Efficacy of Vegetables Intercropping in Mulberry on Sericulture Productivity and Economy

Md. Shoriful Islam¹, Faruque Ahmed²*, and Md. Mostafizur Rahman³

ABSTRACT

A field experiment was carried out in three (03) areas viz: experimental field of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, 05 farmers field of Bholahat, Chapainawabganj and 05 farmers of Paba, Rajshahi during 2020–2022. The objective of this research was to assess the effect of vegetables intercropping in mulberry garden on sericulture productivity and economy. Randomized completely block design (RCBD) with 3 replications and 7 treatments which includes, T0 = Sole mulberry (Control) T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak. The growth and yield parameters of mulberry viz average branch number per plant, total leaf number per plant, total branches height per plant (cm), nodes per meter per plant, length of longest shoot (cm), leaf present per branch, 10 leaves area (cm²), total leaf weight per plant (g), total shoots weight per plant (g) and total leaf yield/ha/crop (mt) were higher in T1 (10.89, 1223.35, 753.12, 23.03, 118.16, 20.58, 537.98, 833.35, 402.84 and 10.37) followed by other treatments except control (12.3, 1365.77, 768.82, 23.62, 122.5, 23, 572.92, 901.03, 414.76 and 10.82), respectively. Leaf quality viz moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral percentage were significantly higher in T3 (75.7, 38.8, 20.85, 6.48, 4.1 and 12.71) respectively over the T6 (74.86, 38.05, 19.61, 5.59, 3.12 and 11.1). The silk cocoon attributes like weight of 15 larvae (g), single cocoon weight (g), shell weight (g), cocoon shell ratio, highest filament length (m), renditta and cocoon productivity/100 dfls (kg) were higher also in T3 (53.46, 32.41, 0.21, 19.85, 977.84, 11.1 and 70.66) as compared to T6 (51.48, 31.42, 0.18, 18.24, 966.04, 12.31 and 69.24), respectively. The growing of Cauliflower as an intercrop was given maximum B: C (2.31) due to expansion soil fertility, higher leaf yield (except control), leaf quality, cocoon yield and additional income paralleled with other intercrops (cabbage-2.09, red amaranth-2.05, spinach-1.67, potato-1.49, sole mulberry-1.34 and data shak-1.22).

Keywords: Cocoon yield, Intercropping, Pruning, Rendita.

1. Introduction

Sericulture is a traditional agro-industry and mulberry (Morus spp) is the only food to silkworm (Bombyx mori L), which is reared to produce the silk. Recently, sericulture has become an attired source for profitable upliftment for its fast income creating nature of rural people [1]. Mulberry as a monoculture does not appear to invite the farmers who feel hesitant to allocate their land entirely to mulberry cultivation as only one crop is taken at farmers level that too for a period of less than a month. Thus horizontal expansion rather than vertical expansion hold promise providing sericulture is practiced in an integrative way with other agricultural activities to enable the farmer to get manifold products for assorted use [2]. Mulberry unlike other tree species of the region remains bereft of leaf almost for seven months during the year, hence providing plenty excellent to produce additional crops beneath. Integrating cultivation of mulberry and vegetable create to help the farmers to get better returns per unit of land and utilize the resources more efficiently and professionally [2]. Mulberry (Morus spp.) is a deciduous or moist deciduous perennial tree species, is a basic raw material for sericulture sectors...
that plays as a source of sole feed for mulberry silkworm, *Bombyx mori* L.

The limited land resources and opposition through other agricultural crops sericulture is facing severe competition. Hence, it is a vital obligatory to development a combined synchronization between sericulture and agriculture for a defensible co-existence. Most of the sericulture farmers have inadequate land and mainly depend upon their family labour and unpretentious tools. Besides, they neither have the ability to take risk nor have sufficient land to enlarge their cropping system. Thus, they growing of other short duration crops as an intercrops can earn additional incomes [3]. Practicing of diverse intercrops along with mulberry to increase farmer’s income and silk products without hindered the sericulture [4].

Intercropping of short duration pulses viz., green gram, black gram, horse gram, soybean, cowpea etc., in mulberry field sustains soil fertility and benefits not only to increase the leaf yield, grain and fodder yields but also addition bulk organic matter [5]. Several recent findings also recommend that medicinal plants viz: Aloe barbadense, Asparagus racemosus, Acorus calamus etc can be successfully intercropped with mulberry [6]. The intercropping of field crops in mulberry garden is one of the best ways for increase the productivity as well as net returns of per unit area [7]. This study was undertaken an effort to identify the possibility of growing suitable intercrops with mulberry plant to increase the financial returns per unit area of land so that sericulture becomes more remunerative.

Information of intercropping of diversified crops viz: legumes, grain, spices and medicinal plant in mulberry garden is unavailable but scared form in mulberry growing countries of the world. Intercropping especially vegetables in mulberry garden is totally new idea in other countries as well as Bangladesh. Recently, India has developed intercropping technologies in mulberry garden those are practiced widely for earning greater profit than the major agricultural crops [1]. That why the present study was undertaken to assessment the effect of vegetables intercropping in mulberry garden on mulberry growth and yield, leaf quality, silkworm performance, soil properties as well as sericulture economy. However, vegetables intercropping in mulberry garden may be more economic and remunerative for the sericulture farmers.

