Soybean as ground cover plant and intercrop in immature oil palm plantation

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Abstract. One of the solutions to fulfil the demand is optimizing large area of land between oil palm before the fused canopy. This study aimed to determine the potential of soybean as ground cover plant and intercrop in immature oil palm plantation and to obtain the information on soybean varieties that have been developed as added value for farmers income (RC ratio). The study was conducted in Tanah Laut district, South Kalimantan province. The treatments used a new superior variety namely Anjasmoro, Dena 1 and Grobogan. As ground cover plant, soybean was planted when oil palm plantation was under 3.5 years. The result showed that using recommended fertilizers 40 days after planting, soybean has been able to cover 98%, 95%, and 93%. Until the 50th day, the ground will be covered 100%. Whereas using fertilizers done by farmers, the land cover was 93%, 94%, and 93%, and on the 50th day, it also reached 100%. The result of an economic analysis based on the R/C was profitable with the value of 1.42 by applying fertilizer according to cropping calendar recomendations.

1 Introduction

Currently, soybean is one of the primary commodities in the provision of food and industry for agricultural development in Indonesia [1]. An increase in the need for food, especially soybeans, is based on the condition of Indonesias population, wich continues to increase in number and income per capita. Besides food diversification, public awareness of nutritious food also has and impact on increasing soybean utilization. If linked directly, it will be associated with an increase in public consumption of tofu, tempeh, soy sauce, and other soy processing results [2].

Indonesian soybean production from 2010-2014 was increased with an average growth of 1.93% per year. The rise was caused by an increase in productivity in the 2010-2014 period of 1.37, 1.37, 1.48, 1.41, and 1.55 tons/ha respectively, with an average growth of 3.25% per year. Unfurtunately, increase in production, is still not able to meet the domestic demand for soybeans. According to central statistic agency, Indonesia had to import 1.96 million tons of soybeans to meet domestic needs, which reached around 2.95 million tons in 2014 [3].
The Ministry of Agriculture has targeted soybean self-sufficiency by 2020, with 2.5 million tons target production, and if possible, reduce soybean import quota. On the other hand, the low level of productivity and profitability of soybean farming compared to other commodities

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such as rice and corn, causes farmers to be less interested in planting soybeans. Thus, it causing planting soybeans areas to decline and productivity enhancement relatively unchanged [4]. An alternative that can be implemented is to expand the area of soybean planting by utilizing land that utilized for soybean cultivation without having to compete with other food crop commodities.

Related to the expansion of soybean cropping, one of the options offered is to utilize the land between the rubber or oil palm plants, which is quite extensive and is usually rarely used. This plant-free area can be optimized for cultivation before the canopies overlapping or under 4 years of age. Besides that, soybean plants can also be used as a ground cover because they play a vital role in influencing surface runoff and preventing erosion.

Moreover, the use of soybean plants is also an appropriate way to improve or maintain soil fertility by suppressing existing weeds, increasing the availability of organic matter, and nitrogen in the soil [5, 6]. Several other supporting studies show that cover crops in oil palm plantations function to reduce soil density [7], as a place to store carbon [8] influence soil hydrology and protect against erosion caused by water and wind [9], increasing the rate of water infiltration [10]. According to [11], soybean plants do not become competitors for the main crops in the use of natural resources, fast growth, dense and lush, able to compete with weeds, do not become a host for pests and diseases that can attack main crops.

The problem faced in the cultivation of soybean plants as intercropping or ground cover is the presence of shade caused by main crops. [12] stated that soybean plants were planted in shaded environmental conditions, would cause a decrease in photosynthetic activity. So that the allocation of photosynthate to the reproductive organs would be reduced, then decrease in yield. [13] suggested that soybean plants that shaded or intercropped could experience yield decreases ranging from 6-52% in soybean intercrops, and 2-56% at 33% shade levels. Furthermore, [14] stated that the shading stress of 50% caused the yield per hectare of soybean to decrease by 10-40%.

