Research Article

Accumulation of Pb in Chinese cabbage (Brassica rapa) and bean (Phaseolus vulgaris) from the use of fertilizer and pesticide

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Abstract: A series of experiments in a plastic house were carried out to test the accumulation of Pb metal in Chinese cabbage and bean plants from the application of several Pb sources. The research method used was a split-plot design with the main plot was the application of Pb source consisting of A1 = pesticide (99 mg Pb/kg), A2 = fertilizer (21 mg Pb/kg), A3 = Pb(NO3)2 (50 mg Pb/kg) and A4 = control (without the application of Pb), and the subplot was the vegetable crops consisting of B1 = Chinese cabbage (Brassica rapa) and B2 = bean (Phaseolus vulgaris). The results of the experiment showed that the Pb content in the shoots of Chinese cabbage and bean plants that were previously sprayed with pesticide was significantly 231.02% (Chinese cabbage) and 257.18% (bean) higher than control plants. Meanwhile, the largest Pb concentrations in the roots of Chinese cabbage and bean plants were obtained in plants applied with Pb(NO3)2. Compared to the control treatment, there was an increase in Pb concentration by 206.32% in the roots of Chinese cabbage plant and by 310.03% in the roots of bean plant which were applied with Pb(NO3)2. Pb concentrations of Chinese cabbage which were given fertilizer increased by 14.86% in the shoot and 30.59% in the root, while those in bean increased by 10.74% in the shoot and 98.77% in the root. Pb concentrations in Chinese cabbage and beans that were given fertilizer were not significantly different from control plants. These results indicate that the application of pesticide and fertilizer containing Pb results in Pb accumulation in the plant shoots and roots as well as in the soil.

Keywords: fertilizer, Pb concentration, pesticide, soil, vegetable crops

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Introduction

Lead (Pb) is one of the heavy metals that received much attention because of its toxicity which is harmful to the environment and human health. Lead is hazardous for children because Pb exposure in low levels can cause disability, stunted growth, kidney damage and impair hearing. While high concentrations of Pb in the body can cause mental retardation, coma and even death (Galadima and Garba, 2012). There is a positive relationship between lead exposure and blood pressure associated with hypertension and on clinical cardiovascular outcomes including cardiovascular, coronary heart disease, death from stroke, wherein some study observed blood lead levels <5 μg/dL (Navas-Acien et al., 2007). A medical review from the American Cancer Society (2014) states that lead exposure is also very closely related as a trigger for liver tumours and liver cancer. Lead is classified as a carcinogenic trigger for humans and animals and some study refer to lead as a trigger for lung cancer, stomach cancer and gliomas (Järup, 2003). Zhuang et al. (2009) state that Pb and Cd had the potential as carcinogens and are related to the etiology of a number of diseases, especially cardiovascular, liver, nervous system, blood and bone diseases.
The concentration of heavy metals in the soil is very dependent on the geological characteristics of the soil, but agricultural activities such as fertilization can also cause the accumulation of heavy metals in the soil. Chemical fertilizers play an important role in increasing soil fertility and productivity, but excessive long-term use can reduce soil organic matter, which risks reducing agricultural soil fertility, including increasing soil acidity (Guo et al., 2010; Ning et al., 2017). The use of agrochemicals, in addition to affecting soil fertility, also affects the content of heavy metals in the soil. Atafar et al. (2010) revealed that the concentration of Cd, Pb and As in cultivated soils increased with regard to fertilizer application. Kumpiene et al. (2008) also revealed that Cu, Zn and Pb can be retained in soil amended with materials containing phosphorus, Fe and clay.

The results of the above studies show that the accumulation of heavy metals including Pb in plants is mostly produced from absorption through the soil, because the majority of heavy metals are built up in the root system, and are taken up by the main plants through the root system continuously (Bondada et al., 2004). However, other facts reveal that Pb sources in agricultural lands can also come from the deposition of Pb from the atmosphere, fertilizers, and impurities (Nicholson et al., 2003). Research results of AlKhader (2015) showed that Pb in some soils from agricultural land was derived from rocks, application of pesticides, and long-term use of P fertilizer. Mausi et al. (2014) also showed that high levels of Pb in citrus fruits and mangoes that exceeded the permissible level (0.3 mg/kg) were related to the use of pesticides, fertilizers and contaminants in groundwater.

