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Priyanka Kashyap
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Piyusha Yadav
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Dayanand Sai Painkra
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Manish Kumar Mankur
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Jaimangal Tirkey
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Jhanendra Kumar Patel
Research Scholar, Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Priyanka Kashyap
Department of Forestry, Indira Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Effect of *Acacia nilotica* (Babul) bund based agroforestry system on the yield of paddy crop

Priyanka Kashyap, Piyusha Yadav, Dayanand Sai Painkra, Manish Kumar Mankur, Jaimangal Tirkey and Jhanendra Kumar Patel

Abstract

The present research examined the effect of the Acacia nilotica (Babul) bund agroforestry system on rice crop. The study was conducted at farmer's field village Khudmda of Durg district (C.G.). The Acacia nilotica are grown naturally on field bund in north-south direction of the tree row. The experiment was carried out in a Randomized Block Design (RBD) with one control. Trees dimension i.e. (diameter at breast height) and crown width range from 22.61-26.27 cm and 7.62-8.90 m, respectively. Data on the growth and yield of rice were recorded at various distances (1, 3, 5, 7, and 9 m and control > 9 m). The results showed that the bund agorforestry of Acacia nilotica had adverse affect on growth and yield of rice which differs with the different dbh and crown width of the tree row and distance from the tree line. Due to increasing crown width and closeness from the tree, the growth of rice i.e. no of hills quadrat-1 and number of tillers quadrat-1 of rice were drastically reduced. The maximum number of hills (9.33) and tillers (159.33) were recorded at the distance of 9 m from tree 3 and the minimum number of hills and tillers were found at the distance, i.e. 1-3 m from the tree line. Whereas the minimum reduction in yield attributes like grain weight with inflorescence/quadrate (g), and number of grains of rice, (300.29), and (26630.80), respectively were observed at a distance of 9 m from tree 3, and the maximum decreased was observed at a distance of 1 m from tree 1, (10.07), and (1617.40), respectively in comparison with all other distances. However the biological yield, and grain yield of rice recorded at a distance of 9 m from tree 3, (74.27 q / ha), and (29.39 q / ha), respectively and was substantially higher relative to 7 m from tree and from the control plot. The highest (47.78 percent) harvest index percent was found on the control plot, followed by tree 3 (39.49 percent) at 9 m distance from tree line. Thus it can be concluded that minimum crown width and increasing distance from the tree line of Acacia nilotica had less effect on the growth and yield of rice as compared to the trees with maximum crown width and closeness with tree or tree line.

Keywords: *Acacia nilotica,* agroforestry, crop yield, bund plantation, harvest index, plant DBH, Crown width, paddy crop

Introduction

Agroforestry is the deliberate integration of trees with agricultural crops and/or livestock either simultaneously or sequentially on the same unit of land (Nair, 1993). Agroforestry is the sensible integration of woody perennials with crops and/or animals on the same unit of land for meeting the multiple demand of the community like food, fodder, fire wood, timber and other ancillary benefits. It facilitates the nutrient recycling, improves the soil fertility, arrests soil erosion and land degradation, conserves soil and water, improves village environment, conserves biodiversity and serves as a major carbon sink.

Rice (*Oryza sativa* L.) is the main crop of Chhattisgarh state and is grown at approximately 3.7mha area, which accounts for approximately 81 percent of agricultural land during the rice season. This crop is mainly grown under rain-fed conditions (about 85 percent) and about 8-10 percent of the rice area is grown under large bunds. Generally, new bunds having 1.5 m width and height around the paddy fields for one or two years used for developing upland crops for one or two years (Bargalli *et al.,* 2009) [1]. Those bunds are subsequently left fallow and occupied by naturally growing tree species. In the plains of Chhattisgarh, the naturally growing trees on bunds and boundaries form an important traditional agroforestry system, dominated by *Acacia nilotica, Butea monosperma, Tectona grandis, Terminalia tomentosa* and *Albizia procera.*

Acacia nilotica L. Willd. Ex Del commonly called babul, kikar or Indian gum Arabic tree, it has been identified internationally as a multipurpose tree. The subalata subspecies of *Acacia nilotica* is a source of fodder, wood, gum and fuel and has pharmacological effects as well

(Bargali & Bargali, 2009) [1]. *Acacia nilotica* is a common tree observed on farmlands in addition to their presence on wastelands and roadsides in relative to India. They are maintained as scattered timber in crop fields in addition to on crop subject bunds (raised risers) in rotations of ten to twelve years. The basic contribution of bushes to neighbourhood farming device is complex and subtle, which include non-tangible benefits such as development in microclimate, inputs through leaching and nutrient cycling. It is well known to raise soil organic matter, enhancing soil fertility build-up and restoring soil physical situations. Improvement in water-holding capacity and soil structure along side with several fold boom of nitrogen and organic carbon content within the soil beneath trees than fallow has already been pronounced and gives timber, fuel, shade, food, fodder, etc. (Ingram *et al.*, 1990) [7].

