EFFECT OF DIFFERENT DISTANCES AND ORIENTATIONS ON GROWTH AND YIELD PERFORMANCE OF MUSTARD GROWN AS UNDERSTOREY CROP WITH AKASHMONI TREE

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ABSTRACT

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The experiment was conducted at Agroforestry Farm of Bangladesh Agricultural University, Mymensingh during November 2004-March 2005 to evaluate the effect of different distances and orientations on growth and yield of mustard under Akashmoni tree. The highest grain yield was observed in 3 m away from the base of tree. Compared to open field, the dry seed yield of mustard in different distances i.e. 3m, 2m and 1m away from the tree base of Akashmoni were 2.13, 1.75 and 1.53 t/ha, respectively. The lowest grain yield was obtained from the O_N - orientation and it was gradually increased in O_E, O_W, O_S and open field (O_O). Orientation also showed the significant effect on plant height, number of branch plant^{-1}, root weight plant^{-1}, shoot weight plant^{-1}, number of siliqua plant^{-1}, length of siliqua (cm), number of seeds siliqua^{-1}, fresh yield, dry yield and 1000 seed weight. Compared to open field, the dry seed yield of mustard under Akashmoni tree in different orientations i.e. south, west, east and north were 2.07, 1.59, 1.34 and 0.98 t/ha, respectively. It can be concluded that near the base of tree obtained lowest yield of mustard due to shading and nutrient competition and gradually increased 1, 2 and 3 m away from the base of Akashmoni tree. Although the open field produced maximum yield, but combined production system may become beneficial for the farmers from sustainable point of view.

Key word: Effect of distance and orientation, growth, yield

INTRODUCTION

Mustard is an important oil crop of the world after soybean and palm (FAO, 1996). In Bangladesh, oilseed mustard is the number one edible oil crop, covering about 64% of the total oilseed area and contributing to more than 48% of the total oil crop production (BBS, 1995). Mustard is the single most important oil crop of Bangladesh. The climate edaphic factors are quite favourable for the cultivation of this crop (Haque *et al.*, 1987). But the average seed yield is low (0.73 t/ha), which is unfortunately much lower than the average yield of many countries of the world (FAO, 1996). The poor yield of mustard under Bangladesh condition might be attributed to inefficient and inappropriate uses of production inputs and improved technologies of crop production. To increase the yield, proper Agroforestry practices is necessary.

Most of the people of Bangladesh are faced with problems of food, fuel wood, timber and fodder shortage, high population growth rates have put enormous pressures on the lands thereby exacerbating the problems of food shortage and degradation through indiscriminate, extensive land clearing and poor land management. Forest plays an important role in maintaining environmental equilibrium and socio-economic upliftment of the people. Unfortunately, the production of forest is very meager. Estimated wood demand of the country is about 13.2 million cubic meters with per capita consumption of 0.12 cubic meter per annum. The present supply of wood is about 8.2 million cubic meter. Of this 4.7 million cubic meter of wood comes from the homestead and the rest 3.5 million cubic meters comes form the forest. Generally farmers grow shade loving/tolerant spice and vegetables under different trees in their homestead and surrounding areas. In agroforestry system among different production limitations light availability is the most important limitation to the performance of the understorey crops/vegetables particularly when an upperstorey perennial forms a continuous overstorey canopy (Miah *et al* 1995).

Akashmoni (*Acacia auricoliformis*) is a fast growing middle-sized multipurpose tree species, soon it became very popular to the farmers because of their wide range of adaptability, which can be grown at any type of soil. These are an ideal fuel wood and growth, farmers can get a very quick return from the trees. It is also used as ornamental plant. Farmers who were practicing monocultures for all the years are now switching over to a combine production system of the tree and crop. So, now it is necessary to determine whether the interaction between Akashmoni and mustard in production system is beneficial or not. Considering the aforementioned facts and potentiality, the present study was carried out to evaluate the effect of different distances and orientations on growth and yield of mustard under Akashmoni tree.

