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**Original article**

# Effect of population densities on diseases and the yield of *Oryza sativa* L

## Efecto de densidades de siembra sobre enfermedades y el rendimiento de *Oryza sativa* L

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**ABSTRACT:** Farmers in Cuba sow high doses of seeds to guarantee rice populations and therefore obtain better yields, however, this trend is counterproductive since production becomes more expensive due to seed costs, fertilizers, fungicides, insecticides and they are not always achieved the expected yields due to the inadequate development of plants and the high incidence of pests. Based on this problem, the objective of this work was to evaluate the interaction between four doses of cultivar LP-5 seed and the incidence and severity of fungal diseases on rice yield. For this, plots were made and sown with four doses of seeds (100, 120, 140, 160 kg $ha^{-1}$). A randomized block design with five repetitions was carried out. In each of the variants, the incidence and severity of the main rice diseases were evaluated, and the theoretical yield and its components were also evaluated. Highest incidences and severity of diseases were observed when the highest doses of seeds were applied (160 and 140 kg $ha^{-1}$), regardless of the disease and the evaluation time. It was found that it is not always that high planting densities lead to higher yields. As the seed dose increased, the distribution and incidence of diseases increased, fundamentally affecting the number of filled grains per panicle and the weight of one thousand grains. Highest yields were obtained at doses of 120 and 140 kg $ha^{-1}$.

**Key words:** Pyricularia, Rhizoctonia, incidence.

**RESUMEN:** Los agricultores en Cuba siembran altas dosis de semillas para garantizar poblaciones de arroz y, por ende, obtener mejores rendimientos; sin embargo, esta tendencia resulta contraproducente, ya que se encarece la producción por los costos de semilla, fertilizantes, fungicidas, insecticidas y no siempre se logran los rendimientos esperados, por el inadecuado desarrollo de las plantas y por la alta incidencia de plagas. Sobre la base de esta problemática, el objetivo de este trabajo fue evaluar la interacción entre cuatro dosis de semillas del cultivar de arroz INCA LP-5, así como la incidencia y severidad de enfermedades fúngicas sobre el rendimiento de arroz. Para ello, se realizaron parcelas y se sembraron con cuatro dosis de semillas (100, 120, 140, 160 kg $ha^{-1}$). Se realizó un diseño de bloques al azar con cinco repeticiones. En cada una de las variantes se evaluó la incidencia y la severidad de las principales enfermedades del arroz, además, se evaluó el rendimiento teórico y sus componentes. La mayor incidencia y severidad de las enfermedades se observó cuando se aplicaron las más altas dosis de semillas (160 y 140 kg $ha^{-1}$), independientemente de la enfermedad y del momento de la evaluación. Se comprobó que, no siempre resulta que altas densidades de siembra conllevan a mayores rendimientos. A medida que aumentó la dosis de semillas se incrementó la distribución y la incidencia de las enfermedades, afectando fundamentalmente, el número de granos llenos por panícula y la masa de mil granos. Los mayores rendimientos se obtuvieron a las dosis de 120 y 140 kg $ha^{-1}$.

**Palabras clave:** Pyricularia, Rhizoctonia, incidencia.

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## INTRODUCTION

In Cuba, rice is the staple food in the population's diet, with an average consumption rate of more than 70 kg per person per year. However, domestic production only guarantees 40 percent of this demand, so the country is forced to import more than 400 000 tons of rice annually (1).

One of the basic aspects to be taken into account in rice cultivation is planting density. According to research on adequate stocking densities, to achieve high rice yields, under Cuba's soil and climatic conditions, more than 150 plants per square meter should be planted, which guarantees around 350 to 400 panicles per square meter (2). Based on this premise, it is recommended to sow at the dose of 120 kg $ha^{-1}$; however, the efficiency in the number of plants $m^2$ in most cases is very low. Among the factors that influence this are deficiencies in the seed quality, soil preparation, soil leveling and the effects of pests present in the soil (3).

In spite of the efforts made to improve the agro-technology of the crop, it is not possible to reach the adequate population to obtain high yields. To solve this problem, farmers use increasingly higher doses (150-160 kg $ha^{-1}$), with which high populations are achieved, but production becomes more expensive due to seed costs, fertilizers, fungicides, and insecticides, and the expected yields are not always achieved due to inadequate plant development and the high incidence of pests. In addition, studies have shown that high doses of seed do not always result in high initial plant population (4).

