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EFFECT OF COAL MINING SOIL ON GROWTH PHYSIOLOGY OF LOCALLY CULTIVATED RICE PLANTS IN MAIGANGA, AKKO LGA GOMBE STATE, NIGERIA.

***Abubakar Z. A, Jingi, B., Idris A.A and Kulawe, D**

Department of Biological Sciences, Faculty of Science, Gombe State University, Nigeria.

Abstract

This study was designed to assess the effect of coal mining soil on growth and some physiological parameters on locally cultivated rice plants. The experimental design was laid out in Randomized Complete Block Design (RCBD) with five replications. It consists of five different varieties of rice seeds grown on two different soil types, where 25 pots were used for the Coal mining soil and another 25 pots for the Normal fertile soil were utilised for the control treatment. Plant growth and physiology such as plant height, leaf area, number of tillers, number of leaves, root length and Relative Water Content were measured and leaf colour were also observed. Results indicated decrease in plant growth and relative water content in Coal Mining Soil compared to Normal Fertile Soil (P<0.05). This values were however significantly lower than the control. Leaf colour were also noticed to have changed compared to in the Normal fertile soil, from this study decreased in plants growth of varieties on coal mining soil could be as a result of heavy metals present in the soil (though heavy metals concentration in the CMS was not analysed during the course of study). The results imply that mining activities (anthropogenic activities) like excavation during coal mining could impact negatively on the growth of crop plants not only rice. Noteworthy, was that some locally cultivated rice plants were able to withstand the coal contaminated soil like JAMILA and MAZA HAJI varieties which could be recommended to farmers in that area.

KEY: *Coal Mining Soils (CMS), Jamila and Maza Haji Rice Varietie*

1. Introduction

Rice (*Oryza spp.*) is one of the most popular field crops among other cereals in the world, being cultivated in different agro-ecosystems. Rice serves as the staple food for world's half population (FAO, 2004). Rice is a source of energy for major portion of world's population and ranks second after Maize and Wheat with respect to production (Manjappa and Shailaja, 2014).Rice growth is influenced by a combination of genotype, environment and management factors. Balancing and improving soil fertility is one of the main factors in enhancing rice growth and yield. The intensive cultivation of rice that depends on chemical fertilizers and pesticides have led to the decrease in soil fertility and deteriorating soil health. The excessive use of chemical fertilizers in the current decades has led to soil toxicity through the presence of toxic heavy metals and adverselyaffecting the health of rice plants (Habibah *et al.*, 2011).Soil contamination and degradation are important issues from both environmental and agricultural points of view. The continual anthropogenic activities, extensive use of chemical fertilizers, pesticides and rapid industrialization are responsible for increasing environmental pollution (Singh *et al*., 2017). These activities are major causes of soil degradation and contamination and thus pose a great challenge for food safety and public health (Tripathi *et al.,* 2016).

Open-pit coal mining involves excavation of the earthly bound ore, a process which releases large quantities of mine spoil (Choudhury *et al.*, 2017). Waste rock material derived from open pit coal mining contains significant concentrations of reduced sulfides. These include pyrite (FeS_2), chalcopyrite ($CuFeS_2$) and other metal sulfides, including covellite (CuS), chalcocite (Cu2S) and galena (PbS). In contaminated areas, these elements may be transported by colloidal or suspended particulates present in water used to irrigate agricultural land (Blowes *et al.,* 2017).

Trace elements in soils have detrimental effects on the growth of staple crops (e.g., rice, barley, garlic, wheat, maize) (Adriano, 2001), and can accumulate in their edible parts posing a serious health risk to humans (Martinez, 2013). Cadmium, Cu and Pb have been identified as having adverse effects on rice (*Oryza sativa* L.) and wheat (*Triticum estivum* L.) growth (Abin, *et al.*, 2017). In addition, toxic metal tolerance in crop varieties has been shown in rice, sunflower, wheat and leguminous species, leading to an increment in metal uptake and to their concentration in edible plant parts, posing a severe health risk (Lei, 2011).

