EFFECT OF RICE STRAW MULCH AND BIOFERTILIZER ON SOYBEAN (*Glycine max* L. Merr.) YIELD

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ABSTRACT

The use of straw mulch and biological fertilizer is expected to provide sufficient and balanced nutrients for the growth and yield of soybean plants. This study aims to determine the effect of the dose of rice straw mulch and biological fertilizer on the yield of Anjasmoro cultivar soybeans. The study was conducted from January to April 2025 in Rancaekek Kencana Village, Bandung Regency, with an altitude of around 700 m above sea level. The study used a randomized block design with two treatment factors and three replications. The first factor was the dose of straw mulch, consisting of three levels, namely 0, 2, and 4 tons/ha of rice straw mulch. The second factor was the dose of biological fertilizer consisting of four levels, namely 50, 100, 150, and 200 kg/ha of KCl. Observations were made on the yield components and the yield of soybeans. The results showed an interaction between the dose of rice straw mulch and the dose of biological fertilizer on the number of pods per plant, seed weight per plant, harvest index, and soybean seed weight per hectare, except for the weight of 100 seeds per plant. The best treatment was a dose of 4 tons/ha of rice straw mulch and 150 kg/ha of biofertilizer, with a yield of 2.18 tons of seeds per hectare at 14% seed moisture content.

Keywords: Anjasmoro cultivar; Biofertilizer; Rice straw mulch; Soybeans.

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INTRODUCTION

Soybean (*Glycine max* (L.) Merill) contains high levels of protein, making them widely used as a food and industrial raw material (Ibáñez et al., 2020; Kudelka et al., 2021). Soybeans have low productivity, primarily when cultivated on Ultisol soils, which have low fertility, are easily eroded, and lack organic matter (Lin et al., 2023; Afrida et al., 2023). Low yields are also caused by pest and disease attacks (Bradley et al., 2021; González et al., 2020). These problems can be addressed by applying biofertilizers and organic mulch.

Biofertilizers can be used to increase soil nutrient content and availability, plant uptake, and resistance to pests and diseases (Harahap et al., 2022; Ajeng et al., 2022; Tariq et al., 2022). *Rhizobium* sp. bacteria can increase nitrogen uptake by plants through their symbiosis with soybean roots (Hu et al., 2023; Nakei et al., 2022). Nitrogen can also be provided to plants through free-living bacteria in the soil, one of which is *Azospirillum* sp. (Jehani et al., 2023; Cassán et al., 2020). Disease prevention can be carried out by *Pseudomonas fluorescens* and *Trichoderma harzianum* (Gade & Koche, 2022; David et al., 2018).

Mulch can be used to prevent soil erosion (Shojaei et al., 2019; Lee et al., 2018). Organic mulch can also increase the organic matter content of the soil (Dong et al., 2018). The nutrient content of organic mulch can also improve soil fertility (Ngosong et al., 2019). Other benefits of using organic mulch include maintaining soil temperature and moisture and suppressing weed growth (Sun et al., 2017; Pupalienė et al., 2015). Rice straw can be used as organic mulch for soybean plants, especially when soybeans are planted in rice fields after rice cultivation (Kader et al., 2017).

The organic material contained in organic mulch can provide a nutrient source for the growth of microorganisms, both fungi and bacteria (Zhang et al., 2020). Increasing organic matter is expected to make the application of biofertilizers, which contain *Rhizobium*, *Azospirilum*, *Trichoderma*, and *Pseudomonas*, more effective and efficient. The aim of this study was to examine the interaction between the dosage of biofertilizer and the dosage of organic mulch, in the form of rice straw mulch.

MATERIALS AND METHODS

The experiment was conducted in an open field with Ultisol soil in Rancaekek Village, Bandung Regency, at an elevation of approximately 700 m above sea level and in the Oldeman agroclimatology zone D2. The study was conducted from January to April 2025.

