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Comprehensive Phenotypic Assessment of Rice Diseases in Cultivated Farms within Okpuitumo Community, Ikwo Local Government Area, Ebonyi State: Implications for Sustainable Rice Crop Management

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ABSTRACT

Rice stands as a pivotal economic crop in Ebonyi State, particularly flourishing in Ikwo Local Government Area. However, the productivity of this vital crop faces significant challenges owing to pestilence and diseases. This study sought to employ advanced PLANTIX image analysis software to systematically screen rice farms suspected of disease infestations within Okpuitumo Community. The aim was to precisely identify prevalent diseases impacting the region's rice cultivation. Leveraging the iterative capabilities of the PLANTIX smartphone application, images of afflicted rice leaves were meticulously examined to identify specific disease types and quantify their severity. The study meticulously selected four villages—Anumocha, Odeligbo, Ettam, and Ogidiga—with three farms per village and five sampling points per farm, employing rigorous randomization protocols. The findings showcased a hierarchy of prevalent rice diseases within the community, highlighting the severity in the following descending order: Potassium deficiency (40%), Brown spot disease (38.33%), Magnesium deficiency (31.67%), Nitrogen deficiency (26.67%), Rice blast (6.67%), Zinc deficiency (5%), Bacterial blight (3.33%), Green horned caterpillar (1.67%), and Leaf scald (1.67%). Notably, the study underscored soil nutrient depletion and the prevalence of brown spot disease as primary impediments to rice cultivation in the area.

Consequently, the study advocates for the implementation of robust soil nutrient restoration strategies alongside the development of brown spot disease-resistant or tolerant rice varieties that harmoniously align with the local agro-ecology. These interventions are imperative to safeguard the burgeoning population and the farming community against exacerbating food security crises and persistent poverty challenges

Keywords: Rice diseases, nutrient deficiency, Image analysis, Plantix and Ikwo Local Government Area

INTRODUCTION

Rice (*Oryza sativa*) is one of the most widely grown crops in all parts of Nigeria with consumption per capita of 32 kg. In the past decade, consumption has increased by 4.7%, almost four times the global consumption growth, and

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6.4 million tons in 2017, accounting for 20% of Africa's consumption [1-4]. It is grown for market and home consumption. Ikwo Local Government Area of Ebonyi State is well known for rice production in Nigeria, but pest and disease infestation have been progressively affecting rice production potential of the area. Rice blast disease caused by Fungus [5-10], Stem nematode disease caused by Nematodes (*Ditylenchus dipsaci*), Rice Yellow Mottle Virus (RYMV) disease caused by Virus (Sobemovirus) and Maize Streak Virus (MSV) disease caused by viruses as well as brown spot disease caused by the fungus (*Bipolaris oryzae*) have been identified as major constraints to rice production in Nigeria, causing low grain quality and significant yield loss [11-16]. Rice farmers in the study area are really suffering serious yield loss which is discouraging young persons from engaging in rice production business for a leaving. To date, there is no sustainable effort by both government and researchers to tackle the rice disease problems in the area. One of the major drawbacks for researchers is lack of reliable and accurate research methods for effective research in many areas of plant pathology, including evaluation of crop disease management practices, modeling of crop disease epidemics, disease forecasting, understanding relationships between symptoms and the environment, and evaluating germplasm for resistance to pathogens [17-18]. Currently, most of these kinds of evaluations are often performed based on visual assessments at various levels including plots, plants, and/or tissues level evaluations. Nowadays, Artificial Intelligence (AI) technology is making most scientific studies easier, faster, and more accurate. Disease incidence estimation based on artificial intelligence (AI) is inherently less subject to bias and errors of perception by raters, as compared with visual estimates of disease severity [12]. The adverse effect of rice diseases on rice production as well as the dearth of affordable scientific technologies for accurate detection of crop diseases in the area necessitated this study to exploit easy to use AI technology for quick and onsite assessment of rice diseases.

METHODOLOGY

Study Area and Design

The study was carried out in Okpuitumo Community in Ikwo Local Government area, a major rice producing area in the Ebonyi State. The study covered four villages in the community including Anumuocha, Ogidiga, Odeligbo and Ettam. Ikwo Local Government Area has a population size of about 173,009 people and is geographically located at 12.473°N and 7.487°E respectively. Samples were collected randomly from the selected 4 villages, 3 farms per village and 5 sampling points per farm giving a total of 60 samples that were used for the study

Sample collection

First, the Community and Village Heads were consulted and they helped organize a participatory meeting with the village youth leaders and farmers before we were allowed access to their farms to inspect and identify infected farms. Photographs of the rice leaves with symptoms of rice diseases such as yellowing, mottling, brown discoloration, lesions, stunted growth, etc., were taken *in situ* according the manufactures instructions.

