minimum days required to 50% flowering of cotton (AKH09-5) in T_4 treatment (54.2) at 12-15 m distance. Whereas the significantly maximum days required to 50 % flowering in T_1 treatment (63.0) at 0-3 m distance followed by T_2 treatment (59.2) at 3-6 m distance and T_3 treatment (57.0) at 6-9 m distance. The ranged observed from 54.2 to 63.0 with mean 58.35.

Table 5. Days to 50% Flowering required to cotton as influenced by different distance from teak tree

Treatment	Days to 50% Flowering		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	64.0	63.0	62.2
T_2	59.8	59.2	59.2
T_3	57.8	57.0	57.0
T_4	54.8	54.2	55.0
Mean	59.10	58.35	58.30
Range	54.8 - 64.0	54.2 - 63.0	55.0- 62.2
SE (m)±	0.33	0.28	0.34
CD (5%)	1.02	0.87	1.04
C. V.	1.25	1.08	1.29
'F' Test	Sig	Sig	Sig

The mean performance of days to 50% flowering of cotton (AKH9916) was ranged from 55.0 to 62.2 with mean 58.30. The maximum days required significantly to T_1 treatment (62.2) at 0-3 m distance followed by T_2 treatment (59.2) at 3-6 m distance and T_3 treatment (57.0) at 6-9 m distance from the teak row.

4.1.1.5 Days to 50% Boll Bursting

The mean number of days required to 50% boll bursting of cotton crop at three different varieties (AKH8828, AKH09-5 and AKH9916) as influenced by different treatment are presented in Table 6 and graphically shown in Fig.6.

The days to 50 % boll bursting required significantly maximum days to cotton (AKH8828) variety in T_1 treatment (134.8) at 0-3 m distance followed by T_2 treatment (131.0) at 3-6 m distance and T_3 treatment (128.2) at 6-9 m distance. The ranged from 126.0 to 134.8 with mean130.00.

The mean performance of days to 50% boll bursting of cotton (AKH09-5) was ranged from 125.6 to 133.8 with mean 129.40. The significantly maximum days required to 50% boll bursting in T_1 treatment

(133.8) at 0-3 m distance followed byT_2 treatment (130.0) at 3-6 m distance and T_3 treatment (128.2) at 6-9 m distance from the teak row.

Table 6. Days to 50% Boll Bursting required to cotton as influenced by different distance from teak tree

Treatment	**Days to 50% Boll Bursting**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	134.8	133.8	132.4
T_2	131.0	130.0	129.0
T_3	128.2	128.2	127.0
T_4	126.0	125.6	125.0
Mean	130.00	129.40	128.35
Range	126.0 - 134.8	125.6 - 133.8	125.0 - 132.4
SE (m)±	0.39	0.32	0.37
CD (5%)	1.20	0.97	1.15
C. V.	0.67	0.55	0.65
'F' Test	Sig	Sig	Sig

The minimum days required to 50% boll bursting of cotton variety (AKH9916) in T_4 treatment (125.0) at 12-15 m distance. The ranged of days to 50% boll bursting from 125.0 to 132.4 with mean 128.35. whereas the significantly maximum days required in T_1 treatment (132.4) at 0-3 m distance followed by T_2 treatment (129.0) at 3-6 m distance and T_3 treatment (127.0) at 6-9 m distance from the teak row.

4.1.1.6 Number of Sympodial per Plant

Mean number of sympodial branches per plant as influenced by different treatment at harvesting stage is shown in Table 7 and depicted in Fig. 7.

The more number of sympodial branches per plant of cotton variety (AKH8828) was significantly observed in T_4 treatment (17.7) at 12-15 m distance followed by T_3 treatment (11.9) at 9-6 m distance and T_2 treatment (8.1) at 3-6 m distance at par with T_4 treatment. The ranged from 6.4 to 17.7 with mean 11.02.

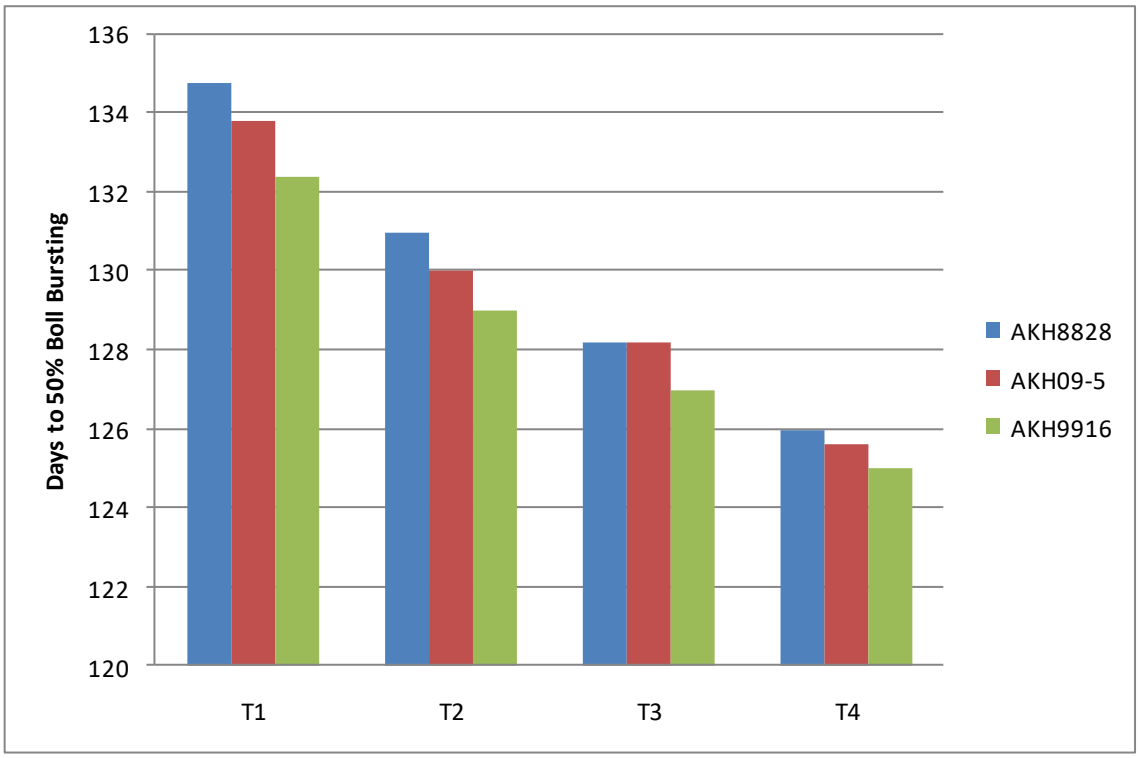

Fig. 6. Days to 50% Boll Bursting required to cotton as influenced by different distance from teak tree

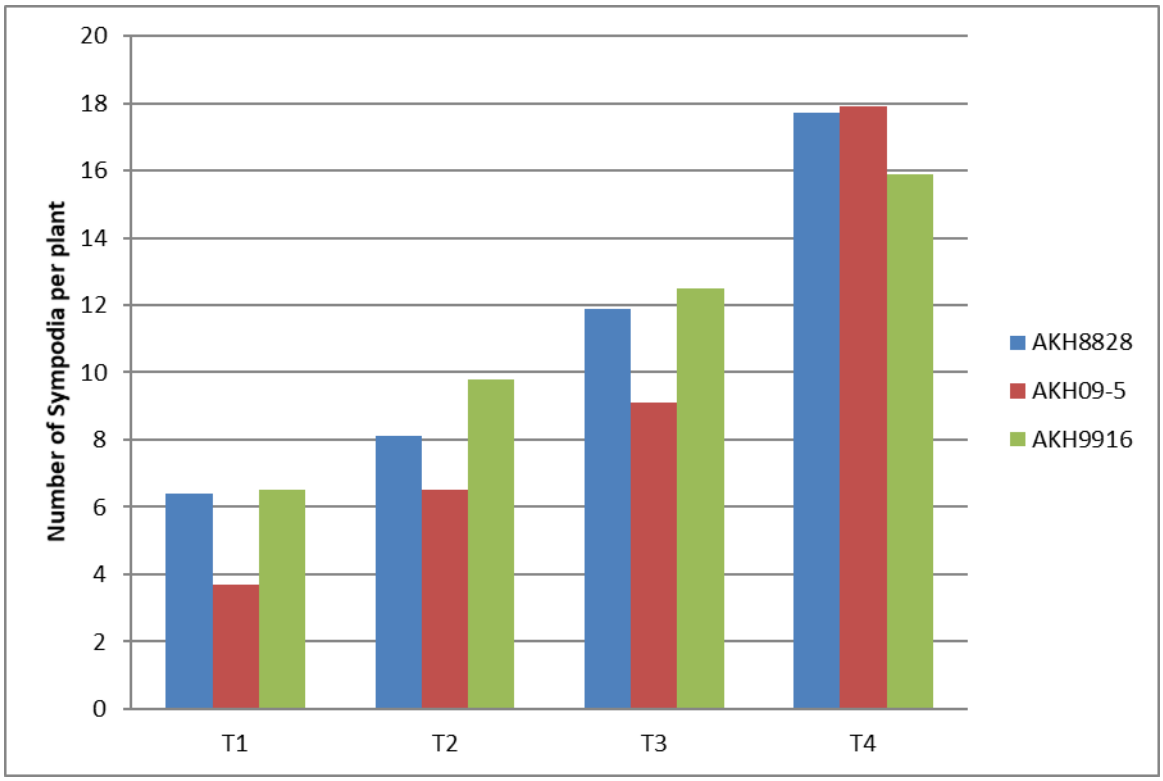

Fig. 7. Number of sympodial branches per plant of cotton as influenced by different distance from the teak tree.

The mean performance of cotton variety (AKH09-5) was ranged from 3.7 to 17.9 with mean 9.30. The significantly maximum number of sympodial branches at harvest stage was observed in T_4 treatment (17.9) at 12-15 m distance followed by T_3 treatment (9.1) at 6-9 m distance and T_2 treatment (6.5) at 3-6 m distance from the teak row at par withT_4 treatment.

Table 7. Number of sympodial branches per plant of cotton as influenced by different distance from the teak tree.

Treatment	**Number of Sympodia per plant**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	6.4	3.7	6.5
T_2	8.1	6.5	9.8
T_3	11.9	9.1	12.5
T_4	17.7	17.9	15.9
Mean	11.02	9.30	11.17
Range	6.4 - 17.7	3.7 - 17.9	6.5 - 15.9
SE (m)±	0.67	0.61	0.69
CD (5%)	2.08	1.89	2.13
C. V.	13.67	14.7	13.81
'F' Test	Sig	Sig	Sig

The number of sympodial branches per plant cotton variety (AKH9916) was significantly maximum observed in T_4 treatment (15.9) at 12-15 m distance followed by T_3 treatment (12.5) at 6-9 m distance and T_2 treatment (9.8) at 3-6 m distance at par with T_4 treatment.

4.1.1.7 Number of Monopodia per Plant

Data recorded on mean number of monopodial branches per plant on harvesting stage as influenced by different treatment are presented in Table 8 and graphically shown in Fig. 8.

The mean performance of cotton variety (AKH8828) was ranged from 1.3 to 2.1 with mean 1.75. The significantly maximum number of monopodia per plant was observed in T_4 treatment (2.1) at 12-15 m

distance followed by T_3 treatment (2.0) at 6-9 m distance and T_2 treatment (1.6) at 3-6 m distance at par with T_4 treatment.

The number of monopodia per plant of cotton variety (AKH09-5) was significantly minimum in T_1 treatment (1.1) at 0-3 m distance followed by T_2 treatment (1.5) at 3-6 m distance and T_3 treatment (1.8) at 6-9 m distance. The ranged from 1.1 to 2.0 with mean 1.60.

Table 8. Number of monopodia branches per plant of cotton as influenced by different distance from the teak tree.

Treatment	**Number of Monopodia per Plant**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	1.3	1.1	1.1
T_2	1.6	1.5	1.5
T_3	2.0	1.8	1.8
T_4	2.1	2.0	2.2
Mean	1.75	1.60	1.60
Range	1.3 - 2.1	1.1 - 2.0	1.1 - 2.2
SE (m)±	0.07	0.12	0.13
CD (5%)	0.20	0.37	0.41
C. V.	8.45	16.55	18.06
'F' Test	Sig	Sig	Sig

At harvesting stage, the number of monopodia of cotton variety (AKH9916) was significantly maximum inT_4 treatment (2.2) at 12-15 m distance followed by T_3 treatment (1.8) at 9-6 m distance and T_2 treatment (1.5) at 3-6 m distance at par with T_4 treatment. The ranged from 1.1 to 2.2 with mean 1.60.

4.1.2 Yield performance of cotton in teak

4.1.2.1 Number of Bolls per Plant

Data in respect of mean number of bolls picked per plant is presented in Table 9. and graphically shown in Fig. 9.

The number of bolls per plant of cotton variety (AKH8828) was significantly maximum in T_4 treatment (18.6) at 12-15 m distance

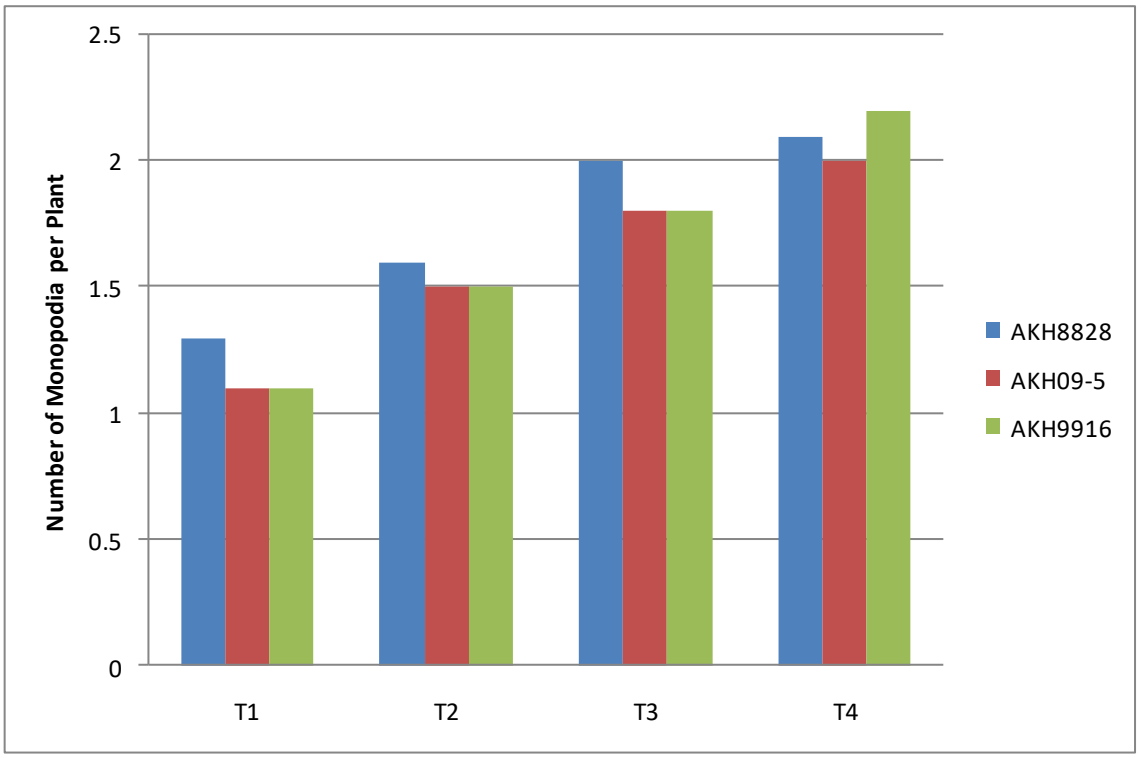

Fig. 8. Number of monopodia branches per plant of cotton as influenced by different distance from the teak tree.

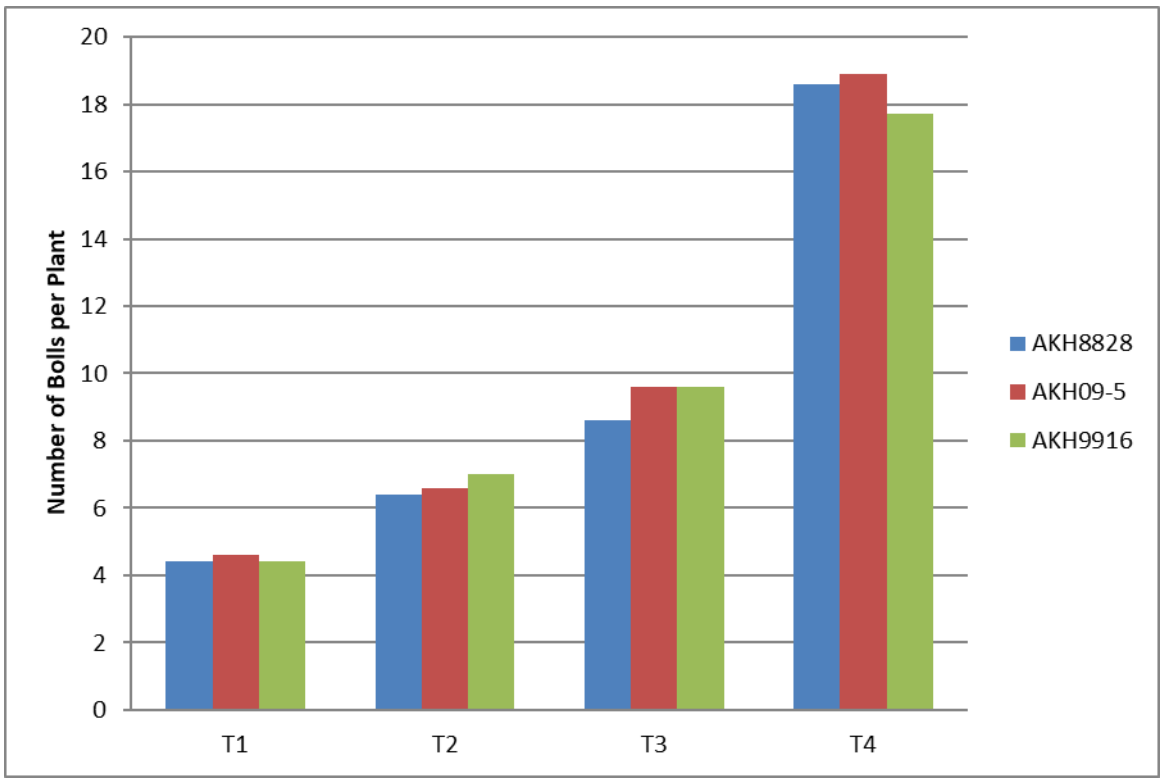

Fig. 9. Number of Bolls per plant of cotton as influenced by different distance from the teak tree.

followed by T_3 treatment (8.6) at 6-9 m distance and T_2 treatment (6.4) at 3-6 m distance. The ranged from 4.4 to 18.6 with mean 9.50.

The mean performance of number of bolls per plant of cotton variety (AKH09-5) was ranged from 4.6 to 18.9 with mean 9.90. The significantly maximum number of bolls per plant in T_4 treatment (18.9) at 12-15 m distance followed by T_3 treatment (9.6) at 6-9 m distance and T_2 treatment (6.6) at 3-6 m distance.

Table 9. Number of Bolls per plant of cotton as influenced by different distance from the teak tree.

Treatment	**Number of Bolls per Plant**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	4.4	4.6	4.4
T_2	6.4	6.6	7.0
T_3	8.6	9.6	9.6
T_4	18.6	18.9	17.7
Mean	9.50	9.90	9.70
Range	4.4 - 18.6	4.6 - 18.9	4.4 - 17.7
SE (m)±	0.14	0.22	0.22
CD (5%)	0.43	0.67	0.69
C. V.	3.30	4.90	5.18
'F' Test	Sig	Sig	Sig

4.1.2.2 Boll Weight (g)

Data in respect of boll weight of *Gossypium hirsutum* influenced by teak with different treatment at harvesting stage is presented in Table 10. and graphically shown in Fig. 10.

