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by Bambang Joko Priatmadi

Submission date: 26-Jan-2023 08:53PM (UTC+0700)
Submission ID: 1999805234
File name: Liquid_Organic_Fertilizer_as_Amendment_for_Ex-coa.pdf (273.64K)
Word count: 5105
Character count: 24807

Australian Journal of Basic and Applied Sciences, 10(4) February 2016, Pages: 179-186

AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Liquid Organic Fertilizer as Amendment for Ex-coal Mining Soil in Asam-asam Village-South Kalimantan, Use for Corn Grow Media

[1]Hastirullah Fitrah, [2]Moch. Sasmito Djati, [2]Amin Setyo Leksono, [3]Bambang Joko Priatmadi

[1]*University of Brawijaya, Doctoral Program of Environmental Studies, Graduate School, Mayjen Haryono No. 169, 65145 Malang, Indonesia*
[2]*University of Brawijaya, Department of Biology, Faculty of Mathematics and Natural Sciences, Veteran Malang, 65145 Malang, Indonesia*
[3]*Lambung Mangkurat University, Department of Soil Sciences, Faculty of Agriculture, A Yani km 63, Banjarbaru, Indonesia*

Address For Correspondence:
Amin Setyo Leksono, University of Brawijaya, Department of Biology, Faculty of Mathematics and Natural Sciences, Veteran Malang, 65145 Malang, Indonesia.
Phone: +62 341-571260; E-mail: amin28@ub.ac.id

ARTICLE INFO

Article history:
Received 12 January 2016
Accepted 22 February 2016
Available online 1 March 2016

Keywords:
Doses, liquid organic fertilizer, soil amendment

ABSTRACT

Background: Coal mining activities, especially open pit mining has significant impacts towards soil and land use. It causes decreased biodiversity and soil quality, thus also affect the soil productivity on post-mining period. Efforts to improve the soil condition have been implemented, such as soil amendment by using liquid organic fertilizer. Coal mining in Asam-asam Village, South Kalimantan will end its operational activities in 2019. Thus it is important to prepare the soil sustainability for post-mining productivity. **Objective:** This study was aimed to determine the dose of liquid organic fertilizer as amendments for ex-coal mining soil to be used as grow media of corn. **Method:** This soil sample was taken from PT. Jorong Barutama Grestone, Asam-asam Village, South Kalimantan. This study used complete randomized design with treatments of different liquid organic fertilizer, i.e. Formula, Nasa, Biofast, Green Tonic with dose variation 3, 6, 9, and 12 liter per ha, 4 times repetition. Bonanza F1 corn was planted after 2 days post fertilizing in polybag. Plant height, leaves number and dry weight were measured weekly until 6th week. **Results:** The existing characteristics of soil in the coal mining area are low quality in term physical, chemical and biological indicators. Experimental results showed that Formula liquid organic fertilizer affects most of the parameter. The results showed that Formula affects the plant height on 9 liter/ha dose, leaves number on 6 liter/ha dose, wet and dry weight on dose of 12 liter/ha. Statistic analysis showed that the Formula dose of 12 liter/ha is significantly affecting the soil permeability, dose of 6 liter/ha increase the soil acidity. Formula also cover the Hydrogen ion on 12 liter/ha, Al-exc saturation on 9 liter/ha, Fe content on 6 liter/ha, SO_4 content on 9 liter/ha, and Pyrite on 9 liter/ha. It also affect the total number of microbes on 12 liter/ha. **Conclusion:** Ex-coal mining soil after amendment with liquid organic fertilizer could be used for re-vegetation and other productive purposes.

INTRODUCTION

Coal mining has significant negative impacts on the soil and land use, such as decreased biodiversity economic loss due to land use change from agriculture land, decreased quality of water resources (e.g. low pH, increased sedimentation and heavy metals contents. Acid Mine Drainage (ACD) produced from the leaching of sulfide mineral in the coals directly affect the drinking water quality, tools corrosion, and damage the soil structure (Dhruv *et al*., 2013).

