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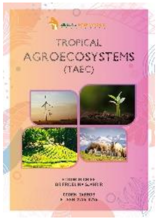

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RESEARCH ARTICLE

COMPREHENSIVE ANALYSIS OF EFFICIENCY AND ECONOMIC VIABILITY IN MAIZE-POTATO INTERCROPPING

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ABSTRACT

The study was executed during rabi season of 2020-21 and 2021-22 at the research field of Agricultural Research Station, BARI, Rajbari, Dinajpur (Latitude: $25^0387.3'$ N, Longitude: $88^0395.65'$ E) to evaluate how well intercropping potatoes with long-duration maize performs economically. Six treatments viz. T_1= Sole maize (60cm×20cm), T_2= Maize planting (60cm×20cm) + 1 row potato in between two maize rows, T_3= Maize paired row (30cm/120cm/30cm × 20cm) + 1 row potato, T_4= Maize paired row (30cm/120cm/30cm×20cm) +2 rows potato, T_5=Maize paired row (30cm/120cm/30cm × 20cm) +3 rows potato and T_6= Sole potato (60cm ×25cm). Among the intercropping treatments, the highest maize yield was recorded in Maize paired row (30cm/120cm/30cm × 20cm) +1 row potato (T_3). In contrast, the highest potato yield was also achieved in T_5 (Maize paired row (30cm/120cm/30cm × 20cm) +3 rows potato), indicating its superior productivity. From an economic perspective, the highest gross return, gross margin, and benefit-cost ratio (BCR) were recorded in T_5 (maize paired row with 3 rows of potato), while the lowest values were observed in sole maize cropping (T_1). These results highlight the advantages of intercropping, particularly in systems combining maize and potato, for improving yields and economic returns compared to sole cropping.

KEYWORDS

Maize; Potato; intercropping; Economic viability.

1. INTRODUCTION

Intercropping is the strategy of cultivating more than one crops together in a single field to maximize resource use and boost productivity, represents an innovative approach to enhancing agricultural productivity (Ouma and Jeruto, 2010). This technique is especially relevant for countries like Bangladesh, where agricultural land is limited, and intensification is necessary to meet rising food demands. Intercropping enables farmers to maximize resource use efficiency by exploiting the complementary nature of different crops. For example, crops with differing growth habits, rooting depths, or nutrient requirements can better utilize sunlight, water, and soil nutrients when grown together than in monoculture systems (Andrade et al., 2020; Von Cossel et al., 2019 and Wezel et al., 2014). This synergy often results in yield advantages, as documented by (Gitari, 2018). Additionally, intercropping acts as a risk management strategy for farmers with limited resources: if a particular crop underperforms or loses due to environmental or economic factors, the other crop provides a safety net (Islam et al., 2014). Intercropping enables farmers to maximize the production of the main crop while also obtaining an additional yield (bonus) from the increased plant population of the secondary crop (Hailu, 2015). Maize (*Zea mays*), a versatile and resilient C_4 crop, is particularly well-suited for intercropping. Its high photosynthetic efficiency, short growth duration, and adaptability to diverse agro-climatic conditions contribute to its status as the third most significant cereal crop in Bangladesh (BBS, 2015). In regions like Dinajpur, maize cultivation is rapidly expanding, often replacing wheat, driven by the availability of high-yielding hybrid varieties and favorable growing conditions (Shaheenuzzaman et al., 2015). Its popularity during the *rabi* season underscores its economic and agricultural significance. Given its row-based planting and spacing requirements, maize creates an opportunity for intercropping with short-duration vegetables or tuber crops, such as potatoes, which can provide farmers with quick cash income without compromising maize yields. For instance, innovative maize-legume intercropping strategies involve adjusting row spacing or reducing maize density to accommodate legumes while maintaining overall productivity (Ahmed et al., 2008). Similarly, pairing maize with potato (*Solanum tuberosum*) offers significant potential. Potatoes, with their complementary photosynthetic pathway (C_3), growth duration, and resource requirements, efficiently utilize the resources that maize does not fully exploit. This results in a more effective overall use of light, nutrients, and water, leading to increased land productivity (Talukder et al., 2016). Potatoes are increasingly recognized as a vital crop for food security in Bangladesh due to their high yield potential and nutritional value. Their integration into intercropping systems with maize not only enhances overall productivity but also provides quick financial returns for farmers. Research indicates that combining arrangements, instead of single cropping, consistently achieve more total productivity each unit of area and offer greater economic returns through improved land and resource utilization (Huss et al., 2022; Boras et al., 2006; Quayyum et al., 1985; Maitra et al., 2019 and Seran et al., 2010). This study explores the optimization of plant populations in maize-potato intercropping systems, aiming to maximize both productivity and profitability. By leveraging the complementary characteristics of these crops, the research seeks to provide practical, sustainable solutions for farmers, promoting food security and economic resilience in Bangladesh.

