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DETERMINING OPTIMUM SOWING DATE FOR EARLY UPLAND RICE CULTIVAR USING MODELLING APPROACH

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ABSTRACT: The objective of this study was to determine the optimum sowing date for early upland rice cultivar at Santo Antonio de Goiás, GO, Brazil. To optimize solar radiation and precipitation during the upland rice sowing period (from November to December) it was used the crop model RICE06 from Ecotrop plataform. To mimic the conditions of region, two scenarios were created: a) no restriction to root development (0.8 m effective root depth) and b) restrictions to root development (Al toxic in the subsoil – 0.4 m effective root depth). The crop model was run based on the climate historical date (22 years of daily data for precipitation, solar radiation, maximum and minimum temperature, maximum and minimum relative humidity, and wind speed) collected at Embrapa Rice & Beans weather station. Five different sowing dates (01/11, 15/11, 1/12, 15/12, and 31/12) were taken into account. The decision criterions used to determine the optimum sowing date were the variability, comparison of exceedance probability and mean variation for yield and the averaged index stress factor. The results obtained showed that the optimum sowing date for both scenarios was 15-Nov.
KEYWORDS: *Oryza sativa*, crop model, root depth

INTRODUCTION: Subtropical flooded rice cultivated in the South of Brazil accounts for 65% of Brazilian rice production. During the last decade, the demand for rice in Brazil as well as in the world has increased considerably. However, the area available for rice production in the South of Brazil is limited, largely due to environmental and social constraints, such as competing demands for freshwater for industry and for domestic use. Rainfed upland rice cultivated at Brazil Central can play an important role in this scenario. Optimization of sowing dates during the rainy season may decrease the need of supplementary irrigation. Upland rice crop in Brazil Central may be affected by restrictions to rooting depth as a result of acid subsoil, which in turn increases the effects of intermittent drought caused by variable rainfall. This restrictive soil depth reduces the available water to the plants and, therefore, drought resistance is a major breeding objective for annual crops in the Cerrados, particularly for upland rice. Crop simulation models can be an alternative research tool for determining optimum sowing dates and other management practice, giving support for breeder decision. This tool can integrate climate variables (precipitation, solar radiation, and maximum and minimum temperature), soil, cultivar coefficients and management practices. The objective of the present study was to determine the optimum sowing dates for early upland rice cultivar at Santo Antonio de Goiás, GO, Brazil, taking into account two different scenarios, no restriction and restrictions to root development.

METHODOLOGY: To determine the optimum sowing date it was used the crop model RICE06 from Ecotrop platform (ecotrop.cirad.fr). This model is particularly suited for the analysis of climate impacts on cereal growth and yield in dry, tropical environments (DINGKUHN et al., 2003). The model was calibrated and validate for an early upland rice cultivar ("Guarani") based upon observed data obtained from two different environments (Porangatu, GO – sowing date 12/05/2006 and 11/06/2006). Two scenarios were created to mimic the region reality: a) no restriction to root development (0.8 m effective root depth) and b) restrictions to root development due to Al toxic in the subsoil and low inputs (0.4 m effective root depth). Crop model was run for 22 years of daily climate data (precipitation, solar radiation, maximum and minimum temperature, maximum and minimum relative humidity and wind speed) obtained from Embrapa Rice & Beans weather station located at Santo Antonio de Goiás. Sowing dates were defined at 15-day intervals during the main sowing period (from November to December). Because sowing dates were fixed independently of rainfall occurrence, a provision was made that allowed germination only if the available soil water in the top soil layer was 70% or higher. For any given year and sowing date, if soil moisture did not permit germination within 10 days of sowing, the crop was considered as failed. Simulation runs were generally initiated in July, regardless of sowing date, in order to allow the establishment of a realistic soil water profile on the basis of rainfall patterns occurring before sowing, with the starting water profile as zero due to completion of a previous crop. Among the many model output variables, only attainable (water and radiation limited) grain yield at maturity and the averaged water stress index were used. The water stress index is a daily model output based on the ratio of actual transpiration/potential transpiration. The daily water stress index was averaged by crop cycle and its scale is 1 to 0, being 1 no water stress and 0 maximum water stress (plant do not survive). Details for crop model soil dynamics, plant water, carbon assimilation and partitioning and phenology are described in HEINEMANN et al. (2007) and KOURESSY et al. (2008). As a criterion to determine the optimum sowing date it was used variability among sowing dates, comparison of the probability of exceedance as well as the mean variance for yield and water stress index. Probability of exceedance is defined as:

$$E(x) = 1 - F(x),\ F(x) = P(X \leq x) \quad (1)$$

where E(x) is the probability of exceedance (%), F(x) is the function of accumulative distribution (%), and $P(X \leq x)$ is the probability that variable X is less or equal to x.

