



RELATING WATER MANAGEMENT REGIMES AND RICE GENOTYPES WITH OCCURRENCE OF INSECT PESTS AND DISEASES OF RICE IN UGANDA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author TA designed the study, conducted field trials, performed the statistical analyses and wrote the first draft of the manuscript. Authors JK and BB advised on the design of the trials, data entry and analysis. Author JL provided the rice genotypes used in the study and guided in data collection. All authors read and approved the final manuscript.

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ABSTRACT

The research was conducted to assess the effect of water management regimes and/or rice genotypes on occurrence of insect pests and diseases of rice in Uganda. The study was conducted in phased field trials under natural conditions during the second rainy season of 2012 and the first rainy season of 2013. The trials were laid out in a Randomised Complete Block Design arranged as a split plot with three replications. Water management regimes (alternate wetting and drying-AWD, continuous flooding-CF and continuous drying-CD) constituted the main-plots and rice genotypes the sub-plots. Results indicated that the stalked-eyed fly (*Diopsis* spp) and African rice gall midge (*Orseolia oryzivora*) were the most encountered insect pests and both pests occurred highest in CF fields. Rice blast, brown spot, grain rot, rice yellow mottle virus (RYMV) and sheath rot were the diseases recorded in rice during the study. Rice blast and brown spot were the most prevalent diseases (>10% incidence), and brown spot was most prevalent under the AWD regime whereas RYMV was most prevalent in the CF regime. The level of occurrence of rice blast and RYMV recorded in the different water management regimes was dependent on the rice genotype. Generally, different genotypes had different insect pest/diseases occurrence profiles. The implication of these findings therefore is that for effective integrated pest management, knowledge of the most limiting pest/disease is important in deciding the appropriate water management regime. However, further experimental trials need to be conducted in different agro-ecological zones to verify these findings.

Keywords: Alternate wetting and drying; rice genotypes; disease incidence and severity.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal in terms of the area under cultivation and the number of people

who depend on it for consumption and income generation in many sub-Saharan African countries [1]. Rice is a major cereal crop providing up to 21% of the calorie intake and as such, it is an important strategic

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component of food security and crucial element in the staple food economies of the region where it has gained prominence in the farming systems and diets [2,3]. In Uganda, rice has become an important food staple and source of income for a big portion of the populace with a total production of 350,000 tonnes per annum from 150,000 hectares [4,5]. However, the demand for rice is estimated at 450,000 tonnes per annum [5]. Therefore, there is a need to increase rice productivity to meet the increasing demand.

The inability to reach self-sufficiency in rice production in Uganda is attributed to several biotic and abiotic constraints, notably, ravages of pests and diseases, low inherent yielding cultivars, poor agronomic practices, poor production technologies, unreliable water supply, and competition from weeds [6]. With the variability and changes in climate, rice production is even further threatened. The new environmental conditions may necessitate farmers to shift production practices, especially with regard to water management and genotypes grown in order to sustain optimal levels of yield. For instance, high yielding rice varieties developed at the International Rice Research Institute (IRRI) are reported to contribute to the achievement of Millennium development goals (MDGs), with a demonstrated increase in production of up to 86% in Asia [7].

Previous studies have indicated that water management in rice fields has a significant bearing on insect pests and disease prevalence as well as yield of rice [8-11]. For instance, stress from erratic and irregular water supply systems have been reported to increase the intensity of some diseases of rice especially rice yellow mottle virus, brown spot and rice blast [9,12]. It is believed that growing improved rice varieties and water management technologies are potential strategies in the effective management of biotic and abiotic problems of rice. This study therefore aimed at establishing the effect of improved rice genotypes and water management regimes, singly or interactively, on occurrences of insect pests and diseases, and yield of rice in Uganda.

2. MATERIALS AND METHODS

The study was conducted in the field at National Crops Resources Research Institute (NaCRRI), Namulonge-Uganda in 2012 and 2013. NaCRRI-Namulonge is located 25km north of Kampala and lies at 0°32'N 32°34'E; 1200 m above sea level and receives an average annual rainfall of 1300 mm. The study was conducted in two phases: Phase I involved screening rice genotypes under different water management regimes for abiotic and biotic stress parameters; while Phase II further assessed the

performance of selected rice genotypes from Phase I for resistance to abiotic and biotic stresses and yield.

