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GENETIC PERFORMANCE OF FOUR SOYBEAN VARIETIES GROWING ON THE LAND POLLUTED BY FLY ASH SLUDGE

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ABSTRACT

Fly ash sludge was treated to soybean with 300 ppm/plant increased plant height, generative parameter, and to make earlier the firs flowering and harvest time. There are indications that soybean eight weeks after planting with 300 ppm / plant treated to four soybean varieties significantly increased the plant height from 86.17 cm into 95.0 cm for ijen variety, 89.67 cm into 91.33 cm for kaba variety, 96.83cm into 101.67 cm for tanggamus and 87.83 cm into 93.17 cm for anjasmoro. Dose of 300 ppm / plant treated to four soybean varieties significantly increased the average of seed weight 184.17 g into 191.25 g for ijen, 185,57 g into 188,83b for kaba, 214.13 g into 293.13 for Tanggamus and 148.50 g into 213.63cm for anjasmoro. Between four varieties tested that tanggamus registered a good genetic performance compared to other varieties. Fly ash is not only polluting the environment, but it could be also increased growth and production of seeds of four soybean varieties. Fly ash waste treated to soybean with suitable doses could increase growth and dry weight of seed. Fly ash is a fertilizer in low doses to plant and it could be used as fertilizers to save our environment.

KEY WORDS : Soybean, Fly ash, Genetic performance

INTRODUCTION

The urgent contemporary waste problems is an utilization of contaminated with heavy metals sewage sludge produced in large quantities as a result of widespread biological treatment of municipal wastewater (Vasilind and Spinosa (2001; Constantinescu. 2008). They are highly concentrated stable suspensions of biological cells, their metabolites and heavy metals as main components of sludge waste (Nikovskay *et al.* 2013),

Most conventional sewage treatment options are based on approaches to Indonesian and Asian countries' problems, which has usually meant a reduction in biodegradable organic material and suspended solids, plus perhaps some nutrients (nitrogen, calcium and phosphorous). Treatment has involved the 'removal' of these pollutants, but removal is usually conversion to another product, usually sludge. The disposal of sewage sludge is a major consideration in many locations, and it is often seen as an offensive product which is either dumped or burned (Beck *et al.*, 1996; Bohm, 2001; Erhadt and Prue, 2000; Leschber, 1992; Sauerbeck and Leschber, 1992;).

In Riau Indonesia, fly ash waste has been producing by two big pulp and paper companies (Riau Andalan Pulp & Paper and Indak Kiat). The production of paper were estimated about 2.5 million ton in 2013 and the production increasingly every year. About 20 % of its wood processing materials appear into fly ash waste. The industrial side product these is a companies is a serious problems if without a good waste management to environment pollutant they are disposed, mainly in the river and swamp lands.

Islamic University of Riau Indonesia research indicated that, the fly ash waste give a positive effect to some vegetables plant growth (Jumin *et al*. 2015; Jumin, 2014). Recently, in Riau region, traditional people plantation has been using the fly ash waste as substitution of fertilizer. This is being resource efficient and reducing raw material to pulp and paper companies consumption, which makes both

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sustainable and economic sense.

A good example in the European pulp and paper industry is the use of residues from papermaking to produce renewable energy and fertilizer. The industry reduced their CO_2 emissions per ton of product by 43%. Additionally, turning residues from recycling operations into useful products is an interesting illustration of the circular economy. On top of that the European paper recycling rate is at a world record level of 71.7% (Confederation of European Paper Industries, 2014; Clair *et al*., 2003)

Some of the industries of pulp and paper conducted integrated waste management using life cycle analysis attempts to offer the most benign options for waste management. In Indonesia, we have no special regulation concerning application of the waste to agriculture use. However, in European Union they have policies to enhance sludge use in agriculture (Marmo, 2000). Event fly ash production seen as a problem requiring treatment and disposal (Marmo, 2000; Tidestrom, 1997).

Soybeans were first introduced to North America in 1765 to Asian country and became a main food, because soybean oil and protein content account for about 60% of dry soybeans by weight (protein at 40% and oil at˙20%). The remainder consists of 35% carbohydrate and about 5% ash. Soybean cultivars comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ (Chaplin. 1996).

Objective

The main objective of the experiment is to evaluate the genetic performance of four soybean varieties cultivated on land polluted by fly ash waste. Second objective is to find re-cycle possibility of fly ash waste to apply as fertilizer for agriculture use.

