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Evaluation of Maize and Pulses Intercropping System under Rainfed Condition in Western Zone of Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in *rabi* seasons (2022) at Karunya Institute of Technology and Sciences, Coimbatore to study the maize-based intercropping with different legumes under rainfed condition as there are less research work regarding intercropping of maize in this area. Greengram (*Vigna radiata*), cowpea (*Vigna unguiculata*) and horsegram (*Macrotyloma uniflorum)* were selected as intercrops in 4:1 and 6:1 row ratio. The result of the study indicated that intercropping of greengram and cowpea with maize (*Zea mays L*.) in 4:1 gave higher total grain yield and stover yield compared to the sole cropping of maize under rainfed condition. Other intercropping indices like grain equivalent yield, land equivalent ratio, relative crowding coefficient, competition index and

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income equivalent ratio were calculated. Intercropping system of maize + greengram (4:1) recorded the higher net return and B: C ratio followed by it maize+ cowpea (4:1). Therefore, under rainfed conditions of western zone of Tamil Nadu, maize + greengram 4:1 intercropping system may be suggested to get greater net return and B: C ratio.

Keywords: Intercropping; pulses; yield; economics; GEY; LER.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereals next to wheat and rice in the world. The crop has been referred to as the "Queen of Cereals" because of its high genetic production potential. Next to rice and wheat, maize (Zea mays L.) is the third-most significant cereal crop worldwide. When compared to other cereal crops, maize yields more, and it is also more environmentally adaptable. In India, it is consumed as food, fodder and also has industrial uses. Similar to rice, wheat, and millets, maize plays a significant role in the Indian economy.

The practise of growing two or more crops simultaneously in the same field is known as intercropping [1]. In addition to meet the nutritional needs of the rapidly expanding population, intercropping minimises the risk of crop failure due to unfavourable weather condition or changes in the market price.

Due to its tall plant height and wider spacing, maize offers enough interrow space that can be used profitably for growing crops with short lifespans and small statures that are profitable for farmers in terms of production and profitability. When legumes and maize are intercropped, the companion maize crop gets benefitted. Inclusion of legumes as intercrop not only provides nitrogen content but also provides additional income to the farmers. Pulses like cowpea, horsegram and greengram can be intercropped with maize. The goal of the present research was to analyse the different legume intercrops with maize and to determine the most profitable maize-based intercropping system.

2. MATERIALS AND METHODS

A field experiment was carried out during the *rabi* season (2022) to study the maize-based intercropping with legumes under rainfed condition at Karunya Institute of Technology and Sciences, Coimbatore district of Tamil Nadu using randomized block design with seven treatments. The entire experiment field is located at 10.934° North latitude and 76.73° East longitude, at an altitude of 467 metres above mean sea level and it is situated in the Western agroclimatic zone of Tamil Nadu. The intercropping system treatments are., T_1- sole crop of maize, T_2- maize + greengram (4:1), T_3- maize + cowpea (4:1), T_4- maize + horsegram (4:1), T_5- maize + greengram (6:1), T_6- maize + cowpea (6:1) and T_7- maize + horsegram (6:1). The soil of experimental site was clay loam with pH of 7.0 and EC of 0.16 dSm^{-1}. The treatments were replicated thrice and sown in replacement series. Hybrid Maize CoH(M) 6 was intercropped with greengram (VBN 2), cowpea (Co7) and horsegram (Paiyur 2). Economic benefits like net returns and B:C ratio was calculated according to market price of each crop.

The effectiveness and sustainability of the systems are evaluated using a variety of indices. These indexes are often calculated using the information gathered using conventional survey techniques.

Lal and Ray [2] proposed economics of crop by converting grain/seed/ fodder in terms of gross return for valid comparison as grain equivalent yield (GEY). Maize equivalent yield (GEY) of intercropping system was calculated by the formula:

$$\text{GEY (kg ha}^{-1}\text{)} = \frac{Yield\ of\ intercrop\ (Yi) \times price\ of\ intercrop\ (Pi)}{price\ of\ base\ crop\ (Pp)}$$

LER (Land Equivalent Ratio) was worked out by using the formula of Willey [3]. It is actually the proportionate land area required under pure stand of crop species to yield the same produce as obtained under an intercropping at the same management level.

