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Improving Soil Properties and Yield of Corn (*Zea Mays* L.) by Application of Organic Amendment on Abandoned Tin-Mining Land in Bangka Island

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ABSTRACT

An abandoned land after tin-mining activities are degraded lands with undulating and destructed land scape and low soil fertility status. The objective of this study was to determine the effects of organic amendments on the soil properties, growth, and grain yield of corn (*Zea mays* L.) on abandoned tin-mining areas in Bangka Island, Bangka Belitung Archipelago. The field experiment was conducted at the abandoned tin-mining areas in Cambai Village, Bangka Belitung Archipelago. Five treatments of organic amendments were applied and replicated three times and laid out in a Randomized Completely Block Design. All treatments were applied with the recommended rate fertilizer of 135 kg N ha^{-1}, 72 kg P_2O_5 ha^{-1}, and 120 kg K_2O ha^{-1}. The treatments were T_1= 20 Mg chicken manure ha^{-1};T_2= 20 Mg cattle manure ha^{-1}; T_3= 20 Mg rice straw compost ha^{-1}; T_4: 10 Mg of chicken manure ha^{-1} + 10 Mg rice straw compost ha^{-1}; and T_5= 10 Mg cattlemanure ha^{-1} + 10 Mg rice straw compost ha^{-1}. Application of organic amendments (chicken manure, cattle manure, and rice straw compost) on abandoned tin-mining land improved soil fertility due to the increasing of soil pH and nutrient availability, especially available-P and -K, and exchangeable bases. Application of chicken manure and cattle manure were significantly better than rice straw compost to improving soil fertility, nutrient uptake, growth and yield of maize. Application of cattle manure gave the highest yield of maize, namely 6.24 Mg ha^{-1}.

Keywords: Bangka Island, corn, organic amendment, tin-mining land

ABSTRAK

Lahan bekas kegiatan tambang timah adalah lahan yang telah mengalami degradasi dengan lanskap bergelombang dan tidak beraturan, dengan status kesuburan tanah yang rendah. Tujuan dari penelitian ini adalah untuk mempelajari pengaruh pemberian lahan organik terhadap sifat tanah, pertumbuhan, dan hasil tanaman jagung (*Zea mays* L.) pada lahan bekas tambang timah di Pulau Bangka, Kepulauan Bangka Belitung. Penelitian dilaksanakan di lahan bekas tambang timah Desa Cambai, Kepulauan Bangka Belitung. Lima perlakuan pemberian bahan yang diaplikasikan adalah organik yang diulang tiga kali dan disusun dalam Rancangan Acak Kelompok. Semua perlakuan diaplikasikan pupuk standar yang terdiri dari 135 kg N ha^{-1}, 72 kg P_2O_5 ha^{-1}, dan 120 kg K_2O ha^{-1}. Perlakuan T_1= 20 Mg kotoran ayam ha^{-1}; T_2= 20 Mg kotoran sapi ha^{-1}; T_3= 20 Mg kompos jerami padi ha^{-1}; T_4= 10 Mg kotoran ayam ha^{-1} + 10 Mg kompos jerami padi ha^{-1}; dan T_5= 10 Mg kotoran ternak ha^{-1} + 10 Mg kompos jerami padi ha^{-1}. Pemberian bahan organik (kotoran ayam, kotoran sapi, dan kompos jerami padi) di lahan bekas tambang timah meningkatkan status kesuburan tanah karena terjadi peningkatan pH dan ketersediaan hara tanah, terutama P dan K tersedia, serta basa-basa tertukar. Perlakuan kotoran ayam dan kotoran sapi secara nyata meningkatkan kesuburan tanah, serapan hara, pertumbuhan dan hasil jagung dibandingkan perlakuan kompos jerami padi. Aplikasi kotoran sapi memberikan hasil jagung tertinggi, yaitu 6.24 Mg ha^{-1}.

Kata Kunci: Bahan organik, lahan, tambang, timah, Pulau Bangka

INTRODUCTION

Indonesia is known as the second largest tin producer in the world after china (Gardiner *et al.* (2015) and Fong-Sam*et al*. (2012)). Most of Indonesia's tin ores are found in Bangka Belitung Archipelago, which is located in the South-East Asia Tin Belt. The combined output of China and Indonesia accounts for about two-thirds of the world's mined tin output. Other significant refined tin producers in the region are Malaysia and Thailand.

Abandoned-mining areas generally consists of two parts, namely (1) the dry part (tailing) and (2) watery part, an abandoned tin-mining pond (Sujitno, 2007). Tailing is a stretch residual leaching of lead minerals (Madjid *et al*. 1994). The tailings consist of two fractions – sand tailing and slime tailing. Sand tailing is very coarse textured and shows an absence of aggregation and profile development, while slime tailing mainly consists of very fine soils and minerals (silt and clay), and has compact structure (PT Timah 2009; Ashraf *et al*. 2013).