MATERIALS AND METHODS

The experiment was conducted at the field laboratory, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh, during November 2004 to March 2005. The soil of the experimental area was a medium high land belonging to the Old Brahmaputra Floodplain Agro Ecological Zone-9. The experiment was carried out in a factorial Randomized Complete Block Design (RCBD) with three replications. Two factors were involved in the study. Factor A was five distances (D) viz. D_0 = Open field, D_1 = 1 m away from the tree base, D_2 = 2 m away from the tree base and D_3 = 3 m away from the tree base, and Factor B was five orientations (O) viz. O_0 = Open field. O_N = North side of the tree, O_S = South side of the tree, O_E = East side of the tree and O_W West side of the tree. Three *Akashmoni* trees were involved in this experiment. Four plots each of (3.0m ×1.0m) were laid at north, south, east and west direction around the tree base. All plots were divided into three sub-plots for each replication. The size of each sub-plots were (1.0m×1.0m). The plots were selected at a distance of 1m away from the tree base. The crown diameter of each of the three trees was measured along north-south and east-west axis using a measuring tape. All *Acacia auriculiformis* trees having an average plant height of 8.16m, clean bole of 1.91m, and canopy area of 25.06 m^2. All of *Acacia auriculiformis* trees were 12 years old. Mustard (*Brassica napus*) crop var. BARI sharisha 13 was used as plant material.

The experimental land was well prepared following laddering. Manures and fertilizers were applied Cowdung @ 8-10 ton/ha, Urea @ 250-300 kg/ha, TSP @ 170 kg/ha, MP @ 90 kg/ha and Gypsum @ 160 kg/ha. Seed were sown on 7 December 2004 by broadcasting method. The crop was harvested after 83 days (1 March 2005) from the date of sowing at full maturity. The data were recorded on yield and yield parameters. All the parameters were taken from each 10 plants which were randomly selected from each sub-pot. Total grain yield was calculated in t ha^{-1} by threshing the whole plants as per replication. Similar procedure was followed in calculating Stover yield. The recorded data after final harvest were completed and analyzed statistically to find out differences among treatment means were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of different distances from the base of Akashmoni tree and different orientations of Akashmoni tree on growth parameters of mustard at 40 and 60 DAS

Plant height

Distances from the base of Akashmoni tree did not significantly affect the plant height at 40 DAS (Table 1). Plant height varied from 26.27 to 30.00 cm, while the highest plant height was observed in open field (D_0) and the lowest was in distance 1 m from the base of tree (D_1). In case of 60 DAS, plant height was significantly affected by the distances. The tallest plant (62.67 cm) was found in D_0 and the smallest (55.67 cm) was in D_1 (Table 1). Orientations showed significant effect on plant height at 40 DAS (Table 2). Plant height ranged from 24.78 to 31.33 cm, where the tallest plant was recorded in open field (O_0) and the smallest was in O_N. In case of 60 DAS, plant height was not significantly affected by different orientation. The tallest plant (63.89 cm) was found in O_0 and the smallest plant (54.44 cm) was in O_N (Table 2).

Number of branch plant^{-1}

Distances from the base of Akashmoni tree did not significantly affect the number of branch plant^{-1} at 40 DAS (Table 1). Number of branch ranged from 3.33 to 4.97, while the highest number of branch was observed in open field (D_0) and the lowest was in distance 1 m away from the base of tree D_1. In case of 60 DAS, distances from the base of Akashmoni also did not significantly affect the number of branch (Table 1). The number of branch varied from 5.13-6.91. The highest number of branch was obtained in open field (D_0) and the lowest number of branch was in 1 m away from the base of tree (D_1). Orientations showed significant effect on number of branch at 40 DAS (Table 2). Number of branch varied from 2.67 to 5.00, where the highest number of branch was recorded in open field (O_0), which was statistically similar to O_S (4.00) and the lowest was in O_N, which was statistically identical to O_E (3.11), O_W (3.67). On the other hand in case of 60 DAS, orientations also showed significant effect on number of branch (Table 2). Number of branch ranged from 4.00 to 8.00, where the highest number of branch was observed in open field (O_0), which was statistically similar to O_S (6.44) and the lowest was in O_N, which was statistically identical to O_E (4.67), O_W (5.11).

