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RESEARCH ARTICLE

Performance of multipurpose trees and field crops under different management practices in an agroforestry system

K.C. Roy[1], M.S. Zaman[1], M.A. Salam[2], M.S. Bari[3*] and M.F. Hossain[4]

[1] *Rangpur Dinajpur Rural Service (RDRS), Rangpur, Bangladesh.*
[2] *On-Farm Research Division, Barind Station, Bangladesh Agricultural Research Institute (BARI), Rajshahi, Bangladesh.*
[3] *Department of Agroforestry, Hajee Mohammad Danesh Science & Technology University (HSTU), Dinajpur, Bangladesh.*
[4] *Department of Agronomy, Hajee Mohammad Danesh Science & Technology University (HSTU), Dinajpur, Bangladesh.*

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Abstract: Studies were conducted to evaluate crop yield and tree growth as affected by tree species and pruning managements in an agroforestry system. Three multipurpose tree species (*Albizia lebbek, Eucalyptus camaldulensis* and *Melia azedarach*) and five management practices involving three pruning managements (Root pruned, Shoot pruned and Root+shoot pruned), one unpruned treatment (control) and open field (no tree but crop only) were used. Results indicated that biomass yield (t ha^{-1}) of wheat was significantly superior in *M. azedarach* plot over other two species. But grain and straw yields (t ha^{-1}) of rice were significantly higher in *E. camaldulensis* plot compared to other two species. *A. lebbek* plot produced lower yield for both crops. Crop yield (grain and straw) of wheat was significantly superior in root plus shoot pruned plot than those in other pruning managements. Open field showed better yield performance than that of root and shoot pruned. Comparative study of three tree species showed that *E. camaldulensis* attained significantly the highest height and breast diameter growth while *A. lebbek* showed the highest fuel wood and green leaves. The overall results imply that *M. azedarach* can be compatible with wheat and *E. camaldulensis* with rice under irrigated conditions if both roots and shoots are pruned periodically and green biomass is incorporated into soils.

Key words: Biomass, breast diameter, height, management, multipurpose, pruning, yield

INTRODUCTION

Agroforestry is an ancient practice and now it is becoming an integral part of the traditional farming systems in Bangladesh. Various authors have defined agroforestry in different ways. As a science, agroforestry is the study of interaction between woody vegetation and other animals and/or crop. According to ICRAF "Agroforestry is a practice where woody perennials are deliberately grown on the same land management unit with agricultural crops and or animals in some form of spatial mixture or in temporal sequence".[1]

The present national forest cover in Bangladesh is only 5.4%[2], which is far below the critical level (25%). Due to rapid growth of population, there is a tremendous pressure on the forest lands. About 7,300 ha of forest were cleared for agricultural lands, aquaculture, homesteads and other purposes. Annual deforestation rate is estimated to be 8,000 ha.[3] Village forest mainly covered by homesteads accounts only for 0.27 million ha. Out of 64 districts, 28 districts have no public forest land.[4] Fuel wood, which accounts for about 90% of rural energy consumption in developing countries,[5] is becoming a scarce source. Fuel shortage in Bangladesh has led to increasing use of cowdung and agricultural residues causing loss of soil fertility and crop yield.[6] There is pressing need to develop a system of land management that allows sustainable levels of food production while maintaining soil fertility and providing reasonable supply of fuel wood .

Shading by trees is believed to be responsible for poor yields of associated crops. This problem is more acute when the tree remains unpruned. Alley cropping agroforestry system has emerged as a sound technology, where tree canopies are periodically pruned to prevent shading the companion crops.[7] A substantial improvement in crop yield in forestry systems was reported where tree prunings were used as mulch or as green manure.[8] However, not much information is available in local context. Thus, an experiment was undertaken to study the performance of three multipurpose tree species and two crops (rice and wheat) under different management practices.

