The Effect of NPK Compound Fertilizer and Green Manure on Soil pH, Exchangeable K, Cation Exchange Capacity on Ultisols Jatinangor

Muhammad Iqbal Fauzan*, Septrial Arafat

Department of Agriculture, Faculty of Animal and Agricultural Science, Diponegoro University, Indonesia

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Abstract- One of Indonesia's soil ordo, ultisols, covers roughly 45.794.000 ha, or about 25% of the country's total geographical area. Low pH and insufficient nutrition availability are Ultisol's problems. Ultisols might have turned into cropland if the limitations were observed. This study examined how adding green manure to NPK compound fertilizer affected soil pH, exchangeable K, Cation Exchange Capacity (CEC), and paddy yield on Ultisols Jatinangor. At Ciparanje Experimental Farm, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, which is located at a height of around 700 meters above sea level, this research was carried out from October 2016 to January 2017. In this study, a randomized block design (RBD) with eight treatments and three replications was used which consist of Control (soil only); NPK compound fertilizer dose 300 kg/ha; NPK compound fertilizer dose 300 kg/ha and 10 ton/ha *Tithonia diversifolia*; NPK compound fertilizer dose 225 kg/ha and 15 ton/ha *T. diversifolia*; NPK compound fertilizer dose 150 kg/ha and 20 ton/ha *T. diversifolia*; NPK compound fertilizer dose 300 kg/ha and 10 ton/ha *C. odorata*; NPK compound fertilizer dose 225 kg/ha and 15 ton/ha C. odorata; NPK compound fertilizer dose 150 kg/ha and 20 ton/ha *C. odorata*. The results showed that the combination of NPK compound fertilizer with green manure significantly affects soil pH and yield of pakcoy. Still, there was no significant effect on Soil Exchangeable K and Cation Exchange Capacity. . The combination of NPK compound fertilizer 225 kg/ha with *C. odorata* 15 ton/ha gave the best fresh weight yield, averaging 63,71 g/plant.

Keywords: CEC, Exchangeable K, Green Manure, NPK Compound Fertilizer, pH, Ultisols, Yield of Pakcoy.

I. INTRODUCTION

Ultisols are one of the soil orders that are widely distributed in Indonesia. The distribution of Ultisols in Indonesia reaches 45,794,000 ha or about 25% of the total land area in Indonesia [1]. The widest distribution is in Kalimantan (21,938,000 ha), then Sumatra (9,469,000 ha), Maluku and Papua (8,859,000 ha), Sulawesi (4,303,000 ha), Java (1,172,000 ha), and Nusa Tenggara (53,000 ha). Ultisols are scattered in various reliefs, both flat to mountainous relief.

Ultisols result from intensive weathering and soil formation processes in tropical climates with hot temperatures and high rainfall. Ultisols are included in the marginal soil group because they have a low level of productivity because of the minimum content of nutrients and organic matter. To increase the fertility of Ultisols and increase their productivity, it is necessary to carry out efforts to improve the soil either by fertilizing or applying organic matter. Providing organic fertilizers can increase soil fertility because fertilizers can supply macro and micronutrients for plants.

In Indonesia, most farmers still rely on fertilization using synthetic chemicals. In 2015 the consumption of synthetic chemical fertilizers in agriculture reached 8,305,130 tons, with a dominance of single chemical fertilizers [2]. One of the commonly used inorganic fertilizers is the compound NPK fertilizer. This fertilizer provides nutrients in the form of Nitrogen, Phosphorus, and Potassium in one formula. These three nutrients are macronutrients that plants need. NPK fertilizers in circulation include NPK 15:15:15 and NPK 16:16:16. Using compound fertilizers is more practical because several nutrients can be given only in one stocking [3]. However, compound fertilizers should also be used by adding organic matter to provide a supply of nutrients for plants and a soil enhancer.

Agricultural systems can be sustainable if the soil contains more than 2% organic matter [4]. Physics, chemistry, and biology all show that organic matter can increase soil fertility [4]. The soil's quality will rise and its physical, chemical, and biological qualities will be enhanced by adding organic matter.

Green manure is one sort of organic material that can be utilized. Organic fertilizer made from plant components is known as "green manure." This substance can be used while it's still in the green [5]. Many farmers discard plant waste or neglect nearby plants that could be used as green manure. Because it is simple to get and plentiful, organic matter generated from plants is a cost-effective source.

An annual weed called Tithonia diversifolia may serve as a source of organic materials. due to its high biomass production of around 5.6-8.1 tons ha/year in two pruning times. As a nutrient source, *Tithonia diversifolia* contains (2.7-3.59% N, 0.14-0.47% P, 0.25- 4.10% K). The advantage of this plant is that it can grow well on less fertile land. Utilization can be as green manure or through composting [6]. Applying *Tithonia diversifolia* can increase the soil's N, P, and K content. *Chromolaena odorata* is one type of green manure that has good prospects. The trimmings have a higher carbon, calcium, magnesium, potassium, and nitrogen content than cow manure so they can be used as an alternative to organic fertilizer [6].