The results of those studies indicate that the deposition of Pb in the soil due to excessive use of fertilizer can cause accumulation of Pb in plants. Besides, the use of foliar pesticides is also at risk of causing the accumulation of Pb in plants. However, information on the influence of the use of fertilizers and pesticides on the accumulation of Pb in plant tissue is very limited. Therefore, this study aimed to study the effect of foliar use of pesticide and the use of Pb-containing fertilizer on the distribution of Pb accumulation in vegetable crops.

Materials and Methods

Time and location of study

This study was carried out in the plastic house of Wonorejo Village, Poncokusumo District, Malang Regency of East Java from August to December 2018. The study location is at an altitude of 678 m above sea level with an average rainfall of 137 mm/year.

Method of experiment

The experiment used a split-plot design, where the main plot was the application of Pb source (A) consisting of A1 = Pb application of pesticide (carbamate group with 40% metomil active ingredient, containing Pb 99 mg Pb/kg); A2 = Pb application of fertilizer (superphosphate fertilizer, containing 21 mg Pb/kg); A3 = application of Pb(NO3)2, containing 50 mg Pb/kg), and A4 = control (without Pb application). The subplot was types of vegetable plants (B), namely B1 = Chinese cabbage (Brassica rapa var. pekinensis) and B2 =
bean (*Phaseolus vulgaris*). Each treatment combination was repeated three times. Ten plant samples were taken for each treatment combination. Vegetable seeds were obtained from the local farm shop, and each plant seed was planted in a polybag containing 5 kg of composite soil obtained from the vegetable planting area of Wonorejo Village which intensively uses Pb agrochemicals. The preparation of planting media was done using composite air-dried soil and mashed to granular size. Furthermore, the plants were planted in polybags and arranged with a planting space of 50 x 40 cm for bean, and 40 x 40 cm for Chinese cabbage. In the application of fertilizer containing Pb, the soil was treated with phosphate fertilizer at a dose of 300 kg/ha. Urea fertilizer of 300 kg/ha and KCl 150 kg/ha were applied as basal fertilizers. Application of 50 mg Pb(NO$_3$)$_2$/kg was given as a comparison of Pb application through the soil. Application of foliar pesticide on the two types of vegetable plants was carried out every three days consisting of insecticide containing Pb 99 mg/kg with the appropriate dosage stated on the packaging label i.e. 4 g/L with a spray application of 1100 L/ha during its growth and stopped two weeks before harvest. Geotextile membranes or tarps were placed over the soil surface in polybags to protect the soil from the splashing of pesticide and avoid soil contamination and metal movement through root absorption (Schreck et al., 2013). The physical-chemical properties of the soil used for the experiment are as follows: pH = 5, organic-C = 1.19%, total-N = 0.13%, total P (Bray) = 97.68 mg/kg, K = 0.71 cmol/kg, Na = 0.14 cmol/kg, Ca = 7.5 cmol/kg, Mg = 1.01 cmol/kg, CEC = 23.06 cmol/kg, base saturation = 41%, silty clay loam texture, available Pb = 1.8 mg/kg, and total Pb = 10.4 mg/kg.

**Method of data collection**

At the age of 60 days after planting, 10 sample plants from each type of vegetable crop were harvested and measured their fresh biomass, dry biomass and Pb content in the shoots, roots and edible parts. For Chinese cabbage, the harvested plant organs were divided into shoots (edible parts, i.e., leaves) and roots; while those of bean were divided into roots, shoots and edible parts (fruit/pods). The plant organs were washed with clean water and then rinsed with deionized water to remove surface dust and soil. After the fresh weight was recorded, the tissue was then oven-dried at 70°C for 48 hours and weighed (Liu et al., 2012). Pb content in plant tissue was analyzed by HNO$_3$ reagent using Atomic Absorption Spectrometer (Agricultural Research and Development Agency, 2012). Soil chemical properties analyzed at harvest were soil pH (H$_2$O 1:1) with a pH meter, total N by the Kjeldahl method (Agricultural Research and Development Agency, 2012), available P (Bray and Kurtz, 1945), organic-C (Walkley and Black, 1934), cation exchange capacity (NH$_4$OAC pH 7.0), and soil Pb content by extraction method with 25% HCl extractor (for total Pb) and 0.1N HCl for Pb dissolved soil using Atomic Absorption Spectrometer (Agricultural Research and Development Agency, 2012).

