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Performance of Maize and French Bean Cultivated Under Intercropping System

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ABSTRACT

In order to investigate the yield benefits and financial gains associated with the variable row arrangements of French bean intercropped with the base crop maize, an experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during rabi season between October to April 2019. The research comprised eight treatments: i) Sole maize, ii) Sole French bean, iii) one row of maize followed by two rows of French bean intercropping, iv) one row of maize followed by three rows of French bean intercropping, v) one row of maize followed by four rows of French bean intercropping, vi) two rows of maize followed by two rows of French bean intercropping, vii) two rows of maize followed by three rows of French bean intercropping and viii) two rows of maize followed by four rows of French bean intercropping. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and total plots number were 24. The results show that the systems of intercropping maize and French bean had a substantial impact on the maize productivity. The highest seed yield was obtained from sole maize (8.56 t/ha). In intercropping situation, the highest seed yield (5.66 t/ha) was obtained from two rows of maize followed by four rows of French bean intercropping and the lowest seed yield (3.64t/ha) was obtained from one row of maize followed by two rows of French bean intercropping. Single maize had the highest maize equivalent yield (8560 kg/ha). The maximum Land Equivalent Ratio was obtained from one row of maize interplanted with four rows of French bean. Economic analysis revealed that two rows of maize followed by four rows of French bean intercropping had the highest gross return (202160 Tk/ha), the highest net return (96759 Tk/ha), and the highest Benefit-Cost Ratio (1.92). Thus, according to the current analysis, the most advantageous intercropping strategy in terms of yield and financial gain is to plant two rows of maize with four rows of French bean.

1. Introduction

A sustainable intensification of agricultural systems is crucial to meet the world's food needs (Loboguerrero et al., 2019). The world's population is expected to reach 9.1 billion people by 2050, which is 34% more than it is now, and food production will need to rise by 70% (Stagnari et al., 2017). Even though global agriculture has grown 2.5–3 times over the past 50 years, there are still some promising developments in agricultural sector that have helped to produce a remarkable amount of food (*The State of the World's Land and Water Resources for Food and Agriculture*, 2011).These developments also help to minimize environmental impacts and support the world's ability to produce food in the future, including contributions to climate change, soil degradation, water scarcity, and biodiversity destruction (European Commission. Joint Research Centre. Institute for Reference Materials and Measurements., 2016). Intercropping is a key component of sustainable development (*Jensen et al*., 2015) that helps developing nations provide a variety of food crops (X. Liu *et al*., 2017) as well as a host of ecological benefits, such as improved land-use efficiency, food security, and currency production (Brust *et al*., 2014). The practice of intercropping grain legumes with cereals has long been used to lower the hazards of biotic and abiotic pressures while increasing agricultural profitability, land-use efficiency, and food security (Gidey *et al*., 2024). Farmers frequently associate maize (*Zea mays L*.) and French bean (*Phaseolus vulgaris L*.) as one of the most popular combinations in intercropping. Maize- French bean intercropping improves the food security both developed and developing countries, especially in situations of inadequate water resources (Tsubo et al., 2005). It determines whether spatial arrangement—such as 1:1, 2:1, or 2:2 rows of maize to Fench bean—produces the most yield, the highest economic return, and the most economical use of resources. When intercropping, row

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arrangement is crucial because it makes it possible for both crops—especially the shorter French bean—to receive enough sunlight, reduces direct competition for water and nutrients, permits root growth, and minimizes the microclimate conditions that encourage pests and diseases. The cropping advantage of intercropping over sole crops can be easily calculated using the land equivalent ratio (LER), which ignores weed inhibition, yield reliability, grain quality, increased plant and soil physical structure, and increased leaf cover in an intercropping system, all of which help to lessen weed infestations. In addition to providing a variety of root systems, maize-French beans also improve water intake, decrease transpiration and evaporation, and cool the soil. When a field with a short-stature crop has rows of maize, the wind speed above the shorter crop is reduced, which lowers the possibility of desiccation. Intercropped legumes do not compete with maize for nitrogen resources since they fix the majority of their nitrogen from the atmosphere (Vesterager et al., 2008). These two crops not only help enhance soil organic matter content (Ding *et al*., 2006), reduce soil erosion (De Baets *et al*., 2011), and control weeds but also provide essential minerals for human diets (Ma *et al*., 2015). French bean is a crucial part of the maize intercrop as they sell for 2 to 2.5 times as more on a weight basis as cereal crops like maize (Singh *et al*., 2001). Compared to rice, maize requires less water and it offers the chance to plant legumes alongside maize for grazing or green manuring without lowering output.

