# Water productivity, Irrigation management and Systematization for Rice Farming Systems in Uruguay

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## 1 Introduction

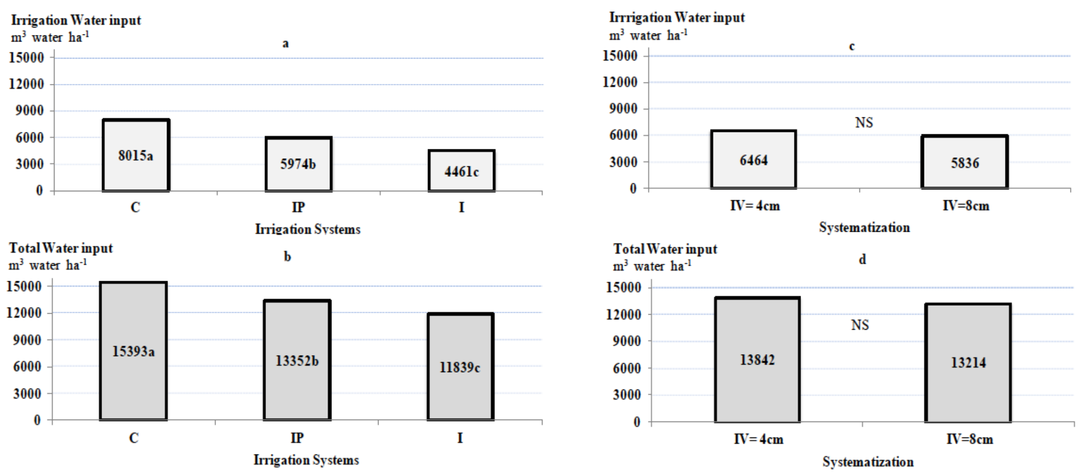
A high proportion of water inputs for rice crop irrigation in the Central Region of Uruguay comes from rainfall water stored in dams. Maximizing water productivity is important as savings in water inputs would reduce the costs of pumping irrigation, increase annually sown rice area, allows to allocate water to irrigate other crops in a rotation and contribute to reduce the impact of farming systems on Water Footprint (Chapagain & Hoekstra, 2011) and to reduce environmental impact based upon Life Cycle Assessment, energy and water analyses (Thanawong *et al.*, 2014). The aim of this experiment is to determine irrigation management practices and systematization field layout techniques that increase water productivity (WP), contemplating the economic and environmental sustainability of rice farming systems in Uruguay.

## 2 Materials and Methods

A split plot experimental design trial was conducted in the Experimental Unit located in Tacuarembó (32.18S, 55.17W). Treatments included two types of systematization with different vertical interval between levees (big plots)l: I. Conventional (VI-8cm) and II. Alternative (VI-4cm) and three irrigation management practices (small plots): 1.Continuous (C), 2.Intermittent until panicle initiation (IP), and 3.Intermittent during all crop cycle (I). In C a water layer of 10cm is maintained after flooding throughout all the crop cycle. In IP and I the water layer alternates between 10 and 0cm and is re-established when the soil is still saturated. Irrigation started 30 days after emergence and finished 20 days before harvest date. Crop was direct drilled on 1th, 16th and 19th October with 160 kg seed/ha with cultivar INIA Olimar (Indica type). Basal fertilization was 160Kg / ha of 19-19-19 (N-P-K) and Urea was 100 kg / ha fractionated at tillering and panicle initiation. The results of the joint analysis of the previous three seasons (2012-2013-2014) were evaluated by analysis of variance and mean separation test of Fisher 5% using statistical package InfoStat (www.infostat.com.ar).

## 3 Results – Discussion

Intermittent irrigation systems led to significant water inputs savings in relation to continuous irrigation C, 2041 and 3554 m3 water ha$^{-1}$ less for IP and I respectively (Fig. 1 a,b) ($P<0.05$). The systematization did not determine significant differences in water input (Fig. 1 c,d) ($P<0.05$).