The mean performance of boll weight of cotton variety (AKH8828) was significantly highest found in T_4 treatment (3.6 g) at 12-15 m distance followed by T_3 treatment (3.0 g) at 6-9 m distance and T_2 treatment (2.7 g) at 3-6 m distance from the teak row. The ranged of boll weight from 2.3 g to 3.6 g with mean 2.90 g.

The data of boll weight of cotton variety (AKH09-5) was ranged from 2.3 g to 3.7 g with mean 2.95 g. The lowest boll weight of cotton was found in T_1 treatment (2.3 g). whereas the significantly highest boll weight was observed inT_4 treatment (3.7 g) at 12-15 m distance followed by T_3 treatment (3.1 g) at 6-9 m distance and T_2 treatment (2.7 g) at 3-6 m distance from the teak boundary plantation.

Table 10. Bolls Weight of cotton as influenced by different distance from the teak tree.

Treatment	**Bolls Weight (g)**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	2.3	2.3	2.4
T_2	2.7	2.7	2.8
T_3	3.0	3.1	3.1
T_4	3.6	3.7	3.7
Mean	2.90	2. 95	3.00
Range	2.3 - 3.6	2.3 - 3.7	2.4 - 3.7
SE (m)±	0.04	0.05	0.03
CD (5%)	0.14	0.16	0.10
C. V.	3.49	3.82	2.53
'F' Test	Sig	Sig	Sig

The boll weight of cotton variety (AKH9916) was ranged from 2.4 g to 3.7 g with mean 3.00 g. The significantly highest boll weight of cotton was observed in T_4 treatment (3.7 g) at 12-15 m distance followed by T_3 treatment (3.1 g) at 6-9 m distance and T_2 treatment (2.8 g) at 3-6 m distance.

4.1.2.3 Seed Cotton Yield per Plant (g)

Data on seed cotton yield was influenced by different treatment at harvesting stage is presented in Table 11. and graphically depicted in Fig. 11.

The seed cotton yield of cotton variety (AKH8828) was significantly highest recorded in T_4 treatment (15.7 g) at 12-15 m distance. The ranged of seed cotton yield of cotton from 7.7 g to 15.7 g with mean

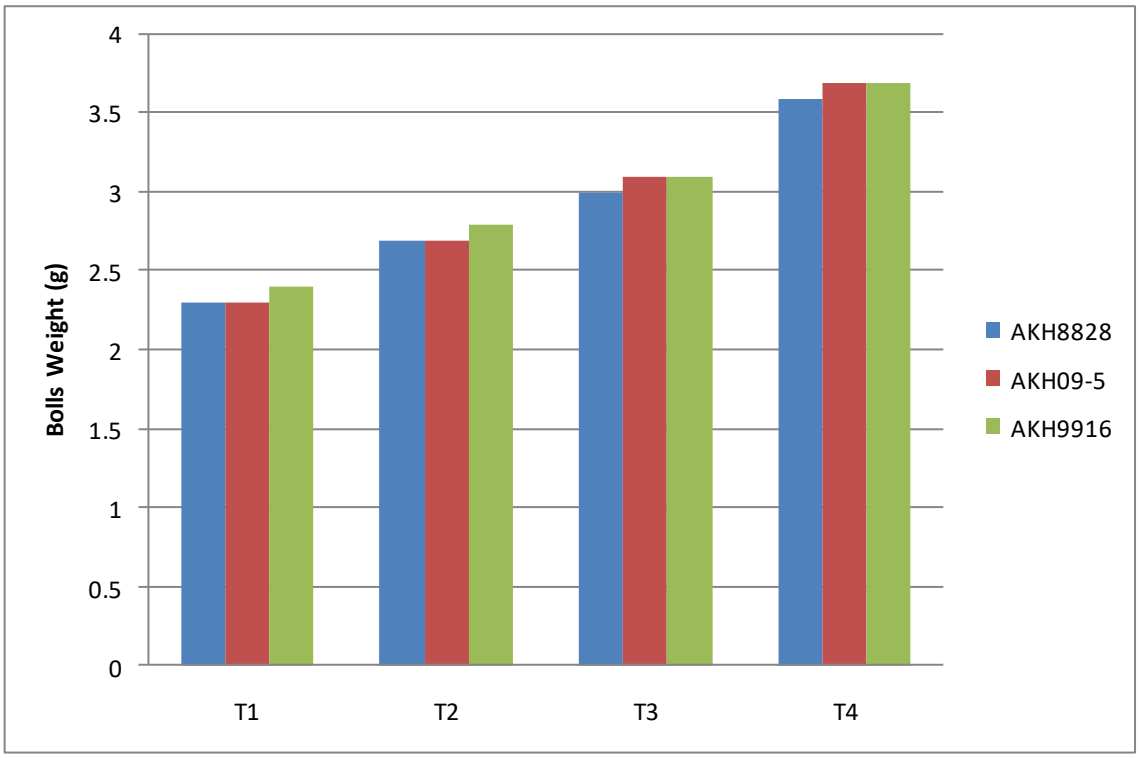

Fig. 10. Bolls weight of cotton as influenced by different distance from the teak tree.

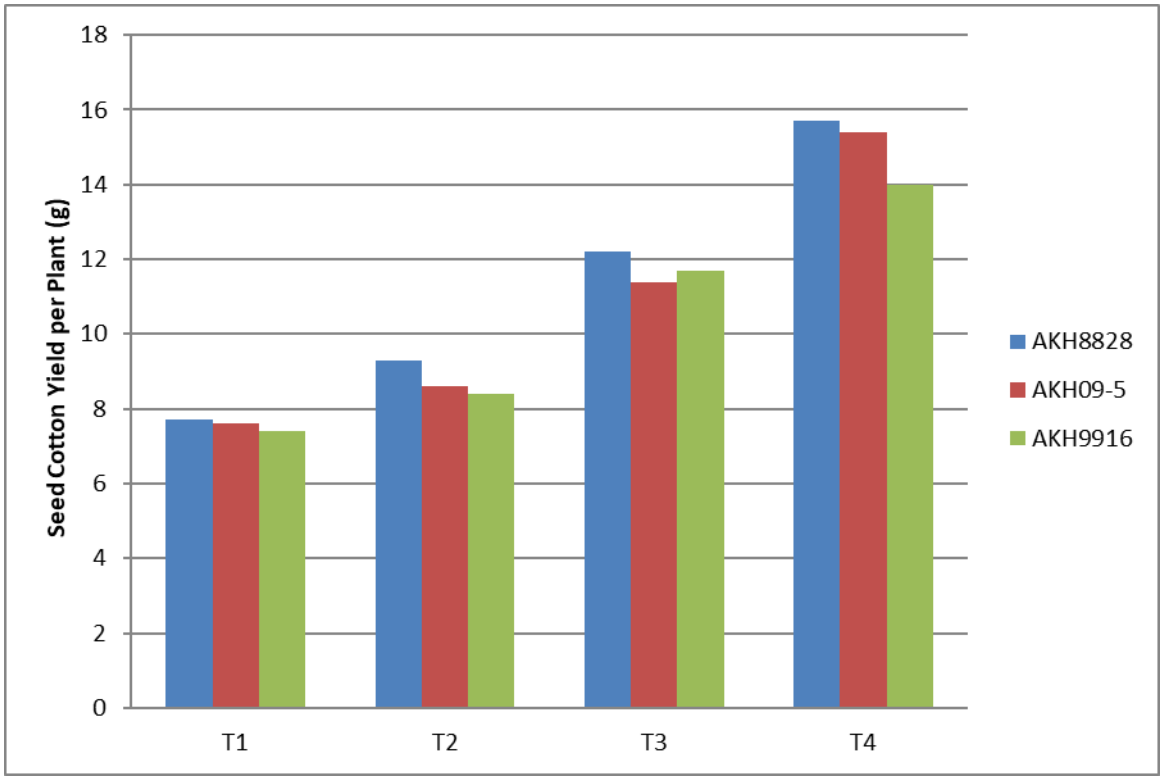

Fig. 11. Seed Cotton Yield per plant of cotton as influenced by different distance from the teak tree.

11.22 g. The lowest seed cotton yield was found in T_1 treatment (7.7 g) at 0-3 m distance followed by T_2 treatment (9.3 g) at 3-6 m distance from the teak row.

The mean performance of seed cotton yield of cotton variety (AKH09-5) was ranged from 7.6 g to 15.4 g with mean 10.75 g. T_4 treatment (15.4 g) at 12-15 m distance resulted in significantly higher production of seed cotton yield per plant followed by T_3 treatment (11.4 g) at 6-9 m distance and T_2 treatment (8.6 g) at 3-6 m distance from the teak row.

Table 11. Seed Cotton Yield per plant of cotton as influenced by different distance from the teak tree.

Treatment	**Seed Cotton Yield per Plant (g)**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	7.7	7.6	7.4
T_2	9.3	8.6	8.4
T_3	12.2	11.4	11.7
T_4	15.7	15.4	14.0
Mean	11.22	10.75	10.37
Range	7.7 - 15.7	7.6 - 15.4	7.4 - 14.0
SE (m)±	0.24	0.35	0.30
CD (5%)	0.75	1.08	0.91
C. V.	4.81	7.34	6.38
'F' Test	Sig	Sig	Sig

The ranged of seed cotton yield from 7.4 g to 14.0 g with mean 10.37 g of cotton variety (AKH9916). The significantly highest seed cotton yield was found in T_4 treatment (14.0 g) at 12-15 m distance followed by T_3 treatment (11.7 g) at 6-9 m distance and T_2 treatment (8.4 g) at 3-6 m distance from the teak boundary plantation.

4.1.2.4 Seed Index (g)

Data on recorded of seed index as affected by different treatment at harvesting stage is presented in Table 12. and graphically shown in Fig. 12.

The seed index of cotton variety (AKH8828) was significantly lowest recorded in T_1 treatment (6.6 g) at 0-3 m distance followed by T_2 treatment (7.5 g) at 3-6 m distance and T_3 treatment (8.1 g) at 6-9 m distance from the teak boundary plantation. The significantly highest result found in T_4 treatment (8.5 g) at 12-15 m distance. the ranged from 6.6 g to 8.5 g with mean 7.67 g.

The mean performance of seed index of cotton variety (AKH09-5) was ranged from 6.9 g to 8.4 g with mean 7.75 g. The T_1 treatment (8.6 g) at 12-15 m distance found significantly highest result followed by T_3 treatment (8.0 g) at 6-9 m distance and T_2 treatment (7.5 g) at 3-6 m, distance.

Table 12. Seed Index of cotton as influenced by different distance from the teak tree.

Treatment	**Seed Index (g)**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	6.6	6.9	6.8
T_2	7.5	7.5	7.2
T_3	8.1	8.0	7.7
T_4	8.5	8.6	8.4
Mean	7.67	7.75	7.52
Range	6.6 - 8.5	6.9 - 8.6	6.8 - 8.4
SE (m)±	0.10	0.06	0.07
CD (5%)	0.32	0.20	0.22
C. V.	3.05	1.86	2.12
‘F’ Test	Sig	Sig	Sig

The ranged of seed index of cotton variety (AKH9916) from 6.8 g to 8.4 g with mean 7.75 g. The lowest result was found in T_1 treatment (6.8 g) at 0-3 m distance. whereas the highest significant result was recorded in T_4 treatment (8.4 g) at 12-15 m distance followed by T_3 treatment (7.7 g) at 6-9 m distance and T_2 treatment (7.2 g) at 3-6 m distance.

4.1.2.5 Lint Index

Data on recorded of lint index of cotton as influenced by different treatment at harvesting stage is presented in Table 13 and graphically shown in Fig.13.

The highest significantly result was observed in T_4 treatment (4.5) at 12-15 m distance from the teak row of cotton variety (AKH8828). The ranged of lint index from 3.1 to 4.5 with mean 3.80. Whereas the lowest lint index was found in T_1 treatment (3.1) at 0-3 m distance followed by T_2 treatment (3.6) at 3-6 m distance and T_3 treatment (4.0) at 6-9 m distance.

The mean performance of lint index of cotton variety (AKH09-5) was ranged from 3.2 to 4.4 with mean 3.77. The highest significant result was recorded in T_4 treatment (4.4) at 12-15 m distance followed by T_3 treatment (3.9) at 6-9 m distance and T_2 treatment (3.6) at 3-6 m distance.

Table 13. Lint Index of cotton as influenced by different distance from the teak tree.

Treatment	**Lint Index**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	3.1	3.2	3.2
T_2	3.6	3.6	3.5
T_3	4.0	3.9	3.9
T_4	4.5	4.4	4.5
Mean	3.80	3.77	3.77
Range	3.1 - 4.5	3.2 - 4.4	3.2 - 4.5
SE (m)±	0.04	0.04	0.05
CD (5%)	0.12	0.14	0.16
C. V.	2.31	2.64	3.10
'F' Test	Sig	Sig	Sig

The data of lint index of cotton variety (AKH9916) recorded T_1 treatment was the lowest lint index (3.2) at 0-3 m distance. The ranged of lint index observed from 3.2 to 4.5 with mean 3.77. The significantly highest result was observed in T_4 treatment (4.5) at 12-15 m distance followed by

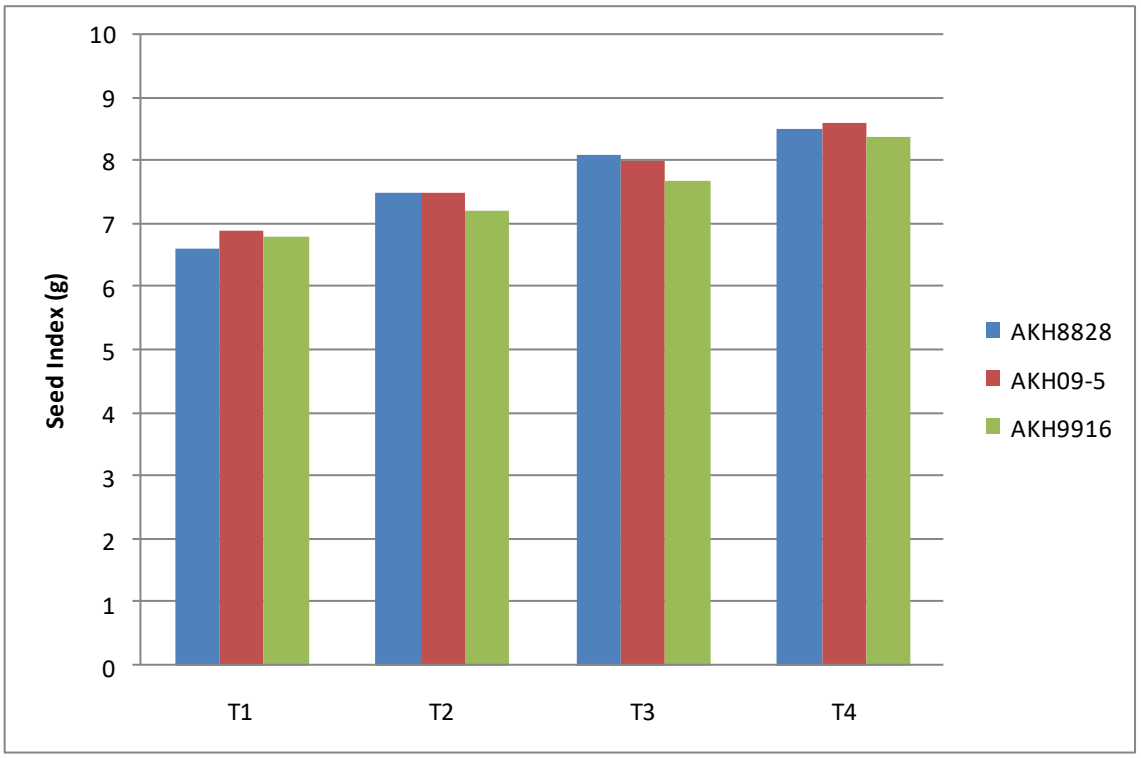

Fig. 12. Seed index of cotton as influenced by different distance from the teak tree.

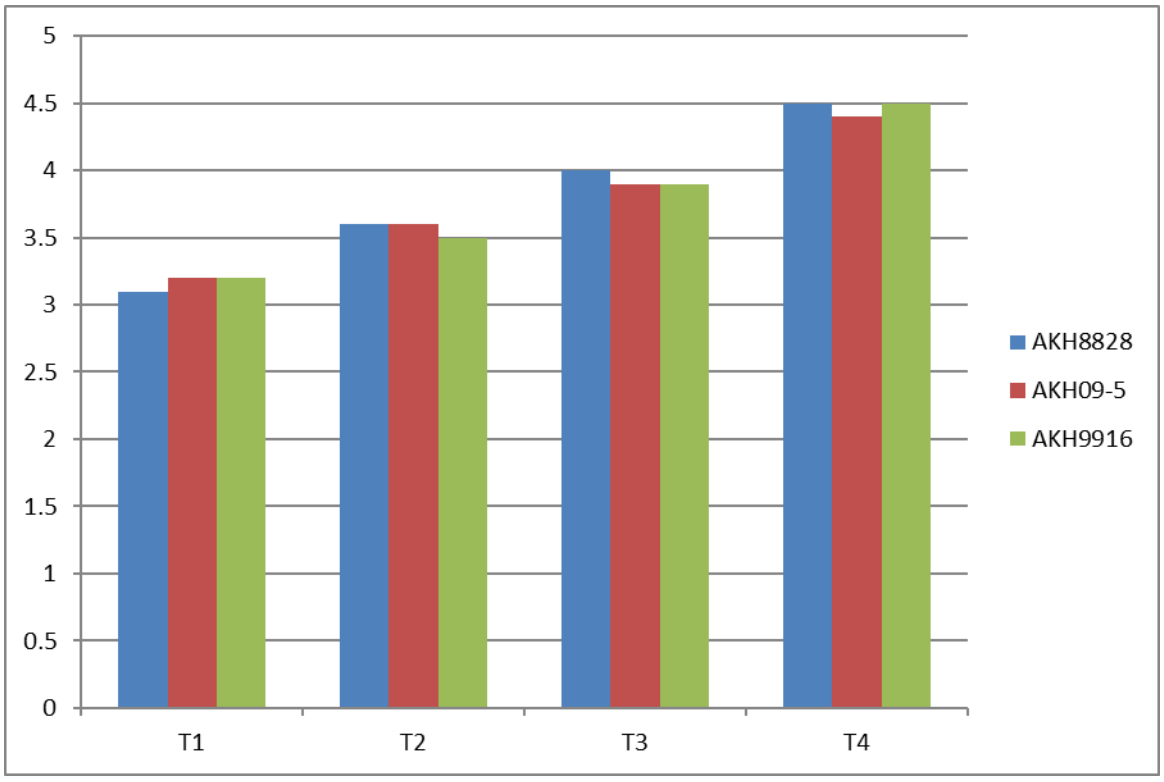

Fig. 13. Lint Index of cotton as influenced by different distance from the teak tree.

T_3 treatment (3.9) at 6-9 m distance and T_2 treatment (3.5) at 3-6 m distance.

4.1.2.6 Ginning Percentage (%)

The data on recorded of ginning percentage (%) of cotton as influenced by different treatment at harvesting stage is presented in Table 14. and graphically shown in Fig. 14.

The mean performance of ginning percentage of cotton variety (AKH8828) was observed in ranged from 32.1 per cent to 35.7 per cent with mean 33.65 per cent. T_4 treatment (35.7 %) at 12-15 m distance was observed significantly the highest ginning percentage followed by T_3 treatment (34.2 %) at 6-9 m distance and T_2 treatment (32.6%)at 3-6 m distance, respectively. The lowest ginning percentage was found in T_1 treatment (32.1%) at 0-3 m distance from the teak row.

T_1 treatment (32.2%) at 0-3 m distance that result was the significantly lowest ginning percentage of cotton (AKH09-5) followed by T_2 treatment (32.9%) at 3-6 m distance and T_3 treatment (33.7%) at 6-9 m distance from the teak row. The ranged of ginning percentage from 32.2 per cent to 35.3 per cent with mean 33. 52 per cent. The significantly highest result was observed in T_4 treatment (35.3%) at 12-15 m distance.

