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COMPARATIVE GROWTH ANALYSIS AND YIELD PERFORMANCE GLYCINE MAX UNDER JATROPHA CURCAS BASED AGRISILVICULTU SYSTEM OF AGROFORESTRY IN THE NORTHERN PART OF BANGLADESH

Niamjit Das[1]
[1]*Department of Forestry and Environmental Science, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology, Sylhet, Bangladesh*

ABSTRACT
This research was conducted at the Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University to quantify the effects of pruning height in Jatropha curcas L. (Jatropha) and fertility levels of the recommended dose of NPK in Glycine max L. (Soybean) on crop growth parameters and yield in the agrisilviculture system of Agroforestry. The pruning in Jatropha and fertility level favored growth parameters with varying magnitudes. Six growth indices like CGR, RGR, NAR, LAI, RLGR, and SLW were observed to be higher under various pruning heights and reduced under no pruning. After that, scale of yield varied with pruning heights and fertility levels. Grain, straw and biological yield of 100 cm pruning height in Jatropha increased by 15.38 %, 13.74 % and 14.61 % respectively in comparison to sole crop and other pruning height level. At that time, I showed that these three yields of 100 % of the recommended dose of NPK (100 % RDF) in Soybean are comparatively higher than other fertility level. Hence, proper pruning system and optimum fertility level are important for improving Soybean yield under Jatropha based agrisilviculture system and it ensures higher income to the farmers and efficient land management compared to its sole cropping.

Keywords: Growth indices, Pruning heights, Fertility levels, Glycine max, Jatropha curcas, Agrisilviculture.

Contribution/ Originality:

This study is one of very few studies that are important for improving Soybean yield under Jatropha based agrisilviculture system than in sole cropping systems and it has the potential to develop the socioeconomic conditions of farmers.

1. INTRODUCTION

Among the different Agroforestry systems, agrisilviculture is the most widely used systems practiced in tropical and sub-tropical countries. Agrisilviculture is a production technique which

† Corresponding author

combines the growing of agricultural crops with simultaneously raised and protected forest crops. As a form of land use, it aims at an integrated use of the available land resource to obtain a maximum amount of goods and services. Jatropha (*Jatropha curcas* L.) is a small oil seed tree/shrub of the family euphorbiaceae having its versatile utility and it is also called as physic nut or purging nut. Jatropha grows under (sub) tropical conditions and can withstand conditions of severe drought [1] and low soil fertility. After that, it is capable of growing in marginal soil, it can also help to reclaim problematic lands and restore eroded areas [2]. Jatropha can be used by hedge around meadows and afforestation areas and as a pioneer species to prevent soil erosion [3]. It has a good potential for cultivation in wide agro-climatic conditions. Once established, it gives a long term economic returns, i.e., up to 15-20 years without much care. Jatropha oil is used for the preparation of soaps, candles and olefins. All its parts are of medicinal use of human and livestock [4]. Seed cakes are rich in nitrogen (3.2 %) and phosphorus (1.4 %) [5] and used as organic manure, but, its toxic nature exempts its use for animal feed. Hence, plantation of Jatropha could be undertaken in various spatial and temporal arrangements in Agroforestry in the production of biodiesel and to replace the fossil fuel. Jatropha offers good scope for intercropping of crops and cash crops for horizontal expansion. Being an oil bearing plant, Jatropha may utilize large quantities of nutrients from soil and may severely compete with crops in Agroforestry to deplete soil fertility under poor nutrient management situations. Therefore, nutrient management is essential to maintain soil fertility for sustainable productivity of a Jatropha based Agroforestry system.

Pruning play important role in moisture conservation, temperature reduction, weed growth suppression, act as green manure crop, enhance available nutrient supply of soil and improve soil physical properties, improve bud sprouting, flowering, fruiting [2, 6, 7]. It helps for optimization of resource (nutrient, water and light) sharing in Agroforestry. The pruned material may serve the purpose of fuel wood, mulch material or fodder depending on species. The time and degree of pruning may also significantly influence resource sharing, micro-climate, crop growth and yield. Jatropha flowers form only at the end of branches, pruning leads to more branches and as such to more potential for fruit production. Pruning of Jatropha is important to prune only under dry conditions and best when the plants have shed their leaves [2]. A well planned and managed Agroforestry system could be more productive, ecologically sound and socially acceptable and therefore, can assist sustainable agricultural production particularly in degraded lands.

