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Land Utilization Efficiency of Corn and Black Soybean Intercropping System on Ultisoll with Various Doses of Cow Dung Fertilizer and Weeding Frequency

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ABSTRACT

The narrow land ownership status among farmers poses challenges for agricultural production, despite the increasing demand for agricultural products in both quantity and variety. To address this issue, intercropping—a planting system that involves cultivating multiple crop types simultaneously—has been employed. This system enhances land productivity, reduces farming risks, and ensures income sustainability for farmers. Corn and black soybeans are ideal crops for intercropping due to their mutually beneficial interactions. Key factors influencing the success of this system include the frequency of weeding and the application of cow dung fertilizer. This study aimed to identify the optimal dose of cow dung fertilizer and weeding frequency to achieve the highest crop yield and land use efficiency in a corn-black soybean intercropping system. Conducted from February to May 2021 in Pematang Gubernur Village, Bengkulu City, the experiment employed a Split Plot Design within a Complete Randomized Block Design (RCBD) with two factors and three replications. The main plot consisted of three weeding frequencies: no weeding, weeding once (2 WAP), and weeding twice (2 and 5 WAP). Subplots included cow dung fertilizer doses: 0, 5, 10, and 15 tons ha^{-1}. Results indicated the highest sunlight utilization efficiency occurred with 2x weeding and 5–10 tons ha^{-1} of cow dung fertilizer. Land use efficiency (LER > 1) was achieved under these conditions, while black soybean generally exhibited lower light efficiency. These findings highlight the importance of proper weeding and fertilization practices to optimize land use, providing valuable insights for sustainable farming strategies in regions with limited arable land.

Keywords: *farming sustainability, Intercropping system, Land Equivalent Ratio*

INTRODUCTION

Agricultural development in several densely populated areas is generally quite advanced, but the status of land ownership by farmers is very narrow, which is less than 1 ha (Manyamsari & Mujiburrahmad, 2014). The narrowness of land makes it difficult to apply modern technology (mechanization) to increase agricultural production, while agricultural products are increasingly needed by the community, both in terms of quantity and type of commodities. Efforts to increase crop production can be done by means of extensification, diversification (Yuwariah, 2018). Intensification has a very high risk for environmental sustainability, while extensification is very difficult to do considering that now new land for agricultural areas is almost unavailable, even what is available is getting narrower due to land conversion. Therefore, intensive crop diversification is an option to increase diverse crop production (Fauzan, 2016). Crop diversification through an intercropping system is done by cultivating two or more types of plants at almost the same time. With the intercropping system, land productivity can be increased, farming risks can be reduced, and the sustainability of farmers' income can be guaranteed (Warman & Kristiana, 2018). Land productivity in the intercropping system is determined by the efficiency of the utilization of production factors by the intercropping system on a plot of land which can be measured based on the Land Equivalency Ratio (LER). Several studies have shown that the intercropping system can increase land productivity with LER of up to 1.39 (Kristiono *et al*., 2020), 1.61 (Rudianto & Haryanto, 2016), and 1.96 (Hermawati, 2016). Efforts to increase land efficiency as reflected in the Land Equivalency Ratio value can be taken by selecting the right types of plants for intercropping in order to produce mutually beneficial interactions between plant types. Ideally, intercropped plants are composed of a combination of C3 and C4 plants planted simultaneously to increase LER (Fowo, 2017). Likewise, by intercropping different types of plants, the products produced through intercropping are diverse and the failure of one plant can be compensated by another plant, so that the risk of crop failure can be minimized (Pertiwi & Gosal, 2019). Economically, farmers' income from intercropping is more secure because the intercropping system can produce more than one crop commodity. The results of Lubis's (2019) study showed that the R/C ratio of intercropping was 4.16 while the R/C ratio for corn monoculture farming was 2.57. Corn is a type of C4 plant that requires a lot of nutrients, especially nitrogen, to support its growth (Karimuna *et al*., 2009). In a monoculture system, the need for nitrogen nutrients is met through fertilization. If corn is intercropped with plants that can fix nitrogen from the air, such as soybeans, the nitrogen produced can be utilized by corn plants so that the need for nitrogen fertilizer in intercropping can be reduced. The results of Suarna *et al*.'s study. (1986) showed that the presence of soybeans can save 84 kg to 160 kg of nitrogen fertilizer per hectare, depending on environmental conditions.

