Original Research Article

Evaluating Intercropping Indices, Yield Attributes and Yield of Baby Corn and Green Gram under Different Planting Patterns

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ABSTRACT

Cereal + legume intercropping provides greater scope for minimizing the adverse impact of moisture and nutrient stress, improves system productivity, and soil health. The lack of adherence to row proportion geometrics during crop sowing in the region results in a notable decline in crop productivity. An experiment was conducted in the summer of 2022, at the experimental farm of the College of Postgraduate Studies at Umiam, Ri-Bhoi, Meghalaya to evaluating intercrop[illegible] indices and yield attributes of baby corn and green gram under different pla[illegible] patterns. The experiment was laid out in randomized block design (RBD) with eight treatments and replicated thrice. The results demonstrated that the planting patterns had significantly higher yield attributes, grain yield, and stover yield in both sole cropping systems and no significant difference with 3:3 strip planting systems adopted in the study. Among the different spatial arrangements, 3:3 strip pla[illegible] of baby corn + green gram had been found to be more remunerative and eff[illegible] in terms of competition indices and biological efficiency than the rest of the treatments.

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Keywords: Biological efficiency, Competition indices, Intercropping, Strip planting

1. INTRODUCTION

Intercropping systems provide a vital solution to enhance agricultural productivity, preserve soil fertility, mitigate the effects of climate change, and meet the growing global food demand in the face of shrinking agricultural land and increasing resource competition (Maitra *et al*., 2019). Optimal resource utilization is largely dependent on the choice of intercrops, and the use of ideal species results in higher biological efficiency and yield benefits. The food preferences in the Indian lifestyle, and the urban population is shifting to a new food item *i.e*., “baby corn”. It is an immature, de-husked and unfertilized maize ear, harvested within two days of silk emergence but prior to fertilization (Bairagi *et al*., 2015). Baby corn ears with a light yellow, a length of 10 to 12 cm, and a diameter of 1.0 to 1.5 cm are preferred in the market.

Cereal + legume intercropping systems offer several advantages compared to sole cropping of rice, wheat, and maize. They contribute to improved soil fertility, increased yields, and enhanced economical returns. These systems help to reduce the risks associated with relying solely on a single crop. The combination of cereals and legumes leads to efficient nutrient utilization and increased dry matter output. Additionally, intercropping improves water uptake, reduces water loss from the soil, and creates a cooler microclimate, benefiting soil temperature and reducing evaporation (Himmelstein *et al*., 2017).

Spatial arrangement of intercrops is a management technique that can increase radiation interception by leaves (Undie *et al*., 2012). Optimizing crop geometry in intercropping systems is crucial for higher production and efficient resource utilization. Growth, yield-attributing characteristics, and yield of any intercropping system rely on the spatial arrangement of component crops (Muhammad e 2010). Thus, it is essential to standardize the crop geometry of baby corn in the intercropping system. Therefore, the present study was conducted to evalu intercropping indices and yield attributes for the biological and compe effectiveness of baby corn and green gram under various planting patterns. A number of indices such as land equivalent ratio, land equivalent coefficient, relative crowding coefficient, area time equivalent ratio, aggressivity, monetary advantages index etc. have been suggested to evaluate the competition between cereal and legume intercrops and advantage of intercropping compared to sole cropping.

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2. MATERIALS AND METHODS

2.1 Experimental details

An experiment was conducted in the summer of 2022, at the experimental farm of the College of Postgraduate Studies at Umiam, Ri-Bhoi, Meghalaya. The experimental site is situated at 91°18’ to 92°18’ East longitude and 25°40’ to 26°20’ North latitude; and at an altitude of 950 m above the mean sea level (MSL). The climate of Ri-Bhoi is classified as subtropical humid, high rainfall and cold winters. The rainfall in monsoon normally sets in the first fortnight of June and extends up to end of September. Withdrawal of monsoon takes place in October first week with a deceasing rainfall trend from September onwards. The mean weekly maximum and minimum temperature during the cropping season was 26.05°C and 16.33°C, respectively. The mean weekly relative humidity was recorded to be 86.78% entire crop duration received good amount of rainfall of 232.52 cm (Fig1).