To Cite This Article: Hastirullah Fitrah, Moch. Sasmito Djati, Amin Setyo Leksono, Bambang Joko Priatmadi., Liquid Organic Fertilizer as Amendment for Ex-coal Mining Soil in Asam-asam Village-South Kalimantan, Use for Corn Grow Media. ***Aust. J. Basic & Appl. Sci.,*** *10(4): 179-186, 2016*

Australian Journal of Basic and Applied Sciences, 10(4) February 2016, Pages: 179-186

Antung (2012) explained that the activities of coal mining, especially open pit mining were potentially damage the environment. Landscape was changed, ground water and surface water flow system was disturbed (run off), physical, chemical and biological characteristics was altered, ecosystem damaged (the loss of habitat for flora and fauna), erosion, sedimentation, and pollution on water and soil. Thus, soil in the ex-coal mining site has been depleted.

Efforts to improve the soil condition have been implemented, such as soil amendment (Dariah, 2012) by using liquid organic fertilizer. Coal mining in Asam-asam Village, South Kalimantan will end its operational activities in 2019. Thus it is important to prepare the soil sustainability for post-mining productivity by conducting soil amendment. It was expected that after the soil amendment with liquid organic fertilizer, the ex-coal mining soil could be used for re-vegetation and other productive purposes, e.g. growing media of corn plants, as in this study.

Several studies on soil amendment stated that the giving of organic matter on the damaged soil is positively affecting the soil physical, chemical, and biological characteristic (Bintoro *et al*., 2006 in Purwandaru *et al*., 2012; Dariah, 2012). Organic fertilizer increase the cation exchange capacity, water catchment capacity, macro and micro matter, and soil microbes population that dissolve phosphate and attach nitrogen from the air; which was improving the soil fertility. Therefore, this study was aimed to determine the dose of liquid organic fertilizer as amendments for ex-coal mining soil to be used as grow media of corn.

MATERIALS AND METHOD

Study Area and Sampling:

The experiment of the corn growth was conducted in the greenhouse of Achmad Yani University, Banjarmasin. The soil sample was taken from PT. Jorong Barutama Grestone (JBG), Asam-asam Village, Jorong District, Tanah Laut Regency, South Kalimantan. Soil sampling was conducted compositely for the growth media of corn in polybags at the green house, whereas soil sample for laboratory analysis was taken by using ring sample on the area of ex-cal mining. Sampling point of the soil used Diagonal System in three areas of JBG, each with 5 diagonal points (Fig.1).

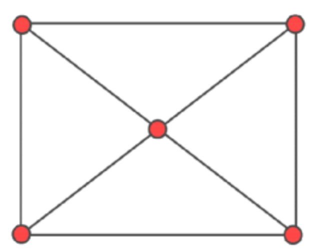

Fig. 1: Scheme of Diagonal System for the Composite Soil Sampling

Data Collection:

We used primary and secondary data for the research. Primary data were obtained from the observed parameters, while secondary data were obtained from the documents of related institution.

Experimental method:

Liquid organic fertilizer Formula:

Organic compounds as the standard nutrient needs for plants such as essential nutrient N, P, and K were fermented with the mature microorganism culture of decomposition bacteria for 1-2 weeks. The result of fermentation used as the liquid organic fertilizer Formula. The composition on the liquid organic fertilizer Formula was analyzed in laboratory (Supplementary 1).

Experiment Procedure:

The research was conducted for 6 months from January to June 2015. This study used complete randomized design with treatments of different liquid organic fertilizer, i.e. Formula, Nasa, Biofast, Green Tonic with dose variation 3, 6, 9, and 12 liter per ha, 4 times repetition. Bonanza F1 corn was planted after 2 days post fertilizing in 35 cm x 40 cm polybag. Plant height, leaves number, and dry weight were measured weekly until 6th week after planting or 35 days when the leaves was open completely. Watering was conducted 2 times a day, morning and evening. The measurement of the wet and dry weight was conducted at the end of the observations.

Complete randomized design in this study was limited to the laboratory, greenhouse and pots experiments (Suntoyo, 1986; Vincent, 2006). The media of the experimentation should be homogen and placement should be randomized. Rndomization equals the opportunity of the treatments (Vincent, 1994).

Data Analysis:

Parameter Analysis:

Physical, chemical, and biological characteristics of the liquid organic fertilizer-treated soil were analyzed in the Laboratory of Soil, Lambung Mangkurat University and Laboratory of Soil, Swamp Soil Research Institute (BALITRA), Banjarbaru, South Kalimantan. The soil sample was analyzed before and after the treatment of liquid organic fertilizer. Parameter and analysis method that used for the soil sample was described in following Table 1.