Table 14. Ginning percentage (%) of cotton as influenced by different distance from the teak tree.

Treatment	**Ginning Percentage (%)**		
Variety	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	32.1	32.2	32.2
T_2	32.6	32.9	33.0
T_3	34.2	33.7	33.9
T_4	35.7	35.3	35.1
Mean	33.65	33.52	33.55
Range	32.1 - 35.7	32.2 - 35.3	32.2 - 35.1
SE (m)±	0.20	0.14	0.16
CD (5%)	0.61	0.42	0.49
C. V.	1.31	0.92	1.05
‘F’ Test	Sig	Sig	Sig

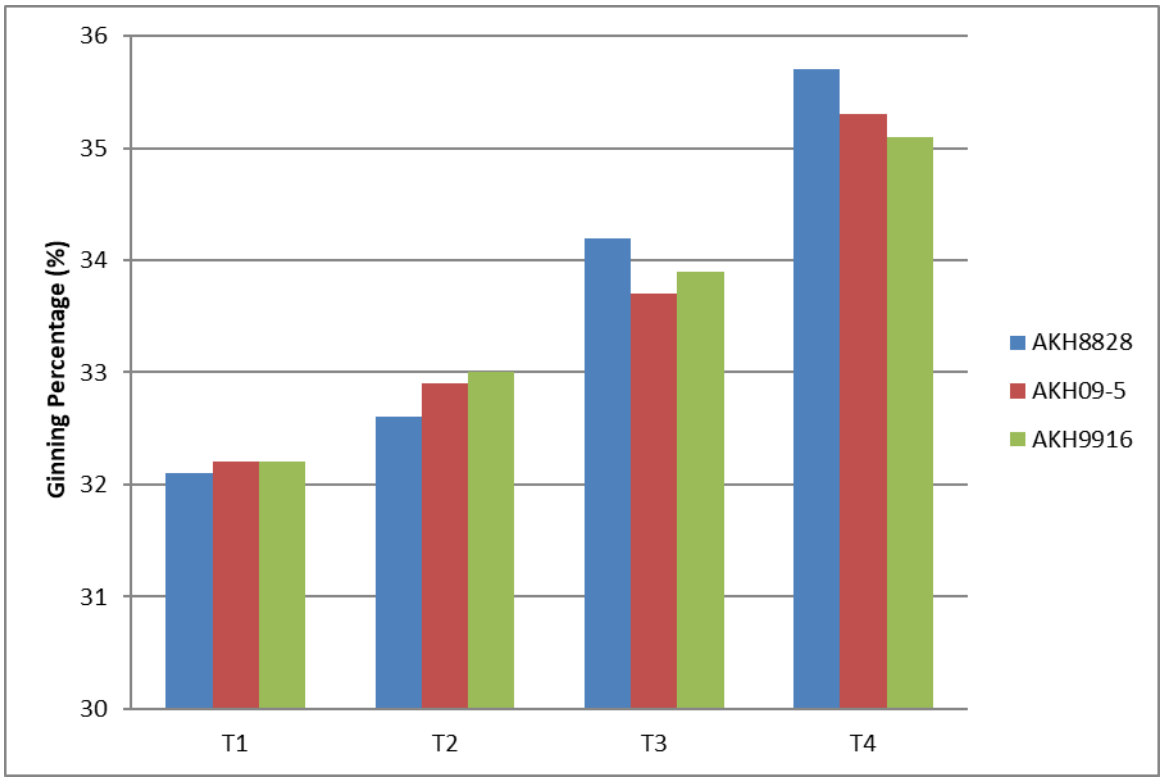

Fig. 14. Ginning percentage (%) of cotton as influenced by different distance from the teak tree.

Data of ginning percentage of cotton variety (AKH996) was significantly the highest result found in T_4 treatment (35.1%) at 12-15 m distance followed by T_3 treatment (33.9%) at 6-9 m distance and T_2 treatment (33.0%) at 3-6 m distance from the teak row. The ranged observed from 32.2 per cent to 35.1 per cent with mean 33.55 per cent.

4.1.3 Microclimatic performance of cotton in teak

4.1.3.1 Canopy Temperature (°C)

Canopy temperature (°C) was recorded on three different stages of cotton i.e., 50% flowering, 50% boll bursting and harvesting at both timing i.e., Morning 8 am and afternoon 4 pm is presented in Table 15 and 16. and graphically shown in Fig. 15 (a to c) and 16 (a to c) respectively.

At 50% Flowering stage

The data on canopy temperature (°C) of cotton variety (AKH8828) was observed significantly the maximum in T_4 treatment (35.5°C) in morning time and (37.7°C) in afternoon time at 12-15 m distance followed by T_3 treatment (34.3 °C) in morning time and (34.6°C) in afternoon time at 6-9 m distance and T_2 treatment (33.7 °C) in morning time and (34.4 °C) in afternoon time at 3-6 m distance at par. The ranged of morning time canopy temperature from 31.1 °C to 35.5 °C with mean 33.80 °C and afternoon time canopy temperature from 34.1 °C to 37.7 °C with mean 35.20 °C.

Morning canopy temperature of cotton variety (AKH09-5) was the minimum as compared to afternoon temperature. The significantly maximum canopy temperature in morning time was found in T_4 treatment (34.0°C) and afternoon time T_4 treatment (35.4°C) at 12-15 m distance followed by T_3 treatment (31.3°C) in morning time and (35.4 °C) in afternoon time at 6-9 m distance. At T_2treatment (31.0°C) at 3-6 m distance and T_1 treatment (31.0°C) at 0-3 m distance same temperature observed in morning time. The lowest canopy temperature in afternoon time was found in T_1 treatment (34.3°C) at 0-3 m distance from the teak row. The ranged of canopy temperature in morning time from 31.0 °C to 34.0°C with mean 31.82°C and at afternoon time from 34.3 °C to 37.1 °C with mean 35.40°C.

Table 15. Canopy temperature of cotton in morning time as influenced by different distance from the teak tree.

Treatment	**Canopy Temperature (°C) in Morning time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	31..1	31.0	31.6	30.4	30.4	29.4	23.2	21.1	18.6
T_2	33.7	31.0	33.2	31.2	30.8	29.5	23.2	21.5	18.6
T_3	34.3	31.3	33.3	32.2	31.3	29.9	23.3	21.7	18.6
T_4	35.5	34.0	34.9	35.1	32.1	34.0	28.6	29.3	29.9
Mean	33.80	31.82	33.30	32.20	31.15	30.70	24.60	23.40	21.42
Range	31.1 - 35.5	31.0 -34.0	31.6 - 34.9	30.4 - 32.1	30.4 -32.1	29.4 -34.0	23.2 - 28.6	21.1 - 29.3	18.6 -29.9
SE (m)±	0.48	0.42	0.39	1.06	0.27	0.15	0.20	0.26	0.07
CD (5%)	1.49	1.29	1.20	3.26	0.85	0.47	0.63	0.81	0.21
C. V.	3.20	2.94	2.62	7.34	1.97	1.12	1.89	2.53	0.69
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

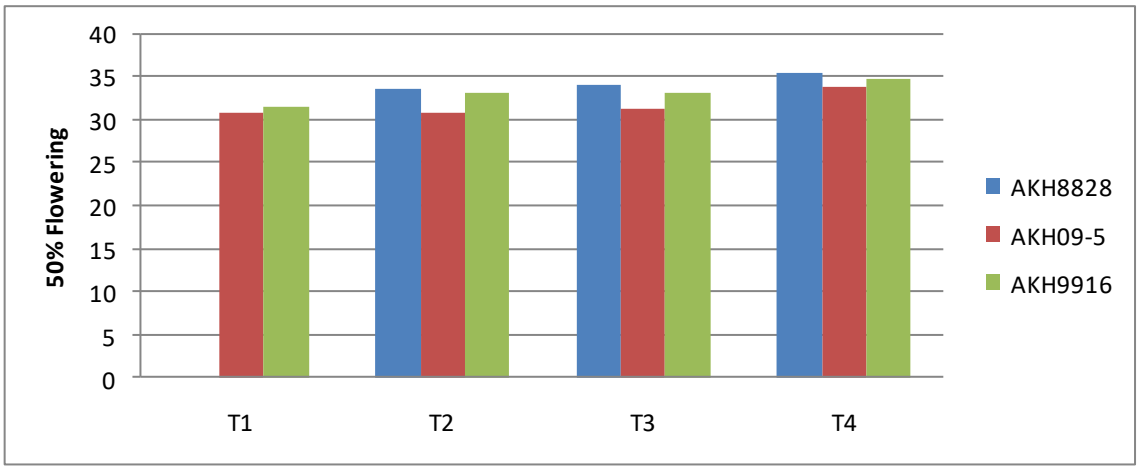

Fig. 15(a). Canopy temperature of cotton in morning time as influenced by different distance from the teak tree.

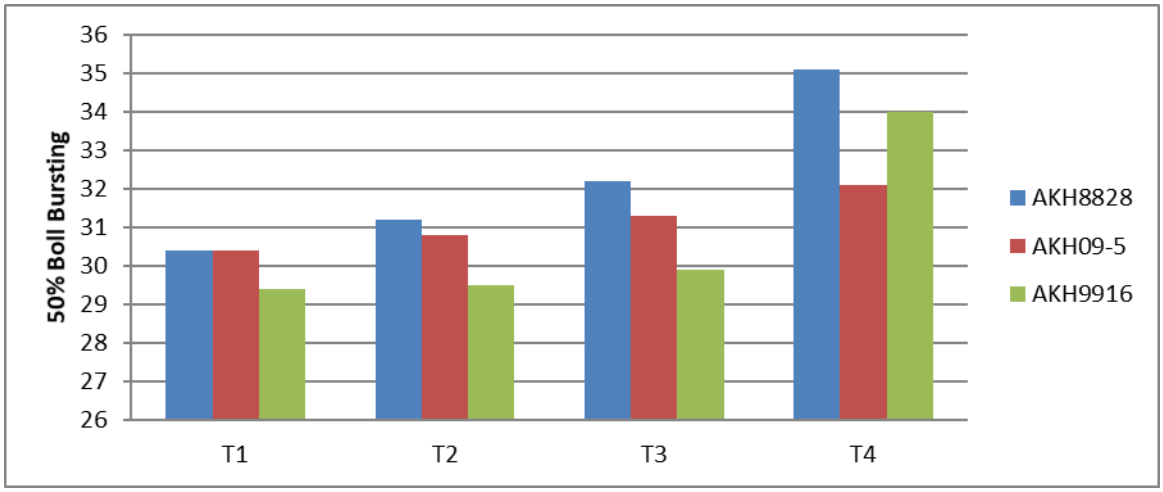

Fig. 15(b). Canopy temperature of cotton in morning time as influenced by different distance from the teak tree.

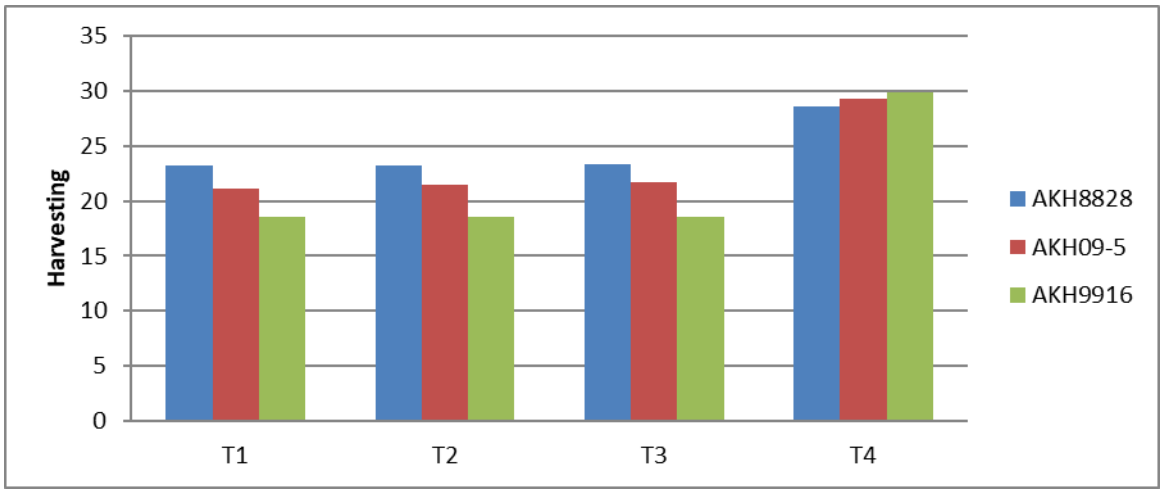

Fig. 15(c). Canopy temperature of cotton in morning time as influenced by different distance from the teak tree.

The ranged of canopy temperature of cotton variety (AKH9916) in morning time from 31.6°C to 34.9°C with mean 33.30 °C and in afternoon time ranged from 35.4 °C to 37.6°C with mean 36.20°C. The maximum canopy temperature significantly found at morning time in T_4 treatment (31.6 °C) and afternoon time in T_4 treatment (37.6°C) at 12-15 m distance followed by T_3 treatment (33.3 °C) in morning time and T_3 treatment (36.0°C) in afternoon time at 6-9 m distance and T_2 treatment (33.2 °C) in morning time and T_2 treatment (35.6 °C) in afternoon time at 3-6 m distance from the teak row.

At 50% Boll Bursting stage

The data on canopy temperature (°C) of cotton variety (AKH8828) was observed significantly the maximum in T_4 treatment (35.1°C) in morning time and (35.0°C) in afternoon time at 12-15 m distance followed by T_3 treatment (32.2°C) in morning time and (32.9°C) in afternoon time at 6-9 m distance and T_2 treatment (31.2°C) in morning time and (32.8°C) in afternoon time at 3-6 m distance at par. The ranged of morning time canopy temperature from 30.4°C to 32.1°C with mean 32.40°C and afternoon time canopy temperature from 32.4°C to 35.0°C with mean 33.30°C.

Morning canopy temperature of cotton variety (AKH09-5) was the minimum as compared to afternoon temperature. The significantly maximum canopy temperature in morning time was found in T_4 treatment (32.1°C) and afternoon time T_4 treatment (34.7°C) at 12-15 m distance followed by T_3 treatment (31.3°C) in morning time and (33.0°C) in afternoon time at 6-9 m distance and T_2treatment (30.8)°C in morning time and T_2 treatment(32.9)in afternoon at 3-6 m distance. The minimum canopy temperature in afternoon time was found in T_1 treatment (33.8°C) and T_1 treatment (30.4 °C) in morning time at 0-3 m distance from the teak row. The ranged of canopy temperature in morning time from 30.4°C to 32.1°C with mean 31.15°C and at afternoon time from 32.8°C to 34.7°C with mean 33.40°C.

The ranged of canopy temperature of cotton variety (AKH9916) in morning time from 29.4°C to 34.0°C with mean 30.70°C and

in afternoon time ranged from 32.3°C to 34.1°C with mean 33.10°C. The maximum canopy temperature significantly found at morning time in T_4 treatment (34.0°C) and afternoon time in T_4 treatment (34.1°C) at 12-15 m distance followed by T_3 treatment (29.9°C) in morning time and T_3 treatment (33.4°C) in afternoon time at 6-9 m distance and T_2 treatment (29.5°C) in morning time and T_2 treatment (32.7°C) in afternoon time at 3-6 m distance from the teak row.

At Harvesting stage

In harvesting stage, the canopy temperature of cotton variety (AKH8828) was ranged from 23.2°C to 28.6° C with mean 24.60 °C at morning time and 30.2°C to 33.5°C with 31.40 °Cat afternoon time. The minimum canopy temperature at morning time was significantly recorded in T_1 treatment (30.2°C) and in afternoon time in T_1 treatment (30.2 °C) at 0-3 m distance followed by T_2 treatment (23.2 °C) in morning time and T_2 treatment (30.3°C) in afternoon time and T_3 treatment (23.3°C) in morning time and T_3 treatment (31.5°C) in afternoon time at 6-9 m distance from the teak row.

The data on canopy temperature of cotton variety (AKH09-5) was recorded the maximum in T_4 treatment (29.3°C) in morning time and T_4 treatment (38.1°C) in afternoon time at 12-15 m distance followed by T_3 treatment (21.7°C) in morning time and T_3 treatment (31.5 °C) in afternoon time at 6-9 m distance and T_2 treatment (21.5°C) in morning time and T_2 treatment (30.9°C) in afternoon time at 3-6 m distance. the ranged of morning canopy temperature from 21.1°C to 29.3 °C with mean 23.40 °C and 30.3°C to 38.1°C with mean 32.70°C.

The mean performance of canopy temperature of cotton variety (AKH9916) ranged from 18.6 °C to 29.9 °C with mean 21.42°C at morning time and 31.1 °C to 34.8 °C with mean 32.20 °C at afternoon time. The maximum canopy temperature was recorded in T_4 treatment (29.9°C) in morning time and T_4 temperature (34.8°C) in afternoon time at 12-15 m distance followed by T_3 treatment (31.3°C) in afternoon time at 6-9 m distance and T_2 treatment (31.4°C) in afternoon time at 3-6 m distance. The minimum canopy temperature was observed in morning time same at three

Table 16. Canopy temperature of cotton in afternoon time as influenced by different distance from the teak tree.

Treatment	**Canopy Temperature (°C) in Afternoon time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	34.1	34.3	35.4	32..4	32.8	32.3	30.2	30.3	31.1
T_2	34.4	34.8	35.6	32.8	32.9	32.7	30.3	30.9	31.3
T_3	34.6	35.4	36.0	32.9	33.0	33.4	31.5	31.5	31.4
T_4	37.7	37.1	37.6	35.0	34.7	34.1	33.5	38.1	34.8
Mean	35.20	35.40	36.20	33.30	33.40	33.10	31.40	32.70	32.20
Range	34.1 - 37.7	34.3 -37.1	35.4 - 37.6	32.4 - 35.0	32.8 - 34.7	32.3 -34.1	30.2 -33.5	30.3-38.1	31.1 - 34.8
SE (m)±	0.43	0.48	0.35	0.45	0.42	0.40	0.33	0.50	0.19
CD (5%)	1.33	1.48	1.08	1.40	1.30	1.24	1.03	1.54	0.60
C. V.	2.75	3.03	2.16	3.05	2.82	2.72	2.38	3.43	1.35
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

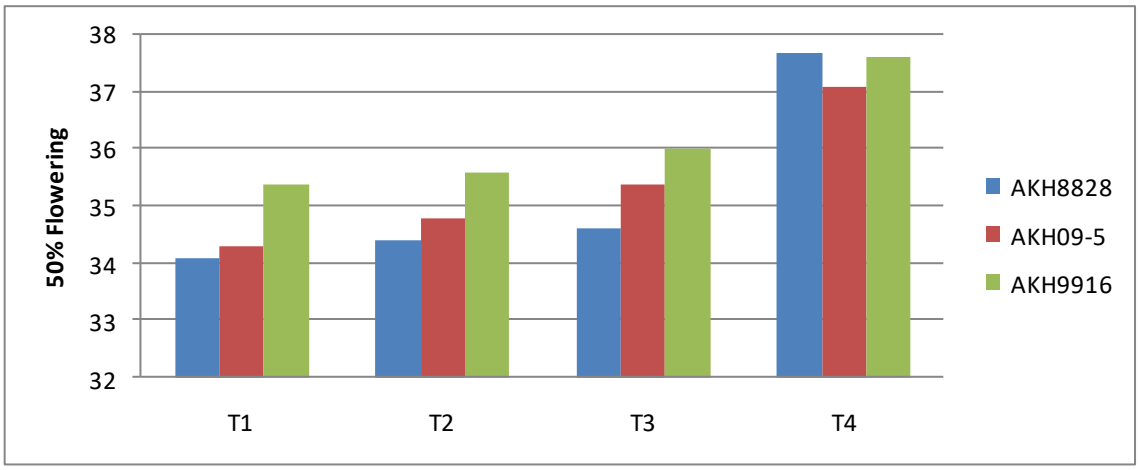

Fig. 16 (a). Canopy temperature of cotton in afternoon time as influenced by different distance from the teak tree.

