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The Combination of Urea and Catfish Organic Fertilizer on the Vegetative Growth of Soybean Plants in Regosol Soil

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Abstract: Soybean (*Glycine max* L.) is the third most important food crop after rice and maize in Indonesia. Improving soybean productivity is essential, particularly through efficient fertilization strategie. This study aimed to evaluate the effect of different combinations of urea fertilizer and catfish organic fertilizer on the vegetative growth of soybean cultivated in regosol soil. The experiment was conducted using a Completely Randomized Design (CRD) with a single factor consisting of five fertilizer treatments: P1 (0.6 g urea), P2 (0.45 g urea + 1.1 g catfish organic fertilizer), P3 (0.3 g urea + 2.2 g catfish organic fertilizer), P4 (0.15 g urea + 3.3 g catfish organic fertilizer), and P5 (4.4 g catfish organic fertilizer). Each treatment was replicated four times. Observed parameters included plant height, number of leaves, leaf area, fresh and dry shoot weight, fresh and dry root weight, root length, and soil pH. The results indicated that the application of 4.4 g catfish organic fertilizer produced vegetative growth comparable to that of 0.6 g urea. This finding demonstrates that catfish organic fertilizer can effectively substitute urea fertilizer during the vegetative growth phase of soybean cultivated in regosol soil. The use of catfish organic fertilizer offers a sustainable alternative for reducing dependence on synthetic nitrogen fertilizers while maintaining soybean growth performance.

Keywords: Nitrogen, Organic Fertilizer, Soybean, Regosol Soil

1.0 Introduction

Soybeans are the third most important food commodity after rice and corn. Soybeans are a good source of nutrition for humans (Alı et al., 2020). Soybeans contain 35-38% protein, which is higher than other types of legumes (Garcia et al., 1997). Demand continues to increase in line with population growth. However, this demand cannot be met due to the low productivity of these plants. According to Harsono et al. (2021) Soybean production in Indonesia in 2020 was 1.5 million tons, while in 2018 it was 1.7 million tons. This shows that soybean productivity has declined. Low soybean productivity can be caused by reduced soil fertility, which results in lower soybean yields.

Regosol soil is soil that originates from various alluvial sources such as volcanic ash, river sedimentation, and marine quartz deposits, so it is commonly found around rivers (Regassa et al., 2023). Regosol soil has a sandy texture. Loose structure, water retention capacity, and easily lost nutrients, as well as soil colloids and nutrients that are easily lost through leaching (Mureithi et al., 2024). Regosol soil has an organic C content (0.94%), available N (70.95 ppm), pH (6.24), and CEC (6.04 me100g -1). Regosol soil is a type of soil with low fertility potential, especially for nitrogen nutrients, but it can still be improved with inputs such as fertilizer application.

Fertilizer is a substance added to the soil, either organic or inorganic, with the aim of replacing nutrients in the soil that can increase crop production under good environmental conditions (Verma et al., 2019). According to Bagale (2021), soybeans, like other crops, also require fertilizer as a source of nutrients. A common problem in fertilization is the low efficiency of nutrient uptake by plants. The efficiency of N and K fertilization is relatively low, ranging from 30-40%, and the efficiency of P absorption is also low, ranging from 15-20%. Nitrogen is very important for the development of plant structures such as leaves, stems, and roots, which are involved in vegetative growth (Leghari et al., 2016). Urea is a single fertilizer containing high nitrogen (N) at 46%. According to Beig et al. (2020), urea fertilizer has hygroscopic properties, meaning it easily absorbs water and reacts quickly, making it easily absorbed by plant roots. However, this property also has disadvantages if applied on the surface and not. When applied to the soil, it will undergo volatilization

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of up to 40% of the amount applied. According to Overrein & Moe (1967), the rate at which urea undergoes hydrolysis depends on soil conditions, but in general, urea begins to undergo hydrolysis on the fifth day after application.

