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Morphological Response of Two Soybean Varieties to Fertilizer Dose Levels in Intercropping Patterns with Maize

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Abstract
Sustainable agriculture refers to agricultural systems and procedures that attempt to reduce the depletion of natural resources in the soil. Intercropping, one of the strategies in agroecological systems, allows farming to take advantage of the symbiotic relationship between different crops to increase land productivity and create a more stable agroecosystem. This study aims to determine changes in the morphological characteristics of soybeans when intercropped with maize at several levels of fertilizer recommendations. The study was conducted in Alue Peunyareng, Meureubo District, West Aceh Regency. The research employed a Randomized Block Design with two factors: variety (4 levels) - V1 (Bonanza + Detap-1), V2 (Exotic + Detap-1), V3 (Bonanza + Grobogan), V4 (Exotic + Grobogan); and fertilizer dosage (5 levels) - D1: 100% recommended dosage (Maize: 300 kg ha-1 Urea + 150 kg ha-1 SP36 + 50 kg ha-1 KCl; Soybean: 30 kg ha-1 Urea + 60 kg ha-1 SP-36 + 30 kg ha-1 KCl), D2: 75% recommended dosage + 10 tons/ha Organic Fertilizer, D3: 50% recommended dosage + 20 tons/ha Organic Fertilizer, D4: 25% recommended dosage + 30 tons/ha Organic Fertilizer, and D5: 40 tons/ha Organic Fertilizer. *This resulted in 20 treatment combinations with three replications.* The observed parameters were the morphological characteristics of soybean. Data were analyzed statistically using the F test, and if significantly different, it was followed by Tukey's least significant difference (LSD) test at a 0.05 significance level. The results showed that the variety significantly affected the height of plants aged 14, 21, 28, 35 and 42 Days After Planting (DAP), and the number of branches at 35 and 42 DAP. The recommended level of fertilizer dosage significantly affected the height of soybean plants aged 14, 28, 35 and 42 DAP and the number of branches at 21, 28 and 35 DAP.
Keywords: Agroecology, Intercropping, Maize, Soybean

Introduction
Sustainable agriculture refers to agricultural systems and practices that seek to reduce the depletion of natural resources in the soil. The sustainable agriculture approach aims to retain more organic matter in the soil, reduce erosion, and retain more carbon in the soil (Soliman et al., 2023). These practices improve soil resilience and health in the long term, ultimately resulting in higher yields. Sustainable agricultural development requires achieving a balance between economic and socio-environmental goals (Gutzler et al., 2015).

In maize and soybean farming, the use of agroecological systems offers great potential to improve productivity, resource efficiency, and environmental compatibility. Overlapping patterns, one of the strategies in agroecological systems, allow agriculture to take advantage of the symbiotic relationships between different crops to increase land productivity and create a more stable agroecosystem (Maitra et al., 2021). Mixed cultivation of maize and soybeans allows optimal use of this land to increase maize and soybean yields (Yuwariah et al., 2017).

To achieve high yields, attention should be paid to the appropriate varieties when managing intercropping systems. Plant diversity is one of the determining factors for the quality of agricultural products. The use of quality plant varieties is expected to make the production process more efficient and productive so as to produce quality food. The maize-soybean intercropping pattern is an interesting example of agroecological practice because the two plants have morphophysiological properties that complement each other. Maize has a deep root system and the ability to absorb nutrients from deeper soil layers, thus serving as a barrier to soil erosion and increasing the availability of nutrients for soybeans (Pratiwi, 2012). On the other hand, soybeans have the ability to increase soil nitrogen levels through symbiosis with rhizobia, so that it can have a positive effect on maize growth and reduce dependence on synthetic fertilizers (Lestari et al., 2024).

The difference between agricultural systems that apply agroecological principles and those that are not obvious, for example in practices that only use chemical fertilizers. Such practices directly exclude the possibility of local resources, such as the use of organic fertilizers from compost, where bacterial material is available from the environment and can be produced by farmers themselves while increasing soil nutrients (Al-Baarri et al., 2020) .

