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Research Paper

QUALITY OF POTATO FROM CULTIVATION WITH LEISA SYSTEM CULTIVATION

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Abstract

The purpose of this study is to examine the effectiveness of bioremediation process of insecticide and fungicide residues. Research on consumption of potato cultivation using spread seeds or seedlings. The study looked at the metal content parameters in the soil and in potato tubers. The metal content of Fe, Pb, Cd and Cr in the soil especially in the root zone of potato cultivation of granola varieties at the beginning of potato cultivation varied from 204.0 to 2013.5 ppm, 14.4 - 70.9 ppm, 0.78 - 5.41 ppm and 1.37 - 7.07 ppm, and the end of cultivation are 157.0 - 1156.6 ppm, 8.8 - 52.8 ppm, 0.44 - 2.76 ppm, and 0.37 - 3.61 ppm. Velocity of bioremediation of is Fe = 25.56 ± 3.6 ppm/month, is Pb = 0.19 ± 0, 03 ppm/month, is Cd = 0.23 ± 0.08 ppm/month, and is Cr = 0.73 ± 0.04 ppm/month. At dosage compost fertilizer is 20 tons/ha, the metal concentration of Fe = 6.14 ± 0.02 - 7.37 ± 0.09 ppm, Cd = 0.1 ± 0.004 - 0.13 ± 0.007 ppm and Cr = 0.11 ± 0.04 - 0.14 ± 0.002 ppm.

Key words: *potato tuber, bioremediation, compost fertilizer, LEISA system*.

INTRODUCTION

Horticultural farmers in Bali-Indonesia mostly use insecticides and fungicides to eradicate pests and plant diseases, in addition to increasing the fertility of their land using compost and NPK chemical fertilizers [1]. The study conducted by Suandewi, 2018, showed that the insecticides and fungicides used in the cultivation of potatoes in Bali-Indonesia contain metals Fe, Pb, Cd and Cr respectively 20 - 247 ppm, respectively 5,0 – 7,3 ppm, 2,1 – 4,1 ppm and 4,5 – 4,9 ppm. In addition, compost which is used as a fertilizer in horticultural cultivation in the highlands also contains Fe, Pb, Cd and Cr metals each of 600 ± 15 ppm, 7,3 ± 0,6 ppm, 2,4 ± 0,3 ppm and 4,7 ± 0,6 ppm [1] and [2].

The direct impact of the use of fungicides, insecticides and compost on potato cultivation is the accumulation of these metals in the soil, plant parts that are consumed or not consumed by humans or animals [3], [4], and [5]. The indirect impacts of the use of insecticides, fungicides and compost fertilizers are environmental pollution (water, air, soil), decreased plant health, decreased animal and human health due to consuming potato tubers that have been contaminated with heavy metals [4], [5], [6], [7], [8], [9] and [10].

The amount of these metals absorbed by plants is influenced by factors of soil physical properties and types of plants [11]. The concentration of these metals in potato tubers if Fe> 0,4 ppm, PB> 0,2ppm, Cd> 0,1 ppm, Cr> 0,1 ppm and Zn> 0,35 ppm are very dangerous for the health of consumers (WHO Standard) [12], [13]. Soil pollution by heavy metals can be reduced by the application of inexpensive and environmentally friendly bioremediation technology [14]. The LEISA system developed by Setiyo et al. (2016) in the cultivation of potatoes with fertilization methods using compost dosage of 10 - 30 tons/ha is able to: (1) improve the quality of soil physical properties [15], and [16], (2) increase soil fertility ([15], 16] and [17], and (3) improving the bioremediation process of insecticide and fungicide residues in-situ in the presence of microbes in compost [14] and [17]. large seen from the quality of physical and chemical properties of the soil and microbial population. The microbial population at the beginning of the cultivation of potatoes in a field that has long been cultivated potatoes between 2,2 x 10^4 – 4,7 x 10^4 cfu, while the microbial population in the newly cultivated potato is 8,8 x 10^3 – 2,8 x 10^4 cfu [17].

II. MATERIALS AND METHODS

Material

The material onthis research are potao tuber, soil, Antracol, Acrobat, Dithane M45. HNO3 Pekat, HCl pekat, aquades, and liquid stock Cr 1000 ppm.

Method Seedling cultivation of potatoes

Research on consumption of potato cultivation uses a factorial design with two factors, the first factor is the group or generation of seed potatoes, and the second factor is the dose of the use of organic fertilizer in the LEISA system. Seed potato generation is G3 and G4 or scattered seedlings that have been certified from official institutions. In the LEISA system the dosage of chicken manure compost used in fertilizing is 0, 10, 20 and

30 tons/ha. In addition to compost, potato plants are also fertilized with NPK compound fertilizer at a dose of 250 kg / ha, and cultivated potato plants are sprayed with insecticides and fungicides every 2 weeks starting at 1 month old plants [1].