Table 1: Parameter Analysis Method for the Soil Sample

No.	Parameter and variable	Unit	Analysis Method
	Physical Characteristics		
1	Bulk Density	g/cm^3	Ring sample
2	Particle Density	g/cm^3	Piknometer
3	Porosity	%	
4	Permeability	cm/hour	Constant Head Permeameter
5	Texture	%	Pipet
6	Structure		
	Chemical Characteristics		
1	pH (H_2O, KCL)	-	Extraction H_2O, KCl, pH meter
2	C-Organik	%	Walkley & Black, (titration)
3	Nitrogen (N)	%	Kjheldhal
4	Phospor (P)	ppm	Bray and Kuts I
5	Aluminium (Al)	Cmol(+)/kg	KCL 1 N
6	Hydrogen (H)	Cmol(+)/kg	KCL 1 N
7	Kalium (K-dd)	Cmol(+)/kg	NH_4OAc 1M pH7
8	Natrium (Na-dd)	Cmol(+)/kg	NH_4OAc 1M pH7
9	Calsium (Ca-dd)	Cmol(+)/kg	NH_4OAc 1M pH7
10	Magnesium (Mg-dd)	Cmol(+)/kg	NH_4OAc 1M pH7
11	Cation Exchange Capacity	Cmol(+)/kg	NH_4OAc 1M pH7
12	Iron (Fe)	ppm	NH_4OAc 1M pH4.8
13	Sulphate (SO_4)	ppm	NH_4OAc 1M pH4.8
14	Pyrite (FeS_2)	%	Oxidation of H_2O_2
	Biological Characteristics		
1	Microorganism population	cell/gram	counting

Statistical Analysis:

Obtained data from the experiment were analyzed with normality test, homogeneity test and data transformation. The analysis was continued to analysis of variance (ANOVA) (Steel dan Torrie, 1995).

RESULTS AND DISCUSSION

Initial Condition of Soil in Ex-coal Mining Area:

The observed area has been dismantled and changes on its landscape (Fig. 2), thus it lost the top soil and vegetation which led to depleted and degraded soil quality.

Fig. 2: Soil and Landscape Condition on the Area Ex-coal Mining Site (Personal documentation)

Physical Characteristic:

Physical characteristics of the soil from the ex-coal mining site of JBG showed in Table 2. The particle density in the soil of ex-coal mining site is 2.26 g/cm^3, below the standard quality 2.6 – 2.7 g/cm^3. Low particle density means that the soil is not good as planting media. By knowing the particle density and bulk density of the soil, we could acquire the percentage of the soil pores. Organic matter has less weight than other solid mineral matter in the soil, thus soil surface commonly has smaller particle density than sub soil. The content of organic matter is affecting the particle density (Hardjowigeno, 2003).

Bulk density implied the density of the soil, the higher bulk density is, the more difficult for water to passing through the water or plant's root. Top soil is generally has lower bulk density than below soil. The bulk density of mineral soil ranged 1.0 – 1.6 g/cm^3, while organic soil has bulk density 0.1 – 0.9 g/cm^3 (Hardjowigeno, 2003). Bulk density of the soil at ex-coal mining site is 1.36 g/cm^3 in the range of 1.0 – 1.36 g/cm^3, which is means that the soil in the area is not to dense.

Porosity is the proportion of soil pore space (empty space) in a volume soil that fill by the water and air, thus as indicator of drainage and aeration for soil. Soil porosity of soil in the ex-coal mining site is 37.92% in the range of 30 – 60%. It is implied that the soil in the area of ex-coal mining JBG still applicable for the growth media of plants (Saefuddin, 1984). It has sufficient spaces of pores for the movement of air, water, and root growth. It is also able to store the water (water catchment). However, more than 60% porosity is dangerous because it has risk of erosion due to high water input and is not able to hold the root plants growth.

Class of permeability for the soil in the ex-coal mining site includes in slow criteria (United States Soil Survey, 2015) with value 0.20 cm/hours in the range of 0.13 – 0.51 cm/hours. This permeability of soil depends on the texture and structure of the soil (Saefuddin, 1984). Structure of the soil in the ex-coal mining area is massive, because the soil particles were strongly attached to each other thus was not formed lumps. This type of structure is bad for the plants growth. The soil texture was composed of sand, dust, and clay.

