Performance of red amaranth and ipil-ipil based alley cropping system

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Abstract: An experiment was conducted at Agroforestry Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2014 to January 2015 to observe the performance of red amaranth (Amaranthus gangeticus) in Ipil-ipil (Leucaena leucocephala) based alley cropping system following Randomized Complete Block Design (RCBD) with three replications separately for unpruned and pruned condition. Different treatments of this study for unpruned and pruned condition were T0 = Control (without fertilizer and manure), T1 = ILB (Ipil-ipil Leaf Biomass), T2 = ILB + 1/2RFD (Recommended Fertilizer Dose), T3 = ILB + 1/4RFD, and T4 = RFD. Growth of red amaranth was recorded under alley cropping system in unpruned and pruned condition harvesting stage. The yield of red amaranth were estimated after the harvest. It was found that growth parameters viz. plant height, no. of leaves plant⁻¹, stem girth, weight per plant, weight of leaves per plant, weight of stem per plant were almost similar in all manure/fertilizer treated plots but it was remarkably lower in control (without fertilizer and manure) plot. The yield of red amaranth was also statistically similar with all fertilizer and manure treated plots both in unpruned and pruned condition but it was drastically reduced in control plots. The yield of red amaranth in this study under unpruned and pruned condition in the treatments T0, T1, T2, T3 and T4 were 2.20, 4.10, 4.50, 4.25 and 4.00 t/ha and 2.18, 4.05, 4.45, 4.28, 4.22 and 3.90 t/ha, respectively. Growth and yield of red amaranth was statistically similar in unpruned and pruned condition but numerically yield was little bit higher (1.16%) in unpruned condition compare to pruned condition. Both unpruned and pruned condition, only ILB treated plots produced statistically similar yield compare to all others treatments. Therefore, it can be concluded that red amaranth vegetables can be cultivated in alley cropping system by using Ipil-ipil leaf biomass as manure without significant yield loss and it is also a sustainable agroforestry practice.

Key words: Red amaranth, alley cropping, Leucaena leucocephala, leaf biomass, prune, unprune.

Introduction
Farmers have practiced agroforestry since ancient times. Agroforestry focuses on the wide range of trees grown on farms and other rural areas. Tree plays a crucial role in almost all terrestrial ecosystems and provide a wide range of products and services to rural and urban people. The origin of agroforestry practices, i.e. growing trees with food crops and grasses, is believed to have been during vedicera (Ancient period, 1000 BC) the agroforestry as a science is introduced recently. The systematic research in agroforestry geared up after the establishment of the International Council for Research in Agroforestry (ICRAF) in 1977, which was renamed in 1991 as the International Centre for Research in Agroforestry. During 2001-02, ICRAF adopted a new brand name "World Agroforestry Centre", to more fully reflect their ICRAF's global reach and also their more balanced research and development agenda; however their legal name "International Centre for Research in Agroforestry" will remain unchanged. The definition developed by Lundgren and Raintree (1982) is one of the simplest and most comprehensive, "Agroforestry is a collective name for land-use systems and techniques where trees are deliberately used on the same land management unit as agricultural crops and or/animals, either in the same form of spatial arrangement or temporal sequence". Alley cropping or hedgerow intercropping is an agroforestry practice in which perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop. The trees managed as hedgerows, are grown in wide rows and the crop is planted in the inter space or 'alley' between the tree rows. During the cropping phase the trees are pruned and the prunings are used as green manure or mulch on the crop to improve the organic matter status of the soil and to provide nutrients, particularly nitrogen, to the crop. Hedgerow trees in alley cropping increase the supply of nutrients mainly through input of nitrogen (N) by biological nitrogen fixation and retrieval of nutrients from below the rooting zone of crops (Buresh and Tian, 1998). Organic matter acts as a reservoir of plant nutrients especially N, P, K and S and prevents leaching of the nutrients (Konboon et al. 1993). Leaf litter supplies the carbon, nitrogen, phosphorus, potassium and other nutrients in soil that are further considered as important indicators of soil productivity and the ecosystem health. The decomposition of leaf litters influence the amount of N availability for plant uptake (Samsuzzaman and Karim, 2002). Through decomposition, the nutrients within leaf litter are converted into available form for uptake by vegetation and thereby exercising a critical control on vegetation productivity (Mitch and Gosselink, 1993).

It was found that, repeated application of inorganic fertilizer can lead to build up of salt in soil and this salt accumulation forces the plants to expand more energy to draw water from the soil and can cause plants to appear wilted or dried out. At the same time, too much application of inorganic fertilizers may result in the roots of the plant burning and inhibiting its ability to absorb nutrients. On the other hand to meet up timber and fuel-wood demand, farmers plant large number of saplings of timber species in their cropland, homestead, and other fallow lands at block plantations, row plantation, woodlot plantation and scattered plantations (Haque, 1996).

