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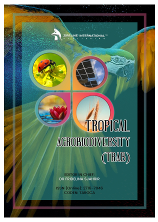

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RESEARCH ARTICLE

EFFECT OF SOIL OXIDO-REDUCTION STATUS ON AGRONOMIC PERFORMANCE OF RICE ON TWO TEXTURALLY DIFFERENT SOILS

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ABSTRACT

The production of rice has its own requirements like other crops, among these requirements include the various soil reactions like acid-base reaction and redox reaction. The experient was set up to determine the effect of different oxido-reduction status of soil on rice performance. The trial was a 3x2x2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. The variables included 3 levels of organic matter from poultry source (0t/ha, 6t/ha and 8t/ha), two levels of NPK 15-15-15 fertilizers (0kg/ha and 200kg/ha) and two watering regimes (Field capacity and waterlogged) this gave rise to twelve treatments and four redox status (oxidized, moderately reduced, reduced and highly reduced). Redox potential was measured using a redox potential meter, growth parameters of rice collected included plant height measured with tape rule, number of leaves and number of tillers which were counted. Yield parameters collected includes 1000 grain weight and grain yield measured with a electrical weighing balance. Data collected were subjected to analysis of variance using SPSS version 17 and means were separated using Tukey HSD. Results from the result indicated that rice performance was best under highly reduce and moderately reduced soils.

KEYWORDS

Redox, rice, reactions, oxidized, reduced

1. INTRODUCTION

Rice is the most consumed cereal in the world and the third most produced crop after maize and sugarcane (FAOSTAT, 2018). It is mostly cultivated in submerged soils or waterlogged soils due to its physiological make up. Just like every other crop rice has its soil requirements under which its production is optimal. One of such soil requirements is the various reactions that go on in the soil. Acid- base reaction denotes the soil pH while the redox potential indicated the presence or absence of electron in the soil system. The oxidation and reduction reaction status of soil affects the chemistry of living organisms and development of microbes in a way that is greater than the acid–base reactions, which focuses more on proton transfers (Dietz, 2003; Falkowski et al., 2008). In anaerobic soils, microbial and enzymatic activities have been discovered to have a negative correlation with redox potential (Brzezinska, 2004; Kralova et al., 1992). Furthermore, the oxido-reduction state of nodules is regarded as a reference point of legume-rhizobium symbiosis (Marino et al., 2009). Also, Changes in root–shoot chemistry of plant can interfere with photosynthesis, ion transport (e.g., K) and plant growth in general (Kludze and DeLaune, 1996).

The reduced uptake of mineral nutrients and insufficient O_2 supply also impede root growth. Reduced root growth can result in lower production of growth regulators, such as hormones and other metabolites that are produced by roots, which in turn impacts the vitality of the entire plant (Fageria and Moreira, 2011) all of which depends on the redox condition of the soil. Despite this, preference is given to the soil pH as the major soil reaction even in rice production. Given that rice is cultivated mostly in waterlogged or submerged soils and that 72% of the world soils and 51% of agricultural soils in Nigeria are submerged (Ojanuga et al., 1996), it is also important to put the oxido-reduction status of the soil into consideration in the establishment of rice. Hence the objective of this study is to evaluate the effect of different oxido-reduction status of soil on the agronomic performance of rice on two texturally different soil.

2. MATERIALS AND METHOD

2.1 The Study Area

The research was conducted concurrently as a pot experiment using two different soil types from two different locations in Apatapiti Layout FUTA west gate Akure, with coordinate (7^{0}20'N; 5^{0}44'E) in the rainforest south-west Nigeria. The soils collected from both sites are Alfisols according to USDA classification but both fall under different textural classes according to the textural triangle. Site 1 is a sandy clay loam and Site 2 is a clayey loam.

2.2 Experimental Design and treatments combination

The experiment was a 3x2x2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. Each replicate has a total of twelve treatments, Three levels of organic manure of poultry source (0 tha^{-1}, 6 tha^{-1} and 8 tha^{-1}) were applied. Two levels of N:P:K 15-15-15 (0 kgha^{-1}, and 20 kgha^{-1}) was also applied. Two watering regime [Field capacity (Fc) and waterlogging (Wt)] was also used. This gave rise to 12 treatments combinations in all.

