

Research article

Productivity and Profitability of Baby Corn-Legume Intercropping Systems in the Charland Area of Bangladesh

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Abstract

Agricultural production in Bangladesh's Charland (Riverine Island) region is primarily threatened by soil fertility and the use of chemical fertilizers. Baby corn can be interplanted with different leguminous crops to increase fertility while reducing the quantity of synthetic fertilizer needed. A field experiment was carried out at Charpakkimari in the Sherpur district of Bangladesh from November 2018 to March 2019 to examine the performance of several leguminous crops and baby corn cultivated as an intercrop. At row ratios of 2:1, 2:2, and 2:3, respectively, intercropping techniques for baby corn + chickpea, baby corn + pea, baby corn + groundnut, and baby corn + lentil were implemented. Additionally, baby corn, chickpea, pea, groundnut, and lentil were sown as sole crops using a randomized complete block design with three replications. Based on the results, the treatments with a row ratio of 2:1 that were determined to be relatively superior in terms of higher production and profitability were baby corn + chickpea, baby corn + pea, as well as baby corn + chickpea and baby corn + lentil (2:3). Baby corn + pea (2:1) intercropping produced the highest baby corn equivalent yield (6.02 t ha^{-1}), net return (214425 Tk), and benefit cost ratio (2.46), compared to sole baby corn. These results demonstrated that it was more profitable and productive to intercrop baby corn with peas, chickpeas and lentils than to grow baby corn alone.

Keywords: baby corn; chickpea; pea; groundnut; lentil; intercropping

1. Introduction

Intercropping is the agricultural practice of growing two or more crops simultaneously in the same area with the goal of increasing overall productivity per unit area and efficiently using labor, input, and land. "Intercropping is a long-standing technique that is marginalized in "modern agriculture," which is dominated by vast tracts of monoculture, and high-yielding, resource-intensive crops (Li et al., 2013). Intercropping has long been the most popular cropping strategy in developing countries. Intercropping systems can more effectively use light, heat, water, and nutrient resources in agroecosystems when they are

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set up correctly and can thus increase yields (Mei et al., 2012). Monocropping increases the consumption of synthetic fertilizers, depletes soil fertility, and promotes the spread of insects and diseases. Intercropping reduces soil erosion, boosts productivity on a small plot of land, lowers risk for smallholder farmers, and yields higher returns per unit of labor during labor shortages (Semahegn, 2022). Intercropping has greater benefits than monocropping since it attracts in more parasitoids and predators, which helps lessen pest infestation (Pierre et al., 2022). As an example, Kennedy et al. (1990) found that intercropping groundnuts with pearl millet (*Pennisetum americanum*) significantly increased the number of parasitoids (*Chelonus* sp.) and predators (*Coccinella* sp. and *Menochilus sexmaculatus*) in a field experiment carried out in India. These actions may create a more diverse ecosystem, which in turn attracts more beneficial insects, including parasitoids and predators (Karabo et al., 2019). The benefits of this intercropping system in susceptible environments include improved soil quality and fertility through increased nutrient availability (Betencourt et al., 2012), as well as improved water use efficiency during drought (Yin et al., 2020).

Legumes are nitrogen-fixing crops because they convert atmospheric nitrogen into mineral nitrogen that the crops can use (Kermah et al., 2018). Legumes can be utilized in crop rotation and intercropping systems as economic crops, cover crops, and green manure. Crop growth and yield are facilitated by fixed nitrogen, which is also readily available for use by subsequent crops (Ruangsanka et al., 2021). Through a symbiotic relationship with rhizobium or *Bradyrhizobium* bacteria, legume crops fix nitrogen. This process, known as biological nitrogen fixation (BNF), transforms atmospheric nitrogen into forms that plants can use and minimizes the cost of nitrogenous fertilizers (Banik & Sharma, 2009a).

Baby corn is a short duration (50-60) crop that can be grown as a vegetable and cash crop. As baby corn is harvested when the plants are green, many young plants may be used as fodder for cattle. Green fodder can be stored through silage for 3 to 5 months and it can fulfill the fodder demand of char dwellers. Baby corn has a shallow root system and efficient use of water which can reduce competition with legumes. Since baby corn is cultivated with wide spacing, there is scope to grow legumes as an intercrop with baby corn either for green manuring or cob without reducing its yield.

Crop compatibility is an essential factor in terms of the success of any intercropping system. So, crops should be carefully chosen for an intercropping system based on the advantages of association and mutual competitiveness. Growing legumes with cereals is the best way to make nitrogen available to nearby crops. The cereal-legume intercropping system is the most popular cropping system worldwide because it encourages crop diversity, production stability, and risk mitigation (Simbine et al., 2018). In cropping systems, cereal-legume intercropping offers a number of significant benefits, such as raising yield, enhancing soil attributes, reducing weeds, and boosting the quantity of bacteria that fix nitrogen (Carton et al., 2020; Cheriére et al., 2020; Nasar et al., 2022). Intercropping legumes with cereals maximizes production by better utilizing the resources that are available (Khonde et al., 2018). For example, the productivity of cereals such as wheat and barley (*Hordeum vulgare* L.) remained unaffected when planted with legumes such as rapeseed (*Brassica napus* L.) and fababean (*Vicia faba* L.) under deficit irrigation (Amanullah et al., 2020).

The Charland's soil is generally sandy, with limited soil moisture retention ability. The soil is also deficient in organic matter and fertility in general. The yields of Charland are meager compared to those in other regions of the country. Baby cobs are harvested to provide organic matter because char land often has a lower amount of organic content.

Since char land is almost infertile, leguminous crops fix atmospheric nitrogen and release it into the soil, enriching soil fertility.

