www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1289-1295

www.thepharmajournal.com
Received: 07-06-2022
Accepted: 29-08-2022

VV Ujjainkar
ICAR–AICRP on Cotton, Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SS Harne
Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

VP Mane
Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Vanashri Hulke
Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

YB Taide
Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
VV Ujjainkar
ICAR–AICRP on Cotton, Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Influence on growth and productivity of cotton (*Gossypium hirsutum* L.) under teak tree belt

VV Ujjainkar, SS Harne, VP Mane, Vanashri Hulke and YB Taide

Abstract
Experiment with three upland cotton (*Gossypium hirsutum* L.) varieties *viz*., AKH-8828, AKH-09-5, AKH-9916 grown in RBD with five replications to record 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 by T_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 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 plantation and highest yield and growth of cotton at 6 m onwards. This kind of investigation will helpful to farmers intending to adopt the agroforestry system.

Keywords: Agroforestry, cotton, *Gossypium hirsutum* L., growth parameters, productivity, teak and *tectona grandis* L.

Introduction
Cotton refers to those species of genus *Gossypium* that bears the spin able seed coat fibers. Cotton, the white gold is one of the leading fibre crops of the country and good number of high yielding varieties and hybrids has been bred by the breeders in India [5]. 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 [1]. 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% 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. 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 [4]. In order to overcome the pressure on existing forests and to utilize natural resources *viz*., light, moisture, nutrient etc., for maximum biomass production and for any other advantages, growing trees on arable lands i.e. 'agroforestry', has become necessary [3, 5].

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 [7]. 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 [8]. 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 [6].

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 [9]. 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 [10, 11]. 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. Present investigation has been undertaken with an objective to find out the effect of its presence on growth and yield parameters by affecting microclimatic and biochemical pathway of cotton crop.

Material and Methods

The experiment was conducted with three ruling upland cotton varieties *viz*., AKH-9916, AKH-09-5 and AKH-8828 of the Vidarbha region having typical plant geometry and yield potential, grown on black cotton soil of main Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Geographically, the 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 experiment was carried out by adopting Random Block Design with four treatments and five replications. The observation on growth *viz*., germination, plant height, number of monopodial branches, number of sympodial branches, days to flowering, days to boll bursting etc. along with the important yield contributing parameters *viz*. number of bolls per plant, boll weight, seed index, lint index, ginning outturn and seed cotton yield per plant of upland cotton planted 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. The growth performance of teak trees constituting belt around the cotton plots were studied using important traits *viz*., height (m), DBH (cm) and canopy spread (m^2/tree)

Results

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.

In Indian contest, our available agricultural land is highly competitive and food production is one of the main challenges to fulfil the basic needs of food, shelter and clothing of over increasing population. In reference to cotton, which is the long duration crop requiring more than six months to yield commercial product. But within these six months farmers can easily grow 2-3 crops in the same land. So we have to think some of the alternative options to grow cotton. Agroforestry is one of the important options to grow cotton. Cotton can grow in different orchard as agroforestry systems [16].

Influence of teak tree belt on Growth Parameters: In present investigation, the effect of teak tree belt was studied on growth parameters of cotton varieties *viz*., germination, plant height, first flowering, 50% flowering, boll bursting stages etc., which significantly influencing the plant geometry and yield (Table 1).

The seed 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 71.8% to 97.8% with an average of 88.20%. The plant height of cotton plants were studied at three stages *viz*., 50% flowering, 50 percent boll bursting and at harvest. The mean performance of plant height at 50% flowering stage, ranged from 40.7 cm to 73.1 cm with mean 58.16 cm whereas, at 50% boll bursting, the mean performance of plant height ranged was 45.4 cm to 84.1 cm with mean 64.36 cm. However, at final picking i.e. maturity stage of cotton crop plant height observed in between from 52.2 cm to 96.5 cm with mean 73.42 cm. Whereas, the initiation of reproductive phase of growth, the first flowering ranged from 45.3 to 52 days with mean of 48.90 days, while days to 50% flowering was completed within 54.6 to 63.0 days with average duration of 58.56 days.

The duration required for 50% boll bursting was ranged from 125.5 to 133.6 days with an average duration of 129.22 days. While the cotton plant geometry deciding factors *viz*., monopodial and sympodial branches shows significant variations over different distances of teak tree belt. The range of monopodial and sympodial branches per plant were observed 1.1 to 2.1 and 5.5 to 17.1 respectively, whereas, the mean values observed are 1.60 and 10.48. The range of Leaf Area Index (LAI) observed for different stages are 50% flowering (0.5 to 0.7), 50% boll bursting (1.2 to 1.4) and at harvesting (0.8 to 1.1), however the means of 0.64, 1.28 and 0.98 in respective stages.