In addition to synthetic fertilizers, the availability of nutrients in the soil can be increased by adding organic materials. Increasing soil organic matter can be done by providing organic fertilizers. The use of organic fertilizers with high humus content is to improve the physical, chemical and biological properties of the soil, so that it can increase the efficiency of inorganic fertilizer use, increase water and nutrients in the soil, increase microorganism activity, increase humus levels, and improve soil structure (Musnawar, 2005). The results of Kriswantoro's research (2016) showed that plant height, number of leaves, wet weight of the crown and flowering age continued to increase when the dose of organic fertilizer was increased to 20 tons ha^{-1}.

Among organic fertilizers, cow dung has advantages, namely easy to obtain, easy to decompose, can improve soil structure and act as a decomposer of organic materials (Nasahi, 2010). Several studies have shown that cow dung fertilizer contains total N nutrients ranging from 1.04% - 1.8%, available P ranging from 1.17% - 1.34%, and available K ranging from 0.03 - 1.03 me/100 g (Maryam *et al*., 2015; Syahidah & Hermiyanto 2019). The main weakness of cow dung fertilizer is the fairly high weed seed content (Pranata, 2010). The presence of weeds in the planting system can be a competitor for plants in obtaining nutrients in the soil and growing space (Dinata *et al*., 2017), so the presence of weeds needs to be controlled with a frequency adjusted to the type and growth rate of the weeds. Weed control can be done manually or chemically.Manual control is carried out by weeding or removing weeds that grow around the plants (Henry, 2010). The main advantage of manual control is that the soil becomes loose (Cahyono, 2007), but it is impractical because it takes a long time, a lot of labor, and high costs (Adisarwanto *et al*., 1996). In contrast, chemical control using herbicides is generally very effective and can save time and labor. However, excessive use of herbicides in the long term can damage the environment (Aditya, 2021).

This study aims to determine the right dose of cow dung fertilizer at each weeding frequency that can achieve the highest crop yield and land use efficiency in the corn and black soybean intercropping system.

MATERIALS AND METHODS

This research was conducted from December 2020 to March 2021 in an empty yard located on Jalan Aur Duri, Talang Kering, Muara Bangkahulu District with ultisol soil type located at an altitude of ±22 meters above sea level.

This research was conducted in the form of a field experiment using a Complete Randomized Block Design (RCBD) with two treatment factors arranged into a Split Plot Design. The treatment of weeding frequency (First Factor) as the main plot consists of: G_0 = No weeding,, G_1 = Weeding once at the age of 2 WAP, and G_2 = Weeding twice at the age of 2 WAP and 5 WAP. The treatment of cow dung fertilizer dosage (Second Factor) as a sub-plot consists of: P_0 = 0 tons ha^{-1}, P_1 = 5 tons ha^{-1}, P_2 = 10 tons ha^{-1}, and P_3 = 15 tons ha^{-1}. Thus, 12 combinations with 3 replications were obtained, so 36 experimental units were obtained. As a comparison for evaluating the efficiency of land use in the intercropping system, corn and black soybeans were also planted in a monoculture system with standard cultivation techniques (according to recommendations). Land preparation begins with clearing the land from weeds and plant remains, then the soil is loosened using a hoe and then divided into 3 blocks with a distance between blocks of 1m. Furthermore, each block is divided into 3 main plots measuring 950 cm x 320 cm with a distance between main plots of 1m and each main plot is divided into 4 sub-plots measuring 200 cm x 320 cm with a distance between sub-plots of 50 cm. In addition to the experimental plots, 6 other plots measuring 200 cm x 320 cm are also provided as comparison plots.