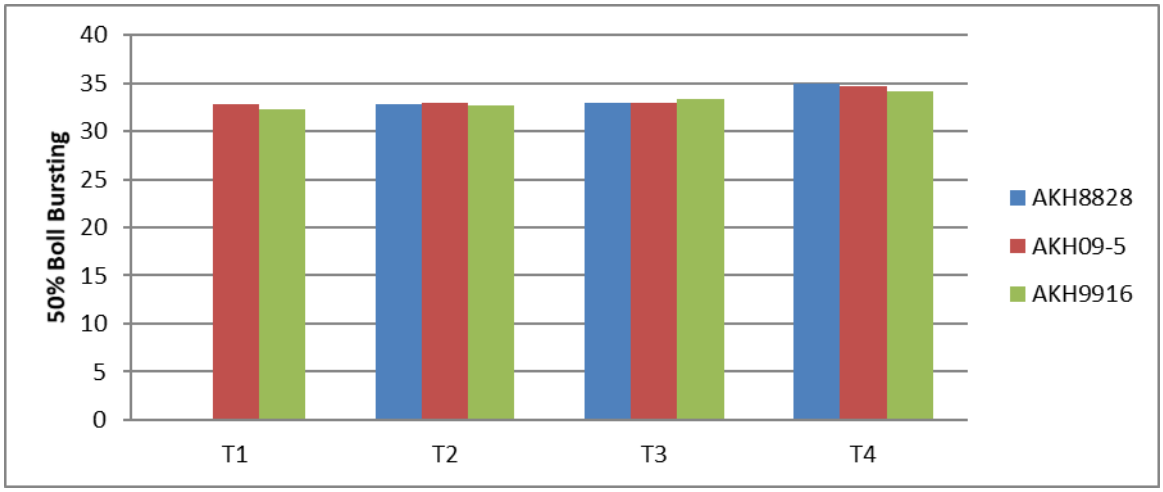

Fig. 16 (b). Canopy temperature of cotton in afternoon time as influenced by different distance from the teak tree.

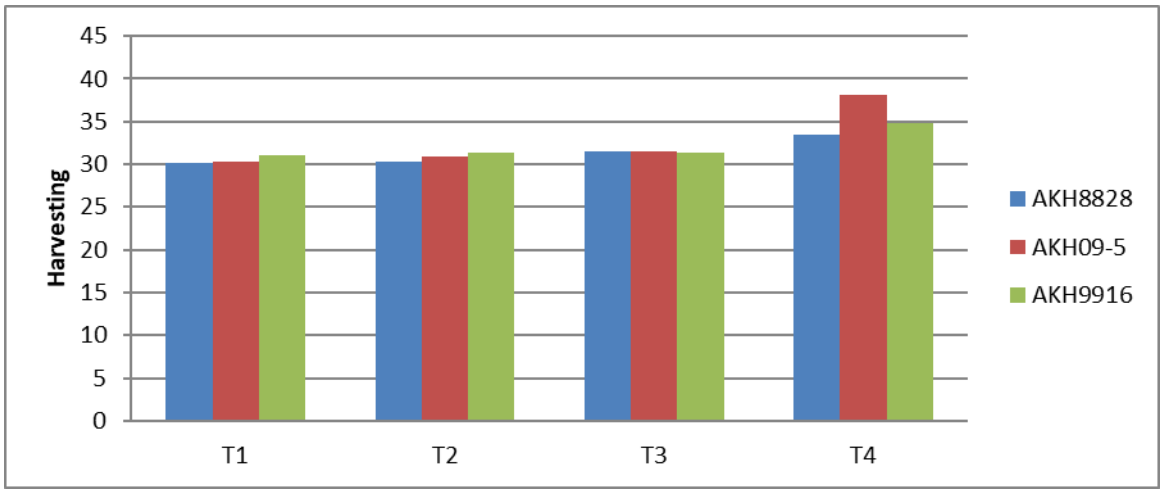

Fig. 16 (c). Canopy temperature of cotton in afternoon time as influenced by different distance from the teak tree.

treatments i.e., T_1, T_2, T_3 treatments (18.6°C) at 0-3 m, 3-6 m, 6-9 m distance respectively.

4.1.3.2 Relative Humidity (%)

The data on relative humidity of cotton recorded at three different stages i.e., 50% flowering, 50% boll bursting and harvesting at two different time i.e., morning 8 am and afternoon 4 pm. as influenced by different treatments is presented in Table 17and 18and graphically shown in Fig. 17 (a to c) and 18 (a to c).

At 50% Flowering Stage

The relative humidity was observed significantly maximum in T_1 temperature (54.0%) at morning and (31.6%) at afternoon on cotton variety (AKH8828) followed by T_2 treatment (52.8%) at morning and (31.2%) at afternoon and T_3 treatment (51.0%) at morning and (29.6%) at afternoon respectively. The relative humidity (%) was ranged from 43.8 per cent to 54.0 per cent with mean 50.40 per cent at morning time and 23.4 per cent to 31.6 per cent with mean 29.00 per cent at afternoon time.

Ranged of relative humidity of cotton (AKH09-5) from 45.8 per cent to 59.2 per cent with mean 50.60 per cent at morning time and 24.0 per cent to 32.0 per cent with mean 29.40 per cent at afternoon time. The relative humidity was recorded significantly maximum in T_1 treatment (59.2%) at morning time and T_1 treatment (32.0%) at afternoon time of cotton (AKH09-5) at 0-3 m distance followed by T_2 treatment (57.0%) at morning time and T_2 treatment (31.2%) at afternoon time and T_3 treatment (56.4%) at morning time and T_3 treatment (30.4%) at afternoon time at par respectively.

The minimum relative humidity of cotton (AKH9916) was found in T_4 treatment (43.8%) at morning time and T_4 treatment (26.6%) at afternoon time at 12-15 m distance followed by T_3 treatment (53.6%) in morning time and T_3 treatment (30.4%) in afternoon time at 6-9 m distance and T_2 treatment (55.0%) in morning time and T_2treatment (33.8 %) in afternoon time at 3-6 m distance. The ranged from 43.8 per cent to 56.6

Table 17. Relative Humidity (%) of cotton in morning time as influenced by different distance from the teak tree.

Treatment	**Relative Humidity (%) in Morning time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	54.0	59.2	56.6	50.8	48.2	52.4	44.0	43.0	47.6
T_2	52.8	57.0	55.0	48.0	47.4	51.4	42.6	42.0	47.4
T_3	51.0	56.4	53.6	46.0	47.0	50.4	41.2	41.2	46.2
T_4	43.8	45.8	43.8	37.6	39.8	35.0	27.8	23.4	20.6
Mean	50.40	54.60	52.30	45.60	45.60	47.30	38.90	37.40	40.50
Range	43.8 -54.0	45.8 - 59.2	43.8 - 56.6	37.6 -50.8	39.8 - 48.2	35.0 -52.4	27.8 -44.0	23.4 -43.0	20.6 -47.6
SE (m)±	0.76	2.33	1.28	0.58	0.86	1.04	0.59	0.48	0.37
CD (5%)	2.35	7.19	3.95	1.79	2.64	3.20	1.82	1.47	1.14
C. V.	3.38	9.55	5.49	2.85	4.20	4.92	3.40	2.86	2.04
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

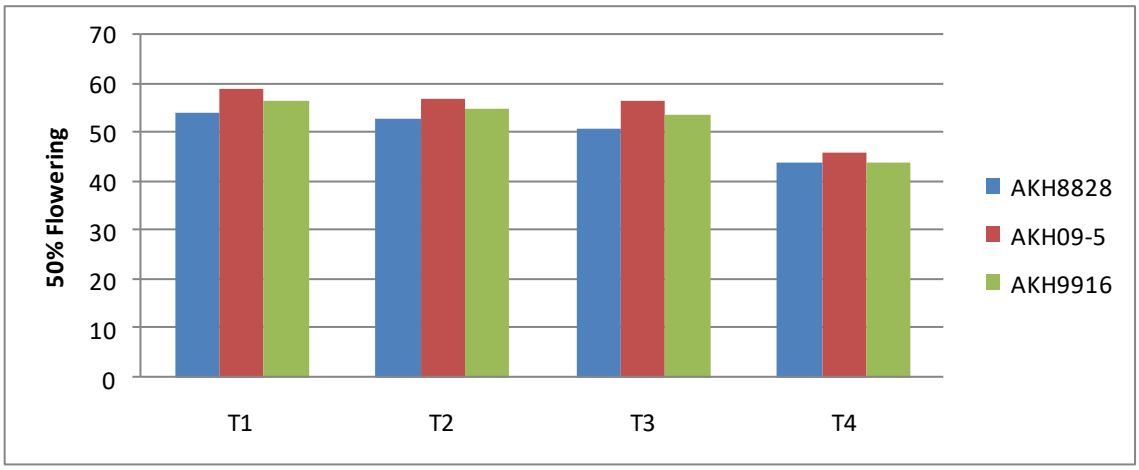

Fig. 17 (a). Relative Humidity (%) of cotton in morning time as influenced by different distance from the teak tree.

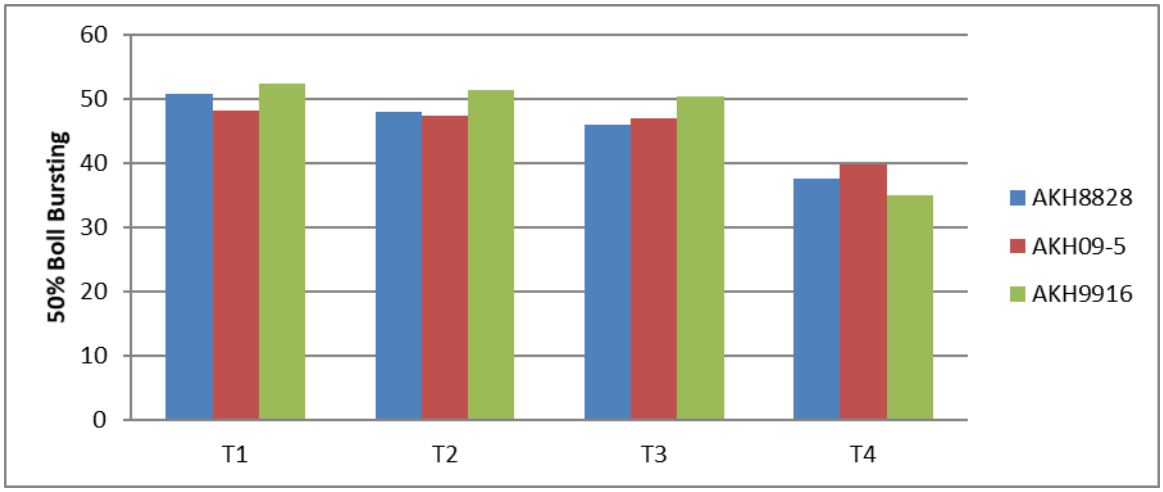

Fig. 17 (b). Relative Humidity (%) of cotton in morning time as influenced by different distance from the teak tree.

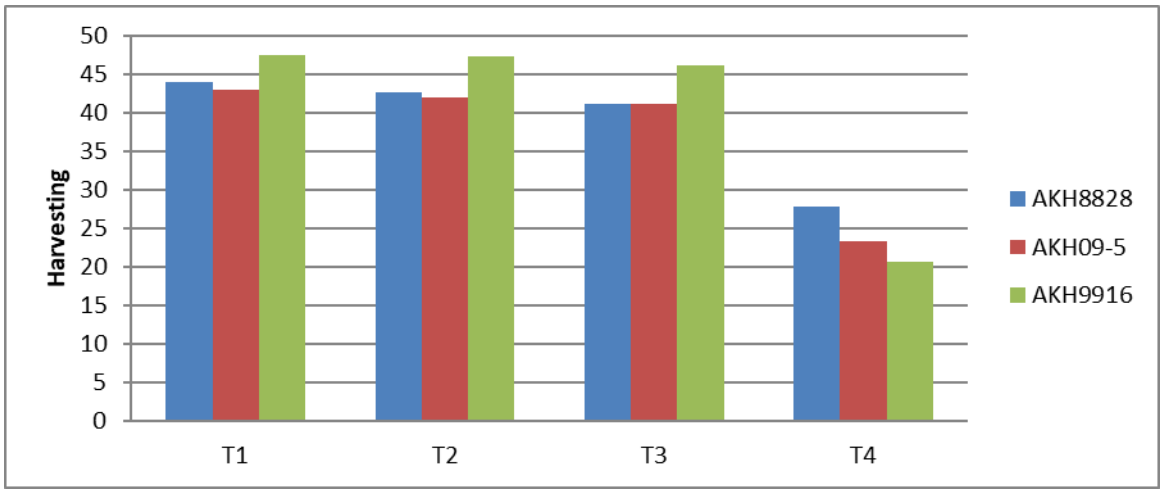

Fig. 17 (c). Relative Humidity (%) of cotton in morning time as influenced by different distance from the teak tree.

per cent with mean 52.30 per cent at morning time and 26.4 per cent to 34.2 per cent with mean 31.30 per cent at afternoon time.

At 50% Boll Bursting

The relative humidity was observed significantly maximum in T_1 temperature (50.8%) at morning and (36.0%) at afternoon on cotton variety (AKH8828) followed by T_2 treatment (48.0%) at morning and (35.8%) at afternoon and T_3 treatment (46.0%) at morning and (35.0%) at afternoon respectively. The relative humidity (%) was ranged from 37.6 per cent to 50.8 per cent with mean 45.60 per cent at morning time and 28.6 per cent to 36.0 per cent with mean 33.90 per cent at afternoon time.

Ranged of relative humidity of cotton (AKH09-5) from 39.8per cent to 48.2 per cent with mean 45.60 per cent at morning time and 29.0 per cent to 36.2 per cent with mean 33.30 per cent at afternoon time. The relative humidity was recorded significantly maximum in T_1 treatment (48.2%) at morning time and T_1 treatment (36.2%) at afternoon time of cotton (AKH09-5) at 0-3 m distance followed by T_2 treatment (47.4%) at morning time and T_2 treatment (34.6%) at afternoon time and T_3 treatment (47.0%) at morning time and T_3 treatment (33.2%) at afternoon time at par respectively.

The minimum relative humidity of cotton (AKH9916) was found in T_4 treatment (35.0%) at morning time and T_4 treatment (27.4%) at afternoon time at 12-15 m distance followed by T_3 treatment (50.4%) in morning time and T_3 treatment (35.6%) in afternoon time at 6-9 m distance and T_2 treatment (51.4%) in morning time and T_2 treatment (37.6 %) in afternoon time at 3-6 m distance. The ranged from 35.0 per cent to 52.4 per cent with mean 47.30 per cent at morning time and 27.4 per cent to 38.4 per cent with mean 34.80 per cent at afternoon time.

Table 18. Relative Humidity (%) of cotton in afternoon time as influenced by different distance from the teak tree.

Treatment	**Relative Humidity (%) Afternoon time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	31.6	32.0	34.2	36.0	36.2	38.4	22.6	22.0	20.8
T_2	31.2	31.2	33.8	35.8	34.6	37.6	21.4	21.4	21.4
T_3	29.6	30.4	30.4	35.0	33.2	35.6	21.0	21.2	21.2
T_4	23.4	24.0	26.6	28.6	29.0	27.4	10.0	10.2	10.0
Mean	29.00	29.40	31.30	33.90	33.30	34.80	18.80	18.70	18.35
Range	23.4 -31.6	24.0 - 32.0	26.4 -34.2	28.6 -36	29.0 -36.2	27.4 - 38.4	10.0 -22.6	10.2 -22.0	10 -21.4
SE (m)±	1.29	0.38	1.02	0.51	0.39	0.75	0.42	0.43	0.46
CD (5%)	3.96	1.17	3.14	1.59	1.19	2.33	1.28	1.33	1.41
C. V.	9.93	2.86	7.30	3.38	2.59	4.85	4.97	5.14	5.56
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

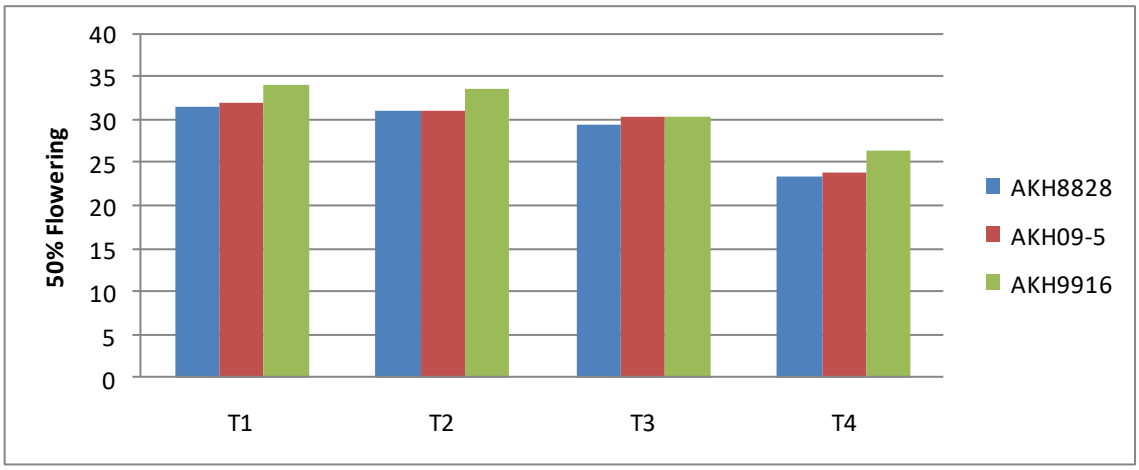

Fig. 18 (a). Relative Humidity (%) of cotton in afternoon time as influenced by different distance from the teak tree.

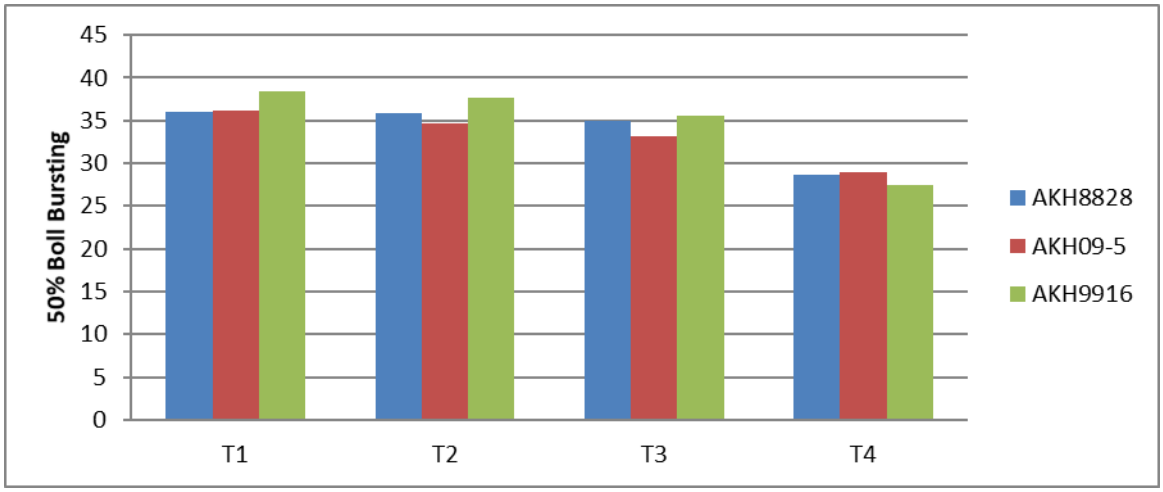

Fig. 18 (b). Relative Humidity (%) of cotton in afternoon time as influenced by different distance from the teak tree.