In bund plantation, except for those liking shade or sensitive shade conditions, tree shade is assumed to be responsible for low yields of associated crops. It affects the increase in plant height, decreases the number of tiller and panicle/hill and panicle/grains, and decreases grain yield. Shade stimulates cellular expansion and rapid division of cell leading to an increased leaf length and height of plant (Schoch, 1972) [15]. Shading treatment has shown the tallest plants, while smallest plants are found in shade-free areas. There is a need for careful selection of species and effective management of trees and crops to maximize development and tremendous effects within the system and to reduce negative competitive effects. Hence, the present investigation was carried out to study the effect of, *Acacia nilotica* bund agroforestry System on associated paddy crop (Swarna MTU-7029).

Study area

The study area was carried out in the experimental field of village Khudmda of Durg district (C.G.), during the year 2019-20 in kharif season (July- November). The climate is tropical and is influenced by monsoon conditions. The year is divisible into three seasons *viz.* rainy (mid June-September), winter (November-February) and summer (April-mid June). October and March comprise transition periods, respectively between rainy and winter, and between winter and summer seasons. The mean monthly temperature varies between 19.4 °C (December) to 33.7 °C (May), and the annual temperature averages 27 °C. The mean annual rainfall is 1264.9 mm, 95% of which occurs during the rainy season. About 8 months of the year are dry. Soils of this order are tropical black with tremendous swell-shrink behaviour, deep (> 50 cm) with high base saturation and dominated by smectite kind of clay minerals. These soils swell on wetting and shrink on drying, which induces development of wide, deep cracks and mostly angular blocky structure.

Materials and Methods

Paddy fields along with *Acacia nilotica* trees on field bunds were selected in village Khudmda of Durg district (C.G.). Phytosociological parameters such as dbh, crown width and girth in Table 1. The distance between the trees was measured for three trees (T1, T2 and T3). The distance from tree to tree ranged between 1.25 to 1.50 m. Tree DBH and crown width ranged respectively, between 22.61 and 28.66.cm, 7.62 m and 9.62 m. The effect of babul trees on growth and yield of paddy was estimated by studying crop parameters like numbers of hills/quadrate, numbers of tillers/hills weight of sample, biological yield (q/ha), Harvest index (%) and grain yield (q/ha). the sample plots of 0.25 m^2 were laid out by using quadrate in a running three perpendicular lines as three replicates were taken for each tree and divided into 5 distance classes (treatments) D1 (1.0 m), D2 (3 m), D3 (5 m), D4 (7 m) and D5 (9 m) and centre of the field from the tree base at 30 degree angle from each other. Control or open area with the assumption that there will be no effect of the tree on growth and yield of the crop because that is away from the canopy spread. In each quadrate, the number of hills was counted along with the number of tillers. The mean tiller value was multiplied with the number of hills to find out the total number of tillers in the quadrate. At harvesting 5 tillers were removed and kept in labelled polythene bags and brought to the laboratory to at harvesting stages of crop from each quadrate estimate the biomass and yield. Tiller density and shoot biomass were measured when the crop was at its peak growth. The sample for grain yield was taken when crop was mature for harvesting. The correlation coefficient test and regression techniques were used to develop the relationship between crop parameters and tree line distance from the crop.

Results and Discussion

Table 1: Characteristics of babul tree

Tree	Girth (cm)	DBH (cm)	Crown Width (m)
T1	90	28.66	9.72
T2	82	26.11	8.95
T3	71	22.61	7.62

T1, T2 and T3 respectively represented Tree one, Tree two and tree three

Growth of rice

Table 2 reveals that due to increasing to increasing crown width closeness from the tree, the no of hills quadrat^{-1} of rice was found drastically reduced. The maximum number of hills at different distances from the line of the tree was reported at a distance of 9 m (9.33) from tree 3 and the minimum number of hills found at the nearest distance, *i.e.* 1-3 m from the tree line. The number of hills of rice was influenced by various aspects at various distances from the tree line recorded by Bargali *et al.* in 2009 [2].

