Limiting Factors for Rice Yield in Argentina

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INTRODUCTION

In Argentina around 200,000 hectares of rice are sowed annually in direct seeding on dry soil and irrigated system, with high mechanization in temperate climate. The average yield of pady rice in Argentina has remained stagnant for the past ten years at 6.6 tn/ha, while countries with similar technology as Uruguay, Southern Brazil and USA continue to progress annually.

What happens in Argentine? What is the potential yield? There is a sufficient gap to increase productivity of rice? What are the main limiting factors of crop productivity?

The aim of this study was to evaluate and characterize the production system of farmers, calculate the rice potential yield for the region and identify the main factors that limit or reduce the yield.

MATERIALS AND METHODS

During the years 2004-2015 more than 200 observations were made at different sites representative of normal production conditions of farmers. Before planting, soil samples at each site for complete chemical analysis were taken and made by traditional methods. Crop management variables were recorded. In the crops: number of plants, number of stems, dates stages (emergency, panicle differentiation, flowering and maturity), presence and severity of insects, weeds and diseases, was quantified. At crop maturity, 5 samples of 1 m^2 of whole plants were taken to determine grain yield and stubble yield. The number of panicles per square meter, the numbers of filled and sterile grains per panicle as well as the weight of 1000 grains were determined.

Plant tissue analysis was performed on samples of whole plants taken during the growing season and maturity in grain and stubble. Irrigation water was analyzed. For each site were available more than 80 variables, which were analyzed by traditional methods of descriptive statistics, correlation and regression and mean comparison test. To set the boundary line or borderline, which defines the optimal or peak condition for a variable with respect to another, BOLIDES method was used.

For the calculation of potential yield the following equation was used:

$$\mathbf{PY} = \sum_{i=1}^{n} (\mathbf{PAR_i} \times \mathbf{f_i}) \times \mathbf{RUE} \times \mathbf{HI} \times \mathbf{1/0.86}$$

PAR_i: Average daily Photosynthetically Active Radiation. f_i : Fraction of the PAR intercepted daily. n: number of days of crop cycle. RUE: Radiation Use efficiency. HI: Harvest Index. 1/0.86: fraction of dry mater in yield at 14% moisture content.

RESULTS AND DISCUSSION

Mean duration of the crop cycle from emergence to physiological maturity was 129 (±11) days. The average radiation received was 20.5 (± 1.0) $MJ/m^2/d$ making a total of 2639 (± 140) MJ/m^2.

Efficiency of use of radiation showed a value of 3.37 g/MJ with a good fit on observations (R^2=0.91).

The harvest index in observations of high yield was 0.53 and this value was taken for the calculation.

The potential yield calculated for the central and southern localities of the region in different planting dates, varied between 14.8 and 15.7 t/ha.

The observations of true production situations showed yields and yield components varied, representative of the conditions of production of Argentina (table 1). Rice is a very plastic species that can compensate for deficiencies in plants density with increased tillering, or fewer panicles with more grains per panicle. Therefore, in our observations, the crops showed yields greater than 10 Mg/ha in very broad conditions: 100 to 400 plants/m^2, 350-700 panicles/m^2, 55-150 spikelets/panicle, 1000 grain weight of 22 to 32 g and sterility of 7 to 35 %. The variation in grain weight was restricted by the variety. Rice is grown in Argentina in a wide range of soils. The yield was negatively related to pH, electrical conductivity of soil and exchangeable sodium. Some significant restrictions may occur in some calcareous (pH> 7.3), saline (EC> 2 dS/m) or sodic soils (ESP>10%).

Table 1. Recorded yield components in 364 farm production sites.

Variable	Unity	Mean	S.D.	Min	P(25)	P(50)	P(75)	Max
Plants	# / m^2	215	78	55	165	210	270	482
Tillers	# / m^2	625	165	314	484	610	723	1105
Tillers / Plants	#	3	2	2	2	3	4	15
Panicles	# / m^2	448	80	242	400	452	498	716
Empty grains / panicle	#	14	9	4	9	12	17	49
Filled grains / panicle	#	85	20	33	71	84	96	139
Spikelets / panicle	#	100	21	53	84	99	113	183
Sterility	%	15	9	4	9	13	17	58
1000 grain weight	g	26	3	16	24	25	28	39
Stubble	Mg/ha	6.62	1.90	2.22	5.27	6.48	7.91	13.94
Yield (14% H)	Mg/ha	8.53	1.81	3.29	7.29	8.65	9.72	12.74
Harvest index	%	57	6	35	54	57	61	74

On average, the waters showed good quality for irrigation. However, some waters had media to high salinity values accompanied by undesirable SAR.
Farmers used an average of P of 14 kg/ha, phosphorus was applied in almost all cases in doses up to 35 kg/ha of P. The use of K was infrequent, over 50% of producers not fertilized with K and the rest did so with relatively low rates (16-34 K kg / ha). The N was used widely. Medium total dose of N was 51 kg/ha, split 10 to 20% at planting, 50 to 60% before the flood and 40-50% in differentiation. The concentration of N and K in the tissues was analyzed in many cases below optimal levels limiting yield. Farmers use only 50 kg/ha of N, which is insufficient for the achievable yield. Fertilization tests show that is necessary to use higher doses of N and K should be incorporated in greater proportion in the fertilizer applied at planting.
Diseases and insect pests were presented in a few cases and it were unimportant. Regarding weeds, good control in most sites was observed. In 7% of cases they were recorded weeds in mid-cycle. At the harvest time, 25% of the sites presented grass weeds over 2 inflorescences/m^2 that significantly depress yield. The rate of yield loss was 211 kg/ha per each inflorescence of grass weeds. Weeds greatly reduce rice yields. Clearfield rice system available since 2005 in Argentina, allowed control red rice, but its prolonged and consecutive use has developed resistance to ALS-inhibitors in Echinochloa, red rice and other weeds. This is a serious problem today that requires an integrated weed management and active ingredients rotation. Although insects and diseases do not cause major damage, the sum of its minor effects, throughout the crop cycle, reduces the yield to some degree.

CONCLUSIONS

Currently, the national average productivity is stagnant in the order of 45-50% of their productive potential. There is not a single limiting factor but a set of factors accumulated that reduce or limit the yield. All factors of production should be considered to aspire to high yields. With careful adjustment of management practices productions can reach 70-80% of the potential (11-12 Mg/ha). Some producers, in large areas, have harvested 9 to 10 Mg/ha and test plots has come to 12-14 Mg/ha. This means that a yield target of 10 Mg/ha is reasonably achievable, with varieties and practices currently used. Two points seem to be the most important to be adjusted to reduce the yield gap. Fertilization (N and K) and the correct control of grass weeds. Technology is available and we have enough knowledge, but it requires careful monitoring and control of all points and aspects that make the yield detailed above. It requires extension work to transfer the more appropriate practices of management to farmers.

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