



The Effect of Cow Manure and NPK Fertilizer on Soil Chemical Fertility, Soybean Growth, and the Yield on Sandy Soil

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Abstract. Research to determine the effect of cow manure and NPK fertilizer on soil chemical fertility, soybean growth, and the yield on sandy soil was conducted in the coastal area of Bengkulu, Indonesia. Doses of cow manure consisting of 0, 30, 50, and 70 t ha⁻¹ and NPK fertilizer composed of 0, 150, 300, and 450 kg ha⁻¹ were arranged according to a randomized block design. The response of soybean plants was observed through plant height, number of leaves, number of branches, number of pods per plant, the weight of 100 seeds, and seed production per plot (1.5 m²). The results showed that coastal land with sandy characteristics was included as marginal land with low chemical and physical fertility. The application of cow manure and NPK fertilizers caused an increase in soil chemical fertility. The growth and yield of soybean plants were not significantly affected by the application of various doses of cow manure and NPK fertilizer. However, soybean seed yields tended to be higher with high dosages of cow manure and NPK fertilizers.

Keywords: Coastal · organic fertilizer · inorganic fertilizer · soybean growth · yield

1 Introduction

The use of marginal land (coastal/sandy land, acid sulfate, tidal, peat, and ex-mining) for plant cultivation is unavoidable, considering that fertile land is used to develop urban areas, for example, housing, public facilities, industry, and infrastructure. In particular, fertile land for soybean cultivation is also decreasing due to conversion to other commodities such as plantations or other more profitable food crops. On the other hand, soybean production remains high because soybean is the third food commodity in Indonesia and is also needed worldwide for food, animal feed, oil, and others [1–4].

Sandy soil is one type of marginal land classified as large in Indonesia and countries with large sea waters. Therefore, sandy soil has the potential to be utilized because of its broad area in Indonesia. The physical characteristics of sandy soil are very loose because it has a crumb structure and a coarse texture. Under these conditions, plant roots easily penetrate soil particles. However, the rough texture and crumb structure cause high porosity, so it does not bind water and contains low nutrients [3, 4].

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Chemical and biological fertility are necessary for good plant growth and high yields. Sources of chemical and biological fertility are organic fertilizers and inorganic fertilizers. The nutrient content of cow manure, one type of organic fertilizer, is 28.1% Nitrogen, 9.1% Phosphorus, and 20% Potassium [5]. Cow manure is easy to get because this animal is one of the sources of food (meat). These animals are widely raised in the community on a small and large scale.

Adding organic fertilizers increases the organic matter content of the soil so that the soil's water-holding capacity increases (decreases porosity). Soybean plants on sandy soil require immediately available nutrients. The provision of inorganic fertilizers helps the availability of nutrients for plants immediately [6].

Research [7] concluded that the growth and yield of soybeans continued to increase with increasing doses of NPK fertilizer 0, 120, and 250 kg ha⁻¹, so the best growth was produced by soybeans applied at a dose of 250 kg ha⁻¹. Research [8] and [9] showed that the NPK dose of 300 kg ha⁻¹ still increased soybean production. A study [10] showed that the highest number of soybean pods planted was the combination of 30 t ha⁻¹ of cow dung with 600 kg ha⁻¹ of NPK. These studies were carried out on land that was not sandy so that it would be used as the basis for determining the treatment on this sandy land.

The importance of managing sandy land as an alternative land for soybean cultivation, a study was conducted that aimed to determine the effect of cow manure and NPK fertilizer on soil chemical fertility, soybean growth, and the yield on sandy soil.

2 Materials and Methods

The research was conducted from January to April 2022 on the sandy land of Bukit Peninjauan I Village, Sukaraja District, Seluma Regency, Bengkulu Province, Indonesia. The soybean variety used was Anjasmoro. The source of organic fertilizer was cow manure. The inorganic fertilizer used was NPK fertilizer (16:16:16).

2.1 Experiment Setup and Data Analysis

This experiment tested two treatment factors: manure application doses (0, 30, 50, and 70 t ha⁻¹) and NPK fertilizer application doses (0, 150, 300, and 450 kg ha⁻¹). The plots for the experimental units were 100 cm × 150 cm (1.5 m²). All experimental units were randomly assigned to the experimental plot following a randomized block design. The experiment was repeated three times, and the repetitions were carried out in blocks.

