Farming analysis of soybean cultivation under coconut plantation in North Sulawesi

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Abstract. The land under coconut plantation in North Sulawesi has not been optimally utilized; one of the commodities that can be cultivated is soybean. The purpose of this experiment was to study the growth and productivity of soybeans and analyze the economic feasibility of soybean cultivating under coconut. The experimental design used was a factorial randomized design experiment. The first factor is the soybean variety, and the second factor is the fertilizer dosages. The soybean varieties used were Dena-1 and Anjasmoro, while fertilization dosage were (i) recommended dosage (Urea 75 kg, SP36 100 kg, and KCl 100 kg/ha), (ii) dosage based on soil analysis (SP36 200 kg/ha and KCl 100 kg/ha), (iii) Manure + Trichoderma 2 ton/ha + bio urine (applied weekly) + NPK 200 kg/ha, and (iv) farmer dosage. The results showed that under shaded conditions of coconut stands, the Dena-1 variety production was higher than Anjasmoro. Productions were 2,210 kg/ha and 1,882 kg/ha, respectively. The recommended dosage (Urea 75 kg, SP36 100 kg, and KCl 100 kg/ha) produced the highest soybean yield. Based on farm analysis, soybeans can be cultivated and developed as a crop under coconut stands. Assuming a soybean price of IDR 6,500/kg, the R/C ratio of soybean cultivation ranged from 1.318 to 1.449. The highest R/C ratio was obtained using organic fertilizers, while the lowest R/C ratio (1.318) was achieved using recommended fertilizer dosages.

1. Introduction
Coconut is a leading commodity in North Sulawesi Province. According to national statistical data, in 2018, coconut cultivation in North Sulawesi reached 262,521 ha [1]. The land between coconut trees is generally not optimally utilized, especially those that are far from settlements. Coconut-based intercropping and mixed cropping systems have to be promoted for bestowing multiple benefits on the farming community. This will enhance the productivity of natural resources, the economic viability of coconut farming, and the food and nutrition security of the nation.
The land under the coconut stands is potentially managed to intercrop with other plants. Intercropping between coconut plantations is highly profitable because 80% of the land under coconut can be used for other crops and livestock. Some research demonstrated that various types of plants could be planted intercropping with coconuts, such as pepper [2, 3], maize [4], bananas [5], and upland rice [6]. Crop productivity under coconut stands was lower than in unshaded environments, but practicing the intercropped pattern, farmer’s income might increase.

Soybean is a food crop that is suitable to be cultivated under coconut stands. Even though the intensity and quality of sunlight received by plants during the reproductive period greatly influence the soybean yield and yield components, some research showed that soybean is considered a shade tolerance crop [7, 8, 9].

The purpose of this experiment was to study the growth and production of soybeans and analyze the feasibility of farming soybean under coconut stands.

2. Methods
A field experiment was conducted at dry land agroecosystem at Laikit village, Dimembe District, Minahasa Utara Regency, North Sulawesi, from March to December 2018. This experiment occupied 4 ha of coconut plantation. The experiment was designed using Factorial Randomized Design, where the first factor was soybean variety, i.e., A1) Anjasmoro and A2) Dena 1. The second factor was fertilizer dosages, i.e. (B1) recommended dosage (Urea 75 kg, SP36 100 kg, and KCl 100 kg/ha), (B2) soil analysis-based dosage, (B3) 2 t/ha chicken manure + Trichoderma + bio urine (applied weekly) + NPK 200 kg/ha, and (B4) farmer dosage. Each treatment had 3 replications. Soybean was planted using integrated cropping technology where the planting space was 40 cm x 20 cm. Soil analysis was done before the experiment to determine fertilizer dosage based on soil analysis. Pest and disease control was done using integrated pest management.

The observed parameters were planted vegetative growth (plant height, number of branches), pest and disease infestation (type, infestation rate), yield (number of pods per plant, number of beans per pod, weight of 1.000 grain), and crop productivity. Sunlight intensity was also measured using a lux meter. Data were then analyzed using the least significant difference (LSD) test [10], while economic data were collected for farming analysis using revenue cost (R/C) ratio [11].

