Yield potential and Yield gaps of irrigated rice in Uruguay and other rice producing countries

G. Carracelas [1], N. Guilpart[2], K. Cassman[3], P. Grassini[3] and G. Zorrilla[4]

[1]National Institute for Agricultural Research (INIA), Road 5, km 386, Tacuarembó, Uruguay.
gcarracelas@inia.org.uy
[2]AgroParisTech - UMR 211, 78850 Thiverval-Grignon, France
[3] University of Nebraska-Lincoln. P.O. Box 830915, Lincoln, NE 68583-0915, USA
[4] National Institute for Agricultural Research (INIA), Road 8, km 281, Treinta y Tres, Uruguay.

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Introduction

The Uruguayan rice sector has become one of the most successful and most integrated agricultural industries in the country. Rice yields in Uruguay have increased at one of the highest rates worldwide (147kg^{-1} ha^{-1} yr^{-1} from 2000 to 2016), although these trends exhibited a marked slowdown in recent years (DIEA, 2016) . The aim of this work is to estimate rice yield potential (Yp) and current exploitable yield gaps (Yg) at regional and local-farm levels in Uruguay and conduct comparative analysis with other rice countries included in the global yield gap atlas - GYGA.

Methods

Methodology developed by GYGA (www.yieldgap.org) was followed to select data sources, define the agro-climatic zones, simulate rice yield potential (Yp) and estimate exploitable yield gap (Yg) at reference weather stations (RWS) within Uruguay (Van Wart et al., 2013a, 2013b; Van Bussel et al., 2015; Grassini et al., 2015). Data on current farm yields (Ya) were collected from the Uruguayan rice Industry database. The crop simulation model Oryza(v3) was used to simulate Yp (Bouman et al., 2001). Two independent datasets were used for model calibration and validation. Comparison of simulated flowering and maturity dates against measured collected data from experiments indicated good agreement between simulated and observed values (r^2=0.72). All simulated dates were falling within ± 10 days of the observed dates, giving confidence in model performance for rice in Uruguay. Yg was determined as the difference between 80% of Yp and average Ya over five years weighted by the cultivated rice area (2010-2014) (Cassman et al, 2003; Lobell et al, 2009).

Results and Discussion

Yield Potential, actual yields and the exploitable gap recorded for each reference weather station (RWS) and rice regions are presented in Table 1. Average estimated rice Yp in Uruguay for a period of 18 years weighed by area in seven weather stations was 14 t ha^{-1}. Given an average Ya of 8 t ha^{-1}, current exploitable Yg is 3 t ha^{-1}.

Exploitable Yield Gap was higher in the Central-East Coast (Tacuarembó, Paso de los Toros and Rocha), hence, there is an opportunity to target those areas to facilitate technological transfer and increase productivity.

Table 1. Exploitable Yield gap (Yg) , Actual Yield and Yield Potential (Yp**)** by reference weather stations (RWS) in Uruguay.

Reference Weather Station (RWS)	Region	Rice Yield (ton ha $^{-1}$)					
		Exploitable Yield Gap (Yg)		Actual (Ya)		Potential (Yp)	
Bella Union (Bu)	North	1,9	c	8,5	a	13,0	d
Salto Grande (S)	North	2,0	c	8,5	a	13,1	cd
Artigas (A)	North	2,9	b	8,4	a	14,1	ab
Treinta y Tres (Tt)	East	2,8	b	8,2	a	13,7	bc
Rocha (R)	East	4,0	a	7,7	a	14,7	a
Tacuarembó (Ta)	Center	3,6	a	8,0	a	14,5	a
Paso de los Toros (P)	Center	3,7	a	7,8	a	14,4	ab
Media		**3**		**8**		**14**	
LSD (P<0,05)		*0,56*		*0,70*		*NS*	
CV (%)		*28,5*		*7,6*		*9,7*	

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

Relative yield (%) for Uruguay and countries with rice included in the World Atlas (GYGA) is presented in Figure 1.

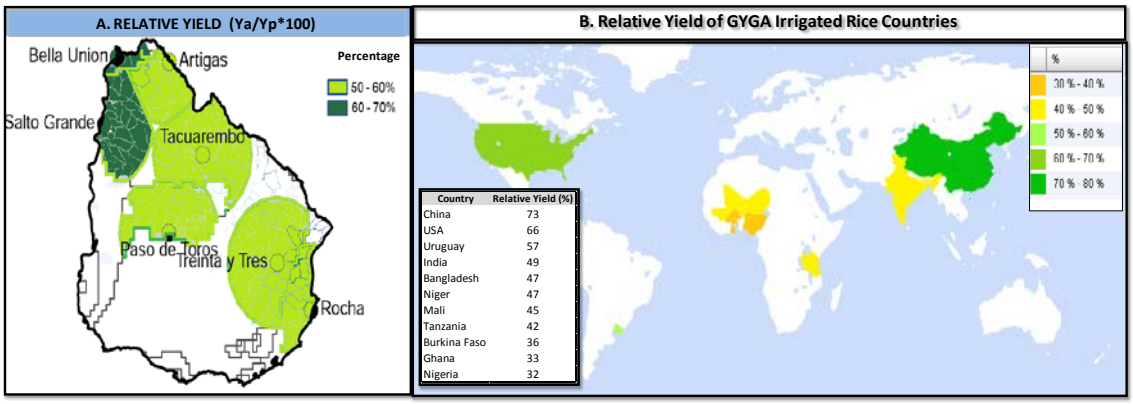

Figure 1. A. Relative yield production (%) for Uruguay by RWS. B. Comparison of relative rice yield (Ya/Yp*100) for countries included in the Global Yield Gap Atlas. Source: www.yieldgap.org