Legumes offer a crucial means of reducing soil nitrogen (N) limitations, increasing crop yields, covering the soil's surface, lowering soil erosion, suppressing weeds, fixing atmospheric N_2, lowering pest & disease populations, distributing labor requirements and increasing land use efficiency. In symbiosis with rhizobia, common beans can fix roughly 72% of atmospheric nitrogen (N_2) increasing soil productivity (Hardarson *et al*., 1993). Intercropping mitigates the risk of one of the component crops failing completely. French bean is a short duration crops (2.5-3 months) that easily grown with maize (Nassary *et al*., 2020a). Since maize is a crop that is widely spaced, there is plenty of room for short-duration intercrops to be grown in the interspaces. Optimizing maize productivity is the farmers' main goal while intercropping maize and common beans, with producing high-quality bean grain yields coming as a secondary objective (Kermah *et al*., 2017).The yield of maize planted with peas was 144% higher than that of maize grown alone. The combination also yielded higher land equivalent ratios, gross and net returns, and was more profitable than maize grown alone (Singh *et al*., 2001).

The timing of the introduction of a legume crop in the system in relation to the cereal crop, the demand for labor, and the selection of compatible crops to be grown in combinations are all crucial management strategies. The benefits of implementing maize-bean intercropping include the potential to increase N-fixation (Nassary *et al*., 2020b), minimal changes to the microclimate or other factors (like planting pattern, water or fertilizer management), yield stabilization (Müller et al., 2018), improved nutrient availability, and enhanced organic matter, which raises grain yield from 6% to 28% when intercropping is used instead of monocropping (Baghdadi *et al*., 2018). Rotational or intercropping grain and legume cultivation is crucial for maintaining soil health and nutrition, lowering chemical use and equipment and labor costs (Franke *et al*., 2019), and disrupting the cycle of weeds, pests, and disease.

As our agricultural land is limited, farmers are now practicing intercropping to raise productivity per area, boost biodiversity and diversification, and harvest two crops from the same field. Finding the best intercropping pattern combinations to increase the growth and output of both maize and beans is the main problem facing to researchers and farmers. Therefore, maize and French bean selection is the most important factor so that the intercropping crops utilize the resource efficiently and increase the productivity.

This study focuses only at the relationship between cereals and legumes. Therefore, we should to investigate into the interactions between other crops in various regions and climates. While this combination produces the best yield, agroecological variables (such as soil fertility, rainfall, and temperature) can sometimes prevent farmers from receiving the crop they had hoped for. Thus, thorough research is required to identify the best row configurations that optimize productivity and maintain complementary growth patterns between French beans and maize.

Considering the background of the study was planned (i) to determine the yield advantages and economic gains obtainable from the variable row arrangements of maize - French bean as intercropping, and (ii) to explore the feasibility and production potential of different maize - French bean intercropping systems

2. Materials and Methods

2.1. Description of the experimental site

The experiment was carried out from October to April 2019 at the Department of Agronomy Field Laboratory at Bangladesh Agricultural University (BAU), Mymensingh. Geographically, the experimental location is situated at latitude 24°25"N and longitude 90°50"E. It is approximately 18 meters above sea level. This dark grey flood plain soil, which belongs to Agro-ecological zone 9, is non-calcareous and belongs to the Sonatola Series of Old Brahmaputra alluvial soil. The medium-low land used for the experiment had a pH of 6.32, was silt loam in texture. From November to April, the experimental location experiences the least amount of rainfall and a dry environment; the rest of the year is marked by adequate rainfall and a moist climate.