Table 2: Average Numbers of hills under *Acacia nioltica* bund agroforestry system hills/quadrat

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	5.00±0.00	5.33±0.33	6.33±0.33
3	6.00±0.58	6.33±0.58	7.00±0.58
5	6.33±0.33	6.33±0.33	7.33±0.33
7	7.00±0.58	7.00±0.33	8.67±0.33
9	7.67±0.33	8.00±0.33	9.33±0.33
Control >9	8.67±0.88	8.67±0.88	8.67±0.88
S.Em±	0.53	0.47	0.49
CD (p=0.01)	0.0087	0.0052	0.0099
Significance	S	S	S

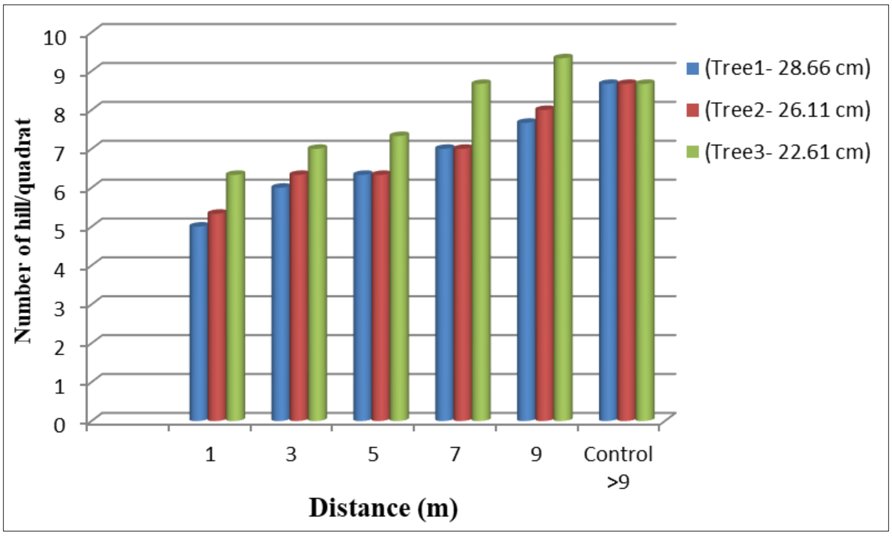

Fig 1: Number of hills/quadrat

Table 3 indicates that the maximum number of rice tillers was found (159.33) at a distance of 9 m from the base of the tree 3 is due to the highest percentage of interception of solar radiation by rice crops (Kiran and Agnihotri, 2001) [8] and the minimum tiller was found to be lower (22.67) at a distance of 1 m from tree 1. The tillers were substantially reduced from the tree line to a distance of up to 9 m.

Table 3: Mean numbers of tillers per quadrat under *Acacia nilotica* bund agroforestry system

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	22.67±1.20	28.33±0.33	35.33±4.91
3	42.00±4.62	49.67±0.33	70.33±5.04
5	59.67±4.06	61.33±6.67	85.00±4.16
7	82.67±10.53	95.67±2.40	134.33±6.49
9	114.33±7.54	120.67±9.28	159.33±6.77
Control >9	123.33±13.20	123.33±13.20	123.33±13.20
S.Em±	7.52	7.77	7.35
CD (p=0.01)	0.0000	0.0000	0.0000
Significance	S	S	S