There is a need to find ways to improve the efficiency of soybean fertilization. Efforts to improve fertilizer use efficiency can be achieved through the principles of right type, right dosage, right method, right application time, and balanced according to plant needs. In addition, the continuous use of synthetic fertilizers can cause soil damage, so it is necessary to balance this with the use of organic fertilizers (Pahalvi et al., 2021). Furthermore, the combination of organic fertilizers provides several benefits, one of which is reducing production costs. One such fertilizer is solid catfish waste. Intensive catfish farming requires high-nutrient feed to ensure the survival of the fish and rapid growth. However, until now, solid catfish waste has simply been discarded after harvest (Edwards, 1993). This can pollute the environment due to its unpleasant odor. In fact, solid catfish waste has the potential to be used as organic fertilizer. Organic fertilizer is fertilizer derived from plant, animal, or human waste, such as manure, green manure, and compost (humus), which can be in liquid or solid form and can improve the physical properties and structure of the soil, improving water retention, soil chemistry, and soil biology. The solid waste content of catfish farming includes N 6.23%, P 4.46, K 3.21, C/N ratio 6.71, and pH 7-8. Thus, organic catfish fertilizer has the potential to be a source of nitrogen (N) needed by soybean plants during the vegetative growth phase (Li et al., 2006). The purpose of this study was to determine the effect of urea fertilizer and organic catfish fertilizer on the vegetative growth of soybean plants.

2.0 Material and Methods

2.1 Time and Location of Study

This research was conducted at the experimental field of the Faculty of Agriculture, Muhammadiyah University Yogyakarta, from February to June 2022. The analysis was carried out at the Soil Science Laboratory of Muhammadiyah University Yogyakarta and the Soil Science Laboratory of Gadjah Mada University.

2.2 Research Tools and Materials

The tools used in this study were hoes, analytical scales, ovens, sieves, trays, shovels, LAM (Leaf Area Meter), labels, and writing instruments. The materials used were Gema variety soybean seeds, regosol soil, Urea, Sp-36 and KCL fertilizers, organic fertilizer, catfish, and 35x40 cm polybags.

2.3 Research Design

This study was an experimental trial using a completely randomized design (CRD) with a single factor and five treatments, as follows: P1: Urea 0.6 g, P2: Urea 0.45 g + Organic Fertilizer Lele 1.1 g, P3: Urea 0.3 g + Organic Fertilizer Lele 2.2 g, P4: Urea 0.15 g + Organic Fertilizer 3.3 g, P5: Organic Fertilizer Catfish 4.4 g. Each balanced treatment of Catfish Organic Fertilizer and Urea was repeated 4 times, resulting in 20 experimental units.

2.4 Experimental Procedure

The research began with the selection of Gema variety seeds, followed by land preparation, which involved clearing the land of rocks/gravel, weeds, and plant debris. Next, each polybag was filled with 10 kg of sifted regosol soil that had been cleaned of dirt and weeds. Planting was carried out by inserting 1 seed per planting hole, and the 5 cm deep holes were covered with soil. Basic fertilization was carried out 7 days before planting with 100 kg/ha of SP-36 and 100 kg ha -1 of KCl.

Maintenance includes watering, weeding, transplanting, and pest and disease control. Watering is done with a 250 ml -1 measuring cup per plant every morning and evening or according to weather conditions. Transplanting is done if there are abnormal or dead seedlings. Pest and disease control are done if there are signs of pest or disease attack. Soybean plants are harvested after the maximum vegetative stage of the plant at 30 days after planting. At the beginning of the study, soil samples were taken to observe soil properties by analyzing the samples in the laboratory along with analyzing the fertilizer to be used.

2.5 Research Variable

2.5.1 Plant Height (cm)

Plant height measurements were taken every 10 days from 1 week after planting to 30 days after planting (until the vegetative stage) by measuring the height of the plant from the base of the stem to the tip of the stem using a ruler.