2. Materials and Methods

2.1. Experimental Areas

The experiment was conducted in three sites viz:

i) Research field of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi in the Agro-Ecological Zones (AEZ-10 and AEZ-11),

ii) Farmers’ field of Bholahat, Chapainawabganj (AEZ-11 and AEZ-26) and

iii) Farmer’s field of Paba, Rajshahi (AEZ-26) during 2021–2022.

2.2. Cultivation System and Mulberry Variety

Paired row high bush mulberry cultivation system maintaining spacing between plant to plant (61 cm × 61 cm), line to line (92 cm × 92 cm) and row to row (183 cm × 183 cm) and mulberry variety BM-11 were used for this study. Respective intercrops seeds were sowed in lines between the rows and maintain standard spacing for individual vegetables.

2.3. Management of the Mulberry Garden

The cultural practices were followed as per requirements for the mulberry garden. On the basis of farmer’s perception the experimental treatments were applied separately in definite farmer’s field at the pruned mulberry garden. The respective vegetables seeds were sown maintaining standard spacing in prepared bed between the rows through broadcasting/line sowing method after 2–3 days of mulberry garden pruned. The BSRTI recommended basal dose of NPK (N300P150K100 kg/ha/year) with 15 mt/ha/year cow dung compost was used for mulberry cultivation. After 75–80 days of pruning the mulberry leaves were harvest through leaf plucking method and respective intercrop was harvested at the maturity stage.

2.4. Details of Experimental Design and Treatments

Randomized Complete Block Design (RCBD) with three replications and seven treatments were used for this experiment. The applied intercropping treatments were:

1) $T_0 =$ Sole mulberry (Control)
2) $T_1 = $ Mulberry + Potato,
3) $T_2 = $ Mulberry + Cabbage,
4) $T_3 = $ Mulberry + Cauliflower,
5) $T_4 = $ Mulberry + Red amaranth,
6) $T_5 = $ Mulberry + Spinach and
7) $T_6 = $ Mulberry + Data shak.

2.5. Soil Properties Measurement Methods

Glass electrode method was used for determined the soil pH in deionizer water using a soil: water ratio of 1:5 [8]. Chronic acid digestion and spectrophotometric analysis method was used for determined the Soil organic C [9]. Multiplying the percent value of organic carbon with the conventional Van-Bemmelen’s factor of 1.724 was followed for determined the soil organic matter content [10]. The nitrogen content was determined by distilling soil with alkaline potassium permanganate solution [11]. The distillate was collected in 20 ml of 2% boric acid solution with methylred and bromocresol green indicator and titrated with 0.02 N sulphuric acid (H$_2$SO$_4$) [12]. The available soil K was extracted with 1 N NH$_4$OAC and determined by an atomic absorption spectrometer [13]. The available P of the soil was determined by spectrophotometer at a wavelength of 890 nm. The soil sample was extracted by Olsen method with 0.5 M NaHCO$_3$ as outlined [14]. The Zn content in soil sample was measured by an atomic absorption spectrophotometer (AAS) after extracting with DTPA [15].

2.6. Recorded Mulberry Growth Parameters

The mulberry growth parameters viz total leaf number per branch, leaf present per branch, total branch height per plant (cm), length of longest shoot (cm), total shoot weight per plant (g), node per meter, 10 leaves area per plant
(cm²), total leaf weight per plant (g) and leaf yield (mt) per hectare/crop were measured followed by the individual method 90 days after pruning of mulberry garden.

2.7. Evaluation of Mulberry Leaf Quality

Mulberry leaves were collected in top, middle and bottom portion of the plant after 75 days of pruning and composite samples were prepared. The moisture (%) was determined followed [16], total Chlorophyll content [17] using the spectrophotometer and were calculated by the standard formula [18], total mineral (%) [19], Kjeldahl’s method for protein (%) [20], total sugar and reducing sugar (%) were determined by the procedure and methods of [21], [22].

2.8. Measurement of Silkworm Rearing Parameters

The silkworm rearing parameters viz. weight of 10 matured larvae (g), single cocoon weight (g), single shell weight, cocoon shell ratio, highest filament length (m), renditta and yield of cocoon/100 dfls (disease free laying eggs) respectively were measured for this study.

2.9. Economics

The inputs prices which were used at that time by the farmers and selling prices of the seeds on the basis of prevailing market rates at the time of harvest of the produce has been taken into account.

2.9.1. Net Returns

The net profit per hectare was calculated by deducting the cultivation cost per hectare from gross returns per hectare.