Number of leaves plant^{-1}

Distances from the base of Akashmoni significantly affected the number of leaves at 40 DAS (Table 1). Number of leaves varied from 6.93 to 9.67, while the highest number of leaves were observed in open field (D_0), which was followed by D_2 (8.13), D_3 (8.40) and the lowest was in D_1. Distances from the base of Akashmoni also significantly influenced the number of leaves at 60 DAS (Table 1). In this case number of leaves ranged from 10.87 to 14.00, while the highest number of leaves was observed in open field (D_0) which was statistically identical to D_2 (12.20), D_3 (12.87) and the lowest was in D_1. Orientations showed significant effect on number of leaves at 40 DAS (Table 2). Here number of leaves ranged from 6.33 to 9.67, while the highest number of leaves was recorded in open field (O_0) and the lowest was in O_N which was statistically similar to O_E (7.11). In case of 60 DAS, orientations also significantly influenced on number of leaves (Table 2). Number of leaves varied from 10.22-14.00, where the

highest number of leaves was observed in open field (O_0) which was statistically similar to O_S (13.00) and the lowest was in O_N (which was followed by O_E (10.89).

Dry shoot weight (g) plant^{-1}

Dry shoot weight was not significantly influenced by different distances at 40 and 60 DAS (Table 1). Shoot weight varied from 0.88 to 1.05 g while the highest dry shoot weight was observed in D_0 and the lowest was in D_1 at 40 DAS. In case of 60 DAS dry shoot weight ranged from 1.73 to 2.10 where the highest weight was found in D_0 and the lowest was in D_1. Dry shoot weight significantly influenced by different orientations at DAS (Table 2). Shoot weight was ranged from 0.75 to 1.05. The highest shoot weight was obtained in O_0, which was statistically similar to O_S (1.01), O_E (0.87), O_W (0.96) and the lowest was found in O_N. In case of 60 DAS shoot weight was not significantly affected by different distances (Table 2). Here shoot weight was varied from 1.49 to 3.13g where the highest weight was observed in O_0 and the lowest was in O_N.

Root length (cm)

Root length was significantly affected by different distances. The tallest root was found in D_0 (3.13cm) which was statistically similar to D_2 (2.91 cm), D_3 (3.00 cm) and the lowest was in D_1 (2.80 cm). In case of 60 DAS root length was also significantly influenced by different distances. The tallest root was observed in open field D_0 (6.47 cm) which was statistically identical to D_2 (6.29 cm), D_3 (6.36 cm) and the lowest was found in D_1 (5.93 cm) (Table 1). Orientations showed significant effect on root length at 40 and 60 DAS. At 40 DAS root length was ranged from 2.72 to 3.13 cm where the highest root length was found in O_0, which was followed by O_S (2.48 cm), O_W (2.90 cm) and the lowest was in O_E. In case of 60 DAS root length was varied from 5.92 to 6.51 cm. The highest root length was observed in O_S which was statistically identical to O_0 (6.47 cm), O_W (6.13 cm) and the lowest was in O_N (Table 2).

Root weight (g) plant^{-1}

Root weight was significantly affected by different distances at 40 DAS (Table 1). Root weight was varied from 0.49 to 0.84 g where the highest weight was found in open field (D_0) which was statistically similar to D_2 (0.62 g), D_3 (0.71 g) and the lowest was in D_1. In case of 60 DAS distances from the base of Akashmoni tree did not significantly effect on root weight of mustard. Here root weight was ranged from 1.24 to 1.84 g where the highest weight was found in D_0 and the lowest was in D_1. Orientations showed significant effect on root weight at 40 DAS (Table 2). Root weight ranged form 0.43 to 0.78 g where the highest weight was observed in open field (O_0) which is statistically similar to O_S (0.76 g), O_W (0.62 g). But root weight was not significantly affected by orientations in case of 60 DAS. Root weight varied from 1.04 to 1.84 g where the highest root weight was found in O_0 and the lowest was in O_N.

