Maize-soybean intercropping in double row plant spacing

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Abstract. Intercropping of maize-soybean can increase land utilization and farmers income. The research was aimed to obtain a better maize-soybean intercropping model on double row plant spacing. The field experiment was conducted on dry land at Research Station in Bontobili, Gowa, Indonesia. The treatment consisted of 1: Maize monoculture with double row at plant spacing of 50-100 cm x 20 cm; 2: Intercropping 1 row of soybean in maize double row at plant spacing of 50-100 cm x 20 cm; 3: Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 cm x 20 cm; 4: Monoculture of maize with double row at plant spacing of 40-110 cm x 20 cm; 5: Intercropping with 1 row of soybean in double row plant spacing of 40-110 cm x 20 cm; 6: Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 cm x 20 cm; 7: Maize monoculture with plant spacing of 75 cm x 20 cm; 8: Soybean monoculture with plant spacing of 40 x 20 cm. Both of maize monoculture and intercropping maintained plant population at 66,666 plants ha^{-1}. Monoculture of soybean population was 125,000 plant ha^{-1}, whereas intercropping whit 1 row of soybean was 33,333 plant ha^{-1} and 2 rows of soybean at 66,666 plant ha^{-1}. The research used randomized complete block design (RCBD) with three replications. Results showed that maize-soybean intercropping in double row plant spacing was able to obtained grain yield of 7.27–7.70 t ha^{-1}, with total relative value of 1.08–1.19, maize equivalent yield of 7.88–9.11 t ha^{-1}, land equivalent ratio of 1.35–1.70, profit of USD 965.46–1,139.78 ha^{-1}, and benefit-cost (B-C) ratio of 1.62–1.74, this results were higher than in case of monoculture. Intercropping of maize-soybean with double row plant spacing of 40-110 x 20 cm and 50-100 x 20 cm with 2 rows of soybean were planting spacing model that can be recommended to be implemented because both have the highest productivity and economic benefit compared to other models.

Key Words: intercrop, land equivalent ratio, total relative value, maize equivalent yield, increasing farmer income.

Introduction. The shortage of land area and low maize productivity at farmer level is often limited farmers income. One alternative to increase the income of maize farmers is to increase the land use index by intercropping. Intercropping increase the efficiency of land utilization by optimization of sunlight, nutrients, and water (Lithourgidis 2011; Choudhary et al 2012; Ghazi-khanlou et al 2014; Gebru 2015; Zhang et al 2105). Intercropping of maize crops were generally with legumes.

Several experiments results showed that intercropping of maize-legumes resulted higher land equivalent ratio and higher productivity per area and time unit than monoculture, in consequences the farmers income is higher (Gao et al 2010; Addo-Quaye et al 2011; Takim 2012; Midega et al 2014; Monzon et al 2014; Shri et al 2014). Intercropping of maize-cowpea with a ratio of 4:2 in a population of 55.550 maize plants/ha increased maize equivalent yield with 29.3% (Marer et al 2007); intercropping maize-peanut with ratio of 1:4 population of maize at 53,333 plants ha^{-1} was increased maize equivalent yield with 44.4% (Alom et al 2009), and maize-soybean with ratio of 2:1 and population of maize at 53,333 plants ha^{-1} can increase maize equivalent yield with 49.9% (Paudel et al 2015). Intercropping maize-legume can improve soil fertility, especially of N by fixation of legumes (Dahmardeh et al 2010), increasing of maize N uptake (Matusso et al 2014), increase soil water content and lower the soil temperature (Choudhary et al 2012). Maize intercropped with legumes is one of principle ecological farming, because it can reduce N_2O emissions and nitrate leaching, namely reducing emissions of N_2O by 25.6-45.8% (Huang et al 2013) and also reduce nitrate leaching by 30-82.4% (Nie et al 2012) which is lower than in maize monoculture.