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2.3 Treatment

T_1= 0 tha^{-1} PM+ 0 kgha^{-1} NPK+ Fc
T_2= 0 tha^{-1} PM+ 0 kgha^{-1} NPK+ Wt
T_3= 0 tha^{-1} PM+ 200 kgha^{-1} NPK+ Fc
T_4= 0 tha^{-1} PM+200 kgha^{-1} NPK+ Wt
T_5= 6 tha^{-1} PM+ 0 kgha^{-1} NPK+ Fc
T_6= 6 tha^{-1} PM+ 0 kgha^{-1} NPK+ Wt
T_7= 6 tha^{-1} PM+ 200 kgha^{-1} NPK+ Fc
T_8= 6 tha^{-1} PM+ 200 kgha^{-1} NPK+ Wt
T_9= 8 tha^{-1} PM+ 0 kgha^{-1} NPK+ Fc
T_{10}= 8 tha^{-1} PM+ 0 kgha^{-1} NPK+ Wt
T_{11}= 8 tha^{-1} PM+ 200 kgha^{-1} NPK+ Fc
T_{12}= 8 tha^{-1} PM+ 200 kgha^{-1} NPK+ Wt

Where PM is Poultry manure, Fc is Field capacity and Wt is Waterlogging.

2.4 Inducing Oxidation-Reduction Processes

Oxidation process involves adequate supply of oxygen to the soil system. Hence, treatments that were subjected to oxidation (field capacity) were perforated underneath to allow for easy drainage of water from the soil. To induce reduction process, three things are important which are; the presence of electron donor, absence of air (oxygen) in the soil system and the presence of electron acceptor. Organic matter was added at different rates to serve as the electron donor, flooding the soil (waterlogging) help to expel all the air (oxygen) in the soil system and the soil components served as the electron acceptor. This gave rise to different redox potential ranges all captured within the twelve treatments.

2.5 Cultural Practice

Rice variety Faro 44 was obtained from the Landmark University Teaching Farm. It was sieved and cleaned to remove debris and raise in a nursery for about 2 weeks before being transplanted to the buckets on the field at the rate of 3 (three) seedlings per bucket giving a population of 9 (nine) plants per experimental unit. Weed infestation was not severe in the buckets, very few were observed in waterlogged treatments. Hence weeding was manually done twice throughout the experimental period.

2.6 Soil Analysis and Sampling

Data collected covers growth and yield parameters of rice, and redox potential of soils. The growth parameters collected include plant height, number of leaf, and number of tillers. This was done at an interval of 4 weeks starting at 4 WAP and ended at 12 WAP. The whole 9 (nine). Plant height was measured using a meter tape, measuring from the base of the shoot to the apical portion of the rice plant. Number of leaves and number of tillers were counted. The yield parameters collected include grain yield, and 1000 grain weight and were measured using electric weighing balance. Harvested grains from the whole 9 (nine) plants of each experimental unit were considered. Redox potential was measured using a redox potential meter.

2.7 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SPSS version 17 and means were compared with Tukey HSD test to verify significant differences among treatments at 5% probability level. Graphs were generated using Microsoft excel 2010 edition.

3. Results

Table 1: Effect of Redox Potential on Rice Plant Height (cm)

Factors	Field Capacity			Waterlogged		
PM (tha^{-1})	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP
0	48.44b	62.50c	62.12c	49.62a	102.60b	110.30b
6	49.44ab	100.42b	117.12b	49.52a	108.77a	127.57b
8	50.10a	102.10a	126.43a	50.12a	108.18a	131.40a
NPK (Kgha^{-1})						
0	48.44b	62.50b	62.12b	49.62a	102.60b	110.30a
200	50.11a	90.64a	95.42a	50.04a	108.12a	112.61a
P(F test)						
PM	*	*	*	NS	*	*
NPK	*	*	*	NS	*	NS
PMxNPK	*	*	*	*	*	*
PMxNPKxWR	*	*	*	*	*	*
Soil 2						
PM (tha^{-1})						
0	48.27b	60.40c	60.22b	48.90b	101.40b	112.60b
6	48.92ab	96.26b	114.00a	50.22a	105.58a	125.51b
8	53.32a	102.70a	115.52a	48.45b	105.70a	130.12a
NPK (Kgha^{-1})						
0	48.27b	60.40b	60.22b	48.90a	101.40a	112.60a
200	50.48a	86.40a	98.42a	50.14a	102.70a	118.40a
P(F test)						
PM	*	*	*	*	*	*
NPK	*	*	*	NS	NS	NS
PMxNPK	*	*	*	*	*	*
PMxNPKxWR	*	*	*	*	*	*

Means followed by the same letters are not significantly (p>0.05) different according to Tukey HSD