Alternative solutions are by planting soybean varieties that have tolerance and can adapt to shade. [15, 16] supported it. They stated that the use of varieties that were resistant to shade stress could provide optimal results. Another effort is the use of labeled seeds, this is because labeled seeds tend to have a better quality. The result is strengthened by [17], that soybean production will increase by 15-25 percent through the use of certified seeds. Therefore, efforts to study soybean varieties suitable for intercropping and ground cover needed as an effort to increase land productivity. This study aims to determine the potential of soybean plants as intercropping as well as land cover on young oil palm and soybean varieties that developed as an alternative land use that has added value for oil palm farmers.

2 Materials and methods

A study relating to the potential use of soybean as ground cover and intercropping on oil palm land was conducted in the Pandan Sari, District of Kintap, Tanah Laut in March untul July 2019. The research was done in an immature oil palm plantation that cultivated independently at 3.5 years of age planting distance of 9 x 9 m^2. The oil palm plantations are altitude is 0.5-7 m above sea level, with a slope of between 8-15% or including the category of moderately sloping.

The new superior variety (VUB) seeds used in the research were Anjasmoro (high production), Dena 1 (shade resistant), and Grobogan (market preferred). Planting was conducted at the end of March, referring to planting calendar information and according to land conditions [18], with a spacing of 40 x 15 cm^2 and using one or two seeds per hole. Fertilizers were applied according to the recommendations by providing manure as much as 2 tons/ha and NPK Phonska Plus 350 kg/ha. Land tillage was done using a tractor. Maintenance was carried out if necessary by a monitoring system, including pest control

activities, or irregated. Monitoring started from 1 week after seedling until the pods begin to dry or willing to harvest, i.e. when the pods become a brownish collor and lose all green one. The experimental design of this study was a randomized block design. Two factors examined namely varieties (Anjarmoro, Dena 1, and Grobogan) and the use of fertilizers (cropping calender recommendations and fertilizer habits of farmers). Four farmers were chose as replication in this study. The parameter consisted of observations included measuring the percentage of ground cover using the wire method measuring 1 x 1 m^2 that consists of small holes 10 cm x 10 cm^2. Percentage measurements of ground cover calculated at 10, 20, 30, and 40 DAP (days after planting) using the formula below [19].

$$Percentage\ of\ ground\ cover = \frac{Number\ of\ holes\ covered}{The\ total\ number\ of\ holes}\ x\ 100\% \qquad (1)$$

Observations of growth variables observed included stem height per plant, number of leaves, age of flowering, number of pods, number of branches at 60 DAP, and yield of soybean seeds at harvest. Data were analyzed with variance at a 5% level. If in the test of variance obtained significantly or very significantly different, then conducted the Duncan Multiple Range Test (DMRT) [20]. To understand the feasibility of this activity, will be analyzed based on the R / C. According to [21], R / C is a comparison between revenue and total costs.

$$R/C = \frac{Total\ Revenue\ (TR)}{Total\ Cost\ (TC)} \qquad (2)$$

Where: Revenue = The amount of revenue obtained Cost = The amount of costs incurred. There are three criteria in the calculation, namely: a. If R / C> 1 means the farm is profitable, b. If R / C = 1 means that the farm is even, c. If R / C <1 means the farm is losing money.

3 Results and discussion

On The research location, oil palm and rubber are the common types of plantation crops. The soil types is dominated by acid dry land. From the soil analysis (Table 1), it was found that the soil needed nutrients input. This condition would affects the dose of fertilizer.

Table 1. Soil characteristics in the experiment site

No	Soil Characteristic	Analysis Results	Information
1	C org (%)	1.339	Low
2	N (%)	0.166	Low
3	C/N	8.050	Low
4	P_2O_5 (HCl) (mg/100g)	12.738	Low
5	P_2O_5 (Bray I) (ppm)	4.339	Very Low
6	K_2O (HCl 35%)(mg/100g)	10.112	Low
7	CEC (me/100g)	10.590	Low
	Cations		
8	K^+	0.043	Very Low
9	Na^+	0.024	Very Low
10	Mg^{2+}	0.750	Low
11	Ca^{2+}	3.361	Low
12	Base Saturation (%)	39.45	Medium
13	Al-saturation (%)	18.68	Low
14	H-exchangeable	2.763	
15	Al-exchangeable	1.024	Low
	pH		

No	Soil Characteristic	Analysis Results	Information
16	pH (H_2O)	4.37	Very acid
17	pH (KCl)	4.08	
	Texture		
18	Sand	81.90	Loamy sand
19	Silt	11.01	
20	Clay	7.09	

