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# Effect of micronutrients on intercropping indices and economics of maize-cowpea intercropping system

**Rachana, Vikram Singh and Judy K Lalrinsangi**

## Abstract
The present investigation was carried out in *kharif* season in 2018 and 2019 at Crop research farm, Department of Agronomy, Nainy Agricultural Insitute, SHUATS, Prayagraj (U.P) to determine the "Effect of micronutrients on intercropping indices and economics of maize-cowpea intercropping system". The experiment was laid-out in randomized block design keeping (1:1) row ratio with three replications. Treatments comprised *viz*., sole maize, sole cowpea, maize-cowpea (1:1). Recommended dose of fertilizer used for maize and cowpea were 120:60:30 and 25:50:20 N;P:K kg $ha^{-1}$ respectively. (K-064) of maize and (MOHINI) of cowpea were taken as test crops during the investigation. The results of the experiment shows intercropping indices *viz*., Maize equivalent yield (MEY), Land equivalent ratio (LER), Aggressivity (A) and economics was significantly influenced by the micronutrients along with RDF and the highest values were recorded by sole maize and cowpea among the treatments all intercropping indices.

**Keywords:** Intercropping system, maize-cowpea, land equivalent ratio (LER), Maize equivalent ratio (MEY), Aggressivity (A), economics

## Introduction
Maize (*Zea mays* L.) remains at third position among the cereals after rice and wheat across the globe. Maize is widely grown as cereal crop in many developing countries including India. Maize is considered as a staple food besides its other uses such as energy, etc. Even as, maize has a high yield potential and is suited to various climatic zones of India. Cowpea (*Vigna unguiculata*) is one of the most important vegetable crops grown as pulse, vegetable and fodder. It is poor man's protein source and considered one of the most ancient human food sources.

Intercropping is an ancient agricultural practice of mixed cropping that involves planting two or more crop species together in the same space and at the same time (Massawe *et al.*, 2016; Dai *et al*., 2019) [10, 6]. The most common combination for this practice is legumes/cereals (Layek *et al*., 2018) [9]. According to the meta-analysis study by Tang *et al*. (2021) [13] on the efficiency of using phosphorus (P) in cereal/legume intercrops, a significant increase in the absorption of P and the equivalent ratio-soil for P uptake was observed. In vulnerable situations, this intercropping system has various benefits such as improving fertility by increasing nutrient availability and soil quality (Betencourt *et al.*, 2012; Bi *et al*., 2019) [1, 3], including water use efficiency likely to improve under drought conditions (Yin *et al*., 2020) [14].

Among the nutrients, though the requirement of micronutrients is less as compared to primary nutrients, it is equally important for plant metabolism, growth and development (Bhanukar *et al*., 2018) [2]. Deficiency of micronutrients results in poor growth and lower yield. Several studies suggest that increased environmental stress due to climate change limits the soil-derived nutrients as a result of higher incidence and duration of heat and drought (Ishfaq *et al*., 2022) [8]. These limitations by the interaction of different nutrients and losses in soil affect the productivity of crops and can be mitigated in the case of foliar fertilization. Foliar spray of micronutrients has an advantage over soil application due to its high effectiveness and rapid plant response (Bhanukar *et al*., 2018) [2]. Foliar application is 7–21 times more effective than soil application (Zaman *et al*., 2019) as nutrients are directly applied onto the leaves where their metabolism takes place and gives a quicker response due to easy access to nutrients (Harris & Puvanitha, 2018) [7]. Monreal, *et al.* (2015) [11] and Dugie *et al.* (2009) found that foliar application of translocated to the developing pods, which macro and micro nutrients play an important role in the production of good crop and higher yield of cereal crops.

## Materials and Methods

The present investigation was carried out in *kharif* season in 2018 and 2019 at Crop research farm, Department of Agronomy Allahabad School of Agriculture, SHUATS, Prayagraj (U.P). Effect of micronutrients on intercropping indices and economics of maize-cowpea intercropping system. The experiment was laid-out in randomized block design thrice replicated, keeping one row arrangement (1:1) with four micronutrients *viz*. Zn, B, Fe and Mg. Treatments comprised *viz*., sole maize, sole cowpea, maize-cowpea (1:1). Each plot with sole cowpea, sole maize and cowpea + maize intercrop (1:1) was 4 m x 3 m (12 $m^2$). Cowpea seeds variety (Mohini) and maize seeds variety (K-064) was sown at 15 cm within a row and 60 cm between rows. Cowpea + maize intercrops planting both crops in alternate row with four micronutrients *viz*., Magnesium, Zinc, Boron, Iron. Recommended dose of fertilizer used for maize and cowpea were 120:60:30 and 25:50:20 N;P:K kg $ha^{-1}$ respectively during the investigation.