Influence of teak tree belt on Yield Parameters

Yield is a complex trait which is highly influenced by environment and various plant traits *viz*., number of bolls, boll weight, seed cotton yield, seed index, lint index, ginning outturn and harvest index were studied to analyze the effect of teak tree belt on yield (Table 2)

The range of magnitudes of number bolls (4.4 to 18.4), boll weight (2.3 to 3.6 g), seed cotton yield (7.5 to 15.0 g), seed index (6.7 to 8.5 g), lint index (3.5 to 4.4), ginning outturn (31.2 to 35.3%) and harvest index (13.2 to 43.1) were recorded. While values over the means of all treatments of 9.70 (number bolls), 2.91 g (boll weight), 10.72 g (seed cotton yield), 7.62 g (seed index), 3.72 (lint index), 33.55% (ginning outturn) and 28.33 (harvest index) were recorded. The lowest seed cotton yield of cotton, irrespective genotypes was found at closer distance from the tree base. Similar lower yield under partial shade condition was observed in pulse crop like mungbean [14, 15]. The decrease in seed cotton yield in closer tree base was probably due to shading which was attributed by almost all yield contributing characters whereas, the lower yield in shaded conditions in cotton was observed [13].

Influence of teak tree belt on Microclimatic parameters

Microclimatic condition plays a vital role in growth and development of cotton plant. The microclimatic parameters *viz*., Photosynthetic Active Radiation (µmol $m^{-2}s^{-1}$), canopy temperature (^{0}C) and Relative Humidity (%) were studied in different distances from teak tree belt.

Photosynthetically active radiation (µmol m^{-2} s^{-1}) and canopy temperature (°C) 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 3. The photosynthetic active radiation (PAR) of 43.40 µmol m^{-2} s^{-1} (50% flowering), 45.81 µmol m^{-2} s^{-1} (50% boll bursting) and 50.16 µmol m^{-2} s^{-1} (Harvesting) while afternoon reading shown mean temperature of 36.36 µmol m^{-2} s^{-1} (50% flowering), 38.00 µmol m^{-2} s^{-1} (50% boll bursting) and 38.29 µmol m^{-2} s^{-1} (Harvesting) were recorded. Whereas, the canopy temperature (°C) was recorded on three different stages of cotton revealed that the mean morning canopy temperature of 32.97 °C (50% flowering), 31.35 °C (50% boll bursting) and 23.14 °C (Harvesting) while afternoon reading shown mean temperature of 35.60 °C (50% flowering), 33.26 °C (50% boll bursting) and 32.10 °C (Harvesting) were recorded. 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. The relative humidity (%) was recorded on three different stages of cotton revealed that the mean morning relative humidity of 52.40% (50% flowering), 46.16% (50% boll bursting) and 38.93% (Harvesting) while afternoon reading shown mean temperature of 30.03% (50% flowering), 34.00% (50% boll bursting) and 18.61% (Harvesting).

Influence of teak tree belt on biochemical Parameters

The Carbon dioxide concentrations and chlorophyll content are also important in regulating factors in plant physiology and biochemistry. The CO_2 controls the openness of stomata, which is essential for plants to operate exchange gasses, with the environment. While, the Chlorophyll pigment is vital for the survival of plants, as it is used in the process of photosynthesis. In present investigation, carbon dioxide concentration (ppm) and chlorophyll content (mg/g) was analyzed at three different stages *viz*., 50% flowering, 50% boll bursting and harvesting.

The CO_2 (ppm) concentration in microclimate of any plant will significantly affects the physiological and metabolic processes of plants which are essential for growth and development of that plant. In present investigation, The data on recorded of CO_2 (ppm) of cotton varieties 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 4. The overall CO_2 (ppm) concentration was ranged in between 327.80 ppm to 354.86 ppm at both timings. Whereas, the decline trend was observed in chlorophyll content (mg/g) was observed in growing age of plant, as the mean chlorophyll content was recorded 59.90mg/g (50% flowering), 53.10 mg/g (50% boll bursting) and 47.10 mg/g (harvesting).

Growth characteristics of teak trees

The nine teak trees were studied for growth characteristics which constituted the tree belt at one of the side of cotton plot. The characters *viz*., height (m), diameter at breast height (DBH) and canopy spread was calculated (Table 5 and Fig.1). The average tree height of 12.01 meters were recorded with average diameter breast height (DBH) of 22.01 cm responsible to built the average crown spread of 8.06 m^2.

