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Effect of Level of Pruning on the Performance of Rice-Sissoo Based Agroforestry System

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Abstract: A field experiment was carried out to investigate the effect of level of pruning on the yield and yield contributing characters of rice cv. BR11 (Mukta) under eight years old Sissoo (*Dalbergia sissoo*) tree in Boalmari Upazilla of Faridpur district, Bangladesh during the period from July to November, 2003. The level of pruning of Sissoo trees were designed as severely, moderately, medium and light pruned. Out of four tree-rice associations, severely pruned tree produced significantly highest yield (3.63 t ha^{-1}) and lowest yield (2.70 t ha^{-1}) was produced by light pruned tree, while control (out side the tree canopy) produced the highest yield as compared to all orientations. As regard to orientations, south orientation (O_S) produced the highest yield (3.86 t ha^{-1}) and north orientation (O_N) produced the lowest yield (3.20 t ha^{-1}) compared to that of control. Therefore, for tree-rice Agroforestry system, tree species having light canopy is suitable since they allow easy penetration of sunlight, while tree of dense canopy required heavy pruning especially in the north-east orientation.

Key words: Sissoo-rice association, pruning, orientations, yield, yield contributing characters

Introduction

There is shortage of reliable information regarding the Forest Area Statistics of Bangladesh since it is described through different figures in different sources. The Forestry Sector Master Plan accounted it as 17.8% of the total land area of Bangladesh (Government of Bangladesh, 1993); whereas the Bangladesh Bureau of Statistics (BBS, 1999) noted 14%, World Bank (1997) reported 11% and Ahmed (2003) found it as 9% in a recent report. Roy (2005) reported that the total forest area is 17.5% of the total land surface but only 7.7% land surface is under tree cover. But this figure was reported as 6% by World Bank (1997), 5% by Ahmed (2003) and Chowdhury (1999), 5.8% by Forest Department (2003). It is one of the most densely populated countries of the world having 123.1 million peoples in 14.4 million ha area (834 persons per km^2) (Forest Department, 2003). Here 77 percent people live in the rural areas. Overall per capita land availability is about 0.12 ha (Zashimuddin, 2003). The per capita consumption of fuelwood (0.1 m^3) in Bangladesh is one of the lowest in the world and there is a big shortfall of supply compared to demand, the balance of fuel wood requirement being met using farm-by products (Douglas, 1982; Ohlsson, 1984; Abedin and Quddus, 1989). Each year this supply and Demand gap is widening. It was estimated that there will be a net deficit of about 3.47 million m^3 of fuel wood by the year 2013 if the tree resources are not managed properly on a sustainable yield

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basis (Government of Bangladesh, 1993). The present forest system of Bangladesh is unable to meet the present demand of forest products for its people due to overexploitation of resources, destruction of forests by different agents and several other unavoidable factors there in. More over it is now known to all that there is no any scope of horizontal expansion of forest in Bangladesh rather the vertical expansion of forest offers a new dimension to the frustrated nation to ensure food security as well as fulfilling the demand of forest products. In fact this is agroforestry, which offers such type of multipurpose products to the users. Agroforestry is a landuse that combines both agriculture and forestry which significantly contribute to fulfill increasing demand of fuel wood, timber, fodder, cash and infrastructure in many developing countries (Solanki, 1998). Since there is neither scope for expanding forest area nor sole grain crop areas, farmers are leaning to develop combined production system integrating trees and crop. The components of Agroforestry utilize and share the resources of the environment. At the same time the growth and development of any of the components influence the others. Of the input resources light is the key factor for successful cultivation of rice in Agroforestry systems (Vitryakon *et al*., 1995). Miah (1999) reported that rice yield decreases linearly with the reduce percent of light incidence and at the same time pruning condition of associated trees increases yield. Moreover Different orientations of associated trees can also be an important factor in the production of agricultural crops in agroforestry system. In the northern part of Bangladesh *Dalbergia sissoo* and rice based agroforestry is relatively a new practice and due to its apparent good performance it has become a popular agroforestry pattern through out the Northern and South Western Bangladesh. Though it is getting popularity specific scientific result regarding the effect of different pruning intensity on the yield of rice is not available in Bangladesh. Keeping this view in mind, the present research has been undertaken to determine the effect of tree canopy volume (as obtained through pruning) and orientations on the yield and yield contributing characters of rice. This paper is an attempt to explore the effect of level of pruning on the yield and yield contributing characters of rice under eight years old Sissoo trees in farmers field.

