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Effect of plant density and planting time on pest incidence and damage of upland rice

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Abstract The most varied agronomic practices among upland rice (*Oryza sativa* L.) farmers in Uganda are time of planting and plant density. Investigations were carried out to assess the effect of these factors on pest incidence and damage of the crop. Upland rice was planted three times at 10 day intervals starting at the onset of rains, and at plant densities of 100, 67, 50 and 40 plants m^{-2}, based on inter-row spacings of 20, 30, 40 and 50 cm. Rice grown at high densities (100 and 67 plants m^{-2}) had significantly higher incidence of grasshoppers (*Orthoptera*), rice bugs (Heteroptera), green leafhoppers (*Nephotettix apicalis*), stalk-eyed fly (*Diopsis thoracica*), and pollen beetles (*Coryna* sp.) compared to the low density plantings. Incidence of grasshoppers, stalk-eyed flies, rice bugs, leaf rollers (*Cnaphalocrocis medinalis*), green leafhoppers and pollen beetles was also significantly higher in early planted rice. In contrast, whitehead/deadheart damage was higher on late planted rice. There were also significant interactions between plant density and time of planting.

Key words: Pests, ricebugs, leafhoppers, leafrollers, whitehead, deadheart, *Oryza sativa,* Uganda

Résumé Les pratiques agronomiques les plus variées parmi les fermiers du riz de montagne en Ouganda concernent la période de plantation et la densité des plants. Des études étaient menées pour évaluer l'effet de ces facteurs sur l'incidence des ravageurs et l'endommagement de la culture. Le riz de montagne était semé trois fois à un intervalle de 10 jours au commencement de la saison des pluies et aux densités plantales de 100, 67, 50 et 40 plants m^{-2} basés sur un écartement des lignes de 20, 30, 40 et 50 cm. Le riz cultivé à hautes densités (100 et 67 plants m^{-2}) avait, d'une maniére considérable, une incidence élevée de sauterelles *(Orthoptera)*, et de punaises du riz (Heteroptera), d' acridiens, de podophthalmes (*Diopsis thoracica*) et de bruches (*Coryna* sp.), par rapport aux semis à basses densités. L'incidence des sauterelles, des podopthalmes, des punaises du riz, des tordeuses de feuilles (*Cnaphalocrocis medinalis*), des acridiens et des bruches était sensiblement élévée chez le riz planté hâtivement et l'endommagement dû à la tête blanche et à la pourriture du coeur était élevé chez le riz planté tardivement. Il y avait aussi des intéractions considérables entre la densité plantale et la période de plantation.

Mots clés: ravageurs, punaises du riz, cicadelles tordeuses, tête blanche, pourriture du coeur, *Oryza sativa,* Ouganda

Introduction

Rice, *Oryza sativa* L. is attacked by a large number of pests, over 80 species of which belong to the Orders Lepidoptera, Diptera, Hemiptera, Orthoptera, Coleoptera and Isoptera. Only 15 species are, however, considered important in Africa, their severity varying in different climatic zones and ecosystems (Alam *et al.*, 1985).

Pests attack rice at various stages ranging from seedling to post-harvest. Their populations are greatly influenced by season and ecosystems under which rice is grown (Anon., 1976). Variation in cultural management practices such as tillage, plant spacing and soil fertilisation, can influence the prevalence of insect pests on field rice (Israel & Vedamoorthy 1955; Buddenhagen, 1978). However, the pest status of rice, especially upland

rice, have not been formally investigated in Uganda. As such little is known of the potential benefit of appropriate agronomic practices to minimise pest infestations on the crop. In the present study, therefore, evaluation was made of the influence of time of planting, plant density and crop phenology on pest incidence and damage on upland rice.

Materials and methods

The study was carried out at Makerere University Agricultural Research Institute, Kabanyolo (0° 28'N, 32° 37'E, and 1,200 m asl) during the long rainy seasons of 1994 and 1995. The area has underlying rocks of Precambrian age, with deep, highly weathered, leached latosols and an average pH of 5.0 - 6.0 (Huxley, 1960). The average monthly rainfall during the long rains of 1994 and 1995 was 92.1 and 109.2 cm, respectively. The maximum temperatures occasionally exceeded 30 °C while the minimum was 15 °C.

In both years, IRAT 112 upland rice variety was planted in a split-plot design, with three replicates. Time of planting constituted the main plots and row spacings the sub-plots. Planting dates were 27 April, 1994 and 5 April, 1995. In each season, rice was planted at the onset of rains (T_1), 10 days after T_1 seedling emergence (T_2), and 10 days after T_2 seedling emergence (T_3). The four inter-row spacings were 20, 30, 40, and 50 cm with plant densities of 100, 67,50 and 40 plants m^{-2}, respectively. Intra-row spacings was 10 cm. Each sub-plot measured 6 x 3 m, and consisted of 31, 21, 15, and 12 rows of rice, respectively.

