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Assessment of yield losses in rainfed rice due to weed competition under different pruning intensity of *Dalbergia sissoo* based Agroforestry system

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Abstract
A field experiment was carried out at Agroforestry research farm, Department of Forestry, JNKVV, Jabalpur, Madhya Pradesh, to assess the yield losses in rainfed rice due to weed competition under different pruning intensity of *Dalbergia sissoo* based Agroforestry system. Rice performance in an agroforestry system with four pruning regimes (light (25%), moderate (50%), heavy (75%), and no pruning) were compared with rice grown in open condition and four weed management treatments (W_1: Pendimethalin@ 1.0 lit/ha as PE, W_2: Pendimethalin@ 1.0 lit/ha as PE *fb* Bispyribac sodium @ 25 g/ha PoE, W_3: Two hand weeding at 30 and 60 DAS and W_4: Weedy check). These treatments were arranged in a strip plot design replicated thrice. Results of study reveal that the maximum plant height (80.4 cm), effective tillers per metre row length (315), length of the panicale (25.4 cm) grain and straw yields (39.2 and 74.3 q ha^{-1}), respectively were observed under heavy pruning (75%) which was significantly at par with moderate pruning. (50%). The lowest yields of grain and straw were found under light pruning as well as no pruning. When compared with open condition (solitary rice), heavy, moderate, light, and no pruning treatments each reduced rice grain yield by 19%, 25%, 36%, and 39 percent, respectively. Weed management practises significantly increased rice yield and yield contributing factors when compared to weedy check plot.

Keywords: Dalbergia sissoo, rice, agroforestry, pruning intensities, weed management

Introduction
Rice (*Oryza sativa*) is the most widely consumed staple food for large part of the world's human population. It is an important cereal crop in Asia and it provides 80% of total calorie intake. In India, rice is grown on 43.8 million ha area and having production of 120 million tonnes (Statista, 2020). The food grain production in India has been doubled during the past green revolution period without increasing the net cultivated area. This marvellous achievement is mainly due to increased better agronomical management practices like proper sowing, management of weed as well as balanced nutrition.

Dalbergia sissoo is the medium to large sizes tree belonging to family Leguminosae and sub family Papillionoideae. It attains a height up to 30 m. Pruning is a common silvicultural practice to increase wood production, improve tree shape and potentially uses to obtain poles and fire wood without decrease in wood productivity. Pruning of tree component is a powerful approach to regulate light, nutrient, and other resource competition (Frank and Eduao, 2003, Dhillon *et al*., 2010) [5]. Many scientists reported that pruning improves wood quality and tree stem shape. Pruning decreased the tree taper and increase the volume. Pruning become an essential practice for reducing both above and below ground competition with associated crop (Bari and Rahim, 2010) [1]. The Agri silviculture (tree + crop) system proved more productive and sustainable than agriculture.

Due to increase in population of human and cattle, there is increasing demand for food as well as fodder, particularly in developing countries like India. The reliability of agroforestry is increasing with more practice and research. Farmers across the globe are discovering ways in which trees and polyculture can replace monoculture so as to make their land more sustainable and productive. Trees are natural part of almost every ecosystem and so it makes sense to incorporate them in agriculture to maintain a healthy environment. It also help to keep the costs low and make the land more productive. Chundawat and Gautam, 1993 [4] reported that some time tree shade gives positive impact on growth and grain yield of intercrops and also increase nutrients level of soil.

Materials and Methods

Field experiment was set up in the Agroforestry Research Farm, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP), located at 23º 12' 50" North latitude and 79º 57' 56" east longitude. The climate of the area is subtropical and sub humid with hot and dry summer and cool dry winter. As per the NAR Project of ICAR, New Delhi, it is designed as the "Kymore Plateau and Satpura hill" agroclimatic zone. It has been classified as Agroecological Region 10, Central high lands (Malwa and Bundelkhand and sub region no. 10.1) Hot sub humid eco region. Jabalpur receives 1000 to 1500 mm of rainfall annually. The majority of rainfall occurs from mid- June to end of September with sporadic rain occurring during the rest of year.

The experiment was carried out in a Dalbergia sissoo Agroforestry system that had been place in. Which was planted in 1998 with a 5m x 5m planting geometry. After a well-established crown had grown, trees were subjected to four distinct pruning regimes based on their overall height. This model has been intercropped with paddy in Kharif every year. Study was carried out to determine the impact of various pruning regimes and weed control treatments on rice productivity and yield contributing traits. Rice variety MTU 1010 was sown at 20 cm row intervals. Treatments were arranged in a strip plot design, with five main plot treatments: (0% pruning, 25% pruning, 50% pruning, 75% pruning, and open condition and four weed management practices (W1: Pendimethalin at 1.0 kg a.i. ha^{-1} at 3 days after sowing. W2: Pendimethalin at 1 kg ha^{-1} at 3 days after sowing followed by Bispyribac sodium. W3: hand weeding at 30 and 60 DAS, W4 weedy check) put under sub plots. Each treatment combination replicated five times. Data pertaining to growth and yields of crop gathered and was subjected to statistical analysis of variance, as Gomez and Gomez (1984) suggested.