2.9.2. Benefit-Cost Ratio

\[ \text{BCR} = \frac{\text{Net returns (Tk/ha/crop)}}{\text{Cost of cultivation (Tk/ha/crop)}} \]

3. Results and Discussion

3.1. Results

3.1.1. Effect of Vegetables Intercropping on Growth and Yield Performances of Mulberry

3.1.1.1. Branch Number Per Plant

The mean branch number of mulberry increased significantly (P ≤ 0.001) with intercropped of vegetables in mulberry (Table 1). The branch number per plant was increased from 10.02 in cabbage (T2) to a maximum of 10.41, T4 (10.11) and T5 (10.09), respectively (Table I, Fig. 1, Fig. 2).

3.1.1.2. Total Leaf Number Per Plant

The number of total leaf per plant of mulberry was significantly varied due to vegetables intercropped with mulberry. However, sole mulberry (T0) cultivation, resulted in a significant increase in the number of total leaf per plant. The number of total leaf per plant increased from 1153.8 in the cabbage (T2) intercropping to 1223.35 with potato (T1) and to a maximum 1365.77 with sole mulberry cultivation, followed by T6 (1198.02), T3 (1191.17), T4 (1156.79) and T5 (1154.24), respectively (Table 1, Fig. 2).

3.1.1.3. Total Branches Height/Plant (cm)

The mean total branches height per plant of mulberry was significantly (P ≤ 0.001) differed from 727.99 cm to 768.82 cm with intercropping of cabbage (T2) and sole mulberry cultivation. However, the obtained greater branch

### TABLE I: Significance Levels from the Analysis of Variance for the Main Effects of Growth and Yield Parameters among Various Intercropped of Vegetables with Mulberry

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>BNP</th>
<th>TLNP</th>
<th>TBHP (cm)</th>
<th>NMP</th>
<th>LLS (cm)</th>
<th>LPB</th>
<th>10 LAP (cm²)</th>
<th>TLWP (g)</th>
<th>TSWP (g)</th>
<th>L YH C (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>LSD value (% level)</td>
<td>2.29</td>
<td>177.44</td>
<td>159.95</td>
<td>7.24</td>
<td>15.51</td>
<td>4.82</td>
<td>9.44</td>
<td>284.02</td>
<td>76.43</td>
<td>1.59</td>
</tr>
</tbody>
</table>

Note: BNP = Branch number/plant, TLNP = Total leaf number/Plant, TBHP = Total branch height per plant (cm), NMP = Node per meter per plant, LLS = Length of longest shoot (cm), LPB = Leaf present/Branch, LAP = Leaf area (cm²) per plant, TLWP = Total leaf weight per plant (g), TSWP = Total shoot weight per plant and L YH C = leaf yield/ha/crop (Mt). Where, ns, *, ** and *** represent probability of > 0.05, ≤ 0.05, ≤ 0.01 and ≤ 0.001. Values were means of three replicates.
Efficacy of Vegetables Intercropping in Mulberry on Sericulture Productivity and Economy

Islam et al.

3.1.1.4. Nodes Per Meter Per Plant

The number of nodes per meter of mulberry markedly differed through vegetables intercropping with mulberry (Table I). However, the maximum number per meter was noted 23.62 for sole mulberry (T0) trailed by T1 (23.03), T6 (23.02), T4 (22.98), T3 (22.78), T2 (22.68), respectively while significantly least was found in T2 (22.57) (Table I, Fig. 4).

3.1.1.5. Length of Longest Shoot

Intercropping of vegetables with mulberry had a substantial (P ≤ 0.001) influence on length of the longest shoot of mulberry (Table I). The obtained maximum length of the shoot was 122.5 cm in sole mulberry (T0) and minimum length T4 (114.02 cm) followed by the T6 (118.43 cm), T1 (118.16 cm), T3 (115.5 cm), T2 (114.72 cm) and T3 (114.32), respectively (Table I, Fig. 5).

3.1.1.6. Leaf Present Per Branch

The presence of mulberry leaves per branch was significantly (P ≤ 0.001) differed by vegetables intercropping (Table I). The maximum leaf per branch was 23 for sole mulberry (T0) and minimum 18.08 for spinach (T5). However, the recorded leaf number per braches for other vegetables intercropping were T1 (20.58), T6 (19.86), T3 (19.65), T2 (18.73), T4 (18.71) and T5 (18.08) respectively (Table I, Fig. 6).

3.1.1.7. 10 Leave Areas (cm²) Per Plant

The 10 leaves area of mulberry was greatly (P ≤ 0.001) varied for vegetables intercropped with mulberry (Table I). However, the recorded maximum 10 leaves area per plant was 572.92 cm² for sole mulberry (T0) cultivation followed by the T1 (537.98 cm²), T6 (531.91 cm²), T3 (531.22 cm²), T4 (527.36 cm²), T2 (525.85 cm²), T5 (524 cm²) respectively (Table I, Fig. 7).

height was 768.82 cm for T0 followed by the T1 (753.12), T6 (735.91), T3 (733.72), T5 (729.86), T4 (729.3) cm, respectively (Table I, Fig. 3).
3.1.1.8. Total Leaf Weight (g) Per Plant

Intercropping of vegetables with mulberry had a significant (P ≤ 0.001) trend on total leaf weight of mulberry plant (Table I). The maximum total leaf weight per plant was found 901.03 g for sole mulberry (T0) and minimum T2 (822.7 g) followed by the T1 (833.35 g), T6 (832.74 g), T3 (831.16 g), T4 (828.82 g) and T5 (828.09 g), respectively (Table I, Fig. 8).