Angand Ho (2002) reported that tailing and ponds are about 85.6% and 14.4% of the total abandoned tin-mining land area respectively. Sand tailings cover approximately 80-90% and slime tailings cover 10-20% of the total area of the tailings (Liem *et al*. 1981). Slime tailings consist of more than 90% clay and silt particles (Ang and Ho 2002).

An abandoned land after tin-mining activities are degraded lands with undulating and destructed landscape (Sengupta 1993; PT Timah 2010) and low soil fertility status (Inonu 2011; Setiadi 2002). Tailings have high portion of sand, low clay content, low soil pH, low organic matter content, low cation exchange capacity (CEC), low water-holding capacity, and very low essential macro elements (Saptaningrum 2001; Inonu 2011; Ashraf *et al*. 2013).

Overcoming physical, chemical, biological, and toxicity problems of abandoned tin- mining areas are the key to improve the growth of crops in these land. It can be accomplished through application of soil amendments such as manure and compost since they will increase the content of soil organic carbon (Srinivasarao *et al*. 2014; Ding *et al*. 2012; Ludwig *et al*. 2011; Purakayastha *et al*. 2008). Besides, soil organic matters play a key role in the improvement of soil physical, chemical and biological properties (Ouédraogo *et al*. 2007; Akala and Lal 2000).

The objective of this study was to determine effects application of organic amendments on the soil properties, growth, and grain yield of corn on abandoned tin-mining areas in Bangka Island, Bangka Belitung Archipelago.

MATERIAL AND METHODS

The field experiment was conducted at the abandoned tin-mining areas in Cambai Village ($02^0$14'39"S and $106^0$08'54"E), Namang Sub District, Central Bangka, Bangka Belitung Archipelago. The soil is classified as Entisols (USDA). The experiment was conducted during dry season in June-September 2015.

Five treatments were applied. The treatments were replicated three times and laid out in a Randomized Completely Block Design. All treatments were applied with chemical fertilizers with the recommendation rate of 135 kg N ha^{-1}, 72 kg P_2O_5 ha^{-1}, and 120 kg K_2O ha^{-1}.

T_1 = 20 Mg Chicken Manure ha^{-1}
T_2 = 20 Mg Cattle Manure ha^{-1}
T_3 = 20 Mg Rice Straw Compost ha^{-1}
T_4 = 10 Mg Chicken Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}
T_5 = 10 Mg Cattle Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}

Plot size of each unit used in this study was 6 m × 4 m. Corn var Lamuru from Indonesian Cereals Research Institutewas used in this study. Maize planting was done through drill as deep as 5 cm at a spacing of 20 cm × 80 cm, with 1 seed per hole.

Organic amendment (rice straw) was composted using M-Dec Bioactivator from Indonesia Soil Research Institute. Organic amendments were applied by broadcasting and mixing to the soil two weeks before planting. N fertilizer (45-0-0) was applied three times, 1/4 was applied at 4 days after planting (DAP), 1/2 was applied at 21 DAP and 1/4 was applied at 42 DAP; Super Phosphate (0-36-0) was applied once at 4 DAP; and Muriate of Potash (0-0-60) was applied twice; 3/4 was applied at 4 DAP and 1/4 was applied at 21 DAP.

Parameters observed were soil chemical properties before planting and after harvesting, growth and yield of corn. The parameters of soil chemical properties were soil pH, Organic-C, Total-N, Total-P, Total-K,Available-P, Available-K, Exchangeable-K, -Ca, -Mg, and -Na, and CEC. The growth and yield parameters observed were plant height, stem diameter, leaf number, dry weight of shoot biomass, dry weight of root biomass, cob length, cob diameter, cob weight, line number, 1,000 grain weight, and yield of corn. N, P, and K uptakes were also observed.

Statistical Tool for Agricultural Research (STAR) was used to compare the effects of the different soil amendments on soil properties, nutrient uptake, and growth and yield of corn. Further, orthogonal contras test was used ($p = 0.05$) to determine the significant differences among the treatments.

RESULTS AND DISCUSSION

Soil Properties at the Experimental Site

The soil criteria proposed by the Indonesia Soil Research Institute (2011) were used to assess the initial characteristics of the soil. Table 1 shows that the soil was extremely acidic and contained very low organic-C and total-N. The soil was extremely

Table 1. Physical, chemical, and biological properties of abandoned tin-mining soil used in the field-experiment.