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The experimental field was prepared using standard packages and practices for cultivating baby corn and green gram. The experiment was laid out in a randomized block design (RBD) with eight treatments: sole baby corn (T_1), sole green gram (T_2), baby corn + green gram (1:1) additive series (T_3), baby corn + green gram (1:1) replacement series (T_4), baby corn + green gram (1:2) additive series (T_5), 2:2 paired baby corn + green gram (T_6), baby corn + green gram (2:2) additive series (T_7), and baby corn + green gram (3:3) strip (T_8), each replicated thrice.

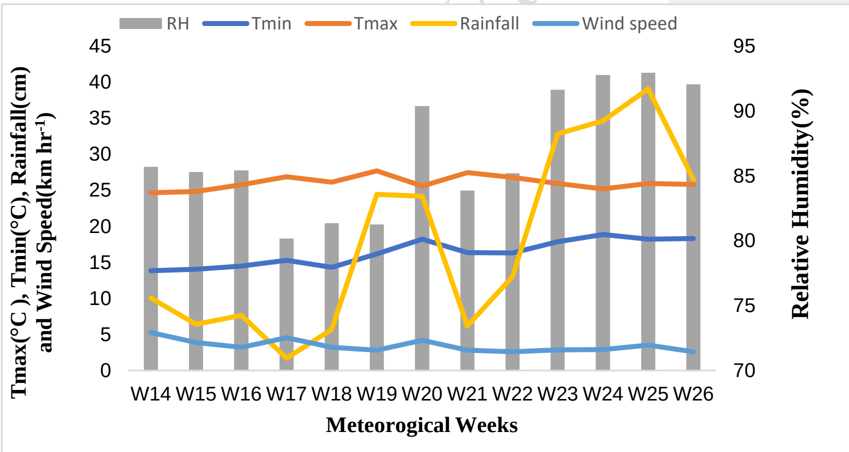

Fig.1: Weather condition during experimental period April 2022 to June 2022

2.2 Data collection and analysis

Observations were recorded for each plot, where 5 plants were selected at random, with the exclusion of the border rows, and subsequently tagged. All the observations of yield attributes were recorded from tagged plants (sample plants). Yield attributes were taken at the time of harvesting and the analysis and interpretation of data were done using the Fisher's method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was p = 0.05. Critical difference values were calculated wherever the ‘F’ test was significant. Duncan multi range test (DMRT) and correlation analysis were performed using IBM SPSS v23 software.

Various indices were employed to evaluate the biological and economic effectiveness of the baby corn-green gram intercropping system. Additionally, these indices were used to assess the level of competition between the individual crops within the intercropping system.

2.2.1 Land equivalent ratio (LER)

Land equivalent ratio (LER) is the relative land area under sole crops that is required to produce the yields achieved in intercropping given by willey (1979).

$$\mathrm{LER} = \frac{\mathrm{Yab}}{\mathrm{Yaa}} + \frac{\mathrm{Yba}}{\mathrm{Ybb}}$$

Where, Yab and Yba are the yields of intercrops a and b

Yaa and Ybb are the yields of a and b in sole cropping

2.2.2 Land equivalent coefficient (LEC)

Land equivalent coefficient (LEC) was determined by the formula given by Adetilaye and Ezedinma (1983).

$$\mathrm{LEC} = \frac{\mathrm{Yab}}{\mathrm{Yaa}} \times \frac{\mathrm{Yba}}{\mathrm{Ybb}}$$

Where, Yab and Yba are the yields of intercrops a and b.

Yaa and Ybb are the yield of a and b in sole cropping.

2.2.3 Relative crowding coefficient (RCC)

Relative crowding co-efficient (K) determine whether there is yield advantage of mixing, the product of coefficient is formed (K= kab × kba). Each component has its own coefficients (k) which gives a measure of whether that component has produced more, or less, yield than expected. The formula given by Cousens and ‘O’ Neill (1993).

$$\mathrm{RCC} = \frac{\mathrm{RYa}}{(1-\mathrm{RYa})} \times \frac{\mathrm{RYb}}{(1-\mathrm{RYb})}$$

Where, RYa and RYb are the relative yield of ‘a’ and ‘b’ respectively.