The current worldwide mine production of Cu, Cr, Cd, Pb and Hg is considerable. These pollutants ultimately derived from a growing number of diverse anthropogenic sources such as industrial runoff, sewage treatment plants, urban run-off, agricultural fungicide runoff, domestic garbage dumps and mining operations.

The anthropogenic deposition of heavy metal in agricultural soil will either become detrimental to plant growth or to the consumer of the harvested crops depending on the chemical form of the metals present in the soils (Mahler *et al.,* 1980). Plants are known to take up and accumulate heavy metals from contaminated soils (Madejon *et al.,* 2003).

Mining activities in Nigeria are open cast mining, which has a highly damaging effect on the environment. Some of these environmental effects include loss of prime agricultural land, forest cover, water and air quality and biodiversity (Oruonye *et al.*, 2016).

The study will specifically test the effects of coal mining on soil fertility due to anthropogenic activities on the growth physiology of locally cultivated rice plants.

1.2 Origin of Rice (*Oryza glaberrima* Steud.)

Oryza glaberrima, commonly known as African rice, is one of the two domesticated rice species. (Linares, 2016). It was first domesticated and grown in West Africa (Wang *et al.*, 2014), and was brought to the Americas by enslaved West African rice farmers (Judith, 2014). It is now largely a sustenance crop, rarely sold in markets even in West Africa. (Ikhioya and Godwin, 2013) While it has been partly replaced by higher-yielding Asian rice, and the number of varieties grown is declining, it persistently make up an estimated 20 % of rice grown in West Africa. By comparison to Asian rice, it is hardy, pest-resistant, low-labour, suited to a variety of African conditions, filling, and has a distinct nutty flavour. It is also grown for cultural reasons; for instance, it is sacred to Awasena followers among the Jola people, and is a heritage variety in the United States. (Carney, 2009).

1.2.1 History

Humans have independently domesticated two different rice species. African rice (Oryza glaberrima), was domesticated from wild African rice *Oryza barthii*, while Asian rice (Oryza *sativa*), was domesticated from wild Asian rice, *Oryza rufipogon*. *Oryza barthii* still grows wild in Africa, in a wide variety of open habitats. The Sahara was formerly wetter, with massive pale lakes in what is now the Western Sahara. As the climate dried, the wild rice retreated and became increasingly domesticated as it relied on humans for irrigation. Rice growing in deeper, more permanent water became floating rice. It is believed to have been domesticated 2000–3000 years ago in the inland delta of the Upper Niger River, in what is now Mali, It then spread through West Africa. Wild rice seed heads shatter, scattering the rice grains to seed the next generation. Domestic rice does not shatter, masking the grains easy for humans to gather. A mutation that caused rice not to shatter would probably have been the beginning of domestication (Ologbon *et al.,* 2016).

Asian rice came to West Africa in the late 1800s, and by the late twentieth century had substantially supplanted native African rice. However, African rice was still used in specific, often marginal habitats, and preferred for its taste (Ologbon *et al.,* 2016). Farmers may grow African rice to eat and Asian rice to sell, as African rice is not exported.

The 2007 food price shocks drove efforts to raise rice production. Rice-growing regions of Africa are generally net rice importers (partly due to a lack of good local rice-processing capacity) so price increases hurt. Among the efforts to increase yield was the adoption of Nerica cultivars, crossbred to specifications from local farmers using African rice varieties provided by local farmers. These were bred during the 1990s and released in the early 21st century. Results so far have been mixed; the Nerica varieties are less hardy and more labor-intensive, and effects on real- world yields vary. Subsidies of Nerica seeds have also been criticized for encouraging the loss of native varieties and reducing the independence of farmers (NGO, 2009).