Parameter	Methods	Unit	Value	Remarks
pH H_2O (1:1.5)	Electrode Glass		5.4	Acid
pH KCl (1:1.5)	Electrode Glass		4.6	Acid
Organic-C	Walkley-Black	g kg^{-1}	01.10	Very low
Total-N	Kjeldahl	g kg^{-1}	0.10	Very low
C/N			11	Moderate
P_2O_5	HCl 25%	mg kg^{-1}	50	Very low
K_2O	HCl 25%	mg kg^{-1}	30	Very low
P_2O_5	Bray-1	mg kg^{-1}	8.7	Very low
K_2O	Morgan	mg kg^{-1}	22	
Exchangeable-Ca	(NH_4-Acetat 1N pH 7)	cmolc kg^{-1}	0.06	Very low
Exchangeable-Mg	(NH_4-Acetat 1N pH 7)	cmolc kg^{-1}	0.03	Very low
Exchangeable-K	(NH_4-Acetat 1N pH 7)	cmolc kg^{-1}	0.01	Very low
Exchangeable-Na	(NH_4-Acetat 1N pH 7)	cmolc kg^{-1}	0.01	Very low
Cation Exchange	Capacity (NH_4-Acetat 1N pH 7)	cmolc kg^{-1}	1.58	Very low
Base Saturation	(NH_4-Acetat 1N pH 7)	g kg^{-1}	69.60	Very low
Al^{3+}	(KCl 1N)	cmolc kg^{-1}	0.02	
H^+	(KCl 1N)	cmolc kg^{-1}	0.16	
Al-Saturation		%	6.89	Low
Particle size	(Pipette)	g kg^{-1}		Sand
distribution			940	
Sand			20	
Silt			40	
Clay				

deficient in phosphorus and potassium. The quantity of exchangeable bases for exchangeable-Ca, -Mg, -K, and -Na were very low. The content of CEC and base saturation (BS) were also very low, and Al-saturation was low. The soil textural class was sand.

Table 1 indicates that abandoned tin-mining lands had very low soil fertility status compared to unmined land, then in order to make tin-mining land as an ideal media for crop growth, the application of external input is necessary. As mentioned by Asmarhansyah (2015) compared to un-mined soil, sand tailings were dominated by sandy texture and have low soil pH, low content of N, C, P, and exchangeable-Ca,-Mg,-K, and -Na. Shrestha and Lal (2011) stated that the removal and storage of soil notably alter top soil properties, being associated to C and nutrient losses, decreasing microbial activity, disruption soil structure and pH shifts; while Lasmini *et al*. (2015) stated the deficiency of N must be added from the outside through fertilization.

Properties of the Organic Amendment Used in the Experiment

Table 2 presents the properties of the organic amendment used in the experiment. Table 2 shows that rice straw compost had the highest pH compared to cattle manure and chicken manure, but rice straw compost had the lowest organic-C and total-N compared cattle manure and chicken manure, and the chicken manure had the highest C/N.

The highest phosphorus content was achieved by chicken manure, while the lowest was in rice straw compost. The cattle manure and chicken manure had higher calcium, magnesium, potassium, and sodium compared to rice straw compost. The highest CEC was achieved by cattle manure, while the lowest was achieved by rice straw compost. The chicken manure had the lowest content of Pb compared to cattle manure and rice straw compost. The rice straw compost had the highest Sn content compared to cattle manure and chicken manure. Cr was only found in chicken manure, and the contents of Hg were quite similar among organic amendments used.

Effects on Soil Chemical Properties

The effect of application of organic amendments (chicken manure, cattle manure, and rice straw compost) on soil chemical properties is presented in Table 3. The statistical significance because of amendments application on soil chemical properties is presented in Table 4.

Soil pH

Compared to the initial soil pH (Table 1), the application of organic amendments increased soil pH of abandoned tin-mining soils. Table 4 shows that application of cattle manure significantly gave higher pH KCl than chicken manure, namely 5.43 and 5.10, respectively, while application of chicken (T1) and cattle (T2) manures significantly gave higher soil pH H_2O and pH KCl compared to rice straw compost (T3). Increasing soil pH of the tin-mining land because of additional cation from mineralization of organic amendments applied in the tin-mining land. Achiba *et al*. (2009) reported that a possible mechanism how organic amendments can increase soil pH (when the original pH is relatively low) is due to the mineralization of carbon and subsequent production of OH^- ions by ligand exchange as well as the available of basic cations, such as K^+, Ca^{2+}, and Mg^{2+}.

In abandoned tin-mining soil, manure gave higher soil pH compared to rice straw compost since manure had higher organic carbon and total-N compared to rice straw compost, therefore, it gave higher organic carbon and total N to be mineralized and also released N, P, and K and cations. Cooperband (2002) affirmed that animal manure is a good source of organic amendment and nutrients. It can supply N, P, and K needed by crops because of its higher total N, P, and K contents in forms readily available for crop uptake.