2.2. Experimental treatments and design

The experiment comprised eight treatments of maize and French bean intercropping which are i) sole maize (T_1), ii) sole French bean (T_2), iii)1M: 2F one row of maize followed by two rows of French bean (T_3), iv)1M: 3F one row of maize followed by three rows of French bean (T_4), v)1M: 4F one row of maize followed by four rows of French bean(T_5), vi) 2M : 2F two rows of maize followed by two rows of French bean (T_6), vii) 2M : 3F two rows of maize followed by three rows of French bean (T_7), viii) 2M : 4F two rows of maize followed by four rows of French bean

(T_8). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

2.3. Crop husbandry

BARI Hybrid Maize 9, developed by the Bangladesh Agricultural Research Institute (BARI), is a high-yielding single cross hybrid maize variety. This maize variety is best sown between October and November. It is typically grown during the Rabi season, with planting from November to the first week of December and harvesting from mid-March to the end of April. To lessen spatial rivalry in the intercropping system, a short-stature crop, French bean (variety BARI Jherseem 2), was selected as a companion crop. French bean varieties should be sown between the end of October and November. The seeds of maize and French bean were sown on 29 October following the treatment variables. Three seeds of maize were dibbled at 25 cm distance in a line and French bean was sown in a solid line. Thinning was done between 10-15 DAS to keep one seedling of maize per hill and maintaining plant to plant distance as 10 cm. In intercropping two, three and four rows of French bean was sown between the maize rows. The weeding and thinning were done twice, once at 30 days after sowing (DAS) and the other at 45 DAS. After sowing, light irrigation was given for proper germination and then irrigation was given at 30, 60 and 90 DAS with one flood irrigation. The fertilizers of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied in the plots corresponding to 550, 260 and 195 and Gypsum 105 kg/ha respectively. At the time of final land preparation the total amount of TSP, MoP, Gypsum and half amount of urea were applied. Rest of the urea was applied in the two equal splits at 30 and 60 days after sowing (DAS). Maize was harvested at 1st week of April and French bean was harvested at last week of January.

2.4. Data collection procedure

At harvest, five plants were selected randomly from each sole (maize and French bean) and intercropped (five for maize and five for French bean) plots. There were characteristics recorded from the maize such as: Number of plants/ plot, plant height, cob length, number of cobs/plant, number of seeds/cob, 1000 seed weight(g), seed yield (kg/ha), stover yield (kg/ha), harvest index (%) and French bean such as: Number of plants/plot, plant height, number of branches/ plant, number of pods/ plant, number of seeds/pod, 1000 seed weight (g), seed yield (kg/ha), stover yield (kg/ha), harvest index (%).

i) Harvest index (HI) was calculated at the final harvest following formulae:

HI = Economic yield/Biological yield x 100 %

For productivity performance maize equivalent yield and land equivalent ratio (LER**)** were recorded.

ii) Maize equivalent yield was computed by following formulae:

$$\text{Maize equivalent yield} = \text{Ym} + \frac{\text{YixPi}}{\text{Pm}}$$

iii) Land equivalent ratio (LER**)** was computed by following formulae:

$$\text{LER} = \frac{\text{Intercrop yield of French bean}}{\text{Sole crop yield of French bean}} + \frac{\text{Intercrop yield of maize}}{\text{Sole crop yield of maize}}$$

Economic performance was recorded by the combined yield, total cost of production, gross return & net return and benefit- cost ratio (BCR).

Benefit- cost ratio (BCR) = Gross return (Tk/ha)/ Total cost of production (Tk/ha).

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 or LSD.

3. Results

3.1. Yield contributing characters and yield of maize

Number of plants and height of maize were significantly influenced by the maize- French bean intercropping systems. The highest plants number (117) was obtained from T_1 (sole maize) and T_3 (one row of maize followed by two rows of French bean), T_4 (one row of maize followed by three rows of French bean), T_5 (one row of maize followed by four rows of French bean) showed the same result and it was lowest (Table 1). The tallest plant (193.50 cm) was obtained from T_1 (sole maize) and the shortest plant was observed in T_5 (one row of maize followed by four rows of French bean intercropping) (Table 1). The plant height was reduced when maize was intercropped with French bean. No statistical variation was noted for cob length, number of cobs/plant, number of seeds/cob, 1000 - seed weight (g) (Table 1). Seed yield, stover yield and harvest index were influenced by the maize-bean intercropping. Maximum seed yield was obtained from T_1 (sole maize) (8.56 t/ha) (Table 1). In intercropping system the highest seed yield (5.66 t/ha) was obtained from T_8 (two rows of maize followed by four rows of French bean intercropping) and lowest seed yield (3.64 t/ha) was obtained from the T_3 (one row of maize followed by two rows of French bean intercropping) (Table 1). Maximum stover yield (11.84 t/ha) was obtained from T_1 (sole maize) and minimum stover yield (5.11 t/ha) from T_4 under intercropping system (Table 1). The seed and stover yields were reduced when maize was intercropped with French bean compared to the sole crop of maize. The highest harvest index (41.96%) was obtained from the treatment of T_1 (sole maize) and lowest harvest index (40.06%) was found in the intercrop situation T_7 (two rows of maize followed by three rows of French bean intercropping) (Table 1).

