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# Effect of Fertilization on Lead Accumulation in Cabbage (*Brassica oleracea* L.) and White Mustard (*Brassica rapa* L.)

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**Abstract :** Toxic metals accumulation in growing plant is influenced by the soil composition, water, air and planting sites, fertilization and crop types. Cabbage (*Brassica oleracea* L.) and Chinese cabbage (*Brassica rapa* L.) are plants that is able to absorb toxic metals. This study aimed to determine the effect of dosage of NPK fertilizer and organic fertilizer on metal lead accumulation in cabbage and chinese cabbage. This research was carried out in plastic house in Simpang Tiga Redelong highlands using cabbage (Inpestor 369) and white mustard (Deli. CR) seeds. The procedure used was the addition of lead (Pb) into the soil media as much as 319.71 $mg.kg^{-1}$ in powder form $Pb(NO_3)_2$ for all groups, in 5 kg per polybag. Then organic fertilizer (Petro Organic) and NPK (YaraMila$^{TM}$) was added were 15, 30, 60, 120 and 240 $mg.kg^{-1}$ soil at 7, 15 and 30 DAT (days after planting) by sprinkling on the soil media around the plants. At 75 DAT vegetables were harvested and continued with the analysis for lead content analysis. Analysis using the technique of atomic absorption spectrophotometry (AAS) air-acetylene flame at a wavelength of 283.3 nm. The results showed that the cabbage (*Brassica oleracea* L.) and chinese cabbage (*Brassica rapa* L.) able to accumulate metallic lead during the growth of 3.0289 ± 0.0186 µg/g and 3.2770 ± 0.1601 µg/g. But after treatment decrease the accumulation lead with NPK fertilizer at 15 mg/kg; NPK 30 mg/kg; organic fertilizer 30 mg/kg on cabbage; NPK fertilizer and organic 60 mg/kg, the highest decrease of NPK fertilizer on cabbage and chinese cabbage seen at a dose of 120 mg/kg ie 2.2838 ± 0.0232 µg/g and 1.7482 ± 0.0551 µg/g; and the highest decline of organic fertilizer on cabbage and chinese cabbage at a dose of 240 mg/kg ie 2.0798 ± 0.0379 µg/g and 2.6829 ± 0.1565 µg/g respectively, but in NPK fertilizers 240 mg/kg there is an increase of accumulated back. Cabbage and chinese cabbage plants able to accumulate lead during growth. NPK fertilizer and organic fertilizer effect on a significant reduction in the lead, with the higher dose will further decrease the accumulation of lead.

**Keyword :** Cabbage (*Brassica oleracea* L.), white mustard (*Brassica rapa* L.), lead (Pb), Atomic Absorption Spectrophotometer (AAS).

## Introduction

Fertilizers containing organic compounds could form a bond in a complex reaction. This bond is a bond reaction between organic compounds with metal ions[1], therefore fertilizer is added to the plant can also affect the decline of lead absorbed by plants[2]. It is caused by organic matter tends to bind lead forming chelate complexes. The electron will be used in the formation of a bond with metallic lead, which can bind to lead and form salts in the form of sludge so that the accumulation of lead in plants will decrease[3,4].

Increased doses of vermicompost smakin lowering effect of lead accumulation in potato tubers[2], the effect of fertilizers on the lead content in the soil, root and lettuce tissue showed that the administration of NPK fertilizer and organic fertilizer capable of lowering metallic lead with increasing doses of fertilizer applied[5]. Applications of nitrogen fertilizer in the soil contaminated with metals, showed that nitrogen fertilizer with 21% able to reduce lead metal was higher than 15.5% nitrogen fertilizer on carrot[6] and grape[7]. It can be concluded that the type and dose of fertilizer will affect the accumulation of lead by plants with different absorption capacity.

## Experimental

The tools used are hoes, sacks, scales, a small shovel, polybag, sprinklers plant, analytical balance, furnace, crucible porcelain, rod clamp, flask 10, 25, 50, 100 and 1000 ml, measuring cups 5 and 10 ml, pipette volumes of 1 and 5 ml, pipette, rubber suction, hot plate, Whatman filter paper no. 42, vial bottle, mouthpiece, mask, gloves, blender, atomic absorption spectrophotometer (Shimadzu AA-6300) with an air-acetylene flame.

Materials used are clay, fertilizer NPK (YaraMila$^{TM}$), organic fertilizer (Petro Organic), the seed sprouts (Inpestor 369) and chicory (Deli. CR), a powder of lead nitrate [$Pb(NO3)_2$], the standard solution of lead (II) nitrate concentrated ($Pb(NO3)_2$) (Brands) (1000 µg/ ml), concentrated nitric acid ($HNO_3$ 65%) (Merk), and the mineral-free distilled water.