Phenotypic detection of rice diseases using PLANTIX software

Phenotypic identification of rice diseases was done using PLANTIX digital application software following the manufacturer's instructions. The images of the suspected rice leaves were taken *in situ* using android mobile phone camera with GPS under shade and without camera flash and saved for disease analysis. The PLANTIX App was installed in the android mobile phone and the rice images uploaded into the App. The analysis of the rice leaves for presence disease was done by importing the image into the PLANTIX App and clicking on the 'diagnose' key and allowing it time to analyze the image and display the result. The App evaluates the image by comparing it to standard images of already identified rice diseases (e.g., Figure 5) in cloud databases linked to the software and will show which disease has affected the rice plant with high precision

Data Analysis

Incidence of the rice diseases were evaluated following the method of Teng and James (2002) using the mathematical formula:

$$\text{Incidence of disease (DI)} = \frac{\text{No of samples with symptoms}}{\text{Total no of samples tested}} \times 100$$

RESULTS

The result (Tables 1 & 2) showed that Rice Blast disease (RBD) affected the 4 villages with the incidence rate of 6.67% in each of the villages and at community level. Green horned caterpillar disease affected only Odeligbo village at incidence rate of 6.67% and 1.67% at community level. Brown spot disease occurred in the 4 villages at incidence rate of 46.67% in Ettam followed by Odeligbo (40%) and at 33.33% in Ogidiga and Anumocha. The disease incidence rate at community level was 38%.. Bacteria blight disease was detected in Ogidiga and Anumaocha villages at incidence rate of 6.67% in each village and 3.33% at community level. Leaf scald disease was detected only in farms located in Odeligbo village at incidence rate of 6.67% and a very low incidence rate of 1.67% at community level. Potassium deficiency disease occurred in all the 4 villages with highest occurrence in Anumaocha village (73.33%) followed by Ogidiga village (33.33%) while the incidence rate was 26.67% in each of

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Anumocha and Ettam villages. The observed community level occurrence rate of potassium deficiency disease was 40%. Magnesium deficiency disease also occurred in all the 4 villages at the rate of 33.33% in each of Ogidiga, Anumocha and Odeligbo villages and 26.67% in Ettam village with a community level incidence rate of 31.67%. Zinc deficiency disease was detected only in Ogidiga and Odeligbo at the occurrence rate of 13.33% and 6.67% respectively with a community level incidence rate of 5%. Nitrogen deficiency disease occurred in all the 4 villages with highest occurrence in Ogidiga village (40%) followed by Odeligbo (33.33%) and Anumocha and Ettam villages at 20% and 13.33%, respectively, with community level incidence rate of 26.67%.

Table 1: Summary of Rice Diseases Detected by PLANTIX in Okputimo Community

S/N	Location	Latitude	Longitude	Detected Disease
1	Amenyi Anumocha Okpuitumo	6.024145	8.040457	Brown spot and Nitrogen deficiency
2	Amenyi Anumocha Okpuitumo	6.024040	8.040547	Potassium deficiency
3	Amenyi Anumocha Okpuitumo	6.024095	8.040460	Potassium deficiency, Magnesium deficiency and Brown spot
4	Amenyi Anumocha Okpuitumo	6.024072	8.040353	Potassium deficiency, Magnesium deficiency and Bacteria blight
5	Amenyi Anumocha Okpuitumo	6.024072	8.040353	Image too blurry
6	Imendufu Anumocha Okpuitumo	6.046400	8.053557	Potassium and Nitrogen deficiency
7	Imendufu Anumocha Okpuitumo	6.046395	8.053555	Potassium, Magnesium and Nitrogen deficiency
8	Imendufu Anumocha Okpuitumo	6.046417	8.053512	Brown spot
9	Imendufu Anumocha Okpuitumo	6.046372	8.053517	Rice blast
10	Imendufu Anumocha Okpuitumo	6.046403	8.053503	Brown spot and Potassium deficiency
11	Inyimegu Anumocha Okpuitumo	6.039452	8.047679	Potassium deficiency
12	Inyimegu Anumocha Okpuitumo	6.039480	8.047662	Brown spot, Magnesium and Potassium deficiency
13	Inyimegu Anumocha Okpuitumo	6.039442	8.047670	Potassium deficiency
14	Inyimegu Anumocha Okpuitumo	6.039435	8.047673	Potassium deficiency
15	Inyimegu Anumocha Okpuitumo	6.039455	8.047680	Magnesium and Potassium deficiency
16	Odeligbo Okpuitumo 1	6.032614	8.038694	Brown spot and Nitrogen deficiency
17	Odeligbo Okpuitumo 1	6.032613	8.038598	Brown spot, Magnesium and Nitrogen deficiency
18	Odeligbo Okpuitumo 1	6.032522	8.038635	Nitrogen deficiency
19	Odeligbo Okpuitumo 1	6.032630	8.038537	Image too blurry
20	Odeligbo Okpuitumo 1	6.032633	8.038544	Image too blurry
21	Odeligbo Okpuitumo 2	6.033303	8.036413	Brown spot and Potassium deficiency
22	Odeligbo Okpuitumo 2	6.033462	8.036565	Zinc deficiency
23	Odeligbo Okpuitumo 2	6.033232	8.036328	Magnesium deficiency
24	Odeligbo Okpuitumo 2	6.033432	8.036483	Image too blurry
25	Odeligbo Okpuitumo 2	6.033352	8.036267	Nitrogen, Magnesium and Potassium deficiency
26	Odeligbo Okpuitumo 3	6.030523	8.031100	Image too blurry
27	Odeligbo Okpuitumo 3	6.030510	8.030993	Brown spot, Magnesium and Potassium deficiency
28	Odeligbo Okpuitumo 3	6.030510	8.030928	Brown spot, Magnesium and Potassium deficiency
29	Odeligbo Okpuitumo 3	6.030467	8.030905	Green horned caterpillar and Nitrogen deficiency
30	Odeligbo Okpuitumo 3	6.030540	8.031007	Brown spot, Leaf scald and Rice blast
31	Ettam Okpuitumo 1	6.003517	8.062438	Potassium deficiency
32	Ettam Okpuitumo 1	6.003487	8.06245	Brown spot
33	Ettam Okpuitumo 1	6.003640	8.062468	Potassium deficiency
34	Ettam Okpuitumo 1	6.003527	8.062425	Image too blurry
35	Ettam Okpuitumo 1	6.003640	8.062468	Brown spot