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2. Materials and Methods

2.1 Details of the experimental site

The study was setup at the Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Rajbari, Dinajpur, during the *rabi* seasons of 2020-21 and 2021-22, using a Randomized Complete Block Design (RCBD) with three replications per treatment. The site, located at 25°38'7.5" N and 88°39'5.7" E, with an elevation of 37 meters, lies in AEZ-1. Soil analysis from the field (0-15 cm depth) revealed medium-high land with clay loam texture, 0.96% organic matter, a pH of 6.00, 0.10% total nitrogen, 23.5 µg/g phosphorus, and other nutrients in sufficient amounts. Weather data throughout the time of growth of crops indicated a mean highest temperature range of 22.69-33.99°C and a minimum of 11.15-21.76°C in 2020-21, and 22.25-33.43°C (maximum) and 11.4-23.28°C (minimum) in 2021-22, with rainfall of 25 mm and 106 mm, respectively. The hot, sub-humid conditions at the study site significantly influenced crop growth and productivity.

2.2 Design and treatments of the study

The study was designed as a randomized complete block design and three replications with the sought to assess the economic advantages of growing potatoes alongside long-duration maize, focusing on optimizing land use, enhancing resource efficiency and maximizing profitability through this complementary cropping system. The size of a single plot was 14.4 m^2 (4m×3.6m). The study included six distinct treatments, namely, T_1= Sole maize (60cm×20cm), T_2= Maize planting (60cm×20cm) +1 row potato in between two maize rows, T_3=Maize paired row (30cm/120cm/30cm×20cm) +1 row potato, T_4= Maize paired row (30cm/120cm/30cm×20cm) + 2 rows potato, T_5=Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato and T_6= Sole potato (60cm×25cm).

2.3 Crop management

The field experiment plot was made ready using a tractor, which involved ploughing, cross-ploughing, and the laddering to achieve a fine tilth for planting. Fertilizers were applied at the following rates: 260-72-148-48-4-2 kg ha^{-1} (NPKSZnB) for sole maize, 180-40-180-20-6-1.2 kg ha^{-1} (NPKSZnB) for sole potato, and 320-73-170-50-6-2 kg ha^{-1} (NPKSZnB) for intercropping combinations. The fertilizers were used in a form of Urea, TSP, MOP, Gypsum, $ZnSO_4$, and Boric acid. At final land preparation, approximately one third of the urea fertilizer and the entire amount of other fertilizers were used. The rest of the urea was divided into 2 equal amounts, applied at 30 and 50 days after sowing. Maize (BARI Hybrid Bhutta-16) and potato (BARI Potato-36) were sown on November 12, 2020 and November 13, 2021, respectively, during both experimental years. Following the urea top-dressing, two irrigations were done. Plant protection strategies were also implemented as needed. Potatoes were harvested at 80 days after planting (DAP), after which the third irrigation for maize was applied. To control the fall armyworm on maize, the insecticide Tracer 45 SC (Spinosad) was sprayed at a rate of 0.4 ml/L of water every 7 days for 2-3 applications. For late blight control in potatoes, either the fungicide Acrobat MZ (Mancozeb + Dimethomorph) at 4 g/L of water or Headline Team (Pyraclostrobin + Dimethomorph) at 2.5 g/L of water was applied every 7-10 days. The yield-contributing characteristics of both potato and maize samples were collected from ten randomly picked plants in each treatment's sampling area, with the exception of surround plants. While maintaining a standard moisture level, the yield of potato and maize were estimated using the entire region and then adjusted to a per-hectare basis. Maize equivalent yield = Yim + (Yip× Pp) / Pm Where, Yim = Maize intercrop yield, Yip =Potato intercrop yield, Pm = maize price and Pp = Potato price. Using R software packages, the collected data were statistically examined, and the Least Significant Difference (LSD) test was used to compare the mean differences for each character (Gomez and Gomez, 1984).