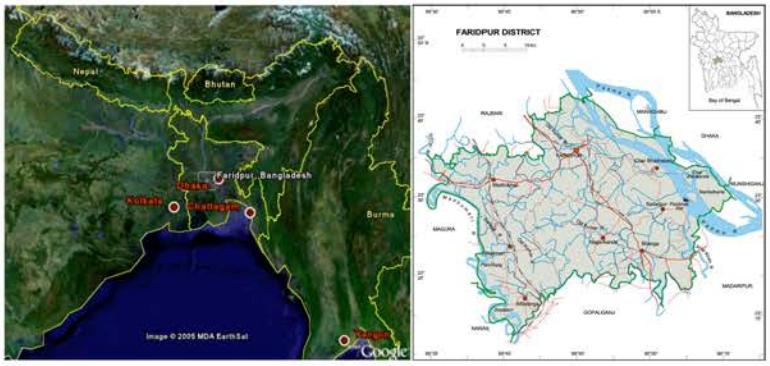
Materials and Methods

The experiment was conducted in the farmer's field at Kadirdi village of Boalmari Upazilla in Faridpur District of Bangladesh (Fig. 1A and B) during June to November, 2003. Geographically it is located at 24°75' North latitude and 90°50' East Longitude. The soil belongs to the agro-ecological zone of the Low Ganges Floodplain (AEZ-12). Soil pH of the experimental field was 7.8. The experiment was conducted by factorial experiment in a Randomized Complete Block Design (RCBD) with three replication involving four levels of pruning and four orientations using the recommended rate of fertilizer for rice (BRRI, 1999). The treatments are as follows:

Factor-1: Tree canopy volume after pruning
T_1: Severely pruned (2.83 m^2)
T_2: Moderately pruned (4.76 m^2)
T_3: Medium pruned (8.20 m^2)
T_4: Light pruned (14.15 m^2)
T_0: Control (open field)

Factor-2: Orientation (O)
O_O: Control (out side of the tree canopy)
O_W: West- 0.5 m from tree base
O_S: South- 0.5 m from tree base
O_N: North- 0.5 m from tree base
O_E: East- 0.5 m from tree base

Thirty two days old seedlings of BR11 rice were collected and two seedlings per hill were transplanted in the prepared main field. Four sampling area each of 1 m^2 were earmarked at the 0.5 m^2



A B

Fig. 1A: Map showing the study area (country side) (Source: Google earth, downloaded on 11.12.05)
B: Map showing the study area (Country along with the Upazilla) (Source: Banglapedia, downloaded on 11.12.05)

distance from the tree base in each association at south, north, east and west orientation. Data were recorded on plant height, number of effective tiller per hill, number of non-effective tiller per hill, number of grain per penicle, number of chapy grain, weight of 1000 grains and grain yield. Light intensity in each of the tree-rice associations was measured with the help of "Quantum Sensor". Three readings were taken from each orientation as well as in control plot and the values were averaged. Finally the collected data were analyzed following the appropriate design of the experiment. Duncan's Multiple Range Test (DMRT) was done to show the significance differences between the treatment means (Zaman *et al.*, 1982).

Results and Discussion

Plant Height

Plant height was significantly affected with the increasing of tree volume. Highest plant height (114 cm) was found in control (T_0) and among the pruned trees highest result (103.62 cm) was found in severely pruned tree while shortest plant height (96.27 cm) was observed under light prune tree (Table 1). In respect of orientation O_S (0.5 m south from tree base) produced tallest (103.51 cm) rice plant and shortest result (102.50 cm) was produced in O_N orientation (Table 2). The result showed that shade condition affected the plant height of rice which is in agreement of the result found by Vitryakon *et al.* (1995).

Effective Tillers per Hill

The production of mean number effective tillers per hill was significantly decreased with increasing the canopy volume of tree. Without any competition (absent of tree) control produced the highest (9.25) number of tiller per hill and in case of pruned trees highest average number of tiller per hill (7.44) was produced under severely pruned tree while lowest (6.06) was observed under light pruned tree (Table 1). Among the different orientation shade effect was severe in north orientation and it produced lowest (6.90) number of tiller per hill. On the other hand highest number of tiller (7.60)

Table 1: Effect of different tree canopy volume on the yield and yield contributing characters of rice

Treatments	Effective tillers/hill	Non-effective tillers/hill	Plant height (cm)	Panicle length (cm)	Grain /panicle	Chapy grain /panicle	'000'grain weight (g)	Yield (t ha^{-1})
T_0	9.25a	1.25e	114.00a	26.13a	103.60a	11.30e	25.30a	5.46a
T_1	7.44b	2.75d	103.62b	22.35b	80.50b	20.50d	24.63b	3.63b
T_2	7.03c	2.81c	100.80c	21.75c	74.76c	22.95c	24.28b	3.27c
T_3	6.63d	3.06b	99.24d	21.06d	68.90d	25.38b	23.79c	2.93d
T_4	6.06e	3.69a	96.27e	20.53e	63.04e	34.10a	23.49c	2.70d

was observed in west orientation (Table 2). This result is supportive to the findings of Nayak and Murty (1980) which reported that effective number of tillers per hill of rice was decreased due to low light.