Each experimental unit occupies a land of 10 x 10 m^2 or with 6 beds, the beds are a repetition of each experimental unit. Potatoes are cultivated on the beds, the beds dimensions are 80 m wide, 30 cm high with drainage channels between beds has a width of 70 cm. Each beds has 2 planting grooves with a spacing of 60 cm and a spacing of 30 cm in each groove. Each mound is covered with black plastic mulch [1].

Method Observation

Analysis of Heavy Metal Pollution of Fe, Pb, Cd and Cr determination by atomic absorption spectrometry (AAS) is described. Soil sample is take from 5 point from each treatment, and five potato plant sample is also take for analysis content of heavy metal. Number potato sample for analysis content of heavy metal is 10 sample for each treatment.

III. RESULTS

3.1 Content of Some Metal on Soil at Root Zone Potatoes Cultivation

Concentration of several types of metals in the soil in the cultivation of potato consumption of granola varieties of groups G4 and G5 amounted to: Fe = 495 – 2013 ppm, Pb = 37,4 – 70,9 ppm, Cd = 2,6 – 5,4 ppm and Cr = 4,3 – 12,0 ppm (Table 1).

Table 1. Content of Fe, Cd, Pb and Cr at the soil potato root zone before potato planting

Dosage of compost, tons/ha	Content of Fe at the soil for group potato plant, ppm		Content of Cd at the soil for group potato plant, ppm		Content of Pb at the soil for group potato plant, ppm		Content of Cr at the soil for group potato plant, ppm	
	G5	G4	G5	G4	G5	G4	G5	G4
0	1267	880	4,1	2,6	58,3	37,4	7,.2	4,3
10	1393	934	5,1	3,5	59,7	37,7	9,3	5,.4
20	1554	1022	5,3	3,2	63,6	41,7	10,4	5,8
30	2013	1311	5,4	3,4	70,9	45,8	12,0	7,1

The concentration of these metals after the potato tubers were harvested is decreased, the concentration of metals Fe, Pb, Cd and Cr each on Table 2 became to 495 – 082 ppm, 23,5 – 49,1 ppm, 1,3 – 2,7 ppm and 1,3 – 5,4 ppm.

Table 2. Content of Fe, Cd, Pb and Cr at the soil potato root zone after potato harvesting

Dosage of compost, tons/ha	Content of Fe at the soil for group potato plant, ppm		Content of Cd at the soil for group potato plant, ppm		Content of Pb at the soil for group potato plant, ppm		Content of Cr at the soil for group potato plant, ppm	
	G5	G4	G5	G4	G5	G4	G5	G4
0	762	495	2,2	1,3	36,6	23,5	2,2	1,3
10	800	543	2,6	1,6	46,0	31,0	4,9	2,8
20	982	673	2,7	1,9	49,1	31,1	5,4	3,1

The metal content of Cd and Pb in the root zone of potato cultivation is lower than the results of research by Cui [18], [11] Jung (2018) and Premanatha [19]. Metal content of Pb = 0,52-13,86 ppm, Cd = 0,01-1,08 ppm, Cr = 1,16 – 62,68 ppm from the results of research by Zeliha [12] in Turkey in potato cultivation. The average value of metal concentrations in soils in Sri Lanka is as follows; Cd = 1,16 ± 0,69 ppm, Ni = (21 ± 25) ppm, Cu = (51 ± 34) ppm, Pb = (60 ± 58) ppm, and Zn = (227 ± 106) ppm [19].

3.2 Content of Some Metal on Potato Tuber

Concentrations of Fe, Pb, Cd and Cr metals in the granola tubers of the G4 and G5 granola varieties grouped as consumption potatoes from 90 days harvesting from seed potato group G3 and G4 are as shown in Table 3. From Table 3, the tendency of increasing concentrations of these metals with increase the fertilizer dosage with compost and increase the generation of seedlings planted. Increasing of Fe, Pb, Cd and Cr if dose compost fertilizer was increasing 10 tons/ha each are 1,22 pmm, 0,35 ppm, 0,008 ppm and 0,007 ppm. Content of Fe, Pb, Cd and Cr were increasing 0,32 ppm, 0,004 ppm, 0,001 ppm and 0,0004 ppm if generation of seed potato increasing one generation.

