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The Application of Different Types and Doses of Organic Mulch on Weed Growth and Soybean (*Glycine Max* L.) Growth and Yield

Enga Fadhli[1], Hasanuddin[2], dan Siti Hafsah[2]
[1]*Student, Master of Agrotechnology, Faculty of Agriculture,Syiah Kuala University, Banda Aceh*
[2]*Lecturer, Master of Agrotechnology, Faculty of Agriculture, Syiah Kuala University, Banda Aceh*

Abstract
The aim of this study was to determine the right types and doses of organic mulch to reduce weed growth and increase soybean growth and yield. This study used a 2 × 4 randomized block factorial design with 4 replications of the different factors of types and the doses of organic mulch. The first factor was the type of organic mulch: Siam weed and neem, and the second factor was the dose of organic mulch: 0; 8; 16; and 24 ton ha^{-1}. The variables observed were number of pods per plant, number of seeds per plant, the weight of seeds per plant, the weight of 100 grains, and yield of dry seeds. The results showed that types of organic mulch affected the number of pods planted, the number of seeds planted, the weight of 100 seeds, and the yield of dry seeds. However, different types of organic mulch did not affect the weight of seeds planted. The doses of organic mulch affected the number of pods per plant, the number of seeds planted, 100-grain weight, and dry seed yield. However, it did not affect the weight of the seeds per plant. The results indicated that there was an interaction between the type and dose of organic mulch on the weight of the seeds per plant.

Keywords: *Siam weed, neem, soybeans*

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I. Introduction

Mulching is one of the weed control techniques that are often used by farmers. Mulch is a soil cover material for cultivated plants that can be used to help maintain soil moisture, evaporation, and suppress weed growth ensuring that plants can grow well (Umboh, 2002). Using organic mulches as weed control provides various benefits, including physical, biological, and chemical aspects of soil. Doring et al. (2006) state that the application of mulch can affect soil temperature. Soil temperature is related to the processes of photosynthesis, respiration, and nutrient absorption by plant roots (Mahmood et al., 2002).

There are several alternatives to weed control using organic mulches such as neem and Siam weed mulch. Neem is a plant that is often used as medicine (pharmacy) and pesticides in agriculture (Maithani et al., 2011). Parrotta and Chaturvedi (1994) state that the pulp from neem extract can be used as mulch for food crops. In addition, neem has an active ingredient that can control plant-disturbing organisms, often called secondary metabolic products, containing active ingredient components, i.e. azadirachtin, salanin, nimbin and meliantriol(Ruskin, 1992). Meanwhile, Siam weed contains allelopathy which can suppress weed growth in plants. The result of the research carried out by Qasem and Foy (2001) notes that several types of weeds produce allelopathy in the form of alkaloids and phenolics, one of which is Siam weed.

The aim of this study was to determine the right type and dose of organic mulch to reduce weed growth and increase soybean growth and yield.

II. Material And Methods

This research was conducted on Jl. T. Nyak Arief, Rumpeet Village, Darussalam, Aceh Besar, with coordinates of $5^0$32'51,27"N, $95^0$22'11,25" E at an altitude of 6 meters above sea level (AMSL), and the Weed Science Laboratory of the Faculty of Agriculture, Syiah Kuala University, Banda Aceh. This research was conducted from April to July 2017. The tools used in this study were a hand tractor, hoe, rake, machete, raffia rope, gembor, analytical scales (KERN EWMax. 4200 g, *Min*. 0.5 g), Oven, Punch Method (using several pipes with different diameters), measuring instruments, bucket, sitting scale (YMCCO 10 kg), and meter. The materials used were the Grobogan soybean seeds obtained from the Balai Penelitian Tanaman Aneka Kacang dan Umbi (Nuts and Tubers Research Institute) of Malang, Siam weed, mulches, and neem, Furadan, Urea, KCl and SP36, and the insecticide deltamethrin.

This study used a 2 × 4 randomized block factorial design with four replications. The first factor was the type of mulch, namely Siam weed and neem and the second factor was the mulch dose, namely 0, 8, 16, and 24 tones ha-1.

The variables observed were weed dry weight, number of pods per plant, number of seeds per plant, the weight of seeds per plant, the weight of 100 grains, and yield of dry seeds. The data obtained were analyzed using a randomized block factorial design. If the F test shows a significant effect, the analysis will be followed by the Duncan New Multiple Range Test (DNMRT) with a significant level of 5%.

III. Result and Discussion

Number of Pods Planted

The results of variance analyses showed that the types and doses of organic mulch affected the number of pods per plant. The average number of pods per soybean plant affectedby the application of the different types and doses of organic mulches can be seen in Table 1.