When plant densities are very high, the incidence of numerous pests is favored and even more when the technology of cultivation is in permanent waterlogging. This is due to the fact that the crop quickly covers the surface and the high temperatures and relative humidity provide ideal conditions for the development of numerous fungi. On the other hand, the constant contact between plants favors the rupture of tissues and, as a consequence, the entry of pathogenic fungi.

In view of the few published studies on the relationship between planting density and the incidence and severity of diseases on rice yields, the main objective was to evaluate the interaction between four seed doses of the cultivar INCA LP-5 and the incidence and severity of fungal diseases on rice yields.

## MATERIALS AND METHODS

The experiment was developed at the Scientific and Technological Base Unit "Los Palacios", belonging to the National Institute of Agricultural Sciences (INCA), in an engineering system of flat terraces.

Dry direct seeding technology was used, in the spring season (April 2019) and the 2015 technical standards for rice cultivation were followed, with the exception that no fungicide was applied (5).

The design used was a randomized block design. Plots had an area of 72 $m^2$ and five replicates were sown per treatment, with the following variants of seed dose to be sown: 1- 100 kg $ha^{-1}$, 2- 120 kg $ha^{-1}$, 3- 140 kg $ha^{-1}$, 4- 160 kg $ha^{-1}$

The category of seed used (cultivar INCA LP-5) was basic with 90 % germination.

Disease incidence and severity were evaluated in 1 $m^2$/ replication: Sheath blight (*Rhizoctonia solani* Khun), Rice blight (*Pyricularia grisea* Sacc.), Helminthosporiosis (*Helminthosporium* sp.) and Grain spotting.

### Incidence evaluation

At 100 days after germination (dag), 100 plants were counted diagonally crossed and the number of plants with disease symptoms was evaluated and the percentage of disease incidence was determined (6).

$$P = (a/100)\,N$$

where:

P- Percentage of incidence

a- Number of diseased plants

N- Total number of plants evaluated

A bifactorial analysis was carried out where the factors were seed dose and diseases, with four levels each, and the means were determined using Duncan's multiple range test with a significance level of 0.05.

### Severity assessment

Disease symptoms were evaluated on plants at 60, 80 and 100 days after seed germination (dag). The evaluation scales used for each disease were those cited in the IRRI Standard Evaluation System (7) and severity was determined through the formula (8):

$$S = \left[\sum (a.b)/NK\right] 100$$

where:

S- Severity

∑ (a.b)- Sum of the products of the number of organs or plants with symptoms (a) by their corresponding scale grade (b).

N- Total number of plants observed

K- Highest grade of the scale

With the data from the evaluated treatments, a simple analysis of variance was performed for each disease. Means were determined using Duncan's multiple range test, with a significance level of 0.05. The statistical package used was Statgraphycs, version 5.1 (7).

### Yield variables

At 110 dag, the number of panicles in 1 $m^2$ , number of filled grains per panicle and the weight of 1000 filled grains were evaluated in each plot and for each seed dose (treatments), taking into account the 1 m edge effect. In addition, the agricultural yield was calculated, for which plants were threshed and grains were dried to 14 % humidity. A simple analysis of variance was performed for each variable (yield and its components).

Means were determined using Duncan's multiple range test at a significance level of 0.05.

## RESULTS AND DISCUSSION

Planting high populations of plants, with the purpose of obtaining optimal populations to reach high rice yields, turns out to be an unwise practice, because in most cases the populations reached are very high, which generally favor the development of very thin and weak plants, with little tillering, susceptible to overturning and to the attack of numerous diseases (4).

As can be seen in Table 1, the percentage of incidence 60 days after rice germination was higher for the fungus *P. grisea* at the 160 and 140 kg ha$^{-1}$ doses, followed by *R. solani* at the 160 kg ha$^{-1}$ dose. This is in agreement with the literature, where it is suggested that similar affectations by these diseases are caused in the phenophase in which the crop was found (active tillering) (2,5); however, in the following evaluations, the incidence of these diseases was more homogeneous.

The highest disease incidences were observed when the highest seed rates (160 and 140 kg ha$^{-1}$) were applied, regardless of the disease and the time of evaluation. This is due to the fact that, as seed doses increased, the number of plants per area increased and the crop quickly covered the field, and under conditions of waterlogging and high temperatures, practically the water vapor contained under the leaves, facilitated a humid climate very favorable for fungal development. In this sense, it is suggested that the upward trends in temperatures and relative humidity influence the development of pathogenesis cycles and disease epidemics, especially those caused by soil pathogens (9). In addition, the experiment was carried out on flat terraces, where soil porosity is very low and below the surface there are iron concretions that facilitate water retention in the soil, an important aspect that emhances the development of fungi (10).