1.3 Rice Cultvars

African cultivars; there are a great many varieties of African rice. In the 1960s older women in Jipalom (a village in the Ziguinchor Region) could unhesitatingly name more than ten varieties of African rice that were no longer planted, besides the half-dozen that were then still being planted. Each woman would plant multiple different varieties, to suite varying microhabitats and to stagger the harvest (Linares, 2016). A 2006 survey showed that a village typically cultivated 25 varieties of rice; an individual household would on average have 14 varieties and grow four per year (NGO, 2009). However, is down from the seven to nine varieties per woman that was average in previous decades. Women, who are traditionally responsible for the seeds, trade them often over long-distance networks.

The cultivars the Africa Rice Center calls TOG 12303 and TOG 9300 have low shattering, and thus yields comparable with low-shattering Asian rice varieties (Moncho *et al.,* 2016).

Scientists from the Africa Rice Center managed to cross-breed African rice with Asian rice varieties to produce a group of interspecific cultivars called New Rice for Africa NERICA (Jones *et al.,* 1997).

1.4 Rice cultivation

Rice is an increasingly important crop in Nigeria. It is relatively easy to produce and is grown for sale and for home consumption. In some areas there is a long tradition of rice growing, but for many, rice has been considered a luxury food for special occasions only. With the increased availability of rice, it has become part of the everyday diet of many in Nigeria (Morgan *et al.,* 2002).

There are many varieties of rice grown in Nigeria. Some of these are considered 'traditional' varieties; others have been introduced within the last twenty years. Rice is grown in paddies or on upland fields, depending on the requirements of the particular variety; there is limited mangrove cultivation. New varieties are produced and disseminated by research institutes, or are imported from Asia. The spread of these strains is determined by their perceived success, and farmers multiply seed for their own plots when they see a variety doing well in someone else's field, or if a variety is fetching a good price in the market. It seems also that strong political factors affect the dissemination of varieties; the most striking example of this is a rice called "China", imported to Nigeria around twenty years ago by a political figure and now grown everywhere despite the fact that seed trials carried out by NCRI declared it unsatisfactory (FAO, 2002).

1.5 Importance of Rice

Rice has shaped the culture, diets and economic of thousands of millions of peoples. For more than half of the humanity "rice is life". Considering its important position, the United Nation designated year 2004 as the "International Year of rice (Molden, *et al.,* 2010).

2.0 Effect of Coal Mining on Soil and Vegetation

Mining operations severely alters the landscape, which reduces the value of the natural environment in the surrounding land. The land surface is dedicated to mining activities until it can be reshaped and reclaimed. If mining is allowed, resident human populations must be resettled from the mine site; economic activities such as agriculture or hunting, gathering food and medicinal plants are interrupted. Existing land uses, such as residential, agricultural, (livestock grazing, crops and timber production, etc) which are temporarily eliminated from the mining site destroyed the genetic soil profile and wildlife habitat alters current land uses, and to some extent permanently changes the general topography of the area mined (William and Mary, 2005). Removal of soil and rock overburden covering the coal resource may cause burial and loss of top soil, exposes parent material, and creates large infertile wastelands. Soil disturbance and associated compaction result in conditions conducive to erosion and flood. Soil removal from the area to be surface-mined alters or destroys many natural soil characteristics, and reduces its diversity and productivity for agriculture. Soil structure may be disturbed by pulverization or aggregate break down (William and Mary, 2005).

2.1 Types and categories of Coal

Coal is classified based on the level of carbon it contains sand the amount of energy it can produce. Coal that contains a high amount of carbon is referred to as high rank coal. They have a low hydrogen and oxygen content and have a high heat value. Low rank coal has low carbon content but contain a high amount of hydrogen and oxygen. The various types of coal include:

2.1.2: Lignite

This is formed when peat is first transformed to coal. It is the lowest rank of coal and often called brown coal. Lignite has about 25 % - 35 % carbon content and is very moist and soft since it has not under gone the extreme heat and pressure experienced by the other types of coal. It is mainly used to generate electric power (William and Mary, 2005).

