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INTERCROPPING PULSES WITH MULBERRY ON SERICULTURE PRODUCTIVITY AND PROFITABILITY

M. S. Islam[1], F. Ahmed[2*] and M. M. Rahman[1]

[1]Agronomy and Agricultural Extension Department, Rajshahi University (RU), Rajshahi;
[2]Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi. Bangladesh.

Abstract

This study was conducted during 2020-2021 in three locations viz: research field of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, five farmer's fields of Bholahat, Chapainawabganj and Paba, Rajshahi to evaluate the effect of growing pulses intercrops with mulberry productivity, silkworm rearing, soil properties and economy. The experiments were laid out in RCBD methods with three replications and six treatments.The growth and yield parameters of mulberry like average branch number/plant, total leaf number/plant, total branches length/plant, nodes/ meter/plant, length of longest shoot, leaf present/branch, 10 leaves area, total leaf weight/plant, total shoots weight/plant and total leaf yield were higher in T_4. Leaf quality viz: moisture content, total chlorophyll, crude protein, total sugar, reducing sugar and mineral in percentage (%) were significantly greater in T_4. The cocoon attributes like weight of 15 larvae, single cocoon weight, shell weight, cocoon shell ratio, highest filament length, renditta and cocoon productivity/100 dfls were better also in T_4 (54.68, 33.75, 0.27, 21.98, 990.41, 10.29 and 72.67) as compared to control (51.23, 31.21,0.19, 19.05, 962.96, 12.44, 69.07) respectively. Chickpea as an intercrop was given higher benefit: cost (1.30) due to increased soil fertility, higher leaf yield (except control), leaf quality, cocoon yield and additional income as compared with other intercrops (1.14, 1.07, 1.01, 0.93 and 0.86 for pea, grasspea, mugbean, sole mulberry and lentil respectively).

Keywords: Chickpea, Cocoon yield, Grasspea, Mugbean, Pruning, Renditta

Introduction

Sericulture is an agro-based industrial plantation crop with deep rooted culture and ritual of Bangladesh society artistic with decent climate. It is an art of systematic cultivation of mulberry and rearing of silkworms for the production of silk. Mulberry (*Morus* spp.) is a sole food plant for silkworm, *Bombyx mori* L. for commercial production of raw silk in sericulture industry. It is a deciduous or moist deciduous tree species originated from slopes of Himalayas that can be endured and grown-up to an elevation of 9000 mean sea level (msl). Sericulture is also an incredible for its low investment, swift and high returns as well as generating self-employment opportunity.

*Corresponding author: moistfaruk@gmail.com

Furthermore, this industry is also gorgeous mostly to small and marginal farmers, mainly steady sources of income.

Sericulture is facing harsh competition due to restricted land resources and competition with other agricultural crops. Therefore, it is a crucial requisite to advance joint harmony between sericulture and agriculture for sustainable co-existence. Generally, most of sericulture farmers have limited land holdings and depends mainly upon family labor and simple tools, they neither have the capability to take risk, nor have adequate land to expand its cultivation. Thus, by growing of other short duration crops, farmers can gets extra profits from intercrops (Ahsan *et al.*, 1989). The eternally swelling need for food, clothing and shelter from the inadequate land on account of rising population, has obligatory man to progress increasing the financial profits from unit area of land. In this regard, multi-cropping and intercropping are cautiously feasible options that mainly emphasize on crops diversification and amplification of land use. Mulberry cultivation is a main component for financially viable and success of sericulture as well as it would be more remunerative, if intercropped with short term crops, than as a mono crop (Ramamurthy *et al.*, 2006).

Intercropping with mulberry is increased productivity per unit area of land and time as well as also helps in impartial and judicious application of land and farming inputs including labour through cultivation of short duration crops between the rows of mulberry without affecting the quantity and quality of mulberry leaf (Vishaka *et al.*, 2017). Lots of study has already been conducted for mixing of Sericulture with agriculture and horticulture (Gargi *et al.*, 1997). In Kashmir saffron intercropping with mulberry yielded a good quality of leaf from the same field where saffron was cultivated alone to generate work as well as good deal of returns to farmers during lean period when there is no operations related to saffron cultivation (Kaur *et al.*, 2002). Several recent studies also suggest that mulberry can be successfully intercropped with medicinal plants (Madhusudan *et al.*, 2015).