Table 1. The average number of pods per soybean plant after the application of the different types and doses of mulch

Treatment	Number of pods per plant
Types of mulch	…….(pod)……
Siam weed	23 a
Neem	28 b
Doses (ton ha-^{1})	
0	24 a
8	25 a
16	24 a
24	30 b

Note: The numbers followed by the same letter and column show no significant difference in the DNMRT test ($\alpha = 0.05$).

Table 1 shows that neem mulch can increase the number of pods per plant compared to Siam weed mulch. This is because the application of neem mulch does not only modify the microclimate in the soil but it can also be used as organic material to supply macro and micronutrients with a small nutrient capacity. The observations, as shown in Table 1, also prove that the application of an increasing dose of organic mulch by 24 tons ha-^{1} can increase the number of pods per plant. Increasing doses of organic mulch can provide a good density in covering the soil surface so that it can affect the microclimate in the soil and can inhibit weed growth. As a result, nutrient competition and light intensity between weeds and soybean plants are low.

The application of neem mulch by increasing its doses can affect microbial activity in the soil like the use of organic C and N derived from neem mulch. Moreover, such application can also increase soil fertility because it can provide a supply of nutrients needed by soybean plants in pod formation (Mendham et al., 2003; Muhammad et al., 2018). Increasing doses of neem mulch can modify soil microclimate conditions through maintaining soil moisture so that it is beneficial for soil microbes to decompose neem mulch into organic matter for the soil and release soil nutrients (Li et al., 2004; Mohapatra et al., 1999). Soil nutrients (N, P, and K) and the availability of groundwater provided by neem mulch can affect the photosynthesis process and the accumulation of assimilates in soybean plants including filling the pods of soybean plants (Bhardwaj, 2013).

According to Ginting (2019), the application of organic mulch as a soil cover can be used as organic material to increase soil fertility which includes several components, such asgood soil structure, increased soil CEC (Cation-Exchange Capacity), increased macro and micronutrients in the soil, increased soil biological activity and increased CO_2 absorption, which will increase growthand the development of soybean plants and affect the number of soybean pods. According to Hasanuddin (2004), pod filling in soybean plants can run well if the photosynthetic process activity occurs optimally with the supports of the availability of nutrients, water, and optimal light intensity. According to Kartono (2005), the filling of soybean pods can go well if there isan accumulation of assimilates translocated to other organs of the plant.

Number of seeds planted

The results of the variance analysis showed that the application of different types and doses of organic mulch affected the number of seeds per plant. The average number of seeds per plant after the application of the type and dose of organic mulch can be seen in Table 2.

Table 2. The average number of seeds per soybean plant due to the application of the type and dose of organic mulch

Treatment	Number of seeds per plant
Types of mulch	…….(seeds)…….
Siam weed	46 a
Neem	56 b
Dose (ton ha^{-1})	
0	48 a
8	50 a
16	47 a
24	57 b

Note: The numbers followed by the same letter and column show no significant difference in the DNMRT test ($\alpha = 0.05$).

Table 2 illustrates that the application of neem mulch can increase the number of seeds per soybean plant compared to Siam weed mulch. It happens because the application of neem mulch can modify the microclimate in the soil and can be used as organic material to support pod formation or the number of soybean plant seeds formed. Increasing the doses of organic mulch can increase the number of seeds per soybean plant. Increasing doses of organic mulch affect the formation of soybean pods because it can modify the microclimate in the soil as well as the availability of nutrients and water needed by soybean plants in the assimilation process during the pod formation process so that it affects the number of seeds formed. The application of increasing doses of organic mulch can also affect the sunlight intensity which may be optimally absorbed by soybean plants because competition between weeds and soybean plants is low.

The availability of water in the soil needed by soybean plants during the pod formation process determines the number of seeds formed. If the availability of water in the soil is not optimal, the formation of pods through assimilates results received from the photosynthesis process could be affected. The availability of water in the soil can be maintained by using organic mulch to modify soil moisture so that it does not experience rapid evaporation (Adeboye et al., 2015).

The application of neem mulch with an increased dose affects the intensity of sunlight absorbed by the soil causing the temperature in the soil to change.It can affect the assimilation results from photosynthesis for pod formation through the flowering phase in soybean plants. This finding is supported by the study conducted by Raza et al. (2019) which found that the initiation of flowering in the photosynthetic process in soybean plants greatly affects the intensity of sunlight needed by soybean plants in the photo-assimilation process for the formation of soybean pods. Kartono (2005) states that the vegetative growth of soybean plants will affect the production of these plants. Increased vegetative growth in soybean plants may help increase assimilates in the photosynthesis process that can be useful for the growth of soybean plant organs.