2.4 Data recorded and Statistical analysis

The yield-contributing traits of both potato and maize was assessed from ten picked at random plants in the taken sample zone for every single treatment, excluding the surround plants. Maize grain yield and potato tuber yield were recorded from the entire plot and then converted to a per-hectare basis, ensuring standard moisture content. The collected data for all crops were subjected to combined statistical analysis using R software. Mean differences for each character were compared using the Least Significant Difference (LSD) test at a 5% level of significance.

2.5 Assessment of economic indices

The competition functions were calculated using the following formulas:

Land equivalent ratio (LER) = $(Yim/Ysm) + (Yip\ /\ Ysp\ )$

Here, Yim = maize yield at intercrop; Ysm = sole maize yield; Yip = potato yield at intercrop; Ysp = sole potato yield,

Replacement value of intercropping (RVI)= $\frac{Yim\times Pm+Yip\times Pp}{Ysm\times Pm-Csm}$ Where, Yim and Yip are the intercrop yield, Pm and Pp are the price of maize and potato, Ysm and Csm are the yield and input cost of the maize in sole stand,

Monetary advantage index (MAI)=$Value\ of\ combined\ intercrop\ yield\ \times (LER-1)/LER$

Aggressivity Index (A)

$A_{maize}= \frac{Yim}{Ysm\times Zmp} - \frac{Yip}{Ysp\times Zpp}$ and $A_{potato} = \frac{Yip}{Ysp\times Zpp} - \frac{Yim}{Ysm\times Zmp}$

where, Yim and Yip are the intercrops yield, Ysm and Ysp are yield of sole maize and potato yield and Zmp and Zpp are the proportion of maize and potato, respectively.

Relative crowding coefficient (RCC): RCC_{maize}×, RCC_{potato}, Where,

$RCC_{maize} = \frac{Yim\times Zpp}{(Ysm-Yim)\times Zmp}$

$RCC_{potato} = \frac{Yip\times Zmp}{(Ysp-Yip)\times Zpp}$ where Z_{mp} and Zpp are the proportion of maize and potato in the mixture, respectively.

System productivity index (SPI) = $\frac{Ysm}{Ysp}\times(Yip+Yim)$ where, Ysm and Ysp are sole crops yield and Yim and Yip are the intercrops yield.

competitive ratio: $CR_{maize} = \frac{LER_{maize}}{LER_{potato}}\times\frac{Zpp}{Zmp}$ and $CR_{potato} = \frac{LER_{potato}}{LER_{maize}}\times\frac{Zmp}{Zpp}$

Where, Zmp and Zpp are the proportion of maize and potato in the mixture respectively