3. Results and Discussion

3.1. Soil Characteristics
Table 1 shows the nutrient content of soil at the experiment site. N total content was categorized medium, P total content was low to medium, and K content was categorized low to medium. Based on this soil analysis, we determined that fertilizer dosage was SP36 200 kg/ha and KCl 100 kg/ha, while N fertilizer was determined using a leaf color chart.

Table 1. Soil chemical characteristics of research site.

| No. | Soil characteristics | Value       | Category      |
|-----|----------------------|-------------|---------------|
| 1   | pH H2O               | 5.84 – 6.06 | Acid          |
| 2   | N-Total (%)          | 0.35 – 0.47 | Medium        |
| 3   | P Bray (ppm)         | 5.1 – 9.3   | Low – medium  |
| 4   | K (%)                | 0.29 - 0.41 | Low - medium  |

3.2. Plant Height
According to statistical analysis, there was no effect of variety and fertilization on plant height (table 2); however, plant height of farmer fertilizer dosage treatment tends to be lower than other treatments. The average plant height of Anjasmoro and Dena 1 was 72.21 cm and 72.17 cm, respectively, higher than the plant height describe in the variety description. Plant height on the variety description was 64 – 68 cm and 59.1 cm for Anjasmoro and Dena 1. It seems soybean planted under coconut stands were
etiolated. This finding was in line with the resulting experiment by [8], where Dena 1 developed avoidance mechanisms to respond to shade through the increase in plant height.

3.3. Number of branches
Based on statistical analysis, fertilization treatment did not affect the number of branches per plant. Different varieties show different characteristics, especially on number of branches. The number of branches of the Anjasmoro variety ranges between 2.27 and 3.00, while number of branches of Dena 1 ranges from 0.43 – 1.33. Number of branches per plant closely related to crop productivity. Anti [12] has shown that number of branches per plant is a factor that determines soybean yield.

Table 2. Effect of fertilizer dosage and crop variety on plant height, number of branches, and insect pest infestation.

| Treatment | Plant height (cm)* | Number of branches | Pest infestation (%) |
|-----------|--------------------|--------------------|----------------------|
| A1B1      | 72.57*             | 3.00*              | 1.49*                |
| A1B2      | 72.80              | 2.27               | 1.23*                |
| A1B3      | 73.63              | 3.00               | 1.64*                |
| A1B4      | 69.87              | 2.83               | 1.23*                |
| A2B1      | 72.67              | 0.43               | 1.82*                |
| A2B2      | 76.23              | 1.33               | 5.04*                |
| A2B3      | 73.90              | 1.27               | 1.16*                |
| A2B4      | 65.90              | 1.30               | 2.47*                |

*) Measured before crop harvest
Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

3.4. Pest infestation
Some pests had been found infested crop growth, yet it depended on the stage of growth. In the early stage of soybean growth, a grasshopper was found as a dominant pest; however, its infestation was relatively low. Aphis sp. was a dominantly attacked pest at the end of the vegetative growth stage, even though the infestation rate is relatively low. At the reproductive growth, three pests were found dominantly attacked soybean, namely pod borer (Etiella zinckenella Treitschke), pod sucker (Riptortus linearis L), and stem borer (Dectes texus). The infestation rate of each pest is presented in tables 2, 3, and 4. These insect pests are considered the major pest of soybean (13). The fourth major group of insect pests that damaged the soybean crop during the pod maturity stage were Bemisia tabaci Genn., Empoasca kerry, Riptortus sp., and Nazara viridula L [14].