NS= Not Significant, *= Significant, WAP= Weeks After Planting

Table 2: Effect of Redox Potential on Rice Leaf Number

Factors	Field Capacity			Waterlogged		
PM (tha^{-1})	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP
0	17a	35b	24b	18a	50b	64b
6	18a	52a	65a	18a	54a	69a
8	19a	52a	62a	18a	57a	70a
NPK ($Kgha^{-1}$)						
0	17a	35b	24b	18a	50b	64b
200	18a	47a	41a	18a	57a	72a
P(F test)						
PM	NS	*	*	NS	*	*
NPK	NS	*	*	NS	*	*
PMxNPK	NS	*	*	NS	*	*
PMxNPKxWR	NS	*	*	NS	*	*
Soil 2						
PM (tha^{-1})						
0	17a	32b	20b	18a	48b	56c
6	18a	48ab	62a	18a	52ab	64b
8	19a	50a	61a	18a	55a	70a
NPK ($Kgha^{-1}$)						
0	17a	32b	20b	18a	48a	56b
200	18a	45a	39a	18a	50a	68a
P(F test)						
PM	NS	*	*	NS	*	*
NPK	NS	*	*	NS	NS	*
PMxNPK	NS	*	*	NS	*	*
PMxNPKxWR	NS	*	*	NS	*	*

Means followed by the same letters are not significantly (p>0.05) different according to Tukey HSD

NS= Not Significant, *= Significant

WAP= Weeks After Planting

Table 3: Effect of Redox Potential on Rice Tiller Number

Factors	Field Capacity			Waterlogged		
PM (tha^{-1})	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP
0	1b	1b	0c	4a	7a	10b
6	3a	8a	11b	4a	8a	13a
8	3a	7a	13a	3a	9a	14a
NPK ($Kgha^{-1}$)						
0	1b	1b	0b	4a	7a	10a
200	3a	5a	9a	4a	7a	10a
P(F test)						
PM	*	*	*	NS	NS	*
NPK	*	*	*	NS	NS	NS
PMxNPK	*	*	*	NS	NS	*
PMxNPKxWR	*	*	*	NS	*	*
Soil 2						
PM (tha^{-1})						
0	1b	1b	0c	4a	7a	10b
6	3a	8a	11b	4a	8a	13a
8	3a	7a	12a	4a	9a	14a
NPK ($Kgha^{-1}$)						
0	1b	1b	0b	4a	7a	10a
200	4a	5a	10a	4a	7a	11a
P(F test)						
PM	*	*	*	NS	Ns	*
NPK	*	*	*	NS	NS	NS
PMxNPK	*	*	*	NS	NS	*
PMxNPKxWR	*	*	*	NS	*	*

Means followed by the same letters are not significantly (p>0.05) different according to Tukey HSD