Benefit-cost ratio (BCR)= $\frac{Gross\ return}{Total\ variable\ cost}$

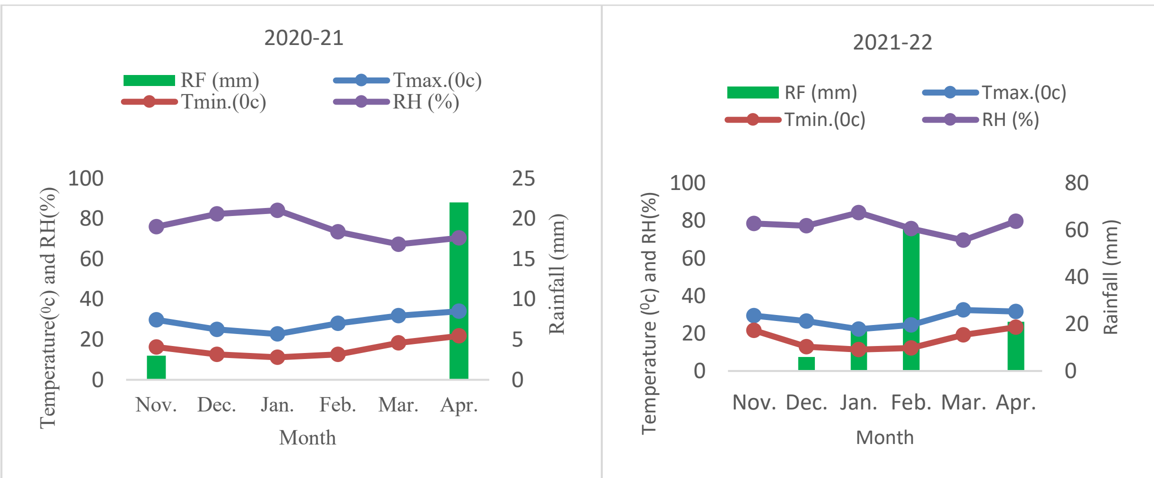

Figure 1: Monthly weather Data (Temperature, Humidity, Rainfall) throughout the Growing Season

3. Results and Discussion

3.1 Yield and yield contributing characters of maize

The yield and yield-contributing traits of intercropped maize were statistically significant (Table 1). Sole maize recorded the highest plant height (184.70 cm), while the lowest plant height (170.07 cm) was noted in the Maize planting (60cm×20cm) + 1 row potato (83%) in between two maize rows (T_2) intercropping combination. Similarly, the highest ear height (85.40 cm) was found in sole maize (T_1) and the lowest (77.10 cm) was recorded in T_2. Sole maize also had the highest cob length (20.76 cm) and diameter (17.76 cm), while T_2 had the lowest values (19.23 cm and 16.83 cm, respectively). The highest number of grains per cob (585.03) and the highest 1000-grain weight (425.83 g) were recorded in sole maize, with the lowest values (547.00 grains per cob and 1000-grain weight 377.00 g) in T_2. The highest maize grain yield (10.50 t ha^{-1}) was observed in sole maize, attributed to the greater number of grains per cob and higher 1000-grain weight. Grain yield in the intercropped combinations ranged from 9.50 to 10.50 t ha^{-1}, showing a yield reduction of 4.95% to 9.52% compared to sole maize. Overall, intercropping resulted in up to a 15.51% yield loss due to competition from the potato crop and its shading effect, which hindered maize growth and reduced kernel yield. These outcomes are consistent with the studies of (Alom et al., 2014; Islam et al., 2013; Begum et al., 2016; Khanum et al., 2022).

Table 1: Yield and yield contributing characters of maize under different treatments (pooled data of two years)

Treatments	Plant height (cm)	Ear height (cm)	Grain/cob (no.)	Cob length (cm)	Cob diameter (cm)	1000-grain wt. (g)	Grain yield (tha^{-1})
T_1	184.70	85.40	585.03	20.76	17.76	425.83	10.50
T_2	170.07	77.10	547.00	19.23	16.84	377.80	9.50
T_3	182.90	81.37	573.30	20.44	17.19	415.83	9.98
T_4	172.00	79.60	560.63	20.35	17.18	383.33	9.70
T_5	175.20	79.63	568.53	19.66	17.00	392.33	9.75
T_6	-	-	-	-	-	-	-
LSD $_{(0.05)}$	4.38	4.78	19.86	0.32	0.51	14.68	5.30
CV (%)	1.31	3.15	1.86	0.84	1.58	1.96	1.05

T_1= Sole maize (60cm×20cm), T_2= Maize planting (60cm×20cm) + 1 row potato (83%) in between two maize rows, T_3= Maize paired row (30cm/120cm/30cm×20cm) +1 row potato (33%), T_4= Maize paired row (30cm/120cm/30cm×20cm) + 2 rows potato (66%), T_5=Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato (100%) and T_6= Sole potato (60cm ×25cm).

3.2 Yield contributing characters and tuber yield of potato

The yield-contributing factors and tuber yield of potato were significantly affected by different potato populations in maize fields (Table 2). The highest plant height (120.5 cm), number of branches per plant (6.8), number of tubers per hill (15.6), and tuber weight per hill (483.50 g) were recorded in treatment T_6 (sole potato). In contrast, the lowest tuber weight (454.50 g) was observed in T_3 (Maize paired row (30cm/120cm/30cm×20cm) +1 row potato) treatment. Sole potato (T_6) produced the highest yield (38.74 t ha^{-1}). Among intercropping treatments, the highest potato yield was recorded in T_5 (37.85 t ha^{-1}), followed by T_1 (30.40 t ha^{-1}). The lowest potato yield (20.77 t ha^{-1}) was recorded in T_3 over two consecutive years. The results suggest that planting arrangements significantly influenced potato yield in different intercropping arrangements, mainly due to varying potato plant populations per unit area (Table 2). Increasing potato population with maize boosted the tuber yield of potato. Similar result was found by (Begum et al., 2016; Kidane et al., 2017). They reported that an increase in plant population density leads to a corresponding rise in tuber yield per unit area. The variations in potato yield across different treatments were likely due to variations in numbers of potato plants per treatment.