2.2.4 Aggressivity (A)

Aggressivity (A) was adopted as a competitive index to measure the extent at which the relative yield of one crop in the mixture was higher than that of the other, as expressed in Eq. and the formula given by McGilchrist in 1965.

$$\mathrm{Aggressivity} = \frac{\mathrm{Sa}}{\mathrm{Ya} \times \mathrm{Zab}} \times \frac{\mathrm{Sb}}{\mathrm{Yb} \times \mathrm{Zba}}$$

Where, Sa and Sb are yield in sole and Ya and Yb in intercrop Zab and Zba are the sown proportions of crop ‘a’ in ‘b’ and ‘b’ in ‘a’ respectively.

2.2.5 Area time equivalent ratio (ATER)

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ATER was calculated according to the formula given by Hiebsch and Macollam (1987).

$$\text{ATER} = \frac{\{(\text{RYa}\times\text{ta})\}+\{(\text{RYb}\times\text{tb})\}}{\text{T}}$$

2.2.6 Monetary advantages index (MAI)

MAI was calculated by using the formula given by Ghosh (2004).

$$\text{MAI} = (\text{value of combined intercop})\,\frac{(\text{LER}-1)}{\text{LER}}$$

3. RESULT AND DISCUSSION

3.1 Yield attributes and Yield

Yield attributes and yield of baby corn like, number of cobs per plant, cob length (cm), girth (cm), cob yield without husk (t ha^{-1}), and cob yield with husk (t ha^{-1}) as influenced by various planting patterns in the intercropping system were recorded at the time of harvest. The results revealed that, in most cases, sole baby corn planting achieved comparable yields to those obtained through the 3:3 strip planting method in intercropping (Table 1). While sole planting of baby corn yielded 46.32% more cob yield over additive planting of baby corn + green gram (1:1). Additionally, these solitary baby corn plants exhibited significantly higher values for the specified parameters as compared to the baby corn intercropped with green gram in 1:1 additive series cropping pattern. The reason for improved yield characteristics in baby corn planted in solitary rows and 3:3 strip pattern was due to the achievement of superior growth in these planting patterns, demonstrated by increased leaf area, leaf area index (LAI), dry matter accumulation and growth rates. These factors ultimately led to enhanced cell division and greater movement of photosynthates from source to sink, as evidenced by significantly influenced the yield attributes and yield of baby corn. The results of the present investigation are in accordance with those of Mandal *et al*. (2014) who reported highest grain yield in sole cropping of maize crop which was statistically at par with intercropping of maize + soybean (1:2) and maize + groundnut (2:4).

However, in case of green gram, the grain yield per unit area is determined by both plant density and yield per plant. The yield of individual plants is predominantly influenced by factors such as the number of pods per plant, the quantity of grains per pod, and the weight of 1000 grains. All of these factors contributing to yield were higher in sole green gram cultivation than baby corn using either the 1:1 additive series or 2:2 paired planting patterns and there was no significant difference between the 3:3 strip planting pattern and intercropping (Table 1). Sole planting of green gram resulted in 89.18% and 75% higher grain yield compared to the intercropping planting of baby corn + green gram (1:1) and paired planting of baby corn + green gram (2:2), respectively. The higher yield could be attributed to the increased planting density and dry matter, along with higher values of yield-

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attributing factors such as the number of pods per plant, grains per pod, and grain yield per plant. The reduced grain yield observed in green gram when it was grown alongside baby corn. This could be attributed to the competition between two plant species for essential resources such as soil moisture, nutrients, space, and sunlight. This competition affects both above and under-ground growth factors, leading to decrease in grain yield. Decreased grain yield observed in intercropped plots may also be attributed to the shading effect caused by baby corn on the green gram plants. This shading effect occurs due to the variations in plant architecture between the two species and aggressive growth characteristics of C_4 plant (baby corn) in comparison to C_3 plant (green gram). The findings of the present study align with previous findings of Das *et al.* (2013) and Banik *et al.* (2006). Similarly, Khan *et al.* (2012) also reported that the number of pods per plant in mung bean was higher in monoculture compared to intercropping system.