More understanding Deep Regarding the interaction of these two plants in the pattern Overlap and its impact on agricultural productivity and sustainability will result in more effective and sustainable agricultural strategies for the future. This study aims to determine the change in morphological characteristics of soybeans when planted intercropped with maize at several levels of fertilizer recommendations.

Research Methods

This research will be carried out at the University Farm Experimental Land at Teuku Umar University, Alue Peunyareng, Meureubo District, West Aceh Regency. The study used a Random Design of Factorial Groups with 2 Factors, namely Variety and Fertilizer Dosage. The design of the treatment that will be carried out is as follows:
First Factor : Maize and Soybean Varieties consisting of:
V1 : Bonanza and Detap1
V2 : Exsotic and Detap1
V3 : Bonanza and Grobogan
V4 : Exsotic and Grobogan

Second Factor : the Fertilizer Dosage which consists of:
D1 : 100 % Fertilizer Recommendation (Maize: 300 kg ha-1 Urea + 150 kg ha-1 SP36 + 50 kg ha-1 KCl and Soybeans : 30 kg/ha Urea + 60 kg/ha SP-36 + 30 kg/ha KCl)
D2 : 75% of fertilizer recommendations + 10 tons/ha of Organic Fertilizer
D3 : 50% of fertilizer recommendations + 20 tons/ha of Organic Fertilizer
D4 : 25% of fertilizer recommendations + 30 tons/ha of Organic Fertilizer
D5 : 40 tons/ha of organic fertilizer

There were 20 treatment combinations with 3 repetitions, a total of 60 plots with a plot size of 2.5m x 1.5m. Sample plants were 10 samples/plot (5 maize + 5 soybeans).

Research Procedure:
1. Land Preparation

The land used is first cultivated according to the area needed, then cleaned of weeds and other plants using a hoe, a koret and a machete. Then tillage is carried out with a tractor. Furthermore, 60 bed maps with a size of 2.5 m x 1.5 m with a distance between the beds of 50 cm were made using hoes and shovels.

2. Liming and Organic Fertilizer Application

Liming is applied by spreading dolomite on beds that have been made with a dose of 6 tons/ha (1.95kg/plot). Then continue to apply compost organic fertilizer with doses according to the treatment.

3. Planting

Planting is carried out by digging with a depth of 3 cm with the number of seeds per planting hole: maize 1 seed, soybean 2 seeds per planting hole. The intercropping distance carried out was double-row maize 40cm x 12.5cm and soybean 30cm x 10cm. The planting materials used are maize seeds of the Bonanza variety, and Exsotic and soybean seeds of the Detap1 variety
and Grobogan.

4. Maintenance

Maintenance carried out includes fertilization, pest and disease control, weeding, and watering. The implementation of fertilization is carried out according to the treatment dose using urea, SP36, and KCL fertilizers. Pest and disease control is carried out by applying Furadan and spraying using FENITE Insecticide and Cabrio Fungicide.

5. Harvesting

Harvesting for maize plants is carried out when the maize is physiologically ripe or about 105-110 days old. Harvesting for soybean plants is carried out when the soybean plants have shown the characteristics of soybeans that can be harvested, including the leaves (90-95%) have turned yellowish and browned and then fallen, and the soybean pods have matured by showing that the soybean pods are fully filled, and the pods are yellowish-brown.

The parameters of soybean vegetative observation were plant height (cm) and number of branches. The data was statistically analyzed using the F test, and if the difference was real, it was followed by the Tukey Smallest Real Difference (BNT) test at a real level of 0.05.

Results and Discussion

Effect of Variety on Plant Height, and Number of Soybean Plant Branches

Based on the results of the Tukey test, it can be seen that the variety has a real effect on the height of soybean plants aged 14, 21, 28, 35, and 42 DAP, and the number of branches 35 and 42 DAP.

