ORIGINAL ARTICLE

# Effect of Water Stress on the Ratoon Crop (*Oryza sativa* L.). First Part

## Efecto del estrés hídrico en el cultivo de rebrote (*Oryza sativa* L.). Primera parte

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**ABSTRACT:** The research was conducted at "Los Palacios" Base Scientific and Technological Unit, from 2014 to 2017, on a Gleysol Nodular Ferruginous Petroferric soil, to know the effect of water stress on the ratoon crop in the medium cycle variety J-104. The results showed that the new variant of water managing (water stress with ratoon) significantly outperformed the control production variant. It produced the highest agricultural and industrial yields of the grain. They ranged between 4.7 and 5.8 t. ha-1 and 63.3 and 67.3% whole grains respectively for a height of cut of the plant of 5 cm. The lowest agricultural and industrial yields ranged between 3.1 and 4.4 t.ha-1 and 60.0 and 67.8% of whole grains respectively for the control variant with a height of cut of the plant 20 cm. Water consumption was always lower in the new variant than in the control variant during the years of study. This indicator is very important as a concept of irrigation water economy, a decisive resource for rice production. The industrial quality of the grain was always higher in the variant with water stress in the ratoon crop compared to the control variant; parameters that decide if a rice variety is accepted commercially.

***Keywords:*** rice, water, whole grains, panicles, industrial quality.

**RESUMEN:** La investigación se condujo en la Unidad Científico Tecnológica de Base "Los Palacios", desde el año 2014 hasta el 2017, sobre un suelo Gleysol Nodular Ferruginoso Petroférrico, para conocer el efecto del estrés hídrico en el cultivo de rebrote en la variedad de ciclo medio J-104. Los resultados arrojaron que la nueva variante de manejar el agua (estrés hídrico con rebrote) superó de manera significativa a la variante testigo de producción, obteniendo los mayores rendimientos agrícolas e industrial del grano, que oscilaron entre 4,7 y 5,8 $t.ha^{-1}$ y un 63,3 y 67,3 % de granos enteros respectivamente para una altura de corte de la planta de 5 cm; mientras que, los rendimientos agrícolas e industrial más bajos oscilaron entre 3,1 y 4,4 $t.ha^{-1}$ y un 60,0 y 67,8 % de granos enteros respectivamente para la variante testigo con una altura de corte de la planta de 20 cm. El consumo de agua siempre fue menor en la nueva variante que en la variante testigo durante los años de estudio, siendo este indicador muy importante por concepto de economía del agua de riego, recurso decisivo para la producción de arroz. La calidad industrial del grano siempre fue superior en la variante con estrés hídrico en el cultivo de rebrote respecto a la variante testigo; parámetros estos que deciden si una variedad de arroz sea aceptada comercialmente.

***Palabras clave:*** arroz, agua, granos enteros, panículas, calidad industrial.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop for human consumption; it constitutes the basic food for more than half of the world population (Ruiz *et al.*, 2012). In Cuba, rice is the main food after beans (MINAG, 2014), and by tradition and eating habits, the country is among the consuming rice nations with 72 kg per capita annually.

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One of the most important inputs for any crop and especially rice, without a doubt is water (PNUD, 2016). The last decade has shown dramatic decreases in the volume of water in reservoirs due to prolonged and frequent droughts influenced by climate change, affecting in this way the production of crops and especially rice, which demands a significant volume of the precious liquid. In a not too distant future, if low volumes of rainfall continue, it will be necessary to resort to the proper and careful use of seawater, as an alternative to mitigate the lack of water for rice production.

An important way to increase the production of rice in the country in a sustainable way and to save water is by using rice crop of regrowth, also known as soca or ratoon, with which acceptable yields are reached and it is a viably economic activity.

The consulted literature reports that with the use of the regrowth crop (second crop) it can be reached a yield between 70-75% from the previous harvest (Galavko, 2002). However, in Cuba, investigations conducted under both, research and production, according to Polón *et al.* (2012), reported a yield, in the shoot (second harvest), superior to the control with medium cycle varieties, exceeding this one by 1 t.ha $^{-1}$ . They also refer a reduction of the shoot cycle in a time range between 60 to 65 days, allowing a lower consumption of irrigation water in this cultivation system of up to 40 %. The use of regrowth crop in the cooperative sector of production, generates agricultural yields between 2,5 and 4,27 t. ha $^{-1}$ with excellent industrial grain quality, crystal clear beads and no white belly in the grain. In addition, the total production of several cultivars such as INCA LP-5, INCA LP-7 and J-104 are higher than 10 t. ha $^{-1}$, enabling to recommend using them in production for this purpose (Castro *et al.*, 2014).

The realization of water stress to rice cultivation sometimes improves the yield depending on the stage and the intensity of the stress, reaching the best results in the vegetative phase, unlike when it is applied in the reproductive phase of the crop, where the quality of the grain is affected (Verma *et al.*, 2014).

The objective of the present work was to evaluate the effect of water stress on the yield in the regrowth crop in a variety of medium cycle rice (J-104).