3.2 **Biological efficiency and competition indices**

3.2.1 Land equivalent ratio (LER)

Land equivalent ratio (LER) is a measure of the relative land area required for sole cropping to achieve the same yield as intercropping. Different planting patterns of baby corn and green gram intercropping led to notable variations in the partial land equivalent ratio of both crops, with the highest value observed in the sole planting method (Table 2). However, the 3:3 strip planting pattern showed significantly higher system LER of 1.55, indicating 55% increase in yield efficiency compared to another planting patterns in the intercropping system. Similarly, Ananthi *et al*. (2017) also found higher LER values in maize-based intercropping systems compared to sole cropping. These reports suggest that intercropping in maize-based systems results better land utilization and increased productivity.

3.2.2 Land equivalent coefficient (LEC)

The LEC is used to assess the land-use efficiency and overall productivity of an intercropping system compared to sole cropping. The 3:3 strip pattern of the intercropping system achieved maximum LEC value of 0.6, indicating that combining baby corn and green gram resulted in higher yields compared to planting these crops separately (Table 2). This highlights the potential benefits of intercropping in terms of maximizing land utilization and overall crop productivity, as LEC is influenced by the partial land equivalent ratios (LER) of both crops. Additionally, LEC values above 0.25 indicate that the intercropping system outperforms sole cropping for all row ratio arrangements of the crops, affirming its advantage in boosting the yield of both baby corn and green gram. This may be due to the incorporation of legume intercrops contributing to higher yields, likely attributed to the efficient utilization of natural resources and available space, along with an increase in baby corn yield as an additional benefit. These results align with similar conclusions made by Kumar *et al*. (2015).

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3.2.3 Area time equivalent ratio (ATER)

Area time equivalent ratio (ATER) represents the optimal utilization of space and time and was observed to be the highest in 3:3 strip planting pattern (1.47) involving baby corn and green gram intercropping and lowest value observed from sole cropping system (1.00) (Table 2). The improved ATER may be attributed to the combined yield and temporal differences that existed between the crops. The result suggests that the intercropping system achieved better efficiency in terms of both space and time utilization compared to sole cropping. Notably, the intercropping treatment resulted in a net saving of 47 % in terms of space and time compared to growing the crops as sole crops. The findings of Almaz *et al*. (2017) yielded similar outcomes when assessing the intercropping of maize and fodder cowpea.

3.2.4 Monetary advantage index (MAI)

The cropping system's profitability is shown by the monetary advantage index (MAI). 3:3 strip planting pattern of baby corn-green gram intercropping provided the highest MAI when the financial benefit was taken into account (Table 2). This may be due to the intercropping system's superior biological efficiency than other systems. Mallikarjuna *et al*. (2011) and Ghosh (2004) reported similar findings.

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Table 1: Effect of planting pattern on yield attributes and yield of baby corn and green gram in baby corn + green gram intercropping syster

Treatments	No. of cob per plant	Cob length	Girth	Cob yield Without husk	Cob yield with husk	Number of pods per plant	Number of seeds per pod	Grain Weight (g)	Grain Yield	Harvest Index	Test Weight
T1	1.57a	9.12a	1.67a	2.59a	7.38a	-	-	-	-	-	-
T2	-	-	-	-	-	18.53a	11.33a	2.24a	0.70a	27.15a	38.61a
T3	1.20b	7.86b	1.39c	1.77c	6.61bc	16.20b	8.67c	1.70c	0.37b	20.15b	36.71ab
T4	1.37ab	8.61ab	1.51bc	2.00bc	6.36c	17.47ab	9.00bc	1.63bc	0.41b	19.26b	38.38a
T5	1.23b	7.98b	1.41bc	2.19b	6.99abc	13.73b	9.33bc	1.51c	0.34b	18.22b	38.54a
T6	1.43ab	8.97a	1.55abc	2.13bc	7.08ab	17.60ab	8.67c	1.55c	0.40b	17.98b	37.36ab
T7	1.34ab	8.77ab	1.51bc	2.06bc	7.07ab	14.90b	9.87bc	1.90b	0.36b	18.82b	34.95b
T8	1.56a	9.00a	1.56ab	2.25ab	7.12ab	18.43a	10.23ab	2.10ab	0.43b	18.81b	37.72a
SE(m)±	0.09	0.28	0.05	0.02	0.20	0.58	0.39	0.11	0.03	1.76	0.75
LSD(*P*=0.05)	0.27	0.87	0.14	0.08	0.60	1.79	1.21	0.35	0.10	5.42	2.32