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S/N	Location	Latitude	Longitude	Detected Disease
36	Ettam Okpuitumo 2	5.989098	8.061912	Magnesium deficiency
37	Ettam Okpuitumo 2	5.989057	8.061895	Image too blurry
38	Ettam Okpuitumo 2	5.989057	8.061895	Brown spot, Rice blast and Magnesium deficiency
39	Ettam Okpuitumo 2	5.989020	8.061887	Brown spot
40	Ettam Okpuitumo 2	5.988998	8.061873	Magnesium deficiency
41	Ettam Okpuitumo 3	6.010038	8.063581	Detection failed
42	Ettam Okpuitumo 3	6.010017	8.063572	Brown spot Nitrogen and Potassium deficiency
43	Ettam Okpuitumo 3	6.010019	8.063574	Magnesium, Nitrogen and Potassium deficiency
44	Ettam Okpuitumo 3	6.010040	8.063590	Brown spot
45	Ettam Okpuitumo 3	6.010040	8.063592	Brown spot
46	Ogidiga Anumocha Okpuitumo 1	6.022877	8.035722	Nitrogen deficiency
47	Ogidiga Anumocha Okpuitumo 1	6.022809	8.035695	Magnesium deficiency
48	Ogidiga Anumocha Okpuitumo 1	6.022803	8.035695	Rice blast, Magnesium and Potassium deficiency
49	Ogidiga Anumocha Okpuitumo 1	6.022877	8.035722	Nitrogen, Magnesium and Potassium deficiency
50	Ogidiga Anumocha Okpuitumo 1	6.022865	8.035630	Nitrogen deficiency
51	Ogidiga Anumocha Okpuitumo 2	6.020118	8.032353	Magnesium, Nitrogen and Zinc deficiency
52	Ogidiga Anumocha Okpuitumo 2	6.020147	8.032318	Brown spot and Nitrogen deficiency
53	Ogidiga Anumocha Okpuitumo 2	6.020212	8.032413	Bacteria blight of rice and Potassium deficiency
54	Ogidiga Anumocha Okpuitumo 2	6.020183	8.032515	Image too blurry
55	Ogidiga Anumocha Okpuitumo 2	6.020245	8.032442	Brown spot, Magnesium and Nitrogen deficiency
56	Ogidiga Anumocha Okpuitumo 3	6.005444	8.029126	Detection failed
57	Ogidiga Anumocha Okpuitumo 3	6.005697	8.029143	Potassium deficiency
58	Ogidiga Anumocha Okpuitumo 3	6.005652	8.029131	Brown spot
59	Ogidiga Anumocha Opkuitumo 3	6.005565	8.029136	Brown spot, Potassium and Zinc deficiency
60	Ogidiga Anumocha Opkuitumo 3	6.005652	8.029131	Brown spot

Table 2: Occurrence and Distribution of Pathogenic Rice Disease in Okpuitumo Community