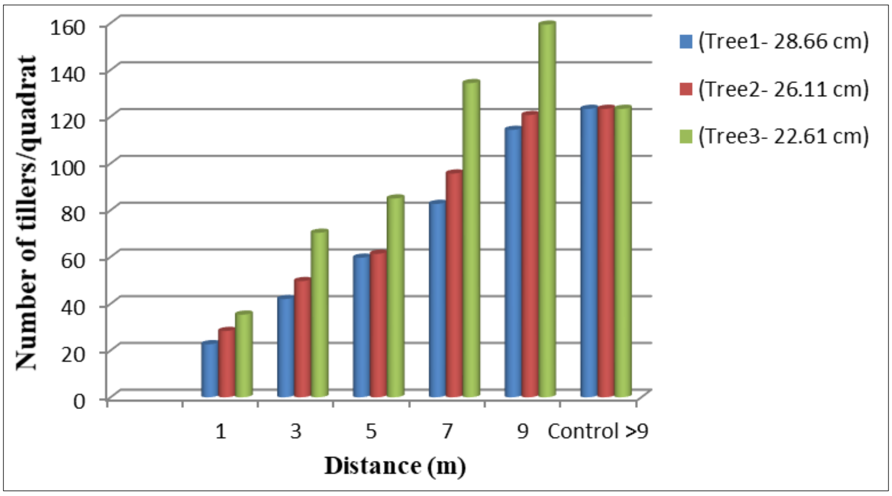

Fig 2: Number of tillers/quadrat

Yield attributes

The minimum reduction in grain weight with inflorescence/quadrate (300.29) was observed at a distance of 9 m from tree 3 and the maximum decreased (10.07) was observed at a distance of 1 m from tree 1, in comparison with all other distances (Table-4). The maximum reduction was observed at the different distances from the line of the tree at a distance of 1-5 m from the tree line, which decreased successively with the rise in distance from the tree line, which indicates that inflorescence/quadrate grain weight (g) was substantially increased due to increased distances from the tree line when the temperature is less favorable and leaves are less turgid, near the tree line receiving low light, restricting the photosynthetic effectiveness of the crop on this aspect. These results are in conformity with the studies of Moss *et al.*, (1961) [10] and Dhillon *et al.*, (1979, 1982, and 1984) [3, 4, 5].

Table 4: Average weight of grain under *Acacia nilotica* bund agroforestry system

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	10.07±0.93	18.31±1.30	19.43±2.91
3	27.65±4.04	40.09±4.47	61.65±6.86
5	53.17±7.57	56.77±12.88	85.11±1.99
7	92.95±22.86	113.00±17.67	186.23±22.21
9	142.36±31.33	172.34±14.66	300.29±21.73
Control >9	242.92±41.43	242.92±41.43	242.92±41.43
S.Em±	24.70	19.64	21.52
CD (p=0.01)	0.0005	0.0001	0.0000
Significance	S	S	S

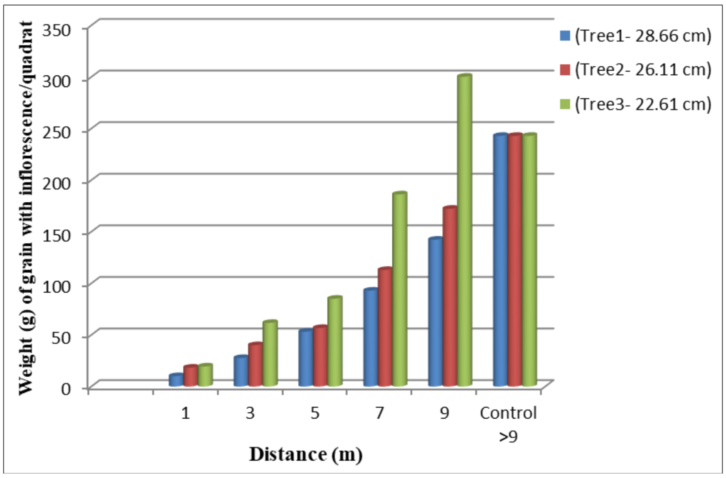

Fig 3: Weight (g) of grain with inflorescence/quadrat

At various aspects and distances from the tree line, the grain numbers per quadrat are given in Table 5 which shows that The minimum reduction in the number of grains was observed at a distance of 9 m from tree 3 (26630.80) and the control plot (18754.87) and the maximum reduction (1617.40) relative to all other aspects was observed at a distance of 1 m from tree 1. Grain numbers were found to increase progressively with decreasing crown width and increasing distance from the line of the tree by 2258.07 at 1 m, 8626.00 at 3 m, 9978.60 at 5 m, 17350.53 at 7 m, and 26630.80 at 9 m from tree 3. This information was similar to reduced number of grains (Rawson and Ruwali, 1972; Fischer 1975) [14, 6].

Table 5: Numbers of grains/quadrate under *Acacia nilotica* bund agroforestry system

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	1617.40±274.41	1750.33±348.55	2258.07±546.52
3	3915.20±992.45	4848.00±185.30	8626.00±880.54
5	6495.80±385.85	7495.73±915.88	9978.60±430.27
7	11024.73±2953.90	13101.80±1334.22	17350.53±2131.61
9	19036.40±2277.84	19547.27±1469.94	26630.80±2312.82
Control >9	18754.87±3034.91	18754.87±3034.91	18754.87±3034.91
S.Em±	1980.87	1600.06	1862.91
CD (p=0.01)	0.0003	0.0000	0.0000
Significance	S	S	S