Plant Height

Table 1. Average plant height in the treatment of soybean plant varieties aged 14, 21, 28, 32, and 42 DAP

Treatment	Varieties				
	14 DAP	**21 DAP**	**28 DAP**	**35 DAP**	**42 DAP**
V1	12.48a	16.09a	22.83a	31.81ab	43.19a
V2	12.37a	16.05a	22.97a	32.51a	42.95A
V3	11,11b	13.45b	20.09b	29.58b	33.15b
V4	11.56ab	13.25b	19.68b	29,00B	33.52b

The same letter in the same column indicates an unnoticeable difference in the 5% Tukey test

Based on Table 1, the highest soybean crops were found in the intercropping treatment of soybean varieties Detap1 + Bonanza (V1) and Detap1 + Exotic (V2) varieties which were significantly different from the Grobogan + Bonanza (V3) and Grobogan + Exotic (V4) varieties at all observation ages. This shows that the Detap1 variety has better adaptability than the Grobogan soybean variety in terms of intercropping with maize. In addition, the difference in plant height is a genetic character between each variety used. This genetic character can serve as a characteristic that will always appear as a differentiator for each variety in different phases of growth. According to Sutopo (2008), when varieties are propagated, they will exhibit traits that can be distinguished from other varieties.

Indonesia has very diverse soybean varieties where each variety has unique genetic traits, as seen from their appearance and characteristics. Such genetic diversity gives rise to different growth responses and production levels (Zahrah, 2011). Hayati (2011) added that although each variety has good growth potential and productivity, it takes time to adapt to certain environments and that it cannot fully demonstrate superior traits. Agung & Rahayu (2004) adds that differences in genetic traits cause

variations in the responses of some varieties to various environmental conditions. The height of the plant can be affected by the variety, planting distance, and fertilizer application. Soybean plants can grow tall due to tight spacing, which leads to etiolation due to the lack of direct sunlight received (Rasyid, 2013).

Number of Branches

Table 2. Average number of plant branches in the treatment of soybean plant varieties aged 14, 21, 28, 32, and 42 DAP

Treatment	Varieties				
	14 DAP	**21 DAP**	**28 DAP**	**35 DAP**	**42 DAP**
V1	0,00	1,02	3,05	3.93a	4.50A
V2	0,00	1,25	3,23	4.03a	4.47A
V3	0,00	1,52	2,72	2.95b	3.23b
V4	0,00	1,50	2,32	2.68b	2.93b

The same letter in the same column indicates an unnoticeable difference in the 5% Tukey test

The number of soybean branches in the intercropping system is influenced by the soybean and maize varieties used at the age of 35 and 42 DAP. The highest number of branches at the age of 35 DAP was found in the V2 treatment while at the age of 42 DAP the largest number of branches was found in the V1 treatment (Table 2). The results show that the Detap1 variety is able to maintain the number of production branches according to the variety description. The Detap1 soybean variety was released in 2017 which is the result of crossing G511H with the Anjasmoro variety. Genetically, this variety produces 3-6 number of branches per plant (DPKP DIY, 2023). Each variety of soybeans has different genetic characteristics in terms of branch formation. In the intercropping system, the interaction with the maize plant affects the number of soybean branches (Permanasari & Kastono., 2012). Some soybean varieties have better adaptability in intercropping conditions, resulting in more branches. Soybean varieties that have strong roots and are tolerant of light competition from maize plants tend to produce more branches than varieties that are more sensitive to shade (Wu et al., 2017).

Plants that are planted intercropping affect each other's growth and yield. In this study, the Detap1 variety gave a good response to the intercropping system compared to the Grobogan soybean variety. The results of the study Kriswantoro & Hermanto (2013) showed that soybean plants planted with the maize intercropping system had a very real influence on plant height, number of branches, number of pods, weight of 100 seeds, production per plot. Productive branches are formed from the results of carbohydrate photosynthesis in the plant body. The rate of photosynthesis is

influenced by various factors including light intensity and water absorption. Increased light intensity can ultimately increase productive branches per plant.