Responses to soybean growth and yield were observed through plant height, number of leaves, number of branches, number of pods, the weight of 100 grains, and weight of seeds per plot. In addition, differences in soil characteristics before and after the experiment were observed through soil nutrient analysis. Analysis of variance was carried out on the data, which is the samples mean, using the F test at the 5% level. Duncan's multiple range test compared the mean values of variables significantly affected by treatment according to the F test.

Table 1. Soil characteristics in the experimental land and land fertility criteria

Content	Before the experiment			After the experiment		
	Result	Standard [12]		Result	Standard [12]	
		Range	Criteria		Range	Criteria
N (%)	0.25	0.21–0.50	Moderate	0.32	0.21–0.50	Moderate
P (ppm)	3.87	<4	Very low	9.11	8–10	Moderate
K (me 100 g ⁻¹)	0.18	<10	Very low	0.30	<10	Very low
C-organic (%)	2.46	2.1–3.0	Moderate	7.28	>5	Very high
pH	4.20			4.71		
Sand (%)	86.16					
Clay (%)	7.99					
Dust (%)	5.84					

2.2 Experiment Procedure

The land was cleared, plowed to a depth of 20–30 cm, loosened, and then leveled with a rake. The experimental plots were formed according to the plot sizes specified above, with the distance between plots in one block being 60 cm. Between blocks are spaced a distance of 100 cm. Each plot was poured with dolomite lime 150 g plot⁻¹ according to a dose of 1 ton ha⁻¹. Dolomite lime was applied one week before planting. Cow manure was also applied together with dolomite at the dosage according to the treatment.

Soybean seeds treated with insecticides, fungicides, and rhizobium inoculants were sown to a depth of 2–3 cm with a spacing of 25 × 25 cm for 2 grains and then covered with light soil. Thinning was done two weeks after planting, leaving one plant per planting hole. NPK fertilizer, according to the treatment, was applied simultaneously with thinning by immersing it as far as 5 cm beside the plant stems. Controlling was carried out until the plants were harvested, including irrigation and control of plant-disturbing organisms.

3 Result and Discussion

3.1 Soil Characteristics

The proportion of sand particles in the soil at the experimental site was 86.16% (Table 1). Soil with a proportion of sand particles of that size is classified as sandy soil according to the distribution of soil texture in the texture triangle issued by the United States Department of Agriculture [11]. Sandy soil is one of the characteristics of coastal land. This experimental field is located on the west coast of Sumatra Island with coordinates 3°57'27.2''S 102°22'29.2''E. The existence of Bengkulu Province, Indonesia, along the west coast of the island of Sumatra, which is directly adjacent to the Indian Ocean, causes a potential area of land with high sandy soil.

Table 2. Probability values (P-value) of the F test for soybean growth and yield

Variables	Cow manure dosages	NPK fertilizer dosages	Interaction of cow manure and NPK fertilizer
Plant height	0.98 ^{ns}	0.72 ^{ns}	0.46 ^{ns}
Number of leaves	0.65 ^{ns}	0.55 ^{ns}	0.72 ^{ns}
Number of branches	0.78 ^{ns}	0.58 ^{ns}	0.80 ^{ns}
Pod number per plant	0.53 ^{ns}	0.09 ^{ns}	0.72 ^{ns}
Weight of 100 grains	0.97 ^{ns}	0.28 ^{ns}	0.54 ^{ns}
Seed yield per plot	0.44 ^{ns}	0.24 ^{ns}	0.77 ^{ns}

Soil nutrient levels before the experiment were classified as very low to moderate according to the classification [12]. The availability of nutrients for plants characterizes soil fertility. Essential nutrients must be available because they cannot be replaced by other nutrients [13, 14]. Three of the 16 essential nutrients often used as indicators of soil fertility, namely N, P, and K, were classified as very low at the experimental site. This chemical characteristic indicated that the land is classified as infertile or marginal.

The application of cow manure and NPK fertilizers caused an increase in some soil nutrient levels to moderate and very high (Table 1). Nitrogen remained at moderate criteria, and K nutrient levels remained at very low criteria. P levels increased from very low to moderate. Applying cow manure and NPK fertilizer increased C- organic levels from moderate to high. Adding organic matter to sandy soil is an effort to help bind/absorb water in a very high porosity of sandy soil and provide plants nutrients [6].