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

Where, Yab is the yield of “a” crop grown in association with “b” crop and Yba is the yield of “b” crop grown in association with “a” crop. Yaa and Ybb represent the yields of “a” and “b” crops grown in pure stand and Zab and Zba are the sown proportion of crop “a” and “b” in

intercropping, respectively. The value of LER greater than unity (1.0) indicates the advantages of the intercropping system [4].

Relative crowding coefficient (RCC) indicates whether a crop, when grown in mixed population, has produced more or less yield than expected in pure stand. The value of RCC greater than unity (1.0) also indicates the advantages of the intercropping system.

$$RCC = \frac{Yab\ x\ Zab}{(Yaa - Yab)x\ Zab}$$

Monetary value of the crop yield is taken instead of yield and IER worked out as in the case of LER. It is also the ratio of the area needed under sole cropping to that of intercropping, at the same time management level, to produce the same amount of gross income [5].

$$IER = \frac{Iab}{Iaa} + \frac{Iba}{Ibb}$$

Where, Iaa and Ibb is the gross income of 'a' and 'b' in sole crop situation. Iab and Iba is the gross income of 'a' and 'b' in intercropping situation.

This is the product of two equivalent factors of each component crops. The index less than one will be an advantage.

CI = Equivalent factor for 'a' x Equivalent factor for 'b'

Where, equivalent factor for 'a' is denoted as per plant yield of 'b' / per plant yield of 'a' and equivalent factor for 'b' = per plant yield of 'a' / per plant yield of 'b'.

3. RESULTS AND DISCUSSION

3.1 Growth and Yield of Maize Based Intercropping System

Intercropping has significant effects on plant growth characteristics including plant height and dry matter production. Plant height of maize was found to be higher under the treatment T_2 - maize + greengram at 4:1 ratio (225.7 cm at harvest) followed by maize + cowpea at 4:1 ratio (T_3) (221.8 cm at harvest) (Table 1). Among the various intercrops, maize + greengram at 4:1 ratio (T_2) intercropping system produced higher dry matter production (14099 kg ha^{-1}). Similar results were also obtained by Sharmili et al. [6] in little millet based intercropping system with pulses.

The grain yield of maize was significantly influenced by various intercrops and the grain yield ranged from 3421 to 4500 kg ha^{-1} (Table 1). Maize sole crop registered the highest grain yield (4500 kg ha^{-1}) and it was on par with maize + greengram at 4:1 ratio (4398 kg ha^{-1}). Maize sole crop registered the highest stover yield (8900 kg ha^{-1}) and it was on par with maize + greengram at 4:1 ratio (8879 kg ha^{-1}).). The results are also in conformity with findings of Nandi et al*.* [7] also concomitant to the present findings reports grain yield of maize differed significantly among the treatments, and it showed that pure stand of maize recorded significantly higher grain yield. Priya *et al.,* 2019 who opined sole maize recorded the maximum yield which was followed by maize + blackgram (2:1).

3.2 Effect of Intercropping on Different Competitive Indices

The maize grain equivalent yield (GEY) was estimated to compare various intercropping arrangements (Table 2). Among the intercropping system 4:1 row proportion of maize + cowpea intercropping system produced the highest maize grain equivalent yield (4903.3 kg ha^{-1}) and was closely followed by the 4:1 row proportion of maize + greengram intercropping system. These were similar to the findings of Sharmili and Manoharan [8] in little millet based intercropping system.

Among the intercropping systems, T_3- maize + cowpea 4:1 (1.17) intercropping system had the highest land equivalent ratio, and it was closely followed by T_2- maize + greengram 4:1 (1.16). This increased value of LER was caused by improved intercrop yield, demonstrating the advantages of intercropping maize in a 4:1 ratio. Similar results were found by Dwivedi et al. [9] observed that the pearl millet-cowpea intercropping was more productive than their mono-crops, which recorded higher the LER of 1.2.