Considering the aforementioned facts and potentiality, a study was undertaken with the broad objective to examine the competitive performance of red amaranth grown in alleys of ipil-ipil tree hedges at pruned and unpruned condition.

Materials and Methods
Experimental site and season: The experiment was carried out at the experimental farm in the field under Department of Agroforestry in Bangladesh Agricultural University (BAU), Mymensingh during the period from 30 November 2014 to 10 January 2015. The place is geographically located between 24°75’ North latitude and 90°50’ East Longitude (FAO, 1988).
**Tree and plant materials:** In this study, one year old previously established four hedges of Ipil-ipil in pruned and unpruned condition (*Leucaena leucocephala*) were used as tree component. The Red amaranth vegetables were used as plant materials which seeds were collected from Natunbazar, Mymensingh.

**Description of hedge used in this study:** Ipil-ipil (*Leucaena leucocephala*) hedge was established during the year 2013 in a plot of 1200 sq. feet area. At first the land was prepared by ploughing and cross-ploughing for several times to make the soil loose & friable, weeds and stubbles were removed from the beds and seeds of ipil-ipil were sown. Irrigation was done three times in a week by the watering cane and weeding was done after every 15 days. Thinning and gap filling was also done at the early days of hedge establishment. Total four hedgerows were established and length of each hedgerow was 40ft. Two hedgerows was pruned at 1m height above the ground level and rest two hedgerows were not pruned.

**Experimental design, layout and treatment combination:** Plot size of this study was 30ft × 40ft. In this plot total three allies were created and inside the each alley a total of 12 plots (3ft × 8ft) were made. Total number of plots was 36 (3×12). Among the 36 plots, 18 were pruned condition and 18 were unpruned condition. This study was laid out in Randomized Complete Block Design (RCBD) with three replications separately for pruned and unpruned condition. Both pruned and unpruned condition, different fertilizer status were considered as different treatments of this study. Therefore the six different treatments in association with fertilizer status were as: \( T_0 = \) Control (without fertilizer and manure), \( T_1 = \) ILB (Ipil-ipil Leaf Biomass), \( T_2 = (ILB + 1/2 \text{ RFD}) \), \( T_3 = (ILB + 1/3 \text{ RFD}) \), \( T_4 = (ILB + 1/4 \text{ RFD}) \), and \( T_5 = \) RFD (Recommended Fertilizer Dose).

**Land preparation:** The land was prepared by spading for seed sowing and kept fallow for few days. All crop residues, weeds and stubbles were removed from the field; finally the land was properly leveled and beds were made in three allies. After proper land preparation the ILB (Ipil-ipil Leaf biomass) was added in the soil and kept few days for decomposition. Land preparation of experimental plot are shown in Plate - 1 (pruned condition and unpruned condition).

**Seed sowing:** Seeds of Red amaranth (*Amaranthus gangeticus*) were sown in broadcasting method in the experimental plot on 30 November, 2014.

**Fertilizer application:** In case of treatment \( T_0 \) (control plots), no fertilizer and manure was applied and in case of treatment \( T_1 \), Ipil-ipil Leaf Biomass was applied. In case of treatment \( T_2 = ILB + 1/2 \text{ RFD} \), \( T_3 = ILB + 1/3 \text{ RFD} \), \( T_4 = ILB + 1/4 \text{ RFD} \) and \( T_5 = \text{ RFD} \) was applied respectively. Recommended dose of fertilizers were used for the respective crop species. Fertilizer doses for red amaranth were 6ton-180kg-120kg-75kg as Cowdung, Urea, TSP, and MP per hectare respectively. Ipil-ipil leaf biomass was added in the respective plot @ 10 kg/plot. Additional leaf biomass collected from other ipil-ipil tree etc.

**Sampling and data collection:** Plant samples of red amaranth were collected randomly from the respective plots. Ten plants of red amaranth were selected from each plot for data collection. Data were collected at harvesting time for measuring plant height (cm), no. of leaves per plant, stem girth(cm), leaf weight(g), stem weight(g) and weight of per plant(g).

**Statistical analysis:** The data were analyzed statistically by using WASP-2 software package and the mean differences were judged by DMRT and LSD (Gomez and Gomez, 1984).