Soil Organic Carbon, Total-N, and C/N

In general, compared to the initial soil organic carbon (SOC) and total-N (Table 1), the application of organic amendments increased SOC and total-N (Table 3), but SOC, total-N, and C/N were not significantly different among treatments (Table 4). Since abandoned tin-mining soil had very low organic carbon and total-N content in the initial soil, then continuous incorporation of manures into the soil are needed to improve soil chemical and physical properties. Liu *et al*. (2013) studed that SOC content in the Northwest of China could be improved by a long-term application of organic manure and inorganic fertilizers.

Total Phosphorus

Compared to the initial total phosphorus (Table 1), the application of organic amendments increased the total phosphorus (Table 3). Table 4 shows that application of chicken manure significantly gave higher total P compared to cattle manure, namely 186.70 mg kg^{-1} and 83.30 mg kg^{-1}, respectively. When it was mixed with rice straw compost, the application of chicken manure also significantly gave higher total P compared to mixture of cattle manure and rice straw compost, namely 123.30 mg kg^{-1} and 80.00 mg kg^{-1}, respectively. Compared to rice straw compost, application of chicken and cattle manure significantly contributed to higher total P, namely 135.00 mg kg^{-1} and 63.30 mg kg^{-1}, respectively since

Table 2. Properties of organic amendments used in the experiment.

Parameter	Cattle Manure	Chicken Manure	Rice Straw Compost
pH H_2O (1:5)	8.00	7.90	9.30
Organic-C (g kg^{-1})	240.70	245.10	95.40
Total-N (g kg^{-1})	23.30	14.50	18.60
C/N	10.00	17	5.00
P_2O_5 (g kg^{-1})	8.06	19.70	1.80
Ca ($cmol_c kg^{-1}$)	15.62	14.97	8.09
Mg ($cmol_c kg^{-1}$)	2.52	3.02	2.91
K ($cmol_c kg^{-1}$)	21.68	21.78	16.26
Na ($cmol_c kg^{-1}$)	6.58	6.83	0.85
CEC ($cmol_c kg^{-1}$)	30.43	26.21	17.81
Pb (mg kg^{-1})	15.00	5.00	14.00
Cd (mg kg^{-1})	BDL	BDL	BDL
Co (mg kg^{-1})	7.00	6.00	7.00
Cr (mg kg^{-1})	BDL	12.00	BDL
Sn (mg kg^{-1})	6.00	7.00	13.00
Hg (mg kg^{-1})	0.10	0.10	0.10

BDL: Below detection limit

chicken manure has the highest total P compared to cattle manure and rice straw compost (Table 1).

Total and Available Potassium

Compared to the initial soil total and available (Table 1), the application of organic amendments increased the total potassium and available potassium (Table 3). Table 4 shows that application of chicken and cattle manures significantly gave higher total and available potassium of abandoned tin-mining soil compared to rice straw compost, namely 71.65 mg kg^{-1} and 46.70 mg kg^{-1} for total K; and 69.5 mg kg^{-1} and 40.33 mg kg^{-1} for available K, respectively since cattle manure and chicken manures have higher potassium compared to rice straw compost (Table 1). The mineralization process of manure releases potassium in soil. Shi (2016) stated manure contains most elements required for plant growth including N, P, potassium and micronutrients.

Exchangeable-K, -Ca, -Mg, and -Na

In general, compared to the initial exchangeable -K, -Ca, -Mg, and -Na (Table 1), the application of organic amendments increased the exchangeable-K, -Ca, -Mg, and -Na of abandoned tin-mining soil (Table 3). Table 4 shows that application of cattle manure significantly increased exchangeable-Ca and –K compared to chicken manure, namely 1.06 $cmol_c kg^{-1}$ and 0.90 $cmol_c kg^{-1}$ exchangeable-Ca and 0.16 $cmol_c kg^{-1}$ and 0.13 $cmol_c kg^{-1}$ exchangeable-K, respectively. The application of chicken and cattle manures significantly increased exchangeable-K, -Ca, -Mg, and –Na compared to rice straw compost, namely 0.98 $cmol_c kg^{-1}$ and 0.40 $cmol_c kg^{-1}$ exchangeable Ca; 0.15 $cmol_c kg^{-1}$ and 0.06 $cmol_c kg^{-1}$ exchangeable Mg; 0.14 $cmol_c kg^{-1}$ and 0.08 $cmol_c kg^{-1}$ exchangeable K; and 0.08 $cmol_c kg^{-1}$ and 0.02 $cmol_c kg^{-1}$ exchangeable Na, respectively. The increasing of bases were due to the releasing of bases from manure. Table 2 shows that manure contained higher bases compared to rice straw compost. Brady and Weil (2007) reported that increasing soil organic matter increase the base cations and CEC through enhancement in available negative charge, which in turn, increase the buffer capacity in soil.