In Phase I, eighty nine (89) rice genotypes obtained from the national cereals program at NaCRRI-Namulonge were screened for resistance to abiotic and biotic stress during the second rainy season of 2012. The experimental design was a randomized complete block arranged as a split plot with water regimes as the main plots and rice genotypes as the sub-plots, with three replications. The water management regimes used were i) alternate wetting and drying (AWD), ii) continuous flooding (CF), and iii) no wetting (continuous drying, CD). Following the methodology of Awio, Bua & Karungi [13], in AWD plots, water was pumped into the demarcated field and kept at 5cm above the soil surface for 7 days after which the field was drained and the soil kept only moist for the next 7 days. The field was alternately flooded and drained every 7 days throughout the growth period of the rice crop. In CD plots, the field was maintained under rain-fed conditions with no additional water supplied. In CF plots, the fields were kept flooded by irrigation water until maturity. In all plots, rice seeds were directly seeded at a spacing of 10 cm x 20 cm. In the subplots, each genotype was planted in a single row with 14 stands. Plots were kept weed free by manual removal and no artificial fertilizers were applied.

Data was collected from all the plants in the subplot at maximum tillering stage, flowering stage and maturity stage on insect pest type and incidence, disease type, disease incidence and severity. Pest and disease incidence was computed as a percentage of the number of rice plants infested/infected over the total number of plants sampled. Disease severity was visually scored using a scale of 0-9, where 0=no disease symptoms, 1=small, brown specks of pinhead size 2=necrotic spots about 1-2mm in diameter with a distinct margin 3=necrotic spots about 1-2mm in diameter with a significant number of lesions on the upper leaves 4=typical lesions, 3mm or longer, infecting <4% of leaf area 5=typical lesions infecting 4-10% of the leaf area 6=typical lesions infecting 11-25% of the leaf area 7=typical lesions infecting 26-50% of the leaf area 8=typical lesions infecting 51-75% of leaf and many leaves dead 9=more than 75% of leaf area affected [14]. Disease severity score was done for all the plants within a plot and average severity score was obtained for each genotype within the sub-plot.

Insect pests and disease data were studied under natural infestation/infection. The data was subjected to Analysis of variance (ANOVA) of the Genstat Computer program (4th Edition) and differences in

means were determined using Least Significant Difference (LSD) at 5% probability level.

In Phase II, 10 rice genotypes selected after analysis of data of Phase I were further studied to assess the effect of water management regimes and/or rice genotypes on occurrence of insect pests and diseases of rice in the field. The trial was laid out as a randomised complete block design arranged as a split-plot with three replications. The water management regimes as detailed in Phase I above constituted the main plots and the 10 rice genotypes were the sub-plots. In Phase II, rice seeds were direct seeded at a spacing of 20 cm x 20 cm with each genotype planted in 4 rows each measuring 2 meters in length; making a total of 88 plants per genotype. Field maintenance, data collection and analysis were as described in Phase I above.

3. RESULTS

3.1 Prevalence and Severity of Rice Diseases as Affected by Genotypes and/or Water Management Regimes

The diseases encountered during the trials were rice blast (*Magnaporthe grisea*), brown spot (*Cochliobolus miyabeanus*), grain rot (*Burkholderia glumae*), rice yellow mottle virus (RYMV), and sheath rot (*Acrocyndrium oryzae*). In Phase I, disease incidence and severity of rice blast, brown spot, grain rot and sheath rot varied significantly ($P < .001$) among rice genotypes. There was also a significant variation ($P < .001$) in disease incidence and severity of rice blast and RYMV under different water management regimes. The interaction of water management regimes and rice genotypes significantly ($P < .02$) influenced rice blast incidence and severity during Phase I trial. Disease incidence and severity of common diseases recorded under different rice genotypes in Phase I is presented in Table 1 and, rice blast incidence and severity among different rice genotypes under different water management regimes is presented in Table 2. Brown spot and rice blast had the highest incidence among rice genotypes at 12 and 14%, respectively. Grain rot recorded the lowest incidence among rice genotypes at 2% (Table 1). For water management regimes, the incidence of rice blast was highest in AWD and lowest in CF (Table 2) and the reverse was true for RYMV, where CF plots had the highest incidence and CD the lowest incidence (Fig. 1). Overall, the highest and lowest disease incidence was recorded from the AWD and CF regime, respectively (Fig. 1), with the most prevalent