**Statistical analysis**

To determine the effect of Pb sources on Pb accumulation in plant organs and plant growth, analysis of variance was done with the Anova table for split-plot design. If the F value was greater than the F table, there was a significant influence, and the average results were then compared with the Honest Significant Difference at 5% level.

**Results and Discussion**

**Plant growth and biomass**

Chinese cabbage plant with a fertilizer containing 21 mg Pb/kg produced higher root dry weight, although not significantly different from plants given Pb(NO$_3$)$_2$, compared to control plants. This indicates that there was a defence mechanism from plants grown in media contaminated by a high Pb so that the plant could grow and develop by increasing root growth and also by extending the root system. Chinese cabbage plant fertilized with a fertilizer containing 21 mg Pb/kg and Pb(NO$_3$)$_2$ containing 50 mg Pb/kg produced roots that were longer than the control and that of the plants applied with Pb from pesticide (Figure 1). Meanwhile, the upper part of the biomass (shoot) of Chinese cabbage and bean plants was not significantly different from the plants applied with Pb from pesticide, fertilizer, and Pb(NO$_3$)$_2$, although the average dry weight of Chinese cabbage and bean plants applied with Pb from pesticide tended to produce lower shoot dry weights than that of the control. The shoot and root biomass of Chinese cabbage and bean plants that were given Pb in foliar through the application of pesticide were lower than those of controls.

The decreases in root and shoot biomass of Chinese cabbage plant previously given foliar application of Pb source were 31.52% and 26%, respectively, while in the bean plant, the decreases in root and shoot biomass were 10.34% and 10.75%, respectively, due to the foliar application of Pb in the form of pesticide. The result showed that Chinese cabbage shoots are susceptible to Pb toxicity from foliar application of pesticide. Sinha
et al. (2006) reported that leafy vegetables such as cabbage (Brassica oleracea L.) which was supplied with Pb from 0.1 to 1.0 mM, at 85 days (43 days after metal exposure), experienced a decrease in plant biomass. Reduction of Chinese cabbage dry weight ranged from 23% to 55% compared to controls at different Pb levels. According to Luo et al. (2011), leaf vegetable plants are more susceptible to the accumulation of air pollutants because they are associated with broader leaf areas. In addition, Chinese cabbage plant has a rougher leaf surface in the presence of fine hairs, which allows the deposition of Pb as a result of the foliar application of pesticide. Some parameters that influence the deposition of pesticide spray are the surface shape of the leaves (Massinon and Lebeau, 2013), leaf roughness and leaf angle of 45° to horizontal (Mercer et al., 2007). Although the number of nutrients taken up by plants applied with Pb from fertilizer, pesticide, and Pb (NO$_3$)$_2$ did not differ significantly from the control plants (Table 2), the visual appearance showed a significant influence of Pb foliar application on root and shoot biomass of Chinese cabbage and bean plants that were lower than the control plants. Sinha et al. (2006) reported that the symptoms of Pb toxicity in leaf vegetable plants such as cabbage (Brassica oleracea L.) appear from young plants to adults. The effect on young leaves is a reduction in leaf size and developed interveinal chlorosis along the leaf margin. While the effect on older plants appeared rosette such as restricted the formation of crop size. Heavy metals can cause some biochemical, morphological and physiological damages (Shahid et al., 2015). Heavy metals can also cause disorganization of grana structures, reduce root and shoot growth, reduce chlorophyll biosynthesis, disrupt respiration and photosynthesis (Pourrut et al., 2013). Necrosis and cell death are seen in many plants that grow under heavy metal stress conditions. Production of reactive oxygen species (ROS), which disrupt the redox status of cells, is known to be a major cause of heavy metal toxicity in plants (Shahid et al., 2014; Iqbal et al., 2015).