Soybean (*Glycine max* L.) is one of the best sources of high quality oil and protein can play an important role in solving the malnutrition problem of Bangladesh. Soybean is a crop which can produce high quality and highest quantity of protein (seed contains about 40 % proteins) per unit area. The oil content of soybean is about 20 %, while all other pulses contain about 1-2 % oil [8]. So, the scope of production of Soybean is important in the country, mainly due to shortage of land and hence agrisilviculture can be used as an effective tool. The northern part (Rajshahi, Dinajpur, Rangpur, Thakurgaon, Panchagar and Bogra district) of Bangladesh is experiencing frequent droughts. A typical dry climate with comparatively high temperature prevails in the northern part. In developing countries like Bangladesh due to the huge increase in population, land resources are shrinking and it is very difficult to bring arable land under forest cover. Increasing demand for food, fuel wood, timber, fodder and efficient management of land can be met through Agroforestry. The higher productivity of the system could be expected only, with optimal resource sharing and proper soil nutrient management. After that, intercrops of soybean with Jatropha could be successfully grown in South Asia region [9]. Hence, the objectives of this research were to determine the growth parameters and yield of Soybean under different pruning height in Jatropha and the fertility level in Soybean of Jatropha based agrisilviculture system of Agroforestryin the Northern Part of Bangladesh.

2. MATERIALS AND METHODS

This research was carried out on Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental plot was medium high land and the soil of the experimental site was silty loam in texture with 28.54% sand, 56.50% loam and 14.96% clay particles. The experiment was composed of a tree/shrub species Jatropha, spacing 3 m x 3 m, number of trees per plot 25, Soybean as intercrop, plot size 15 m x 15 m and number of plots 60. Seeds of Soybean were sown in 30 cm apart rows and seed to seed distance was 6 cm on 11 December 2012. Soybean crop with recommended NPK in the open was used as absolute or sole crop. The experiment was laid out in factorial Randomized Block Design comprising four cutting management viz., no pruning, 50 cm height, 100 cm height, 150 cm height in Jatropha and three fertility levels viz., 50 % of the recommended dose of NPK (50 % RDF), 100 % (110 kg N + 65 kg P_2O_5 + 42 kg K_2O ha^{-1}) of the recommended dose of NPK (100 % RDF), 150 % of the recommended dose of NPK (150 % RDF) in Soybean as intercrop with five replications. The sole cropping of Soybean was used as one rate of fertilizers (100 % of the recommended dose of NPK) and five replications. So, total number of plots was 65.

All sampled green leaves were categorized into small, medium and large size groups and counted. Twenty leaves of each category were collected and a total of sixty samples of leaves was taken from each sampled plot and packed in a plastic bag. After that, the leaf area of each leaf sample was measured by a leaf area meter (CI-203 Handheld Laser Area Meter, CID, Inc., Vancouver, Washington, USA). Six growth parameters viz., CGR, RGR, NAR, LAI, RLGR and SLW were computed using the formulae proposed by Brown [10] and Radford [11]. For determination of dry weight, leaves were dried to electric oven (Perkin-Elmer Corporation, USA) at 60°C for 72 hours, followed by weighing by digital balance (Kaifeng Group Co., Ltd., China). Yield viz. Economic yield (grain yield), Straw yield and biological yield (kg ha^{-1}) were recorded at the maturity of the crop. The whole of yield data was collected and dried in the sun for three to four consecutive days. After that, it was measured with a balance meter. The crop data obtained during the course of the investigation were analyzed using Factorial Randomized Block Design Panse and Sukhatme [12] and critical difference (CD) was calculated at 5% probability level.

3. RESULTS AND DISCUSSION

No significant (P > 0.05) interactions between pruning height and fertility level treatments were observed on six growth indices of Soybean during various growth periods. Therefore, discussion of the results will focus on the main effects of treatments on growth analysis and yield performance of Soybean.