2.5.2 Number of Leaves (Pieces)

The number of leaves was counted every 10 days by counting the number of leaves that had opened, soybean leaves.

2.5.3 Leaf Area (cm^2)

Leaf area is measured using a Leaf Area Meter (LAM). The leaves to be measured are first cut, then measured using the LAM and expressed in cm^2

2.5.4 Fresh Canopy Weight (g)
Fresh weight calculations for plants are performed using the weighing method. Fresh weight observations for plants will be conducted at the end of the observation period, which is 30 days after planting.

2.5.5 Dry Weight of Canopy (g)
The dry weight of the plants was calculated using the oven drying method at 60°C for 24 hours and analytical weighing until the weight was constant. Dry weight measurements of plants will be taken at the end of the observation period, namely 30 HST.

2.5.6 Fresh Root Weight (g)
Fresh root weight is calculated at harvest by pulling up the plants, then cutting the base of the stem and weighing the cleaned roots.

2.5.7 Dry Weight Roots (g)
The dry weight of the roots is calculated by air-drying the roots for 24 hours and then oven-drying them at a temperature of 60°C until their weight remains constant. The dry weight of the roots is observed by weighing the oven- dried roots using an analytical balance and expressed in grams (g).

2.5.8 Root Length (cm)
Root length is measured using a ruler, and observations are made at the end of the observation period.

2.5.9 Soil pH
Measurements were taken at the beginning and end of the study on regosol soil and solid organic fertilizer (POPL) using a pH meter.

2.6 Data Analysis
The research data were then analyzed using Analysis of Variance (ANOVA). If there were treatments that had a significant effect, they were followed up with a True Difference Test (BNJ) at α 0.05%.

3.0 Results and Discussion
The results of the initial soil analysis are presented in Table 1, while the results of the analysis of the properties of solid organic fertilizer for catfish are presented in Table 2. The analysis results show that the soil at the research site has a low level of chemical fertility, as can be seen in Table 1, which shows slightly acidic pH, low organic C, low CEC, low total N, low P 2 O (5), and low K 2 O. According to Putinella (2014), Regosol soil is poor in organic matter, thus its ability to retain water and nutrients is very low. Gunawan et al (2019) state that soil cation exchange capacity (CEC) is related to the cations present in the soil, so if the soil CEC is low, then cations such as Ca, Mg, and Na that can be absorbed by plants are also low.

Table 2. The results of the analysis of solid organic catfish fertilizer show neutral pH values, high N, P_2O_5, and K_2O values, and very high organic C values. Rosmaniar et al (2011) found that solid catfish waste contain3 ed ammonia (NH -) levels of 0.98-21.50 mg L (-1), nitrate (NO 3) levels of 0.436- 79,227 mg L (-1), and nitrite (NO 2 content, calculated as nitrogen, was 0.229–36,216 mg L -1 , which quite meets the nitrogen requirements of soybean plants during the vegetative growth phase.

Table 1: Results of chemical and physical properties analysis of Regosol soil

Type of Analysis	Analysis Results
pH H_2 0	6.21 (Slightly acidic)
pH KCL	5.44 (Acidic)
C-Organic	0.33% (Low)
Exchangeable cations (me/100 g)	
KTK	7.59 (Low)
Ca	0.21 (Very Low)
Mg	0.16 (Very Low)
K	0.25 (Low)

Na	0.03 (Very Low)
N-Total	0.27% (Low)
NH4	271.61 mg/kg
NO_3	411.92 mg/kg
Moisture content	6.12
Available phosphorus	2.41 mg/kg
Soil texture	Sandy loam
Sand	77
Dust	11
Clay	12

Source: Analysis Results from the Department of Soil Science, Gadjah Mada University (2021).