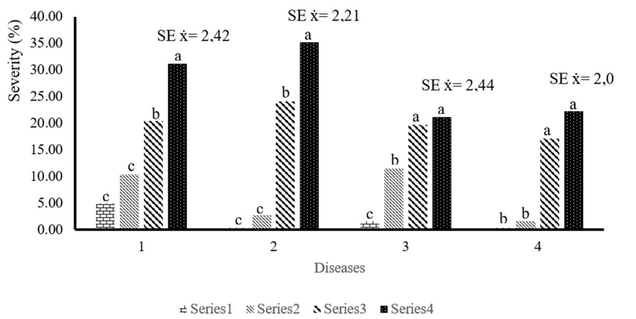


**Figure 1.** Evaluation of fungal severity with different seed doses 100 days after rice germination

On the other hand, high populations facilitate the mobility and refuge of vectors transmitting fungal spores (mites, bugs, weevils, etc.) and allow the appearance of wounds on the plants.

Similar to what occurred with incidence, the highest disease severities were observed as seed doses increased and more markedly when evaluating the severity of *P. grisea* and *R. solani* fungi at the 160 kg ha$^{-1}$ dose (Figure 1).

The greater the severity of the diseases, the more the plant tissues are affected and their photosynthetic capacity decreases, affecting the production of photosynthates necessary for development and, therefore, cereal yields (2). In this sense, when it was analyzed yield and its components, it was found that high planting densities do not always lead to higher yields (Table 2).

As we can observe, the highest yields were obtained when seed doses of 120 and 140 kg ha$^{-1}$ were applied. Similar results were obtained by other authors when evaluating the yield of other rice cultivars at these seed doses (11,12). When analyzing the yield components, as

**Table 1.** Percentage incidence of diseases evaluated at 60, 80 and 100 days after rice germination (dag)

| Disease | Dose (kg ha$^{-1}$) | 60 dag | 80 dag | 100 dag |
|---|---|---|---|---|
| *P. grisea* | 100 | 4.68 ef | 7.52 ef | 22.30 e |
| | 120 | 14.46 cd | 19.58 cd | 49.68 d |
| | 140 | 30.29 b | 46.32 b | 92.82 c |
| | 160 | 64.52 a | 99.21 a | 130.28 b |
| *R. solani* | 100 | 0.4 f | 0.40 f | 0.40 f |
| | 120 | 6.22 def | 13.39 de | 14.56 ef |
| | 140 | 11.18 cde | 27.82 c | 79.24 c |
| | 160 | 15.92 c | 40.14 b | 84.16 c |
| *Helminthosporium* sp. | 100 | 0 f | 1.548 f | 5.84 ef |
| | 120 | 0.56 f | 7.914 ef | 10.81 ef |
| | 140 | 0 f | 49.08 b | 75.11 c |
| | 160 | 2.29 ef | 103.1 a | 245.48 a |
| Grain spotting | 100 | 0 f | 0 f | 4.74 ef |
| | 120 | 0 f | 0 f | 18.08 |
| | 140 | 0 f | 0 f | 51.52 d |
| | 160 | 0 f | 0 f | 120.76 b |
| *SE ẋ* | | 2.907 | 3.729 | 6.398 |

Equal letters do not differ statistically

**Tabla 2.** Agricultural yield (t ha$^{-1}$) and its components for the rice cultivar INCA LP-5, with different seed doses

| Dose (kg ha$^{-1}$) | No panicles/m$^2$ | Weight of 1000 grains (g) | No grains/panicle | Yield (t ha$^{-1}$) |
|---|---|---|---|---|
| 100 | 373.16 c | 29.57 a | 79 a | 5.22 c |
| 120 | 479.06 b | 29.58 a | 75 b | 6.38 ab |
| 140 | 491.8 ab | 29.18 b | 73 b | 6.48 a |
| 160 | 513.8 a | 29.16 b | 65 c | 5.84 b |
| *SE* $\dot{x}$ | 7.209 | 0.065 | 2.293 | 7.209 |

the seed dose increased, the number of fertile panicles per square meter increased; however, the weight of 1000 grains and the number of filled grains per panicle decreased (13). Although these last yield components are the most stable (5), their decrease could be due to disease damage and lower light and nutrient availability due to high population densities (14-16).

## CONCLUSIONS

- The higher the seed dose, the higher the incidence and severity of diseases, mainly affecting the number of full grains per panicle and the thousand-grain weight.
- The highest yields were obtained at 120 and 140 kg per hectare.

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