diseases being rice blast and brown spot. Disease severity did not vary much for the diseases under the different water management regimes except for rice blast, brown spot and sheath rot which had the highest severity score of 2 under AWD.

In Phase II, all the diseases were again significantly ($P < .001$) influenced by rice genotypes, with a significant variation ($P < .001$) in disease incidence and severity of rice blast and RYMV under different water management regimes like in Phase I. The interaction of water management regimes and rice genotypes did not significantly ($P = .06$) influence incidence and severity of all the diseases recorded, except for only RYMV incidence ($P = .03$). The trend in disease incidence with regard to water management regimes during Phase II trial was distinct from that of Phase I trial. Rice blast and brown spot incidences were no longer highest under AWD but were highest under CD (Fig. 2). Rice blast though with the highest incidence in CD, had the highest severity in AWD while brown spot had the highest severity under CF in Phase II (Fig. 3).

The results of reaction of the 10 rice genotypes further studied in Phase II to different diseases of rice are presented in Table 3. All the selected genotypes succumbed to brown spot, grain rot and sheath rot; whereas genotypes NERICA-4, P27H2 and P33H3 were not infected by RYMV while, K5 and IR09A136 did not succumb to rice blast Table 3.

3.2 Insect Pest Occurrence as Influenced by Genotypes and Water Management Regimes during the Trials

The insect pests recorded on rice during the trials included the African rice gall midge (AfrGM, *Orseolia oryzivora*) and the stalked-eyed fly (*Diopsis* spp). During Phase I trial, stalked-eyed fly incidence varied significantly among genotypes ($P < .001$) but not under the different water management regimes whereas the African rice gall midge incidence did not vary significantly ($P = .08$) among rice genotypes and under different water management regimes.

In Phase II, African rice gall midge and stalked-eyed fly incidence both varied significantly ($P = .01$) under different water management regimes but not among genotypes ($P = 0.8$). Generally, stalked-eyed fly and African rice gall midge recorded the highest incidence under CF and the least in the CD during the trials (Fig. 4 and Fig. 5).

Table 1. Disease incidence and severity of rice diseases recorded for different rice genotypes in the field, 2012

Genotypes	Rice blast		Brown spot		Grain rot		RYMV		Sheath rot	
	Incid. ^a	Sev. ^b	Incid.	Sev.	Incid.	Sev.	Incid.	Sev.	Incid.	Sev.
P1H20	16	1	27	2	0	0	3	1	5	2
P27H3	19	1	25	2	0	0	10	2	2	1
P5H3	8	1	27	2	5	1	0	0	10	2
P22H16	14	3	22	2	5	1	0	0	9	4
P34H2	5	1	29	2	3	1	2	1	0	0
P59H13	13	1	29	3	0	0	0	0	10	1
P58H11	3	1	27	2	5	1	2	1	16	4
P59H10	13	2	24	2	0	0	4	1	8	1
NERICA-4	22	2	18	1	0	0	0	0	13	3
P27H2	11	1	22	2	5	2	3	1	8	3
P33H3	21	3	10	1	5	1	5	1	5	2
P49H3	13	2	10	1	3	1	32	3	0	0
P55H17	14	1	8	1	0	0	0	0	6	2
P55H20	24	3	19	1	2	1	3	1	21	5
P8H17	19	2	24	2	5	1	0	0	14	5
P7H14	0	0	18	2	0	0	3	1	5	2
CIERANG	0	0	2	1	0	0	11	2	0	0
K5	0	0	14	1	0	0	10	2	0	0
P59H9	6	2	10	1	3	1	2	1	2	1
Mean	12	2	14	1	2	1	7	1	7	2
LSD (5%)	12***	0.7***	10***	0.4***	3***	0.5***	13	1	10***	2***