3.2 Soybean Growth and Yield

The probability value of more than 5% in the analysis of variance (Table 2) for all variables shows that the application of 4 dose levels of manure, NPK fertilizer, and their interactions had no significant effect on all growth and yield variables of soybean plants. Cow manure and NPK have not been utilized optimally for the growth and yield of soybean plants.

The plant height, number of leaves, and number of branches as indicator variables for soybean plant growth did not show the same pattern with the increasing manure and NPK fertilizer dosages tested. The highest growth tendency was produced by plants that were not applied cow manure and NPK fertilizer (0 ton ha⁻¹ cow manure and 0 kg ha⁻¹ NPK fertilizer) or lower doses such as 30 t ha⁻¹ manure and 150 kg ha⁻¹ of NPK fertilizer (Table 3).

A different pattern of vegetative growth is seen in the yield component variables. The yield component tends to be higher with higher doses of cow manure and NPK fertilizer. Soybean seed yields per plot (1.5 m²) tended to be higher for plants that applied 30 t ha⁻¹ of cow manure and 300 kg ha⁻¹ of NPK fertilizer. The highest seed yield with a single application of cow manure was produced by plants that applied 70 t of ha⁻¹. Meanwhile, a single application of 300 kg ha⁻¹ of NPK fertilizer produced the most seeds (Table 4).

Table 3. The mean value of soybean plant growth at various doses of cow manure and NPK fertilizer

Cow manure dosages (ton ha ⁻¹)	NPK fertilizer dosages (kg ha ⁻¹)				Average
	0	150	300	450	
Plant height (cm)					
0	85.04	86.88	80.25	82.58	83.69
30	80.39	86.02	84.77	80.88	83.02
50	83.17	82.71	82.67	85.58	83.53
70	83.23	82.52	83.50	84.83	83.52
Average	82.96	84.53	82.80	83.47	
Number of leaves					
0	21.9	18.0	13.6	20.9	18.58
30	25.8	21.8	23.9	17.6	22.27
50	18.5	21.9	20.2	18.3	19.72
70	21.8	16.7	19.3	20.9	19.66
Average	22.01	19.57	19.23	19.42	
Number of branches					
0	7.4	6.3	6.1	7.0	6.70
30	8.7	7.5	7.0	6.0	7.30
50	7.4	7.4	6.9	6.1	6.96
70	7.3	5.9	6.5	7.2	6.71
Average	7.71	6.75	6.61	6.59	

Table 4. Mean values of soybean yields at various doses of cow manure and NPK fertilizer

Cow manure dosages (ton ha ⁻¹)	NPK fertilizer dosages (kg ha ⁻¹)				Average
	0	150	300	450	
Pods number (pods)					
0	9.7	12.6	12.1	13.2	11.89
30	11.5	17.2	12.1	12.5	13.31
50	12.4	14.7	14.6	10.0	12.95
70	11.6	12.1	20.0	13.3	14.25
Average	11.30	14.16	14.70	12.25	

(continued)

Table 4. (continued)

Cow manure dosages (ton ha ⁻¹)	NPK fertilizer dosages (kg ha ⁻¹)				Average
	0	150	300	450	
Weight of 100 grains (g)					
0	17.67	17.00	19.67	17.33	17.92
30	17.33	17.33	18.00	19.33	18.00
50	17.00	17.33	19.67	16.33	17.58
70	17.67	20.17	18.67	15.67	18.05
Average	17.42	17.96	19.00	17.17	
Seed yield per plot (g 1.5 m ²)					
0	33.33	60.67	53.67	56.67	51.09
30	56.00	50.67	81.00	66.67	63.59
50	53.33	69.33	58.00	42.00	55.67
70	52.33	62.33	79.00	62.33	64.00
Average	48.75	60.75	67.92	56.92	

4 Conclusion

We conclude that sandy land is one of the marginal land types according to the results of the soil chemical and physical analysis carried out in this study. The addition of cow manure and NPK fertilizer affects changes in soil characteristics. Soil chemical fertility increases with the addition of cow manure and NPK fertilizer. The growth and yield of soybean plants were not significantly affected by the application of various doses of cow manure and NPK fertilizers. Soybean seed yields tend to be higher with high doses of cow manure and NPK fertilizers.

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