Because current Ya is only 57% of Yp, it should be possible to continue improving rice yields and close much of the existing Yg in Uruguay. Average farm yields often begin to plateau when they reach 75 to 85% of the yield potential (Cassman et al., 2003; Lobell et al., 2009).

Average relative yield production for most countries included in the world atlas is below 60% , with lower values in African countries followed by India in relation to countries of North, South America and East Asia (Figure 1B).Therefore It would be possible to maintain or increase yields within existing rice production areas, which will contribute to meet the growing demand for rice worldwide. Rice producers from developing countries could consider the yield gains achieved in Uruguay as feasible targets and take advantage of Uruguayan experience on farming systems and rice chain integration that allowed to achieve a very high rate of yield increase over the past years.

Conclusions

Estimated national average yield potential in Uruguay is 14 t ha^{-1} with a range of 13.0-14.7 t ha^{-1} cross rice-growing regions. Actual average yield was 8 t ha^{-1} ranging from 7.7-8.5 t ha^{-1}, which determined a national exploitable yield gap of 3 t ha^{-1} (from 1.9-4.1 t ha^{-1}).

Current yield levels represent only 57% of estimated yield potential Yp, indicating that it would be possible to further increase actual yields while reducing exploitable yield gaps in Uruguay. Achieving maximum yields in the existing rice production areas without compromising the environment, would improve the economic performance and sustainability of rice farming in Uruguay while increasing cereal production for world trade. An additional 0.5 Mt of rice production would be possible if average farm yields reached 80% of Yp.

Average relative yield production for most countries included in the world atlas suggests it is still possible to increase rice yields within current rice planted areas in order to contribute to meet the growing demand for food worldwide.

