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The increase of Ultisol productivity based on intercropping cassava with peanut and soybean

ARIEF HARSONO, HERDINA PRATIWI♥
Indonesian Legumes and Tuber Crops Research Institute. Jl. Raya Kendalpayak Km 8, Po Box 66, Malang 65101, East Java, Indonesia.
Tel.: +62-341-801468, Fax.: +62-341-801496, ♥email: herdina_p@mail.com

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Abstract. *Harsono A, Pratiwi H. 2017. The increase of Ultisol productivity based on intercropping cassava with peanut and soybean. Nusantara Bioscience 9: 157-163.* The research aimed to determine the productivity and economic benefits of intercropping cassava with peanut and soybean on Ultisol dryland. Field experiment covering 2 ha land was conducted at Ultisol in East Lampung during 2011 growing season. A split plot design was used in this research involving four farmers as replications. Each farmer applied two fertilizer packages for the main plot, i.e., (A) ½ dose of recommended NPK + organic fertilizer + biofertilizer, and (B) the recommended dose of NPK. The sub-plot was intercropping system, i.e., (i) the farmer's monoculture cassava technological package, (ii) the improved farmer's monoculture cassava technological package, (iii) intercropping cassava + peanut, and (iv) intercropping cassava + peanut +/ soybean. The results indicated that improvement of plant spacing and NPK fertilization could increase the productivity of the farmer's monoculture cassava technological model by 54-85% of fresh roots. The productivity could be further increased by intercropping cassava with peanut, or intercropping cassava + peanut/+ soybean. The LER of intercropping cassava + peanut was 3.30 when the technological farmer's monoculture cassava was used as the control in the LER calculation and was 1.78 when the improved technological monoculture cassava was used as the control in the LER calculation. In addition, the LER of intercropping cassava + peanut +/soybean was 3.70 and 1.98, respectively, when the calculation of LER considered, respectively, the farmer's monoculture cassava and improved monoculture cassava as the control. The intercropping system significantly increased the net income of monoculture system up to 210% and the higher income was generated by intercropping cassava + peanut +/soybean. The use of organic and biological fertilizer reduced the NPK fertilizer requirement by 50% and significantly increased the benefit-cost ratio.

Keywords: cassava, intercropping, peanut, soybeans, Ultisol

INTRODUCTION

The role of cassava, peanut and soybean crops to support the achievement of food security in Indonesia will be becoming more important along with the increase in demand for food and food diversification program. Increasing productivity of those commodities is the effort to meet the food sufficiency. However, this effort will face problem such as the lack of agriculture land availability for agriculture production. The optimal agriculture land in Indonesia will be decreasing due to the conversion of optimal land to the non-agricultural land that reaches 1% per year (Directorate General of Infrastructure of Agriculture 2015). Therefore, to solve the problem, future agriculture development should be more focused on sub-optimal lands, among others is acidic dryland. The acidic soils that are suitable for food crops development in Indonesia are about 20.9 million ha which is mostly distributed in Sumatera, Kalimantan, and Papua Islands (Mulyani 206; Mulyani and Nursyamsi 2016).

Acidic soil in Sumatera, especially in Lampung province, is mainly used for cultivation of cassava in a monoculture system; therefore, the land productivity is low. The harvested area of cassava in Lampung in 2014 covered 304,000 ha with the productivity of 18.57 t ha^{-1} fresh roots. Although harvested cassava in Lampung has been declining in the last five years, however, the productivity has increased. The harvested area in 2015 covered 279,000 ha with the productivity of 24.61 t ha^{-1} fresh roots. According to Harsono et al. (2010b), the productivity of acidic soil in Lampung can be increased by improving the cassava-based cropping system. The five to six months duration of the wet season in Lampung enables the intercropping and relay cropping systems between cassava with soybean and peanut to be applied.