Table 1. Effect of different distances from the base of Akashmoni tree on growth parameter of Mustard at 40 and 60 DAS

Distance	Plant height (cm) at 40 DAS	Plant height (cm) at 60 DAS	No of branch /plant at 40 DAS	No of branch /plant at 60 DAS	No of leaves/ Plant at 40 DAS	No of leaves/ Plant at 60 DAS	Dry shoot weight/ plant (g) at 40 DAS	Dry shoot weight/ plant (g) at 60 DAS	Root length (cm) at 40 DAS	Root length (cm) at 60 DAS	Root weight /plant (g) at 40 DAS	Root weight /plant (g) at 60 DAS
D_0	30.00	62.67a	4.97	6.91	9.67a	14.00a	1.05	2.10	3.13 a	6.47 a	0.84 a	1.84
D_1	26.27	55.67a	3.33	5.13	6.93b	10.87b	0.88	1.73	2.80 b	5.93 b	0.49 b	1.24
D_2	26.87	56.80b	3.67	5.60	8.13a	12.20a	0.95	1.88	2.91ab	6.29 a	0.62ab	1.46
D_3	27.93	58.07b	4.07	6.20	8.40a	12.87a	0.95	1.84	3.00 a	6.36 a	0.71 a	1.58
F-test	NS	**	NS	NS	**	**	NS	NS	*	*	*	NS

Table 2. Effect of different orientations of Akashmoni tree on growth parameter of Mustard at 40 and 60 DAS

Orientation	Plant height (cm) at 40 DAS	Plant height (cm) at 60 DAS	No of branch /plant at 40 DAS	No of branch /plant at 6 0DAS	No of leaves /Plant at 40 DAS	No of leaves/Plant at 60 DAS	Dry shoot weight /plant (g) at 40 DAS	Dry shoot weight /plant (g) at 60 DAS	Root length (cm) at 40 DAS	Root length (cm) at 60 DAS	Root weight /plant (g) at 40 DAS	Root weight /plant (g) at 60 DAS
O_0	31.33a	63.89	5.00a	8.00a	9.67a	14.00a	1.05a	2.10	3.13a	6.47a	0.78a	1.84
O_N	24.78b	54.44	2.67c	4.00c	6.33d	10.22c	0.75b	1.49	2.78b	5.92b	0.43b	1.04
O_S	27.22b	56.44	4.00ab	6.44ab	8.22b	13.00a	1.01a	1.97	2.98ab	6.51a	0.76a	1.72
O_E	25.56b	54.67	3.11bc	4.67bc	7.11cd	10.89bc	0.87ab	1.60	2.72b	5.93b	0.47b	1.12
O_W	26.22b	54.78	3.67bc	5.11bc	7.78bc	11.78b	0.96a	1.92	2.90ab	6.13ab	0.62ab	1.40
F-test	**	NS	**	**	**	**	**	NS	**	**	**	NS

Effect of different distances from the base of Akashmoni tree and different orientations of Akashmoni tree on growth parameters of mustard during harvest

Plant height (cm)

Distances form the base of Akashmoni tree did not significantly affect on plant height at harvest period (Table 3). Plant height ranged from 79.13 to 89.33 cm while the highest plant height was observed in open field (D_0) and lowest was in distance 1m from the base of tree (D_1). Orientations showed significant effect on plant height at harvest period (Table 4). Plant height varied from 75.11 to 90.33 cm where the tallest plant was recorded in open field (O_0) and the smallest was in O_1.