Result and Discussion

Growth and yield attributes

Significant differences were observed among pruning intensities for growth and yield attributes (Table-1). Increasing pruning intensity increase height of rice crop and significantly highest plant height of 79.9 cm was record under 75% pruning which was statistically superior over no pruning but at par to 25% (75.4 cm), 50% (77.2 cm) and open conditions (81.6 cm).

The significantly longer panicale (23.6 cm) number of panicales (3.2g) were observed under 75% pruning. However, numerically higher values were recorded under open but statically at par to 75% with respect to panicale weight. The grains per panicle as well as test weight of rice crop did not change significantly due to change of pruning intensity. Number of grains ranging from 71.9 to 73.8/panicle were recorded The test weight possessed the weight of 22.9 to 23.4g from no pruning to open conditions but variations were non-significant.

Among the herbicidal treatments, growth parameters and yield attributes significantly change due to herbicide application. Hand weeding treatment proved its superiority over herbicidal treatments with respect to plant height but in case of yield attributes it found to be at par with Pendimethalin + bispyribac sodium Furthermore, each herbicidal treatment and hand weeding proved superior over weedy plots with respect to growth and yield attributes. Parallel results have been reported by Patel *et al*., 2017, Kar *et al*., (2022) [9, 7]

Yield

Different pruning levels and herbicides treatments exert significant effect on yields of rice (Table-2), data presented in Table-2 showed that grain and straw yield of rice significantly increased due to increasing of pruning intensity and the highest grain (35.60kg / ha) and straw (70.40 q / ha) yields were recorded under 75% pruning which was statistically at par to open. The significantly lowest yields of grains (21.90 q/ ha) and straw (60.20 q/ ha) were recorded under without pruning of Dalbergia sissoo. Moreover, harvest index of rice crop increased with increasing pruning intensity hence highest index of harvest (33.4 %) was observe under 75% pruning, however open condition surpasses all the pruning intensities.

On the other hand, under weedicidal treatments, hand weeding proved it superiority over other treatments for grain, straw yields and harvest index. Among the weedicide, sequential application of pendimethalin as PE followed by bispyribac sodium as per PoE proved effective with respect to suppression and killing of weeds. These treatments produced 34.1, 70.5 q / ha and 32.3% grain and straw yields as well as Harvest index, respectively. Higher the harvest index means higher the production of grain and reduction of total biomass. These results are in close conformity with those of Upadhyaya and Nema (2003) [12], Singh *et al*., (2020) [11], Ganesha *et al*., (2022) [6]

Economics

The parameters with respect to cost of cultivation, gross monetary returns, net monetary returns and returns per rupee investment (B: C ratio) were calculated and presented in Table- 3. The highest net returns of RS. 46064.15/ ha was obtained under open condition with benefit cost ratio of 2.34. Among the pruning intensities, 75% pruning secured Rs. 27267.33/ha as net returns with B: C ratio of 1.68. This inferred that 75% pruning is recommended for getting higher return/ ha. Similar findings were reported by Nayak *et al*., (2014) [8], Sahu *et al*., (2014)

Conclusion

On the basis two years of experimentation, it is concluded that pruning of Dalbergia sissoo without pruning, 25% pruning, 50% pruning and 75% pruning gradually recorded the yield losses and record the loss in yield of 39, 36, 25 and 19 % over open condition. Among all herbicide treatments, it was determined that the application of Pendimethalin @ 1.0 lit/ha as PE at 3 DAS + Bispyribac sodium @ 25 g/ha PoE at 25 DAS was acceptable for the effective control of broad-leaved weeds in rainfed agro-ecosystems. Pendimethalin @ 1.0 lit/ha as PE at 3 DAS + Bispyribac sodium @ 25 g/ha PoE at 25 DAS produced the greatest values of growth metrics and yield attribution under irrigated and rainfed rice. W1 – Pendimethalin @ 1.0 lit/ha as PE at 3 DAS acquired minimum values of growth metrics and yield-attributing attributes in rice fields but superior to weedy plots.