The main constraints of food crops production in acidic soils are the low soil pH, low organic C, N, P, and Ca nutrients, and high soil Al and Mn. The high Al and Mn contents in the soil are toxic to the plant growth, especially for soybean and peanut. Soybean and peanut were known to have the ability to tolerate the acidic soil with Al saturation of 20-30% (Arya 1990; Yost 2000; Zheng 2010). The chemical properties of acidic soil also inhibit the growth and role of *Rhizobium*, and mycorrhiza and phosphate solubilizing bacteria (Habte and Soedarjo 1995; Habte and Soedarjo 1996). Therefore, application of chemical fertilizers alone has not been enough to support the legume growth. Harsono et al. (2009) reported that application of 75 kg ha^{-1} Urea is not able to support the soybean growth on Ultisol Lampung with a pH of 4.2 and Al saturation of >43%. According to Kurnia et al. (2003), the requirement of N fertilizer for optimal growth will be reduced if soybean can form effective nodules. More than 60% of N required by soybean can be supplied through symbiosis with *Rhizobium* (Shutsrirung et al. 2002). Harsono et al. (2010a) reported that application of biofertilizer Agrisoy on soybean that is grown in acidic soil with exchangeable Al saturation of 20% increased the root nodules, improved the plant growth and produced higher soybean yield than that of Urea at a rate of 100-200 kg ha^{-1}. The biofertilizer is also able to reduce the N and P fertilizers requirement more than 50%.

Intercropping cassava with legumes produces higher cassava yield than that of intercropping cassava with non-legume (Silva et al. 2016). According to Ardjasa et al. (2011), the intercropping system has many advantages in food crops production of acidic soil. Intercropping system increases the land productivity, contribute to calories and protein provision and also reduce the soil erosion. Eventually, the intercropping system can increase the farmer's income. Islami et al. (2011) reported that intercropping cassava with soybean could increase the cassava productivity and farmer income in Entisol East Java compared to the monoculture cassava. The productivity of monoculture cassava was high in the first year (9.9 t ha^{-1} fresh roots). However, it was lower in the fourth year (7.44 t ha^{-1} fresh roots). Furthermore, Islami et al. (2011) stated that the productivity of monoculture cassava could be increased to reach 13.0 t ha^{-1} by application of manure with a dose of 7.5 t ha^{-1}. Meanwhile, intercropping cassava with peanut and cowpea can produce 16 t ha^{-1} fresh roots with LER of 1.60 and 1.50, respectively. While Hidoto and Loha (2013) reported that intercropping cassava with haricot bean, cowpea, soybean, and mungbean decreased cassava yield by 27, 37, 52, and 50%, respectively, however, these intercropping were able to increase LER value like 82, 49, 48, 62%, respectively.

This research was aimed to determine the Ultisol productivity and economic benefits by practicing intercropping cassava with peanut and soybean.

MATERIALS AND METHODS

A field experiment was conducted at Ultisol dryland in Sukadana District, East Lampung during March to August 2011. A split plot design with four replications was used in this research. Four farmer's land was used as the replications because of chemical properties variation (Table 2). Each farmer applied two fertilizer packages for the main plot, i.e., (A) ½ recommended NPK dose + organic fertilizer + biofertilizer, and (B) recommended NPK dose. The sub-plot was cropping system, i.e., (i) monoculture cassava by farmers technological package, (ii) monoculture cassava by the improved farmers technological package, (iii) intercropping cassava + peanut, and (iv) intercropping cassava + peanut +/soybean (Table 1). Each plot was 625 m^2 in size, with a total of 0.5 ha managed by each participating farmer.

In the location with Al saturation of above 20%, the Al saturation was decreased to 20% by dolomite application. Fertilizers were applied twice at two weeks and at four months after planting. The first application was 2/3 dose of Urea and all of SP 36 and KCl dosages. The second application was only the rest of Urea dosage. All of the peanut and soybean fertilizers were applied at two weeks after planting between plant rows. Organic fertilizer was applied in each planting hole. Iletri was mixed with the seed before it was applied with a dose of 0.3 kg per 80 kg seed. The crop varieties used in this research were Kancil for peanut, Tanggamus for soybean and UJ-5 for cassava. The soil samples were taken for the analysis of chemical properties i.e. soil pH, N, organic C, available P, Fe, Mn, Zn, K, Ca, Mg, *exchangeable Al*, *exchangeable* H and Al saturation. The analysis was conducted in Soil Chemical Laboratory of Indonesian Legumes and Tuber Crops Institute based on procedure of ISRI (2005).