The corn seeds planted are the Bisi-18 variety. While the black soybean seeds of the Detam-1 variety were obtained from Balitkabi. The seeds selected are those with normal shape and size, full, healthy and intact.

The organic fertilizer used is decomposed cow dung which is black, dry and crumbly. Fertilizer is given evenly to each plot with a dose according to the treatment. Cow dung fertilizer is given 1 week before planting.

Corn and black soybean seeds are soaked in 80% dithane solution for 30 minutes, the corn planting holes are 80 cm x 20 cm apart. The black soybean planting distance is 40 cm x 20 cm. The planting holes are made using a 3-4 cm deep digger, each hole is filled with 1 corn or black soybean seed and 5-8 carbofuran grains, then the planting holes are covered with soil.

Irrigation is done by watering using a watering can if it does not rain and the soil is dry enough. Irrigation is done in the morning and evening when the soil shows signs of drying out.

Replanting is done when the plants are 1 week old in the planting holes where the seeds do not grow and the plants that grow abnormally. In the first replanting, many seeds did not grow, so replanting was done at the age of 2 weeks.

The fertilizers used are Urea, SP-36, KCl. Corn monoculture plants are fertilized with 300 kg of Urea, 150 kg of SP-36 and 150 kg of KCl per hectare. Black soybean monoculture plants are fertilized with 100 kg of Urea, 100 kg of SP-36, 50 kg of KCl. Intercropping plants are fertilized with basic fertilizer of 200 kg of Urea, 125 kg of SP-36, 100 kg of KCl. Fertilizer is given 1/3 part when the plant is 2 WAP old and 2/3 part is given when it is 5 WAP old. Fertilizer is given in a furrow 7 cm away from the row of plants and buried.

Weed control is done by weeding, namely pulling out all weeds growing in the experimental plot using hands or scrapers. Weeding is done with a frequency according to the treatment.

Control of armyworm, grasshopper, and ladybug pests is done by spraying with an insecticide solution containing the active ingredients chlorpyrifos and teta cypermethrin with a dose of 20 mL 15 L^{-1} tank which is sprayed on the entire plant with an interval of once a week at the age of 30 DAP. After 33 DAP, attacks from these pests are no longer present. Downy mildew caused by the fungus *Peronosclerospora* sp, and leaf spot disease caused by *Cercospora sojina*, are controlled by spraying a fungicide solution containing the active ingredient mancozeb with a dose of 3 g L^{-1}. Spraying is done once a week by spraying the entire plant to prevent infection.

Harvesting is done after the plants show signs of being ready for harvest (harvest criteria). Corn plants with the criteria of dry corn silk, white and dry husks, full seeds, when pressed it feels hard and the surface is shiny. Corn is harvested by breaking the cob stalk and then collected for observation. Soybean plants with the criteria of brownish yellow pods, most of the leaves are yellow and starting to fall off. Harvesting is done by uprooting the plants and collecting them for observation.

The data obtained were analyzed using Analysis of Variance (ANOVA) at a test level of 5%. Variable data that showed a significant difference were then further tested using the Duncan Multiple Range Test (DMRT) at a level of 5%.

RESULTS AND DISCUSSION

Research overview

The climate conditions in the field during the research, namely from February to May 2021, had monthly rainfall of 389 mm, 641 mm, 98 mm and 212 mm respectively. The average air temperature was 27.2 ^{o}C; 27.1 ^{o}C; 27.3 ^{o}C and 27.6 ^{o}C. The average air humidity was 82.2%; 84.6%; 83.8% and 84.9% respectively, and the daily sunshine duration was 6 hours; 5.4 hours; 5.8 hours and 6 hours respectively (BMKG, 2021).

The requirements for growing soybean plants are to have rainfall of 100-400 mm/month with a suitable temperature between 23 ^{o}C - 30 ^{o}C and humidity between 60-70% (Maccarthy *et al.*, 2022). Corn plants require ideal rainfall of around 85-200 mm per month during their growth period with an optimal temperature per month ranging from 27 ^{o}C-32 ^{o}C (Rudi & Trias, 2017).