Table 2: Physical Characteristics of the Soil at Ex-coal Mining Site JBG

No.	Physical Character	Soil of Ex-coal mining site JBG	Common Mineral Soil
1	Particle Density (g/cm^3)	2.26	2.6 – 2.7
2	Bulk Density (g/cm^3)	1.36	1.0 – 1.6
3	Porosity (%)	37.92	30 – 60
4	Permeability (cm/hour)	0.20	slow (0.13 – 0.51)
5	Structure	massive	
6	Texture (%)		clay
	Sand	19.34	
	Dust	28.49	
	Clay	52.6	

Chemical and Biological Characteristics:

The acidity of the soil at ex-coal mining site is 2.28 (H_2O) and 1.98 (KCl), implied that the soil in the area is extremely acid. The condition was caused by the acid water from the mine and pollution of heavy metals. This condition is impossible for the plants to grow. C-organic of the soil found in 0.432% which include in very low criteria, because the C-organic was less than 1%. Similarly, N content in the soil of ex-coal mining site is 0.048, less than 0.10% which include in very low N criteria.

Exchangeable Kalium defined as adsorbed-K in the complex of soil colloid. The content of K-exchangeable in the soil of ex-coal mining site is 0.013 cmol(+)/kg, categorized as low criteria because it less than 1 me/100g. Na-exchangeable and Ca-exchangeable in the soil of ex-coal mining site is also included in the low criteria, i.e. 0.106 cmol(+)/kg and 0.004 cmol(+)/kg, respectively. Not differently, Mg-exchangeable in the soil is also in lo criteria, i.e. 0.248 cmol(+)/kg, because it less than 0.4 me/100g.

Cation Exchange Capacity (CEC) of the soil in the ex-coal mining site is 12.535 cmol(+)/kg in the range of 5 – 16 me/100g. Organic content contribute to the CE of soil, about 20 – 70% CEC was originated from humus coloid (Nurhasanah, 2012).

Aluminium (Al) is naturally found in the soil (Rout *et al*., 2000). However, acid soil will lead to excessive Al (Affandie dan Yuwono, 2002), which toxic for the living things in the area, especially plants. Although the soil in the study area has low pH (acid), the amount of found Al 6.683 cmol(+)/kg, which is still in the low criteria (<10). Hydrogen content of the soil in the study area is 0.92 cmol(+)/kg, while Phosphor as macro nutrient compound was found as much as 1.234 ppm, included in very low criteria because it less than 10 ppm.

Iron (Fe) as micro nutrient was need in small amount for plants. Excessive Fe tends to phytotoxic for the plants. The Fe content in the soil of the study area is 4,075.678 ppm, categorized as low criteria. According to Buckman and Brady (1982), the normal amount of Fe in the soil is 5.000 – 50.000 ppm, while Affandi and Yuwono (2002) stated 10.000 – 100.000 ppm. Meanwhile, the sulfide (SO_4) content of the soil in this study is 11,351.98 ppm, whereas Pyrite (FeS_2) content in the study area is 1.701%. Pyrite is easily oxidized and formed concentrated acid, thus hazards the plants and leach the other nutrient compound such as Ca, Mg and K.

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The microorganism number in the soil of ex-coal mining site is 3.27 x 10^5, categorized as low number of microorganism because common soil has number of microorganism for 10^8 – 10^9/gram. The microorganism is important to decompose the organic matter in the soil that will be used for the growth of the plants (Saefuddin 1984).

Table 3: Chemical Characteristics of the Soil at Ex-coal Mining Site JBG

No.	Characteristics	Analysis Results	Criteria (US Soil Survey)
	Chemical		
1	pH H_2O	2.28	Very acid (< 4.5)
2	pH KCL	1.98	Very acid (< 2.5)
3	C-org (%)	0.432	Very low (< 1)
4	N (%)	0.048	Very low (< 0.10)
5	K-exchangeable (cmol(+)/kg)	0.013	Very low (< 0.01)
6	Na- exchangeable (cmol(+)/kg)	0.106	Low (0.1 – 0.3)
7	Ca- exchangeable (cmol(+)/kg)	0.004	Very low (< 2)
8	Mg- exchangeable (cmol(+)/kg)	0.248	Very low (< 0.4)
9	CEC (cmol(+)/kg)	12.535	Low (5 - 16)
10	Al (cmol(+)/kg)	6.683	Very Low (<10)
11	H (cmol(+)/kg)	10.470	-
12	P Bray1 (ppm P)	1.243	Very Low (<10)
13	Fe (ppm)	4,075.678	Low
14	SO_4 (ppm)	11.351.979	-
15	FeS_2 (%)	1.701	-
	Biological		
16	Number of Microorganism	3.27 x 10^5	10^8 - 10^9

