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The behavior of Three Rice Varieties against *Steneotarsonemus spinki Smiley* in Vertientes, Camagüey

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Abstract

Context: In Cuba, the proliferation and spread of rice acarid *Steneotarsonemus spinki Smiley*, is one of the main hindrances to rice productivity growth. Although integrated management is performed in the municipality of Vertientes, the acarid causes yield losses accounting for 15-20%.
Aim: To determine the incidence of acarid *S. spinki* and the agro-productive behavior of rice varieties IA Cuba- 31, J-104, and Prosequisa -4.
Methods: Two evaluations were made to determine the presence of the pest in the crop. Besides, farming and industrial parameters were measured. The data collected were analyzed through simple analysis of variance, using SPSS, version 11.5.1, for Windows.
Results: The results show that variety Prosequisa 4 withstood the lowest incidence of the acarid, being the crop variety with the highest farming and industrial yields, followed by the IA Cuba 31.
Conclusions: This study recommends the following varieties for inclusion in the varietal policy for large and small-scale rice growers: Prosequisa -4 and IA Cuba 31.

Key words: Rice, acarid incidence, farm and industrial yields.

Introduction

Rice (*Oryza sativa Lin*.) is one of the most widely consumed grains worldwide (over half of the population), following wheat (Bellassen et al., 2010).

In Cuba, rice production is performed by large and small-scale growers. At the people's level, it is one of the most relevant sub-programs of urban and suburban farming dedicated to rice production at a smaller scale, accounting for 83% of the grain production (Galbán, 2011).

This item is associated with the rising trends in prices in the international market. Out of every ton produced in Cuba, 200.00 USD can be saved, so the goal is to utilize human and material resources efficiently to increase the production of this vital food for Cubans (González, 2012).

Pests constitute one of the limitations to productivity increases of the crop; they restrict the expansion of crop areas and raise the costs of inputs. Among them is acarid *Steneotarsonemus spinki Smiley*, whose high proliferation and spreading, short life-cycle, and habitats, make it difficult to control the pest chemically or biologically. The main damage is caused directly to the crop as they feed on it, and indirectly due to the injection of toxins or the spread of phytopathogenic organisms, particularly fungi. The acarid causes complex symptoms due to its relation with the fungus S. oryzae. It dwells inside the rice pods achieving high populations of up to 300 acarid/cm^2. The fungus causes pod rotting, and along with S. spinki, is responsible for the sterility of panicles and a drastic reduction of yields (Hernández, 2006).

Researchers have made several efforts to increase rice yields. An important premise is the study of the main effects caused by phytopathogens and the behavior of autochthonous varieties against them, which will permit the design of proper handling strategies (Rivero, Cruz, Martínez & Pérez, 2011).

The municipality of Vertientes in the province of Camagüey is one of the largest producers of the crop. Acarid *S. spinki Smiley* causes yield losses despite integrated management performed in the territory, with estimated damages between 15 and 20%, as a result of increased numbers of sterile panicles. A challenge to local researchers is to determine the behavior of the production varieties under the presence of the acarid to implement a more efficient varietal policy.

Materials and methods

The research was done at the Territorial Grains Research Station in Vertientes, Camagüey, located on Km 5 ½, Batalla de las Guasimas Road, on coordinates 21^{0}5'50" north latitude, and 78^{0}10'30" west longitude, 18 m above seas level. The local soil is carbonated dark plastic glay, according to Hernández et al. (1999), with a pH of 6.4, and 2.67% organic matter content.

The experiment was performed in the spring of 2017, using the muddy soil technology, with the proper leveling to establish a 5.0 cm high water sheet, and a density of 120 kg/ha through the traditional broadcast sowing system. The fertilization, phytosanitary, and other agrotechnical labors were done according to the standards of the Rice Research Institute (2014). The treatments were IACuba 31, J 104, and Prosequisa 4.

The weather variables evaluated were relative humidity (%), maximum, minimum and mean temperatures (^{0}C), wind (km/h), light hours (h), and precipitations (mm). They were provided by the Weather Institute of Camaguey, including the data from the Santa Cruz and Florida weather stations for Vertientes, except for the rainfall, which was read in the experimental area (Appendix I).