In the germination phase, corn plants that grow are around 96% while black soybean plants up to the age of 10 DAP that grow are only 30%. This is due to low seed viability of 70% and it is suspected that the soil conditions are too humid due to high rainfall during the germination phase. This problem is overcome by replanting (embroidery) of seeds that do not grow or die which is carried out at the age of 2 WAP corn and repairing drainage channels. After the embroidery, the black soybean plant population grew 100%.

Pests that occurred in black soybean and corn plants during the study were armyworm pest attacks at the age of 30 DAP, grasshoppers and ladybugs at the age of 60 DAP, pod borers at the age of 90 DAP. In addition to pest attacks, black soybean and corn plants were also attacked by diseases. Corn plants were attacked by downy mildew caused by the fungus Peronosclerospora sp at the age of 36 DAP, while black soybean plants were attacked by leaf spot disease caused by the fungus *Cercospora sojina* at the age of 30 DAP. However, the development of pests and diseases can be controlled after the application of insecticides and fungicides. After control using insecticides with active ingredients chlorpyrifos and tete cypermethrin and fungicides with active ingredients mancozeb showed a decrease in the level of pest and disease attacks so that it could affect plant growth.

Analysis of variance

The interaction between weeding frequency and cow dung fertilizer dosage is found in the corn leaf area and corn leaf area index variables. Meanwhile, weeding frequency as a single factor has a significant effect only on the intercropping leaf area index variable. Likewise, the cow dung fertilizer dosage as a single factor has a significant effect only on the intercropping leaf area index variable (Table 1).

The treatment of weeding frequency and cow manure fertilizer dosage and their interactions did not significantly affect the growth and yield variables of black soybeans and stover as well as corn plant yields. This indicates that soybean plants are not responsive to the treatment of weeding frequency and cow manure fertilizer dosage. It is suspected that soybean plants planted 2 weeks after corn, grow suboptimally because their growth is inhibited due to being suppressed by competition with corn plants that have grown 2 weeks earlier.

Table 1. Summary of variance analysis results on 15 variables of black soybean and corn in an intercropping system.

Variable	F-value		
	Weeding frequency	Cow dung fertilizer dosage	Interaction
Corn leaf area	7.28 *	3.93 *	4.05 *
Soybean leaf area	2.95 ns	0.88 ns	1.17 ns
Corn leaf area index	7.28 *	3.92 *	4.04 *
Soybean leaf area index	2.96 ns	0.88 ns	1.17 ns
Intercropping leaf area index	7.50 *	4.73 *	2.62 ns
Dry biomass weight of corn	3.37 ns	1.38 ns	1.30 ns
Dry biomass weight of soybean	1.23 ns	1.02 ns	0.74 ns
Relative dry biomass weight of corn	3.72 ns	1.45 ns	1.33 ns
Relative dry biomass weight of soybean	0.11 ns	0.74 ns	2.08 ns
Total dry biomass weight	3.15ns	2.08 ns	1.21 ns
Corn yield	2.69 ns	0.28 ns	0.76 ns
Soybean yield	2.35 ns	0.47 ns	0.86 ns
Relative corn yield	2.51 ns	0.22 ns	0.62 ns
Relative soybean yield	2.35 ns	0.47 ns	0.86 ns
Land Equivalent Ratio	2.84 ns	0.47 ns	0.57 ns
F table 5%	6.94	3.16	2.66

Note :* = significant ; ns = non-significant

Leaf Area Index of corn and black soybean intercropping system

The leaf area index is the ratio of the total leaf area per plant to the area of the plant. This figure illustrates the efficiency of sunlight utilization by plants. Sunlight is a source of energy needed for plant life processes, especially in the process of photosynthesis, namely the formation of carbohydrates that occurs in the leaves (Janssen *et al*., 2014). The LAI of the corn - black soybean intercropping system is a combination of the LAI of corn plants with the LAI of black soybean plants, so the amount of LAI depends on the size of the leaf area of each type of plant and its area.