It is challenging to meet the food and nutritional demands in many developing nations due to high population growth and a lack of cultivable land. Low agricultural productivity in developing countries is also largely caused by weeds, drought, and nutrient mining, in addition to poor soil fertility and small-scale farmers' restricted access to resources. Traditional cropping techniques centered on cereals are less productive than intercropping. The effects of intercropping cereals and legumes have been studied in recent years, such as that performed by Benider et al. (2021), but these experiments were conducted in a particular char land area that was much less fertile than other types of land. They also investigated other intercropping combinations and suggested which one would perform best in such location. Therefore, the objectives of this experiment were to find out the compatibility and feasibility of baby corn and legumes as well as to identify the effects of integrated nutrient management on soil fertility, crop productivity and profitability of baby corn legume intercropping systems.

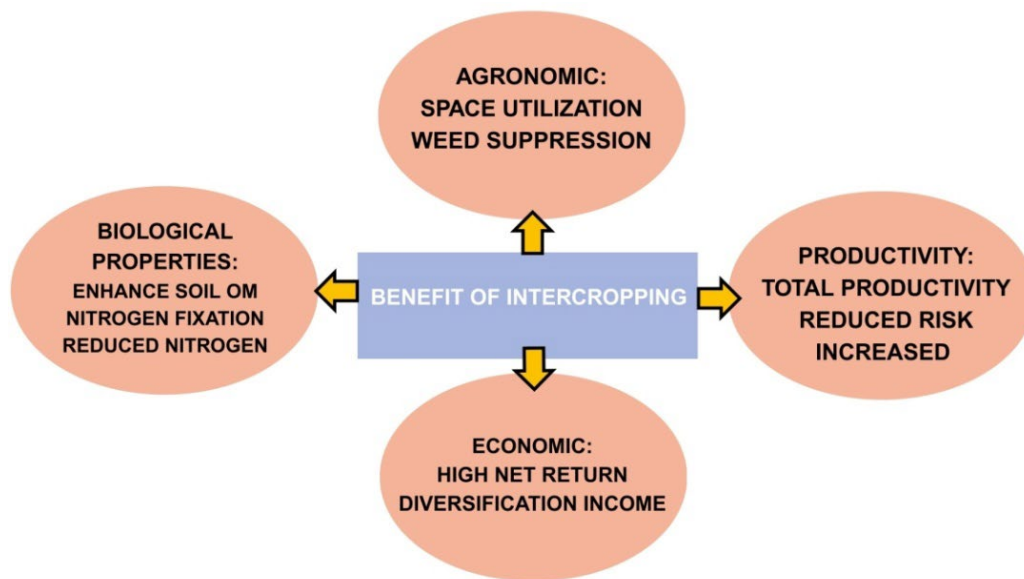


Figure 1. Schematic representation of intercropping benefit

2. Materials and Methods

2.1 Description of the experimental site

The field experiment was conducted in a char land of Char Pakkumari Union of Sherpur District in Bangladesh (Old Brahmaputra Floodplain in Agro-ecological Zone 9; 89°57' and 28.86' N latitudes and 24°56' and 20.32' E longitudes) during the rabi season in 2018-19. The site is characterized by the wet season being hot, oppressive and mostly cloudy and the dry season being warm and mostly clear. The soil of the experimental field had a sandy texture having normal pH (6.4), low organic carbon (0.25%), nitrogen (0.015%), phosphorus (4.8 ppm), potash (0.16meq/100g soil) and sulfur (14.0 ppm) (SRDI, 2019).

2.2 Experimental treatments and design

The experiment comprised seventeen treatments of baby corns and different legumes crops, either alone or in intercropping as follows: T_1 = sole baby corn, T_2 = sole chickpea, T_3 = sole garden pea, T_4 = sole groundnut, T_5 = sole lentil, T_6 = 2B: 1C (two rows of baby corn followed by one row of chickpea), T_7 = 2B: 1P (two rows of baby corn followed by one row of pea), T_8 = 2B: 1G (two rows of baby corns followed by one row of groundnut), T_9 = 2B: 1L (two rows of baby corn followed by one row of lentil), T_{10} = 2B:2C (two rows of baby corn followed by two rows of chickpea), T_{11} = 2B:2P (two rows of baby corn followed by two rows of pea), T_{12} = 2B:2G (two rows of baby corn followed by two rows of groundnut), T_{13} = 2B:2L (two rows of baby corn followed by two rows of lentil), T_{14} = 2B:3C (two rows of baby corn followed by three rows of chickpea), T_{15} = 2B:3P (two rows of baby corn followed by three rows of pea), T_{16} = 2B:3G (two rows of baby corn followed by three rows of groundnut), and T_{17} = 2B:3L (two rows of baby corn followed by three rows of lentil).

The experiment was conducted following a randomized complete block design (RCBD) with three replications. The unit plot size was 5 m × 3 m maintaining row to row distance of 45 cm, plant to plant distance of 20 cm, and a paired row distance of 55 cm in a sole crop of baby corn and one row in intercropping. In the case of baby corn-legume two rows and three rows intercropping systems, the row to row distance was 45 cm, the plant to plant distance was 20 cm and the pair row distance was 90 cm. There was a 1 m distance between two adjacent plots and a 2 m space between two adjacent replications.