RESULTS AND DISCUSSION: For the scenario with no soil restriction to root development (0.8 m effective root depth), the yield and water stress variability for the five sowing dates is showed in Figure 1a and 1b. The reason for a little decrease in the median yield when sowing date is delayed (15-Nov, 01-Dec, and 15-Dec) is related to a decrease in the accumulated global radiation (data did not show) during the upland rice reproductive period due to cloudy weather. However, for the last sowing date (31-Dec), the filling grain phase may be affected by a terminal water stress due to the ending of rainy season.

The highest median yield was obtained at the sowing date of 01-Nov. However, this date also showed a low median for stress index (Figure 1b), showing higher probability for water stress than 15-Nov (Figure 1d). For the sowing date 01-Nov the rainfall is not stabilized yet for all years (begin of rainy season). In spite of the mean yield variance plot (Figure 1e) showed that 15-Nov has the highest standard deviation, this sowing date was chosen as the best. For upland rice, the mean reason for yield variation is the rain distribution. Based on that, 15-Nov showed the lowest deviation for water stress index (Figure 1f). HEINEMANN et al. (2007) also observed that sowing at 15-Nov has the highest probability to obtain the lowest water stress level.

For the scenario with soil restriction to root development, both sowing dates, 01-Nov and 15-Nov showed the highest median valor for yield (Figure 2a). However, the value of median for the water stress index was higher for 15-Nov (Figure 2b). Fig. 2d shows that 15-Nov and 01-Dec has 50% of the probability to exceed water stress values higher than 0.88 for the 22 years of climate historical data. However, 15-Nov has 50% of probability to exceed yield higher than 2800 kg/ha, better than 01-Dec. Also for this scenario, 15-Nov showed the highest mean value for water stress index (no stress) (Figure 2f).

CONCLUSION: In spite of the difficulty to choose the optimum sowing date for both scenarios by the yield variance and probability of exceedance, it was clear that 15 of November showed the lowest yield standard variation for both scenarios. Then, it is possible to conclude that 15 November can be considered the optimum sowing date.