Effect of Fertilizer Dosage on Plant Height, and Number of Soybean Plant Branches Plant Height

Table 3. Average plant height in the treatment of soybean fertilizer doses aged 14, 21, 28, 32, and 42 DAP

Treatment	Fertilizer Dosage				
	14 DAP	**21 DAP**	**28 DAP**	**35 DAP**	**42 DAP**
D1	12.05ab	14,30	19.68b	27.80c	34.27c
D2	11.40b	14,15	20.24ab	28.69bc	35.39bc
D3	11.70ab	15,13	22.54A	32.39a	39.53ab
D4	11.23b	14,79	22.24a	31.88ab	40.93a
D5	13.01a	15,18	22.26a	32.86A	40.87A

The same letter in the same column indicates an unnoticeable difference in the 5% Tukey test

Table 3 shows the average height of soybean crops in intercropping with maize due to fertilizer dose treatment, where the results were significantly different in all ages except 21 DAP. At the age of 14 DAP the best fertilizer dose was found in the D5 treatment, at the age of 28 and 35 DAP the best plant height was found in the D3 treatment, while the height of soybean plants at the age of 42 DAP was found in the D4 treatment.

The results of this study show that the reduction of the combination of recommended fertilizers and organic fertilizers is still able to maintain the growth of soybean plants well. The higher plant height may be due to the gradual release of essential nutrients from chemical fertilizers and organic fertilizers as per the needs of the maize plant. The results of this experiment confirm the findings Rahmatullah (2011) which report that chemical fertilizers and organic fertilizers given as essential nutrients in the early stages of growth produce the best results for the parameters measured, such as plant height. The increase in plant height with the application of combination fertilizers is due to the greater availability of nitrogen from urea and manure during the growing season. These results are in line with the findings Gonzalez (2001) and Mitchell & Tu (2005) which reported that a combination of 50% chicken manure and 50% chemical fertilizer resulted in the highest maize crop compared to the control plots in the maize-soybean cropping system.

Number of Branches

Based on Table 4, fertilizer dosage had a real effect on the number of soybean branches aged 21, 28, and 35 DAP, but had no real effect on 14 and 42 DAP. At 14 DAPs, no branches have yet appeared, while at 42 DAPs, soybean plants have entered the flowering phase so that the nutrients absorbed are no longer used to multiply the number of branches. At the age of 21 DAP, the number of branches is highest in the D5 treatment, while at the age of 28 and 35 DAP the number of branches is the highest in the D3 treatment.

Table 4. Average number of plant branches in the treatment of soybean fertilizer doses aged 14, 21, 28, 32, and 42 DAP

Treatment	Fertilizer Dosage				
	14 DAP	**21 DAP**	**28 DAP**	**35 DAP**	**42 DAP**
D1	0,00	0.48b	1.75b	2.56b	3,31
D2	0,00	1.25A	2.90ab	3.29ab	3,60
D3	0,00	1.50A	3.38A	3.96A	4,29
D4	0,00	1.60A	3.31A	3.81A	4,04
D5	0,00	1.77A	2.81ab	3.38ab	3,67

The same letter in the same column indicates an unnoticeable difference in the 5% Tukey test

The dosage of 40 tons/ha of organic fertilizer (D5) and the recommended dose of 50% fertilizer + 20 tons/ha of organic fertilizer (D3) is better than 100% of the recommended fertilizer. This shows that the combination of recommended fertilizer and organic fertilizer at the right dose is able to stimulate soybean plants for the formation of productive branches. Similar results from the study Saleem (2010) stated that the application of solid fertilizer decanter of oil palm waste at doses of 15 and 45 tons/ha had a significant effect on plant height, number of productive branches, and other generative parameters in soybean plants. In soybeans, the productive branch is related to the potential of the soybean product. According to Amir (2021), the more branches the potential for pods to appear.

Conclusion

The combination of varieties and fertilizer doses has a significant effect on the growth morphology of maize and soybeans in the intercropping system. The combination of soybean and maize varieties significantly affected soybean plant height at 14, 21, 28, 35, and 42 Days After Planting (DAP) and the number of branches at 35 and 42 DAP. The recommended fertilizer dosage level had a notable impact on

soybean plant height at 14, 28, 35, and 42 DAP, as well as on branch count at 21, 28, and 35 DAP. Further research is needed to studies on different varieties and fertilizer doses to obtain more optimal results in agroecological cultivation models.

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