Intercropping of maize-mungbean to increase the farmer’s income

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Abstract. The alternative to increase the income of maize farmers is intercropping with legumes. Intercropping of maize-mungbean should be not maize productivity lowest compared to monoculture. Therefore, to avoid the decrease in the yield of maize, the plant population of maize in intercropping should be the same as the optimal population in maize monoculture and mungbean in intercropping does not interfere or compete with the maize crop. To suppress yield reduction of mungbean in intercropping by setting maize plants as such so that the light intensity obtained by mungbean to be optimum. The research was aimed to obtain maize-mungbean intercropping with high farmer income. The field experiment was conducted on dry land at Gowa, South Sulawesi, Indonesia. The treatment i.e 1. Intercropping 1 row of mungbean in maize twin row at plant spacing of (100-50) cm x 20 cm; 2. Intercropping 2 rows of mungbean in maize twin rows at plant spacing of (100-50) cm x 20 cm; 3. Intercropping with 1 row of mungbean in twin row at plant spacing of (110-40) cm x 20 cm; 4. Intercropping 2 rows of mungbean in maize twin rows at plant spacing of (110-40) cm x 20 cm; 5. Maize monoculture with a plant spacing of 75 cm x 20 cm; 6. Mungbean monoculture with a plant spacing of 40 x 20 cm. Both of maize monoculture and intercropping maintained plant population at 66,666 plants ha-1. Monoculture of mungbean population was 125,000 plant ha-1, whereas intercropping with 1 row of mungbean was 33,333 plant ha-1 and 2 rows of mungbean at 66,666 plant ha-1. The results showed that maize-mungbean intercropping in twin rows of maize was able to obtained maize grain yield 2.9 – 7.0% and profit of 26 – 45% higher than monoculture, had maize equivalent yield 24-50% higher than maize grain yield actual, land equivalent ratio >1, and B-C ratio > 1. Intercropping of maize-mungbean with twin rows of mungbean at spacing (110-40) cm x 20 cm and 2 rows of mungbean can be recommended to increase farmer income because it has the highest land utilities and economic benefit compared to other models.

1. Introduction
Maize farmers in several regions in Indonesia generally have limited land resources (<1 ha) and monocropping system, so, Farmers low income and high risks to crop failure. The alternative to increase the income and reduce risk of crop failure of maize is increase the land use index by intercropping. In tropical area commonly intercropping maize with legumes.

Some results of research were concluded that intercropping maize-legume had increase of farmer’s income though the increased of land equivalent ratio and maize grain yield equivalent. The increase of farmer’s income depends on the legume used and the proportion of the maize-legume in intercropping. Intercropping maize-cowpea increased income 332 – 440% [1], maize-soybean with
proportions 1:1 and 1:2 increased of income respectively 100% and 125%, maize-groundnut with proportion 1:1 increased of income 52% and 1:2 increased 69% [2].

Farmers are easier to sale of maize grain and maize planting profitable than that legume, so that the intercropping of maize-legume is easily to adoption not only monetary advantage, therefore, to make intercropping of corn-legumes easier to adopt by farmers not only has high financial benefits, but also high maize productivity, at least the same as the monoculture planting system, so that legume has added value to increase farmers’ income. In order to avoid decrease in productivity of maize, the plant population of maize in intercropping should be the same as the optimal population in monoculture.

The twin rows of maize is suitable for intercropping. Twin row planting system is every two rows narrow line, and every two of twin rows there is a wider space than a single row. Their wider space should be planting mungbean with intercropping system, without reducing maize productivities because the population remain the same as in monoculture. The research aimed to obtain maize-mungbean intercropping on twin row planting to increase income farmer without reducing the productivity of maize.