METHODS AND MATERIALS

The field experiment was conducted at Sainagar, Dinajpur during the period from October 1995 to November 1996 utilizing three 8-year old multipurpose tree species under highland irrigated conditions. The experimental area was highland with sandy loam soils belonging to the Sonatola series of Tista flood plain soil

* Corresponding author

under Agro Ecological zone 3.[9] The experiment was laid out in a factorial Randomized Complete Block Design with three replications. The factor A consisted of three multipurpose tree species 1. *Albizia lebbek*, 2. *Eucalyptus camaldulensis* and 3. *Melia azedarach* and factor B consisted of 5 management practices including three pruning management methods: 1. Root pruned 2. Shoot pruned 3. Root+shoot pruned, 4. One unpruned treatment (control) and 5. Open field (No tree but only crop). The open fields were free of shading effect of the tree species. All plots including the control were cultivated with wheat – rice cropping pattern.

Tree and crop establishment: The tree species were established during 1987 in Sainagar, Dinajpur by the Community Development Association (CDA - a local NGO) under funding of Swiss Development Cooperation (SDC). The trees were planted at a spacing of 8 x 8 m^2 followed by Randomized Complete Block Design. The land was prepared by ploughing and harrowing five times by country plough and harrow, respectively. Wheat (Var. *Kanchan*) seeds were broadcasted at 120 kg ha^{-1} on 10 November 1995. Fertilizers were applied at the rate of 100-80-60 kg N, P and K ha^{-1}. During land preparation, 50 kg N and all the P and K were applied. After 20 days the rest of the N was applied. The rice (Var. BR-11) seedlings were transplanted at the onset of rains on 15 August 1996. Seedlings were planted in rows 25 cm apart. Wheat and rice were harvested immediately after the physiological maturity during late March and mid November, respectively.

Tree pruning: Pruning (root and shoot) of the trees was done 3 wks before seeding of wheat and transplanting rice. The pruned materials were separated into leaves and branches. The leaves were uniformly placed over the land and branches were chopped and incorporated into the soil by ploughing.

Data Collection: First and second set of data of tree height and diameter were collected on 30 October 1995 and 30 October 1996, respectively. The tree height was measured by a Clinometer. Base diameter of the tree was measured at 0.3 m above the ground level and breast diameter was measured at 1.3 m above the ground level. Pruned old twigs and branches per plant were sun dried and weighed at 14% moisture content before using as fuelwood. Pruned green leaves per plant were also weighed before using as green manure. Grain and straw yields of rice and wheat were recorded from the crop cut of square meter. These yields were converted to get the ton per hectare.

RESULTS AND DISCUSSION

Crop yield as affected by tree species

Wheat: Grain and straw yields of wheat were significantly influenced by tree species (Table 1). The highest grain (3.27 t ha^{-1}) and straw (3.82 t ha^{-1}) yields were obtained from plots with *M. azedarach* and lowest grain (2.57 t ha^{-1}) and straw (2.86 t ha^{-1}) yields were obtained from the plot with *A. lebbek*. This significant yield reduction in wheat as affected by the tree species could be due to differences in the degree of their shading effect. Light and incorporating leaves may have increased yield on a field area basis. Similar results were observed by many scientists.[10-12]

Table 1: Crop yield (t ha^{-1}) as affected by tree species

Tree species	Wheat		Rice	
	Grain	Straw	Grain	Straw
Albizia lebbek	2.57 c	2.86 c	2.76 c	3.20 c
Eucalyptus camaldulensis	2.79 b	3.06 b	3.29 a	3.71 a
Melia azedarach	3.27 a	3.82 a	3.00 b	3.43 b
CV (%)	5.0	4.2	2.7	3.5
Level of significance	**	**	**	**

** = Significant at 1% level.
Values followed by dissimilar letters in a column differ significantly, as per DMRT.

Rice: Grain and straw yields of rice were significantly affected by tree species (Table 1). The highest grain (3.29 t ha^{-1}) and straw (3.71 t ha^{-1}) yields were obtained from *E. camaldulensis* plot and the lowest grain (2.76 t ha^{-1}) and straw (3.20 t ha^{-1}) yields were obtained from *A. lebbek* plot. This dominance of *E. camaldulensis* over *A. lebbek* in rice may be attributed to the closed canopy of *A. lebbek* compared to that of *E. camaldulensis* c, which provides less shading. According to previous work, shading was responsible for suppression of rice yield[10,13] and partial shading (45-50% of normal light) 15 days after transplanting reduced the grain yield of rice.[13]

Crop yield as affected by pruning managements

Pruning management significantly influenced grain and straw yields of rice and wheat (Table 2).The results showed that pruning had a significant yield advantage.