Table 1. Technological packages applied by the participating farmers in Sukadana District, East Lampung during 2011 growing season

Sub-plot (cropping systems)	Main plot (technology inputs)											
	Alternative fertilization (A)						Recommended fertilization (B)					
	Phonska	Urea	SP-36 (kg ha^{-1})	KCl	Santap	Iletri	Phonska	Urea	SP-36 (kg ha^{-1})	KCl	Santap	Iletri
Farmer monoculture cassava	200	200	0	0	0	0	200	200	0	0	0	0
Improved monoculture cassava	0	150	100	50	3,000	0	300	200	100	0	0	0
Cassava + peanut	0	25	75	25	1,500	0.3	100	150	50	0	0	0
	0	150	100	50	3,000	0	300	200	100	0	0	0
Cassava + peanut +/soybean	0	25	75	25	1,500	0.3	100	150	50	0	0	0
	0	150	100	50	3,000	0	300	200	100	0	0	0
	0	25	75	25	1,500	0.3	100	150	50	0	0	0

Note: Santap = organic fertilizer, Iletri = *Rhizobium* inoculant. Cropping system 1: monoculture cassava by farmer technological package at around experimental site (plant spacing 70 cm x 40 cm). Cropping system 2: monoculture cassava with improved plant spacing i.e. 100 cm x 80 cm. Cropping system 3: monoculture peanut was grown with plant spacing 40 cm x 15 cm, one seed per hole. At 20 days after planting of peanut, single rows cassava with plant spacing 120 cm x 60 cm were planted between peanut rows. Cropping system 4: monoculture peanut was grown with a plant spacing of 40 cm x 15 cm, one seed per hole. At 20 days after planting of peanut, double rows cassava with a plant spacing of 240 cm x (80 cm x 60cm) were planted between peanut rows. After peanut had been harvested, soybean was planted between cassava rows with plant spacing of 40 cm x 15 cm, two plants per hole.

The crop yield was obtained by weighting all plant yield from each plot. Peanut and soybean seeds were harvested at 90 days after planting and were then sun-dried to reach 10-14% water content. The peanut yield was dry pod while that of soybean was dry seed. Cassava was harvested at 7 months after planting and the yield was fresh tubers. Land equivalent ratio (LER) was calculated based on a formula by Islami et al. (2011).

$LER=Yc_1 (IC)/Yc_1 (S)+Yc_2 (IC)/Yc_2 (S)+....$

Where:
$Yc_{1=}$ the yield of plant 1
Yc_2=is the yield of plant 2
IC=intercropping system
S=monoculture system.

Rainfall data was collected from Climatology Station of Agricultural Extension Centre, Sukadana. The selling price of cassava, peanut and soybean were obtained based on the market price at the harvest time. The net income and benefit cost ratio (B/C ratio) analysis were calculated from the differences between the selling price and the costs, i.e. planting materials, fertilizers, pesticides, honor for land preparation, maintenance, and harvest.

RESULTS AND DISCUSSION

Soil chemical properties

The participating farmers during this research were Kadirin, Rasidi, Lahir and Suyono. The chemical properties of the soils of the farmer's lands are presented in Table 2. The soil was acidic with a pH range of 4.60 to 5.25. Soils from the fields of Kadirin and Suyono were slightly acid (pH 5.20 and 5.25, respectively), and Al saturation of 13.04% and 11.52%, respectively. Soils from the fields of Rasidi and Lahir were more acidic (pH 4.94 and 4.60, respectively), and Al saturation of 33.98% and 30.74%, respectively. According to Arya (1990), the tolerance limit of peanut and soybean to Al saturation are, respectively, 30% and 20%. In order to make the optimal growth of peanut and soybean, the soils with high Al saturation (>30%) need to be ameliorated by using dolomite to decrease the Al saturation until about 20%. The soil contents of N, K, Ca and Mg in each location were classified very low, while the organic matter was low. The Fe, Mn, and Zn contents in the soil were classified very high, which are toxic to the plants. Therefore, application of dolomite [CaMg (CO_3)] as an ameliorant could decrease the Al saturation and, hence supply Ca and Mg to the soil.

