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Performance of sunflower at different pruning regimes in *Acacia albida* based agroforestry system

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ABSTRACT

A study was conducted in albida (*Acacia albida*) based agroforestry research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) from November/2020-March/2021 to evaluate the performance of sunflower at different light intensity created by pruning off the albida canopy at different levels. The experiment was set up in a single-factor Randomized Complete Block Design with three replications. Five different treatments of the experiment were as follows; T_1: albida tree (no pruning) T_2: albida tree (25% pruning), T_3: albida (50% pruning), T_4: albida (75% pruning) and T_5: sunflower sole cropping in open field. The results revealed that T_1 treatment produced the tallest plant (100.72cm) followed by T_2 (97.48cm) while the treatment T_5 produced the shortest (72.95cm) plant. The fresh weight (81.67g) and dried weight (13.95g) of sunflower leaves were found maximum in T_4 and the minimum fresh weight (53.48g) and dry weight (8.34g) were recorded in T_1 treatment. The highest CGR (1.169mg/cm^2/day) and RGR 66.58 (mg/g/day) values were found in T_5 and was not significant with T_4. The yield parameters of sunflower such as head diameter (15cm) and 1000 seeds weight (43.34g) were found maximum in T_5 (open field) which was statistically similar to that of T_4 treatment. The T_5 yielded the highest (1.13t/ha) sunflower seeds followed by T_4 (1.09t/ha). The study indicated that sunflower can be grown successfully under the albida tree canopy with 75% trimming.

Introduction

Bangladesh is a densely populated country having 169.83 million people in 147570 sq km area (BBS, 2022). The present annual oilseed production is about 1154 thousand tons, but the demand is higher than the production. To meet the growing demands of its population, the nation must therefore spend a staggering amount of foreign currency on the import of edible oils and oilseeds. According to

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BBS's (2016) estimation in 2014–2015, imported edible oils and oilseeds were worth 1574 million USD and 354 million USD, respectively. Among different oilseed crops mustard, groundnut, sesame, soybean, linseed, etc. are common in Bangladesh. But sunflower (*Helianthus annuus*) is less well-known in Bangladesh while, it is a very well-known oilseed crop throughout the world because of its abundant nutrients and tolerance to various climatic and soil conditions (Forleo *et al.,* 2018; Malik and Saini, 2018). Sunflower seeds are full of nutrients and contain unique phytochemicals that are good for enhancing human health, including antioxidants, flavanols, phenolic acids, procyanidins, phytosterols, essential amino acids, dietary fiber, potassium, arginine, and monounsaturated and polyunsaturated fatty acids (Islam *et al.,* 2016; Karangwa *et al.,* 2015). Due to the presence of vitamin E, zinc, and selenium sunflower seeds act as immunity boosters (Sarwar *et al.,* 2013; Shahbaz *et al.,* 2018). It is also a powerful antioxidant and prevents free radicals from injuring healthy cells in our bodies (Nasreen *et al.,* 2011). Human disorders such as diabetes, cancer, hypertension, hypercholesterolemia, and coronary heart disease can be prevented and controlled using sunflower oil (Katsarou *et al.,* 2015).

Among the oilseed growing area in Bangladesh, 67% area is under mustard cultivation followed by ground nut (11.55%), sesame (10.88%), soybean (9.82%), linseed (0.46%) and sunflower (0.29%). However, per hectare production is highest in sunflower seed i.e., 1.75 ton followed by ground nut (1.59 tons), soybean (1.31 tons), mustard 1.28 ton), sesame (1 ton) and linseed (0.947 ton) (BBS, 2018). So, there is a scope to increase the sunflower cultivation for health benefits. But most of the oilseed growing areas are occupied by other oilseeds. On the other hand, the rest of the cultivable land of the country is engaged for producing food crops for feeding the over-increasing population of the country. So, we have to find out new alternatives for growing sunflower. In this scenario, sunflowers can be cultivated under different tree orchards as agroforestry practice. In the agroforestry system, suitable tree species selection is very important for the lower-storied crop. In the tropical and sub-tropical regions Albida (*Acacia albida* syn. *Faidherbia albida,* Family: Leguminosae), is suitable as an upper-storied tree in agroforestry systems for its light crown and easily decomposable small leaves (Hellmann, *et al.* 2011). This tree is deciduous in nature and so it is thought to be best suited as an agroforestry species. The most significant limiting factors for sunflower is light which is controlled by pruning of albida tree at different levels. Thus, the study was undertaken to determine the yield performance of sunflower under Albida in different PAR levels created by various pruning regimes.