2.1.3: Sub-Bituminious Coal

This has about 35 % - 45 % in carbon content and is organically more mature than lignite. It is used for steam electric power generation and also a source of light aromatic hydrocarbon for chemical industries (William and Mary, 2005).

2.1.3.1: Bituminious Coal

It is called hard coal it has a high carbon content of about 45 % - 86 % and a high heating value so It is used largely in the generation of electricity and in steel and iron industries (William and Mary, 2005).

2.1.4: Anthracite

It is very hard and glossy and used mainly for residential and commercial heating. It has a very high concentration of carbon. Its carbon content is about 86 % - 97 % (William and Mary, 2005)

2.1.5: Graphite

This contains the highest amount of carbon but It is not used as fuel due to the fact that It is hard to burn. It is used in making pencil. Coal is used in various sectors and in various ways. It is used in heating and also in generating electricity. It is used to make coke; this is used to smelt iron for making steel. By-products of coal ethylene and methanol are used in plastics, fertilizer, synthetic fibers and medicine. Furthermore it provides foreign exchange because It is a tradable good so It can be exported (William and Mary, 2005)

3.0MATERIALS AND METHODOLOGY

3.1 The Study Area:

The experiment was carried out in the screen house of Biological Sciences Department Garden situated behind Science Complex, Gombe State University. The sample site is located at latitude “10.283333” and longitude “11.166667" and mean daily maximum and minimum temperature of 32ºC “89ºf” and 22ºC “71ºf” respectively.

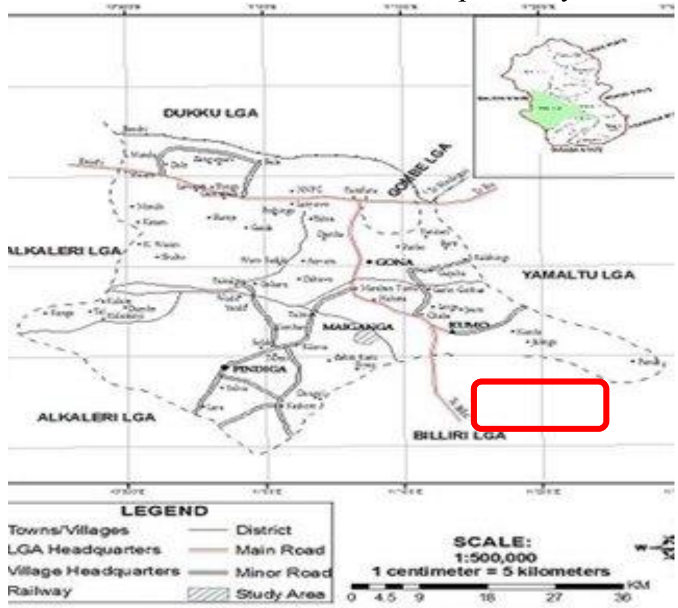

Figure 1: Map of Gombe State, Akko LGA showing Maiganga Village in red box. Source: (Abdulsalam et al., 2016)

3.2 Sample and Seed collection:

Coal mining soil sample was collected at Maiganga Coal mining area, Akko L.G.A. Gombe State.Improved and local rice varieties were utilized, and all the varieties are of the *Oryza glaberrima* African rice species.The local varieties are, *Jamila*, *Mai Kwalli*, *Mai Zabuwa*, and *Maza Haji*, which were obtained from School of Agriculture Tumu Akko L.G.A, while the improved variety is NERICA which was obtained from Department of applied Ecology A.T.B.U Bauchi. New Rice for Africa originally introduced Nerica, an improved rice variety.

3.3 Experimental Design:

The experiment was laid out in Randomized Complete Block Design (RCBD) with five replications. It consists of five (5) different varieties of rice seeds grown on two differentsoil types; 25 pots were used for the coal mining soil and another 25 pots for the normal fertile soil as controls. Watering was done twice a day and weeds were removed when observed.