Pest sampling started 7 weeks after seedling emergence (WAE) and was carried out once every week until harvest. This involved visual counts of insect pests found and damage caused on two outer and one inner row per plot during morning hours (9.00-11.00), when most insects are not very active. Counts were made of the number of grasshoppers, rice bugs, stalk-eyed fly, green leafhoppers, pollen beetles, hairy caterpillars and leafrollers per row. Stemborer and shootfly damage were assessed as the number of whiteheads and deadhearts per row, respectively. Data were subjected to analyses of variance and means separated using Fischer's LSD test. The analyses were carried out using the MSTAT-C computer package (Russell, 1986).

Results

Significant differences in pest abundance on the upland rice crops were observed (Table 1). High plant densities favoured increased incidence of a majority of the upland rice pests. For example, in 1994, increase in plant density resulted in significant ($P \leq 0.001$) increase in population density of rice bugs (*Heteroptera*), stalk-eyed flies (*Diopsis thoracica*), green leafhoppers (*Nephotettix apicalis*), pollen beetles (*Coryna* sp.) and hairy caterpillars. The same trends were observed in 1995. However, deadheart and whitehead damage did not increase with higher rice plant densities. In 1994, early planting of upland rice resulted in significantly ($P \leq 0.001$) higher populations of rice bugs and pollen beetles, while, late planting (T_3) led to significantly ($P \leq 0.001$) higher incidence of green leafhoppers and hairy caterpillars, and to increased deadheart damage (Table 2). Incidence and damage by the stalk-eyed flies were, however, not significantly affected by time of planting. A similar trend was observed in 1995.

There were significant interactions between plant density and time of planting on pest occurrence. In 1994, this effect was significant ($P \leq 0.005$) for the hairy caterpillars, whose populations increased with plant density but more so with delayed planting (Table 3). In the long rainy season of 1995, significant ($P \leq 0.01$) interactions of plant density and time of planting were also observed for incidence of grasshoppers, rice bugs, stalk-eyed flies, pollen beetles and green leafhoppers, with early planting enhancing higher pest populations. In contrast, the population density of green leafhoppers was higher with increased plant density but more so on late planted upland rice (Table 3).

In 1994 leaf roller populations, and deadheart and white head damage were highest during the booting stage. In contrast, the incidence of pollen beetles, hairy caterpillars, green leafhoppers and stalk-eyed flies were highest during flowering stage, while that of rice bugs were most abundant during the grain filling stage (Fig. 1). A similar

Table 1. Influence of four plant densities on pest incidence and damage of upland rice grown during the long rains, 1994 and 1995 at Kabanyolo.

Insect/damage	Season	[1]Plant density m^{-2}			
		100	67	50	40
Grasshoppers	1994	NA	NA	NA	NA
	1995	7.7a	6.9a	6.1b	5.0c
Rice bugs	1994	3.9a	3.2a	2.6b	0.8c
	1995	2.7a	2.2a	2.1a	1.2b
Stalk eyed fly	1994	1.3a	1.4a	1.0a	0.5b
	1995	0.5a	0.7a	0.6a	0.1b
Green leafhoppers	1994	4.9a	2.1b	1.8bc	1.5bc
	1995	5.0a	2.4b	3.4b	2.5b
Pollen beetles	1994	6.1a	3.3b	1.2c	1.4c
	1995	0.5b	1.6a	1.1a	1.1a
Hairy caterpillars	1994	1.3a	0.6b	0.4bc	0.2c
	1995	0.1a	0.0a	0.0a	0.0a
Leafrollers	1994	NA	NA	NA	NA
	1995	1.9a	1.8ab	0.9bc	0.9c
Deadhearts	1994	1.6a	1.5a	1.8a	1.8a
	1995	0.5a	0.3a	0.3a	0.5a
Whiteheads	1994	NA	NA	NA	NA
	1995	0.0a	0.0a	0.0a	0.0a

[1]Data analysed after log(X+1) transformation.
a,b,c = Means for each insect and damage followed by similar letters are not significantly different (LSD 0.05).
NA = Data not collected.

Table 2. Number of insects and damage counts per row on upland rice planted three times at 10 day intervals during the long rains of 1994 and 1995 at Kabanyolo.