The studies were done in 4 x 4 m plots, in a randomized block design with 5 repetitions and three treatments, which included the two varieties in the research and a production standard.

Two evaluations were made to determine the presence of the pest. One took place at 60 days following the crop germination (DDG), or primordium change stage, and the other at 100 days upon the germination of the crop (DDG), or grain filling stage. The former was made when the incidence of the acarid on the crop was the highest, and the latter was to determine the field index days before harvest.

Sampling included the location of 4 spots chosen at random in each field, and 10 plants per point, for a total of 40, which were observed through the stereoscope (20x). The first evaluation was conducted in three spots of the pod (middle, upper, and lower), and the second included the pod from the leading leaf, according to the methodology suggested by INISAV (1998).

The parameters evaluated and read at harvest were,

Plant height (cm); measure ruler, from the plant base to the full panicles.

Panicles per square meter. The number of plants/m^2 was determined using a frame (1 m^2).

Full and empty grains: these were harvested by hand in 1m^2 per variety, from which 5 panicles were taken at random for total grain, full grain, and empty grain counts.

The weight of 1000 grains (g): A HL-2000i digital balance was used, with a measuring limit of 1 g X 2000 g.

Farming yields of paddy rice (t/ha). The square meter harvested was dried in the air, and weighed in the Laboratory for Quality Control at the Ruta Invasora Rice CAI, where the farming yields were determined at 14% humidity, according to the IRRI international scale (1996).

Industrial yields expressed in whole grain per cent: 1 kg of rice dried at 12.5% humidity was milled using the SS-6 Digital Humidity Determiner. The rest of the whole grain % was evaluated through the Zaccaria rice tester, PAZ/1DTA.

The database was made with the information processed by Excel 2007, using SPSS, version 15.0 (2006) for statistical analysis of the parameters studied.

Results and discussion

The results showed the incidence of acarid *S. spinki Smiley* on the three varieties. The best behavior was observed with Prosequisa 4, both at 60 and 100 days of the plant cycle, with the lowest affectation percent. The IACuba 31 variety at 60 and 100 days of germination was observed to be more resistant than variety J104, which at 100 days showed high susceptibility to *S. spinki Smiley* (Table 1).

Table 1. Incidence of the acarid (%)

Treatments	60 days (%)	100 days (%)
IA Cuba 31	18.0[b]	29.1[b]
J104	29.2[a]	60.2[a]
Prosequisa 4	2.0[c]	6.6[c]
ESx	0.52	1.46

Note: the values with different superscripts indicate significant differences $p < 0.05$.

The mean temperatures (^{0}C) during the study varied between 23^{0}C and 28^{0}C. Optimum conditions for the development of this terrible pest to rice (Technical Manual for Rice, 2008). Ramos (2002); Almaguel, Botta, González & Franco (2008), and Hernández (2011) demonstrated that in the months between April and September there are highly favorable climatic conditions for pest development. Their control is hard to accomplish using the traditional fighting ways. The international and Cuban experiences recognize the integrated management of the most promising strategy to face this pest successfully and sustainably. It must be based mostly on the utilization of resistant or tolerant varieties, agrotechnical measures, and the preservation and growth of their natural enemies, in keeping with the characteristics and possibilities offered by each ecosystem. The training and preparation of technicians and farmers to design and implement such management strategies will ensure success in the fight against this significant pest.

In these conditions, Prosequisa 4 showed resistance against *S. spinki Smiley*, whereas IACuba 31 was partly resistant, and Jucarito 104 was susceptible. Coinciding with the findings of Hernández, Moredo & González (2016), the highest values were observed under similar conditions for Prosequisa 4, and González (2015), when the IA Cuba 31 was evaluated in the central region of Cuba.

Plant height at harvest (Table 2) showed the best values in Prosequisa 4, differing significantly from Jucarito 104 and IACuba-31. These results were below the values mentioned by Puldón et al. (2002), in the Catalog of Cuban Rice Varieties, and studies done by Suárez, Puldón, Rivero, Alfonso & Hernández (2009), where the same varieties reached 95.5-117 cm high, respectively under other edaphoclimatic conditions.

