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Growth and Yield of Three Soybean Cultivars on a Combination of Cow Manure and NPK Fertilizers on Sandy Land

Danner Sagala[1*], *Juwinten* Juwinten[1], *Prihanani* Prihanani[1], *Sri* Mulatsih[1], *Eka* Suzanna[1], and *Rahmansyah* Dermawan[2]

[1]Study Program of Agrotechnology, Universitas Prof Dr Hazairin SH, 38115 Bengkulu, Indonesia
[2]Agrotechnology Study Program, Hasanuddin University, 90245, Makassar, Indonesia

Abstract. Food security is an important issue and must be pursued by utilizing all potential resources. Sandy land is a potential resource to be developed as agricultural land due to the decline in fertile land. However, sandy land has a limiting factor for plant growth and yield, namely fertility. This research aimed to determine the effect of cow manure and NPK fertilizer on the growth and yield of three soybean varieties on sandy land. The research was conducted from January to May 2022 on sandy land in Bengkulu. Each experimental plot was arranged based on a randomized block design. The first factor was soybean cultivar, and the second was a combination of cow manure and NPK fertilizer doses. Each treatment was repeated three times. The results showed that the three soybean varieties evaluated showed different characteristics due to genetic diversity. Applying a combination of organic fertilizers in all proportions did not significantly affect the growth and yield of soybeans except for the weight of 100 seeds. NPK fertilizer application showed better growth and yields.

1 Introduction

Several researchers have conducted experiments on food crops on marginal land worldwide to anticipate the reduction of fertile land [1–6]. One of the marginal land resources that is starting to be considered for agricultural development to maintain food security is coastal land. Researchers [7] stated that the use of sandy land is increasing, and one of the uses is for agriculture. Indonesia has land potential in coastal areas. Indonesia is an archipelagic country, so it has a long coastline. Research [8] shows Indonesia's coastline is 91,363.65 km long.

Sandy land, a soil type often found in coastal areas, is less fertile and has limited water retention capabilities. According to [7], there are three problems in using sandy land: physical, chemical, and biological. Studies have been carried out recently to overcome the sandy land problems mentioned above. The researchers [9–11] concluded that inputting organic matter into sandy soils would improve soil quality, ultimately improving the growth performance and productivity of the evaluated plants. Furthermore, to overcome the low nutrient retention in sandy soil, [12,13] concluded that input of organic material in the form

* Corresponding author: danner_10@yahoo.com

of slow release in biochar is beneficial if applied to sandy soil. Their research also continued with fertigation irrigation systems, which allow water savings considering the low water retention in sandy soils.

The use of sandy land still requires further research where the immediate and continuous availability of nutrients is essential. This situation was also conveyed by researchers [7] who stated that the limitations of sandy soil require effective soil management based on an understanding of the characteristics of sandy soil. In this context, our study focuses on the specific application of cow manure and NPK fertilizers to enhance the growth and yield of soybean cultivars in sandy lands.

Soybeans are a familiar crop for Indonesian people. Soybeans are even classified as an essential food crop in Indonesia because they contain high levels of vegetable protein. This plant also has a unique nutrient absorption mechanism, so it plays a role in developing a sustainable agricultural system. Soybean plants can fix nitrogen from nature by collaborating with microbes. Therefore, this plant has the potential to be developed in coastal areas with sandy soil characteristics.

The growth and yield of soybean plants can vary greatly depending on the type of variety used. Various soybean varieties have been developed with unique characteristics, including adaptability to specific soil conditions [1,14,15]. Therefore, research comparing the growth and yield of several soybean varieties grown in sandy soils with organic and NPK fertilizers is essential to understanding how different plant varieties respond to different nutrient treatments.

This research investigates the effect of applying organic fertilizer and NPK on the growth and yield of three soybean varieties planted on sandy land. With a better understanding of how these varieties behave under the influence of different nutrients, we can develop more efficient nutrient management strategies to increase soybean productivity on sandy soils, contributing to food security and agricultural sustainability.