Weight of Seeds per Plant

The result of variance analysis indicates that the types of applied mulch significantly affected the weight of seeds per plant while the doses of the mulch showed no significant effect on it. The interaction between the types and doses of the organic mulch affecting the weight of seeds per soybean plant is presented in Table 3.

Table 3. The average weight of seeds per soybean plant as the result of the interaction between types and doses of organic mulch

Treatment	Weight of Seeds per Plant (g)			
	Doses (ton ha^{-1})			
	0	8	16	24
Types of Mulch				
Siam Weed	10.12 abA	10.40 Ba	7.50 aA	10.73 bA
Neem	10.05 aA	10.86 abA	12.71 bB	13.77 cB

Note: The numbers followed by the same letter (horizontal lowercase and vertical uppercase) show no significant difference in the DNMRT test ($\alpha = 0.05$)

Table 3 shows that the application of the organic mulch with the increasing mulch doses up to 24 ton ha^{-1} caused the weight of seeds per plant to increase. The application of neem mulch with the doses of 24 ton ha^{-1} was able to increase the weight of seeds per soybean plant. The application of neem mulch with increasing doses allegedly influenced changes in soil moisture and soil temperature which might support the development of soybean pods, especially the weight of its seeds. The changes in soil moisture and temperature might also lead to nitrogen fixation by rhizobium contained inactive soybeans which could help soybean pod development focusing on the weight of its seeds.

This fact is supported by Turmudi (2002) which states that the N element as a result of fixation is used by bacteria in the soil or the main crop to support the growth and formation of pods while some of it will be translocated to the root area which can be translocated again to other plant organs. Root nodules of the roots in soybean plants are able to fix N in the symbiosis with Rhizobium sp. Besides, Rao (1994) says that root nodules can effectively fix N from the air and convert N into amino acids that are absorbed by plants to support the soybean pod development, especially the weight of its seeds. Moreover, according to Hasanuddin (2004), the results of photosynthesis, the energy in the form of ATP will be translocated to soybean plant organs, particularly the pods.

Applying neem mulch to cover soil surface can support the production of soybean plants by inhibiting soil erosion and increasing N (Ciaccia et al., 2015). Additionally, Siberali and Mohammadi (2015) say that the increase of N in soybean plants and the supply of N by N_2 fixation must also be supported by the capacity of the soil to absorb through the application of neem mulch as the cover of the soil surface and as the organic matter. The result of soybean yields with the application of organic mulch depends not only on the type of N source but also on the release rate of N available in these organic materials as the nutrient sources with slow and stable absorption.

Furthermore, the availability of water in the soil using organic mulch is a crucial factor supporting the growth of plants because of its function as the nutrient solvent that translocates nutrients and photosynthesis results (Agung and Rahayu, 2004). In addition, according to Nugraha et al. (2014), lack of water during the seed-filling stage of soybean pod cavity might result in a lower number of pods and weight of seeds per plant.

Weight of 100 Seeds

The results of the variance analysis indicate that the types and doses of applied organic mulch affected the weight of 100 seeds. The average weight of 100 seeds due to the types and doses of organic mulch application can be seen in Table 4.

Table 4. The average weight of 100 seeds due to types and doses of organic mulch application

Treatment	Weight of 100 Seeds
Types of Mulch	…….(g)…….
Siam Weed	18.51 a
Neem	19.07 b
Doses (ton ha^{-1})	
0	18.63 a
8	19.02 b
16	18.90 a
24	18.60 a

Note: The numbers followed by the same letter and column show no significant difference in the DNMRT test ($\alpha = 0.05$)

Table 4 shows that the application of neem mulch was able to increase the weight of 100 seeds better than was the siam weed mulch. This was because of the optimal absorption of nutrients, water, and light intensity. The modification of the microclimate in the soil caused by the application of neem mulch resulted in inhibition of weed growth and less competition between the weeds and the soybean plants. This caused the soybean plants to absorb nutrients, water, and light intensity optimally when developing the pods. Table 4 also shows that the application of organic mulch with a doses of 8 tons ha^{-1} could affect the weight of 100 seeds of the soybean plants.

The application of the organic mulch with increasing doses to soybean plants increased soil fertility by modifying the microclimate and becoming soil organic matter. The decomposition of organic mulch with increasing doses caused the nutrients water to be absorbed optimally by soybean plants through the microclimate modification by the organic mulch. The microclimate modification through the application of increasing doses of organic mulch to soybean plants caused nitrogen fixation by *Rhizobium* contained in active soybeans which support the formation of soybean pods, particularly the weight of 100 seeds.