NS= Not Significant, *= Significant

WAP= Weeks After Planting

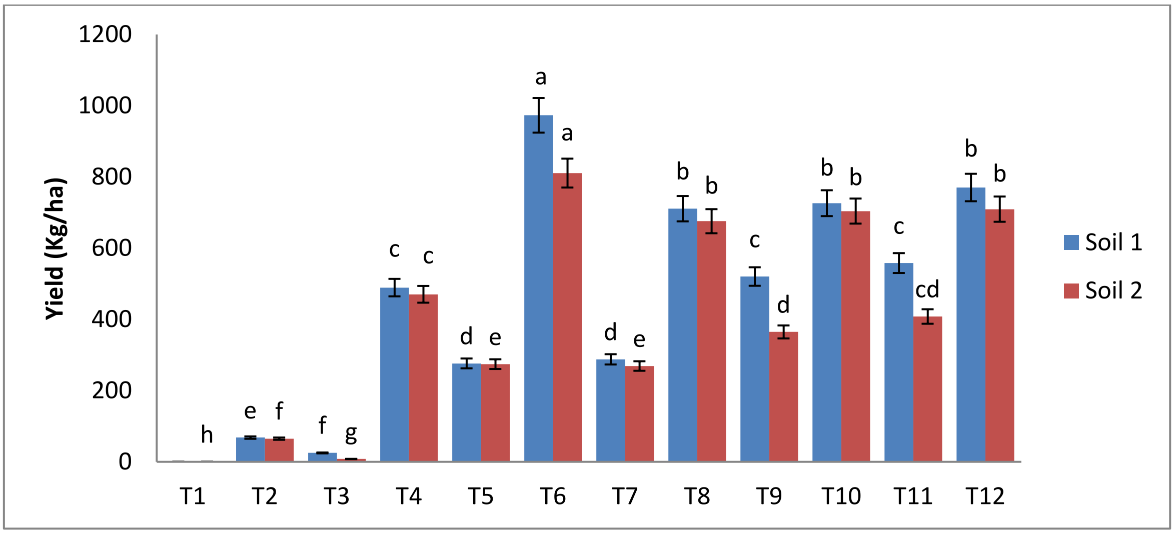

Figure 1: Effect of Redox Potential on Yield of Rice of Both Soils

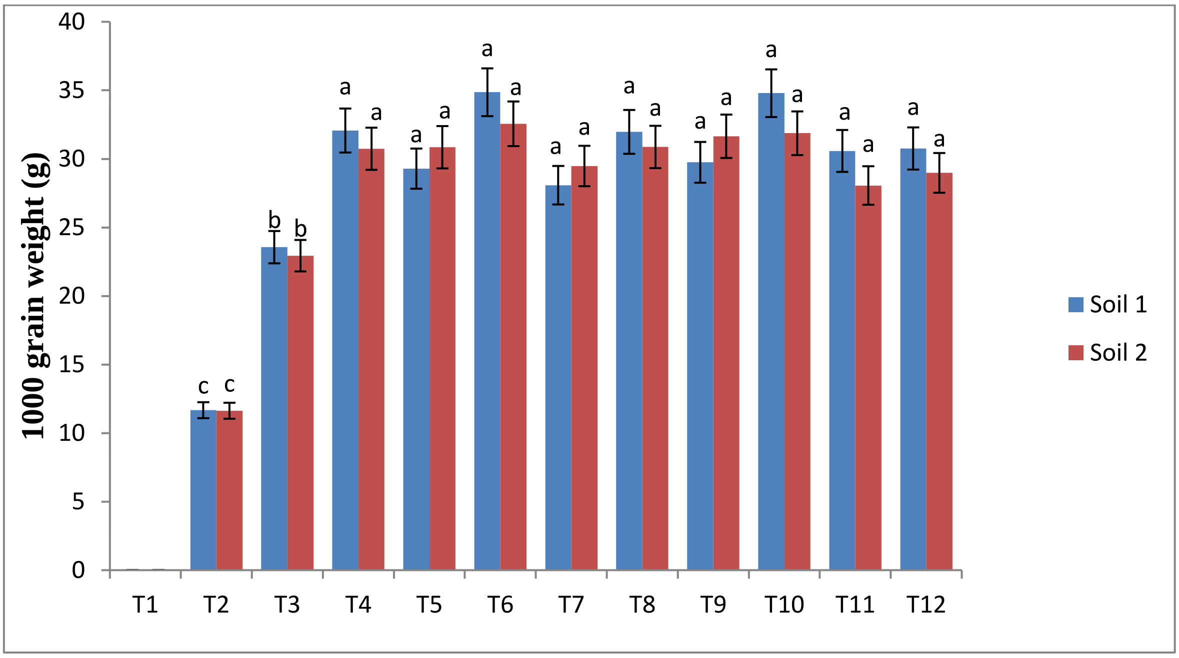

Figure 2: Effect of Redox Potential on 1000 Grain Weight of Rice Both Soil

4. Discussion

The results from this research showed that the oxido-reduction status of soil contributed to the well being and performance of rice. The growth parameters of rice was greatly influenced by the oxido-reduction status. Although flooding the soil expels oxygen from the soil which to other crops is lethal to their root system in that it deprives their root of oxygen (Kozlowski, 1984). However, the adaptation of rice to flooding is due to its physiological make up. Rice has the ability to trap atmospheric oxygen and pass it down to the root, this it does with the help of aerenchyma (Lijima et al., 2017). The best survival and vegetative growth observed on highly reduced and moderately reduced soils can be attributed to this aerenchyma. Aerenchyma has been found to play a vital role in the survival of rice under waterlogged conditions (Yamauchi et al., 2017). Results from the work of Matin and Jalali 2016 showed that waterlogging can increase calcium in solution of soil and consequently absorption by rice plant. Calcium ion has however been found to increase or promote the formation of aerenchyma in rice and as a result help the rice plant to thrive well vegetatively (Yamauchi et al., 2017). The highest yield was also found in highly reduced soils. This could be attributed to the moisture content and dissolved nutrient in solution. In a research found that NERICA rice gave the best yield under treatments with high water content (Akinbile et al., 2007). Yield of rice can also be attributed to nutrient availability in solution. A report state a yield reduction as a result of Nitrogen omission and a delayed flowering as a result of Phosphorus omission in the soil (Kamrunnahar et al., 2017). Nitrogen has been found to be high in form of NH_4^+ under highly reduced conditions (Nguyen, 2018).

5. Conclusion

This research was able to infer that growth and yield of rice (FARO 44) was affected by soil Oxido-reduction status. Highly reduced soils and moderately reduced soils gave the best yield for rice (FARO 44) while soils that were subjected to oxidation did not perform well. It is therefore concluded that to improve nutrient availability and to get the best performance of rice (FARO 44), it should be cultivated in soil whose Redox potential (Eh) range is below 100 mV, that is moderately reduced to highly reduced.

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