First growth index of crop growth rate (CGR) was significantly influenced only during 90-110 days by pruning heights and fertility levels than other growth periods (Table 1). During 90-110 days, significantly higher CGR (42.4 g m^{-2} day^{-1}) was under 100 cm pruning height in Jatropha than other pruning treatments. However, 50 and 150 cm pruning heights did not differ from each other. The differences between 100 and 150 % RDF in Soybean were not significant during 50-70 and 110-130 days harvesting time. Low CGR values were observed during all crop growth stages under no pruning, it may be more due to partial shade than under pruned Jatropha at different heights [13]. The result in respect of CGR values corroborates with the findings of Rabbani, et al. [14]. Followed by second growth index of relative crop growth rate (RGR) was significantly influenced during all growth periods, except during 50-70 and 90-110 days of pruning height and during 50-70 days by fertility levels (Table 1). During 30-50 and 110-130 days to harvest significantly higher (106.5 and 8.1 mg $g^{-1}day^{-1}$ respectively) RGR was observed under 100 cm pruning height than other pruning height or unpruned Jatropha and during 70-90 days, significantly higher (46.4 mg $g^{-1}day^{-1}$) RGR was observed under 150 cm pruning height than other pruning. The maximum and significantly higher RGR was observed with 100 % RDF than other fertility levels during 30-50, 90-110 and 110-130 days. However, during 70-90 days, 100 and 150 % RDF showed superiority in RGR over 50 % RDF. The RGR which was a net increase in dry matter per unit of dry matter already present peaked during early growth period (30 to 50 days) and then decreased with advancing in age, probably due to increase the proportion of non-photosynthetic to photosynthetic plant tissues. Narwal [15] also observed peak in relative growth rate during 37 to 44 day period in Soybean. The result was supported by Amin, et al. [16] who reported more frequent fertility level showed with 100 % RDF than other fertility levels. Subsequently, Third growth index of net assimilation rate (NAR) was significantly influenced by pruning height during 30-50 days and fertility levels during 50-70 and 70-90 day growth period (Table 1). During 30-50 days, the NAR was found to increase with pruning of Jatropha, which was the maximum (8.6 mg $cm^{-2}day^{-1}$) and significantly higher at 100 cm height than others. Unpruned Jatropha proved to be poorer than pruning treatments. The NAR increased significantly with the increase in fertility level only from 100 to 150 % RDF during 50-70 and 70-90 day. The NAR was observed substantially higher under 100 cm pruning height and 100 % RDF as compared to any of the pruning height in Jatropha and fertility levels in Soybean crop. The NAR as an indicator of photosynthetic efficiency of a plant, increased with time, i.e., from 30-50 to 50-70 days and was relatively higher under pruned Jatropha than unpruned and with higher (i.e. 100 and 150 % RDF) fertility levels, which increased during 70-90 day period and is said to be influenced mainly by leaf area index [13]. The NAR decreased under unpruned Jatropha as compared to pruned Jatropha due to limited shading.

After that, forth growth index of leaf area index (LAI) attained by the soybean crop was significantly influenced by pruning height, except 70th day and fertility levels in Soybean at all growth stages (Table 2). LAI decreased significantly under unpruned Jatropha as compared to pruned Jatropha. Significantly higher LAI was obtained under 100 cm pruning height in Jatropha at 30th day as compared to other pruning treatments. Whereas, Maximum LAI (3.3 and 5.3) of the soybean crop was observed with 50 and 150 cm pruning height at 50th and 90th day, respectively. LAI was increased significantly with the increase in fertility levels from 50 to 100 % RDF up to 70th day with no difference between 100 and 150 % of RDF. The leaf area development was slow up to 50th day and developed at a faster rate up to 70th day and, thereafter, it declined. The leaf area development was better under pruned Jatropha as compared to unpruned Jatropha [17]. At that time, Fifth growth index of relative leaf growth rate (RLGR) was significantly influenced by pruning height only during late growth periods, i.e. 70-90 days and fertility levels in Soybean during all growth periods (Table 2). The significantly higher RLGR (-1.1 $mm^2\ cm^{-2} day^{-1}$) was observed under 100 and 150 cm pruning height than unpruned during 70-90 days. The RLGR increased with increase in each successive fertility level from 50 to 150 % of RDF. However, the differences between 100 and 150 % fertility levels were not significant during 50-90 and 70-90 day periods. RLGR is a useful tool in the analysis of leaf area changes which is used for comparison of growth in leaf area/unit of leaf area already present with time scale [18]. The RLGR was higher during 30-50 day period, which decreased sharply to become negative during 70-90 day period both under Jatropha and with fertility levels. The RLGR was observed low under unpruned Jatropha as compared to pruned Jatropha at various heights and was maintained higher with increased in fertility levels either at 100 or 150 % RDF in Soybean. At last, sixth growth index of specific leaf weight (SLW) was significantly influenced by pruning height at 30th and 50th day and by fertility levels at 30th, 50th and 90th day (Table 2). The significantly higher SLW was observed under 150 cm pruning height at both 30th and 50th day than unpruned Jatropha and also 100 cm pruning height at 30th day. The SLW a measure of leaf thickness was relatively higher at 30th day, which slightly decreased at 50th day and again increased at 70th and further at 90th day, indicating the maximum leaf area development/expansion during tillering and early jointing stage. All the growth parameters found to be substantially lower in unpruned Jatropha in comparison to pruned Jatropha and sole crop. After that, 100 % of the recommended dose of NPK (100 % RDF) in the soybean crop showed as higher as compared to fertility treatments in these growth factors.