3.4 Data Collection:

The data was collected thrice weekly, and the data parameters that were collected are: the plant height (cm), number of tillers, number of leaves, leaf area (cm^2), and relative water content (%). Root length (cm) and plant biomass (g) were measured during harvest.

3.5 Data Analysis:

Data collected was subjected to statistical analysis using Analysis of Variance (ANOVA) and test statistic. Values are mean of triplicate determination ± standard deviation. The mean of the samples were compared to control using ANOVA. The individual mean differences were ascertained using Least Significant Difference (LSD) as described by Onuh and Igwemma, (2000). The student package for social sciences (SPSS) version 20-computer software was used for the analysis.

4.0 RESULTS

The results of the study presented shows noticeable variation in growth physiology and on some measured harvest parameters all due to effect of the coal mining soil.

4.1 Effect of Coal Mining Soil (CMS) on plant height of the locally cultivated rice plants

Noticeabale differences in plants height due to the effect of coal mining soil (CMS) at (P=>0.05) were observed, where the plant height of the CMS grown rice plants showed significant effects from week 2 to week 5 of the days of planting, but in the case of *Jamila* and *Maza Haji* they were observed to be able to withstand the heavy metals that might have been present in the coal mining soil (though it was not analysed during the course of the research) (**Table 1**).

Table 1: Means ± Standard deviation of all the varieties for the comparative differences of plants height on the effect of coal mining soil at (P=>0.05)

Plant Variety	Treatment	PHW1(cm)	PHW2 (cm)	PHW3(cm)	PHW4(cm)	PHW5(cm)	PHW6(cm)
Jamila	CMS	28.60±1.34	45.70±3.27	55.16±3.65	70.2±1.64	80.34±5.88	84.8±3.27
	NFS	24.6±7.83	43.4±7.44	59.4±6.96	74.44±6.36	83.08±6.46	88.76±5.05
Mai Kwalli	CMS	24.60±4.23	40.4±3.51	54.00±1.87	72.80±4.27	77.74±1.65	83.20±5.63
	NFS	22.2±12.83	37.34±14.37	56.8±11.32	69.9±7.97	85.04±6.51	90.84±4.20
Mai Zabuwa	CMS	23.8±1.30	34.5±2.60	44.44±2.16	55.84±2.50	66.08±2.72	68.00±1.00
	NFS	25.3±2.28	39.14±2.43	47.8±2.46	57.52±3.67	64.46±2.64	68.16±2.68
Maza Haji	CMS	26.2±5.86	36.9±4.67	50.3±7.73	61.02±5.78	71.48±5.43	74.88±2.70
	NFS	30.4±0.55	44.8±1.68	51.76±2.49	63.84±3.69	67.14±3.43	72.02±4.76
Nerica	CMS	22.1±2.36	32±2.00	43.4±1.74	52.94±2.18	59.60±4.53	61.78±3.49
	NFS	23.1±2.38	40.62±4.68	48.6±3.13	63.4±0.89	70.08±8.13	76.86±8.60
P- Value	Variety	0.0062	0.003	0.036	0.000	0.000	0.000
	Treatment	0.127	0.003	0.055	0.013	0.052	0.001
	Interactions	0.616	0.128	0.114	0.031	0.014	0.001

Keys: CMS= Coal Mining Soil, NFS= Normal Fertile Soil, PHW = Plant Height per Week.

Based on the number of tillers counted, almost all the varieties showed significant effects when exposed to the treatment with the coal mining soil and they produced less tillers and in the case of normal fertile soil (NFS), they were able to give more tillers compared to those on CMS and had thicker stem girths (As shown in **Table 2**).

Table 2: Means ± Standard deviation of all the varieties for the comparative differences of the Number of Tillers on the effect of coal mining soil at (P=>0.05).