Pakcoy (*Brassica rapa* L.) is a vegetable plant that people in Indonesia widely consumed as a food supplement. Pakcoy plant production in Indonesia in 2011 was 564,912 tons, and in 2013 it increased to 583,770 tons, so it is necessary to increase production to meet consumer needs [7]. Pakcoy plants are easy to cultivate and are responsive to environmental changes and fertilizer application [8]. Pakcoy is usually consumed as a complement to food as a vegetable.

In this research, a pot experiment was performed to determine the effect of the combination of compound NPK fertilizer and green manure on soil pH, Exchangeable K, CEC, and yield of pakcoy and to determine the best dosage combination of compound NPK fertilizer and green manure for the yield of pakcoy in Ultisols Jatinangor.

II. MATERIALS AND METHODS

2.1. Experimental Design

The study was carried out at the Universitas Padjadjaran Experimental Farm of the Faculty of Agriculture in Ciparanje, Jatinangor, Sumedang Regency, West Java. The Laboratory of Soil Chemistry, Faculty of Agriculture, Universitas Padjadjaran, performed the initial and final soil analyses. This study will be carried out between October 2016 and January 2017. Soil samples were collected at Ciparanje, the experimental farm of the Agriculture Faculty, Universitas Padjadjaran. A soil sample was taken from 0 to 20 cm depth, dried by air at room temperature, and sieved with a 2 mm stainless steel mesh. This experiment used a completely randomized block design. Eight treatments with three replicates were used as follows:

a. Soil Only (control)
b. NPK 300 kg/ha
c. NPK compound fertilizer 300 kg/ha + *Tithonia diversifolia* 10 ton/ha
d. NPK compound fertilizer 225 kg/ha + *Tithonia diversifolia* 15 ton/ha
e. NPK compound fertilizer 150 kg/ha + *Tithonia diversifolia* 20 ton/ha
f. NPK compound fertilizer 300 kg/ha + *Chromolaena odorata* 10 ton/ha
g. NPK compound fertilizer 225 kg/ha + *Chromolaena odorata* 15 ton/ha
h. NPK compound fertilizer 150 kg/ha + *Chromolaena odorata* 20 ton/ha

2.2 Measurements

The measurements of this experiment consist of two parameters: soil and plant parameters. The soil parameters were pH, CEC, and Exchangeable Potassium (K), and plant parameters were yield of pakcoy. Statistical analysis was performed to determine the effects of the treatments on the experimental parameters. The significance of treatments was tested by one-way analysis of variance (ANOVA), and Duncan Multiple Range Test at a probability lower than 5% ($p < 0.05$) was applied for the differences in mean values. All statistical analyses were performed using SPSS Statistics version 20 (IBM, New York, NY, USA).

III. RESULT AND DISCUSSION

A. Soil pH

The statistical analysis showed that combining compound NPK fertilizer and green manure affected soil pH values. The average pH value of each treatment combination can be seen in Table 1.

Table 1. Effect of the Combination of Compound NPK Fertilizer and Green Manure on Soil pH

Treatment	pH
a. Soil only (control)	5,97 ab
b. NPK compound fertilizer 300 kg/ha	5,64 a
c. NPK compound fertilizer 300 kg/ha + *Tithonia diversifolia* 10 ton/ha	5,93 ab
d. NPK compound fertilizer 225 kg/ha + *Tithonia diversifolia* 15 ton/ha	5,74 a
e. NPK compound fertilizer 150 kg/ha + *Tithonia diversifolia* 20 ton/ha	5,85 a
f. NPK compound fertilizer 300 kg/ha + *Chromolaena odorata* 10 ton/ha	5,79 a
g. NPK compound fertilizer 225 kg/ha + *Chromolaena odorata* 15 ton/ha	6,19 b

h.	NPK compound fertilizer 150 kg/ha + *Chromolaena odorata* 20 ton/ha	5,97 ab

Note: The numbers followed by the same letters are not significantly different according to Duncan's Multiple Range Test at the 5% significance level.

Based on the statistical test results in Table 2, no significant difference existed between the control and the other treatments. While the NPK fertilizer treatment 300 kg/ha (B treatment), NPK 225 kg/ha + *Tithonia diversifolia* 15 ton/ha (D treatment), and NPK 300 kg/ha + *Chromolaena odorata* 10 ton/ha (F treatment) had a significant effect on NPK 225 kg/ha + *Chromolaena odorata* 15 ton/ha (G treatment).