3.1.1.9. Total Shoots Weight (g) Per Plant

The total shoot weight per plant of mulberry was markedly (P ≤ 0.001) different by the vegetables intercropped with mulberry (Table I). However, the recorded maximum total shoot weight per plant was 414.76 g for sole mulberry (T0) followed by the T1 (402.84 g), T6 (390.27 g), T3 (383.99 g), T2 (366.81 g), T4 (364.55 g) and T5 (362.35 g), respectively (Table I, Fig. 9).

3.1.1.10. Total Leaf Yield/Crop (MT)

The total leaf yield of mulberry significantly (P ≤ 0.001) varied for intercropped of vegetables with mulberry (Table I). The recorded highest total leaf yield per hectare per crop was 10.82 mt for sole mulberry (T0) and lowest 9.88 mt for cabbage (T2). However, in case of other vegetables intercropped with mulberry leaf yield were T1 (10.37 mt), T6 (10.23 mt), T3 (10.14 mt), T4 (10.02 mt), and T5 (9.94 mt) per hectare per crop, respectively (Table II, Fig. 10).

3.1.1.11. Intercropping Effect on Mulberry Leaf Yield and Vegetables Production

The mulberry leaf productivity and vegetables production was statistically differed by intercropping the vegetables in mulberry field. In case of mulberry leaf production, the obtained maximum leaf yield per hectare per crop were 10.82 mt for sole mulberry (T0) which was
TABLE II: INFLUENCE OF INTERCROPPING ON MULBERRY LEAF YIELD AND VEGETABLES PRODUCTION

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Mulberry leaf yield (t/ha/crop)</th>
<th>Production of intercrops (t/ha/crop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>10.82 a</td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>10.37 b</td>
<td>17.60 d</td>
</tr>
<tr>
<td>T2</td>
<td>9.88 f</td>
<td>24.77 a</td>
</tr>
<tr>
<td>T3</td>
<td>10.14 d</td>
<td>18.77 e</td>
</tr>
<tr>
<td>T4</td>
<td>10.02 f</td>
<td>8.23 e</td>
</tr>
<tr>
<td>T5</td>
<td>9.94 f</td>
<td>17.77 e</td>
</tr>
<tr>
<td>T6</td>
<td>10.23 c</td>
<td>7.57 f</td>
</tr>
</tbody>
</table>

Note: T0 = Sole mulberry (Control) T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

Fig. 10. Total leaf yield per hectare per year for several treatments mulberry intercropped with vegetables. Vertical bar represent LSD (P ≤ 0.001) for various treatments interaction, where, T0 = Sole mulberry (Control) T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

3.1.2. Effect of Vegetables Intercropping on Leaf Quality of Mulberry Plant

Intercropping of vegetables in mulberry had a significant impact on leaf quality of mulberry plant. The leaf quality viz: moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral contain in mulberry leaf were statistically differed due to vegetables intercropped in mulberry field. Among the six types of vegetables intercropped with mulberry the obtained maximum moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral were (75.70%), (38.80), (20.85%), (6.48%), (4.10%) and (12.71%) respectively for cauliflower intercropped in mulberry field T1 (mulberry + cauliflower) followed by the other vegetables intercropped. The maximum moisture contain for the intercropped of T3 was statistically similar with the T2 (75.35%) and T4 (75.24%) vegetables intercropped in mulberry field. However, the recorded moisture contain for the T0, T1, T2, T5 and T6 vegetables intercropped in mulberry field were statistically similar. The obtained maximum total chlorophyll was 38.80 and minimum 38.05 for the intercropped of cauliflower (T3) and data shak (T6) in mulberry field respectively, which was statistically differed. But the chlorophyll contain for the T2 (38.70), T4 (38.67), T5 (38.57), T1 (38.47) and T0 (38.29) vegetables, respectively were statistically similar with T3 (38.80) vegetable intercropped in mulberry field (Table III).

The maximum crude protein was 20.85% and minimum 19.61% for cauliflower (T1) and data shak (T6), respectively intercropped in mulberry field which was statistically varied. However, the crude protein contain for the T2 (20.48%), T4 (20.25%), T5 (20.13%), T1 (20.07%) and T0 (20.06%), respectively intercropped in mulberry field which was statistically similar with T3 vegetables intercropped. The recorded maximum total sugar, reducing sugar and mineral were 6.48%, 4.10% and 12.71%, respectively for cauliflower and minimum 5.59%, 3.12% and 11.11%, respectively for data shak intercropped in mulberry field, which was statistically differed. On the other hand, the total sugar, reducing sugar and mineral contain for T0, T1, T2, T4 and T3 vegetables intercropped in mulberry field were statistically similar (Table III).