Insect	Season	[1]Time of planting		
		T_1	T_2	T_3
Grasshoppers	1994	NA	NA	NA
	1995	6.1a	6.9a	6.2a
Rice bugs	1994	3.8a	1.1c	2.5b
	1995	7.1a	1.8b	0.3c
Stalk eyed fly	1994	0.9a	1.3a	0.9a
	1995	0.6a	0.3a	0.5a
Green leafhoppers	1994	1.2c	2.3b	4.1a
	1995	2.1b	3.9a	3.8a
Pollen beetles	1994	3.9a	1.6c	2.5b
	1995	1.9a	1.1b	0.5c
Hairy caterpillars	1994	0.3b	0.7a	0.9a
	1995	0.0a	0.0a	0.0a
Leafrollers	1994	NA	NA	NA
	1995	1.8a	1.3a	0.3b
Deadhearts	1994	0.5c	4.9a	1.1b
	1995	0.1b	0.1b	1.1a
Whiteheads	1994	NA	NA	NA
	1995	0.0a	0.0a	0.0a

[1]Data analysed after log(X+1) transformation.
a,b,c = Means for each insect and damage followed by similar letters are not significantly different (LSD 0.05).
T_1 - T_3 = Time of planting upland rice at 10 day intervals from the onset of rains.

NA = Data not collected.

trend was observed during the long rainy season of 1995.

Discussion

The results of this study indicate that upland rice is attacked by a wide range of insect pests. However, the incidence of the pests varied with rice planting density, time of planting, and developmental stage of the rice plant.

There was a sustained high incidence of rice bugs, pollen beetles and hairy caterpillars on upland rice from flowering to harvest. This was partly explained by the fact that a fairly extended tillering period maintained the crop at different developmental stages which then provided a source of food and enabled sustained multiplication of the pests. Availability of food greatly influences the population dynamics of most pests (Risch, 1981; Litsinger *et al.*, 1986).

This study also revealed that planting upland rice at high densities (100 and 67 plants m^{-2}) favoured the occurrence of majority of the insect pests. In studies carried out elsewhere, the number of brown planthoppers dramatically increased in densely planted rice (Hino *et al.*, 1970). Similarly, the number of gallmidges tended to rise proportionately with the density of tillers, leading to greater incidence of galls in dense plantings.

Various reasons have been advanced to explain this pest response. Generally, dense plantings change crop growth and development and its micro-climate. These changes affect the incidence of pests and their natural enemies (Ryan *et al.*, 1980; Teetes, 1981; Ogenga-Latigo, 1988). For example, high relative humidity in dense intercrops is known to favour pest survival (Pillai *et al.*, 1979; Wrigley, 1981; Schinitzler, 1985). More plant surface area is also available resulting in less competition for oviposition or feeding sites (Kenmore *et al.*, 1984).

Conclusion

We observed that the population density of some pests increased in early planted rice while others declined, demonstrating the variable effect of time of planting on the population densities of pest species. This finding contrasts with those of Litsinger *et al.* (1986) and Pathak *et al.* (1994) that

Table 3. Number of rice insect pests per plot as influenced by plant density and time of planting interaction, long rains 1995, Kabanyolo (data analysed after log(X+1) transformation).

Planting time	Plant density m^{-2}	Pest incidence row^{-1}					
		Long rains 1994	Long rains 1995				
		Hairy caterpillar	Grass hopper	Rice bug	Stalk eyed fly	Pollen beetle	Green leafhopper
T_1	100	0.9bcd	8.7a	10.5a	1.4a	0.9de	3.1bcd
	67	0.1e	6.9abc	9.4a	0.7b	1.3cd	2.3cde
	50	0.4de	4.9de	6.7a	0.5bcd	2.4b	1.7de
	40	0.1e	4.6e	3.7b	0.0e	4.1a	1.4e
T_2	100	2.0a	7.9ab	3.6b	0.3bcde	0.8de	6.2a
	67	0.4de	5.9cd	1.4c	0.1de	1.9bc	3.5bc
	50	0.4de	6.9bc	1.6c	0.6bc	1.7bc	4.2ab
	40	0.3de	6.5bc	0.9cd	0.2cde	0.3fg	2.2cde
T_3	100	1.3abc	6.9bc	0.0e	0.1de	0.0g	6.4a
	67	1.8ab	7.9ab	0.4de	1.4a	1.6bc	1.7de
	50	0.5cde	6.5bc	0.5de	0.7b	0.1fg	4.8ab
	40	0.1de	3.9e	0.2de	0.0e	0.5ef	3.8abc
CV (%)		65.4	8.5	74.8	75.7	36.0	25.7

a,b,c = Means in a column followed by similar letters are not significantly different (LSD 0.05).
T_1-T_3 =Time of planting after onset of rains at 10 days' intervals after rice emergence.