The information especially on leguminous crops intercropping with mulberry was unavailable. Therefore, prospect of leguminous crops intercropping with mulberry was a scorching researchable issue in Bangladesh. This study was conducted to estimate the impact of legumes intercropping with mulberry production, silk cocoon productivity, and soil fertility status as well as sericulture economy. It was hypothesized that legumes intercropping with mulberry will be more profitable for sericulture farmers.

Materials and Methods

Location

The Experiment was carried out at the research field of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi in the Agro-Ecological Zones (AEZ-10 and AEZ-11), Farmers' field of Bholahat, Chapainawabganj (AEZ-11 and AEZ-26) and Paba, Rajshahi (AEZ-26) during 2020-2021.

Plantation system and variety

Mulberry variety BM-11 and paired row high bush mulberry plantation system maintaining spacing between plant to plant (61cm × 61cm), line to line (92 cm × 92 cm) and row to row (183 cm × 183 cm) were used for this study. Intercrops were sowed in lines between the rows and maintaining standard spacing for respective pulses.

Garden management

All cultural practices were done as per requirements. Each experimental treatment was applied individually in definite farmer's field according to the farmer's perception at pruned garden. Intercrops seeds were sown in prepared bed between the rows and maintaining standard spacing for respective pulses after 2-3 days of mulberry garden pruning through broadcasting method. Only the BSRTI recommended basal fertilizer dose ($N_{300}P_{150}K_{100}$ kg/ha/year) were used for mulberry cultivation. The mulberry leaves were harvest 75-80 days after pruning and respective intercrop was harvested depend on maturity.

Experimental design and treatments details

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and six treatments. The treatments were 1) T_0 = sole mulberry (control), 2) T_1 = mulberry + pea, 3) T_2 = mulberry + grasspea, 4) T_3 = mulberry + lentil, 5) T_4 = mulberry + chickpea and 6) T_5 = mulberry + mugbean.

Measurement of soil properties

The soil pH was determined by using the glass electrode method (Haber *et al.*, 1909). Soil organic C was determined by chromic acid digestion and spectrophotometric analysis (Heanes, 1984). Soil organic matter content was determined by multiplying the percent value of organic carbon with the conventional Van-Bemmelen's factor of 1.724 (Piper, 1950). The nitrogen content of the soil sample was determined by distilling soil with alkaline potassium per manganate solution (Subhaiah and Asija, 1956). 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_2So_4) (Podder *et al*., 2012). The soil available K was extracted with 1N NH_4OAC and determined by an atomic absorption spectrometer (Biswas *et al.*, 2012). 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 by Huq and Alam (2005). Zn in the soil sample was measured by an atomic absorption spectrophotometer (AAS) after extracting with DTPA Soltanpour and Workman (1979). Initial soil properties of the experimental soil are presented in Table-1.

Recorded growth and yield parameters

The recorded growth and yield parameters were total leaf number/branch, leaf present/branch, total branch height/plant (cm), length of longest shoot (cm), total shoot weight/plant (g), node/meter, 10 leaves area/plant (cm^2), total leaf weight/plant (g) and leaf yield (t)/hectare/crop followed by the respective procedure after 90 days of pruning.