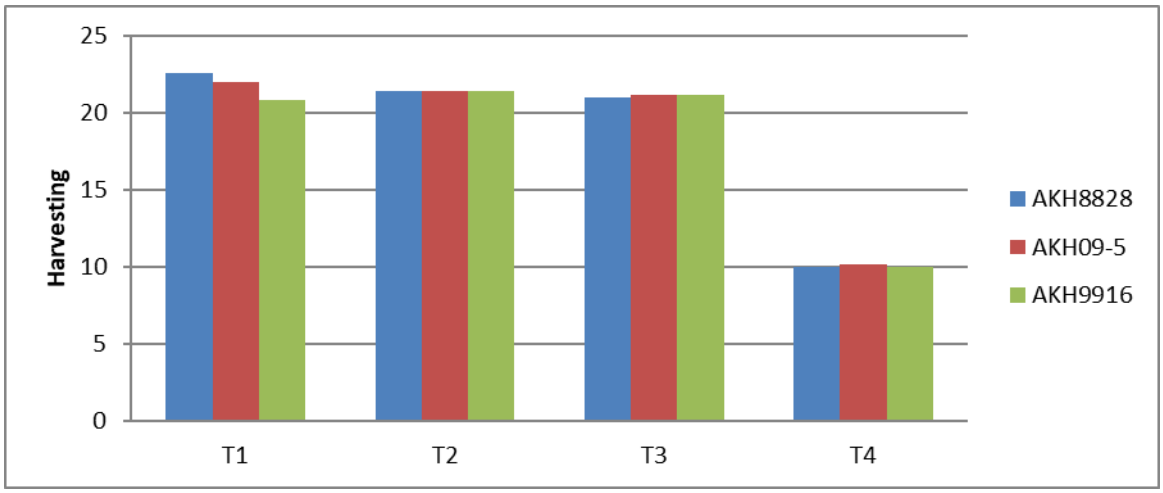

Fig. 18 (c). Relative Humidity (%) of cotton in afternoon time as influenced by different distance from the teak tree.

At Harvesting Stage

The minimum relative humidity of cotton (AKH8828) was found in T_4 treatment (27.8%) at morning time and T_4 treatment (10.0%) at afternoon time at 12-15 m distance followed by T_3 treatment (41.2%) in morning time and T_3 treatment (21.0%) in afternoon time at 6-9 m distance and T_2 treatment (42.6%) in morning time and T_2 treatment (21.4 %) in afternoon time at 3-6 m distance. The ranged from 27.8 per cent to 44.0 per cent with mean 38.90 per cent at morning time and 10.0 per cent to 22.6 per cent with mean 18.80 per cent at afternoon time.

Ranged of relative humidity of cotton (AKH09-5) from 23.4 per cent to 43.0 per cent with mean 37.40 per cent at morning time and 10.2 per cent to 22.0 per cent with mean 18.70 per cent at afternoon time. The relative humidity was recorded significantly maximum in T_1 treatment (43.0%) at morning time and T_1 treatment (22.0%) at afternoon time of cotton (AKH09-5) at 0-3 m distance followed by T_2 treatment (42.0%) at morning time and T_2 treatment (21.4%) at afternoon time and T_3 treatment (41.2%) at morning time and T_3 treatment (21.2%) at afternoon time at par respectively.

The relative humidity was observed significantly maximum in T_1 temperature (47.6%) at morning and (20.8%) at afternoon on cotton variety (AKH9916) followed by T_2 treatment (47.4%) at morning and (21.4%) at afternoon and T_3 treatment (46.2%) at morning and (21.2%) at afternoon respectively. The relative humidity (%) was ranged from 20.6 per cent to 47.6 per cent with mean 40.50 per cent at morning time and 10.0 per cent to 21.4 per cent with mean 18.35 per cent at afternoon time.

4.1.3.3 Photosynthetically Active Radiation (PAR) (µmol m^{-2} s^{-1})

Photosynthetically active radiation (µmol m^{-2} s^{-1}) was recorded on three growth stages of cotton i.e., 50% flowering, 50% boll bursting and harvesting at two time i.e., morning time 8am and Afternoon time at 4 pm is presented in Table 19 and 20 and graphically shown in Fig. 19 (a to c) and 20 (a to c).Data on recorded of PAR (µmol m^{-2} s^{-1}) was found not affected significantly due to the different treatment on three

Table 19. PAR (µmol m^{-2} s^{-1}) of cotton in Morning time as influenced by different distance from the teak tree.

Treatment	**PAR (µmol m^{-2} s^{-1}) Morning time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	48.6	33.5	33.1	49.2	41.7	43.9	38.5	50.7	44.7
T_2	46.2	43.4	40.2	58.9	50.4	42.0	45.2	51.4	52.4
T_3	43.8	29.0	44.4	48.4	47.3	48.4	50.4	62.2	48.0
T_4	59.2	55.1	44.4	35.5	35.7	47.4	55.1	51.5	51.9
Mean	49.45	40.25	40.52	48.00	43.77	45.42	47.30	53.95	49.25
Range	43.8 -59.2	29.0 -55.1	33.1 -44.4	35.5 -58.9	35.7 -50.4	42.0 - 48.4	38.5 -55.1	50.7 -62.2	44.7 -52.4
SE (m)±	2.48	4.10	4.37	3.25	4.42	4.51	3.61	4.71	2.77
CD (5%)	7.64	12.65	13.46	10.02	13.61	13.89	11.11	14.52	8.55
‘F’ Test	NS	NS	NS	NS	NS	NS	NS	NS	NS

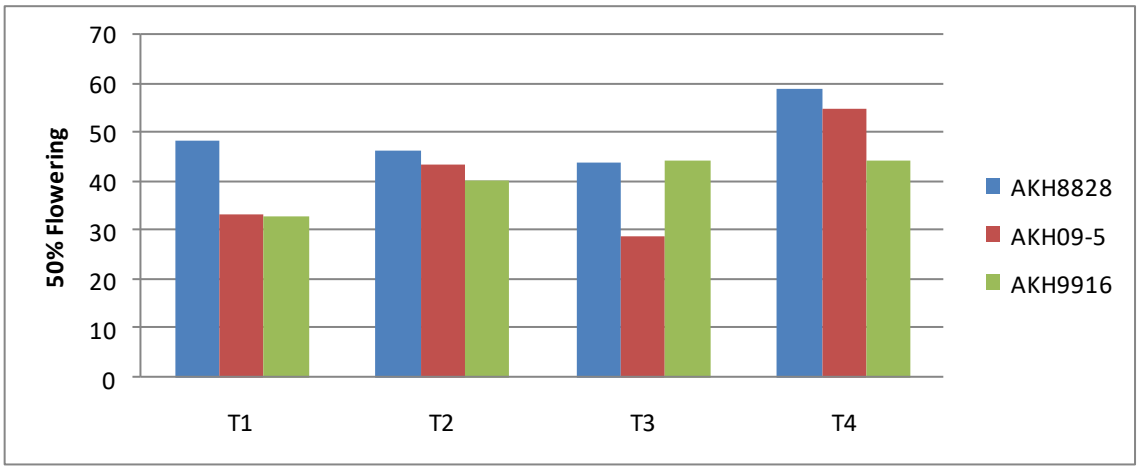

Fig. 19 (a). PAR (µmol m^{-2} s^{-1}) of cotton in morning time as influenced by different distance from the teak tree.

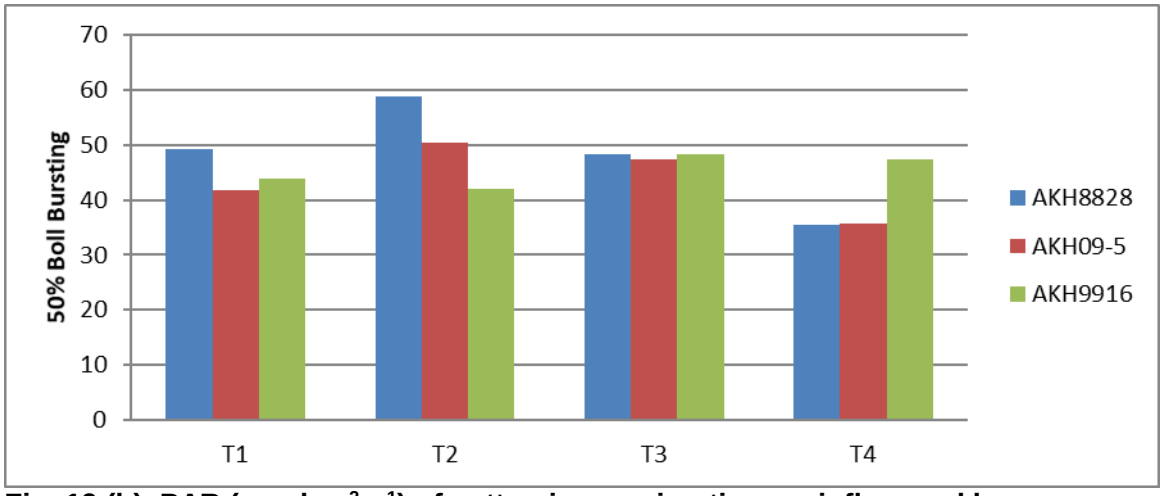

Fig. 19 (b). PAR (µmol m^{-2} s^{-1}) of cotton in morning time as influenced by different distance from the teak tree.

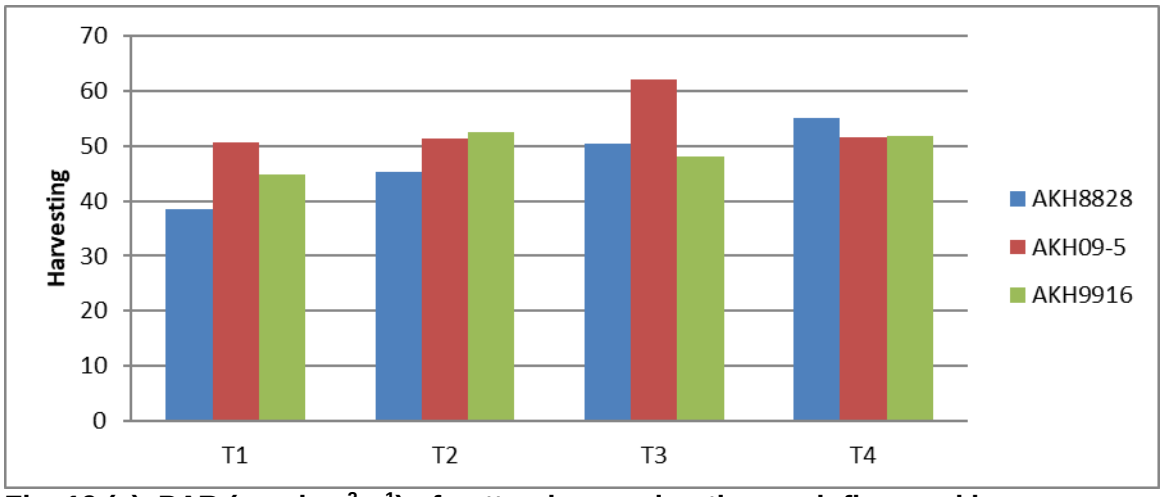

Fig. 19 (c). PAR (µmol m^{-2} s^{-1}) of cotton in morning time as influenced by different distance from the teak tree.

Table 20. PAR (µmol m^{-2} s^{-1}) of cotton in Afternoon time as influenced by different distance from the teak tree.

Treatment	**PAR (µmol m^{-2} s^{-1}) Afternoon time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	40.1	40.3	33.5	36.0	30.5	32.3	52.7	25.7	33.2
T_2	51.5	40.7	31.7	35.0	38.7	37.6	54.9	33.1	30.9
T_3	49.2	43.3	39.9	35.8	40.1	44.6	59.0	30.5	37.5
T_4	42.8	22.6	31.0	39.0	42.2	44.0	33.6	34.3	34.2
Mean	45.90	36.72	34.02	36.50	37.87	39.62	50.05	30.9	33.95
Range	40.1 - 51.5	22.6 - 43.3	31.0 - 39.9	35.0 - 39.0	30.5 - 42.2	32.3 -44.6	33.6 -59.0	25.7 -34.3	30.9 - 37.5
SE (m)±	4.26	3.29	2.90	0.71	3.25	4.82	6.61	3.20	4.81
CD (5%)	13.13	10.15	8.93	2.20	10.02	14.85	18.98	9.87	14.81
‘F’ Test	NS	NS	NS	NS	NS	NS	NS	NS	NS

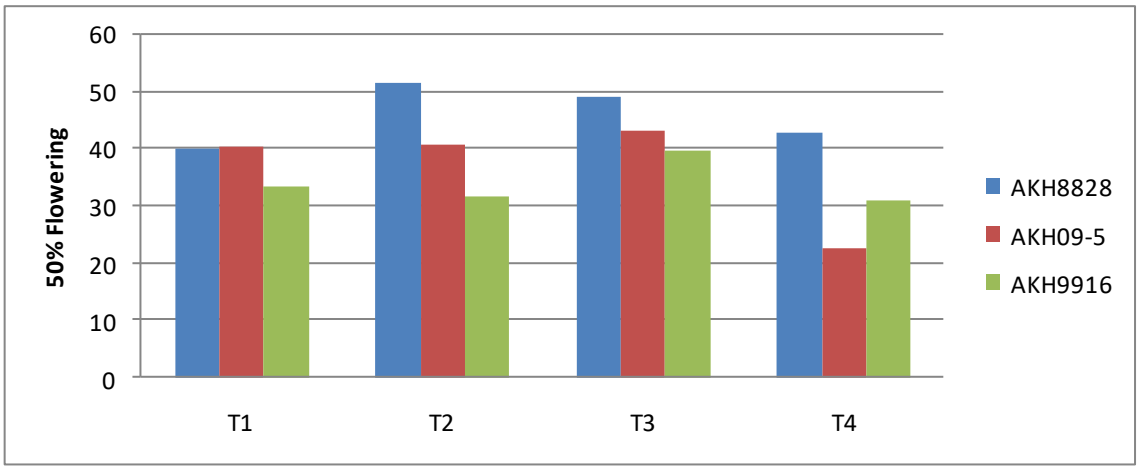

Fig. 20 (a). PAR (µmol m^{-2} s^{-1}) of cotton in afternoon time as influenced by different distance from the teak tree.

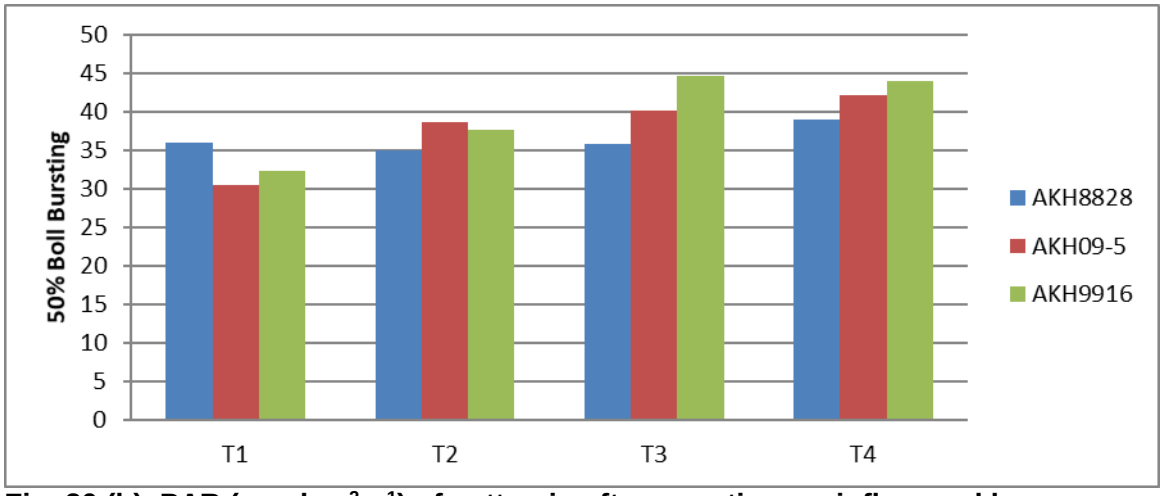

Fig. 20 (b). PAR (µmol m^{-2} s^{-1}) of cotton in afternoon time as influenced by different distance from the teak tree.

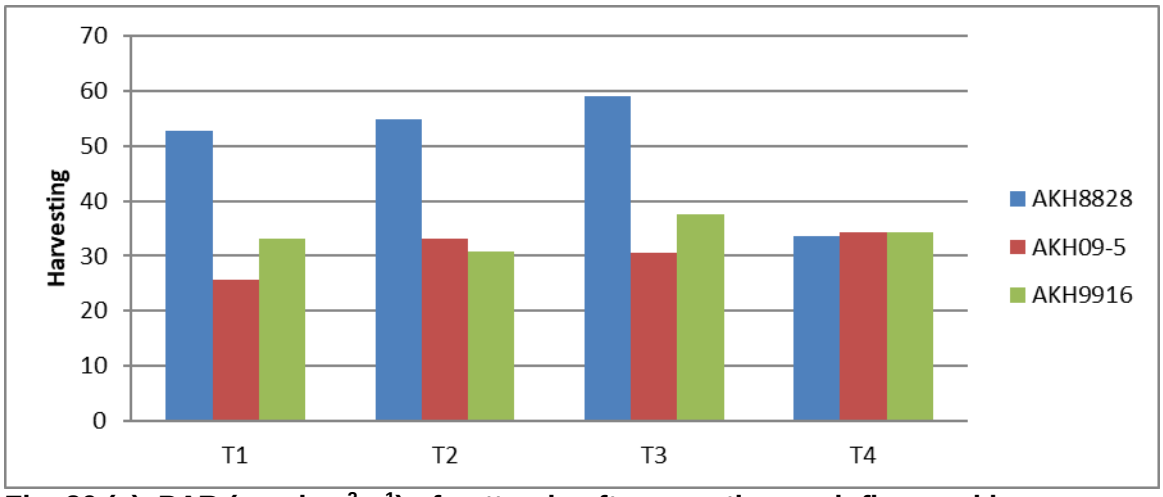

Fig. 20 (c). PAR (µmol m^{-2} s^{-1}) of cotton in afternoon time as influenced by different distance from the teak tree.

Table 21. CO_2 (ppm) of cotton in morning time as influenced by different distance from the teak tree.

Treatment	**CO_2 (ppm) Morning time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	337.7	343.1	333.2	350.7	352.2	347.9	351.4	341.2	356.1
T_2	337.3	345.6	330.3	352.4	347.6	347.6	348.5	345.8	356.4
T_3	335.8	340.9	329.9	351.2	350.6	349.2	345.3	351.2	357.4
T_4	341.00	332.90	329.90	349.90	355.60	350.40	349.00	343.20	340.00
Mean	337.95	340.60	330.70	351.10	351.50	348.70	348.55	345.40	352.50
Range	335.8 - 341.0	332.9 - 345.6	329.4 - 333.2	349.9 - 352.4	347.6 - 355.6	347.6 - 350.4	345.3 - 351.4	341.2 - 351.2	340 - 357.4
SE (m)±	1.86	5.79	1.47	2.64	2.57	2.15	1.67	3.62	1.69
CD (5%)	5.73	17.85	4.52	8.15	7.93	6.64	5.15	11.16	5.21
C.V.	1.23	3.80	0.99	1.68	1.64	1.38	1.07	2.34	1.07
‘F’ Test	NS	NS	NS	NS	NS	NS	NS	NS	NS

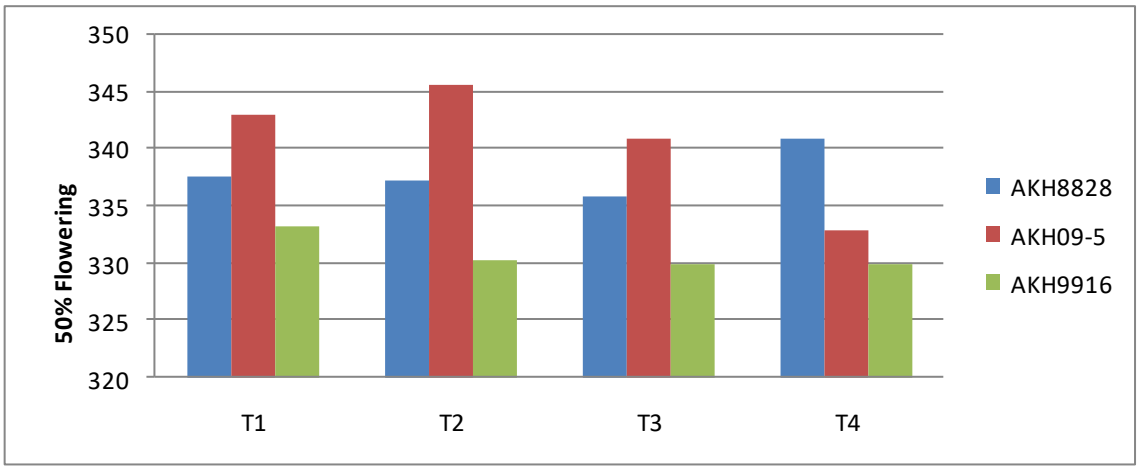

Fig. 21(a). CO_2 (ppm) of cotton in morning time as influenced by different distance from the teak tree.