The pH has a critical function in determining the amount of nutrients that are available to plants in the soil. The pH value can also indicate the presence or absence of toxic elements in the soil and affect plant growth [9]. Soil pH value is affected by the soil's content of acid and base ions. Some ions that can acidify the soil include hydrogen (H^+), aluminium (Al^{3+}), and iron (Fe^{2+} or Fe^{3+}). Alkaline cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^+). The pH value can change by fertilizing, leaching, and adding organic matter. Adding organic matter to the soil can lower soil pH because organic matter's mineralisation process produces organic acids, thereby increasing the concentration of H^+ ions in the soil [10]. On the other hand, adding organic matter is also known to increase soil pH due to the release of OH- ions from the organic matter due to a reduction process [11].

Organic materials that have been decomposed can increase the activity of OH^- ions originating from carboxyl groups (-COOH) and hydroxyl groups (OH^-). OH^- ions will neutralize the H^+ ions in the soil solution. [12] stated that the rise and fall of soil pH is a function of H^+ and OH^- ions, if the concentration of H^+ ions in the soil solution increases, the pH will decrease, and if the concentration of OH^- ions rises, the pH will increase.

Organic materials that have been decomposed will produce OH^- ions which can neutralize the activity of H^+ ions. Fertilization with compound NPK fertilizer can lower the soil pH value. This decrease was due to compound NPK fertilizers containing sulfur and ammonium, which would be hydrolyzed to produce H^+ ions, thereby reducing the soil pH value [13].

B. Exchangeable K

The statistical analysis results showed that the application of compound NPK fertilizer and green manure had no effect on the Exchangeable K value of the soil. The average Exchangeable K value of each treatment combination can be seen in Table 2.

Table 2. Effect of the Combination of Compound NPK Fertilizer and Green Manure on Exchangeable K (me/100g)

	Treatment	Exchangeable K (me/100g)
a.	Soil only (control)	0,31 a
b.	NPK compound fertilizer 300 kg/ha	0,21 a
c.	NPK compound fertilizer 300 kg/ha + *Tithonia diversifolia* 10 ton/ha	0,35 a
d.	NPK compound fertilizer 225 kg/ha + *Tithonia diversifolia* 15 ton/ha	0,43 a
e.	NPK compound fertilizer 150 kg/ha + *Tithonia diversifolia* 20 ton/ha	0,32 a
f.	NPK compound fertilizer 300 kg/ha + *Chromolaena odorata* 10 ton/ha	0,26 a
g.	NPK compound fertilizer 225 kg/ha + *Chromolaena odorata* 15 ton/ha	0,36 a
h.	NPK compound fertilizer 150 kg/ha + *Chromolaena odorata* 20 ton/ha	0,32 a

Note: The numbers followed by the same letters are not significantly different according to Duncan's Multiple Range Test at the 5% significance level.

Based on the table above, it shows that each treatment did not give significantly different results. Potassium (K) is a mobile element, so it is easily leached from the soil. Leaching, fixing, or plant absorption can all affect the soil's exchangeable K content [14]. The kind of clay minerals in the soil and their ability to exchange ions also impact the soil's exchangeable K value. Because plants also take up potassium nutrients in the form of K^+ ions, most of the K^+ ions in the soil solution may be lost through leaching or uptake by plants.The addition of compound NPK fertilizer can increase the Exchangeable K value in the soil because compound NPK fertilizer contains K nutrients which can be mineralized and then converted into K^+ ions which can be exchanged and uptaken by plants.

C. CEC

The statistical analysis results showed that applying a combination of compound NPK fertilizer and green manure did not affect the CEC value of the soil. The average soil CEC value for each treatment combination can be seen in Table 3.

Table 3. Effect of the Combination of Compound NPK Fertilizer and Green Manure on Soil CEC Values

	Treatment	CEC (cmol/kg)
a.	Soil only (control)	20,95 a
b.	NPK compound fertilizer 300 kg/ha	21,68 a

c.	NPK compound fertilizer 300 kg/ha + *Tithonia diversifolia* 10 ton/ha	20,77 a
d.	NPK compound fertilizer 225 kg/ha + *Tithonia diversifolia* 15 ton/ha	21,73 a
e.	NPK compound fertilizer 150 kg/ha + *Tithonia diversifolia* 20 ton/ha	21,01 a
f.	NPK compound fertilizer 300 kg/ha + *Chromolaena odorata* 10 ton/ha	22,60 a
g.	NPK compound fertilizer 225 kg/ha + *Chromolaena odorata* 15 ton/ha	21,90 a
h.	NPK compound fertilizer 150 kg/ha + *Chromolaena odorata* 20 ton/ha	23,51 a

Note: The numbers followed by the same letters are not significantly different according to Duncan's Multiple Range Test at the 5% significance level.