**Within the same column figures sharing the same letters do not differ significantly at p≤0.05*

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Table 2: Yield advantage parameters of intercropping as influenced by different planting patterns in baby corn + green gram intercropping system

Treatments	Partial LER of Baby Corn	Partial LER of Green Gram	System LER	System LEC	Area time equivalent ratio	Monetary advantage index
T1	1.00a	-	1.00b	1.00a	1.00b	-
T2	-	1.00a	1.00b	1.00a	1.00b	-
T3	0.74b	0.53bc	1.28ab	0.42b	1.22ab	34127b
T4	0.85ab	0.59bc	1.44a	0.53b	1.37a	55275ab
T5	0.94ab	0.49c	1.44a	0.47b	1.37a	59894ab
T6	0.89ab	0.58bc	1.48a	0.55b	1.42a	62719ab
T7	0.85ab	0.51bc	1.38a	0.45b	1.31ab	50904ab
T8	0.91ab	0.63b	1.55a	0.60b	1.47a	70584a
SE(m)±	0.06	0.04	0.10	0.07	0.10	11478
LSD (*p*=0.05)	0.19	0.12	0.31	0.23	0.29	34813

**Within the same column figures sharing the same letters do not differ significantly at $p \leq 0.05$*

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3.2.5 Aggressivity

Different planting patterns in intercropping system had significant impact on the aggressivity of baby corn and green gram in the intercropping system. The highest aggressivity value for baby corn was observed in the 1:2 additive series (T_5), while the lowest value was found in the 3:3 strip planting pattern (T_8) (Fig.2). Conversely, the trend was opposite for the aggressivity of green gram. The maximum aggressivity value for green gram was recorded in the 3:3 strip planting method, while the lowest value was observed in treatment T_5. These results indicate that the planting patterns in intercropping system had varying effects on the competitive abilities of baby corn and green gram in the intercropping system.

When the aggressivity value is zero, it indicates that the component crops within the intercropping system have equal competitiveness. In any other situation, both crops will have the same numerical value, but the dominant species will have positive sign, while the dominated species will have negative sign. The row ratio of 1:2 in the additive series of baby corn and green gram revealed the dominance of baby corn over the green gram crop. This could be attributed to the effective utilization of nutrients, light, space, moisture, etc., by baby corn, along with its minimal intraspace competition and shading effects. Similar results have been reported by Gitari *et al.* (2020).

3.2.6 Relative crowding coefficient (RCC)

The relative crowding coefficient (RCC) is measure of the relative dominance of one crop component over the other within an intercropping system. The intercropping system had significant effect on the partial RCC of baby corn. However, the maximum value of partial RCC for baby corn was observed in the 1:2 additive series (T_5), which was statistically similar to treatment T_8 (Fig. 2). On the other hand, for green gram, the highest partial RCC value was recorded in treatment T_8, while the lowest value was observed in the 1:2 additive series (T_5). These findings indicate that the planting patterns in intercropping system can affect the level of interspecific competition and crowding differently for baby corn and green gram in the intercropping system.

The RCC value for baby corn was considerably higher than 1, indicating that baby corn had an absolute yield advantage over green gram in the intercropping system. One important point to consider is that the higher yield per unit area of baby corn, particularly due to its larger canopy, may result in overcrowding within the intercropping system. This finding aligns with similar results reported by Dhima *et al*. (2007) in a cereal-vetch intercropping system.