3.1.3. Effect of Vegetables Intercropping on Silkworm Rearing

Vegetables intercropping with mulberry field exhibited large variation on silkworm rearing performances due to feed on intercropped mulberry leaf. Among the six types of intercropped vegetables better silkworm rearing performances viz: single larvae weight (3.56 g), single cocoon weight (32.41 g), shell weight (0.21 g), cocon shell ratio (19.85), highest filament length (977.84 m), renditta (11.10) and cocoon productivity/100 dfls (70.66 kg) respectively were obtained for the mulberry + cauliflower (T3) treatment. At the same time the lower silkworm rearing performances viz: single larvae weight (3.43 g), single cocoon weight (31.42 g), shell weight (0.18 g), cocon shell ratio (18.24), highest filament length (966.04 m), renditta (12.31) and cocoon productivity/100 dfls (69.24 kg) respectively were found for the treatment of T6 (mulberry + data shak). The maximum weight of single larvae was 3.56 g for T3 which was statically similar (3.55 g) with T2 treatment. Similarly, statistically better single cocoon weight was 32.41 g, renditta 11.10 and cocoon productivity 70.66 kg/100 dfls for the treatment of T3 also. However, the cocoon productivity of T2 was statically similar with the treatment of T3 (Table IV).

3.1.4. Effect of Vegetables Intercropping on Post-Harvest Soil Properties

The mean soil properties viz: organic matter (OM), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe) and copper (Cu) contain in soil was significantly differed except...
TABLE III: Influence of Vegetables Intercropped on Leaf Quality of Mulberry Plants

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture (%)</th>
<th>Total Chlorophyll (SPAD value)</th>
<th>Crude Protein (%)</th>
<th>Total Sugar (%)</th>
<th>Reducing Sugar (%)</th>
<th>Mineral (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>74.89 b</td>
<td>38.29 ab</td>
<td>20.06 ab</td>
<td>5.87 b</td>
<td>3.32 b</td>
<td>11.46 b</td>
</tr>
<tr>
<td>T1</td>
<td>75.0 b</td>
<td>38.47 ab</td>
<td>20.07 ab</td>
<td>5.9 b</td>
<td>3.34 b</td>
<td>11.46 b</td>
</tr>
<tr>
<td>T2</td>
<td>75.35 ab</td>
<td>38.7 ab</td>
<td>20.48 ab</td>
<td>6.03 b</td>
<td>3.46 b</td>
<td>11.72 b</td>
</tr>
<tr>
<td>T3</td>
<td>75.70 a</td>
<td>38.8 a</td>
<td>20.85 a</td>
<td>6.48 a</td>
<td>4.1 a</td>
<td>12.71 a</td>
</tr>
<tr>
<td>T4</td>
<td>75.24 ab</td>
<td>38.67 ab</td>
<td>20.25 ab</td>
<td>5.97 b</td>
<td>3.45 b</td>
<td>11.63 b</td>
</tr>
<tr>
<td>T5</td>
<td>75.09 b</td>
<td>38.57 ab</td>
<td>20.13 ab</td>
<td>5.95 b</td>
<td>3.34 b</td>
<td>11.52 b</td>
</tr>
<tr>
<td>T6</td>
<td>74.86 b</td>
<td>38.05 b</td>
<td>19.61 b</td>
<td>5.59 c</td>
<td>3.12 c</td>
<td>11.11 c</td>
</tr>
</tbody>
</table>

Note: T0 = Sole mulberry (Control), T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

TABLE IV: Mean Performances of Silkworm Rearing for Various Intercropped Vegetable in Mulberry Field

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Single larvae weight (g)</th>
<th>Single cocoon weight (g)</th>
<th>Shell weight (g)</th>
<th>Cocoon Shell ratio</th>
<th>Highest filament length (m)</th>
<th>Renditta</th>
<th>Cocoon productivity/100 dfls (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>3.44 cd</td>
<td>31.67 c</td>
<td>0.18 b</td>
<td>18.28 c</td>
<td>968.83 b</td>
<td>12.25 a</td>
<td>69.28 d</td>
</tr>
<tr>
<td>T1</td>
<td>3.45 c</td>
<td>31.75 c</td>
<td>0.19 ab</td>
<td>19.22 b</td>
<td>970.8 ab</td>
<td>12.23 a</td>
<td>69.79 c</td>
</tr>
<tr>
<td>T2</td>
<td>3.55 a</td>
<td>32.17 b</td>
<td>0.20 ab</td>
<td>19.72 a</td>
<td>977.63 a</td>
<td>11.31 d</td>
<td>70.33 ab</td>
</tr>
<tr>
<td>T3</td>
<td>3.56 a</td>
<td>32.41 a</td>
<td>0.21 a</td>
<td>19.85 a</td>
<td>978.84 a</td>
<td>11.10 e</td>
<td>70.66 a</td>
</tr>
<tr>
<td>T4</td>
<td>3.52 b</td>
<td>32.17 b</td>
<td>0.19 ab</td>
<td>19.68 a</td>
<td>972.38 ab</td>
<td>11.83 c</td>
<td>70.14 bc</td>
</tr>
<tr>
<td>T5</td>
<td>3.46 c</td>
<td>32.05 b</td>
<td>0.19 ab</td>
<td>19.38 b</td>
<td>971.41 ab</td>
<td>11.98 b</td>
<td>70.1 bc</td>
</tr>
<tr>
<td>T6</td>
<td>3.43 d</td>
<td>31.42 d</td>
<td>0.18 b</td>
<td>18.24 c</td>
<td>966.04 b</td>
<td>12.31 a</td>
<td>69.24 d</td>
</tr>
</tbody>
</table>