Tabel 2. Average leaf area and leaf area index of corn and black soybean plants in the intercropping system

Weeding frequency	Cow dung fertilizer dosage (ton ha-1)	Corn leaf area (cm2)	Black soy-bean leaf area (cm2)	Corn leaf area index	Black soy-bean leaf area index	Intercropping system leaf area index
No weeding	0	7389.73 a	740	4.61 a	0.92	3.39
	5	5775.82 b	746.15	3.60 b	0.93	3.86
	10	4992.37 c	889.74	3.12 c	1.11	3.62
	15	5435.26 b	690.76	3.39 b	0.86	3.9
Weeding once at the age of 2 WAP	0	5492.22 b	1106.18	3.43 b	1.34	4.1
	5	6533.86 ab	789.91	4.08 ab	0.98	4.67
	10	5895.60 b	875.04	3.68 b	1.09	5
	15	5962.99 ab	817.43	3.72 ab	1.02	4.46
Weeding twice at the age of 2 WAP and 5 WAP	0	7018.56 a	804.1	4.38 a	1	4.39
	5	7449.05 a	789.74	4.65 a	0.98	3.98
	10	7396.69 a	1208.03	4.62 a	1.51	5.42
	15	6634.99 ab	1285.64	4.14 ab	1.6	5.55

Note : Numbers followed by the same letter in the same column are not significantly different at 5% DMRT

Based on Table 2, it is known that the leaf area of corn plants is influenced by the interaction between the frequency of weeding and the dose of cow manure. In the weeding frequency treatment of 0, meaning not in the afternoon (G0), the largest corn leaf area was produced in the treatment without manure, the dose of manure was 0 tons/ha without fertilization. There was even a tendency for an increase in the dose of cow manure to reduce the leaf area of corn. This is thought to be because corn plants are increasingly hampered by competition with weeds that are increasingly dominant in unweeded land due to the addition of weed seeds contained in cow manure. In the main plot with 1x weeding treatment, or 2x weeding, the leaf area of corn plants was not significantly different by the treatment of the dose of cow manure fertilizer. However, in general, the leaf area of corn leaves in the 2x weeding frequency treatment appeared larger compared to the treatment without weeding or 1x weeding and the highest leaf area size of 7449.05 cm^2 was produced in the combination of 2x weeding frequency treatment with a fertilizer dose of 5 tons ha^{-1}.

The leaf area index (LAI) of corn plants has the same response pattern as the leaf area data to the treatment of weeding frequency and cow dung fertilizer dosage (Table 2). The magnitude of the LAI of corn plants in the intercropping system with black soybeans ranges from 3.12 to 4.65. The size of the LAI of corn plants of this size is quite efficient in capturing sunlight, because the amount of sunlight received by the leaves of corn plants will be greater when compared to the light transmitted. The leaf area index is a description of the plant's ability to receive solar radiation for photosynthesis activity. Leaf area index = 1 means the predicted light intercepted by the plant is around 50%, LAI = 2 means the light is intercepted 90% and LAI = 3 means the light is intercepted 95% (Sinclair & Gardner, 1998).

The leaf area of black soybean plants in the intercropping system with corn plants showed no significant difference due to the treatment of weeding frequency or cow dung fertilizer dosage. The leaf area of black soybeans ranged from 690.76 cm^2 to 1285.64 cm^2. When compared to its area of 800 cm^2, the leaf area is relatively small, namely with the LAI of black soybeans ranging from 0.86 - 1.60. Thus, black soybean plants planted between rows of corn plants in this intercropping system are not efficient in capturing sunlight in their area. This occurs because the growth of black soybean plants is less than normal, allegedly because they are suppressed by corn plants that have grown first and dominate their growing space.

The total LAI data of the corn and black soybean intercropping system showed no significant difference due to the treatment of weeding frequency and cow dung fertilizer dosage. However, it was seen that the treatment without weeding and without giving cow dung fertilizer dosage had the lowest value of 3.39, while the highest was in the treatment of 2x weeding and giving cow dung fertilizer dosage of 15 tons/ha had the highest intercropping LAI of 5.55, meaning that plants that were weeded 2x at the age of 2 WAP and 5 WAP were able to absorb higher sunlight. The availability of sunlight supports the photosynthesis process which causes the biomass produced to be high.