The yield of maize and legumes in intercropping will be higher or lower rather than monoculture; it highly depends on the plant population and maize-legumes ratio. The planting of 2 rows peanut intercropped with maize at plant density of 75 x 25 cm reduce maize yield by 1.8 to 3.8% compared to monoculture and groundnut production was reduced with 47-67% compared to monoculture (Alom et al 2009). Maize-soybean intercropping with population of maize and soybean at 200,000:53,333 plants ha^{-1} with maize-soybean ratio 1:1-2:2 resulted lower maize yields with 21.4-31.9% compared to monoculture, and lower soybean production with 22.3-53.9% compared to monoculture (Paudel et al 2015). Intercropping maize crop with legumes (soybean, mungbeans, and peanuts) using the ratio of rows of maize with legumes 1:2 at 90 x 20 cm spacing of maize resulted in increased maize yield by 3-11%, but reduced legumes yield by 58 - 69% compared to monoculture (Kheroar & Patra 2013).

Intercropping of maize-legumes should not decrease maize productivity and yield of legumes diminution should be as low as possible compared to monoculture. Therefore, in order to avoid decrease in yield of maize, the plant population of maize in intercropping should be the same as the optimal population in maize monoculture and legumes in intercropping does not interfere or compete with the maize crop. To suppress yield reduction of legumes in intercropping by setting maize plants as such so that the light intensity obtained by legumes to be optimum.

Double row system consist of two rows of maize where is narrowed the plant spacing, on the other hand between every two rows of maize plant there is a wider space, however the plant population is not different comparing with the square plant spacing. Productivity of maize obtained was 12% higher with double row than with the square planting method (Balem et al 2014). The wider space can be utilized by the soybean with intercropping system, without reducing maize productivities because the population remains the same as in monoculture.

The research aim was to obtain better pattern of intercropping maize-soybean compared with monoculture, on double row planting without reducing the productivity of maize

Material and Method

Experimental site. The experiment was conducted on dry land at the Research Station, Gowa, South Sulawesi, Indonesia during dry season of 2014. The experiment site was located at S 05^0 17’ 11.6 "and E 119^0 34’ 10.8", at the altitude of 64 m above the sea level. The soil was typical Alfisol, with clay loam texture having pH of 5.54, 2.15% organic matter, 0.11% total N, 115 ppm available P_20_5, and 190 ppm available K_2O.

Experimental design and trial management. The experiment was laid out in a Randomized Complete Block Design with three replications. The treatment consisted of: 1) Maize monoculture with double row at plant spacing of 50-100 x 20 cm; 2) Intercropping 1 row of soybean in maize double row at plant spacing of 50-100 x 20 cm; 3) Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 x 20 cm; 4) Monoculture of maize with double row at plant spacing of 40-110 x 20 cm; 5) Intercropping 1 row of soybean in maize double row at plant spacing of 40-110 x 20 cm; 6) Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 x 20 cm; 7) Monoculture of maize with plant spacing of 75 x 20 cm; 8) Soybean 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 soybean monoculture was 125,000 plants ha^{-1}, whereas the intercropping with 1 row of soybean at 33,333 plants ha^{-1} and 2 rows of soybean at 66,666 plants ha^{-1}. The optimal maize plant population in the tropics area is about 65,000-71,000 plants ha^{-1} (IPNI & IAARD 2009). The plot size was 12 x 8 m. The pattern of planting on the field for each treatment is presented in Figure 1.