Materials and Methods

Study location, and experimental site

The experiment was carried out at the Agroforestry Research fields of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from November 2020 to March 2021. The experimental field is situated at 24° 9 N latitude and 90° 26 E longitude, 8.5 meters above sea level, in the agro-ecological zone of AEZ-28 (Madhupur Tract) (Ferdouse, 2020).

Climate and soil condition

The region has a subtropical climate and silty clay loam soil that is acidic. Pre-monsoon or hot season with little precipitation was seen from March to June, the monsoon season with substantial rainfall from July to September, and the winter dry season from October to February.

Description of the experimental site, design of the experiment and treatment

The *albida* field was established in 2008 maintaining a 4 m × 4 m distance at the research farm of BSMRAU. *Albida* trees were planted in a north-south direction. There are five rows and each row has five *albida* trees. The northernmost *albida* rows were not pruned at all, which served as control. The second, third, and fourth rows of *albida* tree canopies were pruned at 25, 50 and 75%, respectively. The experiment was set up in a Randomized Complete

Block Design (RCBD) with three replications. The study included the use of planting material from the dwarf species BARI Sunflower 3. Five treatments were maintained in this experiment, viz. T_1= No pruning, T_2= 25% pruning, T_3= 50% pruning, T_4= 75% pruning of a*lbida* trees and in T_5 sunflower was planted as sole crop in open field.

Intercultural operations

By the second week of November 2020, the land was thoroughly prepared through ploughing and laddering. The larger clods were broken into smaller pieces and the weeds and stubble were removed. The soil particles were pulverized and the land was leveled uniformly. The experimental field was fertilized with urea 180-200 kg, TSP 160-180 kg, MP 150-170 kg, gypsum 150-170 kg, zinc sulfate 8-10 kg, boric acid 10-12 kg, magnesium sulfate 80-100 kg and cowdung 8-10 tonnes per hectare. All the fertilizers were applied following the broadcasting method before seeding. But urea was applied twice *i.e.,* half as broadcast, and the remaining half was used as a side dressing immediately before flowering (45–50 days after sowing). On November 25, 2020, seeds were sown at a rate of 5–6 kg/ha. Seeds were firmly sown in rows and held in place by earth with the aid of a hand. The spacing followed was 70 cm × 60 cm. After the emergence of the seedlings, the first and second weeding were carried out 20–25 days and 45–50 days later, respectively. Throughout the growing season, three irrigations were given. The first irrigation was performed at 30 days after sowing (DAS), and two more were administered at intervals of 20 days.

Plant sampling and data collection

Five plants from each replication were randomly selected for data collection. Data on plant growth parameters and grain yield were recorded. Plant height, number of leaves, soil plant analysis development (SPAD) score, fresh and dried weight, head diameter, and 1000 seed weight were gathered. For fresh weight, leaf, stem, root, and head data were taken separately just after harvest and the specimens were kept in separate paper bags for sun drying followed by oven drying for the dry weight data. Crop Growth Rate (CGR) and Relative Growth Rate (RGR), were calculated. CGR and RGR were calculated by the following formulae:

$$CGR = \frac{W2 - W1}{T2 - T1} \times \frac{1}{Plant\ area}$$

Where, W_2 = Dry weight at T_2,

W_1 = Dry weight at T_1, T_2 = 90 DAS,

and T_1 = 60 DAS

$$RGR = \frac{l_n W_2 - l_n W_1}{T_2 - T_1}$$

On each treatment and replication, photosynthetically active radiation (PAR) or light was measured using a Sunflex ceptometer (LP-80 AccuPAR). It was carried out to gauge the albida tree's level of shade. Twice a month, measurements of light were taken three times a day (at 9.00 am, 12.00 pm, and 3.00 pm).

Data analysis

MS Excel and STATISTX 10 were used to handle, calculate, and analyze the data after it was collected. To compare the treatment means, the necessary tests were run. Least Significant Difference (LSD) was used to adjust the mean differences at the 5% level of significance.