Crop variety and fertilizer dosage significantly affected pest infestation on soybean crops. Anjasmoro variety seems to be more resistant both to pod borer and stem borer infestation. The infestation rate of pod borer to Anjasmoro was about 1.62%, while in Dena 1, variety was 2.62% (table 3). Combination fertilization of inorganic, manure and Trichoderma decreased pod borer attack on soybean; on the other hand, the highest pod borer attack occurred on soil analyses-based fertilizer dosage. A similar trend was also found in crop variety and fertilizer dosage treatment on stem borers. Anjasmoro variety was found more resistant to stem borer than Dena 1. In contrast, the lowest stem borer attack was found on the trial plot treated with combination fertilization of inorganic, manure, and Trichoderma (see table 3). Some research has shown that Trichoderma's application as a bio-agency may control insect pest attacks on some crops [15, 16].
Table 3. Effect of fertilizer dosage and crop variety on pod borer pest infestation rate (%).

| Treatment | Fertilizer dosage (B) | Average |
|-----------|-----------------------|---------|
|           | B₁       | B₂       | B₃       | B₄       |         |
| Variety A₁ | 1.49     | 2.13     | 1.64     | 1.23     | 1.6²b   |
| A₂        | 1.82     | 5.04     | 1.16     | 2.47     | 2.6²a   |
| Average   | 1.65ᵇ    | 3.58ᵃ    | 1.40ᵇ    | 1.85ᵇ    |         |

Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

Table 4. Effect of fertilizer dosage and crop variety on stem borer pest infestation rate (%).

| Treatment | Fertilizer dosage (B) | Average |
|-----------|-----------------------|---------|
|           | B₁       | B₂       | B₃       | B₄       |         |
| Variety A₁ | 0.7      | 1.4      | 0.3      | 1.1      | 0.875ᵇ  |
| A₂        | 0.8      | 1.8      | 1.9      | 1.1      | 1.4⁰ᵃ   |
| Average   | 0.75ᶜ    | 1.6ᵃ     | 1.1ᵇ    | 1.1ᵇ     |         |

Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

3.5. Number of pods and beans per pod

The number of pods per plant was not affected by fertilizer dosage, as presented in table 5. However, the number of pods per plant was significantly influenced by crop variety (table 6). Anjasmoro variety had number of pods per plant (94.86) higher than Dena 1 (62.27). The number of beans per pod of the two types was similar, where number of beans was about two beans per pod. The number of beans per pod was a specific genotype characteristic of each variety [17].

Table 5. Effect of fertilizer dosage and crop variety on number of pods, number of beans per pod, the weight of 1,000 grain (g), crop productivity (t/ha) of soybean.

| Treatment | Number of pods per plant | Number of beans per pod | Weight of 1000 grain (g) | Crop productivity (t/ha) |
|-----------|--------------------------|-------------------------|-------------------------|--------------------------|
| A₁B₁      | 102.6⁰ᵃ                  | 2.15⁰ᵃ                  | 171.08bc                | 2.29ᵃ                    |
| A₁B₂      | 92.13                    | 2.26                    | 161.29c                 | 2.27                     |
| A₁B₃      | 100.53                   | 2.16                    | 166.03bc                | 2.23                     |
| A₁B₄      | 84.17                    | 2.22                    | 159.14c                 | 2.06                     |
| A₂B₁      | 61.67                    | 2.13                    | 189.59ᵃ                 | 1.99                     |
| A₂B₂      | 59.17                    | 2.16                    | 172.01ᵇ                 | 1.84                     |
| A₂B₃      | 73.77                    | 2.20                    | 176.27ᵇ                 | 2.28                     |
| A₂B₄      | 54.50                    | 2.21                    | 162.30ᶜ                 | 1.17                     |

Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

Table 6. Effect of fertilizer dosage and crop variety on number of pods per plant.

| Treatment | Fertilizer dosage (B) | Average |
|-----------|-----------------------|---------|
|           | B₁       | B₂       | B₃       | B₄       |         |
| Variety A₁ | 102.60     | 92.13     | 100.53    | 84.17    | 94.86ᵃ   |
| A₂        | 61.67     | 59.17     | 73.77     | 54.50    | 62.27ᵇ   |
| Average   | 82.13ᵃ     | 75.ᵃ      | 87.15ᵐ    | 69.33ⁿ   |         |

Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

Fertilizer dosage significantly influenced the number of pods per plant (table 6). The highest number of pods per plants was reached at the treatment of combination of inorganic fertilizers, manure, and Trichoderma application. Application of manure could improve soil fertility in terms of soil structure and soil aeration, and soil nutrient availability. Nurlisan et al. [18] also found that chicken manure's application increased the percentage of pods, the number of seeds per plant, weight of grain per plant, and crop yield. Stewart and Hill [19] stated that the application of Trichoderma
might be as a growth promotion including control of minor pathogens, enhanced nutrient uptake, increased carbohydrate metabolism and photosynthesis, and phytohormone synthesis.

3.6. Weight of 1,000 grain
Data in table 5 shows that the weight of 1,000 grain was influenced by combination treatment of fertilizer dosage and crop variety. On average, the highest 1,000-grain weight was gained in the combination treatments of Dena 1 and recommended fertilizer dosage (table 7). This result was in line with [20], where grain weight was significantly correlated with variety, fertilizers, and combination of variety and fertilizer. Table 5 shows that the development of soybean grain was determined by the availability and amount of soil nutrients. The recommended fertilizer dosage was Urea 75 kg, SP36 100 kg, and KCl 100 kg/ha, where this dosage was determined based on crop nutrient need. Fertilization with inorganic compound fertilizer NPK will supply the nutrient requirements for healthy soybean growth and higher crop productivity. On average, the weight of 1,000 grain of Anjasmoro and Dena 1 was 164.38 g and 130.97 g, respectively. This result indicated that the grain weight of the Anjasmoro variety was higher than its potency, while the grain weight of Dena 1 was lower than its potency. This finding was different compared to the finding of [21] where Dena 1 was more adaptable to the shaded conditions than Anjasmoro.

| Treatment | Fertilizer dosage (B) | Average |
|-----------|-----------------------|---------|
|           | B₁  | B₂  | B₃  | B₄  |       |
| Variety A₁ | 166.03 | 161.29 | 171.08 | 159.14 | 164.38b |
| A₂        | 189.59 | 176.27 | 162.3 | 172.01 | 130.97a |
| Average   | 177.81a | 168.78a | 166.69a | 165.57a |       |

Note: Column and row followed by the same letter were not significantly different on LSD test of 5%.

3.7. Crop productivity
Crop productivity was not influenced by fertilizer dosage and crop variety (table 5). The productivity of Anjasmoro ranged between 2.06 – 2.29 t/ha, while the productivity of Dena 1 ranged between 1.17 – 2.28 t/ha. This evidenced that Anjasmoro can be cultivated under coconut stand without losing its potential yield. As described in the varietal description, the potential yield of Anjasmoro ranges from 2.03 to 2.25 t/ha. The productivity of Dena 1 under coconut stands, however, was lower than its potential yield. Under coconut stands, the productivity of Dena 1 declined by 35%.

3.8. Farming analysis
Table 8 shows cost analysis of soybean cultivation under coconut stands. It reflects that more than 80% of farming costs expended on labor costs. This is due to the scarcity of labor in the village; therefore, they convey labor outside the village. The salary of male labor per day was IDR 175,000 while female labor salary per day was IDR 120,000.

Total farming cost differed depend on the type and amount of fertilizers applied. Soybean cultivation with recommended fertilizer dosage required the highest farming cost; on the other hand, farmer's soybean cultivation model needed the lowest farming cost. Farmers only expended IDR 730,000 for their production input; however, the production cost increased almost by 160% if they apply recommended fertilizer dosage. Such an increase in production cost may become an obstacle for the farmer in using recommended fertilizer technology.

This experiment showed that the highest yield was gained on the soybean cultivation applying inorganic and organic fertilizer dosage, i.e., 2.254 kg. With an assumption of selling prices was IDR 6,500, the farming return was about IDR 13,923,000 the net income was IDR 3,758,000, and the R/C ratio was 1.3696. The farmer cultivation model's farming return was about IDR 10,497,500; however, since the total production cost was IDR 7,240,000, the R/C ratio was higher, i.e., 1.449 (table 8). It
means that economically soybean cultivation under coconut stands was profitable and suitable to be developed in order to increase coconut farmer’s income.