The open field without trees produced the highest wheat grain (3.29 t ha^{-1}) and straw (3.67 t ha^{-1}) yields while unpruned plot produced the lowest grain (2.24 t ha^{-1}) and straw (2.62 t ha^{-1}) yields. Root plus shoot pruning produced grain (3.14 t ha^{-1}) and straw (3.49 t ha^{-1}), which was in par with those of open field and shoot pruned treatments.

Similar to wheat, the highest grain (3.34 t ha^{-1}) and straw (3.86 t ha^{-1}) yields of rice were obtained from the open field plot while the lowest was from the unpruned plot (2.54 t ha^{-1} and 2.98 t ha^{-1}, grain & straw yield, respectively). Root plus shoot pruned treatment showed

a significant improvement in grain yield (3.25 t ha^{-1}) compared to the shoot pruning (3.10 t ha^{-1}) and root pruning treatments (2.78 t ha^{-1}). A substantial improvement in crop yields in the agroforestry system was reported, where tree pruning was used as mulch or green manure. It has also been found that incorporating pruned plant materials increased upland rice yield by 25-30% on a field area basis.[6,8,15,16]

In wheat and rice (seasons), root plus shoot pruning of trees was found better in increasing crop yield compared to other pruning managements due to reduction of above ground competition (light) by shoot pruning and below-ground competition (water nutrient) by root pruning. These findings were in agreement with that of Hughes and Edwards.[16]

Table 2: Crop yields (t ha^{-1}) as affected by pruning managements

Pruning management	Wheat		Rice	
	Grain	Straw	Grain	Straw
Root pruned	2.69 c	3.12 c	2.78 d	3.21 c
Shoot pruned	2.97 b	3.38 b	3.10 c	3.54 b
Root + Shoot pruned	3.14 ab	3.49 ab	3.25 b	3.66 b
Unpruned	2.29 d	2.62 d	2.54 e	2.98 d
Open field	3.29 a	3.67 a	3.43 a	3.86 a
CV (%)	5.0	4.2	2.7	3.5
Level of significance	**	**	**	**

** = Significant at 1% level.
Values followed by dissimilar letters in a column differ significantly, as per DMRT.

Performance of multipurpose tree species

The height and lateral growth (base diameter and breast diameter growth) of the three multipurpose tree species showed significant differences among the species as affected by pruning managements (Table 3). Among the three species, *E. camaldulensis* showed a superior height growth to that of other species with the different pruning managements. The lowest performer was *A. lebbek*. Among the different pruning managements, the highest tree height growth was obtained from shoot pruned plot and the lowest in root pruned plot for each tree species. No significant difference was observed between the unpruned and the root plus shoot pruned treatments with all tree species. This result indicates that shoot pruning enhanced the apical growth possibly because of the reduction of parasitic leaves and branches caused by partial shading of the canopy which eventually might have helped the proper utilization of assimilates for structural growth. These findings are in agreement with previous studies.[15]

No significant difference was observed in increase in base diameter of all the tree species indicating the effect of pruning .The breast diameter (at 130 cm from the ground) growth was significantly influenced by tree species and pruning managements, and *E. camaldulensis* performed better than the other two species. There was no significant difference between *A. lebbek* and *M. azedarach*. Shoot pruned trees of all species showed a significant increase in breast diameter compared to other pruning managements

Root plus shoot pruned trees showed significantly better performance in breast diameter growth than the root pruned and unpruned. There was no significant difference in breast diameter between root pruned and unpruned treatments. These results confirm the findings of Miah[12] who observed a significant effect of tree species and pruning managements on breast diameter.

Fuelwood

Fuelwood (kg $plant^{-1}$) was significantly affected by tree species and pruning managements (Table 4). *A. lebbek* produced significantly higher fuel wood (1.78-12.68 kg $tree^{-1}$) than the other species. *E. camaldulensis* produced lower amount fuelwood (1.11 – 6.85 kg $tree^{-1}$) when pruned before both the wheat and rice cultivation.