Non-effective Tillers per Hill

Number of non-effective tiller per hill was significantly different under different canopy and orientations of Sissoo tree. Lowest number of non-effective tillers (1.25) was produced in control and among the different tree canopy volume the highest and lowest (3.69 and 2.75) result was observed under light and severely pruned tree canopy (Table 1). Regarding different orientations the lowest and highest number of non-effective tiller per hill (2.75 and 3.20) was produced under south and north orientation.

Panicle Length

The panicle length of rice (BR11) affected by different canopy volume of Sissoo tree and its different orientations. In open field (control) produced the longest (26.13 cm) panicle length and among the different canopy volume the highest and lowest result (22.35 and 20.53 cm) was observed under severely pruned and light pruned tree canopy (Table 1). In case of different orientations the shortest and tallest panicle length (22.02 and 22.65cm) was produced in north and south orientation (Table 2). This result is supportive to Park and Kwon (1975) where they reported that creating of shade condition during growing and ear-formation stage of rice gradually decreased the panicle length as well as decreased rice yield.

Number of Grain per Panicle

Different canopy volume and orientations of tree affected the number of grains per panicle. Highest number of grains (103.60) per panicle was produced in control and among the pruned trees the highest and lowest number of grains (80.50 and 63.04) were observed in association with severely and light pruned tree respectively (Table 1). Again in case of different orientations south orientation produced the highest number of grains (80.47) per panicle while lowest (73.41) was recorded in north orientation (Table 2). From the result it was revealed that with the decreasing of canopy volume and availability of light can significantly contribute to increase number of grains per panicle. North Orientation under light pruning tree received the highest shade and causing lowest number of grain per panicle. Similar result also found by Chaturvedi and Ingram (1989), who observed that pre-flowering shade, resulted in reduced grain per panicle in rice.

Number of Chapy Grain per Panicle

The number of chapy grain per panicle was also affected significantly by different canopy volume and orientations. In control (open field) produced lowest number (11.30) of chapy grains per panicle whereas under light pruned tree production of chapy grain was higher (34.10) in comparison with other

Table 2: Effect of different orientations on the yield and yield contributing characters of rice

Treatments	Effective tillers/hill	Non-effective tillers/hill	Plant height (cm)	Panicle length (cm)	Grain /panicle	Chapy grain /panicle	'000' grain weight (g)	Yield (t ha^{-1})
O_S	7.40ab	2.75b	103.51a	22.65a	80.47a	20.82c	24.47a	3.86a
O_N	6.90c	3.20a	102.50b	22.92ab	73.41d	27.60a	23.94b	3.20b
O_E	7.25b	2.60c	102.63b	22.49a	79.19c	21.92b	24.36a	3.56a
O_W	7.60a	2.30d	102.50b	22.02b	79.58b	21.04c	24.43a	3.75a

association (Table 1). Among the four orientations lowest number of chapy grains (20.82) per panicle was found in south orientation while the highest (27.60) was observed in north orientation (Table 2). Increased of chapy grain i.e. unfilled grain per panicle decrease total yield and the result showed that with the increased of canopy volume can significantly decrease rice yield.

Thousand (1000) Grain Weight

Thousand grain weight was also affected significantly with the availability of light i.e. penetration of sunlight to the ground. The open field showed highest 1000 grain weight and among the different pruned tree the highest and lowest 1000 grain weight (24.63g and 23.49g) was produced under severe and light pruned tree (Table 1). In case of four orientations the highest and lowest result (24.47 and 23.94g) was observed in south and north orientation (Table 2). Increasing of light intensity in tree-rice agroforestry system can ensure increasing 1000 grain weight of rice and the result was more or less similar to the finding of Alam *et al.* (2002).

Grain Yield

Different canopy volume of tree and orientations was affected grain yield of rice cv. BR11 significantly. Without any competition and maximum light availability open field (control) produced the best (5.46 t ha^{-1}) grain yield. Among the different canopy volume severely pruned tree produced highest (3.63 t ha^{-1}) grain yield while light pruned tree produced the lowest (2.70 t ha^{-1}) yield (Table 1). In respect of different orientations the highest grain yield (3.86 t ha^{-1}) was produced in south orientation, on the other hand lowest yield (3.20 t ha^{-1}) was produced in north orientation (Table 2). The result showed that light availability and distance from tree base positively related to the grain yield or rice. This finding is similar to the results found by Kudrjavcev, (1964), Binchy and Morgan (1970), Puri and Bangarwa, 1993 and Pandey *et al.* (1999),

Interaction Effect Between Tree Canopy Volume and Orientation on the Yield and Yield Contributing Characters of Rice

The result revealed that absent of tree species (without any interaction) control produced the highest number of effective tillers per hill, plant height, panicle length, number of grain per panicle, 1000 grain weight and grain yield while number of non-effective tillers per hill and number of chapy grain per panicle was the lowest. Among the different treatment combinations number of effective tillers per hill was highest (7.50) in T_1O_W and T_1O_S association while lowest result (5.50) was observed under T_4O_N association. Similarly the plant height, panicle length, grain per panicle, 1000 grain weight and grain yield was highest in T_1O_S (severely pruned tree × south 0.5 m distance from tree base) association while lowest in T_4O_N association. In case of non-effective tillers per hill and chapy grain per panicle was highest in T_4O_N and lowest in T_1O_W (Table 3).