Rainfall distribution

The rainfall in the research location during March to April were quite high, about 194 mm per month with the number of rainy days of 18 and 12 days in March and April, respectively. The precipitation started to decrease in May. Total rainfall in May and June was, respectively, 60 mm and 48 mm, with 8 days and 6 rainy days, respectively. The rainfall increased again in July (67 mm) with 11 days of rain. There was no rain at all during August. The distribution of rainfall during the research period is presented in Figure 1.

The pattern of rainfall distribution during research indicated that application of intercropping cassava with peanut and soybean was suitable because the water is sufficiently available for the growth of peanut and soybean. During the period of peanut growth (March-May), total rainfall reached 445 mm. This amount of rainfall was sufficient to support the plant growth until harvest. Harsono et al. (2006) revealed that rainfall requirement for peanut growth is about 250-800 mm depending on the climate, cultivation technology, and variety. According to Harsono and Karsono (1999), peanut that is grown monoculture in Alfisol required water as much as 372 mm, which is about only one-half of that in the intercropping system with maize, i.e. 700 mm.

During soybean growing season (after harvest of peanut/second week of June), the rainfall began to decrease (Figure 1). Total rainfall in June and July were 115 mm with the number of rainy days 17. There was no rainfall when the soybean entered the pod filling stage, and the rainfall started again in the middle of September when the soybean had been harvested. Based on the rainfall distribution, the soybean experienced water shortage, especially at the end the of reproductive stage. According to Yuliawati et al. (2014), the water requirement of Tanggamus soybean variety for optimal growth is 490 mm or 6.3 mm per day. Soybean requires more water at the peak of flowering stage and at the critical stage.

Table 2. The chemical properties of the soils of the farmer's field used for research in Sukadana District, East Lampung, Indonesia

Locations/ Farmers	pH	N	CO	P_20_5	Fe	Mn	Zn	K	Ca	Mg	Exch-Al	Exch-H	Al saturation (%)
		(%)		(ppm)				(me/100g)					
Kadirin[1)]	5.20	0.08	1.75	79.95	166.8	4.04	2.68	0.05	1.29	0.34	0.33	0.52	13.04
Rasidi [1)]	4.94	0.095	0.85	22.82	175.3	28.5	2.35	0.06	0.64	0.38	0.88	0.63	33.98
Lahir[2)]	4.60	0.09	1.02	22.36	189.0	23.5	1.78	0.04	0.93	0.42	0.91	0.66	30.74
Suyono[2)]	5.25	0.057	0.46	26.23	163.7	13.6	1.29	0.06	0.78	0.37	0.22	0.48	11.52

Note: [1)]previously cultivated with cassava, [2)]previously cultivated with rainfed paddy

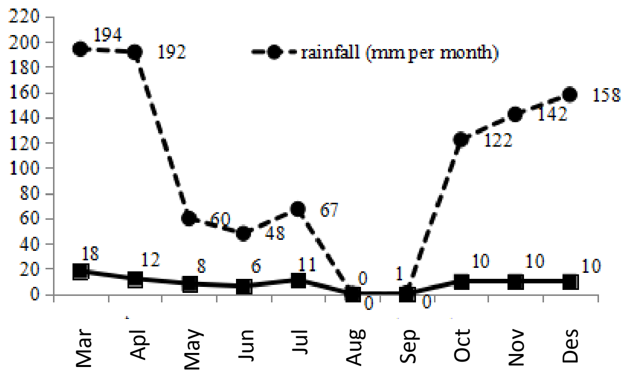

Figure 1. Rainfall distribution during research. East Lampung, Indonesia 2011

Plant yield

The research results indicated that monoculture cassava cropping technology adopted by the farmers in Sukadana, East Lampung (plant spacing 70 cm x 40 cm, fertilized with 200 kg ha^{-1} Urea and 200 kg ha^{-1} Phonska) produced 13.1 t ha^{-1} cassava fresh roots. This tuber yield could be increased by 20.24 t ha^{-1} with the application of plant spacing of 100 cm x 80 cm and recommended fertilization from District Agricultural Departement of 300 kg Urea + 200 kg SP-36 + 100 kg KCl ha^{-1}. The yield could be further increased into 24.21 t ha^{-1} by applying organic fertilizer Santap of 3,000 kg ha^{-1} and a half of recommended dose of NPK fertilizer, i.e. 150 kg urea + 100 kg SP36 + 50 kg KCl per ha (Table 3).