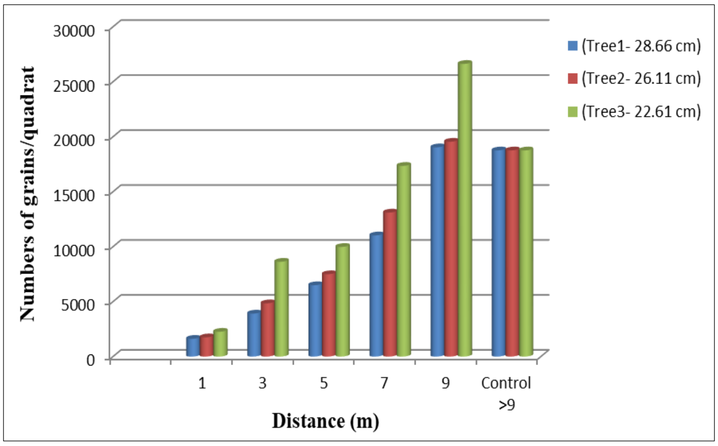

Fig 4: Numbers of grains/quadrat

Yield of rice

The effect of crown width and distance from the line of the tree showed the significant decrease on the biological yield of rice q / ha. Data indicate that the biological yield of rice recorded at a distance of 9 m from tree 3 (74.27 q / ha) was substantially higher relative to all other aspects, followed by 7 m from tree 3 (59.51 q / ha) and from the control plot (46.78 q / ha). At 1-5 near the tree line, the highest reduction was observed. The decrease was therefore in order; tree1, tree2, and tree3 at all distances from the line of the tree (Table-6). The instantaneous change in light intensity has a profound impact on the crop's photosynthetic response (Knapp and Smith, 1990) [9].

Table 6: Effect of under *Acacia nilotica* bund agroforestry system on biological yield (q/ha)

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	3.80±0.40	5.78±0.33	7.45±1.15
3	8.03±1.71	14.63±0.97	21.42±3.54
5	17.08±3.37	22.41±2.67	32.44±1.95
7	25.37±7.29	35.00±1.15	59.51±3.35
9	41.43±5.07	47.34±3.43	74.27±2.29
Control >9	46.78±7.68	46.78±7.68	46.78±7.68
S.Em±	5.02	3.74	3.78
CD (p=0.01)	0.0005	0.0001	0.000
Significance	S	S	S

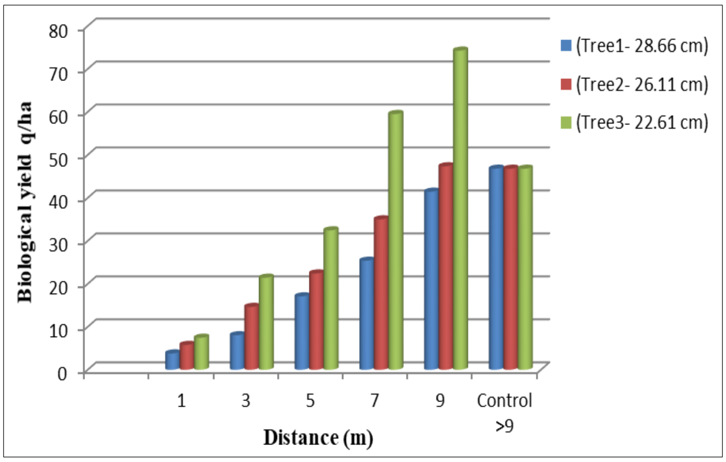

Fig 5: Biological yield q/ha

At a distance of 9 m from tree 3 (11.92 q / ha) and control plot (22.34 q / ha), the grain yield (q / ha) of rice was significantly higher. On tree 1 (0.87), followed by tree 3 (1.21) and tree 2 (1.70), the maximum reduction in grain yield was found (Table-7). At all distances from the line of the tree, the reduction in grain yield was observed to be maximum (0.87) at 1 m from tree 1 and lowest (29.39) at the farthest distance, *i.e.* 9 m from tree 3. Among the different aspects, the grain yield decreased significantly up to a distance of 9, 7, 5, 3 and 1 m from the tree line on tree 1, tree 2, and tree 3 respectively. Sharma *et al.*, (1994) [16] stated that the reduction in the yield of rice grown in association with trees reflects competition for growth resources such as radiant energy, nutrients, and moisture.