3.2. Yield contributing characters and yield of French bean

All the recorded characters were significantly affected by maize – French bean intercropping system expect thousand seed weight. The highest plants number (256) was obtained from T_2 (sole French bean) and lowest plants number (64) was obtained from T_6 (two rows of maize is followed by two rows of French bean intercropping system) (Table 2). The tallest plants were found in T_2 (35.83 cm) in sole cropping of French bean and the lowest plant height was found in T_4 (31.88 cm) where one row maize planted along with three rows of French bean. The highest number of branch value (5.21) and (6.55) pods/plant were found in T_2 (sole crop of French bean) (Table 2). The lowest number of branches value (3.93) and pod/plant were found in T_7 and T_3 respectively (Table 2). For French bean, the highest number of seeds/pod observed in T_2 (sole French bean) (4.00) and lowest value (3.21) was found in T_8 (two rows of maize is followed by four rows of French bean). For sole crops of French bean, seed yield, stover yield & harvest index were always highest. For intercropping the maximum seed & stover yield were found in T_5 (one row of maize is followed by four rows of French bean intercropping) 1.91t/ha and 2.43t/ha respectively because of more plant population (Table 2). The highest harvest index was recorded from sole crop T_2 (36.65%) and lowest value was recorded from intercropping of two rows of maize & two rows of French bean (T_6) (Table 2).

3.3. Productivity performance

Maize equivalent yield and land equivalent ratio varied in maize-French bean intercropping system. The highest maize equivalent yield (8440 kg/ha) and LER (1.05) were obtained from the treatment T_8 (two rows of maize followed by four rows of French bean intercropping). Intercropping French bean with maize enhanced the yield of maize equivalent yield. Growing maize and French bean individually requires more area, but intercropping treatments can save land use, which is advantageous as cultivable land is becoming less available every day (Table 3).

Table 1. Yield contributing characters of maize under different row arrangements of maize-French bean intercropping systems

Treatment	No. of plant plot^{-1}	Plant height (cm)	Cob length (cm)	Number of cob plant^{-1}	Number of seed cob^{-1}	1000 seed weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1	117.00a	193.50a	17.66	1.08	485.00	235.12	8.56a	11.84a	41.96a
T_2									
T_3	39.00c	192.86a	17.12	1.04	483.59	234.05	3.64c	5.21d	41.11ab
T_4	39.00c	192.63ab	17.10	1.05	483.00	233.40	3.67c	5.11d	41.82a
T_5	39.00c	189.33c	17.16	1.06	483.40	234.15	3.72c	5.21d	41.70a
T_6	59.00b	192.63ab	17.53	1.07	484.81	234.51	5.61b	7.99c	41.24ab
T_7	59.00b	191.73abc	16.97	1.14	481.53	233.10	5.51b	8.24bc	40.06c
T_8	59.00b	189.85bc	17.13	1.07	483.20	234.07	5.66b	8.33b	40.49bc
LSD$_{(0.05)}$	3.36	2.84	1.91	0.11	22.72	5.28	2.21	0.29	0.97
Sig. level	**	*	NS	NS	NS	NS	**	**	**
CV%	3.22	0.83	6.23	5.61	2.64	1.27	2.24	2.16	1.32

T_1 = Sole maize, T_2 = Sole French bean, T_3 = 1M : 2F (One row of maize followed by two rows of French bean), T_4 = 1M : 3F (One row of maize followed by three rows of French bean), T_5 = 1M : 4F (One row of maize followed by four rows of French bean), T_6 = 2M : 2F (Two rows of maize followed by two rows of French bean), T_7 = 2M : 3F (Two rows of maize followed by three rows of French bean), T_8 = 2M : 4F (Two rows of maize followed by four rows of French bean)

Table 2. Yield contributing characters of French bean under different row arrangements of maize-French bean intercropping systems