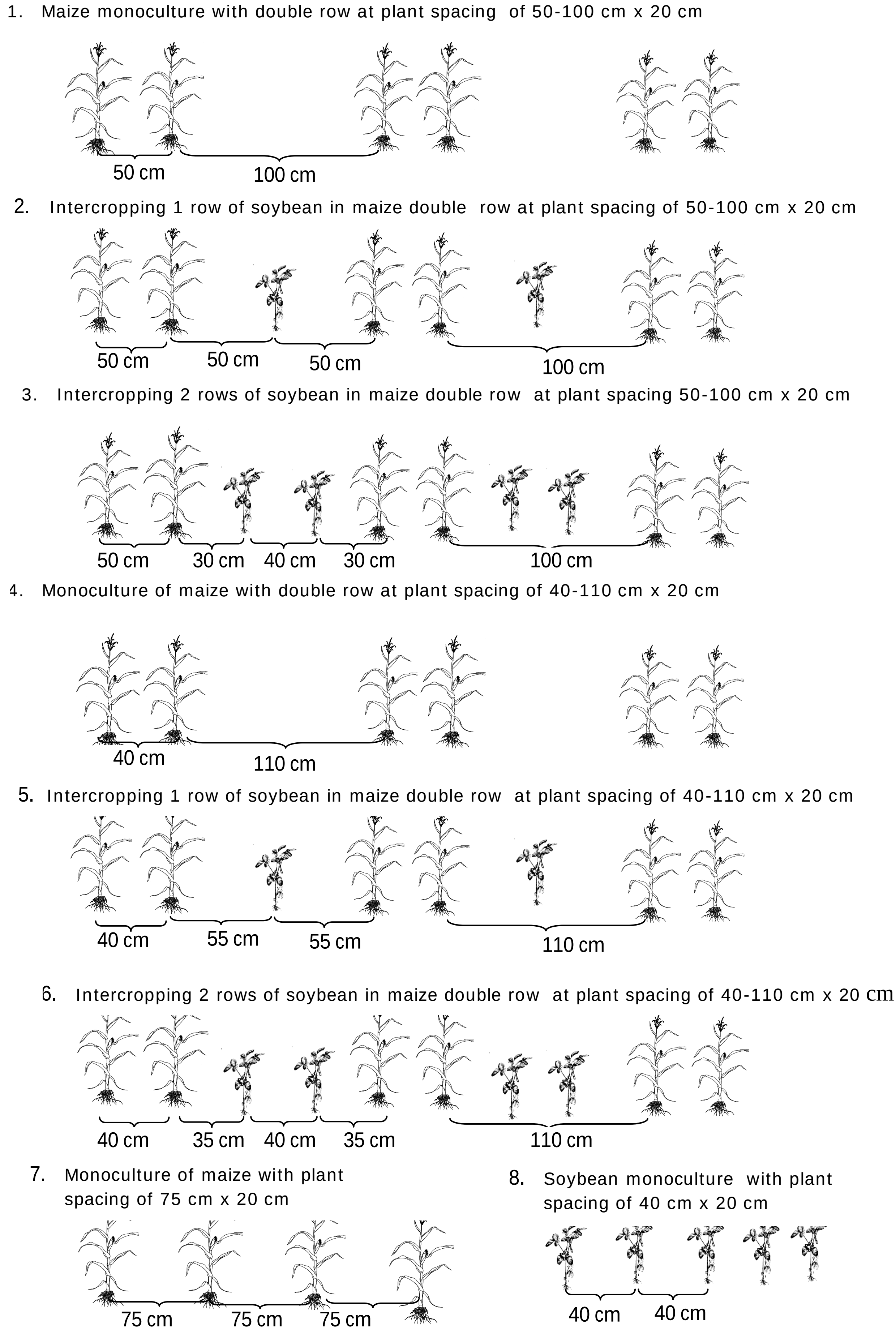

Figure 1. The pattern of planting on the field.

Maize variety used in this experiment was Pioner-21 which has a semi-erect leaf type, and the soybean variety was Dena-1 which is a shade tolerant variety. Seeds were planted with direction of planting row from East-West in order to obtain optimum sunlight on crops. The soybean crop was planted two weeks after maize plantation. The maize plants were fertilized with a rate of 184 kg N, 60 kg P_2 O_5 and 60 kg K_2O 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. Soybean was fertilized with 45 kg N, 45 kg P_2O_5 and 45 kg K_2O ha^{-1} for monoculture, and fertilization of soybean in intercropping was adjusted based on the soybean monoculture pattern. The entire quantity of fertilizer on soybean crop was applied at 7 DAP. Harvesting was performed at physiological maturity.

Data collection and statistical analysis. Ten samples of the maize plant at 65 DAP and soybean at 45 DAP in each treatment were selected randomly for data recording of the following traits: 1) Plant height of maize and soybean; 2) Leaf chlorophyll using chlorophyll meter Minolta SPAD (Soil Plant Analysis Development) 502; 3) Length and width of leaves (for leaf area index on maize); 4) Photosynthetic active radiation (PAR) on soybean plants were measured above canopy of soybean plants in monoculture and intercropping using the tool Plant Canopy Imager CI-110. Ten samples of maize and soybean plant at harvest time were selected for data record of following traits: (1) The length of the cob, cob diameter, weight of 1,000 seeds, biomass of maize; and 2) biomass of soybean.