Based on the table, compound NPK fertilizer and green manure treatment did not affect soil CEC values compared to the control. However, from the analysis results, the CEC value of the soil with the combination treatment of compound NPK fertilizer and green manure was higher than the control treatment.

One of the factors that determine the value of soil CEC is the organic matter content in the soil itself. Adding organic matter into the soil can increase the value of CEC. As the pH increases, organic matter will release hydrogen cations and leave negatively charged particles that will become cations ready to be exchanged [15].

Organic matter is one of the main factors determining soil CEC values because organic matter has a negative charge strong enough to attract positively charged cations. Soils with a high organic matter content also have a high CEC value [16]. Organic materials will be broken down into humus colloids through the humification process. Humus is an organic material that cannot be weathered anymore and is colloidal in size, which can bind cations, exchange ions, and uptake water molecules. This humus colloid then becomes cationic particles that are ready to be exchanged. A suitable property of humus is that humus colloid can bind more ions than clay at the same weight [17].

The average CEC value of all treatment combinations showed a higher value than the results of the initial soil analysis, but there was no difference between the green manure and NPK fertilizer combination treatments; the soil CEC value in the initial soil analysis was known to be 20.55 cmol/kg. This shows that the combination of compound NPK fertilizer and green manure can increase the CEC value of the soil.

D. Yield of Pakcoy

The statistical analysis results showed an effect of the combination of compound NPK fertilizer and green manure on the total fresh weight (Table 4).

Table 4. Effect of the Combination of Compound NPK Fertilizer and Green Manure on Fresh Weight

	Treatment	Fresh Weight (g/plant)
a.	Soil only (control)	28,18 a
b.	NPK 300 kg/ha	46,6 b
c.	NPK 300 kg/ha + *Tithonia diversifolia* 10 ton/ha	60,52 c
d.	NPK 225 kg/ha + *Tithonia diversifolia* 15 ton/ha	47,31 b
e.	NPK 150 kg/ha + *Tithonia diversifolia* 20 ton/ha	27,23 a
f.	NPK 300 kg/ha + *Chromolaena odorata* 10 ton/ha	66,75 c
g.	NPK 225 kg/ha + *Chromolaena odorata* 15 ton/ha	63,71 c
h.	NPK 150 kg/ha + *Chromolaena odorata* 20 ton/ha	47,32 b

Note: The numbers followed by the same letters are not significantly different according to Duncan's Multiple Range Test at the 5% significance level.

Based on the results of statistical analysis, a significant effect on control was shown by B treatment (NPK 300 kg/ha), C treatment (NPK 300 kg/ha + *Tithonia diversifolia* 10 ton/ha), treatment D (NPK 225 kg/ha + *Tithonia diversifolia* 15 ton/ha), F treatment (NPK 300 kg/ha + *Chromolaena odorata* 10 ton/ha) and G treatment (NPK 225 kg/ha + *Chromolaena odorata* 15 ton/ha). The treatment with the highest total fresh weight was in F treatment, namely 66,75 g.

Applying NPK fertilizers and organic fertilizers can increase nitrogen levels in the soil and increase nitrogen uptake by plants. Increasing nitrogen uptake in the vegetative phase of plants will be sufficient to increase plant biomass. Compound NPK fertilizer provides macronutrients in the form of nitrogen, phosphorus, and potassium needed by plants. These three macronutrients are essential nutrients for forming plant cells and tissues.

The organic material used, namely green manure, can also function as a soil enhancer, buffer, and source of nutrients [18]. Organic matter in the form of green manure containing relatively high N nutrients can also increase crop yields because it increases the availability of nitrogen nutrients in the soil [19]. Organic matter also increases the soil's ability to hold water by improving soil structure; water availability is essential in influencing fresh plant weight because 80% of fresh plant weight consists of water [20].

The combination of compound NPK fertilizer and green manure can work synergistically in increasing the yield of pakcoy compared to the control. Compound NPK fertilizer plays a role in providing nutrients for plants and stimulating plant growth and development.

Green manure as an organic matter also improves soil conditions by increasing the availability of macro and micronutrients as a buffer and improving the structure.

IV. CONCLUSION

Based on the research results, the combination of compound NPK fertilizer and green manure affected the pH and yield of pakcoy plants. Still, it did not affect the exchangeable K and CEC of the Ultiosols Jatinangor.

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AUTHORS

First Author – Muhammad Iqbal Fauzan, conception, data collection, and writing the manuscript, muhammadiqbalfauzan@lecturer.undip.ac.id.
Second Author – Septrial Arafat, writing the manuscript, septrialarafat@lecturer.undip.ac.id.
Correspondence Author – Muhammad Iqbal Fauzan, muhammadiqbalfauzan@lecturer.undip.ac.id.