### Research design

This study uses a completely randomized design (CRD) arranged as factorial, consisting of two factors. The first factor is the treatment that is the fertilizer NPK fertilizer (Pn) and organic fertilizers (Po). The second factor is the dose of fertilizer that consists of 6 levels ie D0 = 0 mg / kg; D1 = 15 mg / kg; D2 = 30 mg / kg; D3 = 60 mg / kg; D4 = 120 mg / kg and D5 = 240 mg / kg. So there are 12 treatment combinations, as shown in Table 1.

**Table 1. The experimental design samples**

| Sample and fertilyzer | Concentration fertilization (mg / kg) | | | | | |
|---|---|---|---|---|---|---|
| | **0** | **15** | **30** | **60** | **120** | **240** |
| Cabbage | | | | | | |
| - NPK fertilizer | CD0 | CFnD1 | CFnD2 | CFnD3 | CFnD4 | CFnD5 |
| - Organic fertilizer | | CFoD1 | CFoD2 | CFoD3 | CFoD4 | CFoD5 |
| White mustard | | | | | | |
| - NPK fertilizer | WD0 | WFnD1 | WFnD2 | WFnD3 | WFnD4 | WFnD5 |
| - Organic fertilizer | | WFoD1 | WFoD2 | WFoD3 | WFoD4 | WfoD5 |

### Preparation of plant media

Inceptisol ground prepared as much as ± 360 kg, then soil dried and cleaned from the remains of plant roots, grass, gravel and other foreign objects. Once clean, sieved soil with sand sieve. Used for each treatment of land as much as 5 kg of soil, were then added powdered lead $Pb(NO3)_2$ as much as 1.6 g / 5 kg soil (319.71 mg / kg soil) then stir until evenly[8].

### Preparation of seeds

Before sowing, the seeds soaked in water, the seeds are floating discarded and seeds were submerged taken for sowing. Then the seeds are planted in plots of land that have been prepared for 20 days or after appearing 3 to 4 stalks of young leaves[9].

**Preparation and fertilization of plants**

Polybag which already contain subsequent soil planted seedlings of cabbage and chicory. Then given NPK fertilizer and organic fertilizer with its contents can be seen in Table 2. In this study, there are 12 treatment dose of organic fertilizer and NPK recommendations, namely: 0, 15, 30, 60, 120 and 240 mg / kg of soil; NPK 0, 15, 30, 60, 120 and 240 mg / kg soil. NPK and organic fertilizer application is divided into 3 intervals of administration that is at the age of 7, 15 and 30 DAP (days after planting). Then the plants were grown in plastic housings.

**Table 2. The composition of the fertilizer used**

| Component | NPK Fertilyzers (%) | Organic Fertilizers |
|---|---|---|
| N (Nitrogen) | 15 | - |
| $NH_4$ (Ammonium nitrogen) | 8,30 | - |
| $NO_3$ (Nitrat nitrogen) | 6,70 | - |
| $P_2O_5$ (Fosfat) | 9 | - |
| $K_2O$ (Kalium oksida) | 20 | - |
| MgO (Magnesium oksida) | 2 | - |
| S (Sulfur) | 3,80 | - |
| B (Boron) | 0,015 | - |
| Mn (Mangan) | 0,020 | - |
| Zn (Zink) | 0,020 | - |
| C organic | - | 12,30 % |
| C / N rasio | - | 15,19 |
| Kadar air | - | 8,16 % |
| pH | - | 8,03 |

Description: NPK fertilizer (YaraMila$^{TM}$) produced by Yara International ASA of Norway; Organic fertilizers (Petro Organic) manufactured in Indonesia.

**Plant maintenance**

Maintenance activities include watering plants, replanting, weeding, control weeds, pests and plant diseases. Watering is done 2 times a day by using gembor ie morning and afternoon, weeding done if overgrown with weeds around the plants. Control of pests and plant diseases and Drusband Prepaton pesticide used at a concentration of 2 g / L of water. Pesticide application are given at intervals of 5 days of age 7-60 hst by spraying the plant stem, then grown in plastic house for ± 75 HST.

**Retrieval and preparation plants**

The plants to be tested is a crop that has been harvested. Harvesting is done at 75 days after planting. Plants that had been harvested then washed, then blended and incorporated into each container and labeled per treatment group.