Intercropping of single row cassava (plant spacing 125 cm x 70 cm) with peanut that was accompanied by technology inputs (organic fertilizer Santap 3,000 t ha^{-1} for cassava and 1,500 t ha^{-1} for peanut, a half dose of recommended NPK fertilizers, inoculant Iletrinut of 0.3 kg per ha) increased cassava root yield as 29.85% and peanut pod yield as 5% higher than that of the same cropping system that used recommended NPK fertilizers without Santap and Iletri. The land productivity was still able to be increased with application of double rows cassava + peanut +/ soybean cropping system. With equal dose of organic and NPK fertilizers, the second intercropping could produce cassava yield as high as 23.75 t ha^{-1} of fresh roots, 1.86 t ha^{-1}peanut dry pod, and 1.06 t ha^{-1}soybean seeds. Intercropping cassava + peanut +/ soybean with one half recommended dose of NPK and addition of Santap and Iletri produced higher cassava, peanut, and soybean yield (17.34%, 24.36%, 27.7%, respectively) than that of the same cropping system with application of a half recommended dose of NPK without Santap and Iletri (Table 3).

According to Streck et al. (2014), the smaller plant spacing will increase the plant densities and accelerate the canopy closure. The larger plant densities decrease the photosynthetic leaf area and create competition among the plants for absorbing the nutrient in the soil, which in turn lower the crop yield. Santap is an organic fertilizer that is formulated by combining the manure, phosphate rocks and boiler ash of sugar mill. The addition of phosphate rocks and sugar mill ash to the formulation increased the nutrient content of Santap especially P and K, therefore, Santap can reduce the use of chemical fertilizer (Subandi 2010; Harsono and Subandi 2013). The increase of cassava yield was also supported by the increased number of nodules of peanut. This nodulation was accelerated by application of *Rhizobium* inoculant i.e Iletrinut. Application of Iletrinut could increase the nodule number of peanut until 350%

Table 3. Yield of cassava, peanut and soybean on various cropping systems and fertilizations in Ultisols East Lampung during 2011 growing season

Cropping systems	Phonska	Urea	SP-36	KCl	Santap	Iletri	Yield (t ha^{-1})		
	(kg ha^{-1})						Cassava root yield	Peanut pod yield	Soybean seed yield
Alternative fertilization									
Farmer monoculture cassava	200	200	0	0	0	0	13.10 d	0	0
Improved monoculture cassava	0	150	100	50	3,000	0	24.21 b	0	0
Cassava + peanut	0	25	75	25	1,500	0.3	26.10 a	1.94 a	0
	0	150	100	50	3,000	0			
Cassava + peanut +/soybean	0	25	75	25	1,500	0.3	23.75 b	1.86 a	1.06
	0	150	100	50	3,000	0			
	0	25	75	25	1,500	0.3			
Recommendation fertilization									
Farmer monoculture cassava	200	200	0	0	0	0	13.10 d	0	0
Improved monoculture cassava	0	300	200	100	0	0	20.24 c	0	0
Cassava + peanut	0	150	100	50	0	0	20.10 c	1.85 a	0
	0	300	200	100	0	0			
Cassava + peanut +/soybean	0	150	100	50	0	0	20.24 c	1.56 b	0.83
	0	300	200	100	0	0			
	0	150	100	50	0	0			

Note: Values in a column followed by the same letter (s) were not different at DMRT 5%

from 12-13 nodules per plant to 54-59 nodules per plant (Table 4). This could reduce Urea needs for more than 50%. In accordance with Achakzai (2007), the nodulation in the legumes increases when the source of Nitrogen is limited. On the other hand, the use of Santap organic fertilizer increased available P and K in the soil, which could increase the cassava yield. Kasno (2009) reported that intercropping system prevents the leaching of soil nutrients, which enable a higher nutrient adsorption compared to that of the monoculture cropping system.