Table 1: Average performance of growth parameters of cotton varieties under influence of teak belt at various distances

Treatments	Growth Parameters											
	Germination percentage (%)	Plant Height (cm)			Days to 1st flowering	Days to 50% Flowering	Days to 50% Boll Bursting	No. of Monopodia per plant	No. of Sympodia per plant	Leaf Area Index (LAI)		
		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 to 97.8	40.7 to 73.1	45.4 to 84.7	52.2 to 96.5	45.3 to 52.0	54.6 to 63.0	125.5 to 133.6	1.1 to 2.1	5.5 to 17.1	0.5 to 0.7	1.2 to 1.4	0.8 to 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

Table 2: Average performance of yield character of cotton varieties under influence of teak belt at various distances

Treatments	Yield Characters						
	No. of bolls per plant	Boll Weight (g)	Seed cotton yield per plant (g)	Seed Index (g)	Lint Index	Ginning Outturn (%)	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 to 18.4	2.3 to 3.6	7.5 to 15.0	6.7 to 8.5	3.5 to 4.4	32.1 to 35.3	13.2 to 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

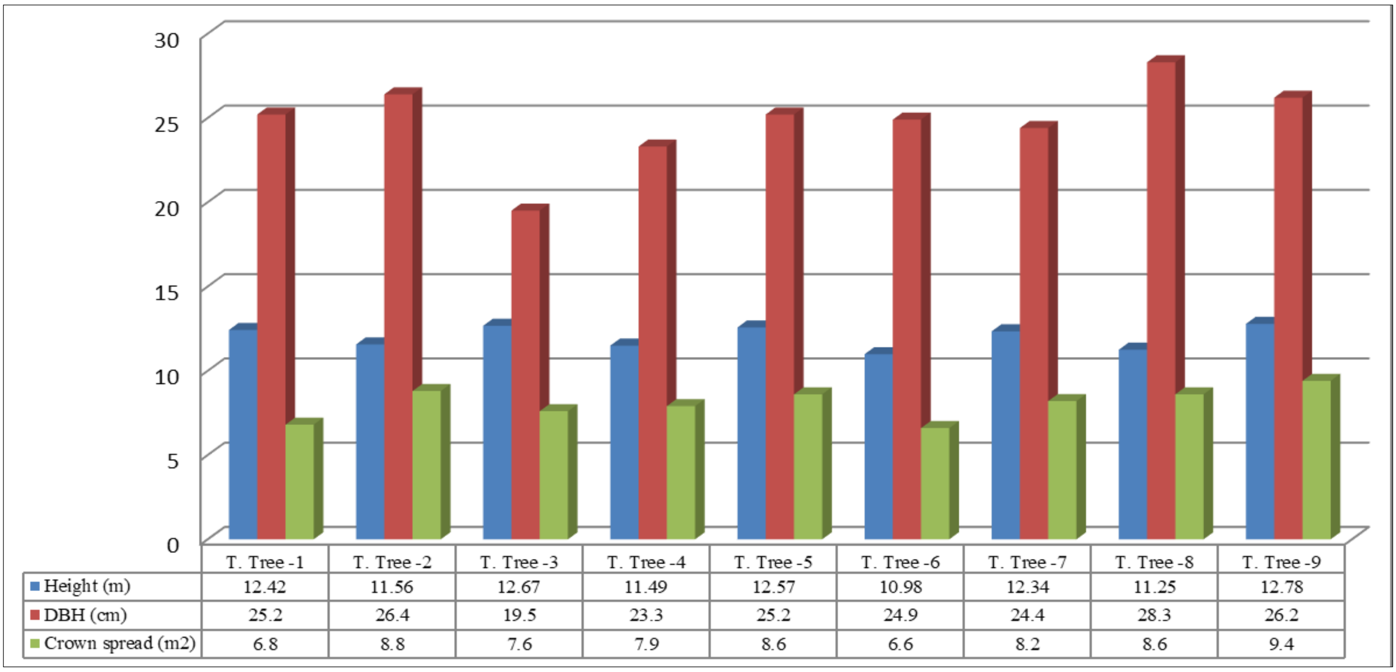

Fig 1: Growth characterstics of Teak Trees constituting Tree Belt

Table 3: Average performance of microclimatic parameters of cotton varieties under influence of teak belt at various distances