Table 7: Effect of Acacia *nilotica* bund agroforestry system on grain yield q/ha

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	0.87±0.05	1.70±0.13	1.21±0.28
3	2.49±0.38	3.78±0.42	5.88±0.67
5	4.91±0.75	5.39±1.28	8.11±0.26
7	8.96±2.24	10.92±1.76	18.09±2.21
9	13.70±3.07	16.66±1.34	29.39±2.15
Control >9	22.34±3.62	22.34±3.62	22.34±3.62
S.Em±	0.0004	0.0001	0.0000
CD (p=0.01)	2.25	1.78	1.96
Significance	S	S	S

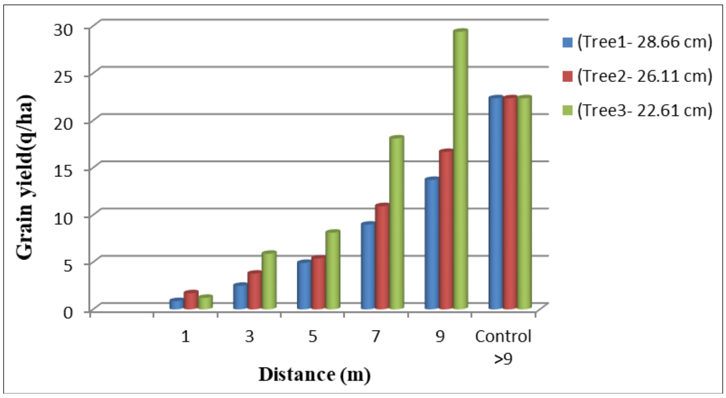

Fig 6: Grain yield q/ha

Harvest index (%)

The highest (47.78 percent) harvest index percent was found on the control plot, followed by tree 3 (39.49 percent), tree 2 (35.17 percent) and tree 1 (32.31 percent) at a distance of 9 m from the tree line and the lowest at a 1 m distance from the tree line at tree 3 (15.86), followed by tree 1 (23.66) and tree 2 (29.43) (Table-8). Due to higher dbh and crown width of the babul tree and decreasing distance from the tree line, the adverse effect of the tree line on harvest index percent was observed (Fig.7). The observations of Sharma *et al.*, (1994.) [16] support the present result.

Table 8: Effect of *Acacia nilotica* bund agroforestry system on harvest index

Distance from the tree line (m)	(Tree1- 28.66 cm)	(Tree2- 26.11 cm)	(Tree3- 22.61 cm)
1	23.66±3.72	29.43±2.05	15.86±1.68
3	32.17±3.39	25.85±2.01	28.02±2.29
5	29.63±3.09	23.93±4.53	25.24±2.02
7	35.96±2.58	31.08±4.48	30.38±3.18
9	32.31±3.58	35.17±1.00	39.49±1.96
Control >9	47.78±0.28	47.78±0.28	47.78±0.28
S.Em±	3.11	2.83	2.17
CD (p=0.01)	0.0054	0.0016	0.0000
Significance	S	S	S

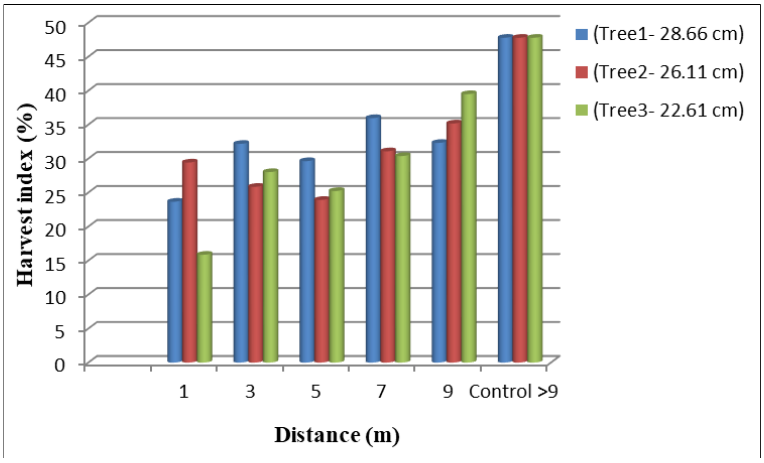

Fig 7: Harvest index (%)

Plate 1: A View of Experiment field (Paddy crop and *Acacia nilotica* in bund agroforestry)

Plate 2: Study site during measurement

Conclusion

The results revealed that the bund based agroforestry of Babul (*Acacia nilotica*) had an adverse affect on growth and yield of rice. Thus it can be concluded that minimum crown width and increasing distance from the tree line of *Acacia nilotica* has a lesser effect on the growth and yield of rice as compared to the trees growing in a near the tree line. As a guide for extrapolating complex planting arrangements using the same tree and crop, the data generated at the interface can be used.

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