**Dry destruction**

Sample that has been blended and then weighed carefully as much as ± 10 grams in a porcelain crucible, charred on a hot plate, then diabukan in a furnace with the initial temperature of 100 ℃ and slowly - land temperature is raised to temperature of 450 ℃ to 25 ℃ intervals every 5 minutes. Ashing done for ± 48 hours (calculated when the temperature is 450 ℃) or after the ash is white, then after the furnace temperature ± 27 ℃, porcelain crucible removed and allowed to cool in a desiccator. Abu added 5 ml $HNO_3$ (1: 1), then evaporated on a hot plate until dry. Porcelain crucible was put back into the furnace with the initial temperature of 100 ℃ and the temperature is gradually raised to a temperature of 450 ℃ to 25 ℃ intervals every 5 minutes. Ashing done for ± 1 hour and allowed to cool in a desicator[10].

**Making the sample solution**

Dissolving a sample of the destruction by adding 5 ml $HNO_3$ into a porcelain crucible (1: 1), and then transferred into a flask of 50 ml, rinsed porcelain crucible with 10 ml akuabides free minerals three times and paid back up to the line mark. Then filtered through Whatman filter paper No. 42 in which the first 5 ml of filtrate discarded to saturate the filter paper and then the filtrate is subsequently accommodated into the bottle. This solution is used for the qualitative and quantitative analysis[10].

**Calibration curves Metals Lead**

From the mother liquor of lead 1000 µg / ml pipette 1 ml is then inserted into the flask 10.0 ml. The solution was diluted with 0.1 N HNO3 until the boundary line then shaken until homogeneous, to obtain a solution with a concentration of 100 µg / ml. Of a solution of 100 µg / ml pipette 1 ml then entered into a 10 ml measuring flask and the solution was diluted with 0.1 N HNO3 until the boundary line then shaken until homogeneous, so we get a standard solution with a concentration of 10 µg / ml. From the standard solution 10 mg / ml pipette respectively of 0.2; 0.4; 0.6; 0.8 and 1 ml. Each solution was put into six 10.0 mL volumetric flask, and then diluted with 0.1 N HNO3 to the boundary line, and beat until homogeneous in order to obtain a solution with a concentration of 0.2; 0.4; 0.6; 0.8; and 1.0 µg/ml[11]. Then measured absorbance at spectophotometric tool Atomic Absorption (AAS) to measure absorbance. From the results of absorbance and concentration that made put in a linear calibration curve.

**Determination of Lead metal concentration in the sample**

Determination of the metal content of lead in the sample using a solution of pre-prepared material. Then measuring the absorbance by atomic absorption spectrophotometer (AAS). These measurements were performed on all the materials that have been didestruksi. Absorbance values obtained are within the range of the calibration curve. Lead content is calculated by substituting the absorbance into the regression equation obtained from the calibration curve as shown below:

**Y = aX + b**
Description: Y = Absorbance Pb sample solution a = Slope
X = concentration Pb sample solution b = intercept
From the calculations, it can be seen the levels of material by using the formula:

$$\textbf{Lead content (µg / g)} = \frac{A \times V \times F}{W}$$

Description:
A = Concentration of Pb solution (µg/ml) (obtained from the calculation based on the absorbance and the calibration curve)
V = Volume of solution (ml)
F = Dilution Factor
W = weight of material (grams)

## Result and Discussion

Metallic lead calibration curve obtained by measuring the absorbance of a standard solution of metallic lead. Based on the measurement results of the calibration curve metallic lead measured in the concentration range of 0.2 ug / ml to 1 ug / ml, thus obtained regression equation Y = 0,00532X + 0.000028. , The absorption spectra of three components are strongly overlapped (Fig. 2) that was sufficiently enough to demonstrate the resolving power of the proposed method.

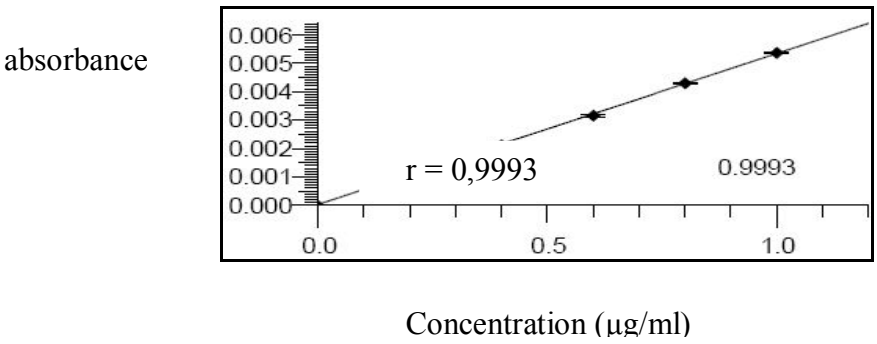


**Fig. 1. The calibration curve of lead standard solution**

Based on Figure 1 above calibration curve obtained absorbance value of the correlation coefficient (r) of 0.9993. The correlation coefficient obtained from the metallic lead can be accepted as the appropriate requirements for the correlation coefficient is not to be less than 0.995[14]. Coefficient above suggested a linear relationship between the concentration of the metal (X) and absorbance (Y)[12].