Table 8. Farming analysis of soybean cultivation under coconut plantation.

| Description            | Farming cost (IDR) | Recommended dosage | Soil analysis-based dosage | Inorganic and organic fertilizer dosage | Farmer dosage |
|------------------------|--------------------|--------------------|-----------------------------|------------------------------------------|---------------|
| A. Labor (IDR)         |                    |                    |                             |                                          |               |
| - Land preparation     | 350,000            | 350,000            | 350,000                     | 200,000                                  |               |
| - Soil tillage         | 450,000            | 450,000            | 450,000                     | 450,000                                  |               |
| - Planting             | 875,000            | 875,000            | 875,000                     | 700,000                                  |               |
| - Fertilization I      | 700,000            | 700,000            | 700,000                     | 700,000                                  |               |
| - Fertilization II     | 700,000            | 700,000            | 700,000                     | 700,000                                  |               |
| - Weeding              | 1,200,000          | 1,200,000          | 1,200,000                   | 960,000                                  |               |
| - Pest control I       | 350,000            | 350,000            | 350,000                     | 175,000                                  |               |
| - Pest control II      | 350,000            | 350,000            | 350,000                     | 175,000                                  |               |
| - Pest control III     | 350,000            | 350,000            | 350,000                     | -                                       |               |
| - Harvest              | 1,400,000          | 1,400,000          | 1,400,000                   | 1,400,000                                |               |
| - Processing           | 700,000            | 700,000            | 700,000                     | 700,000                                  |               |
| - Drying               | 850,000            | 850,000            | 900,000                     | 350,000                                  |               |
| Total A                | 8,275,000          | 8,275,000          | 8,325,000                   | 6,510,000                                |               |
| B. Production input    |                    |                    |                             |                                          |               |
| - Herbicide            | 150,000            | 150,000            | 150,000                     | 110,000                                  |               |
| - Urea N               | 150,000            | 120,000            | 40,000                      | 90,000                                   |               |
| - SP36 P               | 500,000            | 500,000            | -                          | -                                       |               |
| - KCl                  | 550,000            | 550,000            | -                          | -                                       |               |
| - Compost              | -                 | -                 | 500,000                     | -                                       |               |
| - Bio urine            | -                 | -                 | 100,000                     | -                                       |               |
| - NPK (Phonska)        | -                 | -                 | 480,000                     | 240,000                                  |               |
| - Chemical pesticide   | 540,000            | 540,000            | 40,000                      | 40,000                                   |               |
| - Organic pesticide    | -                 | -                 | 300,000                     | 250,000                                  |               |
| Total B                | 1,890,000          | 1,860,000          | 1,610,000                   | 730,000                                  |               |
| Total A+B              | 10,165,000         | 10,135,000         | 9,935,000                   | 7,240,000                                |               |
| C. Yield               |                    |                    |                             |                                          |               |
| - Crop yield           | 2,142 kg           | 2,055 kg           | 2,254 kg                    | 1,615 kg                                 |               |
| - Selling price (IDR/kg)| 6,500              | 6,500              | 6,500                       | 6,500                                    |               |
| - Return (IDR)         | 13,923,000         | 13,357,500         | 14,651,000                  | 10,497,500                               |               |
| - Net income (IDR)     | 3,758,000          | 3,222,500          | 4,716,000                   | 3,607,000                                |               |
| R/C ratio              | 1.3696             | 1.3179             | 1.4746                      | 1.4499                                   |               |
| B/C ratio              | 0.3696             | 0.3179             | 0.4746                      | 0.4499                                   |               |

4. Conclusions
In conclusion, this result showed that soybean technically could be cultivated under coconut stands. Soybean can be cultivated under coconut stand without losing its potential yield. Soybean cultivation under coconut stands was profitable and suitable to be developed in order to increase coconut farmer income.
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