*Incid.^a = Incidence (%), Sev.^b = Severity, ***Significant at P < .001.*

Note: Results presented for 10 least susceptible and 10 most susceptible rice genotypes to the diseases recorded in the field during the trial

Table 2. Disease incidence and severity of rice blast among different rice genotypes under different water management regimes, 2012

Genotypes	Incidence				Severity			
	AWD	CD	CF	Mean	AWD	CD	CF	Mean
P1H20	28	19	0	16	2	0	0	1
P27H3	28	29	0	19	3	2	0	1
P5H3	24	0	0	8	2	0	0	1
P22H16	33	10	0	14	8	2	0	3
P34H2	14	0	0	5	2	0	0	1
P59H13	38	0	0	13	3	0	0	1
P58H11	10	0	0	3	1	0	0	1
P59H10	24	14	0	13	4	1	0	2
NERICA-4	29	29	10	22	3	3	1	2
P27H2	14	19	0	11	2	2	0	1
P33H3	38	19	5	21	5	2	1	3
P49H3	24	14	0	13	4	2	0	2
P55H17	43	0	0	14	4	0	0	1
P55H20	33	24	14	24	5	2	1	3
P8H17	48	10	0	19	5	2	0	2
P7H14	0	0	0	0	0	0	0	0
CIERANG	0	0	0	0	0	0	0	0
K5	0	0	0	0	0	0	0	0
P59H9	19	0	0	6	7	0	0	2
Mean	16	6	1	12	2	1	0	2
LSD (5%)	14**				1**			

***Significant at P = .02*

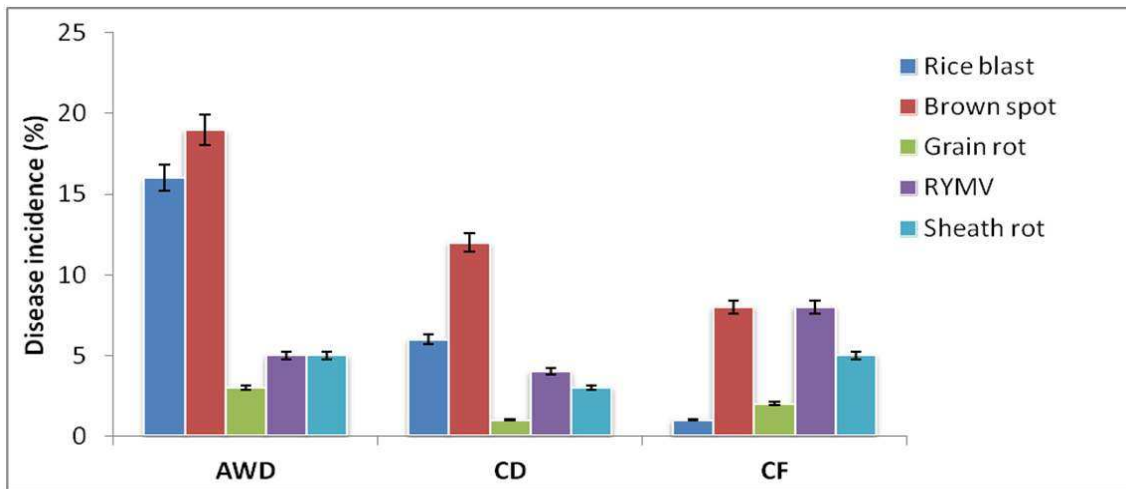


Fig. 1. Incidence of diseases under different water management regimes in the field at NaCRRI, 2012