Source: Indonesian Swampland Agricultural Research Institute Laboratory 2019

3.1 Soybean as ground cover

Utilization of soybean as a ground cover crop on 3.5 years oil palm land can be seen in Table 2. All varieties planted and fertilizing treatments used on the 40 DAP had covered an average of 93%. Then on 50 DAP, the land is 100% covered, as shown in Figure 1. The rating process of the most expansive ground cover occurred on 20 to 30 DAP because soybean is in the vegetative stage, which on a rapid process of increasing biomass. This is supported by [22] stated that soybean plants in vegetative stages V4-V5 at 20-30 DAP the three-leaf series in the fourth and fifth nods have fully developed.

Table 2. Table of observation of percentage of ground cover by soybean

Variety	Observation (DAP)							
	10		20		30		40	
	Cropping calendar (%)	Farmer (%)	Cropping calendar (%)	Farmer (%)	Cropping calendar (%)	Farmer (%)	Cropping calendar (%)	Farmer (%)
Anjasmoro	15	14	42	39	80	80	95	94
Dena 1	17	17	44	41	85	85	98	93
Grobogan	14	15	37	37	78	77	93	93
Mean	15	15	41	39	81	81	95	93

Fig. 1. Ground cover rate graph and soybean at 10, 20, 30, and 40 day after plants (DAP) in oil palm plantations

The advantages of using soybean plants as land cover, among others, are fast growing so that it is optimal as a land cover. Soybean is a type of leguminous plant that can utilize both fixed nitrogen from the air and soil, so the land is relatively more fertile and this can be utilized by main plant. In addition, soybeans have a high economic value so that they can be used as a source of income for farmers before the main crop produces

Observations show that there is not significant difference between the farmers' habits of planting compared to the cropping calendar recommendation. but the use of cropping calendar can optimize planting time so that the land used can be more optimal, besides that there are fertilizer recommendations and vigilance against pests so that the potential to income from soybean seeds will be produced.

Besides, based on its classification: three varieties planted are broadleaf soybeans based on the provisions made by [23], i.e. wide, narrow, and medium soybean leaves have LSI <1.66, > 1.83, and 1.66-1.83, respectively. Genetically this physical trait also provides a response that supports the acceleration of ground cover. The three varieties observed were shrubs even though the type of growth was determinate, because the shade effect caused the vegetative growth to be responsive or the presence of an etiolating effect. This is in line with several studies [24, 25].

Observation at the location of the activity, from the results of calculations using the lux meter (hti-MT30), solar lighting conditions shown in Table 3. If the percentage based on calibration in an open location, the highest light intensity at noon is around 57,394-57,433 lux. Based on this data, the results of measurements of the average light intensity relatively are around 24%, or plants get as much light as much as 78% with long radiation for 11 hours per day. This is the following soybean growth requirements that need 11-12 hours per day of photoperiodism [26]. Besides, several studies also stated that the intensity of the shade is more than 30% will have a significant effect on decreasing physical appearance and production for soybean [27-28].

Table 3. The results of the measurement of light intensity at the site

Measurement time	Position		
	Among the oil palm (%)	1 meter from the oil palm stem (%)	30 cm from the oil palm stem (%)
9 am	71	69	56
12 pm	100	91	70
4 pm	83	76	67
Mean	**85**	**79**	**65**

3.2 Soybean as an intercropping crop on oil palm plantation

The observations for which data were analyzed using variance at 5% level, and continued with the Duncan Multiple Range Test (DMRT) obtained information that in Table 4 shows the age of flowering in soybean plants influenced by genetic factors. From previous research, varieties have an effect on the flowering time of soybean plants, and this is also seen in this study, where different varieties cause different flowering times, and this was not found when compared to farmers' methods and planting calendar recommendations.

In each variety compared, there was a noticeable difference in the age of soybean flowering but no significant differences were found in the treatment of fertilizers in the same variety. It also stated by [29, 30] who conducted yield tests on several genotypes of soybean plants.