Table 2: Analysis results of the chemical properties of organic catfish fertilizer

Type of Analysis	**Analysis Results** pH
	7 (Neutral)
N	6.12%
P_2O_5	4.01
K2O	3.11
C	20.10

Source: Analysis results from the Department of Soil Science, Gajah Mada University

4.0 The effect of urea fertilizer and organic fertilizer on the vegetative growth of soybean plants

4.1 Plant Height

The analysis of variance showed that the application of urea fertilizer balanced with organic catfish fertilizer showed a significant difference ($p<0.05\%$) at 10 days after sowing, while at 20 days after sowing and 30 days after sowing there was no significant difference in plant height. The average plant height values between treatments are presented in Table 3.

The results in Table 3 show that at 10 days after planting, the treatment of 0.15 g + 3.3 g was not significantly different from the treatment of 100% POL 4.4 g, while it was significantly different from the other treatments. The highest average value in each observation was 25% Urea 0.15 g + POL 3.3 g, followed by the POL 4.4 g treatment. Nitrogen is crucial for the development of plant structures such as leaves, stems, and roots, which are involved in vegetative growth (Ohyama, 2010).

4.2 Number of leaves

The analysis of variance results showed that the treatment of balanced urea fertilizer and solid organic fertilizer application did not have a significant effect on the number of leaves ($p>0.05\%$). However, the average treatment of 0.15 g + POL 3.3 g gave the highest average value. The combination of organic and inorganic fertilizers increased the number of leaves (Zhang et al., 2020). According to Karthika et al. (2018), the process of leaf formation is inseparable from the role of nutrients such as nitrogen and phosphorus present in the soil and available to plants. leaves and the number of leaves.

4.3 Leaf area

The results of the analysis of variance indicate that the application of urea fertilizer and organic fertilizer does not have a significant effect on the number of leaves ($p>0.05\%$). However, similar to the data on plant height and number of leaves, the treatment of 0.15 g urea + 75% POL 3.3 g resulted in the highest average leaf area (Figure 1). According to Widayanti (2008), with the addition of nitrogen to rice plants associated with chlorophyll formation in leaves, thereby enhancing photosynthesis to stimulate leaf growth and leaf area. According to Ingestad (1977), plants that do not receive sufficient nitrogen will grow stunted with small leaves, whereas plants that receive adequate nitrogen will grow tall with broad leaves.

Table 3: Effect of urea fertilizer and organic fertilizer application on soybean plant height (cm)

Treatment	Average plant height (cm) at age		
	10 days after sowing	20 days after sowing	30 HST
PI Urea 0.6 g	8.03 b	15.97 a	25.71 a
P2 Urea 0.45 g + POL 1.1 g	8.07 b	16.01 a	25.43 a
P3 Urea 0.3 g + POL 2.2 g	8.11 b	16.11 a	25.92 a
P4 Urea 0.15 g + POL 3.3 g	10.01 a	18.05 a	28.12 a
P5 POL 4.4g	9.44 ab	17.13 a	26.15 a

Note: Numbers accompanied by the same letter in the same column indicate no significant difference based on the BNJ test at the 5% level