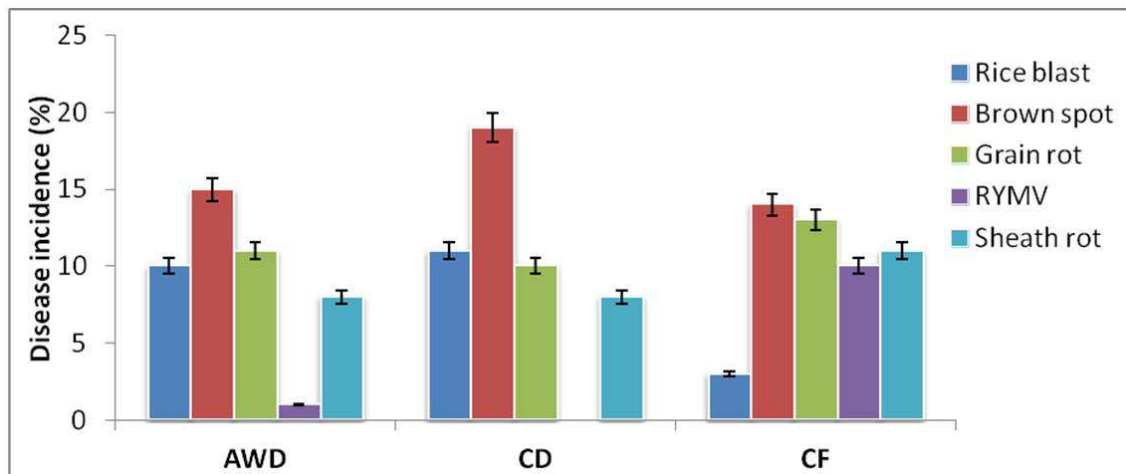


Fig. 2. Incidence of diseases under different water management regimes in the field at NaCRRI, 2013