MATERIALS AND METHODS

This research has been conducted in Faculty of Agriculture, Islamic University of Riau Indonesia. The experiment materials were obtained from PT RAPP located in the center of Sumatra Island along the strait of Malacca. Number of treatments was 16 with 3 replication, therefore total number of unit experiment is 48. First factor of experiment is variety as follow, Ijen, Kaba, Tanggamus, and Anjasmoro. Second factor is fly ash sludge waste as follow; control, 100 ppm fly ash sludge waste, 200 ppm, fly ash sludge waste and 300 ppm sludge waste. A single seed was planted to a polybag (35 x 40 cm). Plants were maintained under natural light intensity with12 hour photoperiods average. Fertilizer was applied to plant with 1.6 g/plant Urea, 2.4 g/plant TSP and 2.4 g/plant KCl.

Genetic Performance Parameter

Plant height

The plant height were counted on a sub-sample four times namely on 10, 17, 24 and 31 days after planting.

Generative parameters

Generative parameters considered is the first flowering, harvest time and dry weight of seeds. The parameters were counted beginning from first flowering blossom until harvest time. Harvest time is counted if more than approximately 95 % of seed matured and already to harvest. Dry weight of seed was counted if water content is approximately 12%.

Biomass

Biomass is biological material derived from plant and its counted at the end of experiment (Biomass Energy Center. 2012). Biomass and dry weight were measured four times beginning from 10 until 31 days age.

Chemical content and heavy metal content

The nitrogen, phosphorus, calcium, and magnesium, Calcium, Cuprum, Zing, Mercury, Cadmium, and Lead content of fly ash waste were analyzed with appropriate procedures at Laboratory PT Central Alam Lestari Resources. Heavy metals as Mercury, Lead, and Cadmium contents in seed were analyzed at Lab. Dinas Kesehatan dan Lingkungan Riau Province Pekanbaru, and Sucopindo Pekanbaru.

RESULTS AND DISCUSSION

Fly ash sludge sewage was treated to soybean with 300 ppm/plant increased plant height, generative parameter, and to make earlier the firs flowering and harvest time. There are indications that soybean eight weeks after planting with 300 ppm / plant treated to four soybean varieties significantly increased the plant height from 86.17 cm into 95.0 cm for ijen variety, 89.67 cm into 91.33 cm for kaba variety, 96.83cm into 101.67 cm for tanggamus and 87.83 cm into 93.17 cm for anjasmoro (Fig. 1). On the other hand, dose of 300 ppm / plant treated to four soybean varieties significantly increased the average of seed weight 184.17 g into 191.25 g for ijen, 185,57 g into 188,83b for kaba, 214.13 g into 293.13 for Tanggamus and 148.50 g into 213.63cm for anjasmoro (Fig. 2).

The reasons behind the fly ash sludge treatment are the scarce in natural land and water resources and the higher demand of clean water supply and possibility to use for agriculture purpose. Moreover the higher volume of fly ash waste back to natural soil deteriorates quality of soil water in receiving land bodies. These matters have emphasized technological development in plant forest industry to provide innovative yet proven technical solution. The efficacy of heavy metals biological leaching (acid ogeneous and alkali geneous) from sludge suspension was closed to the effect of chemical extraction by acidic solution

The main goal of any sewage treatment plant is to reduce or remove organic matters, solids, nutrients, disease-causing organisms and other pollutants from waste water. Fly ash sewage treatment plants go through several steps in a treatment process in order to safely treat large quantities of solid waste buried. In addition to that each sewage treatment plant must hold a permit listing the allowable levels heavy metal accumulation and other requirements of pollutants. Currently the systems like septic tank, burial tank, oxidation ponds and aerated lagoon are used to treat the polluted waste water and solid sewage. These fly ash waste treatment plants are not very efficient in treating sewage.

The leaching of heavy metals was accompanied by sludge suspension destabilization and organic compound in the soil. The most rapid fly ash sludge waste response was observed in plant high growth process (Fig. 1). In heavy metals of fly ash sludge waste leaching processes the ratio of organic and mineral components in Table 1.

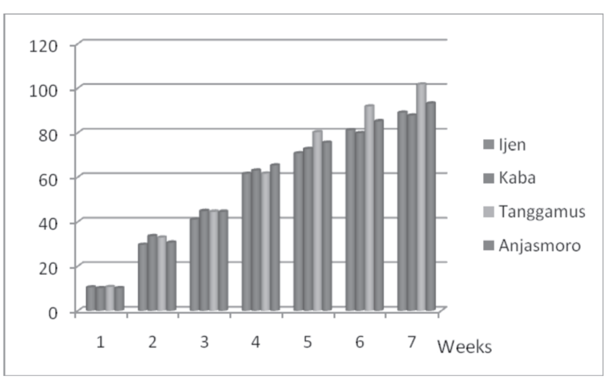

Fig. 1. Growth of four soybean varieties after treatment with 300 ppm of fly ash sewage