Treatments	Microclimatic Parameters																	
	Photosynthetically Active Radiation (PAR) μmol m^{-2} s^{-1})						Canopy Temperature (°C)						Relative Humidity (%)					
	50% Flowering		50% boll bursting		Harvesting		50% Flowering		50% boll bursting		Harvesting		50% Flowering		50% boll bursting		Harvesting	
Time	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft	Morn	Aft
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 to 52.9	27.9 to 44.1	39.5 to 50.7	32.9 to 41.7	44.6 to 53.5	34.0 to 42.3	31.4 to 34.8	34.6 to 36.5	30.0 to 33.7	32.6 to 34.6	20.9 to 29.2	30.5 to 35.4	44.4 to 56.6	25.0 to 32.6	37.4 to 50.4	28.3 to 36.8	23.9 to 44.8	10.0 to 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.	NA	NA	NA	NA	NA	NA	2.92	2.64	3.47	2.78	1.70	2.38	6.14	6.69	3.99	3.59	2.76	5.22

Table 4: Average performance of biochemical parameters of cotton varieties under influence of teak belt at various distances

Treatments	Biochemical parameters								
	CO_2 (ppm)						Chlorophyll Content (mg/g)		
	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 to 338.0	327.8 to 343.7	349.2 to 351.9	343.2 to 347.1	344.0 to 351.3	349.5 to 354.8	55.2 to 62.7	46.9 to 58.9	38.1 to 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

Table 5: Growth characteristics of Teak trees constituting tree belt

Teak Tree	Height (m)	Diameter at breast height (cm)	Crown spread (m^2/tree)
T. Tree -1	12.42	25.2	6.8
T. Tree -2	11.56	26.4	8.8
T. Tree -3	12.67	19.5	7.6
T. Tree -4	11.49	23.3	7.9
T. Tree -5	12.57	25.2	8.6
T. Tree -6	10.98	24.9	6.6
T. Tree -7	12.34	24.4	8.2
T. Tree -8	11.25	28.3	8.6
T. Tree -9	12.78	26.2	9.4
Mean	12.01	22.06	8.06

Discussion

The 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 [6]. 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 [12].

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 [21, 22, 23, 24]. 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, the relative humidity was maximum in shade of tree as compared to open field [26, 27]. The canopy temperature (°C) was affect the growth and yield of cotton crop. The canopy temperature was the 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 as the canopy temperature was maximum in open field as compared to shaded field [25, 26, 27]. 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 [28].

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 the 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 (μmolm^{-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, may be due to the allelopathic effect of teak trees. The reduction in yield was also attributed to depletion of available nutrients and moisture. Further long term experiments should be plan to analyze the long term interaction effect of trees with crop.

Conclusion

It is concluded that 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 for establishing better agroforestry system in region based on timber species like teak.

Acknowledgements

Authors are thankful to the Senior Research Scientist, Cotton Research Unit and Head, Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola 444 104 (MS) for their kind cooperation and providing technical support during the present investigation.