**Accumulated Effect of Fertilization Against Lead In The Cabbage and White mustard**

Mean value and standard deviation of the influence of fertilization on the accumulation of lead in plants cabbage and white mustard can be seen in Table 3 Graph fertilizing effect on the accumulation of lead in cabbage can be seen in Figure 2, and white mustard in Figure 3.

**Table 3. Effect of fertilization on the accumulation of lead in plants cabbage and chicory**

| No | Type and dose of fertilizers | Lead levels (µg / g) (mean ± SD, n = 3) | |
|---|---|---|---|
| | | Cabbage | White mustard |
| 1. | Controls | 3.0289 ± 0,0186 | 3,2710 ± 0,0351 |
| 2. | Organic fertilizers 15 mg / kg | 3,0212 ± 0,3722 $^{ns}$ | 3,2758 ± 0,1594$^{ns}$ |
| 3. | Organic fertilizers 30 mg / kg | 2,6608 ± 0,0425* | 3,0185 ± 0,1251$^{ns}$ |
| 4. | Organic fertilizers 60 mg / kg | 2,4330 ± 0,1073* | 2,9993 ± 0,0693* |
| 5. | Organic fertilizers 120 mg / kg | 2,2547 ± 0,0548* | 3,0053 ± 0,0357* |
| 6. | Organic fertilizers 240 mg / kg | 2,0798 ± 0,0379* | 2,6829 ± 0,1565* |
| 7. | NPK fertilizers 15 mg / kg | 2,8365 ± 0,04281* | 3,1207 ± 0,0746* |
| 8. | NPK fertilizers 30 mg / kg | 2,6673 ± 0,0274* | 2,0899 ± 0,0354* |
| 9. | NPK fertilizers 60 mg / kg | 2,5240 ± 0,0250* | 1,8832 ± 0,0681* |
| 10. | NPK fertilizers 120 mg / kg | 2,2838 ± 0,0232* | 1,7482 ± 0,0551* |
| 11. | NPK fertilizers 240 mg / kg | 2,4556 ± 0,0327* | 2,5419 ± 0,0462* |

Description: ns = not significantly different with control * = Significantly different to controls

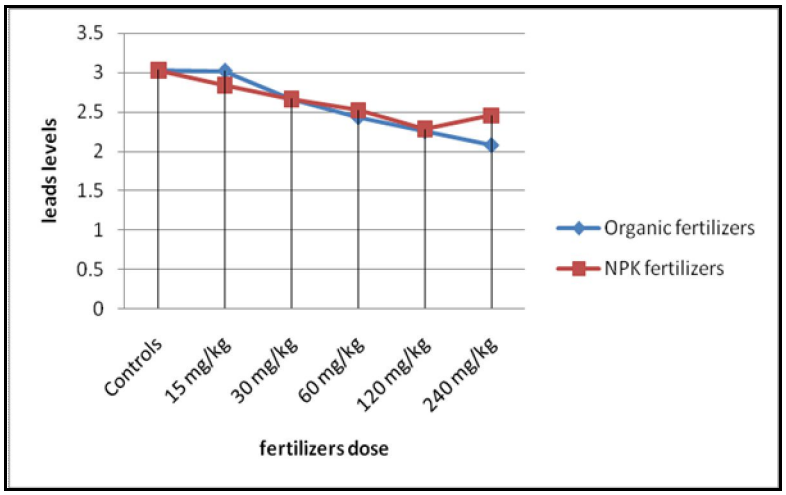


**Fig 2. The influence of the type and dose of organic fertilizer (PO) and NPK (PN) to the accumulation of lead in cabbage control group, PO 15, 30, 60, 120, 240 mg / kg, and PN 15, 30, 60, 120, 240 mg / kg.**

