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Agronomic evaluation of four improved rice varieties in different sowing periods

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ABSTRACT

A study to evaluate the agronomic performance of four rice varieties in different seasons, on flooded soil, using direct plantation, was developed at the Local Station for Grain Research, in the municipality of Vertientes, province of Camaguey, Cuba. A block random design was used in the study, with five replicas, through a bifactorial experiment with four treatments (Prosequisa 4, IA Cuba 31, IACuba 40, and Jucarito 104, as control), the sowing period included January, February, March, April, May, June, July, and August. The parameters evaluated were, cycle (days) from germination to harvest, final plant height, fertile panicles per m^2, filled grain per panicle, 1000-grain mass (14% humidity), crop yields and industrial quality. The highest yields were accomplished in February and June (pattern variety and Prosequisa 4, with 8.2 t/ha-1, in each month). Concerning industrial yields, the best results were achieved in IACuba 31 (66.4; 66.1; and 63.3% full white grain) in February, June and July. The most profitable varieties were Prosequisa 4, Jucarito 104, and IACuba 31, in the different seasons evaluated.

Key words: Oryza sativa, rice, planting season, yield components

INTRODUCTION

Oryza sativa Lin rice may be the most important crop worldwide. Its consumption is widespread, as the staple diet of almost half the inhabitants of the world, and it is cultivated in 113 countries (Hernández, 2010).

Cordero (2013) noted that food production is a priority for the Cuban economy. High yields are expected from all plantation areas to meet the growing demands of the population. Hence, rational and efficient use of resources is an imperative; today, the annual per capita consumption in Cuba nears 72 kg.

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National rice production to cut imports

Considering today´s global changes, the climatic conditions (rainfall and temperature instability), and increase in agriculture input costs, it is important to make efficient use during sowing periods, in order to achieve optimum yields. However, that is one of the main limitations in production and yield stability during crop and industrial processing. Accordingly, new sustainable solutions must be implemented. In that sense, evaluation of sowing effects on crop and industrial yields of four rice varieties (*Oryza sativa* Lin), in the municipality of Vertientes, was made in this paper.

MATERIALS AND METHODS

The study took place at the Local Station for Grain Research, Vertientes, Camaguey, Cuba. The soil was dark, plastic and gleyed, pH 6.4, with organic matter content of 2.67% (Hernández et al., 1999).

The experiment was made in field 6, with monthly sowing of Jucarito 104, as witness; Prosequisa 4; IACuba 40; and IACuba 31, in January-February (dry season), and March-April-May-June-July-August (rainy season), the same year. The varieties were planted in flooded fields. A randomized block design was used, with four treatments (each per variety), and five replicas, in 10m^2 plots.

Variables evaluated in the experiment

a) Cycle from germination to harvest (days).
b) Final plant height (cm)
c) Fertile panicles per m^2
d) Filled grains per panicle
e) Empty grains per panicle
f) Weight of 1000 grains with 14% humidity.
g) Field yields (t/ha -1)
h) Whole grain percentage

The observation data were tabulated (Microsoft Excel 2003), and statistical processing was made through Two-way Variance Analysis (Statgraphics Plus, 5.1). The Duncan Test was used when significant differences were observed after multiple mean comparison ($p < 0.05$).

RESULTS AND DISCUSSION

Biological cycle

The variability of the biological cycle was expressed in the three different sowing periods (Table 1), though, recurrently, the longest cycle duration occurred in Prosequisa 4, and L-104. Both went over 140 days (January-February sowing); whereas the cycle was over 120 days for the other periods. IACuba 31 and IACuba 40 had 120 days for January and February, statistically differing from the other plantation periods for these varieties.

The above results coincide with reports by INRA (1971) and Fedearroz (1997). Coincidence was also shared with studies by González (2013), who found significant differences in the variety cycles, where Jucarito 104 and Prosequisa shortened their cycle in the rainy season, in the provinces of Havana and Sancti Spiritus. The previous corroborates the results from Franco (2000), with cycle differences in the rainy season, in comparison with the dry season, thus shortening their cycles caused by earlier phenophase initiation.

Table 1. Behavior of morphological indicators and components of crop and industrial yields per variety, in different sowing periods