Table 1. Shoot and root dry weights of Chinese cabbage and bean due to Pb application.

| Treatments | Dry Weight (g/pot) | Root | Shoot | Root | Shoot |
|------------|-------------------|------|-------|------|-------|
| A1 (Pesticide, 99 mg Pb/kg) | 2.52 ± 0.22 a | 11.68 ± 1.19 a | 0.78 ± 0.24 a | 19.74 ± 4.13 a |
| A2 (Fertilizer, 21 mg Pb/kg) | 4.55 ± 0.21 b | 19.09 ± 1.25 a | 0.70 ± 0.11 a | 25.94 ± 10.68 a |
| A3 (Pb(NO$_3$)$_2$, 50 mg Pb/kg) | 4.35 ± 1.31 ab | 16.11 ± 5.79 a | 0.63 ± 0.04 a | 22.07 ± 2.53 a |
| A4 (control) | 3.68 ± 1.38 a | 15.80 ± 3.30 a | 0.87 ± 0.45 a | 22.12 ± 4.44 a |
| HSD 5% | 1.90 | 14.95 | 1.90 | 14.95 |

Note: the data presented are means ± SD from three replications; Different letters in the same column show a significant difference (p <0.05) between treatments of the same species.

Figure 1. Root length of Chinese cabbage and bean in several Pb source applications. The error bar is the standard deviation of the average. Note: A1 = pesticide (99 mg Pb/kg); A2 = fertilizer (21 mg Pb/kg); A3 = Pb (NO$_3$)$_2$ (50 mg Pb/kg); A4 = control (without Pb).
Pb and nutrient concentrations in plants

The Pb concentration in the shoots of Chinese cabbage and bean plants sprayed with pesticide containing Pb was significantly higher around 231.02% (38.63 mg/kg) in Chinese cabbage plant, and 257.18% (60.9 mg/kg) in bean plant compared to the control plants (11.67 mg/kg for Chinese cabbage and 17.07 mg/kg for bean) and also compared to other plants given Pb application through the soil (Figure 2). This was probably due to the deposition of pesticide droplets containing Pb in the shoot of Chinese cabbage plant and bean plant, thus allowing retention of the plant shoot and Pb uptake through plant shoot. Massimon and Lebeau (2013) found that one of the parameters that influenced spray deposition was the shape of the leaf surface. Meanwhile, Mercer et al. (2007) found that the behaviour of pesticide droplets in plants was strongly influenced by leaf roughness and leaf angle of 45° to horizontal. De Ruiter et al. (1990) also explained that the factors that most influence the nature of the cuticular surface include the epicuticular waxy layer, feathers, edges, leaf veins, leaf roughness and others.

The surface of Chinese cabbage leaves has fine hairs which facilitate deposition and retention of the leaf surface, while the leaves of bean plant have a thin cuticle layer, which facilitates the absorption of pesticide into leaf tissue. Forster et al. (2012) explained that pesticide droplets would form four patterns starting from deposition, retention, absorption and translocation. When pesticide drops hit plants, they experience different behaviours related to the presence of reflections, sparks, glides, retention, evaporation, and adsorption on target surfaces such as leaves (Jia and Zhu, 2015). Meanwhile, at the roots of Chinese cabbage and bean plants, the largest Pb concentration was obtained from plants that were given the application of Pb(NO₃)₂. The increase in Pb concentration in the roots of Chinese cabbage plant applied with Pb(NO₃)₂ was 206.32% (39.73 mg/kg), and that in bean plant was 310.03% (44.57 mg/kg), compared to the control plants (12.97 mg/kg for Chinese cabbage and 10.87 mg/kg for bean). This was probably because the concentration of Pb in media given Pb(NO₃)₂ was much higher than in other media, so the possibility of accumulating in the roots was also high. In non-acidic soils, uptake of Pb in plant tissue above the soil (shoot) is generally low due to low Pb solubility in non-acid soils (Huq et al., 2006; McBride et al., 2012). Figure 3 shows the accumulation of Pb in each plant organ. Metal accumulation in plants is calculated by multiplying plant biomass by metal concentration (Xu, 2016). The highest accumulation of Pb in the roots of Chinese cabbage (0.17 mg/plant root dry weight), which was 325% higher than that of the control plants (0.04 mg/plant root dry weight), was found in the plants treated with Pb(NO₃)₂. Meanwhile, the accumulation of Pb in the shoot of Chinese cabbage plant was not significantly different, but Chinese cabbage plant supplied with Pb sources from pesticide (0.45 mg/plant shoot dry weight) and Pb(NO₃)₂ (0.42 mg/plant shoot dry weight) showed a tendency for Pb accumulation of 152.58% and 138.87% higher than the control plant (0.18 mg/plant shoot dry weight).