### Competitive Relationships

### Land Equivalent Ratio (LER)

Which verifies the effectiveness of intercropping for using the resources of the environment compared to sole cropping as indicated by Willey *et al.* (1972). The LER values were calculated as: LER = (LERM + LERC), where LERM = YIM/YM and LERC = YIC/YC, where YM and YC are the yields of maize and cowpea as sole while YIM and YIC are the yields of maize and cowpea as intercrops, respectively.

### Crop Yield Assessment

### Maize equivalent yield (MEY)

Maize, and cowpea grain yield were measured at physiological maturity from three sampling areas of three rows maize, or cowpea, for each intercropping and sole crop. We chose the net harvest area at random and hand harvested samples. Grain yields were determined individually for sole crops and intercrops by converting each sampling unit to one hectare. The crop yields of maize and cowpea at different treatments in comparison with market prices were determined based on crop equivalent yield. The crop equivalent yields were MEY and CEY. In determining MEY and CEY, crop yields are converted into one crop form to allow comparison of the crops cultivated under intercropping. The conversion of the yield is carried out in the form of main crop (maize) equivalent yield by considering the intercrop yield and market price of the main crop and associated intercrops. The market prices of maize or cowpea were based on the farm gate prices in 2018 and 2019 in each province. The MEY or CEY expressed in t $ha^{-1}$ were calculated based on the following formulas.

$$\textbf{CEY for intercrop} = \textbf{cowpea yield} + \frac{\textbf{associated intercrop yield} \times \textbf{Price of associated intercrop}}{\textbf{cowpea price}}$$

$$\textbf{MEY for intercrop} = \textbf{Maize yield} + \frac{\textbf{associated intercrop yield} \times \textbf{Price of associated intercrop}}{\textbf{maize price}}$$

### Aggressivity (A)

It was used to determine the competitive relationship between two crops in a mixture as indicated by Mc-Gillichrist *et al.* (2019). The Aggressivity was calculated as: AM = (YIM/YM xZIM) – (YIC/YC x ZIC), and AC = (YIC/YC x ZIC) – (YIM/YM x ZIM) where: ZIM = sown proportion of crop maize (in maize intercropping with cowpea); ZIC = sown proportion of crop cowpea (in cowpea intercropping with maize).

### Economics of the demonstration

On the basis of result obtained from the field experiment, the economics of various treatments was worked out. The gross income per hectare was calculated on the basis of green and dry fodder yield from each respective treatment.

The net profit $ha^{-1}$ was calculated by deducting the cost of cultivation ha-1 from the gross income $ha^{-1}$.

$$\text{B: C ratio} = \frac{\text{Gross returns (Rs. ha} - 1)}{\text{Cost of cultivation (Rs. ha} - 1)}$$

## Results and Discussion

Effect of Cowpea with Maize Intercropping on Competitive Relationships and Yield Advantages in 2018 and 2019 Seasons and Its Combined.

### Land Equivalent Ratio (LER)

Data pertaining to LER given in Table 1 which indicate that land equivalent ratio (LER) is greater than unity in intercropping treatment. Maize + cowpea 1:1 row proportion along with foliar application of boron 1% recorded maximum land equivalent ratio (1.17 and 1.24) in the year 2018 and 2019 respectively during the investigation over rest of other treatments.

It indicated that 1:1 row proportion strongly influenced the crop productivity and utilized the land area more efficiently compared to sole crop and other intercropping system. There was considerable increase in yield of companion crop therefore; higher values of LER were recorded. And all intercropping treatments show LER greater than one which means that this intercropping system is advantageous. Mishra (2014) reported similar type of results.

### Maize equivalent yield (MEY)

The data regarding maize equivalent yield (t $ha^{-1}$) as affected by various treatments are presented in Table 1. Maize equivalent yield was higher in intercrop maize with cowpea (1:1) row proportion along with foliar application of boron 1%. This was due to higher market price of fodder maize than market price of companion crop. Similar types of findings were also reported by Khonde *et al.* (2018)

### Aggressivity Index (A)

Aggressivity index of maize and cowpea influenced by different treatments are given in Table 1. Aggressivity index of intercrop was negative indicating the dominance of maize in the intercropping system. In case of maize aggressivity index was higher in treatment i.e. Maize + Cowpea 1:1 intercropping over rest of the other treatments. In intercrop cowpea aggressivity higher in intercrop.