Three yields of grain, straw and biological, were significantly influenced by pruning height (Figure 1) and fertility levels (Figure 2). The significantly higher grain yield (2249 kg ha^{-1}), straw yield (4211 kg ha^{-1}) and biological yield (6471 kg ha^{-1}) were obtained by 100 cm pruning height level in Jatropha. These three yields of 100 cm pruning height in Jatropha increased by 15.38 %, 13.74 % and 14.61 % respectively in comparison to sole crop and other pruning height level (Figure 1). The grain, straw and Biological yield were increased in fertility level of 100 and 150 % of RDF than sole crop. So, these three yields of 100 % of the recommended dose of NPK in Soybean are comparatively higher than other fertility level (Figure 2). The maximum and substantially higher grain, straw and biological yield were obtained under 100 cm pruning height in Jatropha and 100 % of the recommended dose of NPK in Soybean crop as compared to both the pruning and fertility treatments. Numbers of studies have shown increases in grain, straw and/or biological yield under trees [19-22]. Jha and Marak [23] reported that intercropping of soybean with bamboo species is feasible on degraded land and gave better results than sole cropping systems. Seshadri [24] found that cultivation of soybean (*Glycine max*) along with *Jatropha curcas* was technically feasible and economically viable. However, the magnitude of production may depend and vary with the tree species and density, plantation geometry and tree management practices.

As a result, it can be concluded that pruning in Jatropha is promising for agrisilviculture since the yield increases of Soybean were highest under pruned Jatropha (100 cm pruning height) in comparison to no pruning. Therefore, it is suggested to adopt tree management (pruning) practices to maximize the yield increases of Soybean which would be utilized by the Jatropha and production ability can be improved substantially by the use of recommended dose of NPK (100 % RDF) for Soybean. The standing biomass (stem + branches) ensures additional benefit from the system. However, the overall productivity (trees + crops) in Agroforestry systems is higher than that in sole cropping systems and has the potential to improve the socioeconomic conditions of farmers.

4. ACKNOWLEDGEMENTS

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<u>Table Contents</u>

Table-1. Effect of pruning heights and fertility levels on Crop growth rate (CGR), Relative crop growth rate (RGR) and Net assimilation rate (NAR) of Soybean during various growth periods

Treatment	**Days after sowing**														
	CGR (g m^{-2} day^{-1})						**RGR (mg $g^{-1}$$day^{-1}$)**						**NAR (mg cm^{-2} day^{-1})**		
	30-50	50-70	70-90	90-110	110-130		30-50	50-70	70-90	90-110	110-130		30-50	50-70	70-90
Sole crop	3.8	13.4	38.8	40.6	13.5		106.8	69.6	42.0	36.6	7.7		5.9	8.5	7.8
I. Pruning heights															
No pruning	3.6	11.9	37.6	28.5	11.9		95.6	64.2	39.8	33.3	6.2		5.0	7.7	7.3
50 cm ht.	3.7	13.8	39.9	36.1	13.8		103.8	68.6	42.7	36.5	6.5		5.5	8.2	7.4
100 cm ht.	3.8	13.9	41.2	42.4	13.8		110.2	70.0	50.3	37.8	8.6		8.6	8.5	7.9
150 cm ht.	4.0	13.2	41.9	36.4	12.8		102.0	68.8	49.6	38.2	6.7		6.8	8.3	7.6
CD at 5%	NS	NS	NS	3.4	NS		5.8	NS	4.3	NS	0.39		0.89	NS	NS
II. Fertility levels															
50 % RDF	3.2	11.6	37.3	27.1	9.2		99.2	68.2	31.1	30.6	5.5		6.0	7.2	6.5
100 % RDF	3.9	14.0	43.4	40.6	15.4		106.5	70.2	44.5	40.7	8.1		6.5	9.7	8.3
150 % RDF	4.2	13.8	40.1	38.3	15.6		100.6	71.1	46.4	40.2	7.7		6.2	9.7	8.2
CD at 5%	0.32	1.91	3.35	3.43	1.22		5.3	NS	3.9	2.3	0.33		NS	0.41	0.47

NS=Non-significant, RDF-Recommended dose of fertilizer

Table-2. Effect of pruning heights and fertility levels on Leaf area index (LAI), Relative leaf growth rates (RLGR) and Specific leaf weight (SLW) at various stages of Soybean growth