**Results and Discussion**

**Performance of red amaranth vegetable in alley cropping system under pruned and unpruned condition**

**Morphological features of Red amaranth:** Morphological parameters viz. plant height (cm), no. of leaves per plant, stem girth (cm), leaf weight (g), stem weight(g) and weight per plant (g) were recorded in different fertilizer treatment under pruned and unpruned condition harvesting period. All of these recorded data were significantly influenced by different treatments which are presented separately as:

**Plant height (cm):** The result of the experiment showed that the plant height of Red amaranth was affected significantly by different fertilizer treatments under pruned and unpruned condition at different data records period. It was found that plant height of red amaranth was higher in unpruned condition than pruned condition and the difference between pruned and unpruned situation gradually increasing from beginning to harvesting time. Both pruned and unpruned condition it was found tallest red amaranth plant was in treatment \( T_2 \) (ILB + 1/2 RFD) followed by treatment \( T_3 \) (ILB + 1/3 RFD), treatment \( T_4 \) (ILB + 1/4 RFD), \( T_1 \) (ILB), \( T_5 \) (RFD) and shortest red amaranth plant was recorded in treatment \( T_0 \) (control). Highest plant length (26.31 cm) was found (Table 1, Plate 2a) in treatment \( T_2 \) (ILB+1/2 RFD) and lowest plant height (21.17 cm) was found in treatment \( T_5 \) (control). Like pruned condition, the highest plant height (26.97 cm) was found (Table 2, Plate 2b) in treatment \( T_2 \) (ILB + 1/2 RFD) and lowest plant height (20.50 cm) was found in treatment \( T_5 \) (control).

From this study it was observed that plant height of Red amaranth was higher under unpruned condition compare to pruned condition may be due to shade effect. Shade effect...
influence the apical dominance of any plant and consume more moisture (Nair, 1980). Leafy vegetable like red amaranth need more moisture which are relatively more in shade condition which generally occurred in unpruned condition compare to pruned condition. These results are in agreement with the results of Rahman et al. (2014) in different winter vegetables under alley cropping system.

No. of leaves plant\(^{-1}\): During harvesting period at unpruned condition, the highest number of leaves plant\(^{-1}\) (9.46) was found (Table 1) in treatment T\(_2\) (ILB + 1/2 RFD) which is statistically dissimilar to the other treatment. The lowest number of leaves plant\(^{-1}\) (6.72) was found in treatment T\(_0\) (control). The number of leaves plant\(^{-1}\) in treatment T\(_1\) (7.62) which is statistically similar to the treatment T\(_2\) and T\(_0\) was found 7.50 and 7.28 respectively. Like pruned condition, the highest number of leaves plant\(^{-1}\) (9.12) was found (Table 2) in treatment T\(_2\) (ILB + 1/2 RFD) which is statistically dissimilar to the other treatment. The lowest number of leaves plant\(^{-1}\) (6.52) was found in treatment T\(_0\) (control). The number of leaves plant\(^{-1}\) in treatment T\(_3\) (7.30) which is statistically similar to the treatment T\(_2\) and T\(_5\) was found 7.29 & 6.88 respectively.

**Table 1. Morphological characteristics of red amaranth in alley cropping system under pruned condition**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Leaf/plant</th>
<th>Stem girth (cm)</th>
<th>Wt./plant (gm)</th>
<th>Leaf wt. (gm)</th>
<th>Stem wt. (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_0)</td>
<td>21.17 d</td>
<td>6.72 c</td>
<td>1.19 c</td>
<td>4.44 e</td>
<td>1.23 d</td>
<td>2.11 c</td>
</tr>
<tr>
<td>T(_1)</td>
<td>22.70 bc</td>
<td>7.37 bc</td>
<td>1.55 b</td>
<td>5.72 ed</td>
<td>2.11 c</td>
<td>3.23 b</td>
</tr>
<tr>
<td>T(_2)</td>
<td>26.31 a</td>
<td>9.46 a</td>
<td>1.90 a</td>
<td>7.39 a</td>
<td>2.83 a</td>
<td>4.13 a</td>
</tr>
<tr>
<td>T(_3)</td>
<td>25.60 a</td>
<td>7.62 b</td>
<td>1.81 a</td>
<td>6.69 b</td>
<td>2.49 b</td>
<td>3.63 ab</td>
</tr>
<tr>
<td>T(_4)</td>
<td>23.49 b</td>
<td>7.50 bc</td>
<td>1.56 b</td>
<td>6.21 bc</td>
<td>22.26 b</td>
<td>3.39 b</td>
</tr>
<tr>
<td>T(_5)</td>
<td>22.33 c</td>
<td>7.28 bc</td>
<td>1.51 b</td>
<td>5.03 d</td>
<td>1.90 c</td>
<td>3.14 b</td>
</tr>
</tbody>
</table>