The highest corn leaf area was found in the treatment of 2x weeding and the administration of a dose of 5 tons/ha of cow dung fertilizer with a value of 7449.05 cm^2. This is because in the treatment of 2x weeding and the administration of a dose of 5 tons/ha of cow dung fertilizer, competition between plants in obtaining sunlight was higher compared to the treatment of 1x weeding at 2 WAP and without weeding. Meanwhile, high LAI causes the photosynthesis process to run well, so that the photosynthate produced will be high. Meanwhile, the lowest corn leaf area was found in the treatment without weeding and the administration of a dose of 10 tons ha^{-1} of cow dung fertilizer with a value of 4992.37 cm^2. Plant and weed competition can affect plant growth, especially in leaf area. High competition causes the use of photosynthate for leaf development to be lower. The maximum increase in leaf area is needed by plants because the wider the leaf area, the higher the photosynthate content to support growth (Friend *et al*., 2011).

The highest black soybean leaf area was in the treatment of 2x weeding and the administration of a dose of 15 tons ha^{-1} of cow dung fertilizer with a value of 1285.64 cm^2. This is due to the influence of the corn canopy that does not cover the black soybean canopy so that the sunlight absorbed by the black soybean plant is more optimal compared to other plants. While the lowest black soybean leaf area was in the treatment without weeding and the administration of a dose of 15 tons ha^{-1} of cow dung fertilizer with a value of 690.76 cm^2. Plants that are still able to utilize the growth facility factor optimally, the increase in soybean leaf area is not inhibited (Wu *et al*., 2018). The rate of plant photosynthesis is determined by the size of the leaf area of the plant (Sitompul & Guritno, 1995). The larger the leaf area, the more optimal the sunlight absorbed which will later be used to increase the rate of photosynthesis.

Corn and black soybean intercropping plant sludge

The definition of plant sludge here is non-economic plant biomass, namely biomass that is not consumed by humans. Thus, for corn and black soybean plants, the sludge is the harvest in the form of vegetative organs (roots, stems, branches and leaves). Vegetative plant organs play a role in supporting and carrying out the biomass production process needed for the formation of economic products (crop yields) and other organs. Sludge weight is a description of the plant's response to its environment in intercropping. To obtain the overall appearance of the plant, the dry weight of the plant can be measured (Sitompul & Guritno, 1995). Measuring the dry weight of the plant aims to determine the distribution pattern of assimilation from source to target (Goldsworthy & Fisher, 1992).

The weight of the stalks per corn plant and black soybean did not differ significantly due to the treatment of weeding frequency or cow dung fertilizer dosage (Table 3). The weight of the stalks per corn plant in the intercropping system with black soybeans ranged from 189.11 g to 312.61 g, while in the monoculture system it was 248.59 g. Thus, the relative weight of the stalks per corn plant (RBBJ) ranged from 0.76 to 1.25. The RBBJ value > 1 means that the growth of corn plants in the intercropping system is higher than that of corn plants in the monoculture system, conversely for those with RBBJ < 1.

Table 3 also shows that in the main plot with no weeding treatment for all doses of cow dung fertilizer, the RBBJ value is <1. These data indicate that the growth of corn plants in the intercropping system without weeding is lower than the corn plants in the monoculture system. This shows that corn plants in this system are not efficient in utilizing their growth factors. This is thought to be because in the treatment without weeding, the presence of weeds has a negative effect on the growth and production of corn plants, namely becoming competitors for corn plants in the absorption of nutrients and water in the soil. Crop production will decrease if weed growth is above the tolerance threshold (Mayadewi, 2007).

The weight of the black soybean stover per plant in the intercropping system with corn ranged from 31.45 g to 51.01 g, while in the monoculture system it was 77.24 g. Thus, the relative weight of the black soybean stover per plant (RBBK) ranged from 0.40 - 0.59. While for all treatments RBBK <1.