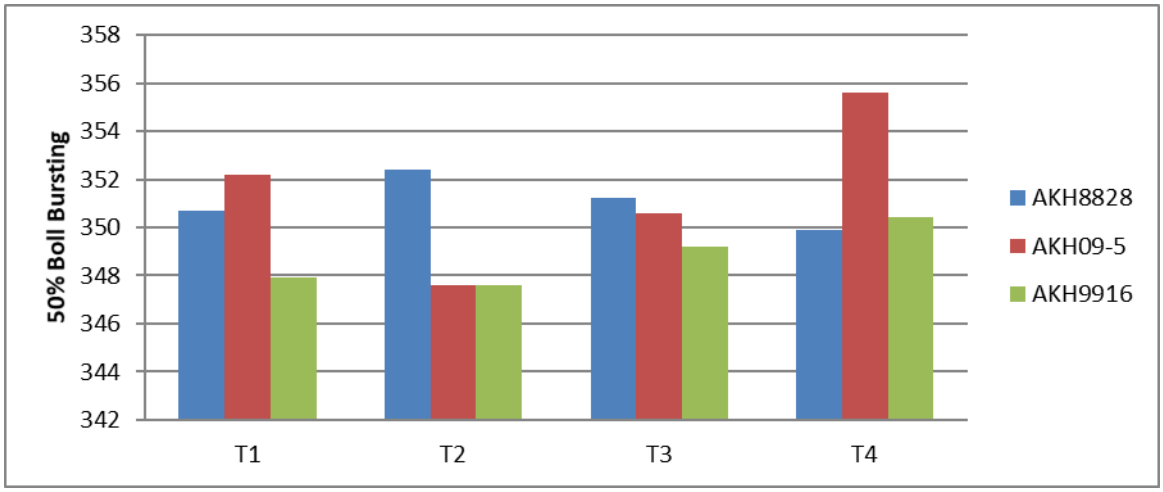

Fig. 21(b). CO_2 (ppm) of cotton in morning time as influenced by different distance from the teak tree.

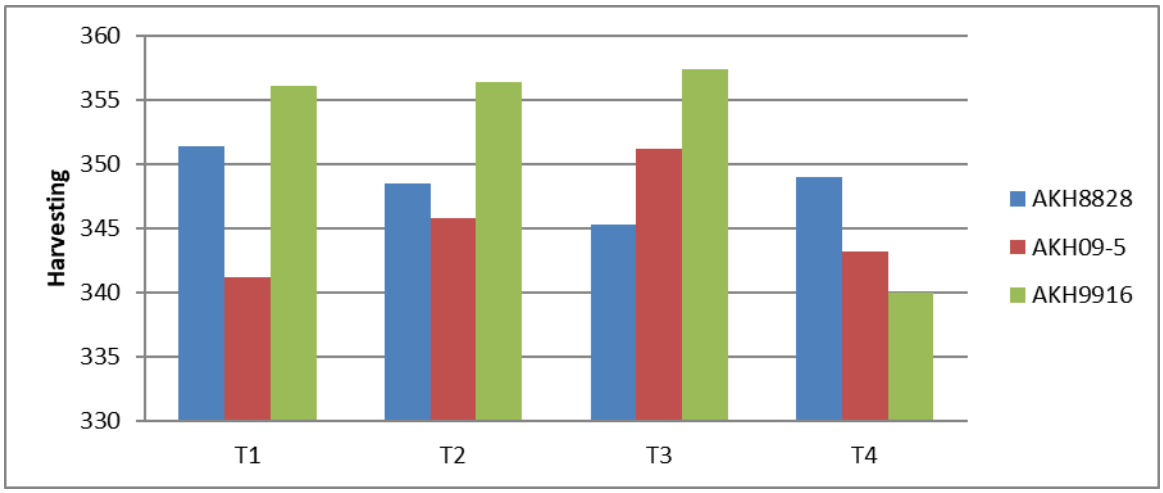

Fig. 21 (c). CO_2 (ppm) of cotton in morning time as influenced by different distance from the teak tree.

Table 22. CO_2 (ppm) of cotton in Afternoon time as influenced by different distance from the teak tree.

Treatment	**CO_2 (ppm) Afternoon time**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	330.3	377.3	323.6	345.8	344.3	344.8	346.8	353	350.4
T_2	343.6	341.4	326.2	346.6	346.4	344.3	352	353.3	342.2
T_3	348.7	339.6	329.4	345.6	343.7	340.3	351.7	352.2	356.6
T_4	329.50	333.60	320.50	347.90	344.90	348.70	341.20	375.60	347.80
Mean	338.05	347.97	324.92	346.50	344.82	344.52	347.70	358.80	349.25
Range	329.5 - 348.7	333.6 - 377.3	320.5 - 329.4	345.6 - 347.9	343.7 - 346.4	340.3 - 348.7	341.2 - 352	352.2 - 375.6	342.2- 356.6
SE (m)±	8.73	12.43	1.18	0.85	0.79	1.86	2.21	3.41	7.28
CD (5%)	26.91	38.3	3.63	2.63	2.42	5.73	6.80	10.49	22.44
C.V.	5.78	7.99	0.81	0.55	0.51	1.21	1.41	2.12	4.66
‘F’ Test	NS	NS	NS	NS	NS	NS	NS	NS	NS

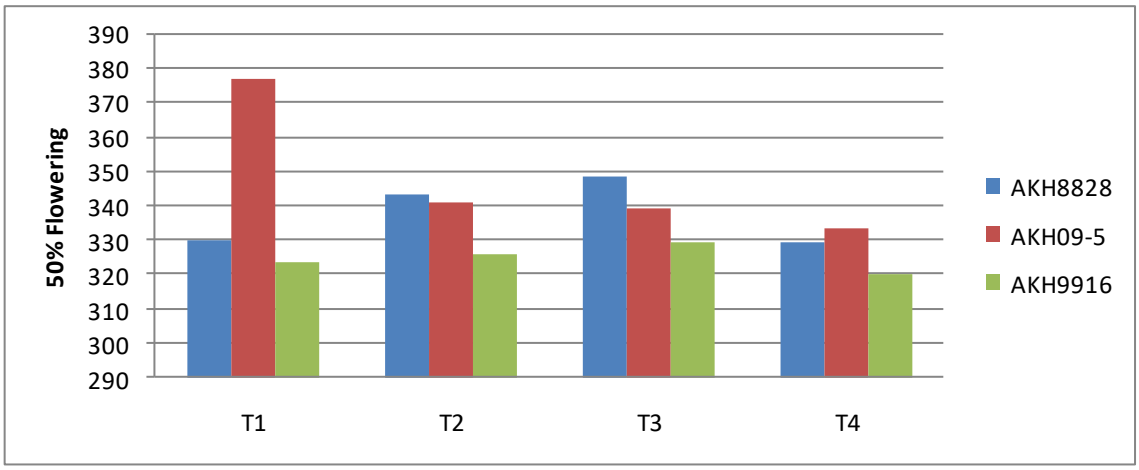

Fig. 22 (a). CO_2 (ppm) of cotton in afternoon time as influenced by different distance from the teak tree.

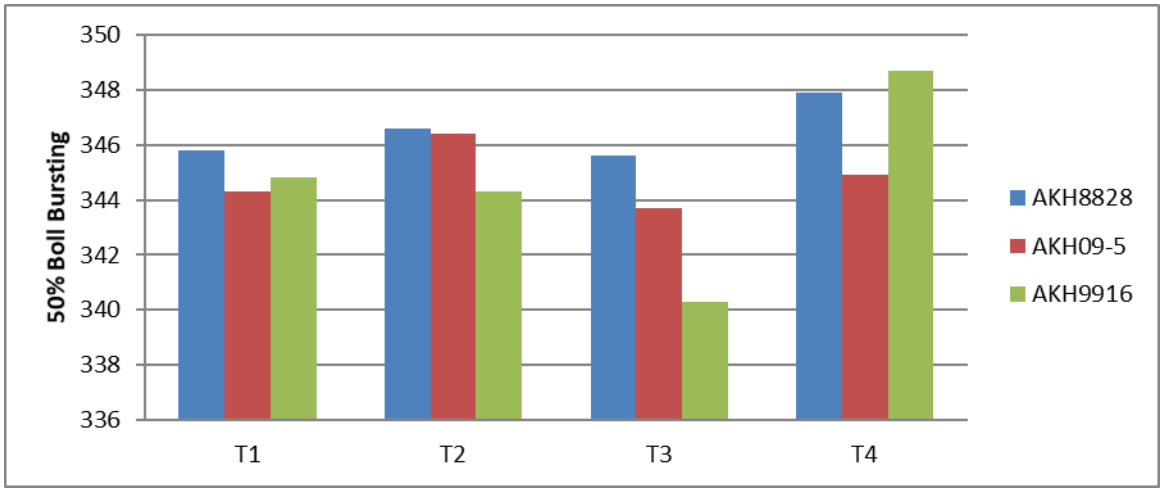

Fig. 22 (b). CO_2 (ppm) of cotton in afternoon time as influenced by different distance from the teak tree.

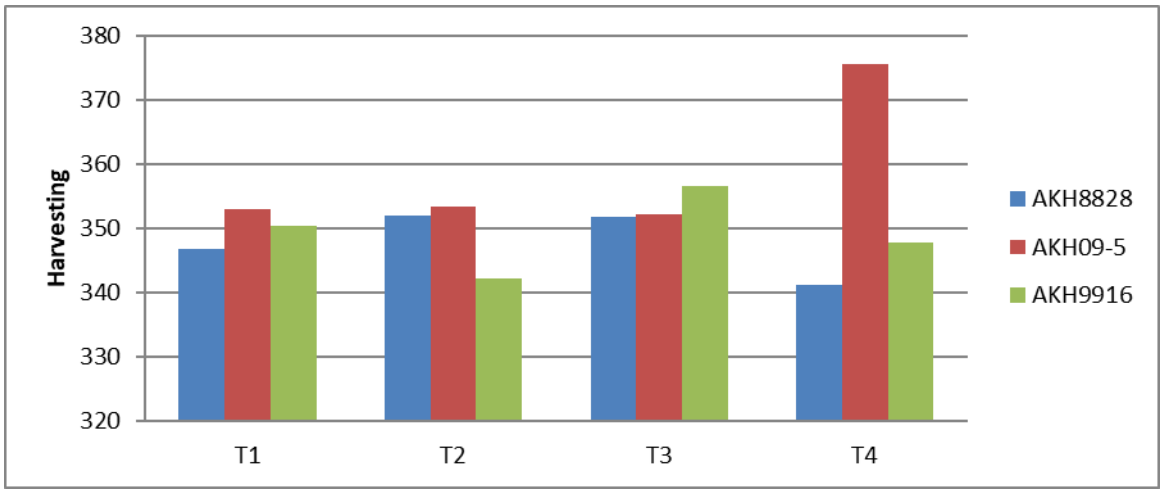

Fig. 22 (c). CO_2 (ppm) of cotton in afternoon time as influenced by different distance from the teak tree.

varieties of cotton i.e., AKH8828, AKH09-5 and AKH9916 with three different growth stages. 50% flowering, 50% boll bursting and harvesting.

4.1.3.4 CO_2 (ppm)

The data on recorded of CO_2 of cotton varieties (AKH8828, AKH09-5 and AKH9916) were not affected by different treatments at both time i.e., morning 8 am and afternoon 4 pm at three growth stages of cotton viz., 50% flowering, 50% boll bursting and harvesting is presented in Table 21 and 22 and graphically shown in Fig. 21 (a to c) and 22 (a to c).

4.1.4 Physiological performance of cotton in teak

4.1.4.1 Leaf Area Index (LAI)

Data relating of leaf area index as influenced by different treatment are presented in Table 23 and depicted in Fig 23.

Leaf area index increased upto the 50% boll bursting and declined thereafter. The maximum value of LAI was recorded at 50% boll bursting and it was to the tune of 1.5. The LAI was recorded at three different growth stages cotton crop i.e., 50% flowering, 50% boll bursting and Harvesting.

At 50% Flowering Stage

The data on LAI recorded of cotton variety (AKH8828) was significantly maximum in T_4 treatment (0.7) and T_3 treatment (0.7). The ranged of LAI from 0.6 to 0.7 with mean 0.65. The Minimum value of LAI was found in T_1 treatment (0.6) and T_2 Treatment (0.6).

The mean performance LAI of cotton variety (AKH09-5) ranged from 0.6 to 0.7 with mean 0.65. The maximum LAI was recorded in T_4 and T_3 treatment (0.7) at 12-15 m distance and 6-9 m distance from the teak row, respectively. The minimum LAI was found in T_1 and T_2 treatment (0.6) at 0-3 m distance and 3-6 m distance from the tree.

Leaf area index of cotton variety (AKH9916) was significantly minimum in T_1 treatment (0.5) at 0-3 m distance followed by T_2 treatment (0.6) at 3-6 m distance and T_3 treatment (0.7) at 6-9 m distance from the teak tree. The ranged from 0.5 to 0.8 with mean 0.65.

Table 23. LAI of cotton as influenced by different distance from the teak tree.

Treatment	**Leaf Area Index**								
Stages	50% Flowering			50% Boll Bursting			Harvesting		
Varieties	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916	AKH8828	AKH09-5	AKH9916
T_1	0.6	0.6	0.5	1.2	1.3	1.1	0.9	0.9	0.8
T_2	0.6	0.6	0.6	1.3	1.3	1.1	1.0	1.0	0.9
T_3	0.7	0.7	0.7	1.4	1.4	1.2	1.1	1.1	1.0
T_4	0.7	0.7	0.8	1.5	1.5	1.4	1.2	1.2	1.1
Mean	0.65	0.65	0.65	1.35	1.37	1.20	1.05	1.05	0.95
Range	0.6 - 0.7	0.6 - 0.7	0.5 - 0.8	1.2 - 1.5	1.3 - 1.5	1.1 - 1.4	0.9 - 1.2	0.9 - 1.2	0.8 - 1.0
SE (m)±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (5%)	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.02	0.02
C.V.	2.36	2.62	2.77	1.33	2.10	1.98	2.22	1.69	1.69
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

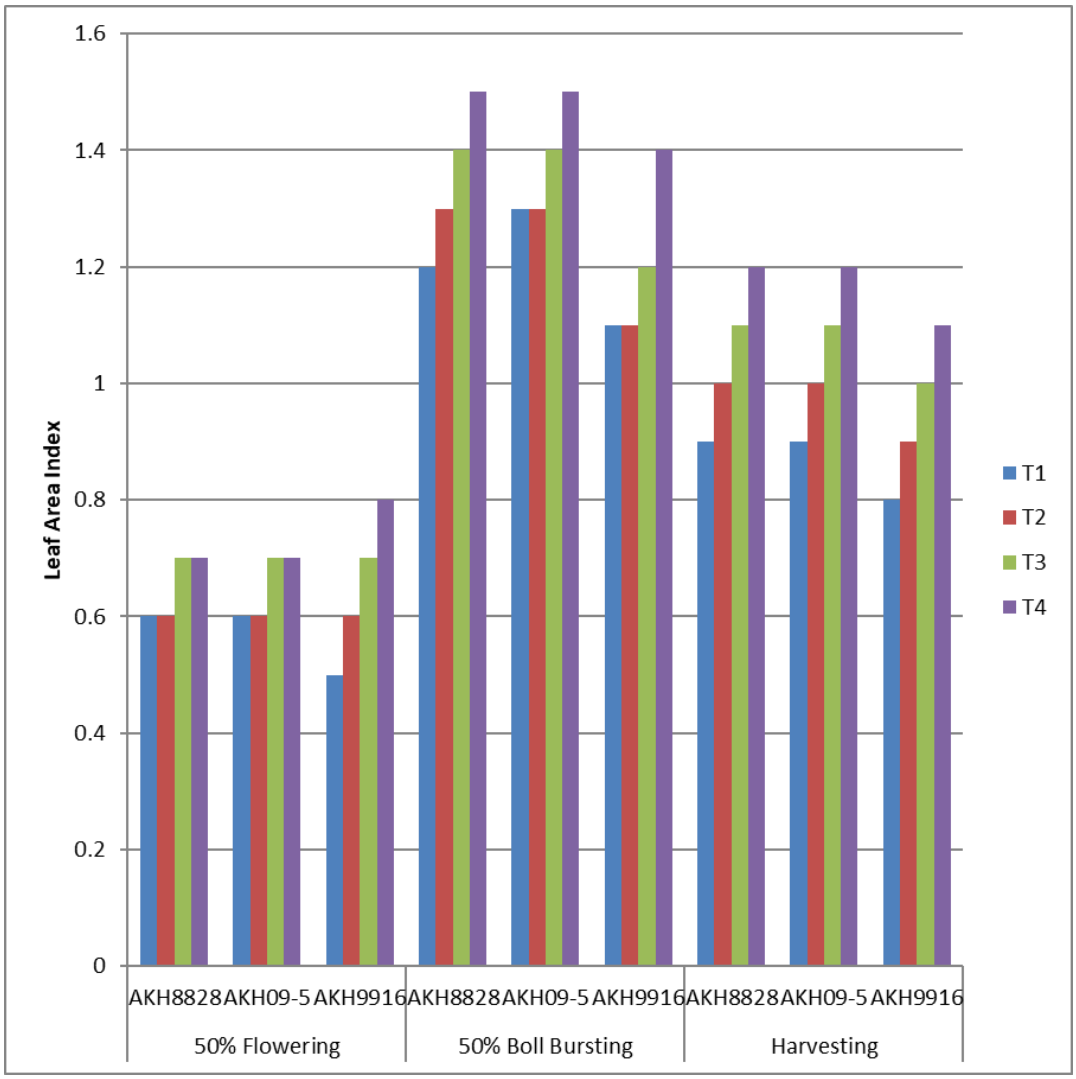

Fig. 23. LAI of cotton as influenced by different distance from the teak tree.

At 50% Boll Bursting Stage

Leaf area index of cotton variety (AKH8828) was significantly minimum in T_1 treatment (1.2) at 0-3 m distance followed by T_2 treatment (1.3) at 3-6 m distance and T_3 treatment (1.4) at 6-9 m distance from the teak tree. The ranged from 1.2 to 1.5 with mean 1.35. The maximum LAI was recorded in T_4 treatment (1.5) at 12-15 m distance.

The data on LAI of cotton variety (AKH09-5) ranged from 1.3 to 1.5 with mean 1.37. The significantly highest LAI was observed in T_4 treatment (1.5) at 12-15 m distance followed by T_2 treatment (1.4) at 6-9 m distance and T_2 treatment (1.3) at 3-6 m distance from the teak row. The T_2treatment and T_1 treatment (1.3) were found same value of LAI.

The mean performance of LAI of cotton variety (AKH9916) was significantly maximum observed in T_4 treatment (1.4) at 12-15 m distance followed by T_3 treatment (1.2) at 6-9 m distance and T_2 and T_1 treatment (1.1) were same LAI in both treatment. The ranged from 1.1 to 1.4 with mean 1.20.