The accumulation of Pb in the roots of bean was not significantly different between each treatment, although there was an increase in the accumulation of Pb (0.03 mg/plant root dry weight of plants) in the bean plant given with Pb(NO₃)₂ about 200% compared to the control plant (0.008 mg/plant root dry weight). While in the shoot of the bean plant, the application of Pb through pesticide resulted in significantly higher Pb accumulation (1.14 mg/plant shoot dry weight) of around 234.06% compared to the control plant (0.34 mg/plant shoot dry weight). The variation of Pb accumulation and concentration in each plant tissue due to the application of various Pb sources which were given either through soil or foliar, was in line with what was revealed by Bondada et al. (2004), that in addition to plant roots, upper plant organs such as leaves, fruit, and flowers can also absorb heavy metals. The metal is predicted to be accumulated in plant leaves through foliar transfer after the deposition of atmospheric particles on the leaf surface. According to Xiong et al. (2014) and Schreck et al. (2012), plants that grow near mining and smelting areas as well as in urban areas, show an increase in foliar concentrations of heavy metals. Examples of previous studies show the presence of foliar uptake from Fe, Cu, Mn, Zn, and it is known that these metals can penetrate or penetrate the cuticles and eventually accumulate by the tissue underlying the leaves of plants (Vu et al., 2013). A study conducted by Salim et al. (1993) also showed that non-essential metals such as Pb, Cd, and Cu could also enter plant leaves via foliar transfer.

Variations in nutrient uptake also occurred in Chinese cabbage and bean plants which were applied with Pb from several sources (Table 2). In this experiment, the ability of Chinese cabbage plant to uptake N, P, and K nutrients was higher than the bean plant. This was probably due to the structure of Chinese cabbage roots that is more shallow but the distribution of roots is wider than bean roots, and thus expanding the absorption area of mineral ions by the roots of Chinese cabbage plant. However, there were no significant differences in the uptake of N, P and K nutrients in
Chinese cabbage and bean plants that were applied with Pb from pesticide, fertilizer and Pb(NO\textsubscript{3})\textsubscript{2} compared to the control plant (Table 2). This is possible because each plant was treated with N, P and K nutrients in a uniform dose. However, there was a tendency that Pb application from fertilizer caused N, P and K uptake in plants to be lower than control. Godbold and Kettner (1991) revealed that Pb could physically block the access of many ions to the location of their uptake at the root, thereby inhibiting the absorption of mineral ions by plants. Lamhamdi et al. (2013) who conducted experiments under hydroponic conditions with Pb concentrations of 1.5, 3 and 15 mM, reported a decrease in absorption of mineral ions such as Na, K, Ca, P, Mg, Fe, Cu and Zn in spinach and wheat.

Figure 2. Pb concentration in shoots and roots of Chinese cabbage and bean plants due to the application of various Pb sources. The error bar is the standard deviation of the average (three replications). Different letters above the column indicate significant differences (p <0.05) between treatments for each organ of the same plant species. A1 = pesticide (99 mg Pb/kg); A2 = fertilizer (21 mg Pb/kg); A3 = Pb(NO\textsubscript{3})\textsubscript{2} (50 mg Pb/kg); A4 = control (without Pb).