Means followed by different letters are significantly different at P < 0.05. NS: non-significant differences . LSD ( least-square difference ) for Irrigation Systems = 460 and LSD for Systematization=1284.

**Fig. 1.** Irrigation Water Input and Total Water Input (Irrigation plus Rainfall) for different irrigation systems and systematization (field layout techniques), Tacuarembó, Uruguay, (average seasons 2011-12, 2012-13 and 2013-14).

The highest WPi (irrigation) and WPt (irrigation plus rainfall) were recorded in treatment I, being 2.0 and 0.88 kg grain $m^3$ water$^{-1}$ respectively. These values are higher than the data reported worldwide where WPt of rice in Asia ranges from 0.2 to 1.2 kg grain $m^3$ water$^{-1}$, with 0.4 as the average value (Tuong *et al.*, 2005).
There were no differences in rice grain yield between irrigation treatments ($P< 0.05$) (Table 1). Similar results in the same region and comparable type of soils were registered by Lavecchia *et al.*, 2011. This results are explained because the soils on which the experiments were performed (planosols) have a low infiltration rate and rainfall was above the historical average throughout the crop cycle, 738 mm (from October to March). In analogous experiments conducted on soils with a higher infiltration rate in a different region (North), the intermittent irrigation determined a rice yield loss of 950 kg in relation to continuous flooding (Carracelas *et al.*, 2014).

**Table 1.** Rice Yield, Grain Quality and Water Productivity compared with three irrigation systems and two types of systematization, Tacuarembó, Uruguay (average seasons 2011-12, 2012-13 and 2013-14).

| Site= Central Región, Tacuarembó. | Rice Yield (kg ha$^{-1}$) | Industrial Quality | | Water Productivity (WP) kg grain $m^3$ water $^{-1}$ | |
|---|---|---|---|---|---|
| | | White Grain % | Whole Grain % | WPi-Irrigation | WPt - Irrigation + Rainfall |
| **Irrigation Systems** | | | | | |
| 1.Continuous (C) | 7850 | 69.22 | 62.73 a | 0.99 c | 0.52 c |
| 2. Intermittent until panicle initiation (IP) | 7446 | 69.17 | 62.17 ab | 1.31 b | 0.57 b |
| 3. Intermittent during all crop cycle (I) | 7843 | 69.08 | 61.94 b | 2.00 a | 0.68 a |
| LSD ($P<0.05$) | *NS* | *NS* | *0.63* | *0.17* | *0.04* |
| **Systematization** | | | | | |
| I. Conventional - VI=8cm | 7735 | 69.2 | 62.61 | 1.57 | 0.60 |
| II. Alternative - VI= 4cm | 7691 | 69.1 | 61.95 | 1.30 | 0.57 |
| LSD ($P<0.05$) | *NS* | *NS* | *NS* | *NS* | *NS* |
| CV % | *12.12* | *0.71* | *1.95* | *22.44* | *12.16* |

Means followed by different letters are significantly different with a probability less than 5% ( $P < 0.05$ ). LSD : least-square difference. NS: non-significant differences. CV: coefficient of variation.

In relation to Industrial quality, continuous irrigation C determined a higher percentage of whole grain in comparison with intermittent irrigation I and no differences in quality with IP treatment ($P<0.05$) (Table 1).

## 4 Conclusions

The intermittent irrigation in low-infiltration rate soils, allowed for significant savings in water input of 35% on average without reducing rice grain yield relative to continuous irrigation, thus determining a significant increase in water productivity ($P <0.05$).
In relation to industrial quality, intermittent irrigation (I) determined a lower percentage of whole grain in relation to continuous irrigation C but with no differences in white grain percentage ($P <0.05$).
There were no significant differences in water input, grain yield, industrial quality and water productivity between the different systematizations-field layouts treatments ($P <0.05$).
Implementing crop irrigation systems involving savings in water input means a greater risk and would only be adopted by farmers on a larger scale if they determine more or equal rice yield per hectare without affecting the grain quality.

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