Treatment	No. of plants plot^{-1}	Plant height (cm)	Number of branches platnt^{-1}	Number of pod plant^{-1}	Number of seed pod^{-1}	1000-seed weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1									
T_2	256.00a	35.83a	5.21a	6.55a	4.00a	400.00	1.98a	3.42a	36.65
T_3	96.00e	33.44bcd	4.29bcd	4.33e	3.61bcd	399.65	0.55d	1.09e	33.87
T_4	144.00c	31.88d	4.61bc	4.33e	3.33de	399.57	0.74c	1.61c	31.84
T_5	192.00b	34.70ab	4.66b	6.00b	3.83ab	399.90	1.19b	2.43b	32.83
T_6	64.00f	32.88cd	4.16cd	5.50c	3.50cde	399.75	0.41d	1.15de	26.06
T_7	96.00e	33.89bc	3.93d	4.85d	3.65bc	399.61	0.55d	1.09e	33.83
T_8	128.00d	34.44abc	4.33bcd	5.53c	3.21e	399.55	0.77c	1.38cd	35.84
LSD$_{(0.05)}$	2.72	1.64	0.47	0.35	0.29	0.42	0.16	0.24	8.84
Sig. level	**	**	**	**	**	NS	**	**	NS
CV%	1.10	2.73	5.88	3.75	4.60	0.06	10.27	7.74	15.06

T_1 = Sole maize, T_2 = Sole French bean, T_3 = 1M : 2F (One row of maize followed by two rows of French bean), T_4 = 1M : 3F (One row of maize followed by three rows of French bean), T_5 = 1M : 4F (One row of maize followed by four rows of French bean), T_6 = 2M : 2F (Two rows of maize followed by two rows of French bean), T_7 = 2M : 3F (Two rows of maize followed by three rows of French bean), T_8 = 2M : 4F (Two rows of maize followed by four rows of French bean)

3.4. Economic analysis

The gross return & net return from maize and French bean intercropping under different row arrangements have been shown in Table 4. Out of eight treatments, the highest gross return (202160 Tk/ha) and net return (96759 Tk/ha) were found in T_8. The results showed that the intercropping treatments consistently produced higher gross returns than the solo crops. It was also found that the treatment of T_8 gave the highest benefit-cost ratio (1.92) (Table 4).

4. Discussion

In this experiment, plant height, number of cobs/pods, seed weight, seed & stover yields and harvest index were always highest in the sole crops compared to intercropping. But the maize equivalent yield, land equivalent ratio, net & gross incomes were always higher in the intercropping system. Two crops share limited resources including nutrients, light, and water. The deeper and taller roots of maize interact with each other, reducing the efficiency of water and nutrient uptake and ultimately lowering seed production. When intercropping with C_3 species, such as the common bean, Suárez *et al.* (2022) demonstrated that crops having C_4 photosynthetic traits, such as maize, were competitively dominant in the system. The poor performance of common beans' as an intercrop with maize may also be attributed to their shallow root distribution and short root systems, which likely lessened their competitive advantage for growth related variables like light, nutrients, water, and space (Karuma *et al*., 2016). In this experiment, it was found that the plant height, number of plant, number of branches were higher from the treatment of T_1/T_2. Suárez *et al.* (2022) discovered that, in contrast to monoculture, intercropping improved plant height and photosynthetic mobilization, which in turn improved the vegetative organ (number of leaves and stem diameter). On the other hand, Franco *et al*. (2018) found that the behavior of beans' under intercropping tends to enhance plant height while decreasing stem diameter. W. Liu *et al*. (2015) and Bedoussac & Justes (2010a, 2010b) noted that under these conditions, the bean plants developed shade avoidance reactions in response to the light decrease caused by the maize plant, resulting in a positive correlation between the density of maize and bean plant height. At higher plant density, the height of beans decreased but the stem diameter increased under intercropping system. Number of pods of beans and cob length of maize were also reduced in the intercropping system due to interspecific competition as both crops uptake nutrient from the same soil. In this condition, limited water availability or other stress factors can lead to kernels abortion that reduce the cob number and ultimately decrease the seed yield. But in the intercropping system, diversity of the root depth & nutrient requirements, different types of pest & disease increase the overall productivity and reduce the risk of one crop failure. According to Bedoussac & Jutes (2010) the partial Nitrogen Uptake by the associated French bean crop contributes complementary to the grain filling of maize, increasing productivity per unit area and resulting in increased grain production under intercropping (Alemayehu *et al*., 2018) (Raza *et al*., 2019). As a result, our findings agree with these earlier reports. Additionally, two crop components—a maize variety and two bean lines—are less competitive with each other and are better suited to the abiotic stress conditions in the area, increasing the overall yield. In this experiment, in intercropping situation the highest yield of maize (5.66 t/ha) obtained from T_8 and highest yield of French bean yield (1.19 t/ha) was obtained from T_5 because of more plant population.