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

Leaf area index (observation on maize) was calculated using the formula suggested by Mokhtarpour *et al* (2010):

$$LAI = \text{Total LA sampling/area}$$

$$LA = 0.75 \times W \times L$$

Where

LA = individual leaf area (cm^2)

L = leaf length (cm), measured from the base of the leaf to the leaf tip

W = leaf width (cm), was measured at the widest part of the leaf that leaves close to the cob.

Harvest index was calculated using the equation:

$$HI = \text{grain yield/biological yield}$$

The data of vegetative growth, yield components, grain yield and harvest index were analyzed using SAS 9.0 program. The differences between each treatment were calculated using Multple Duncan Range Test (DMRT) with 5%.

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

1. Total relative value (TRV) using the formula:

$$TRV = (Yim \times Pm + Yis \times Ps) / Yim \times Pm$$ (Ghazi-khanlou et al 2014)

Where: Yim = maize grain yield in intercropping system (t ha^{-1})

Yis = soybean grain yield in intercropping system (t ha^{-1})

Pm = selling price of maize (USD kg^{-1})

Ps = selling price of soybean (USD kg^{-1})

If TRV>1 its indicating that intercropping is more advantageous than monoculture, and if TRV<1 it indicates monoculture is more advantageous than intercropping.

2. Maize equivalent yield (MEY) based on productivity and the market price of each commodity.

MEY = Ymm + (Yis × Ps)/Pm (Lingaraju et al 2008; Egbe 2010; Sarker et al 2013)

Where: Ymm = maize grain yield in monoculture (t ha^{-1})

3. Land equivalence ratio (LER) is calculated using equation suggested by Yilmaz et al (2008), Alom et al (2009) and Egbe (2010):

$$LER = Yim / Ymm + Yis / Yms$$

Where: Yms = Soybean grain yield in monoculture (t ha^{-1})

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

4. Monetary Advantage

To determine the economic feasibility of intercropping pattern to be applied, the following calculations was performed: cost of inputs (input), labor costs, revenue, benefit and B-C ratio as follows:

B = TR - TC

B-C ratio = B/TC

TR = Ym x Pm + Ys x Ps

Where : B = Benefit

TR = Total Revenue

TC = Total Cost (cost of inputs and labor)

If the B-C ratio >1 it means that maize-soybean intercropping technology is feasible. Conversely, if B-C ratio <1 means is not feasible.

Intercropping will be recommended if B-C ratio is >1 and provide higher profit than monocultures.

Results and Discussion

Effect on maize. Intercropping of maize-soybean did not significantly affect on plant height and leaf area index (LAI)), but significantly affected the leaf chlorophyll of maize 65 days after planting (DAP). Plant height of maize in intercropping ranged from 155 to159 cm and LAI of 4.52 to 4.78 while in monoculture, maize plant height was 155 cm and LAI ranged from 4.32 to 4.42. Optimal LAI of maize was 65 DAP of 4.5 to 5.0 (Bergamaschi et al 2010), which means that the LAI of intercropped maize was considered quite optimal.

Intercropping maize-soybean at double row 50-100 x 20 cm and 40-110 x 20 cm with two rows of soybean in between each row of maize had leaf chlorophyll at 65 DAP of 56.3 and 57.0 units respectively, these are were significantly higher than in monoculture with a plant spacing of 75 x 20 cm which resulted 54.2 units. However, if compared with the double row of maize monoculture or intercropping with 1 row of soybean, the leaf chlorophyll level were equivalent of 55.0 and 55.0 to 55.7 units respectively (Table 1).

Cob length, cob diameter, weight of 1,000 grain and harvest index showed that were no significant differences, whereas grain yield and number of grain cob^{-1} was significantly affected by plant spacing. Cob length in intercropping ranged from 16.4 to 16.7 cm, cob diameter from 4.9 to 5.0 cm, weight of 1000 grain were 315 to 337 g, and harvest index of 0.52 to 0.54. While the maize monoculture with square or double row plant spacing has cob length measuring from 15.9 to 16.2 cm, cob diameter from 4.8 to 5.0 cm, weight of 1,000 grains from 307 to 320 g, and harvest index from 0.50 to 0.54.