CV (%) 1.91 6.25 4.75 4.87 5.55 11.93
LSD (0.05) 0.82 0.87 0.13 0.52 0.21 0.71
LSD (0.01) 1.17 1.23 0.19 0.75 0.3 1.01
Level of sign. ** ** ** ** ** **

Means in column followed by the different letter are significantly different by DMRT at \( P \leq 0.05 \) and \( P \leq 0.01 \)

**Table 2. Morphological characteristics of red amaranth in alley cropping system under unpruned condition**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Leaf/plant</th>
<th>Stem girth (cm)</th>
<th>Wt./plant (gm)</th>
<th>Leaf wt. (gm)</th>
<th>Stem wt. (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_0)</td>
<td>20.50 d</td>
<td>6.52 b</td>
<td>1.00 d</td>
<td>4.38 d</td>
<td>1.13 d</td>
<td>2.28 d</td>
</tr>
<tr>
<td>T(_1)</td>
<td>22.37 bc</td>
<td>6.89 b</td>
<td>1.36 c</td>
<td>5.39 c</td>
<td>2.05 bc</td>
<td>2.87 c</td>
</tr>
<tr>
<td>T(_2)</td>
<td>25.97 a</td>
<td>9.12 a</td>
<td>1.75 a</td>
<td>7.06 a</td>
<td>2.60 a</td>
<td>4.13 a</td>
</tr>
<tr>
<td>T(_3)</td>
<td>24.94 a</td>
<td>7.30 b</td>
<td>1.65 ab</td>
<td>6.69 ab</td>
<td>2.32 ab</td>
<td>3.63 ab</td>
</tr>
<tr>
<td>T(_4)</td>
<td>22.82 b</td>
<td>7.29 b</td>
<td>1.38 bc</td>
<td>6.21 b</td>
<td>2.26 ab</td>
<td>3.39 b</td>
</tr>
<tr>
<td>T(_5)</td>
<td>21.33 cd</td>
<td>6.88 b</td>
<td>1.35 c</td>
<td>5.06 cd</td>
<td>1.73 c</td>
<td>2.86 c</td>
</tr>
</tbody>
</table>

CV (%) 3.52 7.36 11.31 7.05 11.09 8.54
LSD (0.05) 1.47 0.98 0.29 0.74 0.4 0.49
LSD (0.01) 2.09 1.39 0.41 1.05 0.57 0.7
Level of sign. ** ** ** ** ** **

Means in column followed by the different letter are significantly different by DMRT at \( P \leq 0.05 \) and \( P \leq 0.01 \)

**Stem girth (cm):** Stem girth of Red amaranth was affected significantly by different treatments (Tables 1 and 2). At unpruned condition, the lowest stem girth (1.19 cm) was found (Table 1) in T\(_5\) (control) from harvesting stage. The highest stem girth (1.90 cm) was found in T\(_2\) (ILB + 1/2 RFD) which is statistically similar to the treatment T\(_3\) (ILB + 1/3 RFD). At pruned condition, the lowest stem girth (1.00 cm) was found (Table 2) in T\(_5\) (control) from harvesting stage. The highest stem girth (1.75 cm) was found in T\(_2\) (ILB + 1/2 RFD) which is statistically similar to the treatment T\(_3\) (ILB + 1/3 RFD).

**Weight per plant (gm):** Plant weight was also influenced by different treatments (Tables 1 and 2). During harvesting period at unpruned condition, the highest plant weight (7.39 gm) of red amaranth was found (Table 1) in T\(_2\) (ILB + 1/2 RFD), second highest plant weight (6.69 gm) in T\(_3\) (ILB + 1/3 RFD) which is statistically similar to the treatment T\(_2\) and the lowest weight (4.44 gm) was found in treatment T\(_0\) (control). The number of leaves plant\(^{-1}\) in treatment T\(_1\) (7.62) which is statistically similar to the treatment T\(_2\) and T\(_0\) was found 7.50 and 7.28 respectively. Like pruned condition, the highest number of leaves plant\(^{-1}\) (9.12) was found (Table 2) in treatment T\(_2\) (ILB + 1/2 RFD) which is statistically dissimilar to the other treatment. The lowest number of leaves plant\(^{-1}\) (6.52) was found in treatment T\(_0\) (control). The number of leaves plant\(^{-1}\) in treatment T\(_3\) (7.30) which is statistically similar to the treatment T\(_2\) and T\(_3\) was found 7.29 & 6.88 respectively.