Sowing period	Treatments	Cycle	Height (cm)	Panicl. m-2	Filled grains	Weight 1000 grains (g) Granos (g)	Yield t.ha-1	Whole grain %
January	IACuba 31	125f	75f	445e	86f	28e	4.1h	66.1a
	IACuba 40	125f	81d	400g	80g	30c	4.2h	51.6cd
	Jucarito 104	153a	83cd	420f	105de	31b	5.9ef	64.0ab
	Prosequisa 4	153a	78e	465d	89f	25f	6.4d	60.9b
February	IACuba 31	127e	80d	515c	78g	30c	6.,0e	66.4[a]
	IACuba 40	127e	80d	440ef	110d	31b	5.7f	58.3bc
	Jucarito 104	150ab	87c	558a	144a	26c	8.2a	49.6d
	Prosequisa 4	150ab	67h	536b	89f	31b	7.8b	50.9d
March	IACuba 31	112gh	76f	294l	79g	30c	7.6b	32.5f
	IACuba 40	112gh	79de	298l	116c	32b	5.4f	37.9ef
	Jucarito 104	136b	75f	299l	66l	30c	3.6i	40.7e
	Prosequisa 4	136b	93b	325h	128b	27f	6.3d	40.8e
April	IACuba 31	114g	83cd	310l	110d	29d	4.8gh	50.0d
	IACuba 40	114g	80d	321h	102e	33a	4.7gh	48.9d
	Jucarito 104	128cd	81d	303l	145a	30c	4.2h	41.8e
	Prosequisa 4	128cd	115a	301l	111d	21f	4.7gh	48.1de
May	IACuba 31	114g	90bc	166m	72h	28e	2.3l	49.5d
	IACuba 40	114g	85c	161m	85f	27f	2.6k	40.6e
	Jucarito 104	127d	73g	270j	79g	34a	3.0j	47.2de
	Prosequisa 4	127d	90bc	230k	101e	20f	3.8i	59.2bc
June	IACuba 31	110h	83cd	160m	75gh	28e	3.0j	51.3cd
	IACuba 40	110h	80d	138n	72h	31b	3.2j	48.9d
	Jucarito 104	122f	88bc	262l	101e	20e	5.0g	53.6c
	Prosequisa 4	122f	106ab	399g	97ef	30c	8.2a	60.2b
July	IACuba 31	107i	81d	192l	118c	30c	3.8i	63.3ab
	IACuba 40	107i	76f	213lk	87f	30c	2.4k	52.6cd
	Jucarito 104	124d	85c	305l	67l	30c	2.5k	54.4c
	Prosequisa 4	124d	96b	325h	124b	30c	7.1c	59.7b
August	IACuba 31	105ij	75f	247k	85f	30c	4.8gh	58.1bc

	IACuba 40	105ij	83cd	299l	85f	30c	4.2h	50.9d
	Jucarito 104	129c	59j	246k	60j	28e	1.2m	46.1de
	Prosequisa 4	129c	63i	272j	89f	29d	2.6k	40.1f
ES		13.74	2.18	26.62	4.76	0.76	0.37	1.9
CV %		0.11	12.82	36.56	23.69	13.13	35.57	17.67

Treatment means with different letters differ significantly ($p< 0.05$), according to DOCIMA Duncan.

Plant height

As to plant height, Table 1 shows that Prosequisa 4 reached the highest values in the spring (March, April, May, June, July), more than 100cm on some instances. It was followed by the control variety (above 80cm in January, February, April, June, and July). IACuba 31 and IACuba 40 were between 60 cm and 80cm; the highest value for IACuba 31 was achieved in May (90cm), and in January and August, the lowest value was observed (75cm). These results do not coincide with other reports (Tieh, 1993 and Suárez, 2010), when IACuba 31, IACuba 40, and Jucarito 104 were 100cm high; but lower than Prosequisa 4. It may have been influenced by a study from Alonso (1984), who demonstrated that plant height can drop to 20%, depending on the genotype and the cultivation season. Suárez (2009) also demonstrated that plant height does not define yields.

Panicle/m²

To achieve 6.0 t/ha-1 yields of Paddy rice, it is indispensible to grow about 350 panicles/m^2-2.59 filled grain per panicle, considering 29 g weigh for 1000 grains (Rice Technical Guidelines, 2008). Panicle behavior per square meter was varied (Table 1), with values between 400 and 500, in January and February. The control variety (558), Prosequisa 4 (536), and IACuba 31 (515) were the most outstanding during February. In the other months, all the varieties showed a similar behavior, around 300 panicles/m^2, with the worst value observed in IACuba 31, and IACuba 40 (160) in May and June. González (2013) had different results, with 208 panicles/m^2, using IACuba 31; 193 for IACuba 40; 189 for the control; and 187 for Prosequisa 4. These results coincide with Yoshida (1981), which demonstrated that high temperatures, above 30 °C have a negative effect on rice physiological processes, reducing the number of stems per plants. Moreover, García (2009) reported that poor light intensity contributes to a reduction in the number of panicles per plant.

Filled grains per panicle

The number of filled grains per panicle-1 was another variable component in different sowing periods (Table 1). The control had the highest values in February and April (144 and 145 filled grains per panicle-1, respectively); then

Prosequisa 4 (128 and 1124 in March and July, respectively). Significant differences were observed for the IACuba 31 and IACuba 40, with very similar monthly plantation. The most significant negative results were observed in the control (August, March and July). These results did not coincide with reports by Tieh (1993); Puldón et al. (2002), with 135 filled grains per panicle-1, in Prosequisa 4; 127, with the control; and 150 with IACuba 31. It could be explained by Abe (2006), who noted that the fertility of filling percent of panicles may be affected by the climate, soil, fertilizers, and pests and diseases.