Table 1

Plant height, harvest index and leaf chlorophyll of maize observation at 65 days after planting (DAP) in maize-soybean intercropping system

No.	*Treatment*	*Plant height (cm)*	*Leaf area index (m^2m^{-2})*	*Leaf chlorophyll (units)*
1.	Maize monoculture with double row at plant spacing of 50-100 cm x 20 cm	155^{NS}	4.42^{NS}	54.8^{ab}
2.	Intercropping 1 row of soybean in maize double row at plant spacing of 50-100 cm x 20 cm	156	4.52	55.0^{ab}
3.	Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 cm x 20 cm	159	4.70	56.3^{a}
4.	Monoculture of maize with double row at plant spacing of 40-110 cm x 20 cm	152	4.49	54.9^{ab}
5.	Intercropping 1 row of soybean in maize double row at plant spacing of 40-110 cm x 20 cm	155	4.59	55.7^{ab}
6.	Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 cm x 20 cm	156	4.78	57.0^{a}
7.	Monoculture of maize with plant spacing of 75 cm x 20 cm	155	4.32	54.2^{b}
	CV (%)	5	8	2

Value followed by different letters in the same column are significantly different in Duncan's multiple range test (DMRT) level α = 0.05. NS - not significantly different according to DMRT level α = 0.05.

Maize-soybean intercropping with double rows 40-110 cm x 20 cm, with one row or two rows of soybean had number of grain cob-^{1} and grain yield that were actually higher than in monoculture with square plant spacing of 75 x 20 cm. However, when compared to monoculture, double row showed no significant differences. The number of maize grain obtained 549 grain/cob with grain yield of 7.66 t ha^{-1} for intercropping 1 row of soybean and 564 grain cob^{-1} with grain yield of 7.70 t ha^{-1} for intercropping 2 rows of soybean. Maize monoculture with square planting spacing resulted number of grain of 467 grain/cob and grain yield of 6.46 t ha^{-1}, maize monoculture with double rows plant spacing had grain number of 500 to 502 cob^{-1} and grain yield of 6.65 to 7.34 t ha^{-1}.

In general, intercropping maize-soybean using double row plant spacing obtained grain yield of maize 4% to 10% higher than monoculture and 13% to 19% higher than monoculture with square plant spacing. Grain yield of maize was higher in intercropping supported by higher leaf area index and leaf chlorophyll (Table 1). Yield components showed the same pattern (Table 2). The results of Verdelli et al (2012) showed that intercropping maize-soybean has grain yield of maize 13 to16% higher than maize grown in monoculture, allegedly due to added nutrients by fertilizers on soybean or from N fixation by soybean that are transferred to soil and is absorbed by maize plants. It can be seen in leaf chlorophyll in intercropping is relatively higher than in monocultures. In the intercropping, maize leaf chlorophyll range from 55.0 to 57.0 units while in monoculture double row plant spacing ranged from 54.8 to 54.9 units (Table 1). Leaf chlorophyll using SPAD was positively correlated with leaf N concentration (Syafruddin et al 2008; Rorie et al 2011; Effendi et al 2012; Muñoz-Huerta et al 2013). Intercropping maize-legumes improve grain yield, N uptake and its efficient use by maize (Ghosh et al 2007; Latati et al 2013; Wang et al 2014).

Grain yield of maize with double row plant spacing was higher than the square plant spacing. Maize planting with double row 50-100 cm x 20 cm obtained grain yield of 6.65 t ha^{-1} and 40-110 cm x 20 cm obtained grain yield of 7.34 t ha^{-1}, which means 3 and 12% higher than in square plant spacing. Grain yield of maize with double row plant spacing is consistently higher than square plant spacing which supported by yield components, i.e. cob length, number of grain per area, weight of 1,000 grain, and harvest index were relatively higher too. These results are in accordance with Zubachtirodin et al (2009) research which concluded that double row plant spacing increased maize grain yield between 2.5 to 20.0% compared to the grain yield of the square plant spacing. The planting of maize using double row 50-100 cm x 20 cm was obtained grain yield 7% higher than square plant spacing of 70 x 50 cm (Syafruddin & Biba 2015).