## METHODS

The research was conducted during four years, from 2014 to 2017 at UCTB Los Palacios, on a Gleysol Nodular Ferruginous Petroferric soil (Hernández *et al.*, 2015).

Treatments:

$T_1$. Regrowth with water stress to the crop in seedling phase, 10 days after the start of the regrowth with 15 days of stress duration.

$T_2$. Regrowth without water stress to the crop in the seedling phase (production control)

For the development of the experiment, the commercial variety of medium cycle J-104 was used. The sowing density used was 120 kg. ha$^{-1}$ (MINAG, 2014). Two cutting heights were made for the regrowth of 5 cm and 20 cm from the soil surface.

Evaluations and Measurements Made:

- Agricultural yield (t. ha $^{-1}$ to 14% grain moisture).
- Industrial performance (% of whole grains).
- Panicles per square meter.
- Water consumption (m $^{3}$, ha $^{-1}$).
- Water productivity (kg. m$^{-3}$)

$$WP = \frac{Grain\ \ yiel(\ kg.\ \ ha^{-1})}{water\ \ expenditure(m^3.ha^{-1})}$$

Where:

WP - water productivity

Water consumption was estimated from the delivery to each plot (20 L·s$^{-1}$) according to the construction project of the irrigation system of the Scientific Technological Unit "Los Palacios", Pinar del Rio. For the industrial yield of the grain, a sample of 1 kg of seed was taken, to determine the percentage of whole grains. An experimental design of blocks at random was used, with two treatments, one with water stress and one without stress, which was maintained with a water sheet (10 cm) throughout its cycle, according to MINAG (2014). Water stress was applied in the vegetative phase with wilting of the leaves, and the soil totally cracked.

The data obtained were subjected to a simple variance analysis, when significant differences were found between the means, compared according to the Duncan Multiple Range Test, for the level of significance $p \leq 0.05$.

## RESULTS AND DISCUSSION

Many factors affect the performance of rice and its industrial quality, among them, the moment in which it is harvested and the management of irrigation prior to it that generate decreasing in the percentages of whole grains, the amount of panicles per square meter and in agricultural performance itself (Thompson y Mutters, 2006; de Ávila *et al.*, 2015). However, in this work, when irrigation was handled in a different way to the traditional (permanent watering), that is, causing a water stress condition by default, the agricultural and industrial yield of the grain was favored (% of whole grains), panicles per square meter and a significant decrease in water consumption for the years of study.

When the water deficit was applied (by default) to the crop in the vegetative phase with wilting of the leaves and total crack of the soil, for the dry period during the four years of research, the variant of water deficit (regrowth with water stress), significantly outperformed the control (permanent water, without water stress). (Tables 1,2,3 and 4).

As shown in Table 1, the agricultural yield reached higher values in the regrowth with water stress respect to the regrowth without water stress (control), in yields ranging between 5,8 t. ha $^{-1}$ and 4,7 t. ha $^{-1}$, compared to values of 5,2 and 4,0 t. ha $^{-1}$ (regrowth without water stress). On the other hand, the highest values of yields correspond to the variant where the cut was made at a height of 5 cm from the surface of the soil. The lowest yield reached was 3,1 t. ha $^{-1}$ in the control variant and for a height cut of the ratoon of 20 cm. This result coincides with that reported by Polón *et al.* (2012) when practicing equal cutting heights to the regrowth crop, which seems to indicate that, when the cut of the regrowth is lower, there is a favorable response in the crop in terms of its agricultural yield.

Similar behavior, presented industrial grain yield (% of whole grains) as seen in Table 2. Values of 67,3% to 63,3% of whole grains in water stress treatment were reached, while the control was of 66,1% to 62,5% of whole grains, both for a cut height of 5 cm. These values demonstrate once again, the benefit of applying water stress on increasing agricultural output without affecting the industrial quality of grain, as reported by several investigators (Polón *et al.*, 1995, 2012; Polón and Castro, 1999; Ruiz *et al.*, 2012; Castro *et al.*, 2014; Bergson *et al.*, 2015).

In a situation where the water resource becomes increasingly limiting both by quantity and by competition from other areas, it is increasingly important to associate the levels of productivity obtained with the water consumptions required.

With an irrigation management and using the regrowth culture with water stress, there is evidence of high efficiency in the use of water and high productivity of irrigation water (Table 3). The productivity values of the water oscillate

**TABLE 1.** Agricultural yields in the dry season during the years 2014 -2017

| Treatment | Agricultural yield (t.ha $^{-1}$ at 14% humidity) | | | |
|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** |
| | Cutting height 5 cm | | | |
| Regrowth with water stress | 4,7 a | 5,7 a | 5,5 a | 5,8 a |
| Regrowth without water stress (control) | 4,0 b | 4,6 b | 5,4 b | 5,2 b |
| *ESx* | *0,01* | *0,011* | *0,012* | *0,013* |
| | Cutting height 20 cm | | | |
| Regrowth with water stress | 3,5 a | 4,0 a | 4,0 a | 4,4 a |
| Regrowth without water stress (control) | 3,1 b | 3,6 b | 3,8 b | 4,3 b |
| *ESx* | *0,09* | *0,01* | *0,011* | *0,012* |