Total Exchangeable-K, -Ca, -Mg, and -Na

In general, compared to the initial total exchangeable -K, -Ca, -Mg, and -Na (Table 1), the application of organic amendments increased the total exchangeable -K, -Ca, -Mg, and -Na of soil (Table 3). Table 4 showed that application of cattle manure gave significantly higher total exchangeable-

Table 3. Soil properties of experimented site after corn harvesting

Treatment	pH H_2O	pH KCl	Organic-C	Total-N	C/N	P_2O_5 HCl 25%	K_2O HCl 25%	K_2O Morgan	Ca	Mg	K	Na	Total bases	CEC	BS
			------- g kg^{-1} -------			--------mg kg^{-1} ------		--mg kg^{-1}--	----------------$cmol_c kg^{-1}$----------------						%
T_1	5.93	5.10	1.30	0.17	8.67	186.70	70.00	68.33	0.90	0.17	0.13	0.07	1.27	1.77	65.31
T_2	6.13	5.43	1.40	0.17	8.83	83.30	73.30	70.67	1.06	0.14	0.16	0.09	1.46	1.95	82.63
T_3	5.57	4.83	1.50	0.20	7.50	63.30	46.70	40.33	0.40	0.06	0.08	0.02	0.55	1.78	30.78
T_4	5.73	5.13	1.30	0.17	8.67	123.30	66.70	66.00	0.77	0.14	0.12	0.05	1.09	1.84	59.55
T_5	5.90	5.00	1.40	0.17	8.83	80.00	63.30	55.01	0.81	0.11	0.14	0.06	1.12	1.88	60.89

T_1 = 20 Mg Chicken Manure ha^{-1}
T_2 = 20 Mg Cattle Manure ha^{-1}
T_3 = 20 Mg Rice Straw Compost ha^{-1}
T_4 = 10 Mg Chicken Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}
T_5 = 10 Mg Cattle Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}

K, -Ca, -Mg, and -Na compared to chicken manure, namely 1.46 $cmol_c kg^{-1}$ and 1.27 $cmol_c kg^{-1}$, respectively. The application of chicken manure and cattle manure significantly gave higher total exchangeable -K, -Ca, -Mg, and -Na compared to rice straw compost, namely 1.36 $cmol_c kg^{-1}$ and 0.55 $cmol_c kg^{-1}$, respectively.It can be explained since organic amendment of cattle and chicken manure has higher total exchangeable-K, -Ca, -Mgcompared to rice straw compost (Table 1), then they will provide more bases to abandoned tin-mining soil compared rice straw compost. Through 14 long-term trials worldwide, Edmeades (2003) affirmed that the use of manure relative fertilizer could result in excessive enrichment of K, Ca, and Mg in the top soil.

Cation Exchangeable Capacity

Compared to the initial soil CEC (Table 1), the application of organic amendments increased the soil CEC (Table 3), but soil CEC was not significantly different among treatments (Table 4). It can be understood since abandoned tin-mining soils are dominated by sand texture and had low SOC. This situation make abandoned tin-mining soil had low exchanges site capacity and low bases content. Brady and Weil (2007) stated that soil with coarse texture would have less clay and soil organic matter and therefore would have a lower amount of exchange cation and lower CEC.

Base Saturation

In general, compared to the initial BS (Table 1), the application of organic amendments increased the BS (Table 3). Table 4 showed that in abandoned tin-mining soil, application of cattle manure gave significantly higher BS compared to chicken manure, namely 82.63% and65.31%, respectively. The application of chicken manure and cattle manure significantlygave higher BS compared to rice straw compost, namely 73.97% and 30.78%, respectively. Increasing BS is caused by the increasing of base cations and CEC from the manure applied. Manure gave higher BS because manure contained higher bases cation compared to rice straw compost. According to Edmeades (2003) SOM and clay particles have largesurface areas and have a large number of exchange sites. The intrinsic CEC of animal manures can vary widely, and their application to soils will often increase CEC, mainly because its effects on SOM.

N, P, K Contents and N, P, K Uptakes in Corn Short

Effect application of organic amendments (chicken manure, cattle manure, and rice straw

Table 4. Effect of organic matters applications on soil chemical properties after corn harvesting.