Table 1. Physico-chemical characteristics of fly ash waste

Sewage	Parameter Test	Value
Fly Ash	pH	11.24
	C-organic	0.55
	N Total	0.30 %
	P Total	0.24 %
	K Total	1.12 %
	Mg Total	0.43 %
	Fe Total	26720 mg/kg
	Ca Total	7.7 %
	Cu Total	37.8 ppm
	Zn Total	49.6 ppm
	Cd Total	0.15 ppm
	Pb Total	1.53 ppm
	Hg	0.07 ppm
	As	0.08 ppm

Maintaining the proper pH level in the soil was important to the overall health of the plants. The pH of soil is important because it could affect the population of pathogens in the soil, the heavy metal concentration, the nutrient content and the suitable type of plants (Chow. 2010). During three months of study, there was significant differences of pH before and after the plant was being applied with the fly ash sewage and commercial fertilizer. This indicated fly ash sludge waste could maintain values of soil pH, because fly ash sludge waste contains some minerals in high quantity (11.24) pH value (Table 1). Nikovskaya *et al* (2006), mentioned that, fertilizers with alkaline pH are favorable for the formation of water-stable aggregates and maintained pH value which are soil fertility indicator.

For appropriate growth, a root medium must fulfill four functions: continuous supply of water, provide nutrients, allow the exchange of gases to land from the roots, and offer support for the plants (Nelson, 1991). The quality production of ornamental plant can be attained by the use of appropriate potting media, which have a prominent effect on the growth (Vendrame, 2005).

Application of sewage sludge to agricultural land may be beneficial, because it can improve the physical, chemical and biological properties of soils which may enhance crop growth (Beck *et al*., 1996). To achieve this, fly ash sludge sewage application cannot just be a way of disposing of the fly ash sludge but a deliberate application in order to recycle nutrients and to restitute organic matter to soils in order to prevent over-exploitation of agricultural soils in the Community (Marmo, 2000). In addition the use of sludge as a fertilizer would decrease the amounts of chemical fertilizers needed in agriculture (Jumin *et al.* 2015; Jumin, 2014), and supply micro-nutrients which are not commonly restored in routine agricultural practice (Dhir *et al.* 2001). Thus sludge use in agriculture could help save non-renewable materials or energy, a prerequisite to achieve sustainable production (Ocde, 1992 *cit in* Sequi, *et al*. 2000).

Comparisons were made between the different varieties of soybean and fly ash sludge waste treatments in order to determine which fly ash sludge sewage concentration could produce the highest soybean growth and production of seeds if compared to the commercial fertilizer. The growth of soybean was being monitored by measuring its stem high, and production of seeds was being monitored by measuring its dry weight of seeds.

By observing the graph presented in Figure 2, it is noted that the increasing value of fly ash sludge waste application on the plant had affected the growth of development of the plants. The result obtained showed that the highest plant growth was from 300 ppm fly ash sludge waste treatment, followed by 200 ppm and 300 ppm fly ash sludge waste treatments in all varieties of soybeans (90.1 cm, 87.8 cm, and 93.4 cm). Whereas very high of plant height (101.2 cm) was obtained from tanggamus variety. Meanwhile, the lowest growth of soybean was from the 0 ppm fly ash sludge waste treatment on the all varieties. It was noted that the soil itself contained some of the existing nutrients that is enough to promote growth despite a slow growth rate. For the time being, the 300 ppm fly ash sludge waste treatment, which was fed with commercial fertilizer, had shown such a rapid growth of soybean in all varieties in the initial week.

However, it started to decrease growth in early growing due to the excess supply of nutrients. It can be said that the rapid growth of soybean depends on the amount of fly ash sludge sewage concentration in the soil. Dowdy *et al.*, (1978) reported that the increase of plant growth due to bio-solids application often exceed that of well-managed fertilized controls. Unfortunately, the 0 ppm fly ash sludge waste treatment decreased growth because of the insufficient of mineral nutrient inside plant.

Nitrogen is one of the important elements required for the plant growth and reproduction. It ranks after carbon, hydrogen, and oxygen in total quantity needed and it is the mineral element most demanded by plants. Fly ash sludge sewage contained a height amount of nitrogen (Table 1) that can contribute to the plant growth. It can be proven from Figure 1, where the highest applications of fly ash waste in soil, which was 300 ppm fly ash sludge waste treatment gives the rapid growth as compared to the other fly ash sludge waste treatment that contained less amount of fly ash. These results are supported by Coker, (1966); King and Morris, (1972) and Stark and Clapp, (1980), who showed that plants growth and N uptake increased with the bio-solids application as compared to plants that did not received sludge. The growth of plant in all fly ash treatments was increasing greatly, except for the 0 ppm fly ash sludge waste treatment on Ijen variety which the growth rate was slow. The less nitrogen in the soil was the reason of slowed growth.