2.3 Crop husbandry

Baby corn, chickpea, pea, groundnut and lentil varieties: baby star, BARI sola 5, Nator local, BARI groundnut 5 and BARI lentil 7, respectively, were sown at seed rates of 30 kg ha⁻¹, 90 kg ha⁻¹, 50 kg ha⁻¹, 35 kg ha⁻¹ and 180 kg ha⁻¹, respectively, on 19 November 2018. The doses of fertilizer of urea were 260 kg ha⁻¹ in sole baby corn and all intercrops and 25 kg, 40 kg, 40 kg, 40 kg urea were applied in groundnut, chickpea, lentil and pea, respectively. TSP, MP, gypsum and zinc sulfate were applied at a rate of 130 kg, 90 kg, 120 kg, and 8 kg per ha, respectively. Seeds started germinating 3-7 days after sowing (DAS), so thinning was done at 10 DAS to maintain optimum plant population in each plot. Plant populations of 73,333 were maintained in sole baby corn and baby corn + legume (2:1) and 58,666 in baby corn + legume (2:2) and baby corn + legume (2:3). Irrigation was provided before flowering and cob formation, and weeding was done before 70 DAS. At an early stage of growth, few cutworms (*Helicoverma armigera*) infested the young plants, and at a later stage of growth, termite (Isoptera) and fall armyworm (*Spodoptera frugiperda*) attacked the plant. Karate 2.5 EC 3 mL/1mL decimal was sprayed all year round except on rainy days (70-80days) to control the insect cutworms. Ektara 25 WG 2.5g/10L/ 5 decimal was applied as an alternate to control termite and Virtako 40 WG (Thiamethoxam 20% + Chlorantraniliprole 20%) was sprayed against fall armyworms. Baby corn cobs were harvested immediately after the emergence of silk (about 2 cm long) to maintain the quality. Harvesting was done within 2 or 3 days after silking. In the field, baby corn was harvested in the 1st week of March, with the total crop duration ranging from 107-108 days.

2.4 Data collection procedure

At each harvest, five plants were selected randomly from each sole (baby corn and legume crops) and intercropped plots. For baby corn, pre harvest data were collected on plant

height and total dry matter weight at 20, 40, 60, 80 DAS, as well as stem length, number days of tasseling, number of cobs per plant, and harvest duration. Post harvest observation included cob diameter, number of young cobs per plant, cob yield with and without husk (t ha^{-1}), husk baby corn ratio, and green fodder yield (t ha^{-1}). For the leguminous crops, pre harvest data comprised plant height and total dry matter, while post harvest data were number of branches plant^{-1} , number of pods plant^{-1} , number of seeds pod^{-1} , number of seeds plant^{-1} , weight of 1000 seed (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}), and harvest index (%). To evaluate the economic performance, several parameters such as net profit (Tk), benefit cost ratio (BCR), income equivalent ratio (IER), land equivalent ratio (LER), baby corn equivalent yield (BCEY) were also calculated.

Net profit was determined using the following formula:

$$\text{Net profit} = \text{Gross income} - \text{Total cost of production}$$

The benefit-cost ratio (BCR) is a ratio used in cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors. The benefit-cost ratio was calculated as follows:

$$\text{BCR} = \text{Gross return} \div \text{total cost of production}$$

The land equivalent ratio (LER) is defined as the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level. It is calculated as the sum of the fractions of the intercropped yields divided by their respective sole-crop yields and expressed as:

$$\text{LER} = \frac{\text{yield of legume intercropping}}{\text{yield of legume Sole cropping}} + \frac{\text{yield of baby corn in intercropping}}{\text{yield of baby corn in Sole cropping}}$$

Income equivalency ratio (IER) is similar in concept to LER, except that yield is measured in terms of net income, rather than plant product productivity. IER was calculated as:

$$\text{IER} = \frac{\text{Income of legume intercropping}}{\text{Income of legume Sole cropping}} + \frac{\text{Income of baby corn in intercropping}}{\text{Income of baby corn in Sole cropping}}$$

Baby corn equivalent yield (BCEY) was calculated by following these formulae:

$$\text{Baby corn equivalent yield} = \text{Yield of crops} \div \text{price of crops of baby corn}$$

2.5 Statistical analysis

Data on a number of parameters were gathered and subjected to statistical analysis. Using the computer application MSTAT-C, the analysis of variance was computed. According to Gomez et al. (1984), the mean differences were assessed using either Duncan's New Multiple Range Test (DMRT) or the least significant difference (LSD).

3. Results and Discussion

3.1 Growth contributing character of baby corn

In baby corn, plant height, dry matter weight after sowing, stem diameter, number of days of tasseling, and number of cobs per plant contributed to plant growth of baby corn. Plant height and dry matter had a greater influence than other parameters. In this experiment plant height, total dry matter, stem diameter, number of tasseling, cob yield (with and without husk) and green fodder yield were consistently higher in sole crops compared to intercropping. However, baby corn equivalent yield, net profit and BCR were always higher in the intercropping system. In particular, treatment T₁ (sole cropping) or any sole crop produced the highest plant height, dry matter, cob yield and green fodder yield.

3.1.1 Plant height of baby corn

The highest plant height measured at harvest (176.78 cm) was found in sole baby corn (T₁), and it was statistically significant. Among the intercropping systems, the tallest plant (168.22 cm) of baby corn was observed in treatment T₆: baby corn + chickpea (2:1), which was followed by 163.78 cm height in T₇: baby corn + pea (2:1). The shortest plant of baby corn (121.56 cm) was recorded in treatment T₁₅: baby corn + pea (2:3). Mohan et al. (2023) found that a paired row of baby corn and pea (2:1) gave higher height compared to any other intercropping or sole crops, which was similar to treatment T₆. In treatment T₆, a single row of chickpea allowed baby corn to grow higher than in more densely intercropped settings. This arrangement optimally balances resource competition and complementarity. By lowering the amount of chickpeas, baby corn had less competition for light, water, and nutrients, which aided in its vegetative growth. Suárez et al. (2022) found that intercropping enhanced plant height and photosynthetic mobilization, which in turn enhanced the vegetative organs (number of leaves and stem diameter) compared to monoculture.