At Harvesting Stage

In this stage of leaf area index of cotton variety (AKH8828) was lowest as compared to 50% boll bursting stage. The significantly maximum leaf area index was found in T_4 treatment (1.2) at 12-15 m distance followed by T_3 treatment (1.1) at 6-9 m distance and T_2 treatment (1.0) at 3-6 m distance from the teak row. The ranged from 0.9 to 1.2 with mean 1.05.

The mean performance of LAI of cotton variety (AKH09-5) ranged from 0.9 to 1.2 with mean 1.05. The significantly minimum LAI of cotton was recorded in T_1 treatment (0.9) at 0-3 m distance followed by T_2 treatment (1.0) at 3-6 m distance and T_3 treatment (1.1) at 6-9 m distance from the teak row.

In T_4 treatment (1.1) was found significantly maximum leaf area index of cotton variety (AKH9916) at 12-15 m distance followed by T_3 treatment (1.0) at 6-9 m distance and T_2 treatment (0.9) at 3-6 m distance from the teak row. The range from 0.8 to 1.1 with mean 0.95.

4.1.4.2 Chlorophyll content (mg/g)

The data on chlorophyll content (mg/g) of cotton varieties was significantly influenced by different distances at three different stages i.e., 50% flowering, 50% boll bursting and harvesting is presented in Table 24 and graphically shown in Fig. 24.

At 50% Flowering Stage

Chlorophyll content (mg/g) of cotton variety (AKH8828) was significantly the highest in T_1 treatment (63.3 mg/g) at 0-3 m distance followed by T_2 treatment (62.7 mg/g) at 3-6 m distance and T_3 treatment (60.4 mg/g) at 6-9 m distance from the teak boundary plantation. The ranged of chlorophyll content from 56.3 mg/g to 63.3 mg/g with mean 60.70 mg/g.

The mean performance of chlorophyll content (mg/g) of cotton variety (AKH09-5) was ranged from 54.9 mg/g to 62.4 mg/g with mean 59.20 mg/g. The significantly lowest chlorophyll content was found in T_4 treatment (54.9 mg/g) at 12-15 m distance followed by T_3 treatment (58.7 mg/g) at 6-9 m distance and T_2 treatment (60.9 mg/g) at 3-6 m distance from the teak row. The highest chlorophyll content was observed in T_1 treatment (62.4 mg/g) at 0-3 m distance.

At T_1 treatment (62.6 mg/g) observed significantly the highest chlorophyll content of cotton variety (AKH9916) as compared to other treatments. The ranged observed from 54.4 mg/g to 62.6 mg/g with mean 59.80 mg/g. The lowest chlorophyll content recorded significantly in T_4 treatment (54.4 mg/g) at 12-15 m distance followed by T_3 treatment (60.5 mg/g) at 6-9 m distance and T_2 treatment (61.5 mg/g) at 3-6 m distance.

At 50% Boll Bursting Stage

In this stage, the chlorophyll content of cotton variety (AKH8828) was significantly the lowest recorded in T_4 treatment (45.8 mg/g) at 12-15 m distance. The ranged from 45.8 mg/g to 60.9 mg/g with mean 53.40 mg/g. In T_1 treatment (60.9 mg/g) at 0-3 m distance was recorded significantly the highest chlorophyll content as compared to T_2

treatment (54.3 mg/g) at 3-6 m distance and T_3 treatment (52.3 mg/g) at 6-9 m distance.

Chlorophyll content of cotton variety (AKH09-5) was observed significantly the highest near the teak tree at 0-3 m distance i.e., T_1 treatment (57.9 mg/g) followed by 3-6 m distance i.e., T_2 treatment (52.8 mg/g) and 6-9 m distance i.e., T_3 treatment (49.7 mg/g). The ranged obtained from 57.9 mg/g to 48.0 mg/g with mean 52.10 mg/g.

In cotton variety (AKH9916), the chlorophyll content was observed ranged from 47.0 mg/g to 58.0 mg/g with mean 53.80 mg/g. The chlorophyll content was found significantly the lowest in T_4 treatment (47.0 mg/g) at 12-15 m distance followed by T_3 treatment (54.1 mg/g) at 6-9 m distance and T_2 treatment (56.0 mg/g) at 3-6 m distance from the teak tree. The highest chlorophyll content found in T_1 treatment (58.0 mg/g) at 0-3 m distance.

At Harvesting Stage

At T_1 treatment (51.6 mg/g) observed significantly the highest chlorophyll content of cotton variety (AKH8828) as compared to other treatments. The ranged observed from 38.4 mg/g to 51.6 mg/g with mean 46.40 mg/g. The lowest chlorophyll content recorded significantly in T_4 treatment (38.4 mg/g) at 12-15 m distance followed by T_3 treatment (47.3 mg/g) at 6-9 m distance and T_2 treatment (48.1 mg/g) at 3-6 m distance.

The mean performance of chlorophyll content (mg/g) of cotton variety (AKH09-5) was ranged from 37.6 mg/g to 51.2 mg/g with mean 47.20 mg/g. The significantly lowest chlorophyll content was found in T_4 treatment (37.6 mg/g) at 12-15 m distance followed by T_3 treatment (48.9 mg/g) at 6-9 m distance and T_2 treatment (50.9 mg/g) at 3-6 m distance from the teak row. The highest chlorophyll content was observed in T_1 treatment (51.2 mg/g) at 0-3 m distance.

Table 24. Chlorophyll content (mg/g) of cotton as influenced by different distance from the teak tree

Treatment	Chlorophyll Content (mg/g)								
Stages	**50% Flowering**			**50% Boll Bursting**			**Harvesting**		
Varieties	**AKH8828**	**AKH09-5**	**AKH9916**	**AKH8828**	**AKH09-5**	**AKH9916**	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	63.3	62.4	62.6	60.9	57.9	58.0	51.6	51.2	52.8
T_2	62.7	60.9	61.5	54.3	52.8	56	48.1	50.9	50.9
T_3	60.4	58.7	60.5	52.3	49.7	54.1	47.3	48.9	49.7
T_4	56.3	54.9	54.4	45.8	48.0	47.0	38.4	37.6	38.3
Mean	60.70	59.20	59.80	53.40	52.10	53.80	46.40	47.20	47.90
Range	56.3 - 63.3	54.9 - 62.4	54.4 - 62.6	45.8 -60.9	48.0 -57.9	47.0 -58.0	38.4 - 51.6	37.6 - 51.2	38.3 - 52.8
SE (m)±	1.05	0.82	0.78	0.85	0.69	1.47	1.91	1.50	1.19
CD (5%)	3.25	2.53	2.41	2.61	2.14	4.53	5.89	4.63	3.67
C.V.	3.88	3.10	2.93	3.55	2.98	6.11	9.22	7.13	5.56
‘F’ Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

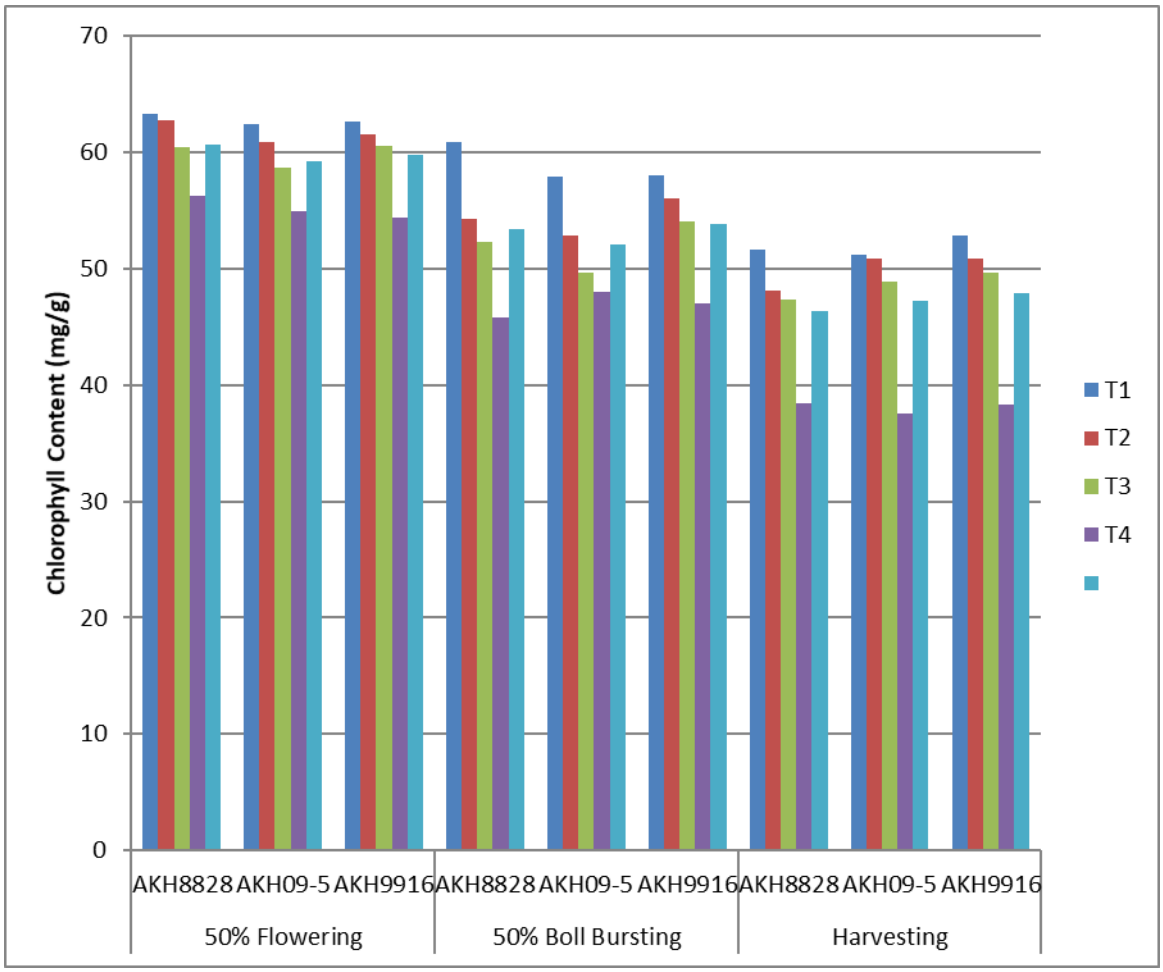

Fig. 24. Chlorophyll content (mg/g) of cotton as influenced by different distance from the teak tree

In this stage, the chlorophyll content of cotton variety (AKH9916) was significantly the lowest recorded in T_4 treatment (38.3 mg/g) at 12-15 m distance. The ranged from 38.3 mg/g to 52.8 mg/g with mean 47.90 mg/g. In T_1 treatment (52.8 mg/g) at 0-3 m distance was recorded significantly the highest chlorophyll content as compared to T_2 treatment (50.9 mg/g) at 3-6 m distance and T_3 treatment (49.7 mg/g) at 6-9 m distance.

4.1.4.3 Harvest Index (%)

Harvest index (%) was recorded of different varieties of cotton (AKH8828, AKH09-5 and AKH9916) at harvesting stage in different distances is presented in Table 25 and graphically shown in Fig. 25.

In harvesting stage, the harvest index of cotton variety (AKH8828) was recorded significantly the highest at 12-15 m distance i.e., T_1 treatment (45.8 %) followed by T_3 treatment (31.8%) at 6-9 m distance and T_2 treatment (21.7%) at 3-6 m distance from the teak tree. The ranged was observed from 10.8 % to 45.8% with mean 27.52%. At 0-3 m distance, the lowest harvest index was recorded.

Table 25. Harvest index (%) of cotton as influenced by different distances from the teak tree

Treatment	Harvest Index (%)		
Varieties	**AKH8828**	**AKH09-5**	**AKH9916**
T_1	10.8	17.3	11.7
T_2	21.7	27.8	24.2
T_3	31.8	32.2	31.5
T_4	45.8	41.8	43.5
Mean	27.52	29.77	27.72
Range	10.8 - 45.8	17.3 - 41.8	11.7 - 43.5
SE (m)±	1.38	2.37	1.12
CD (5%)	4.26	7.29	3.46
C.V.	11.22	17.77	9.06
‘F’ Test	Sig	Sig	Sig

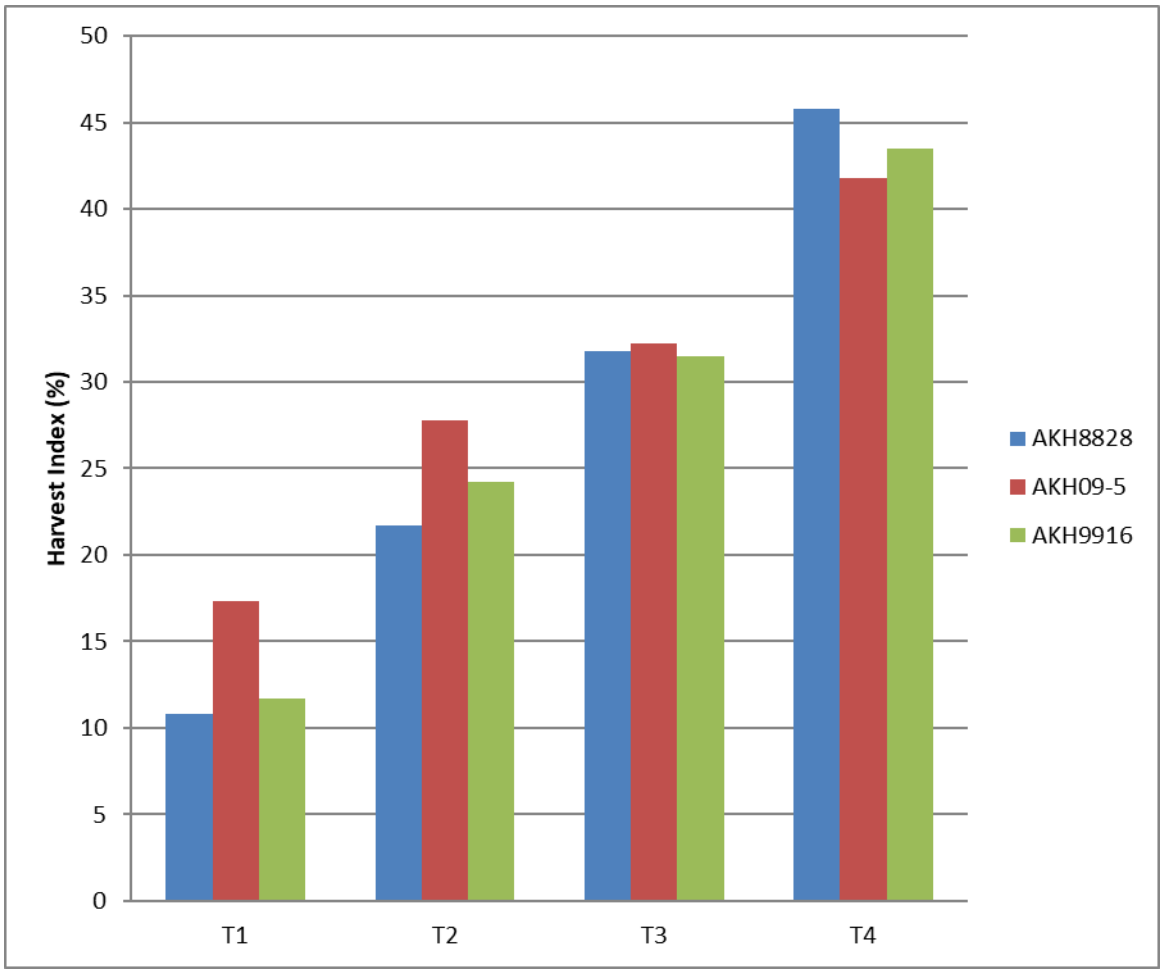

Fig. 25. Harvest index (%) of cotton as influenced by different distances from the teak tree

Mean performance of harvest index of cotton variety (AKH09-5) was ranged recorded from 17.3 % to 41.8 % with mean 29.77 %. Harvest index of cotton was observed significantly the lowest in T_1 treatment (17.3 %) at 0-3 m distance followed by T_2 treatment (27.8%) at 3-6 m distance and T_3 treatment (32.2 %) at 6-9 m distance from the teak tree. At 12-15 m distance i.e., T_4 treatment (41.8%) the highest harvest index was found.

Harvest index of cotton variety (AKH9916) was recorded significantly the highest at distance 12-15 m distance i.e., **T_4** treatment (43.5%) as compared to other distances. The ranged from 11.7 % to 43.5 % with mean 27.72 %. The lowest harvest index was found in T_1 treatment (11.7) at 0-3 m distance followed by T_2 treatment (24.2%) at 3-6 m distance and T_3 treatment (31.5 %) at 6-9 m distance from the teak tree.

4.1.5 Growth performance of teak tree

The tree growth performance of teak is presented in Table 26.

4.1.5.1 Height (m)

The maximum and minimum height of teak tree was 12.78 m and 10.98 m respectively. The mean of teak height was 12.006 m.

4.1.5.2 Diameter at breast height (cm)

The ranged of diameter at breast height from 19.5 cm to 26.4 cm with mean 22.055 cm.

4.1.5.3 Crown Spread (m^2/tree)

The maximum crown spread of tree was observed 9.4 m^2 / tree. The mean is 8.055m^2/tree.

Table 26. Growth performance of Teak tree

Teak Tree	Height (m)	Diameter at breast height (cm)	Crown spread (m^2 /tree)
Tree -1	12.42	25.2	6.8
Tree -2	11.56	26.4	8.8
Tree -3	12.67	19.5	7.6
Tree -4	11.49	23.3	7.9
Tree -5	12.57	25.2	8.6
Tree -6	10.98	24.9	6.6
Tree -7	12.34	24.4	8.2
Tree -8	11.25	28.3	8.6
Tree -9	12.78	26.2	9.4
Mean	12.006	22.055	8.055

4.2 Discussions

In teak based agroforestry system performance of cotton principally depends upon availability of resources like light, moisture and nutrients. The effects and thereof interactions are discussed as under.

4.2.1 Growth performance of cotton in teak

The growth parameters of cotton i.e., germination percentage (97.8%), plant height (cm), number of sympodia per plant, number of monopodia per plant, number of bolls per plant, boll weight (3.6 g), seed index (8.5 g), lint index (4.4), ginning percentage (35.3%) and harvest index (43.7%) leaf area index were more in T_4 treatment at 12-15 m distance (control plot) from the teak row as compared to other treatments at three growth stages of cotton.

Due to interaction of teak, cotton plants produced the lowest bolls upto distance of 6-9 m. Though the rate of production of new vegetative leaves and new fruiting branches sites is highly depending on temperature, it is also very sensitive to water stress. For that reason, the rate of vegetative leaf growth was observed which depends on the complex soil, weather and plant interactions.

Table 27. Average performance of growth character of cotton varieties (AKH9916, AKH09-5, AKH8828) in teak based agroforestry system.

Parameters / Treatment	Germination percentage (%)	Plant Height (cm)			Days to 1st flowering	Days to 50% Flowering	Days to 50% Boll Bursting	No. of Monopodia/ plant	No. of Sympodia / plant	Leaf Area Index (LAI)		
Stages		50% Flowering	50% boll bursting	Harvesting						50% Flowering	50% boll bursting	Harvesting
T_1	71.8	40.7	45.4	52.2	52.0	63.0	133.6	1.1	5.5	0.5	1.2	0.8
T_2	89.2	54.9	59.5	65.3	50.2	59.4	130.0	1.5	8.1	0.6	1.2	0.9
T_3	94.0	62.7	68.8	79.7	48.1	57.2	127.8	1.8	11.1	0.7	1.3	1.0
T_4	97.8	73.1	84.7	96.5	45.3	54.6	125.5	2.1	17.1	0.7	1.4	1.1
Mean	88.20	58.16	64.36	73.42	48.90	58.56	129.22	1.60	10.48	0.64	1.28	0.98
Range	71.8 - 97.8	40.7 - 73.1	45.4 - 84.7	52.2 - 96.5	45.3 - 52.0	54.6 - 63.0	125.5 - 133.6	1.1 – 2.1	5.5 – 17.1	0.5 – 0.7	1.2 – 1.4	0.8 – 1.1
SE (m)	2.22	2.39	2.04	1.77	0.27	0.31	0.36	0.32	0.65	0.01	0.01	0.01
CD (5%)	6.84	7.37	6.29	5.48	0.84	0.97	1.10	0.25	2.03	0.02	0.03	0.02
C.V.	5.66	9.44	7.19	5.34	1.25	1.20	0.62	14.35	14.07	2.58	1.80	1.86

These results are in conformity with the work of Mutanal (1998), Reddy *et al*. (2006), Kumar *et al*. (2015), Nandal *et al*. (1999) and Biswas *et al.* (2016) reported that the growth of crop increased with increased the distance from the tree upto 6 m onwards are presented in Table 27.