Results and Discussion

Photosynthetically active radiation (PAR)

The most significant limiting element for any intercrops in an agroforestry system is the availability of light or PAR. However, the incident light level was gradually reduced by 88.53% in T_4, 65.91% in T_3, 55.37% in T_2, and 44.6% in the T_1 treatments, respectively (Fig. 1a) due to different pruning regimes. The month-wise average PAR% is shown inFig. 1b where it has been found that the maximum PAR (62.18%) was measured in the month of March and the minimum (54.38%) was in the month of

December. Similar results were noted in T_2, T_3, and T_4 treatments, respectively, i.e., the PAR levels were increased with the corresponding pruning regime. However, sunflowers received 100% PAR at every month in open field conditions. Ong et al. (1992) studied maize growth performance in the ICRAF's Leucaena leucocephala based agroforestry research field and reported that total maize yield under improved trees were only 50% of the sole maize yield, which increased to 80% due to pruning.

as the albida tree's canopy coverage increased. However, T1 (no pruning of albida tree) treatment had the lowest SPAD value (38.23 at 30 DAS, 41.08 at 60 DAS, and 39.10 at 90 DAS) (Table 1). Similar outcome was also found for wheat by Monostori et al., (2016) which was supportive to the findings of the present study

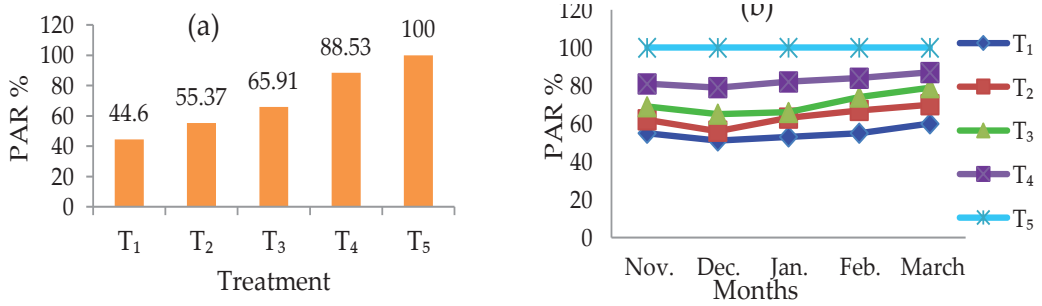

Fig. 1. (a) Availability of average PAR% and (b) monthly average PAR% to the intercrop at different pruning regime of *albida* during the study period.

Note: T_1 = *albida* tree (no pruning), T_2 = *albida* tree (25% pruning), T_3 = *albida* tree (50% pruning), T_4 = *albida* tree (75% pruning), T_5 = sunflower was planted in open field.

Table 1. SPAD value of sunflower at different pruning regime of *Albida* at different DAS

Treatments	SPAD value at different intervals			
	30 DAS	60 DAS	90 DAS	Mean
T1	38.23	41.08	39.10	39.47
T2	42.48	45.00	44.40	43.96
T3	50.34	52.37	49.81	50.84
T4	55.11	57.19	51.31	54.53
T5	57.67	58.26	54.31	56.75

Note: T_1 = No pruning of *Albida* tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75%, T_5 = planting Sunflower in open field.

Results of Soil Plant Analysis and Development (SPAD)

Due to pruning of albida trees and the SPAD value of sunflower leaves changed (Table 1). With an increase in light levels, the SPAD value increased. The treatment T_5, which represents the open field condition, had the highest SPAD value (57.67 at 30 DAS, 58.26 at 60 DAS, and 54.31 at 90 DAS) among the five treatments, and it steadily dropped

Plant height of sunflower

Plant height is one of the most important plant growth characteristics that were significantly influenced at different pruning regimes of *albida* tree (Table 2). At all the sampling dates, the tallest plants (38.47 cm at 30 DAS, 68.7 cm at 60 DAS and 100.72 cm at 90 DAS) were recorded in the treatment no pruning, whereas, the shortest plants (21.67 cm at 30 DAS, 48.29 cm at 60 DAS and 72.95 cm at 90 DAS)

were measured in the T_5 (sunflower in open field) treatment, respectively (Table 2). Hillman (1984) discovered that plants grown under observation had higher apical dominance than plants cultivated under high-light conditions, resulting in taller plants in partial shade. Mortuza *et al.,* (2014) and Roxy, (2017) found the same outcome in okra, while Hasan, (2020) found the same trend in dragon fruit.