Stocks with letters in common do not differ significantly according to Duncan's 5% test.

generally between 1,41 kg. m $^{-3}$ and 0,73 kg.m $^{-3}$, high values since the regrowth crop has a shorter cycle (70 days) and they differ much more than the reported by González *et al.* (2010) in Cuba of 0,31 kg.m $^{-3}$ for long cycles (135 days). These values of water productivity in turn are located in the ranges of values reported by different authors (DIEA, 2014; de Avila *et al.*, 2015; Ruiz. *et al.*, 2016; Riccetto *et al.*, 2017).

Similarly, the application of water stress to the regrowth crop showed a more efficient use of water, with average consumption values of 4300 m $^{3}$. ha $^{-1}$ in regrowth with stress, and 5800 m$^{3}$. ha $^{-1}$ in the treatment regrowth without water stress (control), during the four years of research, with a water saving of 1400 m $^{3}$. ha $^{-1}$. These results coincide with what was reported by the researchers Polón *et al.* (2012) and Castro *et al.* (2014). Benefits are achieved when water stress is applied in the vegetative phase of the crop, with the use of regrowth and with a cutting height of 5 cm from the surface of the soil, since there is always greater water ecomy, because there is a longer period without irrigation.

The behavior of the panicles per square meter (Table 4) was similar to the rest of the variables previously explained. It is observed that the values were always higher in the variant of water stress with regrowth at a height of 5 cm from the

**TABLE 2.** Industrial yields in the dry season during the years 2014 -2017

| | Industrial yield (% of whole grains) | | | |
|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** |
| | Cutting height 5 cm | | | |
| Regrowth with water stress | 67,3 a | 66,9 a | 64,6 a | 63,3 a |
| Regrowth without water stress (control) | 66,1 b | 65,0 b | 63,4 b | 62,5 b |
| *ESx* | *2,13* | *2,17* | *1,85* | *1,95* |
| | Cutting height 20 cm | | | |
| Regrowth with water stress | 66,0 a | 64,3 a | 63,2 a | 60,0 a |
| Regrowth without water stress (control) | 65,0 b | 64,3 b | 62,1 b | 60,8 b |
| *ESx* | *2,1* | *2,15* | *2,14* | *2,1* |

Stocks with letters in common do not differ significantly according to Duncan's 5% test.

**TABLE 3.** Consumption water and productivity of irrigation water in the dry season, during the years 2014-2017

| Treatment | 2014 | | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|---|---|
| | **WC ($m^3.ha^{-1}$)** | **WP ($kg.m^{-3}$)** | **WC ($m^3.ha^{-1}$)** | **WP ($kg.m^{-3}$)** | **WC ($m^3.ha^{-1}$)** | **WP ($kg.m^{-3}$)** | **WC ($m^3.ha^{-1}$)** | **WP ($kg.m^{-3}$)** |
| Regrowth with water stress | 4 200 | 1,41 | 4 700 | 1,21 | 4 100 | 1,34 | 4 200 | 1,38 |
| Regrowth without water stress (control) | 5 400 | 0,74 | 6 300 | 0,73 | 5 800 | 0,93 | 6 000 | 0,87 |

Legend: Water consumption (WC); Irrigation water productivity (WP)

**Table 4.** Panicles .m $^{-2}$ in the dry season, during the years 2014-2017

| Treatment | Panicles.m $^{-2}$ | | | |
|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** |
| | Cutting height 5 cm | | | |
| Regrowth with water stress | 240 a | 2 50 a | 370 a | 380 a |
| Regrowth without water stress (control) | 210 b | 220 b | 285 b | 289 b |
| *ESx* | *2,13* | *2,17* | *1,85* | *1,95* |
| | Cutting height 20 cm | | | |
| Regrowth with water stress | 228 a | 235 a | 296 a | 300 a |
| Regrowth without water stress (control) | 189 b | 190 b | 222 b | 230 b |
| *ESx* | *2,1* | *2,15* | *2,14* | *2,1* |

Stocks with letters in common do not differ significantly according to Duncan's 5% test.

surface of the soil, with respect to the control treatment and with the cut of the regrowth at a height higher than 20 cm. That coincides with that reported by several authors (Polón *et al.*, 1995; Polón and Castro, 1999).

## CONCLUSIONS

It can be concluded that:

- By subjecting the rice crop with regrowth to a water deficit in the vegetative phase in the medium cycle variety J-104, the agricultural yield is increased by approximately 0,5 t. ha-1 and the industrial yield of the grain with values of up to 67,3 % of whole grains, provided that the cutting height of the regrowth is 5 cm.
- A lower water consumption is achieved in favor of regrowth treatment with water stress, with a resource saving of approximately 1 400 m3. ha-1, which leads to a high productivity of irrigation water.


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