Condition of Soil in Ex-coal Mining Area after Amendment:

The results of soil amendment with liquid organic fertilizer showed an improved soil condition on most of the parameters (Table 4). However, several parameters has not been affected or only slightly affected.

Physical characteristics:

Liquid organic fertilizer has not been achieved the range of normal particle density 2.6 – 2.7 g/cm^3. We assumed that it was caused by the organic matter compound in the soil, thus decrease the particle density of the soil. Bulk density is decreased due to the use of liquid organic fertilizer Formula. It means that the Formula showed good performance in amend the soil of ex-coal mining site. Hardjowigeno (2003) explained that high bulk density will make the water or plant's root difficult to penetrate into the soil.

The porosity of soil after amendment is still in the range of normal 30 – 60%. The average permeability of the soil after amendment was ranged from slow to medium permeability 1.66 – 2.34 cm/hour. The permeability is increased; however, the soil is till need more period of amendment to be qualified for plants to grow. Texture of the soil is also slightly changes due to the additional organic matter from the liquid organic fertilizer. Organic matter is one of the forming agents of soil aggregates which act as holder between soil particles (Buckman and Brady, 1982). Affandi and Yuwono (2002) stated that organic matter improve the soil structure, increase the water catchment capacity and improve the permeability of the soil.

Chemical and biological characteristics:

Generally, the acidity of the soil after amendment with liquid organic fertilizer was improved, although the results still in the range of very acid. The soil amendment also increased the C-organic content in the soil of ex-coal mining. The increased K-exc found higher in the use of liquid organic fertilizer Formula. The liquid fertilizer also improved the content of Na-exc in the treated soil of ex-coal mining, ranged from very low to medium criteria. The value of Mg-exc after the amendment was in the high criteria within 2.1 – 8.0 cmol/Kg. Al-exc was decreased in the treatment with liquid organic fertilizer Formula. Soil amendment could either decrease or increase the pH$^+$ in the soil, which then related to the acidity of the soil.

Phosphor content in the soil of ex-coal mining after the treatment was still under the low level (< 10 ppm). It was because the pH in the soil is still acid. In contrast, the liquid organic fertilizer treatment decreased the Fe content significantly. It is because the increased pH of the soil that reduce the heavy metals solubility (Karden, 2009). Similar to the Fe, the content of SO_4 also decreased after the amendment with liquid organic fertilizer, as well as the pyrite content (FeS_2).

The microorganism population in the soil of ex-coal mining site after the amendment with the liquid organic fertilizer was significantly decreased. It was due to the acid soil condition that inhibits the growth of the microorganism. However, the decreased in the Formula was less than the other liquid organic fertilizer type. It is because the Formula has no heavy metal content, thus this type of liquid organic fertilizer was recommended for the soil amendment for ex-coal mining soil.

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Table 4: Characteristics of Ex-coal Mining Soil after Amendment with Liquid Organic Fertilizer