2. Materials and Methods
The experiment was conducted on dry land at Gowa, South Sulawesi, Indonesia during dry season of 2015. The experiment site was located at S 05°17’10.7” and E 119°34’09.8”, at the altitude of 3 m above the sea level. The treatment consisted of: 1) Intercropping 1 row of mungbean in maize twin rows at plant spacing of 50-100 x 20 cm; 2) Intercropping 2 rows of mungbean in maize twin row at plant spacing of 50-100 x 20 cm; 3) Intercropping 1 row of mungbean in maize twin row at plant spacing of 40-110 x 20 cm; 4) Intercropping 2 rows of mungbean in maize twin row at plant spacing of 40-110 x 20 cm; 5) Monoculture of maize with plant spacing of 75 x 20 cm; 6) Mungbean monoculture with plant spacing of 40 x 20 cm. Both of maize monoculture and intercropping model maintained plant population at 66,666 plants ha⁻¹. The plant population in mungbean monoculture was 125,000 plants ha⁻¹, whereas the intercropping with 1 row of mungbean at 33,333 plants ha⁻¹ and 2 rows of mungbean at 66,666 plants ha⁻¹. The plot size was 12.6 m x 8 m.

Maize variety used was Pioneer-21, which has a semi-erect leaf type, and the mungbean variety was Kenari. The row of plants in the direction of the sun (East-West) in order to obtain optimum sunlight on crops. The mungbean crop was planted one week after maize planting. The maize plants were fertilized 184 kg N, 60 kg P₂O₅ and 60 kg K₂O ha⁻¹. Half the rate of N and all rate of P and K was applied at 10 DAP, and the remaining N was applied at 40 DAP. Mungbean was fertilized 45 kg N, 45 kg P₂O₅ and 45 kg K₂O ha⁻¹ for monoculture, and fertilization of mungbean in intercropping was adjusted based on population of the mungbean monoculture. The entire quantity of fertilizer on mungbean crop was applied at 7 DAP.

2.1. Data collection and statistical analysis
Grain yield of maize (intercropping and monoculture) and grain yield of mungbean in intercropping was harvested from an area of 4.5m x 4 m of each plot. On mungbean monoculture, grain yield were recorded in an area of 4m x 2 m. Grain yield data of maize and mungbean were adjusted to 15% moisture content.

To select of intercropping maize-mungbean advantage rather than monoculture we used the following criteria:

1. Maize equivalent yield (MEY) based on productivity and the market price of each commodity suggested by [3].

\[
\text{MEY} = \text{Yim} + \frac{(\text{Yib} \times \text{Pb})}{\text{Pm}}
\]

Where:
- \(\text{Yim}\) = maize grain yield in intercropping system (t ha⁻¹)
- \(\text{Yib}\) = mungbean grain yield in intercropping system (t ha⁻¹)
- \(\text{Pm}\) = selling price of maize ($ kg⁻¹)


$\text{Pb} = \text{selling price of mungbean (}$ \text{kg}^{-1} \text{)}$

2. Land equivalence ratio (LER) is calculated using equation suggested by [4]

\[
\text{LER} = \frac{\text{Yim}}{\text{Ymm}} + \frac{\text{Yib}}{\text{Yb}}
\]

Where:
- $\text{Ymm} = \text{maize grain yield in monoculture (t ha}^{-1}\text{)}$
- $\text{Yb} = \text{Mungbean grain yield in monoculture (t ha}^{-1}\text{)}$

If LER > 1 indicate that the efficiency and productivity of land in intercropping is more profitable than monoculture, and if LER < 1 it means that monoculture is more profitable than intercropping.

2.2. Economic Advantage

To determine the economic feasibility of intercropping pattern to be applied, the following calculations was performed: cost of inputs (seeds, fertilizer, pesticide, and herbicide), cost of labor of carrying out activities (land preparation, planting, weeding, fertilizer application and harvesting), profit and B-C ratio follows:

\[
\text{NR} = \text{TR} - \text{TC}
\]

\[
\text{B-C ratio} = \frac{\text{TR}}{\text{TC}}
\]

\[
\text{TR} = \text{Ym} \times \text{Pm} + \text{Yb} \times \text{Pb}
\]

Where:
- NR = net return/profit
- TR = Total Return
- TC = Total Cost (cost of inputs and labor)