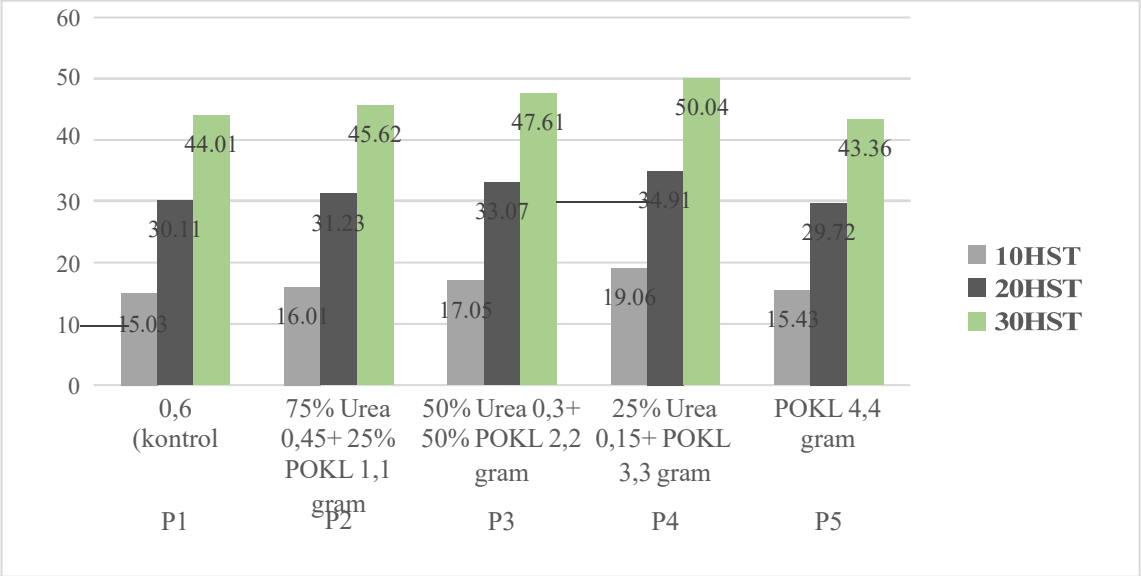

Figure 1: The effect of urea and organic fertilizer balance on the growth of soybean leaves at 10 DAP, 20 DAP, and 30 HST

4.4 Fresh Weight of Crown and Dry Weight of Crown (g)

The results of the analysis of variance indicate that the application of urea fertilizer and solid organic fertilizer to catfish does not have a significant effect on the parameters of fresh shoot weight and dry shoot weight (p>0.05%). Based on the average values of fresh shoot weight and dry shoot weight, the highest average values were found in the treatment with 25% Urea 0.15 g + 75% POPL 3.3 g treatment (Figure 2). Fresh shoot weight and dry shoot weight are the results of accumulation.

Photosynthesis in the form of plant biomass and water content in leaves. According to Lahadassy (2007), to achieve optimal fresh weight, plants still require a lot of energy and nutrients so that the increase in cell number and size can be optimal, as well as enabling an optimal increase in plant water content.

4.5 Fresh Root Weight and Dry Root Weight (g)

The results of the analysis of variance indicate that the application of urea fertilizer and organic fertilizer does not have a significant effect on the parameters of fresh root weight and dry canopy weight (p>0.05%). Based on the average values of fresh canopy weight and average dry root weight, the highest values were found in the treatment with 25% Urea 0.15g + 75% POPL 3.3 g treatment (Figure 3). The availability of sufficient nutrients during vegetative growth ensures that the photosynthesis process runs well. The higher the root biomass, the heavier the dry root weight. Plants that are able to Optimal absorption of nutrients will result in heavier dry weight (Isnaini & Endang. 2009) Nitrogen is an essential element with low availability in the soil because it is easily lost through evaporation and leaching. The main source of nitrogen is organic matter, which then undergoes mineralization, namely the conversion of nitrogen by microorganisms from organic nitrogen (protein and ammonia compounds) into inorganic forms (NH + and NO -), making it available for absorption by plant roots (Croh4n. 2004)