Due to the severity of competition of natural resources between associated crop and tree, yield and yield contributing characters were found decreased significantly. From the above result it revealed that light has direct relationship with the performance of rice. The progressive decrease of

Table 3: Interaction effect between tree canopy and orientations on the yield and yield contributing characters of rice

Treatments	Effective tillers/hill	Non-effective tillers/hill	Plant height (cm)	Panicle length (cm)	Grain /panicle	Chapy grain	'000' grain weight (g)	Yield (t ha^{-1})
T_0O_S	9.25a	1.25j	114.00a	26.13a	103.60a	11.30l	25.30a	5.46a
T_0O_N	9.25a	1.25j	114.00a	26.13a	103.60a	11.30l	25.30a	5.46a
T_0O_E	9.25a	1.25j	114.00a	26.13a	103.60a	11.30l	25.30a	5.46a
T_0O_W	9.25a	1.25j	114.00a	26.13a	103.60a	11.30l	25.30a	5.46a
T_1O_S	7.75b	2.75f	105.00b	22.96b	81.00d	18.10j	24.55abc	3.84b
T_1O_N	7.00cde	3.50c	103.96c	22.25bc	73.40h	26.60f	24.35a-d	3.10b-f
T_1O_E	7.50c	2.50g	103.20cd	22.45bc	82.90c	20.10i	24.90ab	3.75bc
T_1O_W	7.50bc	2.25h	102.20de	21.75c-f	84.70b	17.20k	24.70abc	3.83b
T_2O_S	7.25bcd	3.00e	100.65f	22.02b	78.90e	21.85h	24.42a-d	3.36-e
T_2O_N	6.50efg	3.00c	100.33fg	21.90cde	69.00k	28.70e	23.75cde	2.75efg
T_2O_E	7.00cde	2.75f	101.90e	21.93cd	75.05g	21.23h	24.55abc	3.34-e
T_2O_W	7.50bc	2.00i	100.32fg	21.15def	76.10f	20.00i	24.38a-d	3.62bcd
T_3O_S	6.75def	3.25d	99.57fgh	21.15def	72.55i	23.25g	24.10b-e	3.36be
T_3O_N	6.25fg	3.75b	99.51gh	21.06ef	63.80n	32.10c	23.15c	2.43fg
T_3O_E	6.25fg	2.75f	98.65hi	21.05ef	69.30k	22.85g	23.95b-e	2.88d-e
T_3O_W	7.25bcd	2.50g	99.24ghi	20.96f	69.96j	23.30g	23.97b-e	3.02c-g
T_4O_S	6.25fg	3.50c	98.20i	21.00f	66.30l	29.60d	23.86b-e	3.30b-e
T_4O_N	5.50h	4.00a	94.60k	20.12g	57.25o	39.30a	23.17e	2.25g
T_4O_E	6.00gh	3.75b	95.38k	20.88fg	65.10m	34.10b	23.46de	2.35fg
T_4O_W	6.50efg	3.50c	96.88j	20.10g	63.52n	33.40b	23.46de	2.84d-g

▪ In a column, figures with the same letters do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT).

light intensity correspondingly reduced the growth and yield attributing parameters of rice (Ravi *et al.*, 2001). Lower grain yields under shade was due to the cumulative effect of reduction in the numbers of effectives tillers hill^{-1}, number of grain panicle^{-1} and 1000-grain weight, reported by Jadav (1987) and Chaturvedi and Ingram (1989). In Bangladesh condition out of different orientations South-East received the better light than in North-West orientation and consequentially South-East produced the better yield compare to North-West orientation (Abdullah, 2004). Rice production in tree-rice Agroforestry system was influenced greatly due to the canopy structure (obtained by pruning) of tree species and suggested that more light penetrating canopy size is best for rice cultivation (Samsuzzaman *et al*., 2002). For successful cultivation of rice under tree canopy, orientation and the selection of canopy size with distance from tree base is very important. While practicing Rice and sissoo based agroforestry system farmers can go for pruning to have an intermediate benefit as well as support the best rice production but the intensity should be high in the north east orientation compared to others. Side by side more intensive and long term on farm research should be taken to determine the optimum pruning intensity for different combination of agroforestry in Bangladesh.

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