References

1. Anonymous, All India Coordinated Research Project on Dryland Agriculture. Annual Report, Kovilapatti centre. c1984. p. 24.
2. Nadagoudar BS, Agroforestry Research Manual. Oxford Forestry Institute, Oxford University, Oxford; c1986. p. 28.
3. Lundgren B, Global deforestation, its causes and suggested remedies. Agroforestry Systems. 1985;3(2):91-95.
4. Khosla PK, DK Khurana, Agroforestry for Rural Need. Indian Society of Tree Scientists, Solan. 1987;1(15):7-8.
5. Ujjainkar Vaibhav, Similarity Coefficient Analysis using UPGMA based on Polymorphism of Isozyme and DNA Markers in Cotton, International Journal for Research in Applied Science, Engineering Technology. 2022;10(7):961-977.
6. Vanashri Hulke, Shailesh Harne, Vaibhav Ujjainkar, Vijay Mane and Yayati Taide., Influence of Microclimatic Parameters on Growth and Yield of Cotton in Teak based agroforestry system, Multilogic in Science. 2019;(7):20-23.
7. Anonymous. Annual Report, International Centre for Research on Agroforestry, Nairobi, Kenya, c1976. p. 22-25.
8. Burley J. Global needs and problems of collection, storage and distribution of multipurpose tree germplasm: A background documents. In: I Burley and P. Van Carlowity (Eds.) Multipurpose Tree Germplasm. ICRAF, Nairobi, Kenya; c1983. p. 298.
9. Kumar M. Tree-Crop Interaction studies in agroforestry system productivity, moisture and nutrient dynamics. Ph. D. (AF) Thesis, University of Horticulture and Forestry, Navni, Solan; c1999.
10. Corlett JECK, Ong CR, Black. Microclimatic modification in intercropping and alley- cropping system. In: Meteorology and Agroforestry (Reifsynder WS, Damhofer TO. Eds). ICRAF Nairobi, Kenya; c1989. p. 419-430.
11. Singh RP, CK, Ong N, Saharan. Above and below ground interactions in alley cropping in semiarid India. Agrofor. Syst. 1989;(90):259-274.
12. Singh NR, Jhariya MK, Raj A. Tree Crop Interaction in Agroforestry System. Readers Shelf. 2013;10(3):15-16.
13. Dunlap AA, Fruiting, shedding of cotton in relation to light and other limiting factors. Bulletin No. 677, Texas Agricultural experimental station, College station, Texas, USA; c1945.
14. Bashir MM. Performance of Black gram and mungbean varieties under different light levels. An unpublished MS Thesis BSMRAU. Gazipur. Bangladesh; c2002.
15. Reza TMB. Growth and yield of nungbean varieties as influenced by different light levels. An unpublish MS thesis, BSMRAU. Gazipur. Bangladesh; c2005.
16. Annonymous, Research Review 2014-15 and Programme Planning 2015-16 on Agroforestry Research Activities in Bangladesh, Forest Unit, NRM Division, Bangladesh Agricultural Research council, Farmgate, Dhaka-1215 Eds. M. Shahjahan, Sultan Ahmmed and KNEA Jewel; c2015.
17. Nilesha Jibhkate, Dipika Ayate, Ujjainkar VV. Correlation studies in teak for stem volume production International J Farm Sciences. 2016;6(4):203-206.
18. Datke SB, JS Minimol, Ujjainkar VV. Response of groundnut gentoypes to time of sowing in different seasons, Annals of plant physiology. 2003;17(2):173-176.
19. Nilesha Jibhkate, Dipika Ayate, Ujjainkar VV. Genetic variability studies in Teak (*Tectona grandis* L.), International J Farm Sciences, 2018;(1):107-109.
20. Ujjainkar VV, atke SBD, Mahurkar DG, Rathod TH, Dispersion study for annual volume production in teak (*Tectona grandis* L.) growing in natural and managed habitats, Annals of plant physiology, 2001;15(1):80-84.
21. Mutanal SM, Prabhakar AS, Nadagoudar BS. Compatibility of sorghum (*Sorghum bicolour*) in teak (*Tectona grandis*) based agroforestry system. Indian. J Agric. Sci. 2001;71(3):197-200.
22. Reddy SBP, Munirathnam, Madhusudhan S Reddy. Effect of eucalyptus trees on growth and yield of cotton. Indian J Agric. Res. 2006;40(3):190-194.
23. Kumar R, Performance of intercrops on growth and yield of American cotton under dryland condition. M. Sc. (Agronomy) Thesis, University of Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola; c2015.
24. Nandal DP, Rana P, Kumar A. Growth and yield of wheat under different tree spacing of Dalbergia sissoo based agriculture. Indian Journal of Agronomy. 1999;44:256-260.
25. Steffan-Dewenter I, Kessler M, Barkmann J, Bos M, Buchori D, Erasmi S, *et al*. Tradeoffs between income, biodiversity and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. PNAS. 2007;104:4973-4978.
26. Mukherjee A, Banerjee S, Nanda MK, Sarkar S. Microclimate study under agroforestry system and its impact on performance of tea. Journal of Agrometeorology. 2008;10(1):99-105.
27. Verma SK. Rana BS. Effect of light intensity on paddy and wheat grain yield under Eucalyptus tereticornis Sm. Based agri-silvicultural systems. The Indian Forester, c2014. p. 140.
28. Venkatarao M. Physiological investigations on groundnut (*Arachis hypogeal* L.) in a teak based agroforestry

system. M.Sc. (Agri) Thesis, University of Agricultural Sciences Dharwad; c2005.
29. Rani Sharma and Vaibhav Ujjainkar. A review on Tree improvement through candidate plus tree selection (CPTs) in Indian Butter tree (Madhuca spp), International J science and Research, 2022;11(7):842-845. (http://dx.doi.org/10.21275/SR22712230645)
30. Hosur GC, Dasog GS. Effect of tree species on soil properties. J Indian Soc. Soil Sci. University of Agricultural Sciences Dharwad. 2005;43(2):256-259.
31. Dipika Ayate and Ujjainkar VV. Assessment of genetic variability in elite clones of teak J of Agroecology and Natural Resource management. 2017;4(1):75.