Table 1. Average of initial physical and chemical properties of the experimental soil

pH	OM (%)	N (%)	P ($kgha^{-1}$)	K (me/ 100 g soil)	Ca (me/ 100 g soil)	Mg (me/ 100 g soil)	Zn (ppm)	Fe (ppm)	Cu (ppm)
8.35	1.01	0.06	11.3	0.33	28.036	2.86	0.94	2.65	0.48

Analysis of leaf quality

The mulberry leaf samples at different heights of the plant (top, middle and bottom) were collected in poly bags at 75 days after pruning (DAP) and composite leaf samples were made. The moisture (%) was determined by followed the Vijayan *et al*., (1996), total Chlorophyll content Hiscox and Israelstam (1979) using the spectrophotometer and were computed using the standard formulae (Arnon, 1949), total mineral (%) AOAC (1980), protein (%) Kjeldahl's method (Wong 1923), total sugar and reducing sugar (%) followed by the Miller (1972) and Loomis *et al*., (1937) procedure and methods.

Recorded silkworm rearing attributes

The leaves from mulberry were fed to silkworms and yield contributes 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 disease free laying eggs (dfls) and economics of mulberry leaf production with intercrops were also recorded during the study period.

Economics

The prices of inputs were used at the time of their use and selling prices of seeds based on prevailing market rates at the time of harvest of the produce will be taken into account.

Net returns

The net profit/ha was calculated by deducting cost of cultivation/ha from gross returns/ha.

Benefit- Cost Ratio (BCR)

BCR= Net returns (Tk /ha/crop) / Cost of cultivation (Tk/ha/crop)

Statistical analysis

The collected data were statistically analysed and mean values were evaluated by Duncan's Multiple Range Test (DMRT) through using the Statistic10 software. In the case of soil, the mean values of post-harvest soil properties were recorded for this study through using the Genstat $12.1^{th}ed^{n}$ for Windows (Lawes Agricultural Trust, UK) software.

Results and Discussion

Effect of pulses intercropping on growth performances of mulberry plant

Number of branches/plant

The number of branches/plant of mulberry was statistically significant for the treatment of T_0 which was statistically similar with the treatment of T_4 (Table 2). However, the maximum branch number/plant was 12.30 for sole mulberry (T_0) cultivation followed by T_4, T_1, T_5, T_2 and T_3 respectively.

Table 2. Growth performances of different pulses intercropped with mulberry garden

Treatments	Branch number/ Plant	Total leaf number/ Plant	Total branch height/ plant (cm)	Node/ meter/ Plant	Length of longest shoot (cm)	Leaf present/ branch	Leaf area (cm^2)	Total leaf weight/ plant (g)	Total shoot weight/ plant (g)	Total leaf yield/ hectare/year (t)
T_0	12.30 a	1354.3 a	961.60a	24.77 a	132.59 a	25.37 a	61.32a	923.21 a	435.69 a	11.08a
T_1	11.55 bc	1296.9 b	882.66b	23.33 c	124.58 b	21.81 b	56.59b	896.70b	413.03 b	10.76b
T_2	11.10 c	1258.0 c	799.95c	23.23 c	122.79 b	21.47 c	54.34c	872.84 c	407.46 b	10.4 c
T_3	9.89 d	1152.0 d	720.94d	22.20d	113.26 c	18.83 d	52.38d	820.79d	347.13 c	9.85d
T_4	12.08 ab	1349.2 a	885.90b	23.64b	126.55ab	21.87 b	56.74b	899.03b	413.78 b	10.81b
T_5	11.49 bc	1296.0 b	885.35b	23.28 c	123.44 b	21.75 b	56.45b	894.65b	412.82 b	10.75b

Here, T_0 = sole mulberry (control) T_1 = mulberry + pea, T_2 = mulberry + grasspea, T_3 = mulberry + lentil, T_4 = mulberry + chickpea and T_5 = mulberry + mugbean

Total leaf number per plant

The significant trend was observed for total leaf number/plant of mulberry through pulses intercropped with mulberry (Table 2). Statistically significant total leaves were recorded for the T_0 treatment that was similar with the treatment of T_4 (Table 2). However, the maximum leaves number/plant was 1354. 28 for sole mulberry (T_0) plant followed by the other treatments.

Total branches height per plant

Total branches height/plant of mulberry was significantly greater for the T_0 treatment (Table 2). The recorded maximum branch height was 961.6 cm for sole mulberry (T_0) cultivation.