Note: Here, T0 = Sole mulberry (Control), T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

TABLE V: Mean Post-Harvest Soil Properties for Various Intercropped Vegetables in Mulberry Field

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>OM (%)</th>
<th>N (%)</th>
<th>P (kg/ha)</th>
<th>K (me/100 g soil)</th>
<th>Ca (me/100 g soil)</th>
<th>Mg (me/100 g soil)</th>
<th>Zn (ppm)</th>
<th>Fe (ppm)</th>
<th>Cu (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>8.0 a</td>
<td>1.35 cd</td>
<td>0.08 b</td>
<td>17.63 a</td>
<td>0.18 cd</td>
<td>28.68 b</td>
<td>3.08 b</td>
<td>2.67 f</td>
<td>3.16 d</td>
<td>0.51 c</td>
</tr>
<tr>
<td>T1</td>
<td>7.9 a</td>
<td>1.30 d</td>
<td>0.08 b</td>
<td>15.60 b</td>
<td>0.27 a</td>
<td>32.47 d</td>
<td>3.76 a</td>
<td>3.23 e</td>
<td>5.02 b</td>
<td>0.53 c</td>
</tr>
<tr>
<td>T2</td>
<td>7.8 a</td>
<td>1.54 b</td>
<td>0.09 ab</td>
<td>15.53 b</td>
<td>0.21 bc</td>
<td>27.16 d</td>
<td>2.89 c</td>
<td>4.82 c</td>
<td>4.20 c</td>
<td>0.65 b</td>
</tr>
<tr>
<td>T3</td>
<td>7.8 a</td>
<td>1.39 c</td>
<td>0.08 b</td>
<td>16.69 ab</td>
<td>0.24 ab</td>
<td>27.89 c</td>
<td>3.09 b</td>
<td>4.22 d</td>
<td>4.02 e</td>
<td>0.63 b</td>
</tr>
<tr>
<td>T4</td>
<td>7.2 b</td>
<td>1.09 e</td>
<td>0.06 c</td>
<td>10.77 d</td>
<td>0.17 d</td>
<td>28.66 b</td>
<td>3.04 bc</td>
<td>6.95 a</td>
<td>3.05 d</td>
<td>0.49 c</td>
</tr>
<tr>
<td>T5</td>
<td>8.0 a</td>
<td>1.40 c</td>
<td>0.08 b</td>
<td>12.47 c</td>
<td>0.18 cd</td>
<td>25.95 e</td>
<td>3.05 bc</td>
<td>5.88 b</td>
<td>4.13 c</td>
<td>0.65 b</td>
</tr>
<tr>
<td>T6</td>
<td>7.97 a</td>
<td>1.65 a</td>
<td>0.10 a</td>
<td>12.32 c</td>
<td>0.19 cd</td>
<td>32.38 a</td>
<td>2.66 d</td>
<td>0.58 g</td>
<td>12.44 a</td>
<td>0.95 a</td>
</tr>
</tbody>
</table>

Note: Here, T0 = Sole mulberry (Control), T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

Influence of Vegetables Intercropped on Leaf Quality of Mulberry Plants

However, the organic matter contain increased from 1.09%–1.65%, nitrogen 0.06%–0.10%, phosphorus 12.32–17.63 kg/ha, potassium 0.17–0.27 me/100 g soil, calcium 25.95–32.47 me/100 g soil, magnesium 2.66–3.76 me/100 g soil, zinc 0.58–6.95 ppm, iron 3.05–12.44 ppm and copper 0.49–0.95 ppm respectively. The recorded maximum OM (1.65%), N (0.10%), Ca (32.38%), Fe (12.44 ppm) and Cu (0.95 ppm), respectively for the treatment of T6 (mulberry + data shak) which was statically greater than the other treatments. Similarly, the obtained maximum potassium (0.27 me/100 g soil), calcium (32.47 me/100 g soil) and magnesium (3.76 me/100 g soil), respectively for the treatment of T1 (mulberry + potato) which was significantly greater than the all treatments. Interestingly, the recorded highest P was 17.63 kg/ha in T0, Zn (6.95 ppm) in T4 and soil pH (8) in T1 treatment, respectively. However, the soil pH was statistically similar for all treatments where minimum pH was 7.2 for the T4 treatment (Table V).