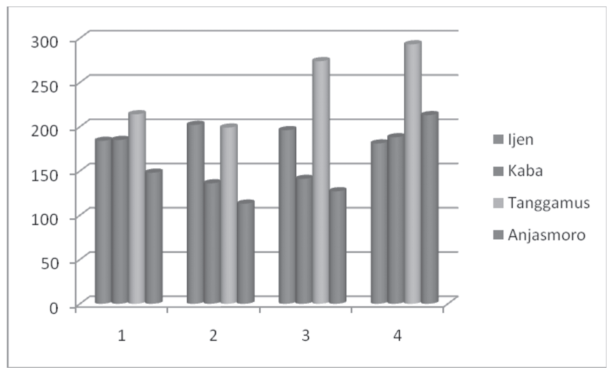

Fig. 2. Seed dry weight of four varieties of Soybean after fly ash treatments
(Colum 1 = 0 ppm, 2 = 100 ppm, 3 = 200 ppm, 4 = 300 ppm)

Normal plant growth cannot be achieved without phosphorus. It activates coenzymes for amino acid production used in protein synthesis and it decomposes carbohydrates produced in photosynthesis. It enhances seed germination and early growth, stimulates blooming, enhances bud set, aids inseed formation and hastens maturity (Jacobs and McCreary, 2001). Seed weight production are the vital elements in soybean, because their protein contents are important to food materials. Balanced potting soil plays an important role in the production of seeds. A high number of seeds will indicate suitable conditions for growing plants.

Based on the result from Figure 2, the dry weight seeds have a positive correlation with the soil phosphorus content because the adequate supply of phosphorus in 300 ppm fly ash sludge waste treatment on Tanggamus variety produced more seeds per plant. In the 34 days (Tabel 2) of experiment, 300 ppm fly ash sludge waste treatment on Ijen variety started to produce flowers and within 82 days soybean produce seeds.

These results were in line with (Strojny and Nowak, 2004), who noted a greater number of flowers in organic residues with a high phosphorus concentration. Besides that, these results were also supported by a study performed by Younis *et al.*, (2007) in which they observed that *Dahlia coccinea* (ornamental plant) produced more flowers when grown in media featuring maximum phosphorus levels. Potassium (K) on the other hand is an essential nutrient for plant growth. Large amounts were absorbed from the root zone in the production of most agronomic crops (Mackay and Barber, 1985). Whenever the plants were deficient of K supplied, the growth of plants was stunted and yields were reduced (Rehm and Schmitt, 1997). Potassium had the ability to stimulate early growth, increases the protein production, improves the efficiency of the water used, and improves resistance to diseases and insects (Rehm and Schmitt, 1997). This statement can be proven by comparing the concentration of potassium (Table 3) and the growth of soybean. Based on the result, whenever the concentration of potassium in the plants was increased the growth rate of plants also increased.

The trace elements in fly ash which are the greatest concern in this study were Copper (Cu), Mercury and Lead (Pb). These elements were essential nutrients for plant growth except for Mercury (Hg) and lead (Pb), which is less concerned because of its insolubility and lower bioavailability. The specific amount of trace elements taken up by a plant species is directly proportional to the amount of sludge metals added and the growth stage of the plants (Lagerwerff. *et al*. 1977).

Although Copper is potentially toxic, it is an essential metal for normal plant growth and development. Thus, plants require Cu as an essential micronutrient for normal growth and development; when this ion is not available, the plants will develop specific deficiency symptoms, most of which affect young leaves and reproductive organs. The leaves twisted or malformed and showed chlorosis or even necrosis (Marschner (1995).

Lead (Pb) concentration in the plant leaves were influenced by the different concentration of additional nutrients. It was observed that, Pb absorption of plants increased proportional to the amount of bio-solids in the growth media. Lower concentration of Pb in stem and leaves of *R. chinensisis* shows no negative influenced to growth (Roslan *et al*. 2013). Accumulation of Pb was in order of stems>roots>leaves (Alloway and Jackson,

Table 2. Flowering in of four Soybean varieties after fly ash sludge treatments

Soybean Varieties	Fly ash solid sewage treatments				Average
	F0	F1	F2	F3	
Ijen	34,33a	34,67a	34,83a	35,00ab	34,71a
Kaba	35,33ab	34,83a	35,00ab	36,00b	35,29b
Tanggamus	45,33c	45,00c	44,33c	44,50c	44,79d
Anjasmoro	36,67b	35,83ab	35,67ab	35,33ab	35,88c
Average	37,92	37,58	37,46	37,71	