Treatment	Days after sowing										
	LAI				RLGR (mm^2 cm^{-2} day^{-1})			SLW (g cm^{-2})			
	30	50	70	90	30-50	50-70	70-90	30	50	70	90
Sole crop	0.32	2.7	5.6	4.4	4.9	4.1	-1.4	2.4	2.0	3.3	5.1
I. Pruning heights											
No pruning	0.27	2.5	5.1	4.3	4.6	3.9	-1.8	2.2	1.7	3.0	5.0
50 cm ht.	0.29	3.3	5.7	4.9	4.8	4.1	-1.6	2.5	2.0	3.1	5.5
100 cm ht.	0.33	2.8	5.8	4.8	4.9	4.1	-1.4	2.3	2.1	3.2	5.2
150 cm ht.	0.29	2.6	5.3	5.3	5.2	4.1	-1.1	2.8	2.5	3.1	5.6
CD at 5%	0.02	0.37	NS	0.47	NS	NS	0.27	0.3	0.3	NS	NS
II. Fertility levels											
50 % RDF	0.27	2.1	4.1	4.2	3.5	3.4	-1.6	1.5	1.4	2.8	4.8
100 % RDF	0.35	3.3	6.6	5.3	5.3	5.0	-1.4	2.6	2.1	3.3	5.9
150 % RDF	0.36	3.4	6.5	5.8	5.6	5.1	-1.5	3.0	2.2	3.3	6.5
CD at 5%	0.02	0.33	0.44	0.41	0.45	0.23	0.18	0.2	0.1	NS	0.53

NS=Non-significant, RDF-Recommended dose of fertilizer

Figure legends

Figure-1. Effect of pruning height levels on grain, straw and biological yields of Soybean.

Figure-2. Effect of fertility levels on grain, straw and biological yields of Soybean.

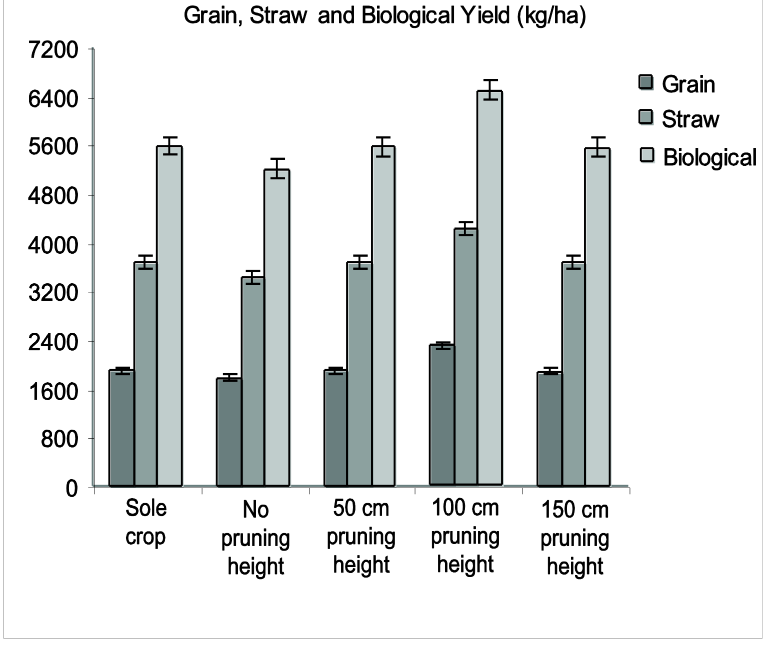

Figure-1. Effect of pruning height levels on grain, straw and biological yields of Soybean.

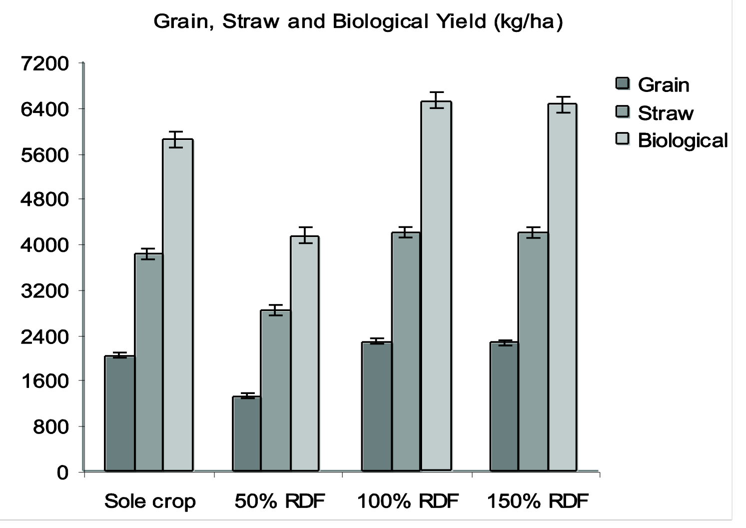

Figure-2. Effect of fertility levels on grain, straw and biological yields of Soybean.

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