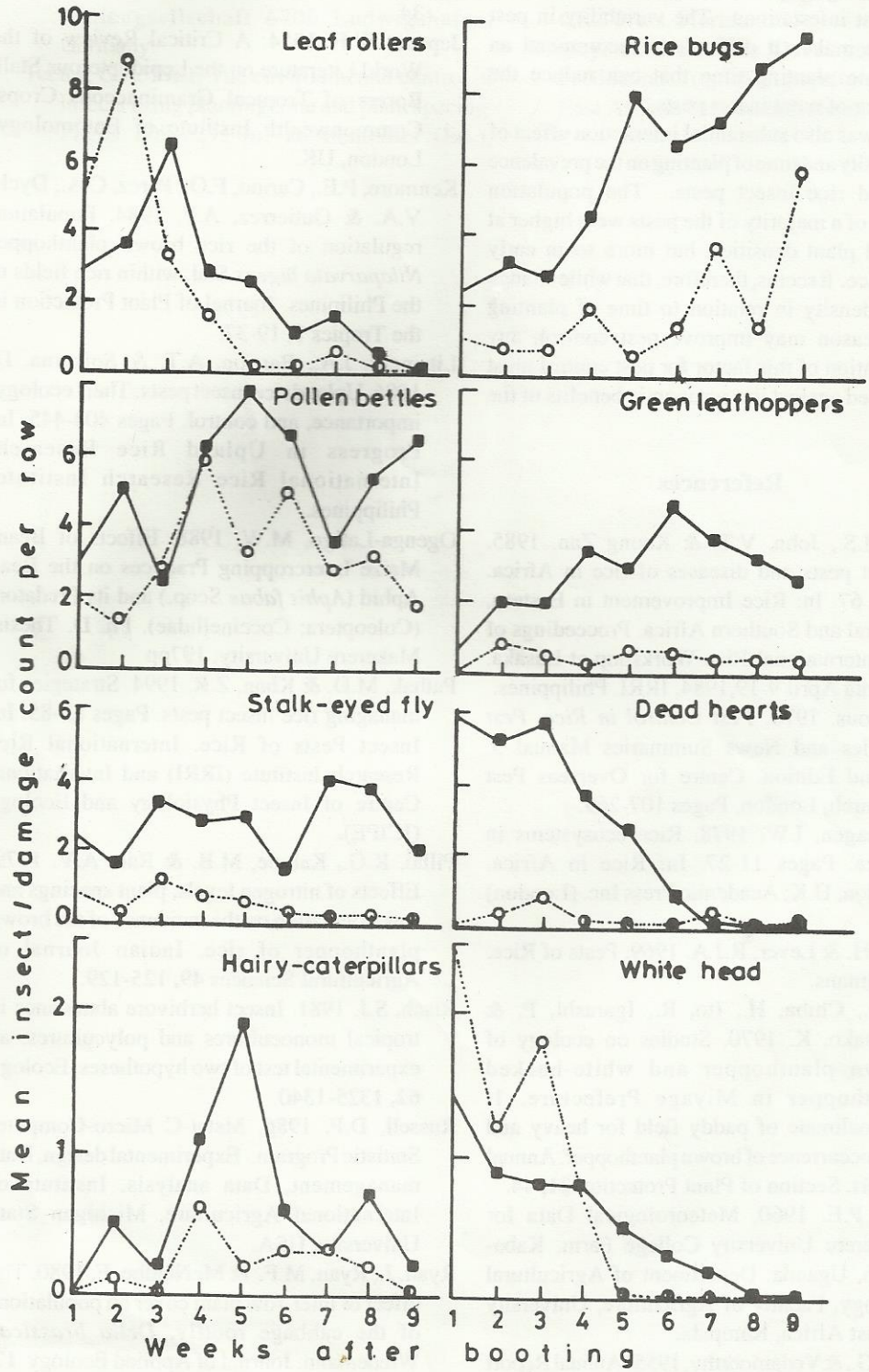

Figure 1. Population dynamics of insect pests on upland rice grown at Kabanyolo, during the long rains of 1994 (■—) and 1995 (o.....).

early planting of upland rice (at the onset of rains) lower pest infestations. The variability in pest incidence makes it difficult to recommend an appropriate planting time that can reduce the abundance of most insect pests.

There was also substantial interaction effect of plant density and time of planting on the prevalence of upland rice insect pests. The population densities of a majority of the pests were higher at increased plant densities, but more so in early planted rice. It seems, therefore, that while change in crop density in relation to time of planting within season may improve pest control, any consideration of this factor for pest control must be weighed against the agronomic benefits of the choice.

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