Treatment	pH H_2O	pH KCl	Organic-C	Total-N	C/N	P_2O_5 HCl 25%	K_2O HCl 25%	K_2O MORGAN	Ca	Mg	K	Na	Total Bases	CEC	BS	Al^{3+}	H^+
T_1 Vs T_2	1.41 ns	9.80*	0.09 ns	0.00 ns	0.01 ns	90.66**	0.31 ns	0.14 ns	9.58*	5.29 ns	16.88**	1.41 ns	13.03**	1.79 ns	7.39*	0.14 ns	0.15 ns
T_4 Vs T_5	0.98 ns	1.57ns	0.19 ns	0.00 ns	0.01 ns	15.94**	0.31 ns	3.17 ns	0.40 ns	6.69*	5.21 ns	0.46 ns	0.40 ns	0.10 ns	0.04 ns	0.69 ns	0.26 ns
T_1T_2 Vs T_3	10.21*	22.09**	0.48ns	1.00 ns	0.92 ns	41.09**	21.13 **	29.73 **	163.81**	99.17**	116.74**	13.15**	319.60**	0.44 ns	61.30**	4.74 ns	17.11**
T_1T_2 Vs T_4T_5	0.32ns	0.65 ns	0.01 ns	0.00 ns	0.00 ns	18.87**	2.50 ns	0.03 ns	0.01 ns	0.45 ns	1.68 ns	0.01ns	0.15 ns	0.11 ns	0.02 ns	0.01 ns	0.92 ns

* significant ** highly significant ns not significant

compost) on soil chemical properties is presented in Table 5 and its statistical significance is presented in Table 6. In general, application of cattle manure significantly increased both N, P, K contents and in shoots NPK uptakes compared to chicken manure (Table 6). NPK content of cattle manure and chicken manure were 19.43 g kg^{-1} and 18.90 g kg^{-1}; 2.20 g $kg^{-1}$and 1.63 g kg^{-1}; and 37.53 g kg^{-1} and 36.53 g kg^{-1}, respectively, while NPK uptake of cattle manure and chicken manure were 1.32 g and 1.09 g; 0.15 g and 0.09 g; and 2.55 g and 2.10 g, respectively.

Application of chicken manure and cattle manure significantly increased NPK contents and NPK uptakes in corn shoots compared to rice straw compost (Table 6). NPK content of cattle manure and chicken manure were 19.16 g kg^{-1}, 1.91 g kg^{-1}, and 37.03 g kg^{-1}, while NPK content of rice straw compost were 14.33 g kg^{-1}, 1.10 g kg^{-1}, and 27.00 g kg^{-1}, respectively. NPK uptake of cattle manure and chicken manure were 1.21 g, 0.12 g, and 2.33 g, while NPK uptake of rice straw compost were 0.50 g, 0.04 g, and 0.94 g, respectively.

The higher NPK content and uptake in corn shoots were related to the soil properties, such as soil pH since available nutrients will occur at an optimum soil pH, then it will affect the nutrient uptake by crops. Budianta *et al.* (2013) stated application of cover crop and compost were able to increase sorption of N and P significantly compared to mineral soil and control. Comerford (2005) and Mengel and Kirkby (2001) stated that plant uptake of soil nutrients is optimum in pH neutral soils; thus, increasing the pH from acid to neutral will generally increase plant growth.

Effect on Grain Yield and Yield Component

Application of organic amendments (chicken manure, cattle manure, and rice straw compost) on grain yield and yield component are presented in Table 7. The statistical significance of application organic amendments on grain yield and yield components are presented in Table 8. In general, application of chicken manure and cattle manure significantly had higher grain yield and yield components of corn compared to rice straw compost (Table 7). Table 8 shows that application of chicken manure and cattle manure significantly increased grain yield of corn compared rice straw compost, namely 5.84 Mg ha^{-1} and 3.39 Mg ha^{-1}, respectively. Compared to application of rice straw compost, the application of chicken manure and cattle manure significantly had higher yield components of corn, namely in cob length, cob diameter, cob weight, line number, and 1,000 grain weight. The cob length, cob diameter, cob weight, line number, and 1,000 grain weight of chicken manure and cattle manure were significantly higher compared to rice straw compost, namely 13.91 cm and 10.29 cm; 4.20 cm and 3.43 cm; 24.78 g and 13.74 g; 12.57 and 10.75; and 380.33 g and 217.67 g, respectively. The differences in grain yields are correlated to the soil properties parameters.

Most of the soil parameters were correlated strongly to grain yield of corn, particularly soil chemical. Improvement of soil chemical properties such as N, P, K, base cations will provide the nutrient needed by plant. Banger *et al.* (2009) and Gong *et al.* (2009a) stated that generally combination of organic and chemical fertilizers could improve crop yields and biomass production. Large number of studies have shown that long-term applications of organic manure or straw increase SOC content and soil fertility (Liu *et al.* 2010; Zhang *et al.* 2010). In general, there is a positive relationship between SOC and crop productivity (Pan *et al.* 2009).

Application of organic amendment on abandoned tin-mining soils improved soil physical

Table 5. N, P, K contents and N, P, K uptakes in corn shoots.