Aggressivity was the competitive relationship between maize and cowpea. Maximum aggressively was recorded (0.44) in maize+cowpea intercropping (1:1) along with foliar

application of boron in the year 2018 and maize+cowpea intercropping (1:1) along with foliar application of iron in the year 2019 was recorded (0.46) in intercropping in case of maize over rest of the treatments. Negative aggressively index of cowpea indicated that dominance of maize. Similar types of results were in agreement with findings of Chaudhari and Jana (2015) and Manasa *et al.* (2018) [15].

**Table 1:** Effect of micronutrients on intercropping indices of maize-cowpea intercropping system.

| Notations | Land equivalent ratio (LER) | | | Maize equivalent ratio (MEY) t ha$^{-1}$ | | | Aggressivity (A) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 1 | 0.58 | 0.66 | 0.62 | 3.64 | 3.89 | 3.77 | - | - | - |
| 2 | 0.60 | 0.69 | 0.65 | 4.20 | 4.21 | 4.20 | - | - | - |
| 3 | 0.58 | 0.69 | 0.64 | 4.78 | 4.79 | 4.78 | - | - | - |
| 4 | 0.69 | 0.70 | 0.70 | 4.85 | 5.00 | 4.92 | - | - | - |
| 5 | 0.63 | 0.68 | 0.66 | 4.32 | 4.49 | 4.40 | - | - | - |
| 6 | 0.51 | 0.60 | 0.56 | 5.66 | 5.93 | 5.80 | - | - | - |
| 7 | 0.45 | 0.47 | 0.46 | 6.93 | 7.65 | 7.29 | - | - | - |
| 8 | 0.44 | 0.52 | 0.48 | 7.64 | 7.86 | 7.75 | - | - | - |
| 9 | 0.48 | 0.54 | 0.51 | 8.02 | 8.22 | 8.12 | - | - | - |
| 10 | 0.44 | 0.45 | 0.45 | 7.30 | 8.29 | 7.79 | - | - | - |
| 11 | 1.09 | 1.26 | 1.18 | 9.30 | 9.82 | 9.56 | 0.12 | 0.12 | 0.12 |
| 12 | 1.05 | 1.16 | 1.10 | 11.13 | 11.86 | 11.50 | 0.31 | 0.45 | 0.38 |
| 13 | 1.02 | 1.21 | 1.11 | 12.41 | 12.65 | 12.53 | 0.29 | 0.35 | 0.32 |
| 14 | 1.17 | 1.24 | 1.20 | 12.87 | 13.22 | 13.04 | 0.44 | 0.31 | 0.37 |
| 15 | 1.07 | 1.14 | 1.10 | 11.62 | 12.78 | 12.20 | 0.37 | 0.46 | 0.42 |
| F-test | S | S | S | S | S | S | - | - | - |
| S.Ed.(±) | 0.052 | 0.071 | 0.048 | 0.248 | 0.278 | 0.146 | - | - | - |
| CD at 0.5 | 0.106 | 0.146 | 0.099 | 0.508 | 0.569 | 0.299 | - | - | - |

**Treatment details**

$T_1$ Control (Maize sole crop), $T_2$ (Maize sole with foliar application of Magnesium 1%), $T_3$ (Maize sole with foliar application of Zinc 1%), $T_4$ (Maize sole with foliar application of Boron 1%), $T_5$ (Maize sole with foliar application of Iron 1%), $T_6$ Control (Cowpea sole crop), $T_7$ (Cowpea sole with foliar application of Magnesium 1%), $T_8$ (Cowpea sole with foliar application of Zinc 1%), $T_9$ (Cowpea sole with foliar application of Boron 1%), $T_{10}$ (Cowpea sole with foliar application of Iron 1%), $T_{11}$ control (Maize-Cowpea (1:1), $T_{12}$ (Maize-Cowpea (1:1) with foliar application of Mg 1%), $T_{13}$ (Maize-Cowpea (1:1) with foliar application of Zn 1%), $T_{14}$ (Maize-Cowpea (1:1) with foliar application of Boron 1%), $T_{15}$ (Maize-Cowpea (1:1) with foliar application of Iron 1%).