3.1.5. Effect of Vegetable Intercropping on Sericulture Economy

3.1.5.1. Cultivation Cost (INR./ha/crop)

The cost of cultivation for mulberry along with different vegetables was found higher in mulberry + potato (T1) intercropping (INR 232380 Tk/ha/crop) and lower sole mulberry cultivation (T0) (96500 Tk/ha/crop) followed by the mulberry + cabbage (T2) (INR 213290 Tk/ha/crop), mulberry + cauliflower (T3) (INR 208130 Tk/ha/crop), mulberry + data shak (T4) (INR 151750 Tk/ha/crop), mulberry + spinach (T5) (INR 147432 Tk/ha/crop) and mulberry + red amaranths (T6) (INR 125075 Tk/ha/crop) respectively intercropped in mulberry field (Table VI).

3.1.5.2. Net Returns (INR./ha/Crop)

The obtained net return was extended from INR. 1,29,137 Tk/ha/crop to INR. 4,80,972 Tk/ha/crop. How- ever, the earned net return of Tk. 4,80,972 Tk/ha/crop. However, the earned net return of Tk. 4,80,972 of cauliflower, cucumber (Tk. 4,44,998), potato (Tk. 346771), red amaranths (Tk. 256307), spinach (Tk. 2,46,397) and data shak (Tk. 1,85,138) compared to sole mulberry crop (Tk. 1,29,137) cultivation, respectively (Table VI).
Table VI: Economics for Mulberry Leaf Production with Vegetable Intercrops

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Gross returns (Tk/ha)</th>
<th>Cost of cultivation (Tk/ha)</th>
<th>Net returns (Tk/ha)</th>
<th>B: C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount of cocoon</td>
<td>Amount of intercrops</td>
<td>Total amount</td>
<td>Mulberry</td>
</tr>
<tr>
<td>T0</td>
<td>225637</td>
<td>0</td>
<td>225637</td>
<td>46500</td>
</tr>
<tr>
<td>T1</td>
<td>227151</td>
<td>352000</td>
<td>579151</td>
<td>46500</td>
</tr>
<tr>
<td>T2</td>
<td>212068</td>
<td>446220</td>
<td>658288</td>
<td>46500</td>
</tr>
<tr>
<td>T3</td>
<td>220352</td>
<td>468750</td>
<td>689102</td>
<td>46500</td>
</tr>
<tr>
<td>T4</td>
<td>216782</td>
<td>164600</td>
<td>381382</td>
<td>46500</td>
</tr>
<tr>
<td>T5</td>
<td>216129</td>
<td>177700</td>
<td>393829</td>
<td>46500</td>
</tr>
<tr>
<td>T6</td>
<td>223038</td>
<td>113850</td>
<td>336888</td>
<td>46500</td>
</tr>
</tbody>
</table>

Note: Here, T0 = Sole mulberry (Control) T1 = Mulberry + Potato, T2 = Mulberry + Cabbage, T3 = Mulberry + Cauliflower, T4 = Mulberry + Red amaranth, T5 = Mulberry + Spinach and T6 = Mulberry + Data shak.

3.1.5.3. Benefit Cost Ratio

The obtained greater B: C ratio was 2.31 for the cauliflower intercropped with mulberry that was on par with cabbage (2.09), red amaranths (2.05), spinach (1.67) and potato (1.49) respectively compare to mulberry sole crop (1.34) except data shak (1.22) (Table VI).

4. Discussion

4.1. Effect of Vegetables Intercropping on Productivity

Intercropping of vegetables in mulberry garden has a significant impact on mulberry plant productivity. The recorded greater average leaf yield was 10.82 mt/ha/crop in sole mulberry (T0) with maximum number of branches/plant (12.30), total leaf number/plant (1365.77), total branch height/plant (768.82 cm), node/meter (23.62), length of longest shoot (122.5 cm), leaf present/branch (23.0), 10 leaves areas/plant (572.92 cm²), total leaf weight/plant (901.03 g) and total shoot weight/plant (414.76 g) followed by the intercropping treatments. It could be due to none completion from the intercrops for necessary inputs in sole mulberry which was lined with the previous findings [23]. They found that in case of sole mulberry due to non-competition of numerous efforts and non-significant effect of associated intercrops the growth parameters as well as leaf yield was greater compared to the other intercropped vegetables. Our another speculation was as the growth and yield contributing characters were comparatively better in sole mulberry which might be influenced the leaf yield. This observation was also lined with [7] who found that in mulberry plant better growth attributes enhanced higher leaf yield. However, among the six types of intercropped vegetables the obtained maximum leaf yield was 10.37 mt/ha/crop for intercropped of potato next to sole mulberry followed by the data shak (10.23 mt/ha/crop), cauliflower (10.14 mt/ha/crop), red amaranths (10.02 mt/ha/crop), spinach (9.94 mt/ha/crop) and cabbage (9.88 mt/ha/crop) respectively. It may be due to the differential canopy height, position of the root in the soil, growth nature as well as nutrient requirements between the mulberry plant and numerous intercrops might be varied, resulting the mulberry leaf production were differed among the intercropped of potato followed by the data shak, cauliflower, red amaranths, spinach and cabbage respectively in the mulberry garden. This statement was supported by the findings of [1] who reported that mulberry and the intercrops compete with each other due to differential canopy height, growth cycle, requirement of nutrients and position of root in the soil. However, might be due to the better improvement of soil and maximum uptake of nutrients by the various intercropped vegetables were varied. In terms, vegetables production were cabbage (24.77 ton), cauliflower (18.77 ton), spinach (17.77 ton), potato (17.60 ton) red amaranths (8.23 ton) and data shak (7.57 ton) per hectare/crop respectively. The present findings were supported by the previous reports of [24], [25]. They recommended that the growing of vegetables with mulberry as these don’t require additional inputs in soil.