Among the intercropping treatments higher Relative crowding coefficient (RCC) value of 1.16 was obtained with maize + greengram at 4:1 ratio (T_2). The combined RCC value greater than unity in this intercropping system denotes the advantage of intercropping (Table 2). The findings were similar to Sharmili et al*.* [6].

Table 1. Effect of intercropping on growth, yield and economics

Treatments	Plant height (cm)	Dry matter production (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Intercrop yield (kg/ha)	Net return (Rs/ha)	B:C ratio
T_1-Maize sole crop	207.9	14205	4500	8900	-	88700.0	2.49
T_2-Maize + greengram (4:1)	225.7	14099	4398	8879	8450	93573.5	2.56
T_3- Maize + cowpea (4:1)	221.8	11825	4319	7996	12100	92914.0	2.53
T_4-Maize + horsegram (4:1)	183.8	8237	3480	4401	1625	54316.5	1.90
T_5-Maize + greengram (6:1)	199.6	13447	4361	8826	2795	86774.0	2.44
T_6-Maize + cowpea (6:1)	193.3	12424	4058	8229	6300	78133.5	2.28
T_7-Maize + horsegram (6:1)	175.3	8412	3421	4694	975	52092.0	1.86
Sed	11.4	789.4	315	308			
CD (*P* = .05)	25.0	1720	686	672			

Table 2. Effect of intercropping on various competitive assessments

Treatments	Grain equivalent yield	Land equivalent ratio	Relative crowding coefficient	Income Equivalent Ratio
T_1-Maize sole crop	-	-	-	-
T_2-Maize + greengram (4:1)	4781.7	1.16	1.16	1.12
T_3-Maize+ cowpea (4:1)	4903.3	1.17	1.01	1.19
T_4-Maize+ horsegram (4:1)	4554.1	0.84	0.36	0.83
T_5-Maize + greengram (6:1)	4593.1	1.02	1.09	1.02
T_6-Maize +cowpea (6:1)	4665.0	0.99	0.68	1.00
T_7.Maize +horsegram (6:1)	4532.5	0.80	0.34	0.79
Sed	236.1	*	*	*
CD (*P* = .05)	514.5			

**Data not statistically analysed*

Income equivalent ratio for maize based intercropping system were significantly greater than unity in most of the treatments (Table 2) which is advantageous. T_3- maize + cowpea 4:1 recorded highest IER value of 1.19 followed by T_2- maize + greengram at 4:1 ratio (1.12). Least IER value was found on maize + horsegram in both 4:1 (0.83) and 6:1 (0.79). These results were similar to the findings of Bantie, [10].

3.3 Economics of Intercropping

Maize + greengram 4:1 combination recorded higher gross return and net return than other treatment studied (Rs.1,53,708 ha^{-1} and Rs. 93,573 ha^{-1}). It was followed by maize + cowpea 4:1 (Rs. 1,53,664 ha^{-1} and Rs. 92,914 ha^{-1}). Intercropping was always beneficial and recorded higher B:C with respect to maize monoculture. Among the intercropping system maize +greengram 4:1 recorded the highest B:C ratio of 2.56. It was followed by maize + cowpea 4:1 (2.53) Table Choudhary et al. [11] also reported that intercropping of pearl millet with greengram at 2:2 pair row ratio was distinctly superior over sole pearl millet and found most profitable by realizing the highest net return and LER and this is in support of the present study.

4. CONCLUSION

Based on the findings of the earlier study, it can be inferred that, in comparison to other intercrops, intercropping maize with greengram at 4:1 ratio reported the highest net return and B: C ratio. Therefore, under rainfed conditions, maize + greengram 4:1 intercropping system may be suggested to get more net return and B: C ratio. As an alternative, intercropping system of maize+ cowpea in 4:1 can also be suggested.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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