Figure 3. Accumulation of Pb in the shoots and roots of Chinese cabbage and bean plants due to the application of several Pb sources. The error bar is the standard deviation of the average (three replications). Different letters above the column indicate significant differences (p <0.05) between treatments for each organ of the same plant species. A1 = pesticide (99 mg Pb/kg); A2 = fertilizer (21 mg Pb/kg); A3 = Pb(NO\textsubscript{3})\textsubscript{2} (50 mg Pb/kg); A4 = control (without Pb).
Accumulation of Pb in Chinese cabbage and bean from the use of fertilizer and pesticide

Table 2. N, P, and K contents in Chinese cabbage and bean plants due to the application of various Pb sources.

| Treatments Nutrient Content (% plant dry weight) | N     | P     | K     |
|------------------------------------------------|-------|-------|-------|
| Pb sources applied:                             |       |       |       |
| A1 (Pesticide = 99 mg Pb/kg)                    | 3.91 ± 0.87 a | 0.41 ± 0.14 a | 1.83 ± 0.43 a |
| A2 (Fertilizer = 21 mg Pb/kg)                    | 3.52 ± 0.38 a | 0.30 ± 0.04 a | 1.53 ± 0.98 a |
| A3 (Pb(NO₃)₂ = 50 mg Pb/kg)                     | 3.60 ± 1.71 a | 0.41 ± 0.07 a | 1.83 ± 0.85 a |
| A4 (without Pb)                                 | 3.80 ± 0.82 a | 0.36 ± 0.12 a | 1.75 ± 0.69 a |
| HSD 5%                                          | 0.11  | 0.11  | 0.74  |

Plants:

| Plants: Chinese cabbage (B1)                    |       |       |       |
|                                                  | 4.43 ± 0.12 b | 0.48 ± 0.08 b | 2.39 ± 0.36 b |
| Plants: Bean (B2)                                | 2.98 ± 0.33 a | 0.26 ± 0.34 a | 1.08 ± 0.34 a |
| HSD 5%                                          | 0.59  | 0.10  | 1.5   |

Note: the data presented are means ± SD from three replications; Different letters in the same column show a significant difference (p <0.05) between each treatment.

Pb and nutrients concentrations in the soil

The effect of the application of Pb from various sources on soil Pb after planting Chinese cabbage and bean plants for 8 weeks is presented in Table 3. The total Pb concentration after harvest remaining in the media given Pb(NO₃)₂ was higher than that in the media given Pb from pesticide, fertilizer and control (Table 3). This was because the applied Pb(NO₃)₂ had a higher Pb content of 156.34 mg per 5 kg of soil. Besides, the concentration of Pb in the media applied with Pb(NO₃)₂ appeared to be higher than that in other media. This was because the pH in the medium was lower (4.9) than that of the media applied with the Pb source from pesticide (pH = 5.1) and fertilizer (pH = 5.1). According to Clemente et al. (2005), soil pH is a major factor influencing the bioavailability of metals. Kumpiene et al. (2008) revealed that the washing of the three elements Cu, Zn and Pb were highly dependent on pH where the highest mobility was found at acidic pH.

Table 3. Effect of application of various Pb sources on soil chemical properties after planting Chinese cabbage and bean plants for 8 weeks.

| Soil chemical characteristics | Chinese cabbage (B1) | Bean (B2) |
|------------------------------|----------------------|----------|
|                              | A1                   | A2       | A3       | A4       | A1       | A2       | A3       | A4       |
| pH (H₂O)                     | 5.10                 | 5.10     | 4.90     | 4.80     | 5.00     | 5.00     | 4.80     | 4.60     |
| pH (KCl 1N)                  | 4.60                 | 4.60     | 4.50     | 4.40     | 4.40     | 4.50     | 4.20     | 4.30     |
| Organic-C (%)                | 1.14                 | 1.07     | 0.97     | 1.09     | 1.00     | 0.97     | 0.97     | 1.06     |
| Total N (%)                  | 0.14                 | 0.14     | 0.13     | 0.14     | 0.13     | 0.13     | 0.13     | 0.13     |
| C/N ratio                    | 8.00                 | 8.00     | 7.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     |
| Organic Matter (%)           | 1.97                 | 1.85     | 1.67     | 1.89     | 1.74     | 1.68     | 1.67     | 1.83     |
| P-Bray (mg/kg)               | 92.99                | 72.19    | 92.03    | 125.88   | 110.88   | 89.47    | 118.55   | 103.93   |
| K (mol/kg)                   | 1.04                 | 1.49     | 0.99     | 1.09     | 1.15     | 1.76     | 1.25     | 1.11     |
| Total Pb (mg/kg)             | 8.97                 | 5.56     | 30.77    | 5.39     | 9.67     | 6.02     | 38.71    | 6.24     |

Note: A1 = pesticide (99 mg Pb/kg); A2 = fertilizer (21 mg Pb/kg); A3 = Pb(NO₃)₂ (50 mg Pb/kg); A4 = control (without Pb).