Table 1: Influence of pruning intensities and herbicidal treatments on growth and yield attributes of rice under rainfed low land (pooled data of 2 year)

Treatments	Plant height	No. of effective tillers /mrl	Panicale length (cm)	Panicale weight (g)	No. of Grain Panicale	1000 grain weight (g)
Pruning intensity						
P0 - 0 % Prunning	74.0	234.9	21.6	1.8	71.9	22.9
P1 – 25% Prunning	75.4	256.3	22.4	2.3	73.3	23.1
P2 – 50% Prunning	77.2	274.6	23.6	2.8	73.4	23.2
P3 – 75% Prunning	79.9	300.9	23.6	3.2	73.5	23.3
Open	81.6	315.4	24.4	4.0	73.8	23.4
SEm ±	1.65	11.08	0.70	0.25	0.36	0.43
C.D. at 5 %	5.25	34.5	2.08	0.74	NS	NS
Herbicidal treatment						
W1 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS	75.9	272.9	23.2	2.6	72.5	21.2
W2 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS + Bispyribac sodium@25 g/ha PoE at 25 DAS	77.2	289.7	23.7	3.0	73.2	23.1
W3 – Hand weeding@ 30 and 60 DAS	80.4	305.1	25.4	3.4	75.6	23.8
W4 – Weedy check	74.5	237.9	19.9	2.0	66.2	18.6
SEm ±	1.25	5.09	0.68	0.28	0.99	1.03
C.D. at 5 %	3.80	15.3	2.05	0.79	3.01	3.15

Table 2: Effect of different pruning intensity and weed control treatment on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index (%) in direct seeded rice and sissoo based agroforestry system.

Treatment	grain yield (q ha^{-1})			straw yield (q ha^{-1})			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Pruning intensity									
P0 - 0 % Pruning	23.9	20.0	21.9	62.2	58.2	60.2	27.5	25.3	26.4
P1 – 25% Pruning	31.4	28.4	29.9	66.8	61.9	64.3	31.7	31.3	31.5
P2 – 50% Pruning	34.4	31.8	33.1	69.2	65.4	67.3	33.0	32.5	32.7
P3 – 75% Pruning	37.6	33.6	35.6	72.6	68.1	70.4	33.9	32.8	33.4
Open (sole crop)	40.8	36.6	38.7	76.1	72.2	74.2	34.8	33.5	34.1
SE(m)±	2.05	1.06	1.75	5.2	3.7	5.8	1.31	1.36	1.37
C.D. at 5 %	6.12	3.19	5.25	15.7	12.8	17.4	3.9	4.16	4.12
Herbicidal treatment									
W1 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS	31.2	27.5	29.4	68.2	63.0	65.6	31.2	30.1	30.6
W2 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS + Bispyribac sodium@25 g/ha PoE at 25 DAS	36.3	32.0	34.1	73.4	67.6	70.5	32.7	31.8	32.3
W3 – Hand weeding@ 30 and 60 DAS	41.2	37.2	39.2	77.2	71.5	74.3	34.6	34.0	34.3
W4 – Weedy check	25.7	23.7	24.7	58.7	58.5	58.6	30.1	28.5	29.3
SE(m)±	1.06	1.40	1.21	2.8	1.83	1.56	1.23	1.12	1.13
C.D. at 5 %	3.20	4.2	3.65	8.2	5.5	4.7	3.66	3.39	3.46

Table 3: Effect of various herbicidal and weed control treatments on cost of cultivation and gross monetary return and net monetary return with B:C Ratio

Treatment	Total Cost of cultivation Rs./ha			Gross monetary return Rs./ha			Net monetary return Rs./ha			B:C Ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
Pruning intensity												
P0 - 0 % Pruning	33437.50	33475.00	33437.50	44122.50	38087.23	41104.86	10722.50	4612.23	7667.36	1.31	1.13	1.22
P1 – 25% Pruning	37437.50	37475.00	37437.50	58090.00	54052.78	56071.39	20690.00	16577.78	18633.89	1.54	1.43	1.49
P2 – 50% Pruning	38187.50	38225.00	38187.50	63640.00	60518.10	62079.05	25490.00	22293.10	23891.55	1.66	1.57	1.62
P3 – 75% Pruning	39437.50	39475.00	39437.50	69467.50	63942.15	66704.83	30067.50	24467.15	27267.33	1.75	1.61	1.68
Open (without tree)	33437.50	33475.00	33437.50	89355.00	69648.30	79501.65	55955.00	36173.30	46064.15	2.61	2.07	2.34
Herbicidal treatment												
W1 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS	34750.00	34800.00	34750.00	57794.00	52344.50	55069.25	23094.00	17544.50	20319.25	1.67	1.50	1.59
W2 – Pendimethalin@ 1.0 lit/ha as PE at 3 DAS + Bispyribac sodium@25 g/ha PoE at 25 DAS	35500.00	35600.00	35500.00	67118.00	60825.40	63971.70	31718.00	25225.40	28471.70	1.90	1.71	1.80
W3 – Hand weeding@ 30 and 60 DAS	41300.00	41300.00	41300.00	87357.00	70787.25	79072.13	46057.00	29487.25	37772.13	2.14	1.71	1.93
W4 – Weedy check	34000.00	34000.00	34000.00	47471.00	45041.69	46256.35	13471.00	11041.69	12256.35	1.40	1.33	1.36

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