S/N	Disease Type	Frequency and % Occurrence by Village				Total and % Occurrence in the Community
		Ogidiga	Anumocha	Odeligbo	Ettam	
1	Rice blast	1(6.67)	1(6.67)	1(6.67)	1(6.67)	4(6.67)
2	Green horned caterpillar	0(0.00)	0(0.00)	1(6.67)	0(0.00)	1(1.67%)
3	Brown spot	5(33.33)	5(33.33)	6(40.00)	7(46.67)	23(38.33)
4	Bacterial blight	1(6.67)	1(6.67)	0(0.00)	0(0.00)	2(3.33)
5	Leaf scald	0(0.00)	0(0.00)	1(6.67)	0(0.00)	1(1.67)

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Table 3: Occurrence and Distribution of Nutrient Deficiency Rice Diseases in Okpuitumo Community

S/N	Disease Type	Frequency and % Occurrence by Village				Total and % Occurrence in the Community
		Ogidiga	Anumocha	Odeligbo	Ettam	
6	Potassium deficiency	5(33.33)	11(73.33)	4(26.67)	4(26.67)	24(40.00)
7	Magnesium deficiency	5(33.33)	5(33.33)	5(33.33)	4(26.67)	19(31.67)
8	Zinc deficiency	2(13.33)	0(0.00)	1(6.67)	0(0.00)	3(5.00)
9	Nitrogen deficiency	6(40.00)	3(20.00)	5(33.33)	2(13.33)	16(26.67)

DISCUSSION

Ikwo Local Government Area of Ebonyi State is the rice production hub of the state contributing very significantly to the total rice production level of Nigeria. In the past few decades, rice cultivation was the main the major source of income for the people of Ikwo Local Government area but in the recent years, pests and diseases have been progressively affecting the production potential of the area [9]. There is limited knowledge of the different kinds of rice diseases in the area, hence this study. The result of the study revealed the presence of rice blast, green horned caterpillar, brown spot and bacterial blight diseases in the community with brown spot disease topping in occurrence at the rate of 38.33%, while the occurrence of the others were low (ranging from 6.67 – 1.67%).In Nigeria, [10] had earlier reported rice blast disease (caused by *Pyricularia* oryzae Cav.) and brown spot disease (caused by *Cochliobolus miyabeanus* Dreschler ex Dastur) as the two major fungal diseases of rice in Nigeria with potential to cause loss in grain yield ranging from 11.5–39.6% and 12–43%, respectively. Since then, rice blast disease has been reported in Kaduna State [17], Jigawa State [13], and much earlier in Rivers State [3]. For rice blast disease, this result is in line with the assertion by [13] that rice blast disease is wherever rice is grown in Nigeria. However, this is the first scientific report of the disease in Ebonyi State, the producer of the popular Abakaliki rice in Nigeria. Brown spot disease of rice, the result is also in support of the reports by [5-6] who asserted that brown spot is a key disease of rice in Nigeria. The study also showed that these two major diseases are spatially distributed across all the villages in the assessed community. Bacterial blight, green horned caterpillar and leaf scald diseases appear to be either emerging newly in the area or the environment is not favourable to them as their occurrence rates are very low (3.33 - 1.67%) and they are still localized in few villages in the community. The study also revealed significant occurrence of Potassium, Magnesium and Nitrogen deficiency diseases in the studied area in decreasing order of magnitude (40%, 31.67% and 26.67%), respectively. These nutrient deficiency diseases were observed in all the 4 villages of the community at varying degrees with Anumocha having the highest deficiency of Potassium and Odeligbo showing the highest deficiency of nitrogen. These three nutrients are among macronutrients required in large and optimum quantities by rice to grow and yield well. These nutrient deficiency problems in the area may be attributed to poor agricultural land management practices mainly, continuous cropping of rice without rotation with legumes, inappropriate soil, inadequate/unbalanced mounts of fertilizer application. These poor agricultural land management practices are common in the area, like other African countries, as the people intensify land use to meet the food needs of the rapidly growing human population. In particular, Nitrogen and potassium losses primarily arise from leaching and soil erosion [8]. The problem may also be associated with the poor weather conditions occasioned by the progressively changing climate that lead to increased atmospheric temperature, heat, waterlogging and soil drying with the associated increased in soil pH which in turn lead to depletion of soil organic carbon, nitrogen and potassium levels [17-18].

CONCLUSION

The study revealed that brown spot disease as the major pathogenic rice disease in Okpitumo Ikwo community of Ebonyi State while potassium, magnesium and nitrogen are the major nutrient deficiency diseases affecting rice productivity in the area. Although population pressure are forcing the people to engage in excessive utilization of their agricultural land in effort to meet the food demand of the growing population coupled with the negative effect of climate change on soil fertility, there is urgent need for the government and researchers to develop soil nutrient restoration strategies to avert the impending worse food crises.

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