2 Materials and method

The current field experiment was conducted from January to May 2022 in Bukit Peninjauan I Village, Seluma Regency, Bengkulu, Indonesia. The materials used in this research were soybean seeds of the Gepak Kuning variety, Dering 1 variety, Anjasmoro variety, cow manure, and NPK fertilizer (16:16:16). The treatment evaluated on three soybean varieties was a combination of manure with NPK fertilizer, namely (1) 0 tons/ha of manure + 450 kg/ha of NPK fertilizer, (2) 10 tons/ha of manure + 300 kg/ha of NPK fertilizer, (3) 20 tons/ha of manure + 200 kg/ha of NPK fertilizer, and (4) 30 tons/ha of manure + 100 kg/ha of NPK fertilizer. The four fertilizer combinations and three varieties were arranged in a randomized block design repeated three times.

The experiment was carried out on a plot measuring 1 m x 1.5 m. Each experimental plot was applied dolomite lime at a dose of 1 ton/ha. Dolomite lime was poured on the land's surface after the first tillage and mixed in during the second tillage, namely when loosening and levelling. Dolomite lime is applied simultaneously with manure treatment two weeks before planting. NPK fertilizer treatment was carried out two times; half of the treatment dose was applied one week before planting by pouring the fertilizer on the plot's surface and the remaining six weeks after planting by immersing it around the plant roots.

Plant growth and yield data were analysed for variance using the F test at the 5% level after checking the plausibility of the data (normality and homogeneity). Each variable that showed a significant influence continued to be analysed using the Duncan multiple range test at the 5% level.

3 Result and discussions

3.1 Experimental site characteristics

The trial field was laid out on the west coast of Sumatra Island of Indonesia with coordinates 4° 2' 33.22" S and 102° 22' 30.01" E. The elevation of the place is 5 meters above sea level.

Table 1. Soil physicochemical properties of the experimental site.

Content	Result	Standard [16]	
		Range	Criteria
N (%)	0.25	0.21-0.50	Moderate
P (ppm)	3.87	<4	Very low
K (me 100 g^{-1})	0.18	<10	Very low
C-organic (%)	2.46	2.1-3.0	Moderate
pH	4.20		
Sand (%)	86.16		
Clay (%)	7.99		
Dust(%)	5.84		

Source: [17]

According to the United States Department of Agriculture (USDA)'s soil texture triangle, the soil of this land is classified as sandy soil [18]. The classification is based on sand-silt-clay proportion, as shown in Table 1. The Table 1 is the same data as the research of [17] because the two experiments were carried out at the same time and location. The Bengkulu Province's proximity to the Indian Ocean helps explain why sandy soil is so common there. Wave energy, climate, sedimentation, and other environmental factors on the coast cause land in coastal areas to have a sandy texture [19,20].

The levels of many nutrients in the soil prior to the experiment were noticeably very low to moderate, according to reference [16], especially those that are crucial for plant growth, such as nitrogen (N), phosphorus (P), and potassium (K). These soil characteristics are classified as infertile or marginal soil. Sandy soil texture affects the fertility of the soil. Sandy soil cannot hold water and dissolved nutrients. High porosity causes nutrient leaching to occur in sandy soil. Therefore, water and nutrient retention is a weakness of sandy soil for plant cultivation [12,13,21] and needs to be overcome by applying nutrients from outside.

3.2 Soybean Traits and Fertilizer Effects

The three soybean varieties evaluated did not have statistically different characters (P-value ≥0.05) except for the weight of 100 seeds (P-value <0.05). The application of organic and inorganic fertilizers combined in various proportions had no different effect on all growth and yield variables (P-value≥0.05) except for the weight of 100 seeds (P-value<0.05). Likewise, in the interaction between cultivar and combined fertilizer treatment, all variables had a p-value above 0.05, which meant that the interaction did not affect the soybean growth and production (Table 2).

Although statistically not different, the three soybean varieties evaluated showed unique characteristics. The Depak Kuning variety tended to have the highest physical performance, number of leaves, and number of branches but smaller seed size. The seed size of the Anjasmoro cultivar was the biggest and was statistically significantly different from other varieties, but the physical performance of this variety was not the highest; even for the number of pods and total seed yield, it was the lowest (Table 3 and Table 4). Genes drive each cultivar's physical performance, growth, and yield. The general theory is that the phenotype results from genetic and environmental factors. Many efforts are continuously being made from a genetic perspective to increase the productivity of soybeans and even the nutritional content of the soybeans. Therefore, evaluating and selecting adaptive varieties for specific environmental conditions, such as sandy coastal areas, is mandatory [22–24].

Table 2. Probability value (P-value) of the variables variance at cultivar and fertilizer treatment.