Nodes per meter per plant

The intercropping treatments had a significant effect on nodes/meter of mulberry (Table 2). However, the maximum nodes / meter was 24.77 for sole mulberry (T_0) which was statistically significant followed by the T_4, T_1, T_5, T_2, respectively while least was found in T_3 (22.20).

Length of longest shoot

The length of longest shoot of mulberry was significantly greater for the T_0 treatment which was statistically similar with the treatment of T_4 (Table 2). However, the recorded maximum length of longest shoot was 132.59 cm in sole mulberry (T_0) plant followed by T4 (126.55), T_1 (124.58), T_5 (123.44), T_2 (122.79), respectively while least was found in T_3 (113.26).

Leaf per branch

The presence of mulberry leaves/branch markedly varied for intercropping treatments. The recorded maximum leaves present/branch was 25.37 for sole mulberry (T_0) cultivation that was statistically highest among all treatments (Table 2). However, in case of pulses intercropping with mulberry where leaves /branch was obtained in T_4 (21.87), T_1 (21.81), T_5 (21.75), T_2 (21.47) and T_3 (18.83), respectively.

Leaf area

The significantly greater 10 leaves area of mulberry was recorded for the treatment of T_0 (Table 2). However, the maximum leaf area was 61.32 cm^2 for sole mulberry (T_0) cultivation followed by the treatments of T_4 (56.74), T_1 (56.59), T_5 (56.45), T_2 (54.34), respectively while least in T_3 (52.38).

Total leaf weight per plant

The intercropping treatments had a highly significant trend on total leaf weight of mulberry plant. However, the maximum total leaf weight/plant was found 923.21g for sole mulberry (T_0) plant that was statistically highest followed by the treatment of T_4 (899.03g), T_1 (896.70g), T_5 (894.65g), T_2 (872.84g) and T_3 (820.79g), respectively (Table 2).

Total shoots weight per plant

The total shoot weight/plant of mulberry was highly significant for the treatment of T_0 (Table 2). However, the maximum total shoot weight/plant was found 435.69g for cultivation of sole mulberry (T_0) plant followed by T_4 (413.78g), T_1 (413.03g), T_5 (412.82g), T_2 (407.46g) and T_3 (347.13g) treatments respectively.

Effect of pulses intercropping on productivity

The mulberry leaf productivity was statistically differed by the intercropping of pulses with mulberry plant. Among the treatments average leaf yield was greater in sole mulberry (11.08 t ha^{-1}) compared to rest of intercropping treatments was mainly due to increasing all yield attributes characters (Table 3). Vishaka *et al.,* (2017) reported that in sole mulberry at 60 days after pruning compared to other intercropping treatments the growth parameters were significantly greater due to no competition from the intercrops for various inputs in sole mulberry. However, the mulberry leaf yield was T_4 (10.81 t ha^{-1}), T_1 (10.76 t ha^{-1}), T_5 (10.75 t ha^{-1}), T_2 (10.47 t ha^{-1}) and T_3 (9.85 t ha^{-1},) respectively with reasonable yield due to better growth and yield contributing characters (Table 3). Rajegowda *et al.,* (2020) also found that intercropping of mulberry with legumes performed better growth attributes and produced higher leaf yield due to enhancement of soil fertility.

In case of pod production for various pulses the maximum pod production was 1 ton/hectare/crop for the treatment of T_4 (chickpea) which was statistically highest than

the other treatments. The pod production for grasspea and mugbean was statistically similar but the lowest pod production was found for lentil. However, the recorded pod production for mugbean were (0.80 t), grasspea (0.75 t), pea (0.60 t) and lentil (0.50 t) per hectare per crop respectively (Table 3).