Table 3 shows that the average soil pH in the media planted with Chinese cabbage and bean for 8 weeks and applied with Pb from pesticide, fertilizer and Pb(NO₃)₂, and control were in the acid range of 4.6-5.1. Meanwhile, organic-C content and soil organic matter content in media planted with Chinese cabbage and bean for 8 weeks with Pb application from pesticide, fertilizer and Pb(NO₃)₂, and the control showed low values (range 1-2%). Some research results indicate that the decrease in soil pH is related to the increase in metal solubility of a soluble complex from both organic and inorganic amendments (Beesley et al., 2010; Khokhotva and Waara, 2010; Xu et al., 2016). The low pH in this experiment was probably because of the uniform application of inorganic fertilizers, which according to Czarnecki and Düring (2015), the use of N, P, NP, and NPK fertilizers significantly affected the low soil pH. The decrease in pH in the surface layer applied by...
fertilizers contributes to the process of nitrification and acidification which is stimulated by continuous application of fertilizer so that the release of H+ by the roots (Liang et al., 2012). The total N content of the soil in Chinese cabbage media that were given Pb(NO$_3$)$_2$ was also low, while the bean plants showed the average total N in soil treated with pesticide (A1), fertilizer (A2) and Pb(NO$_3$)$_2$ (A3) was relatively stable in the range of 0.13% compared to control bean plants and initial total N conditions in the soil.

The results of this experiment indicate that the total N in the media of the four treatments that have been planted with Chinese cabbage and beans fall into the low category (0.1-0.2%). Xu et al. (2016) reported that experimental soil that was polluted with heavy metals could significantly reduce the availability of nitrogen in the soil, although metal toxicity was reduced by the application of biochar and straw to improve soil pH and organic carbon (Kim et al., 2015). The content of available P in soils planted with Chinese cabbage and beans for 8 weeks was generally very high at more than 15 ppm. The result indicates an excess of phosphorus in the soil which can become a waste resource and might be able to pollute groundwater (Sharpley et al., 2001; Ning et al., 2017). Meanwhile, the K content in the soil planted with Chinese cabbage for 8 weeks showed that of the four treatments, only the media that was applied with Pb(NO$_3$)$_2$ left K in the soil lower than the other treatments and control. However, the result of soil chemical analysis of all treatments in this experiment showed that the K content was still in the high category (0.6-1 cmol/kg) and very high (> 1 cmol/kg). This was probably because the cation exchange capacity in the experimental soil from the beginning in the medium range was around 23.06 cmol/kg, so the application of inorganic fertilizers to the media further increased the retention or storage of Ca$^{2+}$, NH$_4^+$, and K$^+$ ions in the soil colloid that resulted in soil CEC (Radulov et al., 2011; Czarnecki and During, 2015).

**Conclusion**

Chinese cabbage and bean plants that were applied with Pb foliar from pesticide yielded a greater Pb concentration in the shoots than in the roots. So the use of pesticide containing Pb needs to be considered safe, especially if sprayed on vegetable plants that have an edible part located in the shoots such as Chinese cabbage on the leaves and beans on the pods. While Chinese cabbage and bean plants that were applied with Pb sources through the soil from fertilizer and Pb(NO$_3$)$_2$ yielded Pb concentrations in the roots higher than in the shoots. In the control plants, the Pb concentrations in the shoots and the roots of the two plants were significantly lower than those given the Pb from various sources. These results indicate that the application of Pb sources both foliar and through the soil can make Pb to be concentrated in the plant shoots and roots, as well as providing the potential remaining in the soil.

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Accumulation of Pb in Chinese cabbage and bean from the use of fertilizer and pesticide

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