3.1.2 Dry matter accumulation plant⁻¹ of baby corn

The highest significant dry matter accumulation plant⁻¹ at harvest (108.91 g) was recorded in sole baby corn. Among the intercropping systems, baby corn + lentil (2:1) showed the highest dry matter accumulation per plant of baby corn (100.00 g), which was statistically at par with baby corn + pea (2:1) and baby corn + chickpea (2:1) (Figure 2b). The highest dry matter accumulation in sole baby corn might be due to less competition of baby corn plants among themselves for nutrients and moisture under limited nutrients and moisture. The lowest dry matter accumulation plant⁻¹ (66.18 g) was recorded in baby corn + pea (2:3), which might be due to the proportionally smaller area allotted to baby corn in this row ratio. Baby corn accumulates more dry matter through efficient resource utilization. Superior absorption of water, nutrients (particularly nitrogen), and solar radiation promotes vigorous leaf development and photosynthesis. This maximizes assimilate production, giving in higher overall biomass and dry matter yields. The intercropping system with two rows of baby corn and one row of lentil (T₉) had the highest dry matter accumulation, followed by T₇. Mohan et al. (2023) also noticed that the paired row of baby corn and peas produced the highest total dry matter due to plant height and leaf area, while the sole treatment produced the lowest plant height. Crops having C4 photosynthetic pathways have been known to be dominant when interplanted with C3 species such as legumes, according to Suárez et al. (2022).

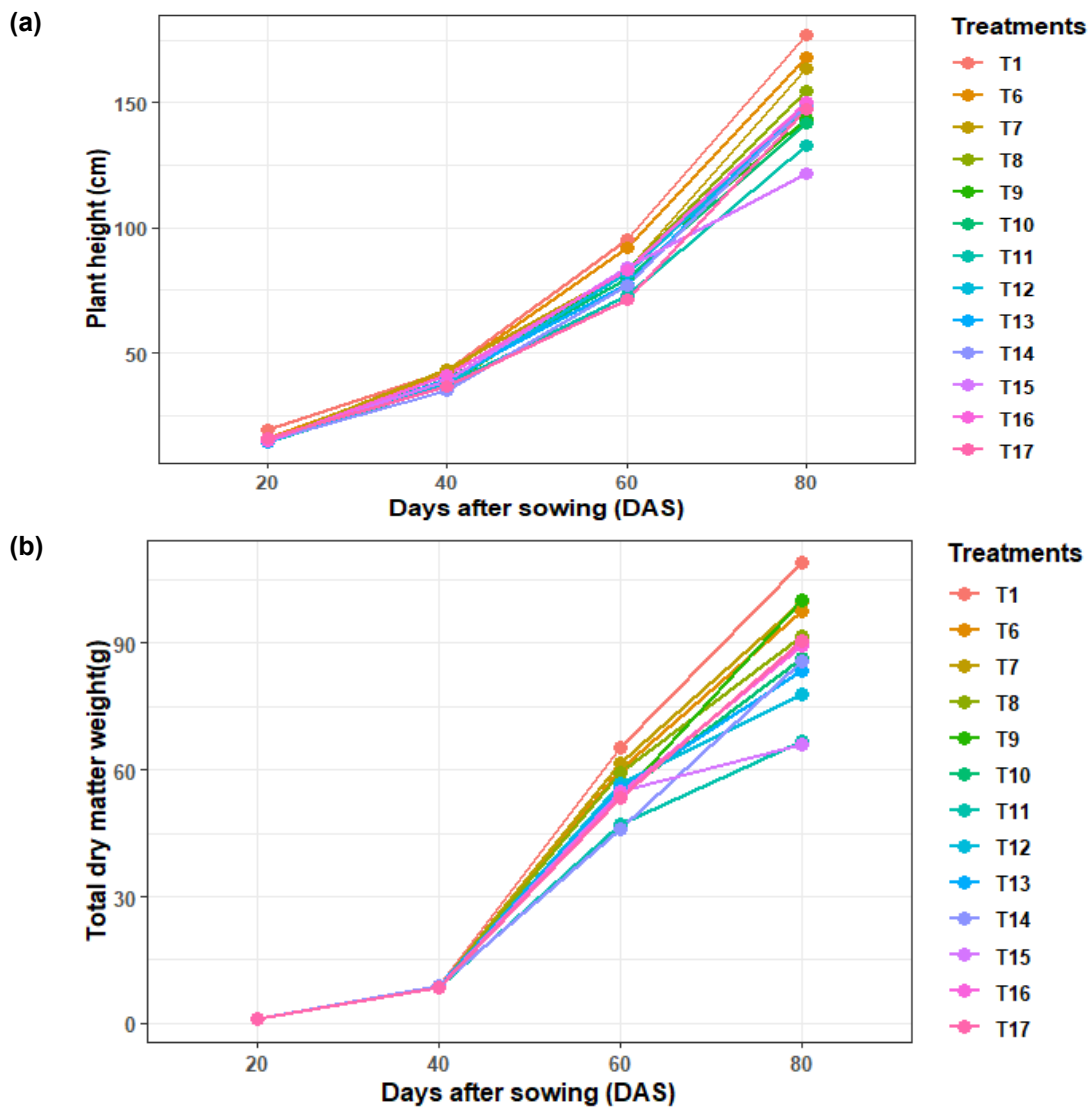


Figure 2. Plant height (a) and dry matter (b) of baby corn at different days after sowing (DAS)