Treatment	N Content	P Content	K Content	N Uptake	P Uptake	K Uptake
	g kg^{-1}			g		
T_1	18.90	1.63	36.53	1.09	0.09	2.10
T_2	19.43	2.20	37.53	1.32	0.15	2.55
T_3	14.33	1.10	27.00	0.50	0.04	0.94
T_4	17.07	1.10	27.80	0.78	0.05	1.26
T_5	18.23	1.37	35.33	0.87	0.06	1.68

T_1 = 20 Mg Chicken Manure ha^{-1}
T_2 = 20 Mg Cattle Manure ha^{-1}
T_3 = 20 Mg Rice Straw Compost ha^{-1}
T_4 = 10 Mg Chicken Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}
T_5 =10 Mg Cattle Manure ha^{-1} + 10 Mg Rice Straw Compost ha^{-1}.

Table 6. Statistical significances of N, P, K contents in corn shoot and N, P, K uptake in corn shoots.

Treatment	N Content	P Content	K Content	N Uptake	P Uptake	K Uptake
T_1 Vs T_2	28.13**	180.63**	166.7**	7.59*	23.24**	7.76*
T_4 Vs T_5	134.62**	40.0**	9458.5**	1.16 ns	1.82ns	6.82*
T_1T_2 Vs T_3	2627.7**	203.06**	14210.6 **	92.8**	69.18**	99.80**
T_1T_2 Vs T_4T_5	455**	525.31**	9961.5**	7.39*	23.84**	14.31**

*: significant at 5% level **: highly significant at 5% level ns: not significant

properties such as soil water retention and better soil aggregation. These conditions will promote the availability of nutrients. Besides, higher CEC of cattle and chicken manures (Table 2) also contributed to enhance plant growth and yields by improving the nutrient availability in the soil, particularly those in cation forms. The enhancement yield components (cob length, diameter, weight, line number, and 1,000 grain weight) may be ascribed to increase translocation of organic material that improves soil chemical properties to be favorable for the development of yield components. Organic and inorganic fertilizer amendments do not only increase soil nutrient availability to plant but also, improve soil fertility including soil physical, chemical and biological properties, thus maintain or increase crop yields (Gong *et al*. 2009b). Animal manures may enhanced the plant growth on degraded mined soils, due to (i) the release of plant nutrients and also (ii) improvements on soil organic matter, microbial activity,water retention and others soil properties (Larney and Angers 2012).

Effect Application of Organic Matters on Shoot Growth and Biomass, and Root Biomass at Flowering

Effect application of organic matters (chicken manure, cattle manure, and rice straw compost) on shoot growth and biomass, and root biomass at flowering are presented in Table 9, while the statistical significance presented in Table 10.

Shoot Growth

Table 10 shows that application of chicken manure and cattle manure significantly increased

Table 7. Grain yield and yield components of corn.

Treatment	Cob Length	Cob Diameter	Cob Weight	Line Number	1,000 Grain Weight	Grain Yield
	----------cm----------		------g-----		------g------	---Mg ha^{-1}---
T_1	12.98	4.04	23.63	11.86	243.67	5.45
T_2	14.85	4.37	25.93	13.28	273.33	6.24
T_3	10.29	3.43	13.74	10.75	217.67	3.39
T_4	12.35	3.82	18.05	11.71	240.00	4.76
T_5	12.88	3.97	18.97	11.75	244.67	4.87

T_1 = 20 Mg Chicken Manure ha^{-1}
T_2 = 20 Mg Cattle Manure ha^{-1}
T_3 = 20 Mg Rice Straw Compost ha^{-1}
T_4 = 10 Mg Chicken Manure ha^{-1} + 10 Mg of Rice Straw Compost ha^{-1}
T_5 =10 Mg Cattle Manure ha^{-1} + 10 Mg of Rice Straw Compost ha^{-1}.

Table 8. Statistical significance of grain yield and yield components of corn.

Treatment	Cob Length	Cob Diameter	Cob Weight	Line Number	1,000 Grain Weight	Grain Yield
T_1 Vs T_2	5.26 ns	4.97 ns	1.73 ns	12.23**	10.34*	2.77 ns
T_4 Vs T_5	0.42 ns	1.07 ns	0.28 ns	0.01 ns	0.26 ns	0.05 ns
T_1T_2 Vs T_3	26.49**	37.74 **	53.31**	26.61**	26.11**	35.77**
T_1T_2 Vs T_4T_5	0.03 ns	0.36 ns	5.29 ns	0.80 ns	0.18 ns	0.49 ns

*: significant at 5% level **: highly significant at 5% level ns: not significant

plant height, stem diameter, and leaf number at flowering stage and it were higher than rice straw compost, namely 148.91 cm and 121.17 cm; 1.48 and 1.08; and 15.51 g and 13.75 g, respectively. Increasing shoot growth were associated with better soil physical and chemical properties and increase the availability of soil nutrients by the increasing rate of organic amendments. It indicated that abandoned tin-mining areas did not have a proper physical and chemical properties for crop growth. Low soil fertility status in abandoned tin-mining areas are correlated to soil physical properties which are dominated by sand fraction. Sand fraction give a consequence in low of SOC, CEC, and essential macro nutrients. Nurtjahya *et al*. (2009) stated land mining decreases soil properties, with soil texture changing from about 70% to 97% of sand faction.