Table 2: Yield and yield contributing characters of potato and under various treatments (pooled data of two years)

Treatments	Plant height (cm)	No. of branch/ Plant	No. of tuber/ Hill	Wt. of tubers/hill	Tuber yield (tha^{-1})
T_1	-	-	-	-	-
T_2	112.9	4.10	10.3	526.00	30.40
T_3	114.5	5.6	13.7	454.50	20.77
T_4	117.3	5.6	14.3	458.50	25.10
T_5	110.3	6.67	12.7	459.00	37.85
T_6	120.5	6.8	15.6	483.50	38.74
LSD $_{(0.05)}$	6.71	1.03	2.79	48.21	1.85
CV (%)	3.09	9.53	11.11	5.38	3.48

3.3 Maize equivalent yield (MEY)

As a more widely spaced plant, maize allows certain types of tubers crop especially potato to coexist without incurring financial losses, resulting in a higher overall production in terms of time and land. Due to its effective use of growth resources, this method provided significant yield benefits and increased economic return than sole cropping (Yang et al., 2018; Seran et al., 2010). In every instance, the intercropped arrangements produced more maize equivalent yield than single maize. Out of all the treatments, the maize paired row (30cm/120cm/30cm×20cm) +3 rows potato intercrop combination (T_5) produced the highest maize equivalent yield (41.29 tha^{-1}). The combination of planting 60cm×20cm of maize and one row of potatoes between two rows of maize (T_2) produced the lowest maize equivalent yield (27.29 tha^{-1}).

3.4 Cost and return analysis

Each of the combination of intercrops produced a higher gross return than a single crop. The greatest gross return (Tk. 495500 ha^{-1}) and gross margin (Tk. 385400 ha^{-1}) were found in the maize paired row (30cm/120cm/30cm×20cm) + 3 rows of potato. Only maize produced the lowest gross margin and gross return. The paired row of maize (30cm/120cm/30cm×20cm) + 3 rows of potato yielded the largest benefit cost ratio (4.50), while sole maize yielded the lowest one (1.78). It found that maize intercropping produced higher net returns than monoculture, which is compatible with these findings (Mohid et al., 2024). Similarly, confirmed the current findings by finding that maize-potato combination systems were more profitable and efficient than sole cropping (Begum et al., 2016). Furthermore, the results are compatible with those, who found that intercropping arrangement improved net returns and gross margins over sole cropping systems of (Verma et al., 2021; Gitari et al., 2018; Khanum et al., 2019).

Table 3: Cost and return analysis of maize and potato under sole and intercropping situations

Treatments	Maize equivalent yield (tha^{-1})	Gross return	Total variable cost	Gross margin	BCR
T_1	10.50	126000	70620	55380	1.78
T_2	34.83	418000	106920	311080	3.91
T_3	27.29	327460	100930	226530	3.24
T_4	30.62	367400	100680	266720	3.65
T_5	41.29	495500	110100	385400	4.50
T_6	32.28	387400	100943	286457	3.84

