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Response of INIA Olimar a new indica Uruguayan rice cultivar to rates and timing of application of nitrogen

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ABSTRACT - The economic and environmental sustainability of the rice production system requires the generation of high productivity with minimal alteration of the used natural resources. The optimum use of N should result from matching supply with crop demand. Rice N requirements are related to productivity, but they are also dependent on climate conditions (solar radiation and temperature) during the growing season and the supply of other nutrients. Crop management practices can affect those relationships and the pattern and quantity of N supplied from natural sources (bacterias of the ecosystem). Only one rice crop per year is grown in Uruguay, with risk of cold temperature occurrence during its reproductive stage. The crop is dry-direct seeded (drill or broadcast). Depending on rainfall ocurrence, flushing (1 or 2) is required to prevent water stress, before establishing the permanent flood 35-45 days after planting. One or two N nitrogen top dressings are normally used (tillering /panicle initiation). INIA Olimar is a new semidwarf, high yielding, reduced growth duration cultivar. It has erect leaves and higher harvest index than the traditional varieties grown in the country. A series of experiments were conducted in order to improve N split applications efficiency for the new cultivar. Five N rates (0, 35, 70, 105, 140 kg ha^{-1}) as urea, were applied in 3 times: planting (P), tillering (T) and internode elongation (IE); each rate was divided as follows: 1) 33,3-33,3-33,3%; 2) 20-50-30%; 3) 20-30-50%; 4) 20-80-0%, (P-T-IE) respectively. Tillering applications were made pre-flood. The results of 2 experiments were.examined accros growing seasons. Rice yield, chlorophyll meter readings, and N uptake responses to N rates and timing were different in 2005 and 2006. Significant effects on rice yield were found only due to N rates (p<0,000) in 2006. With a relatively high yield in control plots, the statistical analysis indicated that there was only a slight tendency of response of rice yield to N application (p<0,11), without N x Partitioning interaction in 2005. Results of the study support the hypothesis that rice responses to N applications depend on other factors (weather conditions and N soil supply).

KEY WORDS: rice, nitrogen, rates and timing.

I. INTRODUCTION

The challenges for plant nutrition management are to maintain (and where possible increase) sustainable crop productivity to meet demands for food and raw materials, and to enhance the quality of land and water resources [1].

Rice crop in Uruguay shares the use of soils with cattle production, accounting for 25-30% of the time. After rice harvest, it is recommended no till planting of forage species (by airplane) to increase beef/sheep production during the period without rice (3-4 years). Grasses and legumes presence improve soil conditions, which has big impact on the next crop. Farmers sometimes do not plant improved pastures and in that cases native species regenerate in the fallow period. The N fertilizer rate required to achieve optimum yields in rice can be influenced significantly by the preceding crop. When a long term pasture land is put into rice production readily available N is accumulated and few fertilizer is required to achieve the full potential [2].

Uruguayan research teams are studying the presence of cyano and/or endophytic bacteria in the crop production environment, and the possible biological N fixation and/or rice growth promotion [3], [4], [5].

Experiments conducted in Uruguay with different cultivars showed that between 68 and 92% of the N absorbed by plants at panicle initiation came from other sources than fertilizer applied [6].

Rate and timing of N management combined with an appropriate rice variety can reduce nutrient losses and chemical pollution of the environment.. INIA Olimar is a new semidwarf, high yielding cultivar. It has erect leaves and high harvest index (HI); when 80 kg ha-1 was applied to the soil, with a HI of 0.59 it absorbed 168 kg of total N at maturity (42 kg in straw and 126 kg in grain, respectively) [7].

A series of experiments were conducted in order to improve N split applications efficiency for the new cultivar.

II. MATERIALS AND METHODS

A field experiment was carried out in 2004-05 and 2005-06 growing seasons at 2 different paddocks in the experimental farm of Paso de la Laguna, located in the eastern part of Uruguay (54°W; 33°S). Initial soil tests results (0-15 cm depth) indicated:: a) texture: 34-30 % sand, 38-43% silt, 28-26% clay; b) organic carbon content: 16-11.7 g/kg; respectively. The long grain cultivar INIA Olimar was broadcast sowed at a rate of 490 viable seeds m^{-2} on a dry surface and incorporated into the soil with a disk harrow.