3.2 Yield contributing characters of baby corn

The cob yield of baby corn was significantly influenced by different row ratios of baby corn + legumes intercropping. The high yields of cob with husk (21.21 t ha^{-1}) and without husk (3.27 t ha^{-1}) produced in sole baby corn cultivation were significantly higher than intercropping of baby corn + pea at 2:1, 2:2 and 2:3 ratios (Figure 3a). Among the intercropping systems, the highest yields of cob with husk (21.19 t ha^{-1}) and without husk (3.24 t ha^{-1}) were found in baby corn + pea (2:1). In contrast, the highest significant green

fodder yield (31.54 t ha^{-1}) was observed in sole baby corn cultivation, exceeding that of baby corn + chickpea (2:1). In the intercropping system, the maximum yield of green fodder (29.10 t ha^{-1}) was found in baby corn + chickpea in a 2:1 ratio (Figure 3b). The main reason for the highest young cob yield with husk and without husk and green fodder yield under sole baby corn cultivation is the greater plant population of baby corn. There were 25% more baby corn plant population in sole baby corn cultivation than in the baby corn-legume intercropping system at 2:2 and 2:3. Besides, the highest values of number of cobs plant⁻¹ (3), cob length (31.66 cm) and cob girth (97.80 cm) were produced by the sole baby corn. The two main causes of the decreased yield of legume components under intercropping were most likely shading and water stress. According to Banik and Sharma (2009a), the greatest yield of baby corn and green fodder may result from minimum habitat disturbance and less competition for resources because solo cropping systems lacked a diversified cropping environment. When only one treatment was used, the yields of cob and green fodder increased, but the combined effect also raised the total production per hectare. The same finding was also found by Pierre et al. (2022).

3.3 Growth and yield contributing characters of different legumes crop

The best legume crops should be able to take up nutrients from the soil by developing deep roots, yield more biomass in less time, be easy to work and grow, not compete with the main crop, be resistant to diseases and insects, suppress weeds, and be economical to grow (Reddy, 2016). According to Pierre et al. (2022), in order to keep crop species from competing with one another, legumes should be planted 2-4 weeks after maize in a maize-legume intercropping system. Naher et al. (2019), determined that an intercropping system of maize and legumes is a potential method for controlling weeds and boosting maize yields. By providing a home for a variety of insects that would not be able to survive in a monocropping system, intercropping of suitable crops promotes biodiversity. Some insect-repelling legume species may offer a promising way to lessen the use of pesticides in agriculture. Because of the wide variety of crops, Maitra et al. (2019) discovered that beneficial insects like parasites and predators became more prevalent while harmful pests remained below economically harmful threshold. Additionally, the number of beneficial insects increased while the numbers of corn borer (*Ostrinia nubilalis*) and leaf hopper (Cicadellidae) decreased.

3.3.1 Seed yield (t ha^{-1}) in chickpea

Grain yield in chickpea varied significantly with the variation in cropping system and the planting configuration under the intercropping system (Table 1). Sole chickpea gave significantly higher seed yield (1.97 t ha^{-1}) than all the baby corn + chickpea row ratios because of the increasing number of branch plant⁻¹, number of pod plant⁻¹, number of seeds pod⁻¹. Seed yield of chickpea was also significantly influenced by different row ratios of baby corn + chickpea intercropping. Among the intercropping systems, baby corn + chickpea (2:3) gave significantly higher seed yield (1.12 t ha^{-1}) than all the other baby corn + chickpea row ratios due to the highest number of branches and pods plant⁻¹ and also the number of seed pods. The lower population of legumes under the intercropping system may be the reason for the decrease in legume seed yield.

