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Flooding Moment Effects on Yield, Root and Leaf Iron Concentrations in Irrigated Rice

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ABSTRACT - The toxicity of iron (Fe) is caused by high absorption of Fe. Rice plant can be affected when high quantities of reduced Fe are accumulated immediately after the flood. The objective of this study was to evaluate the effect of different flooding moments on yield, root, and leaf iron concentration.

In the 2003-04 and 2004-05 seasons, three experiments were installed in two different agro climatic regions in Uruguay : Tacuarembó and Artigas, using INIA Olimar cultivar. Soil analyses of Artigas and Tacuarembó 's were: pH in water: 6.3, 5.5; % OM: 6.5, 5.4, Fe: 225, 257 mg/kg and K 0.36, 0.49 meq/100 gr. respectively.

Early flooding (10-25 day after emergence (DAE)), Intermittent flooding (10-25 DAE during 8 days, followed by 8 days without flood and then the flood was re-established between 26-45 DAE) and Late flooding (26-45 DAE) were evaluated.

Concentration of iron in roots and leaf of all treatments were measured twelve days after later flooding.

A joint analysis of three experiments in two regions and 2 growing seasons were carried out. Flooding treatments did not affect final yield. General average was 10.198 kg/ha of rice, CV : 3.6 % . The levels of Fe in leaf were also not affected by flooding treatments; general average was 963 mg/kg of Fe. The levels of Fe in roots were: 16.890 mg/kg for Early flooding that differed significantly (P= 0.02) from the Intermittent and Late flooding, with 11.256 and 8.367 mg/kg of Fe respectively, CV: 14.6 %.

Considering the conditions in which the experiments were installed, dry soil, prolonged fallows, no incorporation of high level of organic matter, the flooding treatments did not affected the grain race yield. Early flooding treatment presented superior levels of Fe in roots than the Intermittent and Late flooding treatments. For the cultivar INIA Olimar the Iron level in the leaf were significantly more lower than the remained located in the root tissue.

Key words: iron toxicity, water management.

I. INTRODUCTION

The toxicity of iron (Fe) is caused by high absorption of Fe. Rice plant can be affected when high quantities of reduced Fe are accumulated immediately after the flood.

In aerated soils Fe occurs in the Fe^{+3} oxidation state which have a low solubility. However, under the anaerobic conditions of flooded soils Fe^{+3} is reduced to Fe^{+2} which is readily soluble and available to plants. In certain cases, these levels can be Fe toxicity to plants in anaerobic soils. Even though lowland rice is adapted to anaerobic conditions and has developed mechanisms to tolerate certain Fe levels, Fe^{+2} can still become toxic after flooding.

Rice yield are reportedly reduced by 12 -100% depending on the severity of toxicity and the tolerance of the rice cultivars (Benckiser G, Ottow J CG, Santiago S and Watanabe I, 982 [1], Sahrawat K L and Diatta S 1995 [2], Audebert A and Sahrawat K L 2000 [3] , Abifarin, A.O. 1989 [4], Yamauchi M 1989 [5].). Variaying levels of soil solution Fe^{+2} has been reported to cause Fe-toxicity at values ranging between 30- > 3000 mg/L (Van Breemeen N 1978 and Moormann F R 1978 [6]) and at pH levels ranging from 3-7 (Ottow J C G, Benckiser G and Watanabe I 1982 [7]). Iron Toxicity of rice plants has been related to a multiple nutritional soil stress (i.e., insufficient supply of K,P, Zn and sometimes Ca and Mg)

In a culture without nutritional restrictions, the power of oxidation of the plants of rice is generally high in the first stadiums of growth (Tanaka A, Leo R and Navasero S A, 1966 [8], Tanado T 1976 [9]) due to a vigorous and effective development of the aerenchyma.

Both the external concentration of Fe^{+2} and the susceptibility of the plant to excess iron vary with time. The importance of the mechanisms for overall iron toxicity resistance depends on the rice plants developments stage. The Iron oxidation power is high in early growth stage and decreases with age. The iron excluding power is low at the early stage of growth, increases with growth till the flowering stage, and then decreases gradually (Tadano, 1976).

Assuming that the resistant mechanism for iron toxicity increases with de age, an Intermittent flooding or Late flooding, , can be a useful tool to diminish the absorption of Fe in roots and leaf.

In Artigas and Tacuarembó above basaltic soils, the level of Fe was 225, and 257 mg/kg respectively.

II. MATERIAL AND METHODS

Soil samples (0 – 15 cm depth) were randomly collected from two different agro climatic regions in Uruguay: Artigas and Tacuarembó above basaltic soils. The soil analyses of Artigas and Tacuarembó were: pH in water: 6.3, 5.5; % OM: 6.5, 5.4, Fe: 225, 257 mg/kg, available P (Bray-I): 1.3, 3.4 and K 0.36, 0.49 meq/100 gr. respectively.