Table 2. Plant height (cm) of sunflower at different pruning regime of *Albida* at different DAS

Treatments	Plant height (cm) at		
	30 DAS	60 DAS	90 DAS
T1	38.47 a	68.7 a	100.72 a
T2	35.64 a	66.43 a	97.48 a
T3	30.56 b	58.30 b	95.82 a
T4	28.34 b	56.56 b	90.89 b
T5	21.67 c	48.29 c	75.92 c
CV %	7.70	7.10	6.46

Note: At a 5% level of probability, means in a column that are followed by the same letter(s) do not statistically differ from one another.
Note: T_1 = No pruning of Albida tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning, T_5 = planting Sunflower in open field.

DAS, 14.14 at 60 DAS, and 21.77 at 90 DAS) leaves per plant (Table 3). Mortuza *et al.* (2014) reported that the number of leaves of cotton plants was lower in aonla-based agroforestry systems compared to open fields indicating lower production of photosynthates under lower light conditions. Interestingly in this experiment, T4 treatment produced the highest leaf numbers compared to the rest treatments including open field conditions at all the sampling dates indicating a better environment for the sunflower plant growth.

Table 3. Leaf number per plant at different pruning regime of *Albida* at different DAS

Treatments	Leaf number at				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
T1	9.77 c	13.8 b	14.14 c	20.94 c	21.77 c
T2	10.4 ab	14.14 ab	17.2 bc	21.54 b	23.0 ab
T3	10.57 b	14.93 ab	18.6 b	22.0 b	23.5 ab
T4	13.54 a	15.2 a	19.2 a	24.27 a	25.54 a
T5	11.64 b	14.67 ab	18.07 b	21.8 b	22.5 ab
CV%	4.13	4.54	5.49	6.02	6.83

Note: At a 5% level of probability, means in a column that are followed by the same letter(s) do not statistically differ from one another.
Here, T_1= no pruning of *Albida* tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning), T_5 = Sunflower in open field.

Number of leaves per plant

At various pruning regimes of the albida tree, the number of leaves per sunflower plant was considerably altered (Table 3). The treatment with 75% pruning of albida tree showed the highest leaves per plant (13.54 at 30 DAS, 19.2 at 60 DAS, and 25.54 at 90 DAS) while the treatment T1 (no pruning of albida tree) had the fewest (9.77 at 30

Fresh and dry weight of leaf, stem, and root

Fresh and dry mass of sunflower plant grown at different pruning regime of albida varied significantly (Table 4). For leaf, maximum fresh weight (81.67g)

and dry weight (13.95g) was recorded in the T_5, which was statistically similar (78.80g and 13.27g, respectively) to that of T_4 treatment. Statistically the lowest leaf fresh and dry weight (53.48g and 8.34g) was recorded in the T_1 treatment. For stem, the T_5 had the highest fresh weight (106.54g) and dry weight (17.22g), although there was no significant difference between the T_4 and T_5. However, the lowest stem fresh weight and dry weight (71.54g and 10.16g) were found in the T_1. The same trend was observed in the case of root fresh and dry weight (33.69g and 15.43g) was observed in T5 treatment followed by T4 (33.31g and 14.02g) and both treatments were found statistically similar. Significantly the lowest root fresh and dry weight (21.23g and 6.39g) was observed under T1. The reason for lower fresh and dry weight in intercrops is due to producing lower photosynthates at lower PAR levels. The present findings are also supported by several researchers and they opined that shading reduces the PAR that regulates the photosynthesis rate, transpiration rate, stomatal density, dry matter production and yield (Abou-Kresha et al. 1996; Mortuza et al., 2014; Miah and Hussain, 2010; Wadud, 1999; Rao and Mitttra, 1988).