Table 3. Maize equivalent yield and land equivalent ratio (LER) under different row arrangements of maize- French bean intercropping system

Treatments	Seed yield		Total yield (kg ha^{-1})	Maize equivalent yield (kg ha^{-1})	LER
	Maize	French bean			
T1	8560	–	8560	8560	1.00
T2	–	1980	1980	–	1.00
T3	3640	550	4190	5626.11	0 .70
T4	3670	740	4410	6342.22	0.80
T5	3720	1190	4910	8017.22	1.03
T6	5610	410	6020	5723.89	0.86
T7	5510	550	6060	7496.11	0.92
T8	5660	770	6430	8440	1.05

Table 4. Economic analysis of different treatments

Treatments	Seed yield		Gross return (Tk ha^{-1})	Cost of production (Tk ha^{-1})	Net returrn (Tk ha^{-1})	BCR
	Maize	French bean				
T1	8540	–	201120	113361	87759	1.77
T2	–	1980	178200	105745	72455	1.68
T3	3670	540	142800	89960	52840	1.59
T4	3650	730	159180	91841	67339	1.73
T5	3670	1212	202997	114041	88951	1.78
T6	5600	410	180860	111861	68999	1.62
T7	5510	540	197160	112361	84799	1.75
T8	5560	770	202160	105401	96759	1.92

Price: Maize @18 Tk/kg, French bean @ 110 Tk/kg

The intercropping systems were evaluated on the basis of maize equivalent yield, land equivalent ratio (LER) and BCR. Despite the fact that the grain yields of the intercrop component crops in intercropping were lower than those of their respective sole crops, higher total LERs supported the improvement in the intercrops' overall land productivity (total grain yields). The highest maize equivalent yield (8440kg /ha) was obtained from the treatment T_8 (two rows of maize followed by four rows of French bean intercropping) which attributed to the higher price of French bean seed. According to Nassary et al. (2020), the competitive advantages of these bean types over a component maize crop for light, nutrients, and water could be the reason for the land usage gain obtained from intercropping them with maize. Nurgi *et al.* (2023) found that the mean LER values for maize-faba bean intercrops ranged from 1.1 to 1.21 and 1.12 to 1.22, respectively. Alemayehu *et al*. (2018) reported that intercropping common beans with maize improved land utilization efficiency compared to solitary planting of each crop, as indicated by LERs larger than 1 in all intercrops. In our experiment, we showed that the highest LER (1.05) from the T_8 treatment which was higher than solo cropping. French bean regulates soil temperature or moisture, increase N fixation, decomposed the leaves which add more residue & nutrient in the soil. Economic analysis of the different treatments showed that highest gross return (202160 Tk/ha) and the highest net return (96759 Tk/ha) and BCR (1.92) were found in T_8. Under intercropping, two crops grown on the same land increased productivity & reduced the chance of risk which enhance the overall productivity per unit area. From the findings of the study, it may be concluded that among the tested row arrangement patterns, when two rows of maize was intercropped with four rows of French bean, this combination was most compatible and gave the highest maize equivalent yield, net return, LER and BCR over normal planting of maize.

5. Conclusion

Finding of this this study showed that the maize intercropped with French bean significantly improved the land equivalent ratio & BCR compared to sole crops. This method uses land, light, water, and nutrients more efficiently, resulting in increased total productivity. Due to crop diversity, French bean, a legume, increase soil fertility by fixing nitrogen, which promotes the growth of maize and lowers the demand for synthetic fertilizer. The two crops develop in complimentary ways, which reduce competition and increase resource efficiency. In contrast to monocropping, maize and French bean intercropping is a profitable and sustainable farming method that increases farmers' resilience, production, and resource efficiency. Therefore, intercropping of maize and French bean maintaining two rows of maize and four rows of French bean may be practiced for higher productivity and net return.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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