Number of branch plant^{-1}

Number of branch was significantly affected by different distances at harvest period (Table 3). No of branch varied from 5.87 to 8.33, while the highest number of branch was recorded in open field (D_0) which was statistically identical to D_3 (7.73) and the lowest was in D_1 (5.87). At harvest period different orientations were significantly effect on number of branch (Table 4). In this period number of branch was ranged from 4.44 to 8.33 where the highest number of branch was observed in O_0 (8.33) which was statistically similar to O_S (7.56) and the lowest was in O_N (4.44) which was followed by O_E (5.56), O_W (6.89).

Root length (cm)

Different distances had significantly effect on root length of mustard (Table 3). Root length ranged form 9.71 to 10.70 cm. The highest root length was found in open field (D_0) which was statistically similar to D_2 (10.14 cm), D_3 (10.56 cm) and the lowest was in D_1 (9.71). Root length was not significantly affected by different orientations (Table 4). Root length varied form (9.6 to 10.69 cm). The highest length was observed in O_0 and the lowest was in O_N.

Root length, plant height and number of branch plant^{-1} were lower in the tree base than open field which might be due to the maximum shade and severe competition with tree roots. Miah (1993) reported that the lower number of branches under shaded condition might be due to higher auxin production in plant grown shaded condition which ultimately suppressed the growth of lateral branches.

Root weight (g) plant^{-1}

Root weight was not significantly influenced by different distances (Table 3). Root weight varied form 1.53 to 2.51 g. The highest weight was found in D_0 and the lowest was D_1. Root weight was significantly influenced by different orientations (Table 4). Root weight varied form 1.03 to 2.81 g. The highest weight was found in O_0 and the lowest was in O_N.

Shoot weight (g) plant^{-1}

Different distances did not significantly effect on shoot weight at harvesting period (Table 3). Shoot weight ranged from 2.92 to 3.95 g. The highest weight was found in D_0 and the lowest was in D_1. Different orientations showed significant effect on shoot weight at harvesting period (Table 4). Shoot weight ranged from 2.28 to 3.75 g. The highest weight was found in O_0 and the lowest was in O_N.

Number of siliqua plant^{-1}

A significant difference was showed in number of siliqua plant^{-1} by different distances (Table 3). Number of siliqua ranged form 31.27 to 43.95. The maximum number of siliqua plant^{-1} was found in D_0 which was statistically similar to D_3 (40.80) and the minimum was in D_1. A significant difference was showed in number of siliqua plant^{-1} by different distances (Table 4). Number of siliqua ranged form 23.67 to 43.09. The maximum number of siliqua plant^{-1} was found in O_0 which was statistically similar to D_3 and the minimum was in O_N.

Pod formation in a plant may be influenced by the intensity and duration of shading. Jiang and Egli (1993) observed that shade induced environment changes in flowering and reduced the number of pods plant^{-1} in soybean. Reduction of pods plant^{-1} was the result of both flower and pod abscission numbers of nodes on the main stem as well as flower nodes, which ultimately reduced the number of pods plant^{-1}.

Length of siliqua (cm)

The length of siliqua of mustard was significantly affected by different distances (Table 3). Siliqua length was varied from 8.63 to 9.00 cm. The highest length of siliqua was found in D_0 which was statistically similar to D_2 (8.79 cm), D_3 (8.87 cm) and the lowest was in D_1. The length of siliqua of mustard was significantly affected by different orientations (Table 4). Siliqua length was varied from 8.21 to 9.23 cm. The highest length of siliqua was found in O_0 and the lowest was in O_N.

Number of seeds siliqua^{-1}

The number of seeds siliqua^{-1} of mustarded was not significantly affected by different distances (Table 3). Seeds siliqua^{-1} was varied form 23.67 to 25.30 where the maximum number of seeds was obtained from D_0 and the minimum was in D_1. The number of seeds siliqua^{-1} of mustarded was significantly affected by different orientations (Table 4). Seeds siliqua^{-1} was varied form 21.78 to 26.98, where the maximum number of seeds was obtained from O_0 and the minimum was in O_N.