Table 2. Plant height (cm)

Treatments	Height (cm)
IA Cuba 31	76.2[b]
J104	75.0[b]
Prosequisa 4	93.0[a]
ESx	0.84

Note: the values with different superscripts indicate significant differences $p < 0.05$.

The results may be influenced by the interaction of the varieties and the environment. Hence, the report of different researchers on this parameter varies in the country considerably for every region studied (Díaz González & Xiqués, 2000 and Rojas et al., 2011). In general, this parameter has heredity.

The parameter panicles per m^2 of Prosequisa 4 produced the highest number of panicles, as shown in Table 3.

Table 3. Number of panicles/m^2

Treatments	Panicles/m^2 (one)
IA Cuba 31	292,[b]
J104	299.0[b]
Prosequisa 4	325,0[a]
ESx	0.15

Note: the values with different superscripts indicate significant differences $p < 0.05$.

These findings differ from the reports of Pérez, González & Castro (2002), who obtained 495 panicles/m^2 in Prosequisa 4, and Díaz, Morejón, Castro & Pérez (2011), who in the same campaign and using the same technology, obtained 413 panicles/m^2 in Prosequisa 4 and Jucarito-104. Perhaps this is caused by the influence of the interaction of the genotypes and the environment. This study coincided with Abe (2006), Socorro & Sánchez (2008), and the Rice Research Institute (2014) when they noted the incidence of different ecosystems in each variety development. It also agreed with Abe (2006) in that the percentage of fertility or panicle filling may be affected by the climate, the soil, the application of fertilizers, and the effect of pests and diseases.

Grain filling and emptiness (Table 4) expressed that Prosequisa 4 had the maximum values of filled grains by panicle evaluated, and the lowest values of empty grains, differing from the other varieties studied. The most unfavorable results of the full/panicle grains were observed in Jucarito 104. An analysis of the contents of empty grains in the panicles found that it not only depended on the genotype of each variety, but that it was influenced by factors like climate (temperature, relative humidity, wind), the agrochemical conditions of the soil, genetic causes associated with fertilization, panicle formation, and pests and diseases (MINAGRI, 2000 and 2014).

Table 4. Full and empty grains/panicle

Treatments	Full grains/panicle	Empty grains/panicle (%)
IA Cuba 31	79.0[b]	37.0[a]
J104	66.0[c]	36.0[a]
Prosequisa 4	126.0[a]	16.0[b]
ESx	0.23	0.10

Note: the values with different superscripts indicate significant differences p< 0.05.

The full grains/panicle are below the reports made by Díaz et al. (2011) for Prosequisa 4 and IACuba-31, with 159, and 116 full grains/panicle, respectively, under similar edaphoclimatic conditions, coinciding with Hernández et al. (2016), when they found that Prosequisa 4 had 128 full grains/panicle.

The weather variables were optimum when these results were achieved, in the grain filling stage, with mean temperatures between 26.8 and 27.1 ^{O}C; wind speed had no negative influence on this stage (8.8-8.4 m/s).

The results derived from the trial showed permissible or normal parameters in the emptying of A Cuba 31 and J104, considering the reports of Castro (2003), Socorro & Sánchez (2008), and the Rice Research Institute (2014), which state that during the March-July sowing, the emptying values may be over 25%, due to favorable climatic conditions for pests and diseases associated with emptying. Besides, these experimental areas only implemented agrotechnical control as part of the integrated acarid management.

The presence of *S. spinki Smiley* is considered one of the main factors leading to these results. It causes the emptying of grains and spreads fungi (Technical Manual, 2008, Rice Research Institute, 2014). The most frequently affected varieties were the ones with the least full grains/panicle.

Grain weight is a very stable trait when the crop is under good conditions, and it depends solely on the variety (López, 1991); it is the most influential component of farming yields, followed by the number of filled grains by panicle.