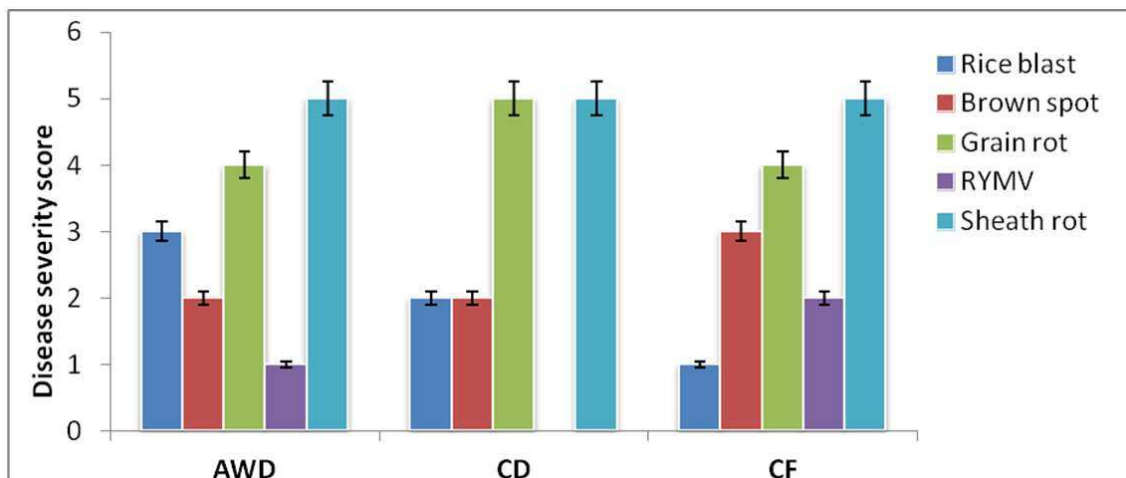
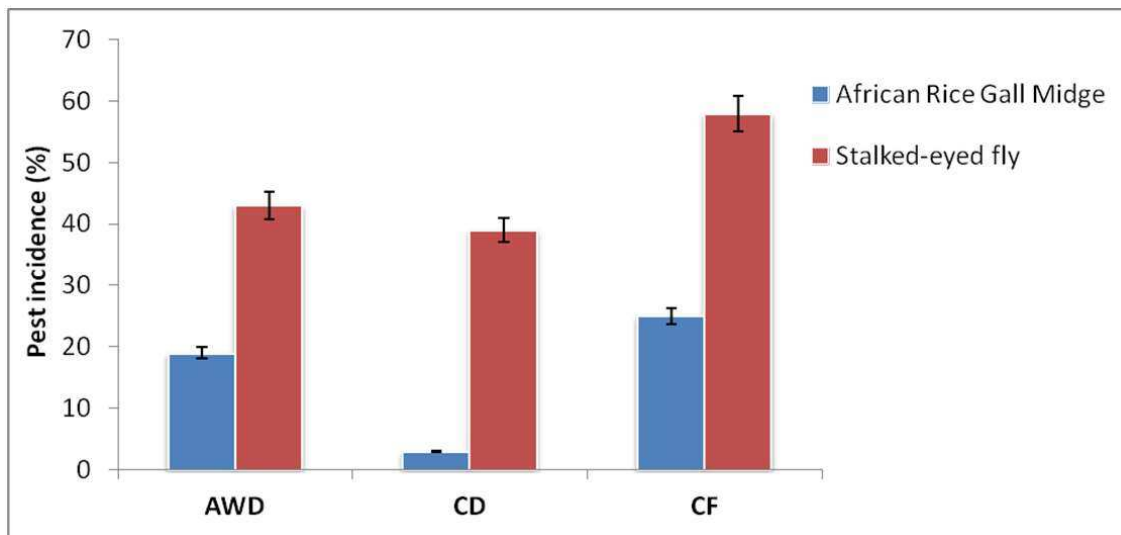
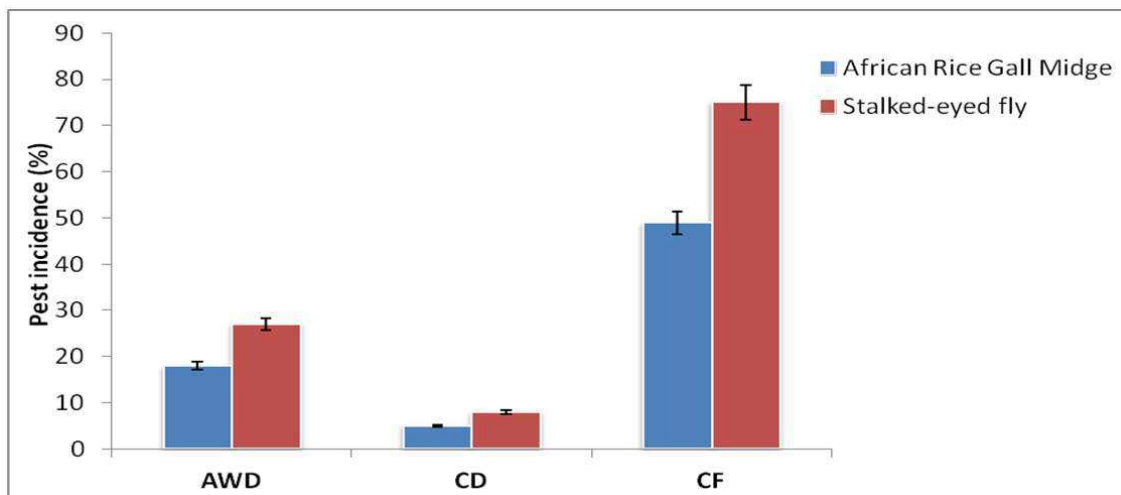


Fig. 3. Disease severity score for diseases recorded in the field under different water management regimes at NaCRRI, 2013

Table 3. Disease incidence and severity of diseases recorded in field at NaCRRI, 2013

Genotypes	Blast		Brown spot		Grain rot		RYMV		Sheath rot	
	Incid. ^a	Sev. ^b	Incid. ^a	Sev. ^b	Incid. ^a	Sev. ^b	Incid. ^a	Sev. ^b	Incid. ^a	Sev. ^b
K5	0	0	43	3	5	1	8	2	1	1
NERICA-4	18	3	8	1	18	5	0	0	14	8
IR09A136	0	0	28	3	12	6	4	1	8	6
P27H14	1	1	11	1	13	6	5	1	9	5
P27H2	3	1	17	3	12	4	0	0	6	4
P33H3	13	3	14	2	11	4	0	0	10	7
P49H3	11	2	14	3	4	3	5	1	4	2
P55H17	15	3	13	2	19	5	2	1	13	8
P55H20	10	2	8	3	12	5	4	1	12	6
P59H9	8	1	4	1	5	4	5	2	14	6
Grand mean	8	2	16	2	11	4	3	1	9	5
LSD (5%)	10***	2***	15***	2***	11***	3***	4***	1***	7***	4***