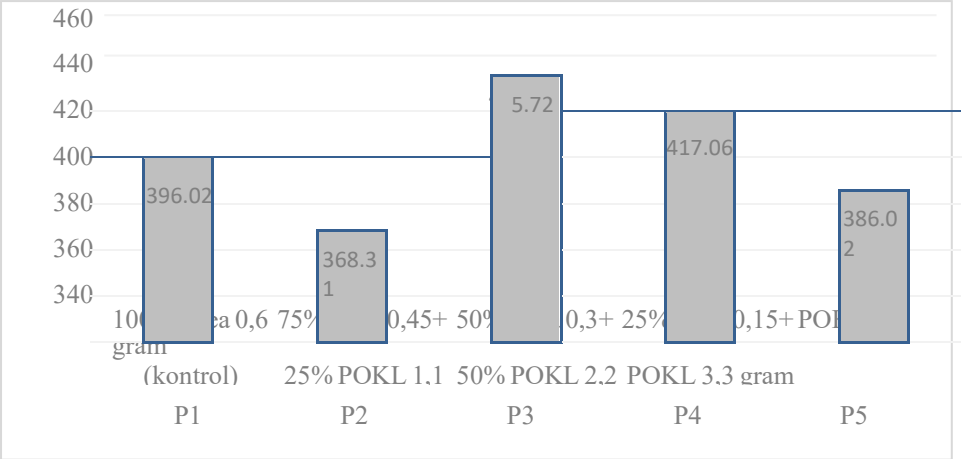

Figure 2: Effect of urea and organic fertilizer balance on soybean leaf area

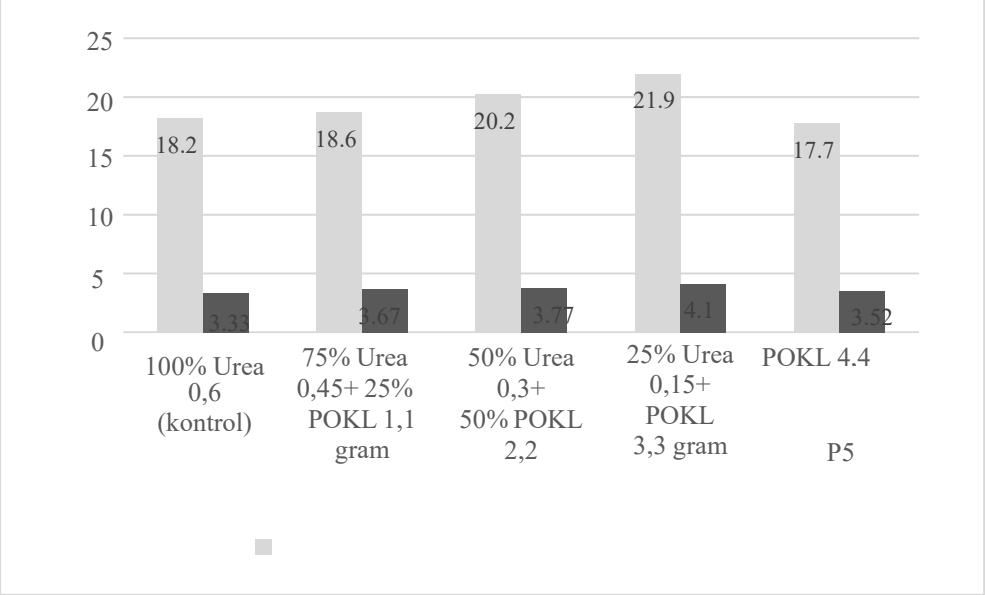

Figure 3: Effevt of urea and organic fertilizer balance on fresh weight and dry weight of soybean plant canopy