Iron Studies: Concentration of iron in roots and leaf of all treatments were measured 28 – 32 days after Early flooding and 12 days after Later flooding.

The level of Fe in root were determine, taking precaution of eliminating before whole Fe precipitated in the roots surface with a solution of slight HCl. This allows determining accurately the Fe really absorbed by the roots and the Fe transported to the vegetative organs.

Pot Experiment: Three (3) flooding treatments, Early flooding (10-25 day after emergence (DAE)), Intermittent

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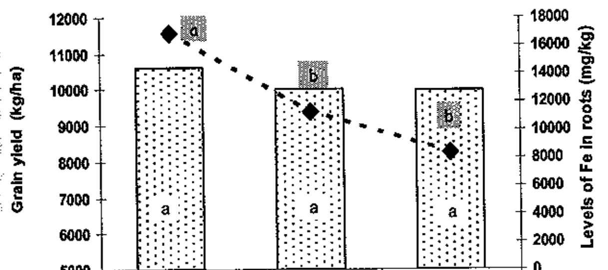
flooding (10-25 DAE during 8 days, followed by 8 days without flood and then the flood was re-established between 26-45 DAE) and Late flooding (26-45 DAE), were allocated to a split plot field design with three replications.

III. RESULTS AND DISCUSSION

Data analysis was done using the statistical package SAS, the flooding treatments did not affected the grain race yield.

A joint analysis of three experiments in two regions and two growing seasons were carried out.

Flooding treatments did not affect final yield (fig. 1). However, significant differences for year and locality effects were found (P> 0.017) and (P> 0.0043) respectively. The general average was 10.198 kg/ha of dry grain rice, with a CV of 3.6 %. The level of Fe in the leaf was not affected for the flooding treatments, with a general average of 963 mg/kg of Fe.



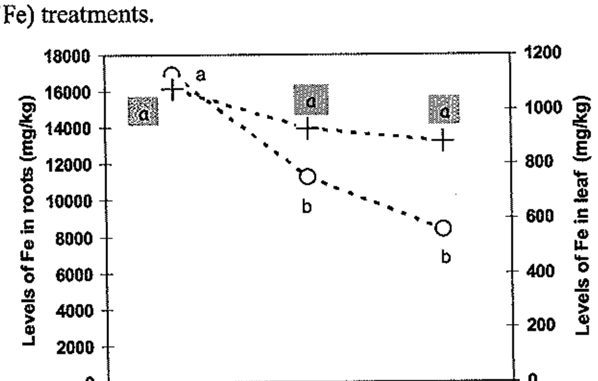
	Early	Intermittent	Late
Grain	10611	10013	9972
Roots	16890	11256	8367

Flooding Treatments

Fig.1. Flooding treatments, Grain yield (kg/ha) and Level of Fe in Root (mg/kg). Columns and point with the same letter are not significantly different at the *t* Test -Least Significant Difference at 5 % -(MDS 5%).

The flooding treatments did not affect the grain race yield. (fig. 1)

The moment of flooding determines the level of iron in root, higher levels of iron were detected at the Early flooding moment (16.890 mg/kg of Fe), that in the Intermittent flooding (11.256 mg/kg of Fe) and Late flooding (8.367 mg/kg of Fe) treatments.



	Early	Intermittent	Late
Roots	16890	11256	8367
Leaf	1076	931	883

Flooding Treatments

Fig. 2. Flooding treatments, Level of Fe in Root (mg/kg) and Level of Fe in Leaf (mg/kg). Point with the same letter are not significantly different at the "*t*" Test LSD 5%.

The quantity of iron in the leaf (average 963 mg/kg of Fe) was lower than in the root tissue (average 12171 mg/kg of Fe) (Fig 2). This indicates that the retention mechanism was operating preventing an excessive transport of iron.

Early flooding treatment presented significantly more iron level in root tissue than Intermittent and Late flooding treatments. However flooding treatments did not affect levels of Fe in leaf (fig. 2).

IV. CONCLUSION

These studies were conducted to determine the irrigation management that achieve maximum grain yield with minor Iron toxicity. in soils with potential iron toxicity problems

In basaltic soils with high levels of iron, the flood moment election showed to be a tool to diminish iron toxicity risk.

The Intermittent flooding treatment, with an early flush and then a drainage period, not superior to 8 -10 days, can be a an irrigation management option that permit to develop a root system and appropriate vegetative mass that causes Fe exclusion and retention mechanisms, without harming the final rice yield.

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