The experiment used a randomized block design with two treatment factors and three replications. The first factor was straw mulch (M), consisting of three doses of rice straw mulch: 0 (m_0), 2 (m_1), and 4 (m_2) tons/ha. The second factor was biofertilizer (P), consisting of four levels: 1 (p_1), 2 (p_2), 3 (p_3), and 4 (p_4) L/ha.

The materials used were Anjasmoro soybean cultivar seeds (14% moisture content, 98% viability); biofertilizer containing *Rhizobium* sp., *Azospirilum* sp., *Trichoderma harzianum*, and *Pseudomonas fluorescens*; Rice straw; urea, SP36, and KCl fertilizer. The required tools are an analytical balance and cultivation equipment.

A 4 x 5 m^2 plot was prepared. Soybean seeds were planted with a spacing of 25 cm x 25 cm, with two seeds per planting hole (a population of 640 plants per plot). Straw mulch was applied between planting holes before planting at a dose according to the treatment. Biofertilizer was diluted with water to a concentration of 3 mL/L, then applied to the planting holes. Half the biofertilizer dose was applied at planting, and the other half 4 weeks after planting (WAS). Synthetic fertilizer was applied between planting holes at a rate of 50 kg/ha of urea, 200 kg/ha of SP36, and 150 kg/ha of KCl.

Observations were conducted at harvest time (82 days after planting (DAP)). Fifteen plants were randomly sampled per plot. Observations included the number of pods per plant, the weight of 100 seeds per plant, the weight of seeds per plant, and the harvest index. The data were analyzed using the F test at a significance level of 5%, then analyzed using the Duncan Multiple Range Test at the same significance level.

RESULTS AND DISCUSSION

Results

The results showed an interaction between the rice straw mulch dose and the biofertilizer dose on the number of pods per plant, seed weight per plant, and harvest index. The single effect of mulch dose or biofertilizer dose also significantly affected the number of pods per plant, seed weight per plant, harvest index, and yield per hectare (Table 1).

Table 1. ANOVA Results Between the Effect of Straw Mulch and Biofertilizer on the Observation Variables and Their Interaction Effects

Variables	Interaction effect	Single effect of rice straw mulch dose	Single effect of biofertilizer dose
Number of pods/plant	*	*	*
Weight of 100 seeds	ns	ns	ns
Weight of seeds per plant	*	*	*
Harvest Index	*	*	*

Notes: * was significant, ns was not significant

The results of the variance analysis showed that there was an interaction effect between the dose of rice straw mulch and the dose of biofertilizer on the number of pods per plant, seed weight per plant, and harvest index. The dose of biofertilizer 4L/ha provided the best number of pods, seed weight per plant, and harvest index at the level of 0 – 2 tons/ha of straw mulch, while the dose of biofertilizer 3L/ha provided the best number of pods, weight of seeds per plant, and harvest index at the level of 4 tons/ha of straw mulch (Table 2-4).

Table 2. Interaction Effect of Treatments on The Number of Pods Per Plant

Rice Straw Mulch Dose	Biofertilizer Dose			
	1L/ha	2L/ha	3L/ha	4L/ha
0 ton/ha	17.52 a A	16.52 a A	17.54 a B	18.61 a C
2 ton/ha	25.60 b A	25.67 b A	26.71 b B	27.80 b C
4 ton/ha	26.66 b A	26.84 b A	29.19 c C	27.92 b B

Notes: Numbers followed by the same lowercase letter in the same column or the same uppercase letter in the same row showed no significant difference based on Duncan's test at a significance level of 5%

The analysis of variance showed no interaction between the rice straw mulch dose and the biofertilizer dose on the weight of 100 seeds per plant. Neither the straw mulch dose nor the biofertilizer dose had a significant effect on the weight of 100 seeds per plant (Table 5).