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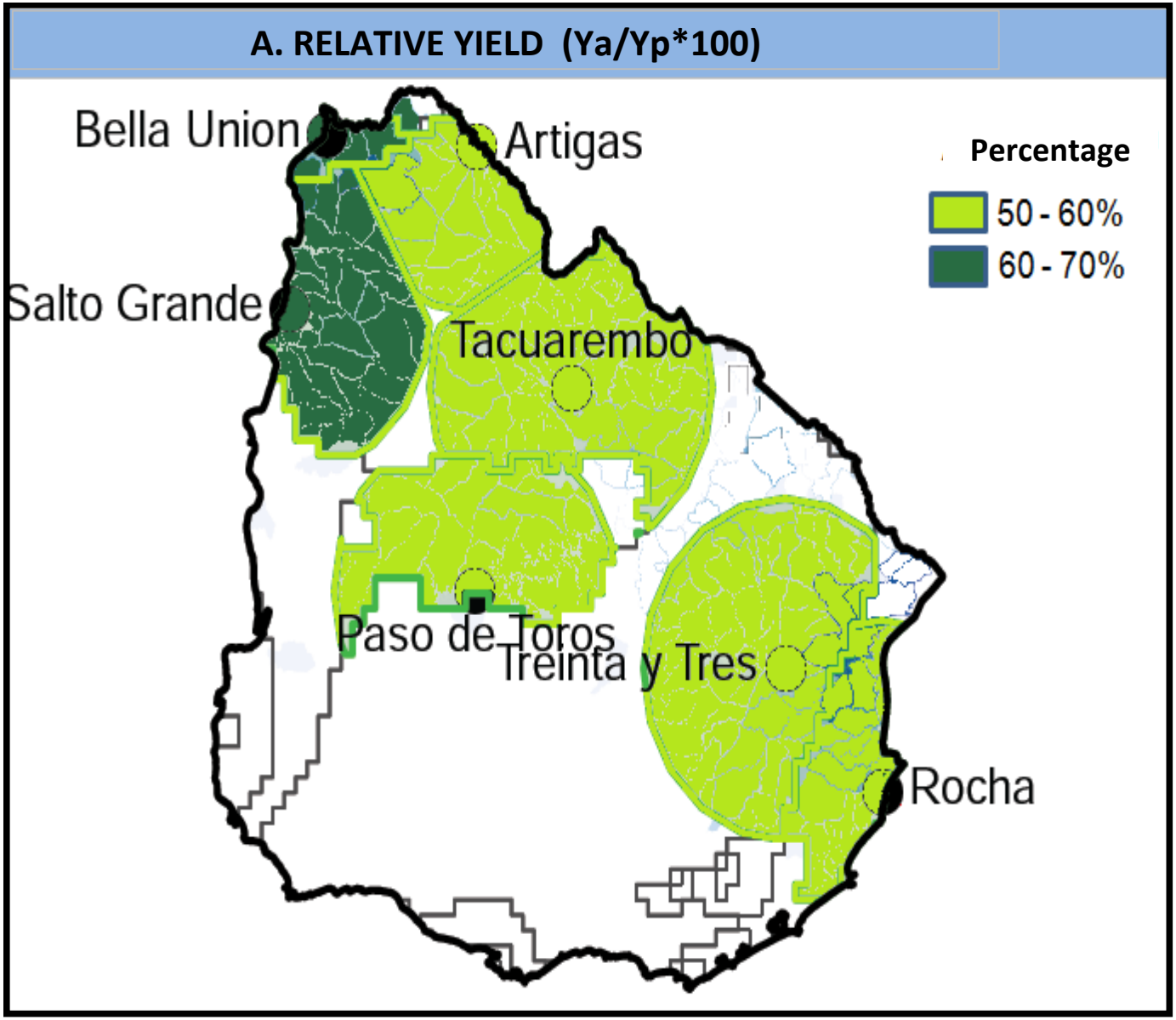
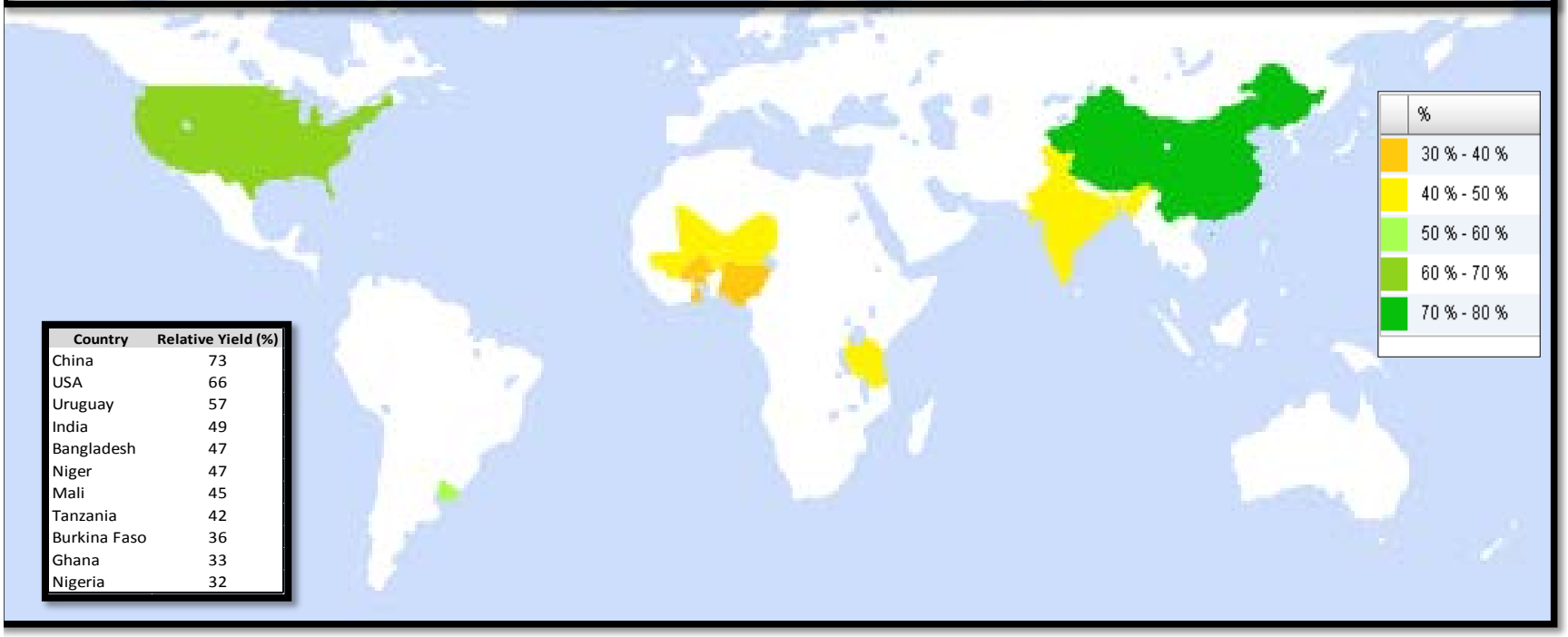

A. RELATIVE YIELD (Ya/Yp*100)
Bella Union
Artigas
Salto Grande
Tacuarembo
Paso de Toros
Treinta y Tres
Rocha
Percentage
50 - 60%
60 - 70%

B. Relative Yield of GYGA Irrigated Rice Countries



Country	Relative Yield (%)
China	73
USA	66
Uruguay	57
India	49
Bangladesh	47
Niger	47
Mali	45
Tanzania	42
Burkina Faso	36
Ghana	33
Nigeria	32

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