Price: (Tk.kg^{-1}) Maize: 12/- and (Tk.kg^{-1}) Potato: 10/-

3.5 Intercropping Indices

3.5.1 Land equivalent ratio (LER)

Considering a two-year average, and irrespective of planting arrangements, the highest Land Equivalent Ratio (LER) value of 1.91 was observed in the T_5 intercropping system Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato in between two maize rows), while the lowest LER value of 1.49 was recorded in the T_3 intercropping system (Maize paired row (30cm/120cm/30cm×20cm) +1 row potato). These findings indicate yield advantages ranging from 33% to 48%. The value of 1.91 suggests that sole cropping would require approximately 91% more land to produce the same total yield as the intercropping arrangement. This indicates that intercropping is more land-efficient, producing higher yields from the same area compared to growing the crops individually in separate plots. They documented substantial differences in the Land Equivalent Ratio (LER) arising from the application of diverse intercropping treatments within maize-potato cropping systems (Fan et al., 2016; Bantie et al., 2015; Ebwongu et al., 2001). The LER is an effective metric for assessing the biological efficiency of intercropping systems and highlights the additional yield benefits over single cropping. In this research, the LER values for intercropping maize and potato varied from 1.49 to 1.91, clearly demonstrating the benefits of intercropping. The analysis further confirmed that all intercropping systems evaluated in this study were biologically effective, with LER values consistently exceeding 1.0 (Table 4). This underscores the production advantages of combining over single maize cropping, demonstrating that intercropping systems offer greater output than monoculture systems.

3.5.2 System productivity index (SPI)

The results indicated that the intercropping system of Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato (100%) (T_5) achieved the highest System Productivity Index (SPI) value of 37.13, outperforming all other intercropping arrangements evaluated (Table 4). The SPI serves as a critical tool for standardizing the yield of the additional crop (potato) relative to the main crop (maize). Additionally, it aids in identifying crop combinations that optimize the utilization of growth resources while ensuring consistent and sustainable yields (Sagar, 2019).

3.5.3 Replacement value of intercropping (RVI)

The Relative Value Index (RVI) values ranged from 2.73 to 4.14, with the lowest RVI observed in T_3 at 2.73. The highest RVI (4.14) was recorded in T_5 (Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato) (Table 4), indicating that this intercropping combination was significantly more profitable than sole maize or other intercropping treatments. The results show that intercropping potato with maize was approximately 50% more lucrative than cultivating maize alone, making T_5 the most economically advantageous option among the evaluated cropping systems.

3.5.4 Monetary advantage index (MAI)

The monetary advantage index (MAI) values were positive across all intercropping arrangements (Table 4), indicating economic benefits from intercropping. The highest MAI (Tk. 235476 ha^{-1}) was recorded in T_5 (Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato), highlighting the exceptional productivity and financial viability of this combination, primarily due to its higher Land Equivalent Ratio (LER).The MAI is a critical metric for recommending cropping patterns, as it reflects the cost-benefit ratio and, more importantly, the total profit- a key concern for farmers who prioritize monetary returns (Mahapatra, 2011). To evaluate the profitability of sole cropping versus intercropping systems, the yields of all crops under various intercropping treatments and single cropping were analyzed alongside their economic returns in monetary terms. This assessment helps determine whether the inclusion of additional component crops is financially advantageous.

Intercropping maize-potato under different planting arrangement

Table 4: Competition indices of maize-potato intercropping arrangement (average data of 2 years)

Treatments	LER values			SPI	RVI	MAI (Tk. ha^{-1})
	Maize	Potato	Total			
T_1	1.00	-	1.00	-	-	-
T_2	0.91	0.78	1.69	31.12	3.49	170586
T_3	0.95	0.54	1.49	23.99	2.73	107187
T_4	0.92	0.65	1.57	27.14	3.07	133643
T_5	0.93	0.98	1.91	37.13	4.14	235476
T_6	-	1.00	1.00	-	-	-

3.5.5 Competitive ratio (CR)

The competitive ratio (CR) values revealed differences between the intercropping treatments, indicating the varying competitive potential of the component crops when intercropped with potato (Table 5). Potato exhibited higher CR values (ranging from 1.05 to 1.69) compared to maize (ranging from 0.59 to 0.95), suggesting that potato was a stronger competitor than maize. In the Maize paired row (30cm/120cm/30cm×20cm) +1 row potato (33%), (T_3) intercropping system, the higher CR (1.10) highlighted a greater difference in competitiveness between the two crops. In contrast, the 30cm/120cm/30cm×20cm) + 3 rows potato (T_5) system, with a lower CR (0.09), showed more balanced competition between the crops. The findings suggest that when competition between the component crops is more equal, with a lower CR, there is a better utilization of available growth resources, leading to better intercropping performance and higher productivity. These results align with the research findings of (Islam et al., 2016).