Table 3. Growth performances of different pulses intercropped with mulberry garden

Treatments	Mulberry leaf yield (t/ha/crop)	Yield of intercrops (t/ha/crop)
T_0	11.08a	-
T_1	10.76b	0.60c
T_2	10.47c	0.75b
T_3	9.85d	0.50 d
T_4	10.81b	1.00a
T_5	10.75b	0.80b

Here, T_0 = sole mulberry (control), T_1 = mulberry + pea, T_2 = mulberry + grasspea, T_3 = mulberry + lentil, T_4 = mulberry + chickpea and T_5 = mulberry + mugbean

Performance of intercropping on mulberry leaf quality

The leaf quality of mulberry, moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral contain in mulberry leaf were significantly improved by pulses intercropped with mulberry. Among treatments the recorded maximum moisture, total chlorophyll, crude protein, total sugar, reducing sugar and mineral were (76.78%), (39.74), (20.86%), (6.41%), (4.17%) and (12.77%), respectively for T_4 treatment followed by the T_1, T_2, T_5 and T_0 respectively (Table 5). Intercropping of pulses with mulberry had a possessive impact on improvement of mulberry leaf quality viz. moisture, total chlorophyll, protein, total sugar, reducing sugar and mineral. But better performance was found for the mulberry + chickpea intercropped followed by the mulberry + pea, mulberry + mugbean and mulberry + grasspea, respectively. However, the moisture and total chlorophyll contain in T_4 treatment were statistically differed compared to all treatments (Table 4).

Intercropping effect on silkworm rearing attributes

The silkworm rearing performance was statistically differed to feed on different types of pulses intercropped mulberry leaf. However, intercropping treatments, the silkworm rearing attributes viz., weight of single larvae (3.65 g), single cocoon weight (33.75g), shell weight (0.27g), cocoon shell ratio (21.98), highest filament length (990.41m), renditta (10.29) and cocoon productivity/100 dfls (72.67 kg), respectively were better in treatment T_4 (mulberry + chickpea) followed by the T_1 (mulberry + pea), T_2 (mulberry + grasspea), T_5 (mulberry + mugbean), T_0 (sole mulberry) and T_3 (mulberry + lentil) treatments, respectively (Table 5).

Table 4. Average leaf quality performances of different pulses intercropped with mulberry garden

Treatments	Moisture (%)	Total chlorophyll (SPAD value)	Protein (%)	Total sugar (%)	Reducing sugar (%)	Mineral (%)
T_0	75.57 d	38.51 d	20.13 d	6.03 c	3.63 ab	11.77 d
T_1	76.69 b	39.66 b	20.77 ab	6.38 a	4.05 a	12.74 ab
T_2	76.53 c	39.59 b	20.75 bc	6.34 ab	4.03 a	12.71 b
T_3	74.83 e	37.98 e	19.72 e	5.52 d	3.44 b	11.11 e
T_4	76.78 a	39.74 a	20.86 a	6.41 a	4.17 a	12.77 a
T_5	75.62 d	38.76 c	20.66 c	6.28 b	3.84 ab	12.60 c

T_0 = Sole mulberry (Control) T_1 = mulberry + pea, T_2 = mulberry + grasspea, T_3 = mulberry + lentil, T_4 = mulberry + chickpea and T_5 = mulberry + mugbean

Table 5. Average silkworm rearing performances of different pulses intercropped with mulberry garden

Treatments	Weight of single larvae (g)	Single cocoon weight (g)	Shell weight (g)	Cocoon shell ratio	Highest filament length (m)	Renditta	Cocoon productivity /100 dfls (kg)
T_0	3.56 c	32.40 d	0.20 bc	20.13 bc	978.14 b	11.13 b	70.55 c
T_1	3.64a	33.65 a	0.26 a	21.36 ab	986.30 ab	10.44 d	72.62 a
T_2	3.62 b	33.36 b	0.25 a	21.05 ab	985.09 ab	10.80 c	71.36 b
T_3	3.42d	31.21 e	0.19 c	19.05 c	962.96 c	12.44 a	69.07 d
T_4	3.65a	33.75 a	0.27 a	21.98 a	990.41 a	10.29 e	72.67 a
T_5	3.57c	32.62 c	0.22 b	20.36 b	979.70 b	11.13 b	71.10 b