Land Equivalent Ratio (LER)

Intercropping cassava with legume crops increased land use efficiency the of the acidic soil of East Lampung. The LER value the of the intercropping system of cassava with peanut or cassava with peanut and soybean were higher than one (Table 5). The calculated LER values of farmer technology were higher than that of the improved monoculture cassava technology. The highest LER value was achieved by intercropping cassava with peanut and soybean based on farmer's monoculture cassava cropping system technology

Table 4. Plant height, nodule number and pod yield of peanut on various cropping systems and fertilizations in Ultisols East Lampung during 2011 growing season

Cropping systems	Phonska	Urea	SP-36	KCL	Santap	Iletri	Plant height (cm)	Number of nodules per plant	Peanut yield ($t\ ha^{-1}$ dry pods)
	($kg\ ha^{-1}$)								
Alternative fertilization									
Intercropping cassava + peanut	0	25	75	25	1,500	0.3	48.27 a	54.32 a	1.94 a
	0	150	100	50	3,000	0			
Intercropping cassava + peanut	0	25	75	25	1,500	0.3	46.49 a	59.66 a	1.86 a
+/soybean	0	150	100	50	3,000	0			
	0	25	75	25	1,500	0.3			
Recommendation fertilization									
Intercropping cassava + peanut	0	150	100	50	0	0	45.00 a	12.66 b	1.85 a
	0	300	200	100	0	0			
Intercropping cassava + peanut	0	150	100	50	0	0	45.50 a	13.00 b	1.56 b
+/soybean	0	300	200	100	0	0			
	0	150	100	50	0	0			

Table 5. The land equivalent ratio (LER) of the cropping systems of cassava with peanut and soybean in Ultisols East Lampung during 2011 growing season

Cropping systems	Phonska	Urea	SP-36	KCl	Santap	Iletri	Yield ($t\ ha^{-1}$)			LER 1	LER 2
	($kg\ ha^{-1}$)						Cassava	Peanut *	Soybean **		
Alternative fertilization											
Farmer monoculture cassava	200	200	0	0	0	0	13.0	0	0	1.00	-
Improved monoculture cassava	0	150	100	50	3,000	0	24.21	0	0	1.86	1.00
Cassava + peanut	0	25	75	25	1,500	0.3	26.10	16.919	0	3.30	1.78
	0	150	100	50	3,000	0					
Cassava + peanut +/soybean	0	25	75	25	1,500	0.3	23.75	16.221	8.012	3.70	1.98
	0	150	100	50	3,000	0					
	0	25	75	25	1,500	0.3					
Recommendation fertilization											
Farmer monoculture cassava	200	200	0	0	0	0	13.10	0	0	1.00	-
Improved monoculture cassava	0	300	200	100	0	0	20.24	0	0	1.55	1.00
Cassava + peanut	0	150	100	50	0	0	20.10	16.134	0	2.76	1.79
	0	300	200	100	0	0					
Cassava + peanut +/soybean	0	150	100	50	0	0	20.24	13.605	6.273	3.07	1.98
	0	300	200	100	0	0					
	0	150	100	50	0	0					

Note: LER 1= LER values were calculated based on the farmer monoculture cassava cropping system. LER 2= LER values were calculated based on improved monoculture cassava cropping system. *=peanut yield was equally converted to cassava yield. **=soybean yield was equally converted to cassava yield

Table 6. Economic analysis of the cropping systems and fertilization in Ultisols East Lampung during 2011 growing season