3.5.6 Relative crowding coefficient (RCC)

The relative crowding coefficient (RCC) for both maize and potato in intercropping arrangement was greater than one, indicating that non-competitive interference outweighed competitive interactions. This suggests that yield benefits were gained from the intercropping treatments. The highest RCC value (285.73) was observed in the T_5 treatment, highlighting the most favorable interaction between the crops in this combination. Across all treatments, intercropped sweet gourd exhibited higher RCC values compared to intercropped potato, suggesting that maize was more aggressive in utilizing available resources. This dominance of maize likely contributed to reduced competition and enhanced overall productivity in the intercropping system. In summary, the greater RCC values in the intercropped maize indicate that this crop had a more dominant role in the intercropping system, enhancing the overall productivity by reducing competition and promoting a more synergistic relationship between the crops. Relative crowding coefficient (RCC) of maize and potato was significantly more than one in that it showed that non-competitive interactions were greater than competitive ones leading to yield gain of intercropping treatments. Among treatments, T_5 (285.73) with the highest RCC value indicating the best performance. Potato also showed greater competitiveness and dominance in the intercropping system with intercropped potato as evidenced by higher RCC values than those in sweet gourd in all treatments.

Table 5: Competitive ratio (CR) and Relative crowding coefficient (RCC) of maize and potato in maize-potato intercropping arrangement (average 2 years)

Treatments	Competitive ratio (CR)			Relative Crowding Coefficient (RCC)		
	maize	Potato	Differences	Maize	potato	Product
T_1	-	-	-	-	-	-
T_2	0.96	1.04	0.09	4.64	4.39	20.37
T_3	0.59	1.69	1.10	2.73	3.47	9.47
T_4	0.95	1.05	0.10	4.31	2.76	11.90
T_5	0.95	1.04	0.09	6.72	42.52	285.73
T_6	-	-	-	-	-	-

4. Conclusion

Intercropping increases productivity and sustainability of agricultural systems, farmers' income, and employment opportunities, as well as reduces the risks of climatic variations and changes. The study showed that the highest maize yield of crop was obtained from single cropping. In an intercropping system, the maximum yield of maize was reported in the treatment with maize arranged at a distance of (60cm×20cm) + 1 row potato in between two maize rows (T_2). The maximum potato yield, maize equivalent yield, gross returns, gross margin, and benefit-cost ratio (BCR) were recorded in T_5 as maize paired row system (30 cm/120 cm/30 cm × 20 cm spacing) with three rows of intercropped potatoes. Finally, Maize-potato intercropping is efficient, economically viable, and sustainable, optimizing land use and resource utilization while diversifying income for smallholder farmers.

References

Andrade, D., Pasini, F., Scarano, F.R. 2020. Syntropy and innovation in agriculture. Current Opinion in Environmental Sustainability, 45: 20-24.

Bantie, Y. B. 2015. Determination of effective spatial arrangement for intercropping of maize (Zea mays L.) and potato (Solanum tuberosum L.) using competition indices Ethiopia. Journal of Horticulture, 2(137):1-7.

BBS (Bangladesh Bureau of Statistics). 2015. Statistical Pocket Book of Bangladesh. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh. Pp. 91-93.

Begum, A.A., Bhuiya, M. S. U., Hossain, S. M. A., Khatun, A., and Das, S.K. 2016. Effect Of Planting System of Potato and Plant Density of Maize on Productivity of Potato-Hybrid Maize Intercropping System. Bangladesh Journal of Agricultural Research, 41(3): 397-409.

Boras, M., Roukia, N., and Babilie, R. 2006. The effect of Corn Intercropping on Autumn Potato in Terms of Productivity and Land Equivalent Ratio. Tishreen University Journal for Studies and Scientific Research -Biological sciences series, 28(1).

Ebwongu, M., Adipala, E., Ssekabembe, C. K., Kyamanywa, S., and Bhagsari, A. S. 2001. Effect of intercropping maize and solanum potato on yield of the component crops in central Uganda. African Crop Science Journal, 9(1): 83-96.

Fan, Z., An, T., Wu, K., Zhou, F., Zi, S., Yang, Y., and Wu, B. 2016. Effects of intercropping of maize and potato on sloping land on the water balance and surface runoff. Agricultural Water Management, 166: 9-16.

Gitari, H.I, Nyawade, S., Kamau, S., Karanja, N.N., Gachene, C.K.K, Raza, M., Maitra, S., Schulte-Geldermann, E. 2020. Revisiting intercropping indices with respect to potato-legume intercropping systems. Field Crops Research, 258: 107957.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York. Pp.97-129.