Table 3. Concentration of Fe, Pb, Cd and Cr on seed potato before planting

Dose of compost fertilizer	Goup potato	Content of Fe on potato tuber, mg/kg	Content of Pb on potato tuber, mg/kg	Content of Cd on potato tuber, mg/kg	Content of Cr on potato tuber, mg/kg
	G3	2.684	0.042	0.075	0.088
	G4	3.123	0.042	0.078	0.088
0 tons/ha	G5	3.211	0.045	0.079	0.092
	G3	4.070	0.082	0.054	0.085
	G4	4.211	0.085	0.056	0.088
10 tons/ha	G5	4.316	0.089	0.056	0.089
	G3	4.561	0.300	0.042	0.088
	G4	4.912	0.305	0.042	0.090
20 tons/ha	G5	5.088	0.320	0.046	0.092
	G3	6.140	0.470	0.100	0.107
	G4	6.491	0.500	0.104	0.114
30 tons/ha	G5	7.368	0.600	0.106	0.115

IV. DISCUSSION

4.1 Content of Some Metal on Soil at Root Zone Potatoes Cultivation

Concentration of these metals in the root zone of potato plants cultivated granola varieties such as Table 1 and Table 2. Decreasing the amount of these metals in the soil as a result of the process: (1) decomposition of metals by microbes or in bioremediation processes in -it [14] andf [15], (2) metal absorption by plant roots [22], and (3) evaporation, and metal washing by irrigation water or rainwater. The metals are present in the soil in conditions bound to particles by the soil or in the form of dissolved by water which is bound in soil particles or their combination. Some of metals that can be absorbed by plants in the form of ions or cat-ions that are soluble and bound to the ground [21].

The rate of decline of Fe, Pb, Cd and Cr metals at a fertilizer dosage of 0 - 30 tons/ha and the cultivation of potato consumption in the G4 and G5 groups were significantly different (P> 0,01). The fastest decrease in metal concentration occurred in the cultivation of potatoes in the G5 group with a fertilizer dosage of 30 tons/ha, the rate of decline in Fe metals= 302,29 ppm/month, Pb = 6,03 ppm/ month, Cd = 0.88 ppm/month and Cr = 3,22 ppm/month. Late metal reduction is cultivation of G3 potatoes with a fertilizer dose of 0 tons/ha, the rate of decline of Fe metal, = 15,67 ppm/month, Pb = 1.86 ppm/month, Cd = 0,11 ppm/month and Cr = 0,33 ppm/month.
Absorption by plant roots in composted land with doses of 10, 20 and 30 tons/ha is: 35,02 ± 5.6 ppm/month, 0,41 ± 0,05 ppm/month, 0, 13 ± 0.08 ppm/ month, and 0,28 ± 0,05 ppm/month. Metals of Fe, Pb, Cd and Cr which can be bioremediated in-situ by microbes in compost are respectively Fe = 25,56 ± 3,6 ppm/month, Pb = 0,19 ± 0, 03 ppm/month, Cd = 0,23 ± 0,08 ppm/month, and Cr = 0,73 ± 0,04 ppm/month. Metals washed by irrigation water or rain water respectively: Fe = 59,3%, Pb = 82,0%, Cd = 26,01% and Cr = 20,04%. This condition shows that: (1) the soil in the study area has the ability to bind weak metals due to low organic matter content, and (2) the metals are more soluble in rainwater or irrigation water. Dissolution of metals by rainwater causes the potential for water pollution around the study site Lake Beratan.

4.2 Metal Content onPotato Tuber

Increased Fe metal concentration = 9,7 ± 1,2 ppm, Pb = 0,36 ± 0,07 ppm, Cd = 0,023 ± 0,006 ppm, and Cr = 0,11 ± 0,02 ppm for each addition of 1 tons/ha of compost fertilizer in potato cultivation land. Chicken manure compost containing metal Fe = 600,5 ± 11,2 ppm, Pb = 7,3 ± 0,3 ppm, Cd = 2,4 ± 0,2 ppm and Cr = 4,7 ± 0,2 ppm. Metal concentrations in organic waste from Ignatowicz and Thoms Brenzko [23] research are Pb = 5,4 -15,7 ppm, Cu = 22,7 – 32,1 ppm, Cd = 0,63 – 0,81 ppm, Cr = 9,9 – 38,1 ppm, Ni = 5,8 - 14 ppm, Zn = 210 - 656 ppm and Hg = 0,58 – 2,.5 ppm. Fe content in chicken manure compost 852,3 ppm, and Mn in cow manure compost 375,0 ppm, Zn concentration in horse manure compost 94,3 ppm. Standard compost containing heavy metals Pb <500 ppm, Cu <800 ppm, Cd <10 ppm, Cr <500 ppm, Ni <100 ppm, Zn <2500 ppm, and Hg <5 ppm. Among the organic and inorganic fertilizers / fertilizers analyzed, triple super phosphate (TSP) had the highest Cd concentration (23,5 ppm). In addition, the metal content of Fe, Pb, Cd and Cr in the soil increases due to the addition of pesticide residues in the soil. Metal Fe and Pb are present in Dithane M45 pesticides with concentrations of 247,3 ppm and 7,4 ppm. The Cd metal is in pesticide type Atracol with a content of 4,0 ppm. Cr metal type is in the Acrobat type pesticide, the amount of Cr metal in Acrobat is 4,96 ppm. Addition of pesticide residues in potato cultivation land each time spraying on average 0,03 – 0,06 ppm. Pesticide residues and insecticide residues cause an increase in the content of Fe, Pb, Cd and Cr metals in the soil by 0.2%, 0.16%, 0.09% and 0.21%, respectively.