Here, T_0 = sole mulberry (control) T_1 = mulberry + pea, T_2 = mulberry + grasspea, T_3 = mulberry + lentil, T_4 = mulberry + chickpea and T_5 = mulberry + mugbean

Intercropping effect on soil properties

The results of the study indicated that post-harvest soil properties were not affected due to intercropping of pulses with mulberry plant except nitrogen and potassium (Table 5). The initial soil analysis showed average soil pH of 8.77, organic matter contents 1.01%, nitrogen N 0.06%, P 11.3 kg/ha, K 0.33 me/100g soil, Ca 28.036 me/100 g soil, Mg 1.96 me/100 g soil, Zn 0.94 ppm, Fe 2.63 ppm and Cu 0.48 ppm (Table 1). After harvest of intercrops, the post-harvest soil properties showed average soil pH 7.82, organic matter contents of 1.38%, nitrogen N 0.13%, P 14.89 kg/ha, K 0.19 me/100g soil, Ca 28.92 meq/100 g soil, Mg 3.11 meq/100 g soil, Zn 3.45 ppm, Fe 3.59 ppm and Cu 0.55 ppm. (Table 6).The maximum organic matter (1.58%), N (0.22%), P

(17.50 kg/ha), K (0.20 meq/100g soil), Ca (30.55 meq/100 g soil), Mg (3.44 meq/100 g soil), Zn (5.17 ppm), Fe (4.12 ppm) and Cu (0.64 ppm) respectively was obtained from T_4 (mulberry + chickpea) followed by other treatments as well as maximum soil pH was 8.03 for T_0. Similarly, the recorded average maximum nitrogen (0.22%) and potassium (0.20 meq/100 g soil) contain was also in mulberry + chickpea where recorded minimum in soil of T_3 (mulberry + lentil) treatment as well as soil pH 7.57 for T_4 treatment (Table 6).

Table 6. Average post-harvest soil properties of different pulses intercropped with mulberry garden

Treatments	pH	OM (%)	N (%)	P (kg/ha)	K (meq/ 100 g soil)	Ca (meq/ 100 g soil)	Mg (meq/ 100 g soil)	Zn (ppm)	Fe (ppm)	Cu (ppm)
T_0	8.03 a	1.31 cd	0.08a	14.00 c	0.18 a	28.10 d	2.87 c	2.69 d	3.13 c	0.51 cd
T_1	7.77 bc	1.45 b	0.15 a	17.33 a	0.20 a	29.71 b	3.42 a	3.56 b	4.08 a	0.57 b
T_2	7.77 bc	1.34 c	0.13 a	14.60 b	0.20 a	28.66 c	3.06 b	3.31 c	4.01 b	0.56 bc
T_3	8.00 ab	1.30 d	0.07 a	11.40 d	0.17 a	28.08 d	2.84 c	2.67 d	3.06 d	0.50 d
T_4	7.57 c	1.58 a	0.22 a	17.50 a	0.20 a	30.55 a	3.44 a	5.17 a	4.12 a	0.64 a
T_5	7.77 bc	1.32 cd	0.12a	14.53 c	0.19 a	28.43 c	3.04 b	3.30 c	3.15 c	0.51 cd
Average	7.82	1.38	0.13	14.89	0.19	28.92	3.11	3.45	3.59	0.55

Here, T_0 = Sole mulberry (control), T_1 = mulberry + pea, T_2 = mulberry + grass pea, T_3 = mulberry + lentil, T_4 = mulberry + chickpea, T_5 = mulberry + mug bean, OM= Organic matter, N = Nitrogen, P = Phosphorus, K = Potassium, Ca = Calcium, Mg = Magnesium, Zn = Zinc, Fe = Iron and Cu = Copper