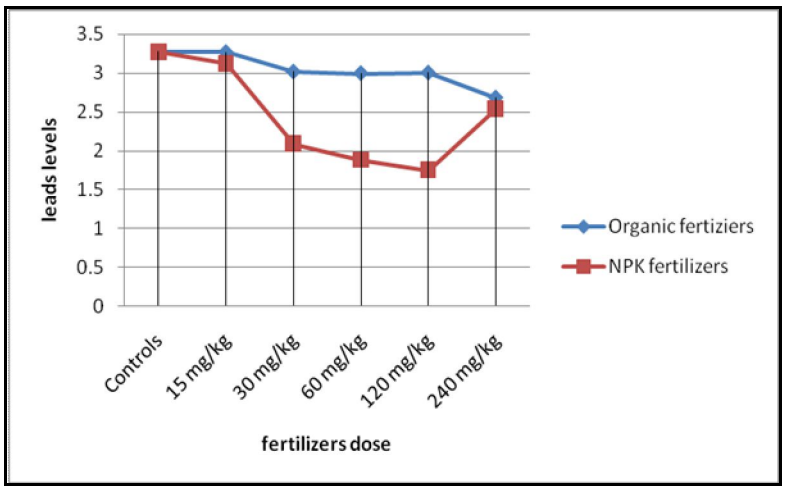


**Fig 3. The influence of the type and dose of organic fertilizer (PO) and NPK (PN) to the accumulation of lead in white mustard control group, PO 15, 30, 60, 120, 240 mg / kg, and PN 15, 30, 60, 120, 240 mg / kg.**

From these results it can be seen that the NPK fertilizer more influential in reducing the accumulation of lead than organic fertilizer on cabbage and chicory, with the higher dose of fertilizer that will further decrease the accumulation of lead. Effect of fertilization on the accumulation of lead in the two plants is in line with the results of research conducted by the states that the type and dose of fertilizer applied to crops greatly influence the decrease in the accumulation of lead by plant[2,5,7]. It added that the higher the value of N contained in the fertilizer will further decrease the accumulation of lead and the higher the dose of fertilizer is also getting lower the accumulation of lead by plants[(6,7)]. This is because fertilizer containing organic matter can reduce the adverse effects of heavy metals and soil microorganisms sustain life under normal circumstances, so the fertilizer added to the soil, positively capable of preventing the movement of heavy metals move into the plant system. This is presumably because of the active group of nitrogen in the form of an active group of nitrogen in fertilizers that can bind lead. Most likely there NTA ligands that will form a salt deposits $PbN(CH_2CO_2)^-$ as in figure 4 [(3)].

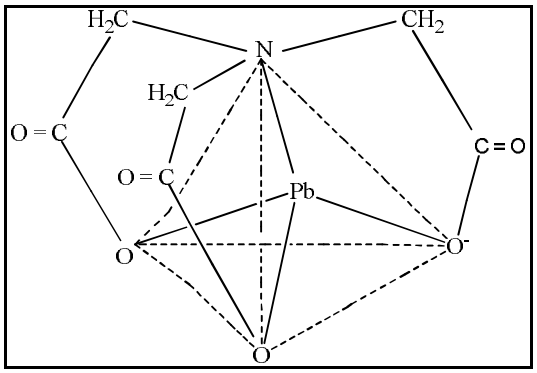


**Fig 3 Timbalnitrilotriasetat structural formula**

In addition to the active group, the accumulation of lead was also affected by temperature, wherein when the low temperature power accumulation will also be slow due to the low temperature evaporation of the water is also low. Diseebutkan that the higher the ambient temperature will cause the process of photosynthesis will be increased so that the absorption of water plants will increase as well[(15)].

Decrease the accumulation of lead seen in every significant group, but the fertilizer dose of 240 mg / kg of NPK accumulation of lead higher returns, it is alleged by NPK fertilizer that is too large given that group active has been saturated with lead (due to the competition between molecules in the ground ) so that the active group $NH_2$ no longer able to hold the lead retained in the root, where the absorption process has reached a balance so that the chances of nitrogen binds with lead to be small. After reaching equilibrium, the percentage of absorption becomes stable or normal again, and the metal will accumulate timbalpun back to the leaf.

This research also found that the growth of cabbage was not optimal ie not form the head of cabbage in the leaves (crop) it is likely caused by several factors: firstly the influence of the plastic housing, in which a live plant airtight and sunlight does not get in, causing the plant is not able to photosynthesize well. Both are caused by metallic lead that has been added to disrupt the process or activity so that the cabbage growing cabbage plants are not able to grow perfectly. Results of previous studies stated that the lead is very influential reduce the rate of plant growth, lead to high uptake by plants can block growth hormone activity, discoloration of stems and leaves of vegetables [(16)].

## Conclusion

Plant cabbage and chicory able to accumulate lead for growth and NPK fertilizers is more influential than the organic fertilizer to decrease the accumulation of lead and The higher the dose of NPK fertilizer and organic fertilizer will affect a decrease in the accumulation of lead in plants cabbage and white mustard.

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