Cropping systems	Phonska	Urea	SP-36 (kg ha^{-1})	KCl	Santap	Iletri	Cost (Rp. ha^{-1})	Income (Rp. ha^{-1})	Benefit (Rp. ha^{-1})	B/C
Alternative fertilization										
Farmer monoculture cassava	200	200	0	0	0	0	3,140,000	11,266,000	8,126,000	2.59
Improved monoculture cassava	0	150	100	50	3,000	0	8,477,000	20,820,600	12,343,600	1.46
Cassava + peanut	0	25	75	25	1,500	0.3	13,762,200	36,996,000	23,233,800	1.69
	0	150	100	50	3,000	0				
Cassava + peanut +/soybean	0	25	75	25	1,500	0.3	16,066,400	41,265,000	25,198,600	1.57
	0	150	100	50	3,000	0				
	0	25	75	25	1,500	0.3				
Recommendation fertilization										
Farmer monoculture cassava	200	200	0	0	0	0	3,140,000	11,266,000	8,126,000	2.59
Improved monoculture cassava	0	300	200	100	0	0	4,761,600	17,406,400	12,644,800	2.66
Cassava + peanut	0	150	100	50	0	0	11,896,200	31,161,000	19,264,800	1.62
	0	300	200	100	0	0				
Cassava + peanut +/soybean	0	150	100	50	0	0	11,478,600	34,501,400	23,022,800	2.01
	0	300	200	100	0	0				
	0	150	100	50	0	0				

Note: Selling prices at harvest time: cassava= Rp. 860 per kg fresh roots, peanut= Rp. 7,500 per kg dry pods, soybean= Rp. 6,500 per kg dry seeds

(3.70) and improved monoculture cassava cropping system technology (1.98). These LER values were higher than that of the previous study by Harsono et al. (2010b), who reported that intercropping cassava with soybean and peanut in acidic soil of Central Lampung increased LER values by 2.81-2.95 compared with the monoculture cassava that had LER value of 1.00. A higher than 1.0 LER value indicates a positive interferences among the crops components in the intercropping system, which also implies that any negative interference that exists in the intercropping system has less influence on the crop yield than the monoculture system (Dariush et al. 2006).

Economic analysis

Although application of Santap organic fertilizer reduced the recommended dose of NPK fertilizer of up to 50% and increased the yield from 20.24 t ha^{-1} to 24.21 t ha^{-1} of cassava fresh roots, however, Santap organic fertilizer decreased the farmer's net income from Rp. 12,644,800 to Rp.12,343,600 and also decreased the B/C ratio from 2.66 to 1.46 (Table 6). The net income could be increased if the cassava was grown in intercropping with peanut or cassava with peanut and soybean. Intercropping of cassava + peanut increased net income by 137-186% of that of the farmer's technological monoculture cassava and 54-86% of that of the improved monoculture cassava cropping system. Intercropping of cassava + peanut +/ soybean increased net income by 183-210% of that of the farmers technological monoculture cassava and 84-102% of that of the improved monoculture cassava cropping system. The highest profit (Rp.25,198,600) was earned if the farmer applied intercropping cassava with peanut and soybean coupled with application of Iletrinut and Iletrisoy biofertilizers, Santap organic fertilizer, and a half dose of recommended NPK dose. Ebukiba (2010) reported that cassava farming will be still profitable as long as the ratio of benefit and the cost is higher than one. According to Nzeh and Ugwu (2014), the success of cassava cultivation is mostly affected by the availability of farmer's finance, adequate processing facilities, and the sustainable market. The choice of legumes as intercrop is depending on the selling price, market preference, and the cost for the maintenance and harvest.

In conclusion, the improvement of plant spacing and fertilization on monoculture cassava at Ultisols increased the roots yield of farmer's technological cropping system by 54-85%. The land productivity could be further increased by intercropping cassava with peanut, or intercropping cassava + peanut/+ soybean. The LER of intercropping cassava + peanut was 3.30 when the technological farmer's monoculture cassava was used as the control in the LER calculation and was 1.78 when the improved technological monoculture cassava was used as the control in the LER calculation. In addition, the LER of intercropping cassava + peanut +/soybean was 3.70 and 1.98, respectively, when the calculation of LER considered, respectively, the farmer's monoculture cassava and improved monoculture cassava as the control. The intercropping system significantly increased the net income of monoculture system up to 210% and the highest income was generated by intercropping cassava + peanut +/soybean. The use of organic and biological fertilizer reduced the need of NPK fertilizer by 50% and significantly increased the benefit-cost ratio.

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