Table 2

Components of yield, grain yield and harvest index of maize in maize-soybean intercropping system

No.	*Treatment*	*Cob length (cm)*	*Cob diameter (cm)*	*Number of grain cob $^{-1}$*	*Weight of 1000 grain (g)*	*Grain yield (t ha $^{-1}$)*	*Harvest index (%)*
1.	Maize monoculture with double row at plant spacing of 50-100 x 20 cm	16.0^{NS}	4.9^{NS}	502^{ab}	3 08 NS	6.65^{ab}	0.52^{NS}
2.	Intercropping 1 row of soybean in maize double row at plant spacing of 50-100 x 20 cm	16. 4	4.9	505^{ab}	315	7.27^{ab}	0.52
3.	Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 x 20 cm	16.4	5.0	536^{ab}	326	7.31^{ab}	0.53
4.	Monoculture of maize with double row at plant spacing of 40-110 x 20 cm	16. 2	4.8	500^{ab}	320	7.34^{ab}	0.54
5.	Intercropping 1 row of soybean in maize double row at plant spacing of 40-110 x 20 cm	16.6	5.0	549^{a}	323	7.66^{a}	0.54
6.	Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 x 20 cm	16.7	5.1	564^{a}	337	7.70^{a}	0.54
7.	Monoculture of maize with plant spacing of 75 cm x 20 cm	15.9	5.0	467^{b}	307	6.46^{b}	0.50
	CV (%)	6	2	8	7	7	18

Value followed by different letters in the same column are significantly different in Duncan's multiple range test (DMRT) level α = 0.05. NS - not significantly different according to DMRT level α = 0.05.

Effect on soybean. Plant height, leaf chlorophyll and harvest index of soybean were not significantly different, but the total photosynthetic active radiation (PAR) and grain yield are significantly different between soybean intercropping with soybean monoculture. Soybean intercropping had height of plants ranged from 28.2 to 31.3 cm, leaf chlorophyll of 42.0 to 44.4 units, weight of 1,000 grains were 217 to 239 g, and harvest index of 0.42 to 0.46%. Soybean monoculture had plant height of 29.6 cm, leaf chlorophyll of 46.0 units and harvest index of 0.42.

Grain yield of soybean in intercropping was lower than in monoculture. In intercropping maize with one row of soybean we obtained grain yield from 0.24 to 0.27 t ha^{-1}, and for two rows of soybean 0.53 to 0.54 t ha^{-1}, while in monoculture 1.07 t ha^{-1}. The difference grain yield of soybean between intercropping compared to monoculture is due to differences in plant population and reduction of grain yield per individual plant. In monoculture, soybean population is of 125,000 plants ha^{-1} while in intercropping 66,666 plants ha^{-1} (53% of the population in monoculture) for 2 rows of soybean, and 33,333 plants ha^{-1} (27% of the population in monoculture) for intercropping 1 row of soybean (Table 3). Grain yield of individual plant in intercropping was declined about 5% compared to monoculture. The similar result was reported by Verdelli et al (2012) where grain yield of soybean was decreased 2 to 11% when was cultivated intercropping with maize. The decline is due to shading, so that photosynthesis is less than optimal, according to PAR value on soybean intercropping was decreased from 665 μmol m^{-2} S^{-1} in monoculture to 440-475 μmol m^{-2} S^{-1} in intercropping (Table 3). These mean that intercropping system cause reduction of light intensity with 29 to 34% for soybean. Low light intensity caused photosynthesis activity reduced and also reduced in photosynthetic enzymes that function as catalysts in the fixation of CO_2 (Taiz & Zeiger 2006). However, grain yield reduction of individual plant was relatively low, because varieties Dena-1 that was used is tolerant to shade.

Table 3

Plant height, leaf chlorophyll, grain yield and harvest index of in maize-soybean intercropping system

No	*Treatment*	*Plant height (cm)*	*Leaf chlorophyll (units)*	*PAR (μmol $m^{-2}S^{-1}$)*	*Grain yield (t ha^{-1})*	*Harvest index (%)*
1	Intercropping 1 row of soybean in maize double row at plant spacing of 50-100 x 20 cm	31.3[NS]	42.0[NS]	440[b]	0.24[c]	0.42[NS]
2	Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 x 20 cm	29.8	42.5	455[b]	0.53[b]	0.48
3	Intercropping 1 row of soybean in maize double row at plant spacing of 40-110 x 20 cm	28.2	42.1	455[b]	0.27[c]	0.43
4	Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 x 20 cm	31.1	44.4	475[b]	0.54[b]	0.46
5	Soybean monoculture 40 cm x 20 cm	29.5	46.0	665[a]	1.07[a]	0.42
	CV (%)	13	4	4	8.3	7

Value followed by different letters in the same column are significantly different in Duncan's multiple range test (DMRT) level α = 0.05. NS = not significantly different according to DMRT level α = 0.05.