Mean value followed by different alphabet/s within column do not differ significantly over one other at $p \leq 0.05$ lead by Duncan's Multiple Range Test

Table 3. Number of pods per plant of four Soybean varieties after fly ash sludge treatments

Soybean varieties	Fly ash solid sewage treatments				Average
	0 ppm	100 ppm	200 ppm	300 ppm	
Ijen	161,67c	159,83c	181,17b	172,50bc	168,79b
Kaba	145,17c	121,00c	123,17c	141,33c	132,67c
Tanggamus	236,83ab	215,17b	284,50a	300,33a	259,21a
Anjasmoro	116,00cd	101,67d	104,67d	167,33bc	122,42c
Average	164,92b	149,42b	173,38ab	195,38a	

Mean value followed by different alphabet/s within column do not differ significantly over one other at $P \leq 0.05$ lead by Duncan's Multiple Range Test

Table 4. The heavy metals analysis of seeds for four soybean varieties

No	No Lab	Description	Parameters	Unit	Result	Method
1	3250/ 2353 AK.K	Ijen (300 ppm)	Lead (Pb)	mg/L	0,1	APHA (Section 3111 B) 2005
			Cadmium (Cd)	mg/L	0,006	
			Mercury (Hg)	mg/L	<0,4 x 10^{-4}	
2	3250/ 2352 AK.K	Kaba (300 ppm)	Lead (Pb)	mg/L	0,2	
			Cadmium (Cd)	mg/L	0,007	
			Mercury (Hg)	mg/L	<0,4 x 10^{-4}	
3	3250/ 2354 AK.K	Tanggamus (300 ppm)	Lead (Pb)	mg/L	0,07	
			Cadmium (Cd)	mg/L	0,008	
			Mercury (Hg)	mg/L	<0,4 x 10^{-4}	
4	3250/2355 AK.K	Anjasmoro (300 ppm)	Lead (Pb)	mg/L	0,1	
			Cadmium	mg/L	0,007	
			Mercury	mg/L	<0,4 x 10^{-4}	

The total number of heavy metal contents is still under threshold of maximum total of heavy metal contents B3 (*Materials with dangerous and poison*) (Baku Mutu Menurut Kep.04/ Bapedal/IX/1995).

1991). A high level of Pb can cause inhibition of growth, interference with the cell division and water absorption and balance and the reduction of photosynthesis. All the essential elements in this study posed relatively little hazard to the growth of the plants (Table 4) because all of them have low solubility in soil and it present in the bio-solids in such small quantities (Table 1). Thus, it only provides the essential nutrient to plants and soil without contaminating them.

Accumulation of Cadmium (Cd) and Mercury (Hg) can cause negative influenced to metabolism of carbohydrate and interference with enzyme activation. Contents of lead, mercury, cadmium and arsenic in seeds are lower than the threshold of human healthy tolerance (Bapedal, 1995).

At similar efficiency, the processes of heavy metals removal with organic compound in soil due to their high speed and exclusion of secondary chemical pollution. The results of the investigation of conditions for heavy metals after soil treatment of fly ash waste have served as a base of appropriate process of bioconversion of sewage sludge into fertilizer and its scheme is shown in Figure 3.

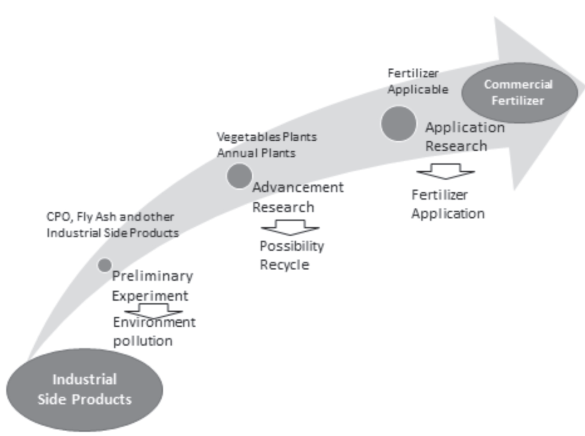

Fig. 3. Circulation system of industrial products will be used as a fertilizer for agriculture use

CONCLUSION

Fly ash treated to soybean with suitable doses could sludge increase plant height and dry weight of seeds. The low dose of fly ash waste is not be a poison to the plant, is a fertilizer. Between four varieties tested tanggamus was shown a good genetic performance compared to other varieties.

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