Table 4. Comparative data on the flowering age of soybean

Varietas	The flowering age		Plant Height		The number of leaves	
	Famer fertilizer	Fertilizer Recommend	Famer fertilizer	Fertilizer Recommend	Famer fertilizer	Fertilizer Recommend
Anjasmoro	32,3[c]	32,8[c]	95,6[a]	101,37[a]	18,9[a]	19,37[a]
Dena 1	30,9[b]	31[b]	103,02[a]	109[a]	19,92[a]	20,76[a]
Grobogan	28,2[a]	28,7[a]	80,65[a]	82,52[a]	21,02[a]	22,76[a]

Table 4 shows a graph of plant height measured at 60 DAP. Data shows that light intensity affects plant height. When compared with the description of soybean varieties released by Indonesian Legumes and Tuber Crops Research Institute (Balitkabi), all observed soybean plant heights undergo a high increase. Height differences in plants have shown by all varieties. The variety that shows differences in plant height is Dena 1, higher compared to other varieties.

No significant difference are found in plant height between fertilizer farmers and fertilizer recommendations in all varieties. It might because plant height parameters are not due to the application of fertilizer recommendations but how the response of each variety to the conditions of lack of light. Several studies state etiolation due to the influence of light that occurs in plants, and rarely by other reasons. As [31] stated that differences in plant height can be caused by genetic factors and different adaptability of each variety. Another opinion related to plant height is [32] that plant height is related to plant age. It is suspected that even though the calculation using the light meter captured at each planting location is not different, but the number of lights influence the measurement of plant height. The shade causes a height increase or etiolation because the plant tries to get its full light throughout the day.

The next measured parameter is the number of leaves, as shown in Table 4. The number of leaf parameters is not different in each variety and fertilization treatment. Supposedly the light intensity did not significantly affect the number of leaf parameters. Several studies on soybean commodities also show the same thing and in plants with short plant life. Some studies show the number of leaves does not differ because both small and wide leaf were counted. Things that might be different if calculated the leaf area [33].

There is no difference between existing and recommendation technology in the number of leaf parameters. Just as described in the previous paragraph, there may be differences if the measurement of the leaf area. Based on observations in the field, the leaves of soybean from fertilizer based on recommendations show a broader leaf width and a greener color than fertilized by farmers.

The next parameter is the number of branches counted based on the number of branches after the main stem, as shown in Table 5. Of all the varieties counted, the stems did not show differences in the number of branches. Supposedly the intensity of the light is less influential on the parameter number of branches. Several studies on soybean commodities also show the same result it might occur in plants with a short duration. Several studies showed the number of branches rarely difference because it more influenced by nutrient content, especially N and varieties. In line with Irwan [34] stated the type of variety and environmental conditions would affect the number of branches in soybean plants.

Calculation of the number of soybean pods is shown in Table 5. The interesting thing is the number of pods fertilized based on the practices of farmers showing a difference compared to fertilizer recommendations. The number of soybean pods fertilized based on recommendations is more numerous than on farmers' habits. One of the causes is thought to be the adequacy of nutrients and fertilizer.

Table 5. The result of data analysis on indicators of the number of branches, number of pods and yield of sample plot (ubinan) of planted soybeans

Variety	Number of branches		Number of soybean pods		Yield sampling (T/ha)	
	Famer's fertilizers	Recommended fertilizers	Famer's fertilizers	Recommended fertilizers	Famer's fertilizers	Recommended fertilizers
Anjasmoro	2.31[a]	2.37[a]	33.08[b]	46.08[a]	0.66[b]	1.05[a]
Dena 1	2.43[a]	2.42[a]	29.45[b]	44.45[a]	0.64[b]	1.11[a]
Grobogan	2.26[a]	2.37[a]	3333[b]	43.33[a]	0.66[b]	1.00[a]

In line with [35] that stated the number of seeds per unit area is determined by the environmental conditions that occur from the flowering phase to filling the seeds. This condition clearly shows the difference because when compared among varieties with the same fertilization, no differences was found, or if there are differences, then it is not significant. Of course, this makes it clear that the use of fertilizers based on recommendations compared to the habits of farmers. This happens in all varieties planted, with other conditions controlled, such as pest management and water resource supply.