Plant Variety	Treatment	NTW 1	NTW 2	NTW 3	NTW 4	NTW 5	NTW 6
Jamila	**CMS**	**2.±0.00**	**3.00±1.00**	**7.20±1.92**	**12.80±4.49**	**15.60±3.91**	**16.60±4.04**
	NFS	**2.20±0.45**	**6.00±1.58**	**10.2±2.59**	**18.20±4.92**	**19.60±5.02**	**21.60±4.51**
Mai Kwalli	**CMS**	**1.60±0.89**	**2.50±1.66**	**4.57±2.36**	**7.20±3.34**	**9.75±4.66**	**13.36±6.73**
	NFS	**1.60±0.89**	**6.20±3.19**	**8.20±2.95**	**11.60±3.71**	**14.00±4.53**	**16.20±5.45**
Mai Zabuwa	**CMS**	**2.40±0.89**	**4.80±1.30**	**6.80±0.84**	**10.00±3.24**	**14.00±2.92**	**16.00±2.65**
	NFS	**2.40±0.89**	**8.40±1.14**	**11.40±2.07**	**15.60±2.30**	**17.20±2.28**	**20.20±2.59**
Maza Haji	**CMS**	**1.80±0.45**	**2.60±0.89**	**4.40±1.67**	**6.60±2.30**	**9.20±3.56**	**11.20±3.96**
	NFS	**2.00±0.00**	**8.00±1.22**	**11.80±2.28**	**16.20±2.94**	**20.20±2.58**	**21.20±1.64**
Nerica	**CMS**	**2.00±0.00**	**3.80±1.30**	**6.80±0.84**	**10.00±2.00**	**11.80±2.05**	**13.40±2.88**
	NFS	**3.00±0.00**	**6.20±0.84**	**10.20±2.05**	**11.80±4.44**	**19.60±5.40**	**40.80±4.60**
P- Value	**Variety**	**0.051**	**0.059**	**0.003**	**0.001**	**0.018**	**0.409**
	Treatment	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.032**
	Interactions	**0.033**	**0.046**	**0.010**	**0.095**	**0.030**	**0.257**

Keys: CMS= Coal Mining Soil, NFS= Normal Fertile Soil, PHW = Number of Tillers per Week.

4.3 The effect of coal mining soil on the number of leaves and leaf area of the locally cultivated rice plants

Varieties grown on the NFS had produced more leaves and the leaves are broader than those on the CMS, but in the case of *Mai Zabuwa*, *Maza Haji* and Nerica the CMS shows no any significance on the varieties (as shown in **Table 3**).Table 4 shows the significant treatment effects from week two of planting to harvest. The varieties were significantly different in leaf area for weeks four and five. Varietal and treatment interactions was observed for weeks five and six respectively (Table 4).

Table 3: Means ± Standard deviation of all the varieties for the comparative differences of the Number of Leaves on the effect of coal mining soil at (P=>0.05).