No.	Parameter and variables	Initial Condition	Liquid Organic Fertilizer				Standard
			Formula	NASA	Biofast	Green Tonic	
	Physical Characteristics						
1	Particle Density (gr/cm^3)	2.26	2.34	2.36	2.25	2.36	2.6 – 2.7
2	Bulk Density (g/cm^3)	1.36	1.31	1.35	1.34	1.34	1.0 – 1.6
3	Porosity (%)	37.92	44.095	31.875	38.025	41.405	30 – 60
4	Permeability (cm/hour)	0.20	2.34	2.11	1.36	1.66	Med: 2.00 – 6.35 Slow: 0.13 – 0.51
5	Structure	massive	massive	massive	massive	massive	
6	Texture (%)	clay	dusty clay	clay	sandy clay	clay	Clay
	Sand	19.34	15.23	20.04	41.65	28.53	
	Dust	28.49	37.46	37.39	20.69	28.55	
	Clay	52.6	47.32	42.57	37.67	42.92	
	Chemical Characteristics						
7	pH H_2O	2.28	4.06	3.00	2.67	2.60	Very acid: < 4.5
8	C-org (%)	0.432	0.765	1.589	1.598	1.601	Very low: < 1 Low: 1 – 2
9	N (%)	0.048	0.087	0.112	0.101	0.096	Very low: < 0.10 Low: 0.1 – 0.2
10	K-exc (cmol(+)/kg)	0.013	0.361	0.131	0.128	0.146	Very low: < 0.01 Low: 0.1-0.2 Med: 0.3-0.5
11	Na- exc (cmol(+)/kg)	0.106	0.5293	0.2685	0.2035	0.0940	Very Low: < 0.1 Low: 0.1 – 0.3 Med: 0.4 – 0.7
12	Ca- exc (cmol(+)/kg)	0.004	2.693	2.313	2.741	1.411	Very low: < 2 Low: 2 – 5
13	Mg- exc (cmol(+)/kg)	0.248	4.30275	4.56625	3.26875	3.726	Very low (< 0.4) High: 2.1 – 8.0
14	CEC (cmol(+)/kg)	12.535	29.255	36.7075	33.67	48.9375	Low: 5 – 16 High: 25 – 40 Very High: > 40
15	Al (cmol(+)/kg)	6.683	1.13725	10.50175	17.63175	30.972	Very Low: < 10 Low: 10 – 20 High: 31 – 60
16	H (cmol(+)/kg)	10.470	0.8765	6.9355	10.316	13.571	-
17	P Bray1 (ppm P)	1.243	1.92	2.68	3.36	4.49	Very Low (<10)
18	Fe (ppm)	4,075.678	37.17125	352.4265	680.595	737.714	Low
19	SO_4 (ppm)	11,351.979	233.921	254.0488	166.6903	184.3275	-
20	FeS_2 (%)	1.701	0.16	0.600	0.662	0.748	-
	Biological						
21	Number of Microorganism (CFFU/g)	3.27 x 10^5	110,075	18,124	11,029	43,628	10^8 - 10^9

Corn Growth during the Soil Amendment:

Based on the observation, the type of liquid organic fertilizer Formula show a better results than the other type, whether in the dose of 3 liter/ha, 6 liter/ha, 9 liter/ha or 12 liter/ha. The average of corn plant height was showed in the Table 5. The statistic analysis showed that the treatment of liquid organic fertilizer affect the corn height significantly (α=1%). Least Significance Difference (LSD) analysis found that the dose of 9 liter/ha from the liquid organic fertilizer Formula has the highest significant results. This liquid organic fertilizer has the ability to improve the condition of the ex-coal mining soil, especially to increase soil pH, decrease pyrite content (FeS_2) and it has no heavy metals content.

The results of analysis on the number of leaves showed that the best treatment to obtain the highest number of leaves is Formula 3 and 6 liter/ha. We assumed that the other type and dose of liquid organic fertilizer has not able to cover the pollution of heavy metals, thus the leaves growth has not been optimal. Meanwhile, the wet and dry weight of the corn plants was found high in the treatment with liquid organic fertilizer Formula, at dose 6, 9, and 12 liter/ha. The highest wet and dry weight of the corn plants found in the dose of 12 liter/ha Formula, i.e. 5.434g.

Table 5: Least Significant Difference on the Height, Number of Leaves, Wet and Dry Weight of Corn Plants

No.	Treatment	Doses (liter/ha)	Mean			
			Height (cm)	Number of Leaves	Wet Weight	Dry Weight
1	Biofast	3	20.25^{a}	14.50^{abc}	3.218^{ab}	2.975^{bcd}
2	Biofast	6	19.05^{a}	14.75^{abcd}	3.115^{ab}	3.094^{bcd}
3	Biofast	9	19.88^{a}	15.50^{bcd}	3.58^{abc}	3.217^{cd}
4	Biofast	12	19.52^{a}	15.25^{abcd}	3.338^{abc}	3.017^{bcd}
5	Green Tonic	3	19.55^{a}	15.25^{abcd}	3.403^{abc}	3.502^{cdef}
6	Green Tonic	6	19.77^{a}	14.25^{ab}	3.771^{bc}	3.415^{cdef}