Table 3. Effect of different distances from the base of Akashmoni tree on growth of Mustard during harvest

Distance	Plant height (cm)	No of branch/ plant	Root length (cm)	Root weight (g)	Shoot weight (g)	No of Siliqua/p lant	Length of siliqua (cm)	No of seeds/ siliqua
D_0	89.33	8.33 a	10.70 a	2.510	3.95	43.95 a	9.00 a	25.30
D_1	79.13	5.87 c	9.71 b	1.529	2.92	31.27 b	8.63 b	23.67
D_2	80.80	6.67 b	10.14 ab	1.88	3.16	35.53 b	8.79 a	24.33
D_3	83.53	7.73 a	10.56 a	2.028	3.23	40.80 a	8.87 a	24.93
F-test	NS	**	*	NS	NS	**	**	NS

NS = Not Significant, In a column, same letter do not differ significantly at 5% (*) and 1% (**) level of DMRT

Table 4. Effect of different orientations of Akashmoni tree on growth of Mustard during harvest

Orientation	Plant height (cm)	No of branch /plant	Root length (cm)	Root weight (g)	Shoot weight (g)	No of Siliqua/plant	Length of siliqua (cm)	No of seeds/siliqua
O_0	90.33 a	8.33 a	10.69	2.81 a	3.75 a	43.09 a	9.23 a	26.98 a
O_N	75.11 b	4.44 c	9.61	1.03 c	2.28 c	23.67 d	8.21 d	21.78 c
O_S	81.78 b	7.56ab	10.26	2.25 ab	3.42 ab	39.89 b	8.97 b	25.22 ab
O_E	77.00 b	5.56bc	10.01	1.29 c	2.74 bc	29.11 cd	8.63 c	23.22 bc
O_W	78.56 b	6.89bc	10.13	1.68 bc	3.15 abc	33.67 bc	8.76 c	24.33 bc
F-test	**	**	NS	**	*	**	**	*

NS = Not Significant, In a column, same letter do not differ significantly at 5% (*) and 1% (**) level of DMRT

Effect of different distances from the base of Akashmoni tree and different orientations of Akashmoni tree on yield and yield parameters of mustard

Fresh yield (t ha^{-1})

Fresh yield was significantly affected by the different distances (Table 5). Fresh yield of mustard ranged from 1.68-2.83 t ha^{-1} while the highest and lowest fresh yield was found in D_0 and D_1 respectively. In this case highest yield which was followed by D_3 (2.34 t ha^{-1}) and the lowest yield followed by D_1 (1.68 t ha^{-1}), D_2 (1.93 t ha^{-1}). Different orientation showed significant effect on fresh yield of mustard (Table 6). The highest fresh yield of mustard 2.83 t ha^{-1} was found in open field (O_0) and the lowest 1.08 t ha^{-1} was in O_N which was followed by O_E (1.48 t ha^{-1}).

Dry seed yield (t ha^{-1})

Dry yield was significantly affected by the different distances (Table 5). Dry seed yield of mustard varied from 1.53 to 2.95 t ha^{-1} while the highest and lowest dry seed yield was found in D_0 and D_1 respectively. Rahman *et al.* (2006) showed that the disease incidence was higher near the tree base in every side (1 m from the tree base) which decreased seed yield of BARI sharisha 13. Different orientations showed significant effect on dry seed yield of mustard (Table 6). The highest dry seed yield (2.85 t ha^{-1}) was found in O_0 and the lowest 0.98 t ha^{-1} was in O_N which was followed by O_E (1.34 t ha^{-1}). Rahman *et al.* (2006) also showed that the disease incidence was higher in North side in all distances at different date of sowing which decreased seed yield of BARI sharisha 13.

1000-seed weight

Weight of 1000-seed was significantly affected by different distances (Table 5). Weight of 1000 seed ranged from 3.36 to 3.82 g. The highest weight of 1000 seed was obtained in D_0 which was statistically similar to D_2 (3.41), D_3 (3.45) and the lowest in D_1. The influence of orientations on the 1000-seed weight of mustard showed significant (Table 6). Weight of 1000 seed varied from (3.25-3.82 g). The highest weight of 1000 seed weight was found in O_0 and the lowest in O_N which was followed by O_E (3.27 g), O_N (3.31 g).