4.2.2 Yield performance of cotton in teak

The yield parameters of cotton i.e., seed cotton yield per plant (15.0 g) in T_4 treatment at 12-15 m distance was observed significantly the highest as compared to T_3(11.7 g), T_2(8.7 g) T_1 (7.5 g) treatment at 6-9 m, 3-6 m and 0-3 m distance from the teak boundary plantation.

Table 28. Average performance of yield character of cotton varieties (AKH9916, AKH09-5, AKH8828) in teak based agroforestry system

Parameters / Treatment	No. of bolls/ plant	Boll Weight (g)	Seed cotton yield/ plant (g)	Seed Index (g)	Lint Index	Ginning (%)	Harvest Index
T_1	4.4	2.3	7.5	6.7	3.1	32.1	13.2
T_2	6.6	2.7	8.7	7.4	3.5	32.8	24.5
T_3	9.2	3.0	11.7	7.9	3.9	33.9	31.8
T_4	18.4	3.6	15.0	8.5	4.4	35.3	43.7
Mean	9.70	2.91	10.72	7.62	3.72	33.55	28.33
Range	4.4 - 18.4	2.3 - 3.6	7.5 – 15	6.7 - 8.5	3.5 - 4.4	32.1 - 35.3	13.2 - 43.1
SE (m)	0.19	0.04	0.29	0.07	0.04	0.16	1.62
CD (5%)	0.59	0.13	0.91	0.24	0.14	0.50	5.00
C.V.	4.46	3.28	6.17	2.34	2.68	1.09	12.68

It was observed that through the growth resources like light and temperature were adequate the crop growth and yield of cotton was inhibited. this could be due to the allelopathic effect of teak trees. The reduction in yield was also attributed to depletion of available nutrients and moisture.

Theses result are in line of work reported by Khan and Aslam (1974), Akbar *et al.* (1990), Khan and Ehrenreich (1994), Venkatrao (2005), Gangle *et al* (2013) and Kumar (2015) reported that the increased the yield with increased the distance from the tree at least 6 m distance from the tree are presented in Table 28.

4.2.3 Performance of microclimatic parameters on cotton in teak based agroforestry system

The PAR and CO_2 was not affected significantly at different treatments of distance from the teak i.e., 0-3 m, 3-6 m, 6-9 m and 12-15 m distance.

The relative humidity (%) was observed maximum in T_1 treatment at 0-3 m distance as compared to control plot i.e., 12-15 m distance from the tree. These results also reported by Steffan-Dewenter *et al.* (2007) and Mukherjee *et al.* (2008) the relative humidity was maximum in shade of tree as compared to open field.

The canopy temperature (°C) was affect the growth and yield of cotton crop. The canopy temperature was highest in T_4 treatment at 12-15 m distance (control plot) as compared to other distance from the tree and also lowest in T_1 treatment at 0-3 m distance from the tree. This similar result is in conformity with the work of Mukherjee *et al* (2008), Steffan-Dewenter *et al.* (2007), and Verma and Rana (2014) reported that the canopy temperature was maximum in open field as compared to shaded field. All the results are presented in Table 29.

4.2.4 Performance of Biochemical parameters of cotton in teak based agroforestry systems

The Chlorophyll contents (mg/g) is the primary pigment involved in carbon assimilation. The present data revealed significant differences in the chlorophyll content due to distance from the tree base. The chlorophyll content was observed significantly the highest in T_1 treatment at 0-3 m distance from the tree as compared to other distance. Venkatrao (2005) reported that total content of chlorophyll increased with an increase in shade intensity and also distance was decreased.

Table 29. Average of performance of biochemicals parameters of cotton varieties (AKH8828, AKH09-5, AKH9916) in teak based agroforestry system.

Parameters / Treatment	Photosynthetically Active Radiation (PAR) (µmol m^{-2} s^{-1})						Canopy Temperature (°C)						Relative Humidity (%)					
Stages	50% Flowering		50% boll bursting		Harvesting		50% Flowering		50% boll bursting		Harvesting		50% Flowering		50% boll bursting		Harvesting	
Time	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
T_1	38.4	27.9	44.93	32.9	44.63	37.2	31.4	34.6	30.0	32.6	20.9	30.5	56.6	32.6	50.4	36.8	44.8	21.8
T_2	43.26	41.3	50.76	37.1	49.66	39.6	32.6	34.8	30.5	32.8	21.1	30.8	54.9	32.0	48.9	36.0	44.0	21.4
T_3	39.06	44.13	48.03	40.1	53.53	42.33	32.9	35.3	31.1	33.1	21.2	31.4	53.6	30.1	47.8	34.6	42.8	21.1
T_4	52.9	32.13	39.53	41.73	52.83	34.03	34.8	36.5	33.7	34.6	29.2	35.4	44.4	25.0	37.4	28.3	23.9	10.0
Mean	43.40	36.36	45.81	38.00	50.16	38.29	32.97	35.60	31.35	33.26	23.14	32.10	52.40	30.03	46.16	34.00	38.93	18.61
Range	38.4 - 52.9	27.9 - 44.1	39.5 - 50.7	32.9 - 41.7	44.6 - 53.5	34.0 - 42.3	31.4 - 34.8	34.6 - 36.5	30.0 - 33.7	32.6 - 34.6	20.9 - 29.2	30.5 - 35.4	44.4 - 56.6	25.0 - 32.6	37.4 - 50.4	28.3 - 36.8	23.9 - 44.8	10 .0- 21.8
SE (m)	3.65	3.48	4.06	2.92	3.69	4.72	0.43	0.42	0.49	0.41	0.17	0.34	1.45	0.89	0.82	0.55	0.48	0.43
CD (5%)	11.25	10.73	12.5	9.02	11.39	14.55	1.32	1.29	1.52	1.27	0.55	1.05	4.49	2.75	2.54	1.70	1.47	1.34
C.V.							2.92	2.64	3.47	2.78	1.70	2.38	6.14	6.69	3.99	3.59	2.76	5.22

Cont….

Cont…. Table 29

Parameters / Treatment	CO_2 (ppm)						Chlorophyll Content (mg/g)		
Stages	50% Flowering		50% boll bursting		Harvesting		50% Flowering	50% boll bursting	Harvesting
Time	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon			
T_1	338.0	343.7	350.2	344.9	349.5	351.0	62.7	58.9	51.8
T_2	337.7	337.0	349.2	345.7	350.2	349.5	61.7	54.3	49.9
T_3	335.5	339.2	350.3	343.2	351.3	353.5	59.8	52.0	48.6
T_4	334.6	327.8	351.9	347.1	344.0	354.86	55.2	46.9	38.1
Mean	336.40	311.92	350.46	345.28	348.75	351.91	59.90	53.10	4.71
Range	334.6 - 338.0	327.8 - 343.7	349.2 - 351.9	343.2 - 347.1	344.0 - 351.3	349.5 - 354.8	55.2 - 62.7	46.9 - 58.9	38.1 - 51.8
SE (m)	3.04	7.44	2.45	1.16	2.32	4.30	0.88	1.00	1.53
CD (5%)	9.36	22.94	7.57	3.59	7.17	13.24	2.73	3.09	4.73
C.V.	2.00	4.86	1.56	0.75	1.49	2.73	3.30	4.21	7.30

CHAPTER V

SUMMERY AND CONCLUSION

The present investigation entitled “Performance of Cotton (*Gossypium hirsutum* L.) in Teak based Agroforestry System” was carried out during *Kharif season*, 2017-18 on research field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The material consisted of three *Gossypium hirsutum* variety from the Cotton Research Unit. The experiment was carried out by adopting Random Block Design with four treatments and five replications. The observation on growth and yield parameters on cotton at 0-3 m, 3-6 m 6-9 m and control plot i.e., 12-15 m distance from the teak row at 50% flowering, 50% boll bursting and Harvesting stage were recorded with following objectives.

1. To study the growth performance of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.
2. To study the yield of cotton (*Gossypium hirsutum* L.) in teak based agroforestry system.

Agroforestry is a modern tool adopted with a view to grow woody species with agricultural crops in some form of spatial arrangement or temporal sequence. Because these species co-exist with the agricultural crops, it involves kinds of interaction among them. It may have positive or negative effect as per the tree-crop combination. The choice of species combination may affect the productivity and ultimate success of agroforestry system. *Tectona grandis* is an important tree species in India, it is used to grow on farm boundaries and is being preferred by the farmers to meet for timber and furniture.

- The observation was recorded on growth parameter such as germination (%), plant height (cm), leaf area index, Number of sympodia per plant and number of monopodia per plant were the lowest in T_1 treatment at three different stages i.e., 50 % flowering, 50% boll bursting and harvesting. these parameters were significantly the highest

in T_4 treatment at 12-15 m distance followed by T_3 treatment at 6-9 m and T_2 at 3-6 m distance from teak row at three stages.

- Days to first flowering, days to 50% flowering and days to 50% boll bursting was significantly required maximum days in T_1 treatment at 0-3 m distance. Also, the days to first flowering, 50% flowering and 50% boll bursting was minimum days required in T_4 treatment at 12-15 m distance followed by T_3 treatment at 6-9 m, T_2 treatment at 3-6 m distance from the teak tree.
- The yield parameter revealed that the number of bolls per plant, seed cotton yield per plant (g), boll weight (g), seed index (g), lint index, ginning percentage (%) and harvest index (%) was significantly maximum in T_4 treatment at 12-15 m distance followed by T_3 treatment at 6-9 distance and T_2 treatment at 3-6 m distance at harvesting stage. These yield parameters were the lowest in T_1 treatment at 0-3 m distance from teak row at harvesting stage.
- The relative humidity (%) was significantly maximum in T_1 at 0-3 m distance at both time 8 a.m. and 4 p.m. followed by T_2 treatment at 3-6 m distance and T_3 treatment at 6-9 m distance from the teak row at three growth stages i. e., 50% flowering, 50% boll bursting and harvesting. Also, the relative humidity (%) was minimum in T_4 treatment at 12-15 m distance at both time 8 a.m. and 4 p.m. at three different growth stages.
- The biochemical parameters canopy temperature (°C) at morning and afternoon and chlorophyll content (mg/g) were significantly maximum in T_4 treatment at 12-15 m distance at both time 8 a.m. and 4 p.m. followed by T_3 treatment at 6-9 m distance and T_2 treatment at 3-6 m distance from the teak row at three different growth stages i.e., 50% flowering, 50% boll bursting and harvesting. Also, the canopy temperature (°C) was minimum in T_1 treatment at 0-3 m distance from the teak row at both time 8 a.m. and 4 p.m. at three different growth stages.

- The PAR ($\mu molm^{-2}s^{-1}$) and CO_2 (ppm) were not affected significantly due to different treatments i.e., T_1 at 0-3 m, T_2 at 3-6 m, T_3 at 6-9 m and T_4 at 12-15 m distance from the teak boundary plantation.
- It was observed that through the growth resources like light and temperature were adequate the crop growth and yield of cotton was inhibited. this could be due to the allelopathic effect of teak trees. The reduction in yield was also attributed to depletion of available nutrients and moisture.

Conclusions

On the basis of present experiment the following conclusion are down :-

- The growth of cotton crop was significantly the lowest in 0-3 m and 3-6 m distance from the teak plantation.
- The yield of cotton crop was significantly higher in 6-9 m and 12-15 m distance from the teak plantation.
- Treatment of sole cotton recorded significantly higher seed cotton yield than the rest of the treatments.
- Hence, the study concluded that the effect of teak on growth and yield of cotton crop were highest at 6 m distance onwards.

CHAPTER VI

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Appendix

Table: Weekly weather data for the year 2017 recorded at Meteorological Observatory, Department of Agronomy, Dr. PDKV, Akola.																				
		A = Actual of				2017				N = Normal of 40 years						1971 - 2010				
Weeks	Dates	T Max. (^{0}C)		T Min. (^{0}C)		BSH (hrs)		WS (km/hr)		RH I (%)		RH II (%)		Evap. (mm)		RF (mm)		CRF (mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
22	28-3 Jun	41.9	40.5	27.6	28.9	9.7	7.3	16.2	8.2	56	58	23	31	16.3	13.7	5.7	0.8	1.6	0.5	0.0
23	4-10	39.0	38.0	25.8	25.5	8.0	7.1	14.9	10.0	62	74	30	41	13.4	10.9	18.3	24.6	26.2	1.2	1.0
24	11-17	38.2	35.6	25.5	23.8	7.5	5.2	15.4	6.3	71	80	42	51	11.1	7.4	43.3	45.4	71.6	2.0	4.0
25	18-24	35.3	37.4	24.9	26.3	7.1	8.9	15.1	11.0	76	67	50	36	9.1	11.5	52.3	5.7	77.3	2.2	1.0
26	25-1Jul	34.1	34.8	24.2	25.0	5.3	5.1	13.4	7.7	80	75	55	48	7.3	8.6	38.2	10.5	87.8	2.3	2.0
27	2-8	33.5	33.2	24.4	24.3	5.2	3.8	12.9	11.3	81	79	58	51	6.8	7.5	34.7	37.6	125.4	2.4	1.0
28	9-15	32.3	33.9	23.7	24.9	3.8	3.7	12.0	12.6	84	77	62	51	5.5	9.3	52.2	10.8	136.2	2.8	2.0
29	16-22	32.0	29.8	23.9	23.8	3.3	0.6	11.2	6.9	84	88	65	72	5.6	4.2	58.6	101.1	237.3	2.6	4.0
30	23-29	31.7	30.5	23.3	23.0	4.3	2.3	11.9	8.2	85	88	64	65	5.3	4.1	44.2	35.8	273.1	2.6	4.0
31	30-5 Aug	31.1	31.9	23.1	23.6	3.6	6.8	11.7	6.3	88	85	66	58	4.6	6.9	49.3	10.0	283.1	2.5	2.0
32	6-12	30.2	30.7	22.9	24.1	3.5	2.9	11.6	6.0	87	80	69	63	4.2	5.8	59.9	4.4	287.5	2.9	1.0
33	13-19	30.5	32.9	22.8	23.8	4.4	5.4	11.7	7.1	86	83	66	58	4.5	6.2	40.6	18.9	306.4	2.2	1.0
34	20-26	30.5	29.1	22.6	23.4	4.3	2.0	11.0	5.9	88	92	66	76	4.3	2.8	46.7	25.3	331.7	2.0	4.0
35	27-2 Sep	30.4	30.5	22.7	23.3	4.4	3.8	10.6	2.5	86	88	64	68	4.2	3.7	47.1	70.2	401.9	2.4	4.0
36	3-9	31.1	32.3	22.5	23.8	5.7	6.5	9.1	2.7	85	89	61	62	4.7	5.0	28.5	9.7	411.6	1.5	1.0
37	10-16	32.2	31.8	22.4	23.8	7.1	2.6	9.0	0.8	85	93	56	69	5.1	3.5	18.9	27.9	439.5	1.1	3.0
38	17-23	33.4	30.8	22.3	23.0	7.2	2.5	8.5	2.5	83	92	53	69	5.3	3.2	24.6	12.5	452.0	1.4	2.0
39	24-30	33.7	33.8	21.9	22.8	7.6	8.4	5.4	1.6	83	89	50	50	4.9	5.1	24.4	4.1	456.1	1.5	1.0
40	1-7 Oct	33.9	35.6	20.2	21.1	8.1	8.0	7.5	1.2	81	81	45	42	5.5	6.5	21.8	0.0	456.1	1.1	0.0
41	8-14	34.1	31.9	18.7	20.0	4.2	4.3	4.1	0.7	76	91	40	64	5.3	4.2	16.0	57.5	513.6	0.9	4.0
42	15-21	33.9	33.7	18.1	20.5	8.4	6.9	4.4	0.8	74	83	36	43	5.5	5.7	3.1	0.0	513.6	0.4	0.0
43	22-28	33.1	33.9	18.5	16.6	8.4	8.5	4.1	0.6	73	77	36	29	5.3	5.8	10.0	4.5	518.1	0.6	1.0
44	29-4 Nov	33.0	32.7	15.8	14.4	8.7	8.5	4.7	0.6	72	82	31	26	5.3	5.9	2.3	0.0	518.1	0.3	0.0
45	5-11	32.4	31.6	14.8	14.7	8.6	8.5	4.5	1.0	70	81	30	28	5.2	5.4	3.7	0.0	518.1	0.3	0.0
46	12-18	31.7	31.0	13.7	13.7	8.6	7.9	4.6	0.4	70	79	30	37	4.9	4.9	1.1	0.0	518.1	0.3	0.0
47	19-25	31.0	31.8	13.1	17.9	8.6	5.3	4.4	0.9	71	84	30	40	4.6	4.6	10.1	0.0	518.1	0.3	0.0
48	26-2 Dec	30.3	30.6	12.4	11.2	8.8	8.2	4.6	0.9	71	79	31	23	4.3	5.4	6.8	0.0	518.1	0.3	0.0
49	3-9	29.8	29.7	11.2	14.5	8.7	5.6	4.7	1.5	70	78	29	38	4.3	4.8	1.3	0.0	518.1	0.2	0.0
50	10-16	29.4	31.2	10.3	13.7	8.8	7.6	4.5	0.8	70	74	27	27	4.2	5.3	1.3	0.0	518.1	0.2	0.0
51	17-23	29.5	29.7	10.6	10.4	8.7	6.6	4.7	0.8	69	80	29	25	4.3	4.6	0.9	0.0	518.1	0.1	0.0
52	24-31	29.2	29.4	10.7	8.7	8.6	8.2	4.8	1.0	70	72	31	22	4.3	4.3	2.6	0.0	518.1	0.2	0.0
												Total RF June to Dec (N)					768.5			41.2
												Total RF June to Dec (A)					517.3			43.0

APPENDIX- II

CHARACTERISTICS OF AGROFORESTRY

1. Adaptability to local climatic condition.
2. Light open crown that less sunlight through.
3. Ability to resprout quickly after pruning, coppicing or pollarding.
4. Productive capacity that includes poles, wood, food, fodder, medicinal and other products.
5. Good leaf litter making nutrients available at appropriate times in the crop cycle.
6. Few and shallow lateral roots (or prunable).
7. Ability to assist in nitrogen fixation.
8. Resistance to drought, flooding, soli variability and other climatic hazards.
9. Deep thrusting taproot system.
10. Easy to manage.
11. Cheep to establish.
12. Higher demand and better value for the produce.

BENEFITS FROM AGROFORESTRY

1. Reduction of pressure on forest.
2. More efficient recycling of nutrients by deep-rooted trees on the site.
3. Better protection of ecological system.
4. Reduction of surface run-off, nutrient, leaching and soil erosion through impeding effect of tree and stems on these processes.
5. Improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading.
6. Increment in soil nutrient through addition and decomposition of litter-fall.
7. Improvement of soil structure through the constant addition of organice matter from decomposed litter.
8. Increment and maintains of outputs of food, fuel wood, fodder, fertilizer and timber

9. Reduction in incidence of total crop failure common to single-cropping or monoculture system.
10. Increase in levels of farm income due to improve and sustained productivity.
11. Improvement in rural living standards from sustained employment and higher income.
12. Improvement in nutrient and health due to increased quality and diversity of food outputs
13. Stabilization and improvement of upland communities through elimination of the need to shift sites of farm activities.