Upon the analysis of the weight-related results (1000 grains) (Table 5), it can be said that Prosequisa 4 was the heaviest, with a statistical difference from the other varieties; Jucarito-104 and ACuba-31 did not differ from each other. These results matched the findings of Puldón et al. (2002) in the Catalog of Cuban Rice Varieties, which referred that these values could vary from minus 10 to more than 50 mg/grain.

Table 5. The weight of 1000 grains (g)

Treatments	The weight of 1000 grains (g)
IA Cuba 31	30.0^{b}
J104	30.0^{b}
Prosequisa 4	37.0^{a}
ESx	0.35

Note: the values with different superscripts indicate significant differences p< 0.05.

The results achieved in the final evaluation of farming yields (Table 6) showed that Prosequisa 4 produced the highest farming yield values, followed by IA Cuba 31, with a significant difference from Jucarito 104.

Table 6. Farming yield by variety

Treatments	Farming yields (t/ha)
IA Cuba 31	6.7^{b}
J104	3.6^{c}
Prosequisa 4	7.6^{a}
ESx	0.20

Note: the values with different superscripts indicate significant differences p< 0.05.

Comparing these results with Puldón et al. (2002), the yields were within the potential described for each variety, over 4.0 t/ha for Prosequisa 4 and IACuba-31, and over 2.0t/ha for Jucarito 104. Other research studies have shown higher yields for IA Cuba 31 than Prosequisa 4.

Crop yield is the result of many plant growth functions, remarkably influenced by the environment, so this kind of farming yield does not necessarily have to be stable for every region or sowing season. (Kawano & Velásquez, 1970 and Pérez, Maqueira, Torres & Rodríguez, 2011).

For any rice-producing country, having a varietal structure with different cycles is critical, especially if it relies on high-yielding genotypes, resistance to the main pests and diseases, and that can adapt to the agroclimatic conditions of the region, as well as excellent industrial culinary qualities.

The industrial analysis (Table 7) of the varieties showed Prosequisa 4 within excellent parameters in terms of the percent of whole grains; it showed significant differences from Jucarito 104, with the lowest whole grain behavior, whereas IA Cuba 31 showed no significant differences with an industrial yield of 59.7.

Table 7. Composition of whole grains in industrial yields

Treatments	Industrial yields (Whole grain %)
IA Cuba 31	59.7^{a}
J104	40.7^{b}
Prosequisa 4	63.3^{a}
ESx	0.18

Note: the values with different superscripts indicate significant differences.

Puldón et al. (2002) and Hernández et al. (2010) reported similar results, though IA Cuba 31 had the best results in farming and industrial yields in similar conditions.

These results may be given by the resistance of Prosequisa 4 to adaptation to different rice ecosystems in the country. Moreover, the pH=6.4 was favorable for the development of the plant. Along with the tolerance to the main diseases and pests that attack rice, like *Pyricularia Oryzae, Helmithosporium orizae, el manchado del grano y el acaro S. spinki Smiley* (IDIAF, 2009).

Conclusions

The lowest affectation percentage by *S. spinki Smiley* was observed in Prosequisa 4.

The best results for farming and industrial yields were found in Prosequisa 4 and IACuba 31, respectively.

Author contribution

Arelys Valido Tome: research planning, analysis of results, redaction of the manuscript, final review.

Maria Casas Morell: research planning, analysis of results, redaction of the manuscript, final review.

Fermin Hernandez Espinosa: analysis of the results and final review.

Amalia Moredo Alvarez: analysis of the results and final review.

Dania Gonzalez Gort: analysis of the results and redaction of the manuscript.

Conflict of interest

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Appendix 1 Weather variables

Month	Temp. (^{0}C)	Rhum. (%)	Wind (km/h)	Light h. (h)	Precip. (mm)
MARCH	23.5	70.0	12.7	9.2	2.3
APRIL	25.9	70.7	11.6	9.13	1.6
MAY	25.9	70.7	10.5	9.3	5.6
JUNE	26.8	81.5	8.8	6.8	9.1
JULY	27.1	81.0	8.4	8.2	7.9
AUGUST	27.4	81.2	7.4	8.7	7.8