**Weight of leaves per plant (gm):** Weight of leaves was also influenced by different treatments (Tables 1 and 2). During harvesting stage at unpruned condition, the highest leaf weight (2.83 gm) of red amaranth was found (Table 1) in T\(_2\) (ILB + 1/2 RFD) and second highest (2.49 gm) was found in T\(_1\) (ILB + 1/3 RFD) which is statistically similar to the treatment T\(_2\) and the lowest weight (4.38 gm) was found in treatment T\(_0\) (control). Low nutrient content of control plot may be responsible for this. Such type of results also recorded by Basak et al. (2014) in soybean and wheat under hedgerow intercropping system and Bithi et al. (2014) in soybean and mustard under alley cropping system with *Leucaena* tree.

**Weight of leaves per plant (gm):** Weight of leaves was also influenced by different treatments (Tables 1 and 2). During harvesting period at unpruned condition, the highest plant weight (7.66 gm) in T\(_1\) (ILB + 1/2 RFD) which is statistically similar to the treatment T\(_2\) and the lowest weight (4.38 gm) was found in treatment T\(_0\) (control). Like pruned condition, the highest plant weight (7.06 gm) of red amaranth was found (Table 2) in T\(_2\) (ILB + 1/2 RFD), the second highest plant weight (6.69 gm) in T\(_3\) (ILB + 1/3 RFD) which is statistically similar to the treatment T\(_2\) and the lowest weight (4.38 gm) was found in treatment T\(_0\) (control). Low nutrient content of control plot may be responsible for this. Such type of results also recorded by Basak et al. (2014) in soybean and wheat under hedgerow intercropping system and Bithi et al. (2014) in soybean and mustard under alley cropping system with *Leucaena* tree.
+ 1/3 RFD). The third highest leaf weight (2.62 gm) was found (Table 2) in treatment T4 (ILB + 1/4 RFD). The lowest weight (1.13 gm) was found in treatment T0 (control). Low nutrient content of control plot may be responsible for this. Similar results also recorded by Basak et al. (2011) in soybean and wheat under hedgerow intercropping system with Leucaena tree.

**Weight of stem per plant (gm):** Weight of stem per plant of amaranth was also influenced by the different RFD (Tables 1&2). During final data harvesting stage at unpruned condition, highest stem weight of red amaranth was found in 4.13 g (T2 = ILB + 1/2 RFD) (Table 1), and second highest was 3.63 g (T3 = ILB + 1/3 RFD) which is statistically similar. The third and lowest weight was 3.39 g and 2.11 g respectively found in T1 (ILB + 1/4 RFD) and T0 (control) which is statistically dissimilar. Like pruned condition, highest stem weight of red amaranth was found in 4.13 g (T2 = ILB + 1/2 RFD) (Table 2), and second highest was 3.63 g (T3 = ILB + 1/3 RFD). The third and lowest weight was 3.39 g and 2.28 g, respectively found in T1 (ILB + 1/4 RFD) and T0 (control) which is statistically dissimilar.

**Yield:** Yield of red amaranth were estimated as t/ha (unpruned - Fig. 1a, and pruned - Fig. 1a) and kg/plot (unpruned - Fig. 2a, and pruned - Fig. 2b) in this study under fresh condition. Like morphological features yield of red amaranth also significantly influenced by different fertilizer treatment both in unpruned and pruned condition. It was found that fresh yield of red amaranth was higher under unpruned condition than pruned condition. Both pruned and unpruned condition it was found that highest red amaranth plant was in treatment T2 (ILB + 1/2 RFD) followed by treatment T3 (ILB + 1/3 RFD), treatment T1 (ILB + 1/4 RFD), treatment T4 (ILB), treatment T5 (RFD) and lowest red amaranth plant was recorded in treatment T0 (control).

Under pruned condition fresh yield of red amaranth were highest per plot and per hectare in the treatment T4 (1.0 kg and 4.45 ton respectively), T3 (0.96 kg and 4.28 ton respectively), T1 (0.95 kg & 4.22 ton respectively), T0 (0.91 kg & 4.05 ton respectively) and T5 (0.88 kg & 3.9 ton respectively) and T2 (0.90 kg & 4.00 ton respectively) and lowest yield in control condition i.e. without fertilizer condition. From this study it was found that fresh yield of red amaranth as higher (1.16 %) in unpruned condition compare to pruned condition may be due to shade effect. Shade condition ensure more moisture then open field condition. Due to above reason may be more fresh yield was found in red amaranth under unpruned condition of this study. Emon et al. (2014) and Islam et al. (2014) also observed more fresh yield in Radish and Amaranth under shade condition in alley cropping system. Relatively more yield was found in ILB and inorganic fertilizer mixed treated plot may be due to addition of organic manure (ILB).