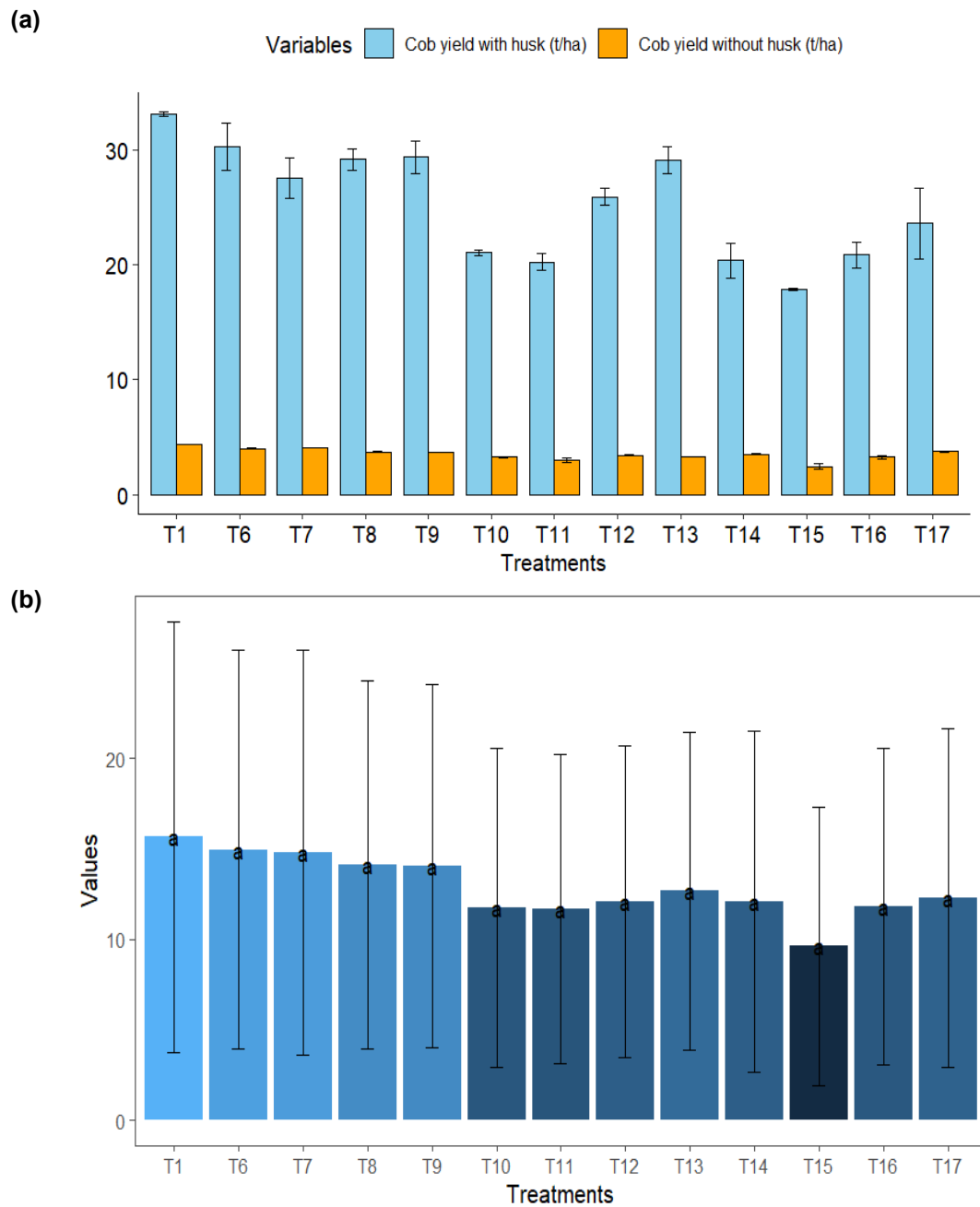


Figure 3. Cob Yield (a) with and without and green fodder (b) yield of baby as influence by intercropping

Table 1. Performance of yield and yield contributing characters of chickpea

Treatment	Number of Branch Plant ⁻¹	Number of Pod Plant ⁻¹	Number of Seeds Pod ⁻¹	Seed Yield (t ha ⁻¹)
T ₂	9.87 ^a	61.67 ^a	1.26	1.97 ^a
T ₆	9.60 ^a	58.67 ^{ab}	1.14	0.61 ^d
T ₁₀	9.24 ^b	50.67 ^{bc}	1.14	0.77 ^c
T ₁₄	8.67 ^c	48.00 ^c	1.13	1.12 ^b
LSD	0.2811**	8.4173*	0.1723ns	0.0898**
CV	1.51	7.70	7.40	4.66

Notes: ** indicates significance at 1% level of probability, ns=not significant; T₂ = Sole chickpea, T₆ = Baby corn + chickpea (2:1), T₁₀ = Baby corn + chickpea (2:2), T₁₄ = Baby corn + chickpea (2:3).

3.3.2 Seed yield (t ha⁻¹) in pea

Sole pea (T₃) gave the highest seed yield (2.16 t ha⁻¹) which was significantly different than all the intercropping systems of baby corn + pea (Table 2). Among the intercropping systems, pea seed yield was higher (1.04 t ha⁻¹) in baby corn + pea at a 2:3 row ratio than in all other baby corn + pea intercropping systems. Sole pea obtained 222.39%, 173.42% and 107.69% more seed yield than baby corn + pea (2:1), baby corn + pea (2:2) and baby corn+ pea (2:3) intercropping systems, respectively. This might be due to competition for resources like light, nutrients, and water in the intercropping systems. As a result, an increased number of branch plant⁻¹, number of pod plant⁻¹ and number of seeds pod⁻¹ were observed in the sole pea. The legumes only received a fourth of the population of their sole crop stand compared to the pure stand of their respective species when they were interplanted in baby corn in a single row after a pair of baby corn rows. Legumes received half the population compared to solitary legume crop when they were combined with maize at a 2:2 ratio.

Table 2. Performance of yield and yield contributing characters of pea

Treatment	Number of Branch Plant ⁻¹	Number of Pod Plant ⁻¹	Number of Seed Seeds Pod ⁻¹	Seed Yield (t ha ⁻¹)
T ₃	3.89	31.66 ^a	4.62	2.16 ^a
T ₇	3.99	29.89 ^a	4.33	0.67 ^d
T ₁₁	3.66	16.44 ^b	4.27	0.79 ^c
T ₁₅	3.53	17.89 ^b	4.26	1.04 ^b
LSD	0.7277ns	5.7643**	0.3709ns	0.0919**
CV	9.66	12.04	4.25	4.82

Notes: ** indicates significant at 1% level of probability, ns=not significant; T₃ = Sole pea, T₇ = Baby corn + pea (2:1), T₁₁ = Baby corn + pea (2:2), T₁₅ = Baby corn + pea (2:3)

3.3.3 Seed yield (t ha⁻¹) in groundnut

The highest significant seed yield (2.17 t ha⁻¹) of groundnut was found in sole groundnut cultivation compared to all the baby corn + groundnut intercropping systems whereas the lowest seed yield (0.50 t ha⁻¹) of groundnut was found in baby corn + groundnut (2:1) (Table

3). Among the intercropping systems, baby corn+ groundnut (2:3) gave significantly higher seed yield (0.86 t ha^{-1}) than all the other baby corn + groundnut row ratios (Table 3). Sole cropping of groundnut typically results in higher yields due to reduced competition for resources. Depending on the type of intercrops and how they were arranged in rows, the number of pods per plant, grains per pod, and 1,000-grain weight fell dramatically in the intercropping system. Maitra et al. (2019) also reported that a maize-legume intercropping technique raised maize yields. In a legume-intercropping system with groundnut (*Arachis hypogaea* L.), maize yielded 7609 kg ha^{-1} , but in a monocropping system, it yielded 5669 kg ha^{-1} . According to Punyalue et al. (2018), the intercropping system of maize and legumes increased maize yield by 31-53%.

Table 3. Performance of yield and yield contributing characters of groundnut

Treatment	Number of Branch Plant ⁻¹	Number of Pod Plant ⁻¹	Number of Seeds Pod ⁻¹	Seed Yield (t ha ⁻¹)
T ₄	7.99	21.99	1.58	2.17 ^a
T ₈	7.91	21.39	1.56	0.50 ^c
T ₁₂	7.88	21.67	1.49	0.78 ^b
T ₁₆	7.63	20.26	1.46	0.86 ^b
LSD	1.6941ns	2.6036ns	0.2649ns	0.0809**
CV	10.79	6.11	8.70	3.75

Notes: ** indicates significance at 1% level of probability, ns = not significant; T₄ = Sole groundnut, T₈ = Baby corn + groundnut (2:1), T₁₂ = Baby corn + groundnut (2:2), T₁₆ = Baby corn + groundnut (2:3).