Total relative value (TRV), maize equivalent yield (MEY) and equivalent ratio (LER). Total relative value (TRV) of maize in intercropping ranged from 1.08 to 1.19. Based on TRV>1 indicate that intercropping is more profitable than monoculture. Intercropping maize with soybean with double plant row spacing was more profitable than maize monoculture. If there are two rows of soybean planted, will be obtained TRV 1.18 to 1.10, higher than of 1 row of soybean were TRV is 1.08 to 1.09 (Table 4).

MEY in intercropping is largely determined by productivity and price of each commodity (maize grain and soybean price). Based on the price of maize grain USD 0.183 $kg^{-1}$and soybeans USD 0.479 kg^{-1}, the obtained MEY in intercropping range from 7.88 to 8.37 t ha^{-1} for maize intercropping with 1 row soybean, and from 8.69 to 9.11 t ha^{-1} for maize intercropping with two rows of soybean. Maize monoculture on double row plant spacing had obtained grain yield from 6.65 to 7.34 t ha^{-1}, while the results of monoculture with square plant spacing of 75 x 20 cm has grain yield of 6.46 t ha^{-1}. This means that if is maize is planted with double row can be intercropped with soybean, it will received additional grain yield of soybean equal to grain yield of maize 0.61 to 0. 71 t ha^{-1} (8-9%) for intercropping 1 row of soybean 1.38 to 1.41 t ha^{-1} (18-19%) for intercropping 2 rows of soybean. The increased of maize grain yield was due to its interaction with soybean in intercropping which was equal with 1.60 to 2.27 t ha^{-1} (13-20%) in the 1 row intercropping of soybean and 2.52 to 3.16 t ha^{-1} (15-23%) in intercropping with 2 rows of soybean. Indirectly, maize intercropping obtain supplies of N derived from soybean root nodule fixation, which showed an increase of maize leaf chlorophyll content of 65 DAP on intercropping compared to monoculture on double row treatment (Table 1).

Table 4

Total relative value (TRV), maize equivalent yield (MEY), and land equivalent ratio (LER) in maize-soybean intercropping system

No.	*Treatment*	*TRV*	*MEY (t ha^{-1})*	*LER*
1.	Maize monoculture with double row at plant spacing of 50-100 x 20 cm	1.00	6.65	1.03
2.	Intercropping 1 row of soybean in maize double row at plant spacing 50-100 x 20 cm	1.08	7.88	1.35
3.	Intercropping 2 rows of soybean in maize double row at plant spacing of 50-100 x 20 cm	1.19	8.69	1.63
4.	Monoculture of maize with double row at plant spacing of 40-110 x 20 cm	1.00	7.34	1.14
5.	Intercropping 1 row of soybean in maize double row at plant spacing of 40-110 x 20 cm	1.09	8.37	1.44
6.	Intercropping 2 rows of soybean in maize double row at plant spacing of 40-110 x 20 cm	1.18	9.11	1.70
7.	Maize monoculture with 75 cm x 20 cm plant spacing	1.00	6.46	1.00
8.	Soybean monoculture with 40 cm x 20 cm plant spacing	-	2.57	1.00

LER reflect the relative efficiency and productivity of land use. In intercropping maize with soybean was obtained value of LER of 1.35 to 1.70. This means that intercropping maize-soybean improve the efficiency of land use by 35-70%. Increased LER was obtained by maize yield range of 7.27 to 7.70 t ha^{-1} and soybean yield was 0.24 to 0.54 t ha^{-1}. Monoculture maize produced only 6.46 t ha^{-1} (Table 1 & 2). Maize intercropped with 2 rows of soybean had LER higher than intercropping with 1 row of soybean. If intercropping is applied with 2 rows of soybean the LER is from 1.63 to 1.70, while 1 row of soybean had LER of 1.35-1.44. LER is very dependent on 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 higher grain yield of maize is by maintaining plant population of maize in intercropping such as the optimal population in monoculture. In intercropping maize-soybean based on the grain yield and LER is it suggested to use double row plant spacing of maize 40-110 x 20 cm or 50-100 x 20 cm and 2 rows intercropped with soybean.