Volume of 1000 grains (g)

Grain volume is a very stable feature when the crop is properly attended, and it depends mainly on the variety (López, 1991). It is the most influential component on crop yields, followed by the number of filled grains by panicles.
Table 1 shows the behavior of 1000 grains (g) per variety, which was somewhat unstable in the months. Accordingly, Jucarito 104 and IACuba 40 produced the largest volumes (34 and 33 g, in April, May, respectively). On the contrary, Prosequisa 4 had 27.0 g, the poorest value. These results coincided with reports by Suárez (2013), who claimed that 1000 grains in the study ranged between 10 to more than 50 mg/grain. Ismail (1984) had already referred to similar values.

Crop yields (t/ha)

One of the elements that favored yields was the number of panicles/m^2, similar to González (2013).
The results accomplished in the fields can be observed in Table 1, with February, March, and June showing the highest values, for Jucarito 104 (8.2 t/ha-1), IACuba 31 (7.6 t/ha-1), and Prosequisa 4 (same value as the witness). Prosequisa 4 had the best behavior in all the planting seasons, excluding August. In August, (Jucarito 104, 1.2 t/ha-1; Prosequisa 4, 2.6 t/ha-1), and in July and May (IACuba 40, 2.4 t/ha-1, and Jucarito 104, 2.5 t/ha-1), the variables behaved below their potential. These adverse results coincided with reports from several authors (Yoshida, 1981; Lerch et al., 1972; Martínez, 1975; Canet et al., 1982; and Delgado et al., 2011). They found a correlation between yields and the sowing season, when there is an increased trend to diminish daylight due to more cloud formations, having a negative effect on yields. In that sense, Laza et al. (2004) corroborated the following results.

Whole grain percent

The industrial and culinary qualities of rice, is influenced, among other factors, by the genotype of the cultivar, the agricultural and climatic conditions, cultural practices, and post-harvest management. The industrial yields of whole white grains of Cuban varieties, is over 55%. The Cuban varieties have higher industrial yields of whole white grains (González, 2013), so there is a growing interest in quality, production, benefits, and consumption.

The industrial quality, given in whole white grains % was above 50% for all the varieties in January, February, June, and July. In that period (Table 1), IACuba 31 had the best results (66.4 and 66.1%) for the January and February sowing period. Statistical differences were observed, though when compared to the other varieties. Favorable results were also achieved in the June and July sowings in Prosequisa 4 and IACuba 31 (over 60.0%).

These results are better than the ones achieved by Puldón et al. (2002); Technical Rice Guidelines (2008); and Suárez (2009 and 2010), with 57% for IACuba 31; 4; 57% for Prosequisa 4; and 49.0% for Jucarito 104. It may have been influenced by the high temperatures measured during the periods evaluated, according to Morita (2000) and Zakaria et al. (2002), about their negative influence in industrial yields.
Other authors, like González (2013), highlighted that the climatic conditions, especially, high temperatures, break up grain filling, making it brittle, which affects industrial quality. The same author states that in the dry season, the water vapor pressure is lower than in the rainy season, which makes the dried grain re-absorb moisture, and it turns fragile.

Economic feasibility of the sowing scheme per variety, based on the results achieved (CUP)

The cost of a hectare, the price of a ton of Paddy rice (14% humidity), and the yields for each variety were included for this indicator. Table 2 shows the variant with the highest usefulness is Prosequisa 4, in February (19 551.32 t), the same as the control, in June, followed by IACuba 31 ($18 636.61) in March. The cost of the technological package for a rice hectare is $5 400.00 CUP; income in CUP was $24 951.32 for every hectare with Prosequisa 4 and Jucarito 104. The income for IACuba 31 was 23 125.61.

Table 2 Economic feasibility of income per variety (CUP/ha), based on field yields

Varieties	Crop yields	Income	Profits	Cost/kg
Prosequisa 4	8.2	24 951.32	19 55.32	0.28
Jucarito 104 (Control)	8.2			
IACuba-31	7.6	23 125.61	18 635.61	0.29

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Table 3 Economic feasibility of income per variety (CUC/ha), based on industrial yields

Varieties	Whole white grain %	Income	Profits
IACuba-31	66.1	3 128.77	2 912.77
J 104 (Control)	64.0	3 253.76	3 0 7.76
Prosequisa 4	60.0	3 050.40	2 834.40

Income (CUC/ha) was based on the percent of whole white grains, considering the price ($620.00 CUC) of the ton of rice in the world market. Income (CUC) was $3 128.77 for IACuba 31 in the sowing period (February); $3 253.76 for Jucarito 104 (January); and $3 050.40 for Prosequisa 4 (January).

CONCLUSIONS

The highest crop yields were achieved with Jucarito 104 in February, and Prosequisa 4, in June. The best industrial results in terms of whole white grain percent were achieved with IACuba 31, in October and January. The best economic feasibility, regarding field and industrial yields was achieved with Prosequisa 4, Jucarito 104, and IACuba 31.

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