3.3.4 Seed yield (t ha⁻¹) in lentil

The seed yield of lentil varied significantly with the variation in cropping system and the planting configuration under intercropping. Sole lentil gave a higher significant seed yield (1.84 t ha^{-1}) than all the intercropping systems of baby corn+ lentil. Lentil seed yield was also significantly influenced by different row ratios of baby corn + lentil in the intercropping systems (Table 4). Among the intercropping systems, baby corn + lentil at 2:3 row ratio gave the highest seed yield (1.23 t ha^{-1}) among all the other baby corn + lentil row ratios. The lowest seed yield (0.57 t ha^{-1}) was obtained from baby corn + lentil at 2:1 row ratio. Sole lentil obtained 86.13%, 71.10% and 54.34% more seed yield than baby corn + lentil (2:1), baby corn + lentil (2:2) and baby corn + lentil (2:3) intercropping systems, respectively. The primary cause of the yield drop was likely crop rivalry for growing resources, which was reduced in the solo cropping systems. Due to optimal resource utilization, sole lentil cropping produced the highest yield; however, intercropping systems with crops such as baby corn in different row ratios (e.g., 2:1, 2:3) led to lower yields because of increased competition. The lentil sole crop outperformed the intercropped lentil in terms of yield parameters.

3.4 Economic analysis

The intercropping systems were evaluated on the basis of baby corn equivalent yield, net profit, income equivalent ratio (IER), land equivalent ratio (LER), benefit cost ratio (BCR). Compared to solo crops, the baby corn equivalent yield from intercropping is larger because it includes the combined economic value of both crops (legumes and baby corn).

Table 4. Performance of yield and yield contributing characters of lentil

Treatment	Number of Branch Plant ⁻¹	Number of Pod Plant ⁻¹	Number of Seeds Pod ⁻¹	Seed Yield (t ha ⁻¹)
T ₅	5.55 ^a	59.55	1.5667	1.84 ^a
T ₉	5.44 ^a	57.46	1.5033	0.57 ^d
T ₁₃	4.73 ^b	56.51	1.5333	0.82 ^c
T ₁₇	4.44 ^b	50.99	1.5400	1.23 ^b
LSD	0.5912 **	9.452^{ns}	0.1421^{ns}	0.2242**
CV	5.87	8.43	4.63	10.06

Notes: ** indicates significance at 1% level of probability, ns = not significant; T₅ = Sole lentil, T₉ = Baby corn + lentil (2:1), T₁₃ = Baby corn + lentil (2:2), T₁₇ = Baby corn + lentil (2:3).

3.4.1 Baby corn equivalent yield (BCEY)

The highest BCEY (6.02) was recorded in baby corn + pea (2:1), which was statistically the same as baby corn + chickpea (2:1). Among the cropping systems, the lowest BCEY (2.16) was obtained in the sole chickpea. Baby corn + pea (2:1), baby corn + chickpea (2:1), baby corn + lentil (2:3) and baby corn + chickpea (2:3) obtained 12.14%, 9.69%, 5.02% and 2.79% more BCEY than sole baby corn (Table 5). This might be because these intercropping techniques offered the best crop compatibility. As they had diverse rooting patterns, these combinations of baby corn and legumes dug deeper into the soil.

3.4.2 Net profit

The highest net profit (214425 Tk ha⁻¹) was recorded in the intercropping treatment of baby corn + pea (2:1), which was followed by the treatments of baby corn + chickpea at a 2:1 ratio (206522 Tk ha⁻¹) and baby corn + lentil at a 2:3 ratio (196766 Tk ha⁻¹), respectively. The intercropping treatment of baby corn + pea (2:1), baby corn + chickpea (2:1), baby corn + lentil (2:3) and baby corn + chickpea (2:3) obtained 35.72%, 30.72%, 24.54% and 19.78% more net profit, respectively, than sole baby corn (Table 5).

3.4.3 Income equivalent ratio (IER)

The highest income equivalent ratio (1.39) was found in baby corn + chickpea (2:3), which was statistically comparable with baby corn + lentil (2:3). The significantly lowest (1.11) IER was recorded in baby corn + groundnut (2:2) cultivation. The IER value was higher in baby corn + chickpea (2:1) due to high resource use efficiency and equivalent yield. This system gave a 39% higher economic advantage over growing crops in pure stand (Table 5). The IER value was higher in baby corn + pea (2:1) due to high resource use efficiency and equivalent yield. Legumes like lentils and groundnuts gain high market prices, which boost income and raise net profit. An IER > 1 indicates that intercropping generated more income compared to sole crops. The economic benefits of T₁₄ in this experiment were 39% more than those of sole crops produced in a pure stand.

Table 5. Net profit intercropping, benefit cost ratio, income equivalent ratio, land equivalent ratio and baby corn equivalent yield of baby corn

Treatment	Baby Corn Equivalent Yield (t ha ⁻¹)	Net Profit Intercropping (Tk)	IER	LER	BCR
T ₁	5.37	157994	-	-	1.96
T ₂	2.16	60302	-	-	1.87
T ₃	2.40	74352	-	-	2.07
T ₄	2.68	81435	-	-	2.02
T ₅	2.22	72012	-	-	2.17
T ₆	5.89	206522	1.29	1.28	2.40
T ₇	6.02	214425	1.33	1.29	2.46
T ₈	5.41	177668	1.13	1.15	2.21
T ₉	5.42	178368	1.15	1.17	2.21
T ₁₀	4.90	157346	1.16	1.11	2.15
T ₁₁	4.92	156611	1.16	1.08	2.13
T ₁₂	4.94	158456	1.11	1.10	2.15
T ₁₃	5.04	166317	1.15	1.13	2.22
T ₁₄	5.52	189243	1.39	1.32	2.33
T ₁₅	4.48	124639	1.15	1.10	1.86
T ₁₆	5.07	160791	1.16	1.15	2.12
T ₁₇	5.64	196766	1.36	1.35	2.39