4.2. Leaf Quality for Intercropping of Vegetables with Mulberry Plant

Intercropping of cauliflower with mulberry garden significantly enhanced the leaf quality viz: moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral contain in mulberry leaf. Among the six types of intercropped vegetables viz: cabbage, cauliflower, spinach, potato, red amaranths and data shak the recorded quality mulberry leaf for cauliflower intercropped mulberry garden. However, the moisture contain for the intercropped of cabbage, and red amaranths were statistically similar with cauliflower. The total chlorophyll and crude protein contain in mulberry leaf were more or less similar for vegetables cultivation as intercrop between the row of mulberry garden. The plant or soil nutrients uptake by the various intercropped vegetables through soil might be varied; resulting leaf quality of mulberry was varied among them. However, may be due to comparatively maximum nutrients uptake by the intercropped cauliflower influenced the grater moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral contain in mulberry leaf then the others vegetables intercropped in mulberry garden.

4.3. Silkworm Rearing Performance for Feeding of Vegetables Intercropped Mulberry Leaf

Silkworm reared by cauliflower intercropped mulberry leaf significantly improved the single larva weight, single cocoon weight, shell weight, cocoon shell ratio, highest...
filament length, rendita and cocoon productivity/100 dfls respectively. Among the six types of different intercropped vegetables viz: potato, cabbage, cauliflower, red amaranth, spinach and data shak the maximum cocoon productivity was 70.66 kg followed by the cabbage (70.33 kg), red amaranth (70.14 kg), spinach (70.10 kg) and data shak (69.24 kg) per 100 dfls, respectively with better rendita (11.10). These silkworm rearing performances might be influenced by the improved mulberry leaf quality for the cultivation of various vegetables as intercrop with mulberry plant, especially for the better leaf quality of cauliflower intercropped mulberry leaf. Because, mulberry leaf quality is the vital factor for successful silkworm rearing as well as improvement of silk cocoon quality and quantity. This speculation was lined with the previous findings of [26] who reported that successful silk cocoon production 38.20% depend on mulberry leaf quality. Similarly, [27] reported that silkworm growth and development as well as cocoon and silk production entirely depends upon the quantity and quality of mulberry leaf. Reference [28] also found that the nutrient composition of the mulberry leaves is greatly influenced the silkworm development as well as it is also the determining factor of the quality of silk which was lined with our experimental finding.

4.4. Effect of Vegetables Intercropping in Mulberry Garden on Post-Harvest Soil Properties

Post-harvest soil properties significantly varied by the vegetables intercropped in mulberry garden. The study showed the diversified soil properties for various vegetables cultivation in mulberry garden as intercrop. The post-harvest soil of the data shak intercropped mulberry field was showed the maximum organic matter, nitrogen, calcium, iron and copper contain. Similarly, potato intercropped soil represented the greater potassium, calcium and magnesium in post-harvest soil. Maximum phosphorus was measured in sole mulberry, zinc in red amaranth and soil pH in spinach respectively intercropped soil of mulberry garden. Might be due to the respective nutrients uptakes from the soil by the respective intercropped vegetables were differed among themselves. Because, canopy height, growth cycle, nutrients requirements and position of root in soil for diversified intercropped vegetables were differed from crops to crops. Resulting, the nutrient status in respective intercropped vegetables in post-harvest soil was fluctuated.

5. Conclusion

The result revealed that intercropping of cauliflower with sole mulberry plant conserving spacing between plant to plant (61 cm × 61 cm), line to line (92 cm × 92 cm) and row to row (183 cm × 183 cm) had better leaf quality, highest cocoon yield and economic return with better post-harvest soil quality followed by red amaranth, spinach, potato and data shak respectively. The sole mulberry cultivation method produced higher leaf yield per hectare per year but in terms of commercialization it was not economical for sericulture farmer. Therefore, intercropping of cauliflower, cabbage and red amaranth with sole mulberry garden might be effective for economic productivity for mitigation the risk of sericulture farmers.

Acknowledgment

This work was supported in part by BAS-USD Endowment Program of Bangladesh Academy of Sciences (BAS) via project CR-08 “Crop diversification in mulberry ecosystem for access to more income generation by poor silkworm rearing people”.

References