The results of the yield calculation shown in Table 5. Shows data obtained from the average number of clusters per tile 2.5 x 2.5 m^2 was 93-110 clumps. The results were reached more than 1 ton per hectare in the form of dried seeds harvested for fertilization based on recommendations. Whereas the yield of fertilizers based on farmers showed lower yields of 0.65 tons/ha. This is proportional to the parameter of the number of pods. It shows that fertilizer recommendations are better, especially on the yield compared to the habits of farmers. This is in line with [36], that stated the number of pods per plot, and the number of seeds per pod greatly influences soybean yield. This data also shows that the potential of each variety is not significantly different so that the selection of varieties is due to market potential or farmers' desires. Based on the production potential for all varieties, the results showed no significant difference, both based on existing technology and site-specific technology. So this makes it easier to choose varieties to be developed in the shaded land.

The results of the six parameters observed from this assessment activity were that each variety cultivated on an oil palm shade land less than 3.5 years old, was able to grow well and produce soybean seeds with an average of over 1 ton with a potential land area of 0.85 ha. Fertilizing recommendations by providing 350 kg/ha of NPK fertilizer and 2 tons of manure turned out to be able to increase yield compared to farmers' habits.

The results of cost analysis and R / C ratio on soybean cultivation in farmers' oil palm lands in Pandan Sari village can be seen in Table 6. This Table shows the profit that can be obtained by farmers during immature oil palm, or the land is still possible to cultivate with an intercropping system where soybean is an intercrop. From an area of 1 ha of oil palm plantations, it is still possible for farmers to use 0.85 ha of their land for intercropping with soybean. Besides, with capital estimated at IDR 6,260,000, for around 100 days from the beginning of planting until soybean seeds are ready to sell, farmers can get a revenue of IDR 8,400,000, with an R / C ratio of 1.42 and a net income of around IDR 2,490 .000, -. As a comparison, cultivation is carried out by farmers where the R / C value is only 1.19 or receives a net profit of IDR 830,000. Surely this cultivation should be offered as an alternative source of income before farmers can get the results from the main activities of oil palm cultivation.

Aside from being an alternative source of income, this cultivation is also useful in keeping oil palm land clean and preventing weeds that are competitors for oil palms in utilizing nutrients in the land. Besides this supporting income, can be used as supporting maintenance costs for the main crop. If the scale of cultivation is broad, the income obtained will be more. Another thing is the opportunity for soybeans when harvested young. This potential can be exploited by farmers because it is possible to do so, based on the average size of the arable land, for their large palm oil plants

Table 6. Cost analysis and R / C on soybean cultivation as intercropping on small holding palm oil lands in the village of Pandan Sari

No.	Description	Fertilizer recommendations	Information	Farmer fertilizers	Information
1	Tillage	750.000	0,85 ha	750.000	0,85 ha
2	Seed	500.000	40 kg	500.000	40 kg
3	Planting	900.000	30 person @ 30.000	900.000	30 person @ 30.000
4	Fertilizer				
	Manure fertilizer	1.500.000	2 ton	500.000	600 kg
	NPK	660.000	300 kg	220.000	100 kg
5	Chemical				
	Pest/disease	400.000		400.000	
6	Nursing	300.000	Spray wages	200.000	Spray wages
7	Harvest	900.000	30 person @ 30.000	900.000	30 person @ 30.000
8	Total cost	5.910.000		4.370.000	
9	Yield	1050		650	
	Price (Rp)	8.000	Seeds	8.000	Seeds
10	Revenue	8.400.000		5.200.000	
11	Income	2.490.000		830.000	
12	R/C	1,42		1,19	

Remark: 1 ha = 35 person

4 Conclusion

Soybean plants can be used as land cover crops on immature oil palm plantations, under the age of 3.5 years. Treatment based on the recommendation of Cropping calendar showed that soybean plants were able to cover 93-98% of land at the age of 40 DAP. Soybean plants that are planted as intercrops on young oil palm plantations can still get optimal light so that they can grow well. Varieties Grobogan, Dena 1, and Anjarmoro showed that soybeans could be used as intercrops on oil palm plantation with production of more than 1 ton/ha. The results of the economic analysis based on R/C, soybean cultivation as an intercrop in immature oil palm plantation, is profitable with an R/C value of 1.42 if using the planting calendar recommendation.

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