Crop Growth Rate (CGR) and Relative Crop Growth Rate (RGR) under various pruning regimes

Crop growth rate (CGR) and relative growth rate (RGR) values differed at various pruning regimes of *albida* tree (Fig. 2a, 2b). The maximum CGR (1.169 mg/cm^2/day) and RGR (66.58 mg/g/day) values were recorded in T_5 which was closely followed by T4 (CGR 1.124 mg/cm2/day and RGR 64.46 mg/g/day) and the minimum CGR (0.578 mg/cm2/day) and RGR (52.27 mg/g/day) values were recorded in T1. Zhong et al., (2022) and Deng, (2009) also reported that CGR and RGR values were related

Table 4. Fresh and dry weight (g) of sunflower leaf, stem and root at different pruning regime of Albida

Treatments	Leaf		Stem		Root	
	Fresh mass (g)	Dry mass (g)	Fresh mass (g)	Dry mass (g)	Fresh mass (g)	Dry mass (g)
T1	53.48 d	8.34 b	71.54 c	10.16 c	21.23 c	6.39 c
T2	59.62 c	9.11 b	79.32 b	12.14 b	27.28 b	7.23 c
T3	68.75 b	10.13 b	82.87 b	13.81 b	29.16 b	10.37 b
T4	78.80 a	13.27 ab	102.47 a	16.8 a	33.31 a	14.02 a
T5	81.67 a	13.95 a	106.54 a	17.22 a	33.69 a	15.43 a
CV%	3.36	4.49	6.43	4.34	4.36	5.29

Note: T_1 = no pruning of *Albida* tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning, and T_5 = Sunflower in open field.

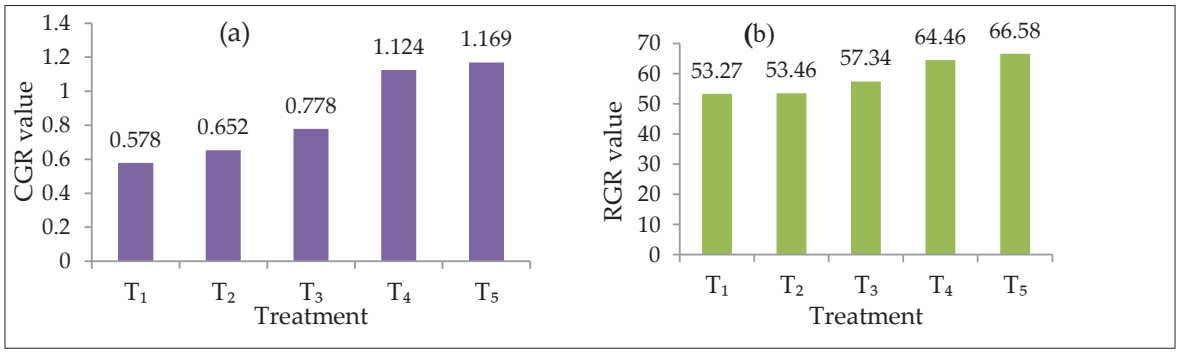

Fig. 2. (a) Crop Growth Rate (mg/cm^2/day) and (b) Relative Growth Rate (mg/g/day) of sunflower at different pruning regime of *albida.*

Note: T_1 = no pruning of *albida* tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning, and T_5 = sunflower in open field.

to photosynthetic rate, transpiration rate, stomatal density, dry matter production, and yield which was regulated by the PAR or shading.

the lowest thousand seed weight (24.26g). This is due to the shade condition in T1 treatment.

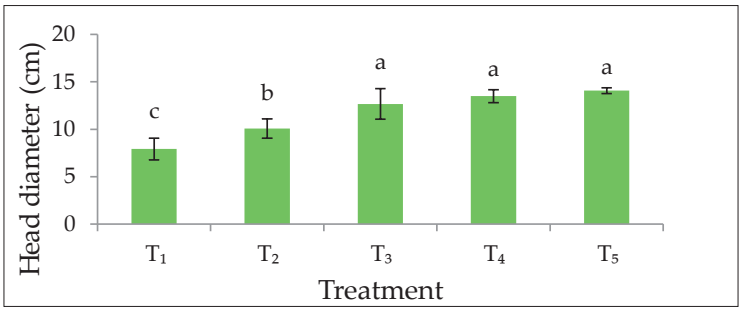

Fig. 3. Head diameter (cm) of sunflower at different pruning regime of *albida.*

Note: T_1 = no pruning of *albida* tree, T_2 = 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning, and T_5 = sunflower in open field.

Head diameter (cm) of sunflower

Different albida tree trimming regimes had an impact on sunflower head diameter as well (Fig. 3). The T5 produced the largest head diameter (15 cm), which was statistically comparable to T4 treatment (14 cm) and T3 treatment (12 cm) head diameters. Significantly, the T1 showed the smallest head diameter (8 cm).