Plant Varieties	Treatments	NLW 1	NLW 2	NLW 3	NLW 4	NLW 5	NLW 6
Jamila	**CMS**	4.00±0.00	6.00±0.00	4.60±0.55	5.20±0.45	5.00±0.71	5.60±1.34
	NFS	3.80±1.10	5.80±0.40	4.60±0.55	5.40±0.55	5.60±0.55	6.00±0.71
Mai Kwalli	**CMS**	3.20±0.45	5.00±0.71	4.40±0.55	5.00±0.71	4.40±0.55	6.00±1.58
	NFS	3.00±1.87	5.00±1.73	4.60±0.55	4.80±0.45	5.07±0.71	5.80±0.45
Mai Zabuwa	**CMS**	3.80±0.84	6.00±0.00	4.60±0.55	5.60±0.55	5.40±1.14	5.60±0.89
	NFS	5.00±1.00	6.00±0.00	4.80±0.45	5.00±0.00	5.00±0.71	6.40±0.55
Maza Haji	**CMS**	3.20±0.84	5.00±0.71	4.80±0.45	5.20±0.45	5.60±1.14	5.40±1.14
	NFS	4.00±0.00	6.00±0.00	4.80±0.45	5.20±0.45	5.20±0.71	6.20±0.45
Nerica	**CMS**	4.20±0.45	5.80±0.45	3.80±0.45	5.20±0.83	4.40±0.55	5.60±0.89
	NFS	4.60±0.55	6.00±0.00	4.60±0.55	5.00±0.00	5.40±0.55	6.40±0.89
P- Value	**Variety**	**0.009**	**0.009**	**0.018**	**0.381**	**0.890**	**0.821**
	Treatment	**0.120**	**0.010**	**0.484**	**0.274**	**0.394**	**0.245**
	Interactions	**0.318**	**0.314**	**0.546**	**0.504**	**0.747**	**0.607**

Keys: CMS= Coal Mining Soil, NFS= Normal Fertile Soil, PHW = Number of Leaves per Week.

Table 4: Means ± Standard deviation of all the varieties for the comparative differences of the Leaves Area on the effect of coal mining soil at (P=>0.05)

Plant Varieties	Treatments	LAW2(cm2)	LAW3(cm2)	LAW4(cm2)	LAW5(cm2)	LAW6(cm2)
Jamila	**CMS**	14.37±1.58	35.20±1.66	36.53±2.08	56.53±15.31	56.90±15.37
	NFS	13.92±8.21	26.03±18.17	32.24±16.05	48.84±27.56	49.07±27.62
Mai Kwalli	**CMS**	11.44±9.45	16.36±14.39	20.72±17.66	38.99±28.56	39.43±28.73
	NFS	18.08±14.56	30.46±17.06	40.56±27.21	62.34±39.48	62.51±39.62
Mai Zabuwa	**CMS**	13.83±8.45	22.27±11.37	23.21±10.25	33.30±14.39	35.72±15.27
	NFS	15.38±7.35	22.08±9.90	29.52±10.47	54.83±29.59	55.25±29.71
Maza Haji	**CMS**	10.15±4.25	19.67±11.97	24.33±16.02	37.05±25.01	37.57±24.10
	NFS	13.23±8.72	22.39±14.07	29.42±20.22	37.76±16.27	38.04±16.44
Nerica	**CMS**	10.79±9.39	18.09±9.23	33.18±21.71	44.02±27.51	44.45±27.75
	NFS	13.74±9.26	24.77±15.22	36.97±27.77	64.67±48.65	65.06±48.91
P- Value	**Variety**	**0.570**	**0.091**	**0.067**	**0.006**	**0.000**
	Treatment	**0.131**	**0.004**	**0.009**	**0.000**	**0.000**
	Interactions	**0.908**	**0.127**	**0.320**	**0.043**	**0.043**

Keys: CMS= Coal Mining Soil, NFS= Normal Fertile Soil, LAW = Leaf Area per Week.

4.4 Effect of Coal mining soil on RWC and Root length of locally cultivated rice plants

The table shows no effect of CMS on the RWC for all the varieties (**Table 5**). In the case of Root Length, it showed a highly significant effect, the varieties on the NFS had more longer than those of CMS and from the varieties both the varieties on NFS are longer and thicker compared to those on CMS because of the suspicion of the presence of heavy elements present in the soil which were not able to allow them to grow well in the soil contaminated with the coal (As shown in the result of **Table 5)**.