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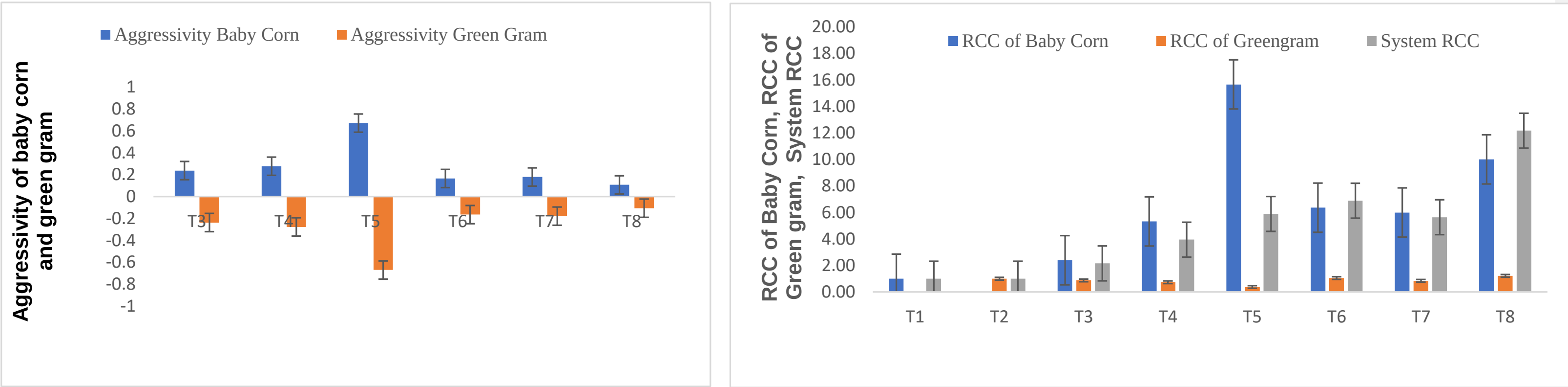

Fig. 2: Competition indices as influenced by different planting patterns in baby corn + green gram intercropping system

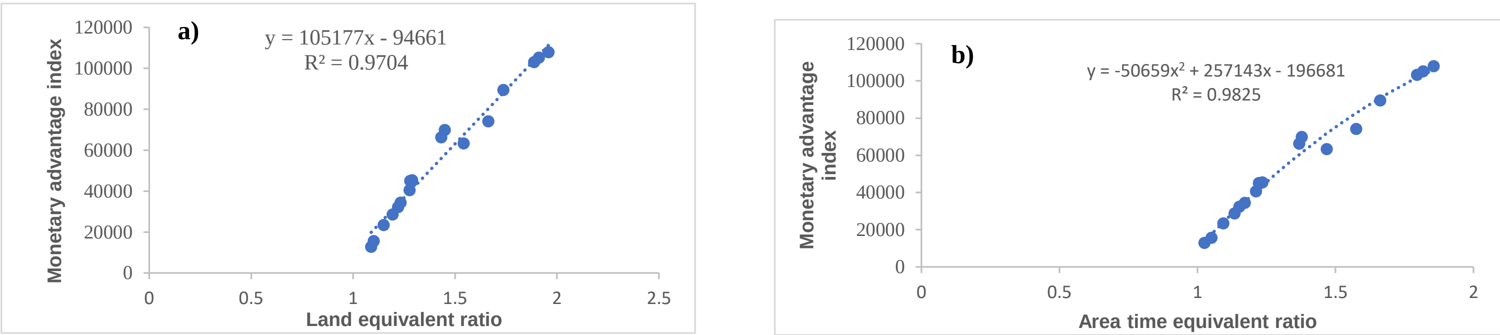

Fig.3: Baby corn- green gram intercropping system influenced the relationship of monetary advantage index with a) land equivalent ratio (LER) and b) area time equivalent ratio (ATER).

2.3 Relationship between land equivalent ratio and monetary advantage index

There was a positive significant relationship between LER and MAI. Fig 3a depicted that LER and MAI followed the positive linear with R^2 = 0.97, However, MAI followed the quadratic relationship between ATER with R^2 = 0.98 (fig. 3b). This clearly showed that LER and ATER gradually increased with increase in MAI.

4. CONCLUSION

The study concluded that among various spatial arrangements, the 3:3 strip planting method of baby corn + green gram proved to be the most profitable as well as efficient in terms of competition indices and biological efficiency. Thus, it was identified as the optimal planting pattern for maximizing returns and resource utilization, particularly beneficial in regions like Meghalaya where fields remain fallow during the summer season.

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