Table 3. Interaction Effect of Treatments on the Weight of Seeds per Plant (g)

Rice Straw Mulch Dose	Biofertilizer Dose			
	1L/ha	2L/ha	3L/ha	4L/ha
0 ton/ha	8.23 a A	8.74 a A	9.44 a B	10.04 a C
2 ton/ha	10.62 b A	10.67 b A	11.74 b B	11.85 b C
4 ton/ha	10.65 b A	10.83 b A	13.10 c C	12.04 b B

Notes: Numbers followed by the same lowercase letter in the same column or the same uppercase letter in the same row showed no significant difference based on Duncan's test at a significance level of 5%

Table 4. Interaction Effect of Treatments on The Harvest Index

Rice Straw Mulch Dose	Biofertilizer Dose			
	1L/ha	2L/ha	3L/ha	4L/ha
0 ton/ha	0.39 a A	0.39 a A	0.42 a B	0.44 a C
2 ton/ha	0.45 b A	0.45 b A	0.47 b B	0.49 b C
4 ton/ha	0.45 b A	0.46 b A	0.54 c C	0.50 b B

Notes: Numbers followed by the same lowercase letter in the same column or the same uppercase letter in the same row showed no significant difference based on Duncan's test at a significance level of 5%

Table 5. The Single Effect of Mulch and Biofertilizer Doses on The Weight of 100 Seeds

Treatments	Weight of 100 Seeds (g)
Rice Straw Mulch Dose	
0 ton/ha	14.51 a
2 ton/ha	14.50 a
4 ton/ha	14.48 a
Biofertilizer Dose	
1L/ha	14.58 a
2L/ha	14.62 a
3L/ha	14.69 a
4L/ha	14.76 a

Notes: Numbers followed by the same letter in the same column showed no significant difference based on Duncan's test at a significance level of 5%

Discussion

This study revealed the interaction between rice straw mulch and biofertilizer doses on soybean yield components. The interaction is due to the beneficial effect of straw mulch on

the growth and development of microorganisms present in the biofertilizer. The results demonstrated that this interaction occurs when the addition of straw mulch reduces the biofertilizer dose.

Straw mulch is known to maintain soil water availability, thus maintaining soil humidity and temperature (Kader et al., 2017). With water, whether sufficient or excess, microorganisms can grow well (Yan et al., 2015). Water is necessary not only for substrate transport but also for enzymatic processes through hydrolysis (Fricke, 2017). Excess water will result in limited oxygen in the soil, reducing the activity of aerobic microorganisms (Berg et al., 2022). However, microorganisms such as *Azospirilum* and *Pseudomonas*, used in this study, can fix nitrogen in oxygen-depleted conditions (Zehr et al., 2006). *Rhizobium* bacteria can also adapt to anaerobic environments by forming nitrogen-fixing nodules on soybeans (Wiraguna et al., 2021).

The presence of straw mulch can also provide carbon and energy for microorganisms by degrading the organic matter within it (Ngosong et al., 2017). Organic matter also increases soil cation exchange capacity and soil aeration, which are beneficial for soybean plants (Ramos et al., 2018; King et al., 2020). Furthermore, increased soybean growth will enhance the symbiosis with *Rhizobium* (Albrecht et al., 1984). Root infection, leghemoglobin activity, and nitrogenase are influenced by plant nutrients (Bagale, 2021).

Microorganisms can break down the decomposition of lignin, polysaccharides, or nucleic acids into simple compounds and then transform them into complex compounds, such as sulfuric acid or humic acid (Feng et al., 2024). As we know, humic and fulvic acids are organic materials that can increase nutrient availability to plants, thus benefiting plant growth and yield.

The interaction between rice straw mulch and biofertilizer doses in increasing nutrient availability for plants resulted in increased soybean yield components, such as the number of pods per plant. This resulted in increased crop yields.

CONCLUSION

There is an interaction effect between straw mulch treatment and biofertilizer on the number of pods per plant, seed weight per plant, and Harvest Index, while the weight of 100 seeds per plant does not show an interaction effect.

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