If the B-C ratio > 1 means that intercropping maize with mungbean is feasible. Conversely if B-C ratio < 1 means is not feasible. Recommendation for intercropping if B-C ratio > 1 and highest profit

3. Results and Discussion

In general, intercropping maize-mungbean using twin rows obtained grain yield of maize 2.0 to 7.9% higher than monoculture, as a similar result of the intercropping maize-soybean with twin rows gave grain yield of maize 4 to 10% higher than monoculture [5] and results of Verdelli et al [6] that intercropping maize-soybean gave grain yield of maize 13 to16% higher than monoculture. The higher maize grain yields in intercropping these research because 1) twin rows spacing is relatively higher than single row was caused the positive effect of the border row as in the result of research was conducted Zubachtirodin et al [7] and Syafruddin and Biba [8] that twin rows increasing maize grain yield 2.5 to 20.0% compared to the grain yield of the single row, 2) additional nutrient by fertilizers on mungbean or from N fixation or by mungbean that is transferred to soil and is absorbed by maize plants.

The grain yield of mungbean in intercropping was lower than monoculture. Intercropping of mungbean in maize gave mungbean grain yield 0.54 to 1.15 t ha-1, while in monoculture 2.30 t ha-1 (Table 1). The difference grain yield of mungbean between intercropping compared to monoculture is due to differences in plant population and reduction of grain yield in an individual plant. In monoculture, mungbean population has 125,000 plants ha-1, while in intercropping two rows of mungbean have population 66,666 plants ha-1 (53% of the population in monoculture) and one row of mungbean have population 33,333 plants ha-1 (27% of the population in monoculture). Mungbean grain yield of an individual plant in intercropping was declined about 6-47% compared to monoculture, this decreasing was caused by shading of maize. Intercropping two rows of mungbean
with maize twin rows with spacing (110-40) cm x 20 cm gave mungbean grain yield (1.15 t ha\(^{-1}\)) higher than other intercropping.

Maize equivalent yield (MEY) different cropping system, MEY in intercropping is largely determined by productivity and price of each commodity (grain maize and soybean price). Intercropping provided higher MEY (7.62 – 9.67 t ha\(^{-1}\) ) over monoculture (5.99 t ha\(^{-1}\) for maize monoculture and 6.44 t ha\(^{-1}\) for mungbean monoculture). This means that intercropping maize-mungbean, it will receive additional grain yield of mungbean equal to grain yield of maize 1.51 to 3.22 t ha\(^{-1}\) (24-50% of maize grain yield actual). The increase of MEY in intercropping was due to the value of the mungbean and an increase in maize yield. The higher MEY in intercropping was also obtained in intercropping maize-legume [2],[9],[10],[11] and maize-soybean [12]. Two rows of mungbean intercropping in maize with twin rows (110-50) cm x 20 cm resulted in the highest MEY of 9.67 t ha\(^{-1}\) than other intercropping.

Land equivalent ratio (LER) reflect off the efficiency and productivity of land use. In intercropping maize with mungbean was obtained value of LER by 1.25 – 1.58. This means that intercropping maize-mungbean improves the productivity of land use by 25- 58% rather than monoculture. The increased of LER was obtained due to the increased yield of maize and additional from mungbean. Several experiments showed that intercropping of maize-legumes have LER monoculture, i.e intercropping maize-mungbean [2],[13] maize-soybean [5],[12],[14], maize cowpea [11],[15]. Intercropping of 2 rows of mungbean had LER higher than intercropping with 1 row of mungbean. If intercropping is applied with 2 rows of mungbean the LER value 1.37 - 1.58, while 1 row of mungbean had LER value 1.25 - 1.44. LER is influenced by the productivity of each commodity, while the productivity of each commodity is affected by the ratio of plant population between main crops and secondary crops. Therefore, to improve the efficiency and productivity of land use and obtain a higher grain yield of maize is to maintain the plant population of maize in intercropping such as the optimal population in monoculture. In the intercropping maize-mungbean based on the grain yield and LER is it advisable to use twin row at plant spacing of maize (110-40) cm x 20 cm with 2 rows of mungbean