Table 3. Average dry biomass weight and relative dry biomass weigh in the intercropping system

Weeding frequency	Cow dung fertilizer dosage (ton ha-1)	BBJ (g)	BBK (g)	RBBJ	RBBK	RBB Total
No weeding	0	189.11	35.06	0.76	0.45	1.22
	5	213.78	44.27	0.86	0.56	1.42
	10	135.8	39.95	0.54	0.53	1.08
	15	219.91	45.88	0.89	0.56	1.45
Weeding once at the age of 2 WAP	0	211.11	40.03	0.85	0.52	1.37
	5	226.15	44.33	0.92	0.57	1.49
	10	242.39	51.01	1.33	0.5	1.83
	15	269.72	39.01	1.08	0.51	1.6
Weeding twice at the age of 2 WAP and 5 WAP	0	256.84	43.32	1.03	0.55	1.58
	5	254.78	47.34	1.02	0.59	1.61
	10	312.61	31.45	1.25	0.4	1.65
	15	296.1	43.99	1.19	0.57	1.77
Monoculture		248.59	77.24			

Note: BBJ= dry biomass weight of corn. BBK= dry biomass weight of black soybean. RBBJ= relative dry biomass weight of corn. RBBK= relative dry biomass weight of black soybean. RBB Total= relative dry biomass weight total.

The data in Table 3 show that in the main plot with the treatment without competition, 1x weeding and 2x weeding for all doses of cow dung fertilizer had a RBBK value <1. These data indicate that the growth of black soybean plants in the intercropping system is lower than in the monoculture system. This shows that black soybean plants in this system are not efficient in utilizing their growth factors. This is thought to be because the growth of black soybeans is suppressed by corn plants due to delayed replanting, namely when the plants are 2 MST old. Planting that is later than the period under consideration will significantly reduce yields due to the lack of light received due to competition with other plants in the vicinity (Raffiuddin, 1994).

Total RBB is a combination of RBBJ plus RBBK, Table 3 shows that total RBB > 1, which ranges from 1.22 - 1.83, meaning that the corn and black soybean intercropping system is more efficient in utilizing growth factors.

Land utilization efficiency of intercropping system of corn and black soybeans

The intercropping system is one way to increase land productivity by increasing land efficiency. Land efficiency can be measured by adding the relative yields of the two crops planted in intercropping, namely corn and black soybeans. The agronomic advantages of the intercropping system need to calculate the LER. Land equivalency ratio (LER) is the sum of the comparative values of the results of intercropping with monoculture planting (Jaya *et al*., 2014).

Table 4 shows that the yield of corn per plot planted in intercropping is smaller than that planted in monoculture, namely in the range of 3,600-5,400 g or equivalent to 5,625-8,437 tons ha^{-1}. This result is smaller than the description of corn plants, which is 9.1 tons/ha while those planted in monoculture are 6867.00 g equivalent to 10,729 tons ha^{-1}. This result is higher compared to the description of corn plants, which is 9.1 tons ha^{-1}. However, the relative yield of corn plants (HRJ)> 0.5 means that based on land equivalence, the yield of corn plants is higher than corn plants planted in monoculture. The data in Table 4 shows that in the main plot with no weeding treatment for all doses of cow dung fertilizer, the HRJ value> 0.5 means that this data shows that the growth of corn plants in the intercropping system without weeding is lower than corn plants than the monoculture system. This shows that corn plants in the intercropping system are not efficient in utilizing growth factors. It is suspected that in the treatment without weeding there is competition between corn plants and weeds, where weeds are nuisance plants that if not weeded can become competitors for corn plants to obtain nutrients, sunlight and other growing space. Moenandir (2010) explained that competition between plants and weeds during the critical period can reduce yields by 60%.