**Economics**

As regards economics of the demonstration revealed that sole maize along with foliar application of boron 1% recorded highest gross returns of (Rs. 1,45,500.00 and 1,50,000.00 ha$^{-1}$), net returns (1,06,614.46 and 1,06,921.06) and B:C ratio (2.74 and 2.48) than the other treatments in both the year of investigation during 2018 and 2019 respectively.

**Table 2:** Effect of micronutrients on intercropping indices and economics of maize-cowpea intercropping system.

| Notations | Cost of cultivation (Rs. ha$^{-1}$) | | | Gross return (Rs. ha$^{-1}$) | | | Net return (Rs. ha$^{-1}$) | | | Benefit cost ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 1 | 38,635.54 | 42,828.94 | 40,732.24 | 109200.00 | 116700.00 | 112950.00 | 70,564.46 | 73,871.06 | 72,217.76 | 1.83 | 1.72 | 1.775 |
| 2 | 38,925.54 | 43,118.94 | 41,022.24 | 126000.00 | 126300.00 | 126150.00 | 87,074.46 | 83,181.06 | 85,127.76 | 2.24 | 1.93 | 2.085 |
| 3 | 38,915.54 | 43,108.94 | 41,012.24 | 143400.00 | 143700.00 | 143550.00 | 1,04,484.46 | 1,00,591.06 | 1,02,537.76 | 2.68 | 2.33 | 2.505 |
| 4 | 38,885.54 | 43,078.94 | 40,982.24 | 145500.00 | 150000.00 | 147750.00 | 1,06,614.46 | 1,06,921.06 | 1,06,767.76 | 2.74 | 2.48 | 2.61 |
| 5 | 38,865.54 | 43,058.94 | 40,962.24 | 129600.00 | 134700.00 | 132150.00 | 90,734.46 | 91,641.06 | 91,187.76 | 2.33 | 2.13 | 2.23 |
| 6 | 37,093.16 | 40,046.92 | 38,570.04 | 93800.00 | 98000.00 | 95900.00 | 56,706.84 | 57,953.08 | 57,329.96 | 1.53 | 1.45 | 1.49 |
| 7 | 37,383.16 | 40,336.92 | 38,860.04 | 114800.00 | 126700.00 | 120750.00 | 77,416.84 | 86,363.08 | 81,889.96 | 2.07 | 2.14 | 2.105 |
| 8 | 37,373.16 | 40,326.92 | 38,850.04 | 126000.00 | 130200.00 | 128100.00 | 88,626.84 | 89,873.08 | 89,249.96 | 2.37 | 2.23 | 2.3 |
| 9 | 37,343.16 | 40,296.92 | 38,820.04 | 132300.00 | 137200.00 | 134750.00 | 94,956.84 | 96,903.08 | 95,929.96 | 2.54 | 2.40 | 2.47 |
| 10 | 37,323.16 | 40,276.92 | 38,800.04 | 120400.00 | 135800.00 | 128100.00 | 83,076.84 | 95,523.08 | 89,299.96 | 2.23 | 2.37 | 2.3 |
| 11 | 41,824.16 | 44,940.02 | 43,382.09 | 111000.00 | 135300.00 | 123150.00 | 27,351.68 | 45,419.96 | 36,385.82 | 0.65 | 1.01 | 0.83 |
| 12 | 42,114.16 | 45,230.02 | 43,672.09 | 126700.00 | 145600.00 | 136150.00 | 42,471.68 | 55,139.96 | 48,805.82 | 1.01 | 1.22 | 1.115 |
| 13 | 42,104.16 | 45,220.02 | 43,662.09 | 138400.00 | 166200.00 | 152300.00 | 54,191.68 | 75,759.96 | 64,975.82 | 1.29 | 1.68 | 1.485 |
| 14 | 42,074.16 | 45,190.02 | 43,632.09 | 163500.00 | 177900.00 | 170700.00 | 79,351.68 | 87,519.96 | 83,435.82 | 1.89 | 1.94 | 1.915 |
| 15 | 42,054.16 | 45,170.02 | 43,612.09 | 134200.00 | 153700.00 | 143950.00 | 50,091.68 | 63,359.96 | 56,725.82 | 1.19 | 1.40 | 1.295 |

**Conclusion**

Based on the present investigation the results demonstrate that foliar application of micronutrients play an important role in the production of good crop, higher yield and economics. The obtained results show that the vegetative growth, yield and quality of maize plants were enhanced by foliar application of micronutrients with NPK. The treatment of with RDF along with 1% foliar application of boron gave better results of growth and yield characters of maize.

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