Table 5: Means ± Standard deviation of all the varieties for the parameters of RWC and RL on the effect of coal mining soil at (P=>0.05)

PARAMETERS		RWC %	RL (Cm)
Plant Varieties	Treatments		
JAMILA	CMS	12.15±5.37	26.6±2.90
	NFS	16.53±16.34	35.16±5.94
MAI KWALLI	CMS	8.49±2.98	28.78±5.13
	NFS	10.24±5.83	33.86±7.31
MAI ZABUWA	CMS	12.59±3.98	31.76±5.80
	NFS	11.47±4.00	31.56±3.38
MAZA HAJI	CMS	11.51±5.24	36.24±4.71
	NFS	12.44±2.24	38.28±2.39
NERICA	CMS	15.77±3.38	28.84±2.54
	NFS	16.92±10.25	32.00±6.44
P – Value	Variety	0.269	0.022
	Treatment	0.490	0.011
	Interactions	0.944	0.361

Keys: CMS = Coal Mining Soil, NFS = Normal Fertile Soil, RWC = Relative Water Concentration, RL = Root Length

5.0 DISCUSSION

From the results of the study, it has been observed that there were significant differences in measured growth parameters of the locally cultivated rice plants grown on the coal mining soil compared with those grown on the normal fertile soils.The coal mining soil has shown effects on the physiology of some of the locally cultivated rice plants that grew on them due the heavy element present in the coal mining soil as reported in a similar study by (Osuocha *et al.,* 2015). Leaf colour and Relative Water Content (RWC) were some traits that were noticed to have shown variation in the growth of the plants whereas the numbers of leaves were not affected as observed in a study by (Osuocha *et al.,* 2016). Plant growth and development are affected by the conditions of the growing environment. Accumulation of toxic metals in plant cell results in various deficiencies such as reduction in cell activities and inhibition of plant growth (Osuocha *et al.,* 2015). They also result in Chlorosis, reduced water, nutrient intake, and damage root tips (Iqbal and Shafiq, 2001). Findings from the study (Tables 1, 2, 4 and 5) showed a significant decrease in plant growth parameters such as plant height, number of tillers, leaf area and root length respectively, grown in coal mining soils compared to control normal fertile soil under ($P<0.05$). This reduction in plant growth could be due to the effect of high trace metals content in soil reported by Osuocha *et al.* (2016), nutrient uptake and distribution within the plant cell or could be attributed to unavailability of nutrients due to increased level of trace metals in the mining sites thus inducing stress. Similar decrease in plant growth in metal contaminated sites has been reported on *Cucumis sativus* (Abu-Muriefah, 2008), on Lemna polyrrhiza (John *et al.*, of most of the locally cultivated rice plants.

2008), on *Veronica anagallis* (Fazal *et al.*, 2014). Non-essential trace metals such as cadmium, chromium and lead have been reported to cause significant decrease in plant growth parameters (Abdussalam *et al.*, 2015). According to Sandalio *et al.* (2005) reduction in plant growth by trace metals induced toxicity could be the direct consequence of decreased uptake of nutrient elements, inhibition of various enzyme activities, and induction of oxidative stress including alterations in enzymes of the antioxidant defense system. Pritesh *et al*. (2013) reported that decreases in plant growth are due to irregular cell division. Osuocha et al. (2016) that elevated concentration of both essential and non-essential trace metals in plants can lead to toxicity symptoms and plant growth inhibition have reported similar findings. Osuocha *et al.* (2016) also noted that plants growing on soils with high metal concentration exhibit characteristics of unhealthy growth.

5.1 Conclusion

In conclusion, the coal mining soil has shown to affect the growth physiology of some of the locally cultivated rice plants in respect to the parameters taken while some were able to withstand the accumulation of the heavy metals in the soil and grew relatively well.

With the result presented, it indicated that coal mining soil has significant effects on the growth physiology of some of the locally cultivated rice plants.

5.2 Recommendations

It was recommended that serious measures should be taken during most of the anthropogenic activities like the excavation of coal mining, because it has a negative effect on growth physiology .

Noteworthy, was that some locally cultivated rice plants were able to withstand the coal contaminated soil like *JAMILA* and *MAZA HAJI* varieties which could be recommended to farmers in that area.

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