Among the pruning managements, root plus shoot pruned trees gave significantly higher amount of fuelwood than that of other two pruning managements with both *A. lebbek* and *M. azedarach* before wheat while the former treatment was in par with shoot pruning before rice. In *E. camaldulensis*, shoot pruning yielded similar amounts of fuel wood to that of root plus shoot pruned treatment before both wheat and rice. Root pruning had significantly lowered yield of fuel wood (1.11-2.2 kg $tree^{-1}$) with all the tree species before both wheat and rice.

Pruned green leaves

Amount of pruned green leaves (kg $plant^{-1}$) was determined by tree species (Table 5). *A. lebbek* performed better in pruned green leaves than the other two species, and *E. camaldulensis* produced the lowest pruned green leaves before both the wheat and rice cultivation. Miah observed that differences in leaf dry biomass among the tree species varied significantly at all sampling dates. Many researchers reported that pruned green leaves increased organic matter in the soil and it helped to increase grain yield.[8,10,19,20]

CONCLUSION

The overall results imply that *M. azedarach* can be compatible with wheat and *E. Camaldulensis* with rice under irrigated conditions if both roots and shoots are pruned periodically and green leaf biomass is incorporated into soils before wheat and rice cultivation.

Table 3: Effect of pruning managements on tree height, base diameter and breast diameter of different tree species.

Tree species	Pruning management	Increase in tree height (cm yr^{-1})	Increase in base diameter (cm yr^{-1})	Increase in breast diameter (cm yr^{-1})
Albizia lebbek	Root pruned	10.16 g	1.59	1.16 de
	Shoot pruned	20.26 e	3.50	2.44 b
	Root + Shoot pruned	15.75 f	2.44	1.80 e
	Unpruned	13.72 fg	1.70	1.48 d
Eucalyptus camaldulensis	Root pruned	35.15 c	1.59	1.48 cd
	Shoot pruned	53.14 a	3.82	3.61 a
	Root + Shoot pruned	41.35 b	2.65	2.44 b
	Unpruned	43.89 b	1.80	1.48 cd
Melia azedarach	Root pruned	16.05 f	1.16	0.85 e
	Shoot pruned	33.02 c	3.39	2.86 b
	Root + Shoot pruned	26.42 d	2.34	1.49 cd
	Unpruned	22.86 de	1.27	1.06 de
CV (%)		4.1	11.1	12.1
Level of significance		**	NS	*

** and * = Significant at 1% and 5% level.
NS = Not significant
Values followed by dissimilar letters in a column differ significantly, as per DMRT.

Table 4: Effect of pruning managements of fuelwood (kg $plant^{-1}$) of different tree species.

Tree species	Pruning management	Fuelwood	
		Before wheat	Before rice
Albizia lebbek	Root pruned	2.2 e	1.78 e
	Shoot pruned	11.07 b	8.80 ab
	Root + Shoot pruned	12.68 a	10.03 a
Eucalyptus camaldulensis	Root pruned	1.3 e	1.11 e
	Shoot pruned	5.83 d	4.67 c
	Root + Shoot pruned	6.85 cd	5.48 d
Melia azedarach	Root pruned	1.92 e	1.5 e
	Shoot pruned	8.02 c	7.05 c
	Root + Shoot pruned	9.78 b	7.88 bc
CV%	8.7	12.1	
Level of significance	**	**	

** = Significant at 1% level.
Values followed by dissimilar letters in a column differ significantly, as per DMRT.

Table 5: Pruned green leaves (kg plant^{-1}) as affected tree species (Average over pruning management).

Tree species	Pruned green leaves	
	Before wheat	Before rice
Albizia lebbek	4.51 a	3.85 a
Eucalyptus camaldulensis	2.51 c	2.05 c
Melia azedarach	3.48 b	2.80 b
CV (%)	8.5	8.8
Level of significance	**	**

** = Significant at 1% level.

Values followed by dissimilar letters in a column differ significantly, as per DMRT.

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