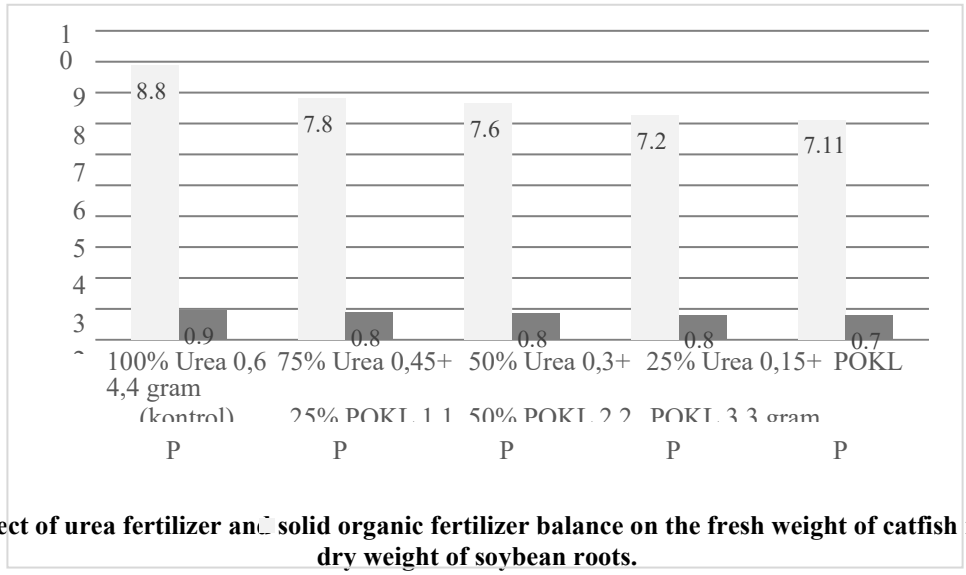

Figure 4: Effect of urea fertilizer and solid organic fertilizer balance on the fresh weight of catfish roots ( ) and dry weight of soybean roots.

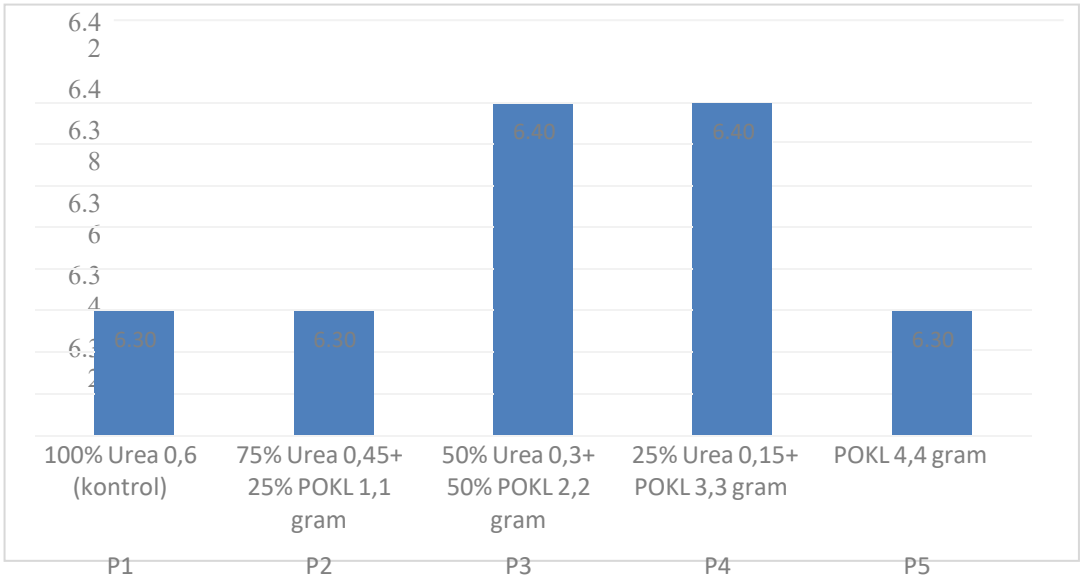

Figure 5: Effect of urea fertilizer and organic fertilizer ( ) balance on the fresh weight and dry weight of soybean roots

5.0 Conclusion

The results of this study show that there are no significant differences in the parameters of plant height, number of leaves, leaf area, fresh canopy weight, dry canopy weight, fresh canopy weight, and dry root weight. There was no significant difference between the combinations of urea and solid waste from catfish farming treatments. Therefore, the use of 4.4 grams of solid waste from catfish farming can replace the use of 0.6 grams of urea fertilizer in soybean cultivation during vegetative growth.

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Conflict of Interest

The authors declare no conflicts of interest.

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