Hailu G. 2015. A Review on the Comparative Advantages of Intercropping to Mono-Cropping System. Journal of Biology, Agriculture and Healthcare, 5(9): 1-13.

Huss, C.P., Holmes, K.D., Blubaugh, C.K. 2022. Benefits and Risks of Intercropping for Crop Resilience and Pest Management. Journal of Economic Entomology, 115(5): 1350-1362.

Islam, H.M.S., Choudhury, R.U., Ahmed, B., Shabnam S. and Rahman, M.M. 2014. Adoption of Mixed Cropping in Rabi Season by the Farmers of Madaripur Sadar thana under Madaripur District. International Journal of Business Social and Scientific Research, 1(3):168-171.

Khanum, M.M., Bazzaz, M.M., Ahmed, B., Huda, M.S., and Hossain, M.A. 2019. Intercropping Of Cabbage with Maize. Bangladesh Agronomy Journal, 22 (1):115-120.

Khanum, M.M., Huda, M.S., Nuruzzaman, M., Muzahid, M.A.A.A., and Alam, M.M. 2022. Intercropping of Cauliflower with Sweet Gourd at Different Plant Population. Bangladesh Agronomy Journal, 25(1):129-138.

Kidane, B.Z., Hailu, M. H. and Haile, H.T. 2017. Maize and Potato Intercropping: A Technology to Increase Productivity and Profitability in Tigray. Open Agriculture, 2(1): 411-416.

Mahapatra, S. C., 2011. Study of Grass-Legume Intercropping System in Terms of Competition Indices and Monetary Advantage Index under Acid Lateritic Soil of India. American Journal of Experimental

Agriculture, 1(1): 1-6.

Maitra, S., Palai, J.B., Manasa, P., and Kumar, D.P. 2019. Potential of Intercropping System in Sustaining Crop Productivity. International Journal of Agriculture, Environment and Biotechnology, 12(1): 39-45.

Ouma, G. and Jeruto, P. 2010. Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops: A review. Agriculture and biology Journal of North America, 1(5):1098-1105.

Quayyum, M.A., Akanda, M.E. and Islam, T. 1985. Effect of intercropping maize with groundnut at varying levels of plant population and nitrogen levels. Bangladesh Journal of Agriculture, 10(3): 1-6.

Seran, T. H., and Brintha, I. 2010. Review on maize-based intercropping. Journal of agronomy, 9(3):135-145.

Shahenuzzaman, M., Saha, R.R., Ahmed, B. Rahman, J. and Salim, M. 2015. Green cob and fodder yield of sweet corn as influenced by sowing time in the hilly region. Bangladesh Journal. Of Agricultural Research, 40(1):61-69.

Talukder, A.H.M.M.R., Ahmed, B., Nahar, L., Hossain, K.M.F., Rahman, J. and Paul, S.K. 2016. Enhancement of Farm productivity through intercropping of vegetables, pulse and oilseed crops with wheat at Jamuna Char area of Islampur in Jamalpur District. International Journal of Applied Research, 2(2): 71-76.

Verma, V.K., Meena, R.N., Singh, D.N., Upadhyay, P.K., Singh, R.K., and Singh, R.K. 2021. Cropping geometry and nutrient management study on winter maize (Zea mays) + potato (Solanum tuberosum) intercropping. Indian Journal of Agricultural Sciences, 91 (7): 1005-9.

Von Cossel, M., Wagner, M., Lask, J., Magenau, E., Bauerle, A., Von Cossel, V., Warrach-Sagi, K., Winkler, B. 2019. Prospects of Bioenergy Cropping Systems for A More Social-Ecologically Sound Bioeconomy. Agronomy, 9: 605.

Wezel, A., Casagrande, M., Celette, F., Jean-Franc, V., Ferrer, A., Peigne, J. 2014. Agroecological practices for sustainable agriculture. A review. Agronomy for Sustainable Development, 34:1-20.

Yang, C., Fan, Z., and Chai, Q. 2018. Agronomic and Economic Benefits of Pea/Maize Intercropping Systems in Relation to N Fertilizer and Maize Density. Agronomy, 8(4):52.