Incid.^a = Incidence (%) Sev.^b = Severity ***Significant at $P < .001$

**Fig. 4. Insect pest prevalence under different water management regimes at NaCRRI, 2012****Fig. 5. Pest prevalence under different water management regimes at NaCRRI, 2013**

4. DISCUSSION

The results of this study showed a significant variation in incidence and severity of rice diseases under different water management regimes during the trials. The significant variation in disease incidence and severity observed under different water management regimes in this study is in agreement with findings from other studies; the national agricultural research organization (NARO) reported RYMV as a severe problem in flooded fields in Uganda especially in the eastern and northern regions [12]. These authors [9] also reported high levels of RYMV in flooded rice fields in West Africa. On the other hand, the fact that rice blast was found to be more prevalent in the AWD and CD water regimes is in line with reports by [15] who found high levels of rice blast disease in upland rice fields (fields which are well aerated or well drained). In contrast, [10] found rice blast incidence and severity to be lower in the AWD plots compared to the conventional (continuously flooded) plots. They attributed the lower incidence in AWD to the fact that intermittent supply of water created unfavorable environments for successful development of the disease pathogens hence the inability to cause severe damage to crops. This author [16] also reported that rice crops grown under intermittent irrigation were more resistant to diseases thereby reducing the need for chemical protection. Additionally, [17] reported that the condition of agricultural microclimate in rice fields under AWD is favourable not only for rice growing but also for reducing diseases.

Despite relatively higher disease incidence recorded under AWD regimes, higher grain yield [13] was recorded under AWD regimes compared to CF during the study. This could imply that the advantages due to AWD, notably good soil aeration resulted into better root development, efficiency in water and nutrient use thereby increasing rice yields [18] and these advantages outweighed the penalty due to the two diseases.

The variation in disease incidence and severity among rice genotypes observed during the trials could be attributed to the difference in the level of disease resistance among genotypes to the different diseases. Genotypes which had high incidence and severity for certain diseases could be less resistant to the diseases than those which they showed very low or no incidence and severity.

With regard to insect pests, in Phase II, the stalked-eyed fly and African rice gall midge, the predominant insect pests during the trials were highest in the CF

water regime. This finding is in agreement with several other studies, notably, the study conducted in Guinea found populations of the adult stalk-eyed fly to be most abundant in the lowlands and least abundant in the uplands [19]. According to [20], stalked-eyed fly is most abundant in lowland rain-fed and irrigated ecosystems. Similarly, outbreaks of the African rice gall midge are reported to occur in years that are wetter than usual [21]. This author [22] reported the midge to be most abundant in irrigated and rain-fed lowland ecosystems and not in the uplands. However, [23] reported that in Burkina Faso, the midge was noted to feed on lowland rain-fed, lowland irrigated and upland rice as well. These reports and the findings of this study seem to point to the fact that the stalked-eyed fly and African rice gall midge are most damaging in flooded (high moisture) rice environments. The results of this study add credence to reports that there are lower pest occurrences under AWD compared to CF [10]. Additionally, the same authors [10] showed that AWD minimized the incidence of insect pests compared to the conventional irrigation (continuous flooding).

5. CONCLUSION

The results of this study have indicated pests and disease occurrence to be variable under different water management regimes and among genotypes. Incidences of different diseases were affected differently by water management and rice genotypes. As such, water management in rice fields aimed at integrated disease management should be with respect to the target disease organism. For the stalked-eyed fly and the AfRGM, the two key insect pests of rice in Uganda; reducing flooding conditions by AWD can provide a reducing effect on occurrence of the pests.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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