Monetary advantage. Cost of inputs (seeds, fertilizers, pesticides, and herbicides) base on the market price at the time of the study, the cost of labor for planting, fertilizing, weeding, application of herbicides and pesticide were considered. The price of maize and soybean was based on the price at harvest at the time around the study site.

Total cost of inputs and labor in intercropping was higher than in monoculture. In intercropping, total cost of inputs range from USD 222.38 to USD 242.84 ha^{-1} and labor costs USD 375.20 to USD 413.91 ha^{-1}, while in maize monoculture had total input cost of USD 201.37 ha^{-1} and labor costs of USD 317.19 to USD 334..80 ha^{-1} and soybean monoculture had input of USD 90.35 ha^{-1} and labor costs of USD 219 ha^{-1} (Table 5).

Although intercropping had higher production costs, but total revenues and profits was higher than in monoculture, due to increased productivity of maize and soybean yield. Total revenues in intercropping model were USD 1,563.04 to USD 1,796.53 ha^{-1}, with profit of USD 965.46 to USD 1,139.78 ha^{-1}, whereas maize monoculture get the total revenue of USD 1,288.28 to USD 1,464.40, and soybean monoculture had total revenue of USD 513.85 ha^{-1} and profit of USD 204.50 ha^{-1}.

Intercropping with double row plant spacing 50-100 x 20 cm had B-C ratio higher than monoculture. B-C ratio of double row maize 50-100 x 20 cm intercropped with 1 row of soybean was 1.62 and with 2 rows of soybean was 1.66, while monoculture was 1.54. However, maize intercropping with double row plant spacing 40-110 x 20 cm has a same B-C with monoculture, i.e. 1.73 to 1.74. Apparently, intercropping maize with double row plant spacing 40-110 x 20 cm planted with two rows of soybean is very feasible to be adopted because the profit rate and B-C ratio was the highest, i.e. benefit was USD 1,139.78 with a B-C ratio of 1. 74. The alternative model is maize intercropped with double row plant spacing 50-100 x 20 cm with 2 rows of soybean, i.e. with benefit of USD 1,078.71 and B-C ratio of 1.66.

Table 5

Input costs, labor, advantages and B/C ratio in maize-soybean intercropping system

No.	*Treatment*	*Cost (USD ha^{-1})*		*Total revenue (USD- ha^{-1})*	*Benefit (USD ha^{-1})*	*B-C ratio*
		Input	*Labor*			
1.	Double row maize monoculture with 50-100 x 20 cm plant spacing	201.37	321.12	1,327.59	805.09	1.54
2.	Intercropping 1 row of soybean in maize double row at plant spacing 50-100 x 20 cm	222.38	375.20	1,563.04	965.46	1.62
3.	Intercropping 2 rows of soybean in maize double row at plant spacing 50-100 x 20 cm	242.84	407.12	1,728.67	1,078.71	1.66
4.	Double row maize monoculture with 40-110 x 20 cm plant spacing	201.37	334.80	1,464.40	928.23	1.73
5.	Intercropping 1 row of soybean in maize double row at plant spacing 40-110 x 20 cm	222.38	384.83	1,659.40	1,052.19	1.73
6.	Intercropping 2 rows of soybean in maize double row at plant spacing 40-110 x 20 cm	242.84	413.91	1,796.53	1,139.78	1.74
7.	Maize monoculture with plant spacing of 75 cm x 20 cm	201.37	317.19	1,288.28	769.71	1.48
8.	Soybean monoculture with plant spacing of 40 cm x 20 cm	90.35	219.00	513.85	204.50	0.66

Conclusions. Maize-soybean intercropping with double row plant spacing had grain yield of maize, total relative value, maize equivalent yield, land equivalent ratio, profit and B-C ratio higher than monoculture.

Intercropping of maize-soybean was best in models of double row plant spacing of 40-110 x 20 cm and 50-100 x 20 cm intercropping 2 rows of soybean, both obtained the highest productivity and profitability.

Soybean was intercropped 2 row on maize with double row plant spacing of 40-110 x 20 cm and 50-100 x 20 cm exhibited additional grain yield of soybean equal to grain yield of 18-19% of maize monoculture.

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