The yield of black soybeans in the intercropping system with corn ranged from 335-571.33 g, while in the monoculture system it ranged from 2479.33 g of this black soybean yield, thus the relative yield of black soybeans (HRK) ranged from 0.11-0.27 g. For all treatments HRK <0.5, the data in Table 4 shows that in the main plot with treatments without weeding, 1x weeding, and 2x weeding for all doses of cow dung fertilizer had a value of <0.5. These data indicate that black soybean plants in the intercropping system are lower than in the monoculture system. This shows that black soybean plants in this system are not efficient in utilizing growth factors. This is thought to be because the growth of black soybean plants is suppressed by corn plants due to delayed replanting, namely when the plants are 2 WAP old.

The value of LER of corn with black soybeans ranges from 0.71-1.08. While LER <1 except in the treatment of 2x weeding and administration of cow manure fertilizer dose of 5 tons ha^{-1} and in the treatment of 2x weeding and administration of cow manure fertilizer dose of 10 tons ha^{-1}.

Table 4. Average yield, relative yield corn and black soybean, and LER

Weeding frequency	Cow dung fertilizer dosage (ton ha-1)	Corn yield (g)	Black soybean yield (g)	HRJ	HRK	LER
No weeding	0	3,867	435.66	0.61	0.18	0.79
	5	4,533	335. 00	0.72	0.13	0.85
	10	3,6	354. 00	0.59	0.11	0.71
	15	3,867	432.66	0.61	0.14	0.75
Weeding once at the age of 2 WAP	0	4,866	252.66	0.77	0.11	0.89
	5	4,833	515.33	0.75	0.19	0.95
	10	4,733	474.66	0.73	0.22	0.95
	15	5,266	421.66	0.8	0.16	0.96
Weeding twice at the age of 2 WAP and 5 WAP	0	4,333	510.33	0.69	0.23	0.92
	5	4,733	471.33	0.73	0.27	1.01
	10	5,4	571.33	0.81	0.27	1.08
	15	4,7	523.66	0.71	0.21	0.92
Monoculture		6,867	2,479			

Note: HRJ = relative corn yield ; HRK = relative black soybean yield

The data in Table 4 shows that with the treatment without weeding, 1x weeding and 2x weeding and cow manure fertilizer dose LER <1, meaning that the intercropping system is not profitable from the monoculture planting system because it is inefficient in land use and is unable to increase land productivity. The results of the study by Dewi *et al*. (2017) showed the efficiency of intercropping land use compared to monoculture can be seen from the LER produced by intercropping sorghum plants with peanuts, green beans, cowpeas, and soybeans more than one (<1) meaning it gives profitable results. However, in the treatment of 2x weeding and giving a dose of cow dung fertilizer of 5 tons ha^{-1} with 2x weeding and giving a dose of 10 tons ha^{-1} of fertilizer, the LER value is> 1, but overall land use in the intercropping system is inefficient, this is thought to be because the corn plants have quite high yields because corn plants with larger habitus can control the growing space so that they are superior to competing with black soybean plants. Thus, the black soybean plant yields are very low. This happens because the growth of black soybean plants is suppressed by corn plants due to delayed replanting, namely 2 WAP.

CONCLUSION

Based on the LER value, it can be concluded that the efficiency of light utilization by corn plants in the intercropping system with black soybeans is on average the highest in 2x weeding with a cow manure fertilizer dose of 5 tons ha^{-1} and 10 tons ha^{-1}. While black soybean plants generally have low light efficiency. Based on the land equivalency ratio (LER) value, the right dose of cow manure fertilizer for each weeding frequency, namely the one that produces the highest land utilization efficiency or the highest LER, cannot be determined, because there is no real difference. In general, this intercropping system is not efficient in land utilization, namely with an LER value of <1, except for 2x weeding with a cow manure fertilizer dose of 5 tons ha^{-1} and 10 tons ha^{-1}, which produces land utilization efficiency> 1, meaning it is quite efficient in utilizing land even though the value is not far from 1. These findings highlight the importance of proper weeding and fertilization practices to optimize land use, providing valuable insights for sustainable farming strategies in regions with limited arable land.

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