Yield performance of sunflower

The yield of sunflower was greatly influenced by different pruning regime of albida tree (Table 5).The maximum sunflower yield (1.13 t/ha) was noted in T5 followed by T4 (1.09 t/ha). On the other hand, T1 showed the lowest yield (0.45 t/ha). The yield was 0.698 t/ha for T2 and 0.72 t/ha for T3, respectively.

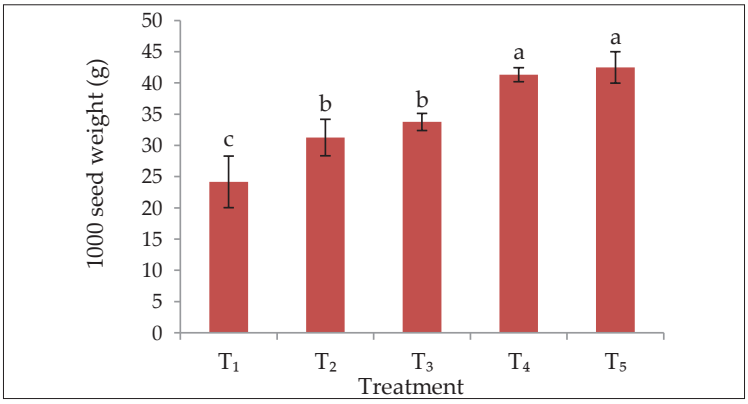

Fig. 4. Thousand seed weight (g) of sunflower at different pruning regime of *albida.*

Note: T_1 = no pruning of *albida* tree, T_2 25% pruning, T_3 = 50 % pruning, T_4 = 75% pruning, and T_5 = sunflower in open field.

1000-seed weight of sunflower

At various pruning regimes of albida, 1000-seed weight of sunflower was also dramatically impacted (Fig. 4). The highest thousand seed weight (43.34g) was found in T5 followed by T4 (40.62g) with no statistically significant difference. The T1 showed

According to the study, trimming practices had a significant impact on sunflower seed yield. Crop yield was found to decline as the quantity of shade increased (Mortuza *et al.* 2014).

Table 5. Yield performance of sunflower at different pruning regimes

Treatment Albida tree pruning %	Sunflower yield (ton/ha)
T1 = no pruning	0.45
T2 = 25% pruning	0.69
T3 = 50 % pruning	0.72
T4 = 75% pruning	1.09
T5 = Sunflower in open field.	1.13

Relationship of sunflower yield and PAR% at different pruning regimes

Relationship of sunflower yield and PAR (%) at different pruning regimes of *albida* and in open field was estimated and presented in Fig. 5. The association between sunflower yield (t/ha) and PAR (%) was linear. The PAR (%) at various pruning regimes of the albida tree contributed 95.92% of the sunflower yield, as shown by the R^2 value's positive and significant value of 0.9592. The connection also showed that the rate at which the yield of sunflower changed with changes in light intensity was 0.0504 t ha^{-1} $unit^{-1}$ (PAR mole m^{-2} s^{-1}).

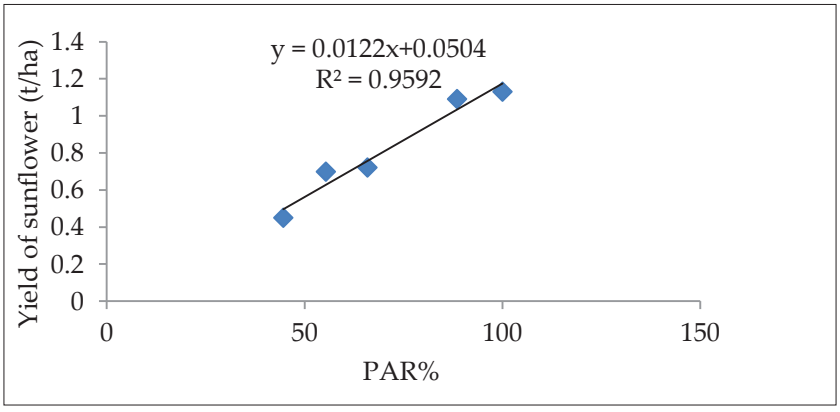

Fig. 5. Relationship between the yield of sunflower and PAR% at different pruning regime of *albida*.

Conclusions

The study revealed that to achieve better performance of sunflower when grown under albida trees; the lower branches of albida tree should be pruned up to 75%.

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