Notes: T₁ = Sole baby corn, T₂ = Sole chickpea, T₃ = Sole pea, T₄ = Sole groundnut, T₅ = Sole lentil, T₆ = Baby corn + chickpea (2:1), T₇ = Baby corn + pea (2:1), T₈ = Baby corn + groundnut (2:1), T₉ = Baby corn + lentil (2:1), T₁₀ = Baby corn + chickpea (2:2), T₁₁ = Baby corn + pea (2:2), T₁₂ = Baby corn + groundnut (2:2), T₁₃ = Baby corn + lentil (2:2), T₁₄ = Baby corn + chickpea (2:3), T₁₅ = Baby corn + pea (2:3), T₁₆ = Baby corn + groundnut (2:3), T₁₇ = Baby corn + lentil (2:3).

3.4.4 Land equivalent ratio (LER)

The LER is the relative land area required for sole crops to produce the yield achieved under intercropping system. The values of land equivalent ratio (LER) in different intercropping systems were found to be greater than unity, indicating the higher land use efficiency of intercropping systems over monoculture. Yield advantages occurred in intercropping mainly due to the development of both temporal and spatial complementarities. The LER of baby corn and legumes was calculated, and they were added to get the combined LER. The highest LER (1.35) was recorded in baby corn + lentil (2:3) intercropping system and the lowest LER (1.08) was recorded in baby corn + pea (2:2). The LER indicates how well intercropping uses natural resources compared to monocropping; a value of greater than one, equal to one, or less than one indicates a higher yield, a lower yield, or neither (Khonde et al., 2018). In this experiment, the maximum LER (1.35) was obtained from T₁₇ whereas the highest LER (1.23) was found in another experiment when baby corn was intercropped with lentils or any other legumes (Banik & Sharma, 2009b, Salinas-Roco et al., 2024). The highest LER was 1.35, indicating that there was yield advantage of 35% in intercropping over sole cropping. This means there is 35%

more land for sole crops to achieve the yield obtained in the intercropping. Baby corn grows more slowly in its early stages and is widely dispersed. Furthermore, baby corn planted in paired rows gave the legumes enough space to flourish. As a result, the crops were able to express the higher LER and benefit from the baby corn-legume intercropping system. According to Yang et al. (2018), maize-guar intercropping produced the highest LER over two years and demonstrated advantages over maize-cowpea intercropping, which may be the result of its effective and efficient use of natural resources like light and land.

3.4.5 Benefit cost ratio (BCR)

The BCR means benefit-cost ratio, which is used for cost-benefit analysis of the treatments to summarize the overall relationship between the relative costs and benefits. BCR can be expressed in monetary or qualitative terms. If BCR of a treatment is greater than 1.0, the treatment is expected to deliver a positive net return. Maximization of income from the farm produce is the most desirable criterion for any farmers. The highest BCR (2.46) was recorded in baby corn + pea (2:1), which was statistically comparable with those of baby corn + chickpea (2:1), baby corn + lentil (2:3) and baby corn + chickpea (2:3) while the lowest BCR (1.86) was recorded in the T₁₅ baby corn + pea (2:3) cultivation (Table 5). Intercropping in baby corn improved the monetary value of the total productivity compared to the respective sole crops, which might be due to the additional yield of intercrops. This benefit was due to the total yield of cluster baby corn and maize, which was achieved with a lower cost of cultivation. The highest BCR was found in treatment T₇ and indicated effective use of the available resources. From the findings of the study, it may be concluded that among the tested row arrangement patterns, two rows of baby corn followed by one row of peas produced the highest net profit, baby corn equivalent yield, and BCR. In contrast, the highest IER and LER were obtained when two rows of baby corn were followed by three rows of lentil.

4. Conclusions

In both natural and agricultural ecosystems, abiotic stresses are destructive limiting forces for agriculture, and finding means to cope with them has always been difficult. When compared to intensified monoculture production, intercropping seems to be one of the promising solutions that improves the sustainability of farming systems. Intercropping is frequently used in marginal situations where fewer inputs are needed to maximize productivity. Intercropping legumes greatly enhance nutrient availability, rhizobacteria community and variety, and soil fertility—all of which are factors that contribute to improved crop growth performance.

Baby corn can thrive in the char land ecosystem when intercropped alongside peas, groundnuts, chickpeas, and lentils. Among these intercropping systems baby corn + pea (2:1) produced 21.19 tons per hectare with husks, surpassing baby corn + chickpea (2:1), baby corn + groundnut (2:1), and baby corn + lentil (2:1) intercropping systems by 1.46%, 8.91%, and 9.53%, respectively. The economic performance such as BCR and net profit was also better in the T₇ treatment. Future studies should focus on assessing new legume species and identifying those that are likely to adapt to the soils and climate of the area. Researchers should also look at the physiology of the various crop species, including their growth patterns, canopy, and root architecture, in order to determine how best to use water and nutrients in low-fertility soil.

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6. Authors' Contributions

Partha Sharathi Kar implemented the research activities, wrote the first draft of the manuscript; Md. Rashedur Rahman designed and monitored the research activities, finalized the manuscript; Ahmed Khairul Hasan designed and monitored the research activities, edited the manuscript; Joysree Pual Tandra wrote the first draft and edited the manuscript; Md Jahangir Alam did the statistical analysis of the results.

7. Conflicts of Interest

There is no conflict of interest in the publication of this manuscript.

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