The average nitrogen contains in intercropped soil T_1 (0.15), T_2 (0.13), T_4 (0.22) and T_5 (0.12%) respectively greater than the control (0.08%) which may be due to the atmospheric N_2 fixation through nodule formation of legumes intercrops. The other soil nutrients viz: phosphorus (P), Potassium (K), calcium (Ca), magnesium, zinc (Zn), iron (Fe) and cupper (Cu) were grater in intercropped soil compared to sole mulberry growing soil. However, the obtained maximum P (17.50 kg/ha), K (0.20 me/100g soil), Ca (30.55 me/100 g soil), Mg (3.44 me/100 g soil), Zn (5.17 ppm), Fe (4.12 ppm) and Cu (0.64 ppm) in T_4 (mulberry + chickpea) treatment followed by other treatments. These could be greater biomass production in intercropped soil least of sole mulberry growing soil during the co-growing stage, resulting attributed soil nutrients improvement as corroborates with findings of Zheng *et al.*, (2011).

Cost benefit analysis as intercropping of mulberry with pulses

Total cost of cultivation was more in mulberry + mug bean intercropping (Tk. 133500 ha/crop) followed by mulberry + lentil (Tk. 111500 /ha/crop), mulberry + chickpea (Tk. 103300 /ha/crop), mulberry + pea (Tk. 102500 /ha/crop) and mulberry + grasspea (Tk. 101700 /ha/crop), respectively, while least in sole mulberry cultivation TK. (95000 /ha/crop). The gross return was ranged from Tk. 88,750 /ha/crop to Tk. 1, 34,450 /ha/crop. The maximum gross return of Tk. 1, 34,450 /ha/crop was obtained from intercropping of mulberry + chickpea followed by mulberry + mug bean (Tk. 1, 34,250/ ha), mulberry + pea (Tk. 1, 17,250/ha), mulberry + grasspea (Tk. 1,09,050/ha) and

mulberry + lentil (Tk. 96,250/ha), respectively The lowest gross returns of Tk. 88,750 /ha/crop was found in sole mulberry cultivation (Table 7). The recorded higher BCR (1.30) was found in mulberry intercropped with chickpea which was at par with mulberry + pea (1.14), mulberry + grasspea (1.07), but mulberry + mugbean (1.01), sole mulberry (0.93) and mulberry + lentil (0.86), respectively (Table 7). In this study it was found that better cocoon yield, market price as well as additional income for chickpea and pea. These findings are in conformity with previous findings of Ahsan *et al.,* (1989), Kabir *et al.,* (1991), Gargi *et al.,* (1997) an Shankar *et al.,* (2000) found higher net returns and B: C ratio in mulberry and legume intercropping system compared to sole mulberry cultivation. Similarly, Ramamurthy *et al.,* (2006) also reported that intercropping of mugbean and chickpea with mulberry, the net returns was Tk. 35,552/ha/year and income equivalent ratio 1.9 whereas in case of sole mulberry crop net returns was Tk. 18,712 /ha/year.

Table 7. Economics of mulberry leaf production with pulses intercrops

Treatments	Gross return (Tk. /ha)			Cost of cultivation (Tk./ha)				Gross margin (Tk./ha)	BCR
	Cocoon	Intercrop	Total	Mulberry	Silkworm rearing	Intercrop	Total		
T_0	183750	-	183750	45000	50000	-	95000	88750	0.93
T_1	183750	36000	219750	45000	50000	7500	102500	117220	1.14
T_2	183750	27000	210750	45000	50000	6700	101700	109050	1.07
T_3	183750	24000	207750	45000	50000	16500	111500	96250	0.86
T_4	183750	54000	237750	45000	50000	8300	103300	134450	1.30
T_5	183750	84000	267750	45000	50000	38500	133500	134250	1.01

Here, T_0 = Sole mulberry (Control) T_1 = Mulberry + Pea, T_2 = Mulberry + Grasspea, T_3 = Mulberry + Lentil, T_4 = Mulberry + Chickpea, T_5 = Mulberry + Mugbean

Conclusion

The results of the present study exposed that intercropping in mulberry provides in utilization of space between mulberry plants. Intercropping of pulses could increase the income of sericulture farmers along with sericulture activities. In the long run, farmer's income as well as productivity could be increased by growing chickpea as intercrop in mulberry and enhanced soil fertility.

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Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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