Plant Traits	Cultivar	Manure-NPK combination	Interaction of cultivar and fertilizer
Plant height (cm)	0.31 ns	0.14 ns	0.95 ns
Leaves number (leaves.plant^{-1})	0.36 ns	0.26 ns	0.93 ns
Branches number (branches.plant^{-1})	0.37 ns	0.24 ns	0.92 ns
Chlorophyll index (SPAD unit)	0.37 ns	0.51 ns	0.59 ns
Pod number (pod.plant^{-1})	0.30 ns	0.88 ns	0.59 ns
Weight of 100 seed (g)	0.00*	0.04 *	0.23 ns
Seed yield (g 1.5 m^{-2})	0.62 ns	0.83 ns	0.80 ns

Note: ns = not significant, * = significant

Table 3. The growth component of three soybean cultivars at four fertilizer combinations.

Cultivars	Fertilizer combination*				Average
	0 + 450	**10 + 300**	**20 + 200**	**30 + 100**	
Plant height (cm)					
Gepak Kuning	46.87	42.25	46.40	42.35	44.47
Dering 1	42.51	36.71	45.77	39.21	41.05
Anjasmoro	42.50	41.67	44.07	39.98	42.05
Average	43.96	40.21	45.41	40.51	
Leaves number (leaves.plant^{-1})					
GepakKuning	35.16	29.56	33.81	30.90	32.36
Dering 1	30.45	25.06	33.15	27.73	29.10
Anjasmoro	30.71	30.68	31.70	28.63	30.43
Average	32.11	28.43	32.88	29.08	
Branches number (branches.plant^{-1})					
GepakKuning	11.72	9.85	11.27	10.31	10.79
Dering 1	10.16	8.33	11.13	9.23	9.71
Anjasmoro	10.25	10.22	10.57	9.48	10.13
Average	10.71	9.47	10.99	9.67	
Chlorophyll index (SPAD unit)					
GepakKuning	33.20	30.16	30.91	29.82	31.02
Dering 1	30.29	29.60	30.34	29.38	29.90
Anjasmoro	29.94	32.24	33.23	29.99	31.35
Average	31.15	30.67	31.49	29.73	

* = ton ha^{-1} of cow manure + kg ha^{-1} of NPK fertilizer

For the vegetative growth component, 20 tons ha^{-1} manure + 200 kg ha^{-1} NPK produced taller plants, more leaves, more branches, and greener leaves than other combination treatments. The second highest growth was produced by NPK fertilizer treatment without manure. However, the highest value was obtained from soybeans applied 450 kg ha^{-1} of NPK fertilizer for the yield component variable. Applying NPK fertilizer without manure was better than combining those two fertilizers. (Table 3 and Table 4). The low retention of water and nutrients in sandy soil due to high porosity causes plants to require immediately available nutrients without a long decomposition process in sandy soil. NPK fertilizer is an inorganic fertilizer containing nutrients immediately available to plants. Meanwhile, manure and other organic fertilizers require a long time for the nutrients contained therein to be available to plants through decomposition.

Table 4. The yield component of three soybean cultivars at four fertilizer combinations.

Cultivars	Fertilizer combination*				Average
	0 + 450	**10 + 300**	**20 + 200**	**30 + 100**	
Pod number (pod.plant^{-1})					
Gepak Kuning	31.08	28.58	18.69	23.65	25.50
Dering 1	22.00	19.88	22.25	25.08	22.30
Anjasmoro	18.54	22.17	22.42	17.29	20.10
Average	23.88	23.54	21.12	22.01	
Weight of 100 seed (g)					
Gepak Kuning	11.33	9.67	10.67	11.67	10.83 a
Dering 1	11.00	11.33	10.67	13.00	11.50 a
Anjasmoro	13.33	13.67	17.00	16.67	15.17 b
Average	11.89	11.56	12.78	13.78	
Seed yield (g 1.5 m^{-2})					
Gepak Kuning	48.67	48.67	31.00	44.33	43.17
Dering 1	42.67	33.33	41.33	37.67	38.75
Anjasmoro	39.33	33.00	39.67	37.33	37.33
Average	43.56	38.33	37.33	39.78	

* = ton ha^{-1} of cow manure + kg ha^{-1} of NPK fertilizer

4 Conclusions

The three soybean varieties evaluated showed different characteristics. Applying a combination of organic fertilizers in all proportions did not significantly affect the growth and yield of soybeans except for the weight of 100 seeds. NPK fertilizer application showed better growth and yields.

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