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7	Green Tonic	9	21.05[a]	15.50[bcd]	4.062[c]	3.617[def]
8	Green Tonic	12	19.50[a]	14.75[abcd]	3.684[bc]	3.322[cde]
9	Nasa	3	21.27[a]	15.25[abcd]	3.086[ab]	2.637[abc]
10	Nasa	6	19.12[a]	14.00[a]	3.199[ab]	3.046[bcd]
11	Nasa	9	22.32[a]	15.00[abcd]	3.477[abc]	2.273[ab]
12	Nasa	12	22.98[a]	15.75[cd]	3.277[abc]	2.997[bcd]
13	Formula	3	30.00[b]	16.00[d]	2.832[a]	2.074[a]
14	Formula	6	29.75[b]	16.00[d]	5.463[d]	4.246[f]
15	Formula	9	32.58[b]	14.75[abcd]	5.416[d]	4.187[ef]
16	Formula	12	32.48[b]	15.25[abcd]	6.981[e]	5.434[g]

Effect of Type and Dose of Liquid Organic Fertilizer towards the Soil Characteristics and Corn Growth:

Based on the statistic analysis, the treatment of soil amendment towards the ex-coal mining soil for the grow media of corn showed that the type and doses of liquid organic were significantly affect the observed parameters. Table 6 describes the effect of the treatment that most affecting the mentioned parameters.

Table 6: Statistical Analysis on the Effects of Liquid Organic Fertilizer towards Observed Parameters

No.	Parameter	Effects	Type of Fertilizer	Doses (liter/ha)
	Physical Characteristics			
1	Particle Density	ns	-	-
2	Bulk Density	ns	-	-
3	Permeability	**	Formula	12
4	Porosity	ns	-	-
	Chemical Characteristics			
1	pH (H_2O)	**	Formula	6
2	C-organic	**	Biofast	9
3	Nitrogen	**	Biofast	9
4	K-exchangeable	**	Nasa	6
5	Na-exchangeable	**	Nasa	12
6	Ca-exchangeable	**	Biofast	9
7	Mg-exchangeable	**	Nasa	9
8	Al-exchangeable	**	Green Tonic	12
9	Cation Exchange Capacity	**	Green Tonic	12
10	Hydrogen (H)	**	Nasa	12
11	Phosphor	**	Biofast	6
12	Fe	**	Green Tonic	12
13	So_4	**	Nasa	6
14	FeS_2	**	Green Tonic	12
	Biological Characteristics			
1	Total microorganism	**	Formula	12
	Plants Growth			
1	Height	**	Formula	9
2	Number of leaves	*	Formula	6
3	Wet Weight	**	Formula	12
4	Dry Weight	**	Formula	12

Note: ns= not significant, *= affect significantly, **= strongly affect significantly

Conclusion:

The existing characteristics of soil in the coal mining area are low quality in term physical, chemical and biological indicators. Experimental results showed that Formula liquid organic fertilizer affects most of the parameter. The results showed that Formula affects the plant height on 9 liter/ha dose, leaves number on 6 liter/ha dose, wet and dry weight on dose of 12 liter/ha. Statistic analysis showed that the Formula dose of 12 liter/ha is significantly affecting the soil permeability, dose of 6 liter/ha increase the soil acidity. Formula also cover the Hydrogen ion on 12 liter/ha, Al-exc saturation on 9 liter/ha, Fe content on 6 liter/ha, SO_4 content on 9 liter/ha, and Pyrite on 9 liter/ha. It also affect the total number of microbes on 12 liter/ha. Ex-coal mining soil after amendment with liquid organic fertilizer could be used for re-vegetation and other productive purposes.

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Supplementary 1: Composition of Liquid Organic Fertilizer Formula

No.	Composition	Analysis Results	minimal requirement of the liquid organic fertilizer
1	pH (H_2O)	4.36	4 – 8
2	C-org (%)	1.29	6
3	N-total (%)	0.83	3 – 6
4	P_2O_5 (%)	0.123	< 5
5	K_2O (%)	0.14	< 5
6	Ca (%)	0.321	-
7	Mg (%)	0.005	-
8	N-NH_4 (ppm)	41.88	-
9	Na (%)	0.003	
10	Fe (%)	0.0001	Max 0.0400
11	S	0.002	-
12	Total Population of Microorganism	5.71×10^5	-

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