This is in line with Vamerali et al. (2012) that state that the use of neem mulch to cover the surface of the soil can affect the growth and production of soybean plants related to the of N in soybean plant roots. The accumulation of N in the roots of the soybean plants can be used to absorb macro and micronutrients in the soil that can be translocated to other plant organs to support pod development and increase the weight of 100 seeds.

In soybean plants, the N assimilation can increase under the increase in CO_2 contained in the air or the soil due to the application of organic mulch in proportion to the increase in soybean plant biomass, so that the C/ N ratio in soybean plants will not change. Soybean plant leaves experiencing developmental aging phase can be a source of N to be mainly used in developing pods and increasing seed weight (Rogers et al., 2006; Araujo et al., 2012).

Tavares et al. (2011) and Mehmet et al. (2009) add that the application of organic mulch to cover the soil surface has a positive impact on the value of $\overline{ILD}$, $\overline{LTT}$, and $\overline{LAB}$, so that it also has a very significant effect on the weight of 100 soybeans. Since the value of $\overline{ILD}$, $\overline{LTT}$, and $\overline{LAB}$ is in line with the intensity of sunlight absorbed by the plants, it might help the development of soybean pods.

Dry Seed Weight

The results of the variance analysis show that the types and doses of organic mulch affected the production of dry soybean seeds. The average dry seed weight due to the application of the types and doses of organic mulch can be seen in Table 5.

Table 5. The average weight of dry seed due to the application of the types and doses of organic mulch

Treatment	Dry Seed Weight
Types of Mulch	…….(g m^{-1})…….
Siam Weed	1461 a
Neem	1744 b
Doses (ton ha^{-1})	
0	1544 ab
8	1593 ab
16	1434 a
24	1838 b

Note: The numbers followed by the same letter and column show no significant difference in the DNMRT test ($\alpha = 0.05$)

Table 5 shows that the application of neem mulch was able to increase the dry seed weight better than was the siam weed mulch. This was due to the wide surface area of the neem leaves covering the soil surface which could inhibit the growth of weeds competing with the soybean plants for nutrients, water, and sunlight. The inhibition of weed growth through the application of neem mulch could be influenced by allelopathic compounds contained in the neem mulch.

It is also presented in Table 5 that the application of organic mulch with increasing doses up to 24 tons ha^{-1} could affect the yield of dry soybean seeds. The application of the organic mulch with increasing doses influenced the availability of nutrients and water in the soil to support the seed-filling stage of soybean pod cavity associated with the yield of dry seeds of soybean plants. The availability of nutrients, water, and sunlight could optimally support the photosynthesis process and the translocation of the photosynthesis results (photosynthate) to the organs of soybean plants including the pods. The inhibition of growth and development of weeds due to the application of the organic mulch with increasing doses supported the photosynthesis process and resulted in photosynthate in the form of soybean dry seeds.

This result is supported by Akhtar et al. (2019) which implies that applying organic mulch and optimizing the intensity of sunlight absorbed by soybean plants can support photo energy processes in the form of photosynthesis and photostimulus including the process of stem elongation, leaf expansion, chlorophyll formation, and pod development. In general, the photo energy process or photosynthesis requires a greater intensity of sunlight than to stimulate plant growth and movement.

However, the application of organic mulch with an incorrect dose can cause non-optimal availability of nutrients and water in the soil with low sunlight intensity due to the canopy between soybean plants that shade each other and affect the distribution of photosynthate in soybean plants. The low photosynthetic rate in soybean plants can cause the dry seed yield remains low. On the other hand, if the rate of photosynthesis is optimal, it can increase the productivity of the dry seeds of soybean plants. In addition, low intensity of sunlight might result in competition between soybean plants and weeds and even among the soybean plants. This competition can influence the sharing of photosynthate. The capacity or competitiveness of soybean plants is determined by the efficiency of soybean plants in absorbing sunlight intensity (Darmijati, 1992).

Furthermore, Karamoy (2009) explains that the production of dry seeds in soybean plants, apart from being influenced by the amount of sunlight absorbed by the plants, can also be influenced by the level of efficiency of sunlight absorption by the soybean plants in the photosynthesis process for filling the pods. At the end of the flowering stage, with the cessation of vegetative growth, carbohydrates are accumulated in the soybean stems which are used for filling the pods. The production of dry seeds slowly increases starting about 10 days after the flowering stage, and it becomes faster after one week.

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