Stover yield (t ha^{-1})

Stover yield of mustard was significantly affected by different distances. The higher Stover yield of mustard (3.01 t ha^{-1}) was found in open field (D_0) and the lower (1.94 t ha^{-1}) in D_1 (Table 5). Stover yield of mustard was significantly influenced by orientations. The maximum Stover yield (3.46 t ha^{-1}) was found in open field (O_0) and the minimum (1.37 t ha^{-1}) was in O_N orientation (Table 6).

Grain Stover ratio (t ha^{-1})

Different distances affected on grain Stover ratio significantly. The maximum grain Stover ratio (0.89) was found in D_0 and the minimum (0.75) in D_1 (Table 5). Grain Stover ratio was significantly affected by different orientations. The maximum grain Stover ratio (0.88) was found in O_0 which was statistically similar with O_S orientation. The minimum grain Stover ratio (0.71) was observed in O_N which was statistically similar with O_S, O_E orientations (Table 6).

Biological yield (t ha^{-1})

Biological yield was significantly affected by different distances. The higher biological yield (5.51 t ha^{-1}) was found in open field (D_0) and the lower yield (3.46 t ha^{-1}) in D_1 which was statistically identical to D_2 (Table 5). Biological yield showed significantly response due to different orientations. The maximum biological yield (6.51 t ha^{-1}) was observed in open field (O_0) and the minimum in O_N orientation (Table 6).

Harvest index (%)

Harvest index was not significantly affected by different distances. The maximum harvest index (46.95%) was found in open field (D_0) and the minimum (42.83%) in D_1 (Table 5). Different orientations were significantly influenced on harvest index. Numerically higher harvest index (46.60%) was proved by open field and the lowest (41.11%) was found in O_E which was statistically similar to O_N (Table 6).

It can be concluded that near the base of tree obtained lowest yield of mustard due to shading and nutrient competition and gradually increased 1, 2 and 3 m away from the base of Akashmoni tree. Although the open field produced maximum yield, but combined production system may become beneficial for the farmers from sustainable point of view.

Table 5. Effect of different distances from the base of Akashmoni tree on yield of Mustard

Distances	Fresh yield of seed (t/ha)	Dry yield of seed (t/ha)	1000 seeds wt (g)	Stover yield (t/ha)	Grain Stover ratio	Biological yield (t/ha)	Harvest index
D_0	2.83 a	2.95 a	3.82 a	3.01 a	0.89 a	5.51 a	46.95
D_1	1.68 b	1.53 b	3.36 b	1.94 b	0.75 b	3.46 c	42.83
D_2	1.93 b	1.75 b	3.41 ab	2.25 ab	0.78 ab	3.94 c	43.67
D_3	2.34 a	2.13 a	3.45 a	2.56 a	0.81 a	4.68 b	44.10
F-test	**	*	**	**	*	**	NS

Table 6. Effect of different orientations of Akashmoni tree on yield of Mustard

Orientations	Fresh yield of seed (t/ha)	Dry yield of seed (t/ha)	1000 seeds wt (g)	Stover yield (t/ha)	Grain Stover ratio	Biological yield (t/ha)	Harvest index
O_0	2.83 a	2.85 a	3.82 a	3.46 a	0.88 a	6.51 a	46.60 a
O_N	1.08 d	0.98 d	3.25 c	1.37 d	0.71 c	2.35 d	41.54 d
O_S	2.27 b	2.07 b	3.40 b	2.61 b	0.81 ab	4.56 b	44.87 b
O_E	1.48 cd	1.34 cd	3.27 c	1.79 cd	0.73 bc	3.12 c	41.11 d
O_W	1.74 c	1.59 c	3.31 c	2.02 c	0.77 bc	3.61 c	43.53 c
F-test	**	*	**	**	**	**	**

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