Shoot Biomass

Table 10 shows that the application of cattle manure significantly increased shoot biomass at flowering stage compared to chicken manure, namely 67.92 g and 56.89 g, respectively and the application of chicken manure and cattle manure significantly increased dry weight of shoot biomass compared to rice straw compost, namely 62.40 g and 34.73 g, while application of chicken manure and cattle manure significantly increased dry weight of shoot biomass compared to treatments of (chicken manure + rice straw compost) and (cattle manure + rice straw compost), namely 62.40 g and 46.50 g, respectively. Increasing shoot biomass was probably related to the enhancement of soil fertility status as a result of organic amendments application. Boateng (2006) mentioned that higher essential nutrients in poultry manure had been reported to increase photosynthetic efficiency and so it would have higher vegetative growth.

Root Biomass

Table 10 shows that the application of cattle manure significantly increased shoot biomass at flowering stage compared to chicken manure, namely 31.20 g and 26.47 g, respectively and the application of chicken manure and cattle manure significantly increased dry weight of shoot biomass compared to rice straw compost, namely 28.83 g and 15.90 g, while application of chicken manure

Table 9. Plant height, stem diameter, leaf number, dry weight of shoot, and dry weight of root of corn at flowering stage in the experimental site.

Treatment	Plant Height	Stem Diameter	Leaf Number	Dry Weight of Shoot Biomass	Dry Weight of Root Biomass
	----------cm----------			-------------------g-------------------	
T_1	140.13	1.43	15.30	56.89	26.47
T_2	157.70	1.54	15.72	67.92	31.20
T_3	121.17	1.08	13.75	34.73	15.90
T_4	115.33	1.31	14.47	45.40	20.27
T_5	127.20	1.41	15.03	47.59	21.73

T_1 = 20 Mg Chicken Manure ha^{-1}
T_2 = 20 Mg Cattle Manure ha^{-1}
T_3 = 20 Mg Rice Straw Compost ha^{-1}
T_4 = 10 Mg Chicken Manure ha^{-1} + 10 Mg of Rice Straw Compost ha^{-1}
T_5 =10 Mg Cattle Manure ha^{-1} + 10 Mg of Rice Straw Compost ha^{-1}.

Table 10. Statistical significances of plant height, stem diameter, leaf number, dry weight of shoot, and dry weight of root of corn at flowering stage.

Treatment	Plant Height	Stem Diameter	Line Number	Dry Weight of Shoot Biomass	Dry Weight of Root Biomass
T_1 Vs T_2	21.29**	2.05 ns	2.74 ns	7.68*	11.99**
T_4 Vs T_5	9.72*	1.92 ns	4.84 ns	0.30 ns	1.15 ns
T_1T_2 Vs T_3	70.84**	39.66**	65.10**	64.40**	119.34**
T_1T_2 Vs T_4T_5	56.05**	0.05 ns	1.12 ns	6.77*	15.93**

*: significant at 5% level **: highly significantat 5% level ns: not significant

and cattle manure significantly increased dry weight of shoot biomass compare to treatment of (chicken manure + rice straw compost) and (cattle manure + rice straw compost), namely 28.83 g and 21.00 g, respectively. The increasing of root biomass was due to the improvement of soil properties which were caused by application of organic amendments. Weber *et al*. (2007) mentioned that organic matter possess many desirable properties such as high water holding capacity, enhanced nutrient uptake and had beneficial effects on the physical, chemical and biological characteristics. Tordoff *et al*. (2000) stated that application of organic amendments increase the soil pH, improve of soil structure, water holding capacity and CEC, as well as provide a slow-release fertilizer and serve as a microbial inoculum.

CONCLUSIONS

Application of organic amendments on abandoned tin-mining land improved soil fertility due to the increase in soil pH and nutrient availability especially available-P and K, and exchangeable bases. Application of chicken and cattle manures were significantly better than rice straw compost to improve soil fertility, nutrient uptake, growth and yield ofmaize. Application of cattle manure had the highest maize yield compared to chicken manure and rice straw compost, about 14.49% and 84.07%, respectively.

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