Fertilization dose factor, seed group factor used and the combination factor have a very significant effect on the amount of Fe, Pb, Cd and Cr metal in consumption potato tubers. Based on Table 1, fertilizer dosage with compost of more than 20 tons/ha is not good enough for potatoes consumed in G5, G4 or G5 groups, because the concentration of Fe metal = 6,14 ± 0,02 – 7,37 ± 0,09 ppm, Cd = 0,1 ± 0,004 – 0,13 ± 0,007 ppm and Cr = 0,11 ± 0,04 – 0,14 ± 0,002 ppm at harvest time. Although the Pb metal concentration in potato tubers is 0,05 – 0,06 ppm, the value of other metal content is below the SNI threshold. The threshold value of food safety standards determined by SNI is Fe <6 ppm, Pb <0,2 ppm, Cd <0,1 ppm and Cr <0,1 ppm.

Janette Musilova et al. [24] results of the metal content of Cd = 0,039 – 0,106 ppm, Pb = 0,03 – 0,318 ppm in potato tubers. The contents of heavy metals in the potato cultivars were found in the ranges: 48,87-72,64 ppm for iron, 3.07-5.43 ppm for copper, 13,80-18,89 ppm for zinc, 6,93-13,06 ppm for manganese, 0,51-0,77 ppm for lead, 2,02-3,55 ppm for nickel and 0,.08-0,.32 ppm for cadmium [25]. The content of PB in the tuber in plants without amendments reached to 0.38 ppm, Zn – 3,7 ppm, Cu – 2,7 ppm and Cd – 0,04 ppm [26]. The concentration ranges in dry weight basis in decreasing orders were: Mg (420–438 ppm)> Ca (176–254 ppm)> Fe (27,3–90,4 ppm)> Zn (20,6–77. ppm)> (2,00-17,4 ppm) for Pb [27].

Potato tubers are part of plants that are consumed by humans, therefore the contents of these metals in this section must be below the standard food safety standards as stated in SNI. From the research data of the metal content of Fe, Pb, Cd and Cr on potato tubers group G5, G4 and G3 cultivated from potatoes group G4, G3 and G2 which are fertilized using compost fermented chicken manure at a dose of 10-20 tons/ha tuber potatoes are still safe for consumption.

V. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusion

1. The metal content of Fe, Pb, Cd and Cr in the soil especially in the root zone of potato cultivation of granola varieties of G3 and G4 groups at the beginning of potato cultivation varied from 495,0 to 2013,5 ppm, 23,5 to 70,9 ppm, 1,3 – 5,41 ppm and 1,37 – 7,07 ppm. The metal content in the soil at the end of cultivation is 157,0 – 1156,6 ppm, 8,8 - 52.8 ppm, 0.44 - 2.76 ppm and 0,37 – 3,61 ppm. The addition of fertilizer dosage using compost increases the metal content by respectively: 11,11 ± 0,3 ppm/ton compost, 0,34 ± 0,02 ppm/ton compost, 0,02 ± 0,006 ppm/ton compost and 0,007 ppm/tons of compost.
2. Increasing fertilizer dosage using compost increases the percentage of remediated Fe, Pb, Cd and Cr metals. On cultivated potatoes G3 and G4 groups that were not fertilized with compost, the percentage of Fe, Pb, Cd and Cr metals were bioremediated by 1,7%, 7,3%, 25,4% and 26,8%. At the fertilizing dose of 30 tons / ha the total number of these bioremediated metals was 11,9%, 20,4%, 27,4% and 28,2%.

5.2 Suggestion

LEISA system with fertilizing technique using compost in the cultivation of potato varieties of granola is very much needed by farmers, because the microbes present in compost are able to conduct bioremediation in-situ of Fe, Pb, Cd and Cr metals originating from compost decomposition and insecticide residues and fungicide residues . Dose of fertilizing potatoes using compost is done at a dose of 20-30 tons / ha.

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