A factorial arrangement of treatments (5x4) was laid out in a complete randomized block design with 3 replications, each year. Five N rates (0, 35, 70, 105, 140 kg ha^{-1}) as urea, were applied in 3 times of application: planting (P), tillering (T) and internode elongation (IE); each rate was divided as follows: 1) 33,3-33,3-

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33,3%; 2) 20-50-30%; 3) 20-30-50%; 4) 20-80-0%, (P-T-IE) respectively. Basal nitrogen applications and 50 kg P_2O_5 ha^{-1} were incorporated into the soil prior to planting. Tillering applications were made one day pre-flood.

Whole above ground plant samples were taken at random from 0.16 m^2 of each plot at heading, for determining dry matter production (DM) and N uptake. At the same time 10 chlorophyll meter readings (SPAD Minolta 502) were randomly taken on the Y-leaves of rice plants of those plots and averaged; SPAD readings were measured not for guiding N applications but as having an indicator of chlorophyll status of the crop.

Two plant samples of 0.16 m^2 each one were randomly collected at harvest for studying grain yield components and harvest index. Diseases severity index (Aggregated Sheath Spot and Stem Rot) were determined just prior to harvest. Rice grain yield was determined in an area (3m x 3m) located in the central part of the plots; the crop was harvested by hand at maturity and grain yield was corrected to 13% moisture basis. The results of experiments were examined across growing seasons. Linear correlation coefficients between the dependent variables were studied and some quadratic regressions were performed in some cases.

III. RESULTS AND DISCUSSION

Rice grain yield averages were: 10.089 and 9.376 t ha^{-1} in 04-05 and 05-06, respectively. Rice grain yield was affected by N applications ($p< 0.001$) but the responses were different according to seasons ($p< 0.003$). A high positive effect was observed in 2006 ($p< 0.001$), but only a slight tendency ($p<0.11$) in 2005 as result of N application increase (Fig. 1). The relatively high yield obtained in no-N treatments may be one of the reasons of the lack of response in 04-05. The comparison between rice yields obtained in plots with or without N applications in both years, in reference to the organic carbon content of soils (% O.C.) are presented in Fig. 2. Crop yield was not significantly affected by N partitioning; a slight significance ($p<0.1$) indicates that effects were different in the 2 growing seasons. Among yield components number of panicles and % filled grains per panicle were not affected by treatments.

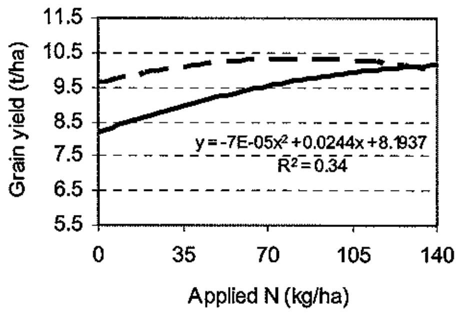

Fig. 1. Response of rice yield to N applications (2005 slashed line; 2006 continuous line)

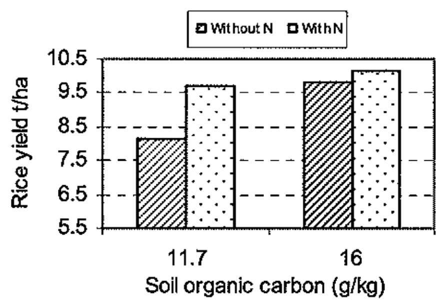

Fig. 2. Rice grain yield comparison between treatments without and with N applications in reference to the organic carbon content of the. soils (2005: 16 g/kg; 2006: 11.7 g/kg).

Solar radiation during the 40 days period around heading (20 days before, plus 20 days after heading) was higher in the first year (38%). They were significant statistical differences in SPAD readings according to N ($p<0.001$), partitioning of N ($p<0.001$), season x N interaction ($p<0.1$), season x partitioning of N interaction ($p<0.01$), and N x partitioning of N interaction $p<0.004$). Harvest index only varied due to growing seasons ($p<0.001$; HI: 0.53 and 0.56 in 04-05 and 05-06, respectively). Nitrogen uptake was affected by N applications ($p<0.001$) and N x season ($p<0.04$) and N x partitioning of N ($p<0.07$) interactions.

Grain yield was only significantly correlated with SPAD readings ($r= 0.26$; $p<0.05$) the first season. Grain yield was correlated with SPAD readings, %N and N uptake at heading (r= 0.5, 0.29, and 0.29; p/ 0.001, 0.03, and 0.03 respectively) the second year.

IV. CONCLUSION

The data suggest for our temperate climate growing conditions that rice responses to N applications are highly variable and depend on soil N supply and weather conditions during the reproductive stage.

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