3.1. Economic advantage.

Technology will be adopted by farmers must be technically and economically feasible. According to economically, production cost (inputs and labour) in intercropping was higher than monoculture. In intercropping had total cost $ 593.80 – 674.28 ha\(^{-1}\), while in maize monoculture had total cost $ 5026 ha\(^{-1}\) and mungbean monoculture had total costs $. 398.28 ha\(^{-1}\) (Table 2). Although intercropping had higher total cost, net return or profits were higher than in monoculture. In the intercropping had total and net return $ 1,520.87- 1929.52 and $927.07 – 1,255.25SD respectively, while maize monoculture had total and net return 1195.23 and 685.97 respectively, and soybean 185.02 and 886.74 respectively. Intercropping maize-mungbean with a twin row of maize at plant spacing (110-40-110) cm x 20 cm and was planted with two rows of mungbean had the highest profit ($1,255.25 ) and B-C ratio (2.86) rather other intercropping.

Therefore, this intercropping model is very suitable to be applied by farmers. Similar to the result of research conducted by [10], [12], [16] that intercropping maize-soybean with two rows of maize and two rows of soybean gave profit rather than another model.

Intercropping maize-mungbean with a twin row of maize at plant spacing (110-40-110) cm x 20 cm and was planted with two rows of mungbean is very suitable to be adopted by the farmer, because had grain yield, also had profited and B-C ratio was highest rather than other models.
Table 1. Grain yield, maize equivalent yield, land equivalent ratio (LER) under maize-mungbean intercropping at South Sulawesi, Indonesia.

| Treatments                                      | Grain Yield ( t ha⁻¹) | Maize Equivalent | LER  |
|------------------------------------------------|-----------------------|------------------|------|
| maize twin rows (100-50), one row of mungbean  | 6.11c                 | 0.54c            | 7.62 | 1.25 |
| maize twin rows (100-50), two rows of mungbean | 6.50a                 | 0.65c            | 8.32 | 1.37 |
| maize twin rows (110-40), one row of mungbean  | 6.36b                 | 0.62c            | 8.10 | 1.33 |
| maize twin rows (110-40), two rows of mungbean | 6.45a                 | 1.15b            | 9.67 | 1.58 |
| Monoculture maize                               | 5.99c                 | 0                | 5.99 | 1.00 |
| Monoculture mungbean                            | 0                     | 2.3a             | 6.44 | 1.00 |
| CV (%)                                          | 9                     | 5                |      |

Table 2. Total cost, Total return, net return, and B-C ratio as influence by different intercropping at South Sulawesi, Indonesia.

| Treatments                                      | Total Cost ($)     | Total Return ($) | Net Return ($) | B-C ratio |
|------------------------------------------------|--------------------|------------------|----------------|------------|
| maize twin rows (100-50), one row of mungbean  | 593.80             | 1520.87          | 927.07         | 2.56       |
| maize twin rows (100-50), two rows of mungbean | 647.34             | 1660.15          | 1012.81        | 2.56       |
| maize twin rows (110-40), one row of mungbean  | 603.26             | 1615.45          | 1012.19        | 2.68       |
| maize twin rows (110-40), two rows of mungbean | 674.28             | 1929.52          | 1255.25        | 2.86       |
| Monoculture maize                               | 509.26             | 1195.23          | 685.97         | 2.35       |
| Monoculture mungbean                            | 398.28             | 1285.02          | 886.74         | 3.23       |

4. Conclusions
- Intercropping of maize-mungbean with twin rows of maize had maize yield, maize equivalent yield, land equivalent ratio, B-C ratio, and profit higher than monoculture.
- Intercropping of maize-mungbean was best in models of twin rows with plant spacing (110-40) cm x 20 cm 2 rows of mungbean with obtained B-C ratio >1 and the highest productivity and profitability.

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