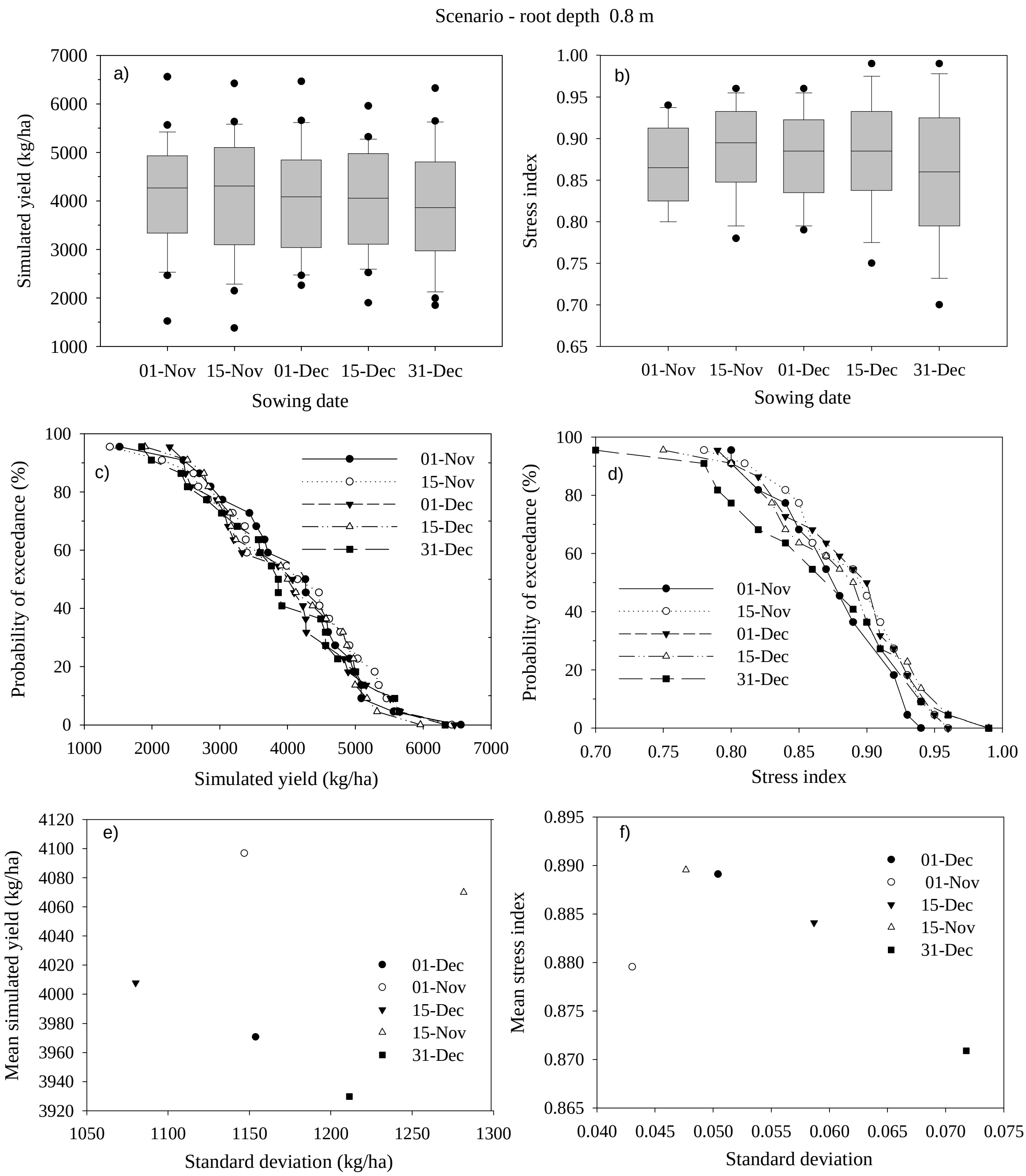

FIGURE 1. Variation and median of a) simulated yield and b) stress index as function of sowing date, probability of exceedance for c) simulated yield and d) water stress index, and mean variance of e) simulated yield and f) water stress index for scenario 0.8 m effective root depth.

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Scenario - root depth 0.4 m

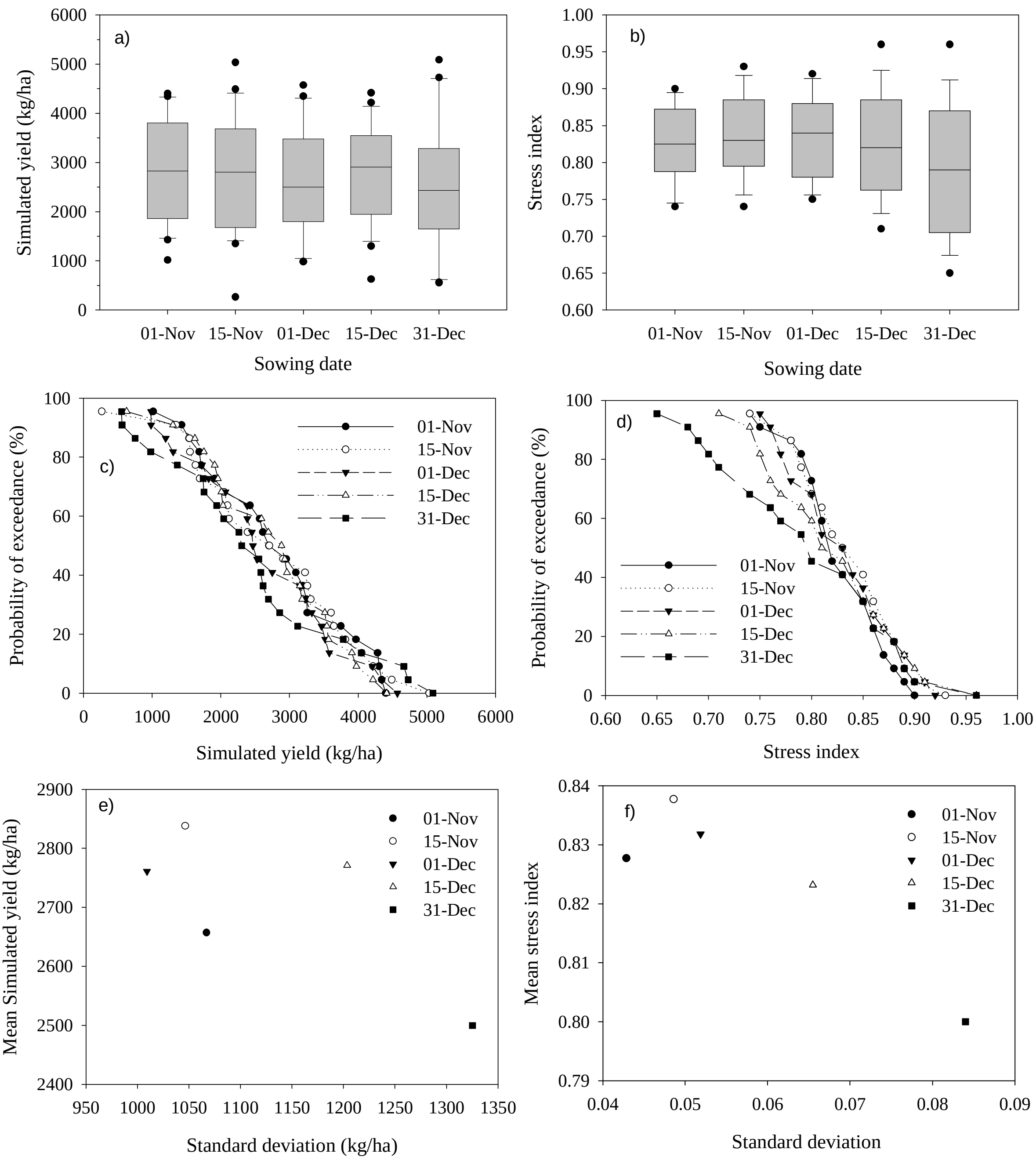

FIGURE 2. Variation and median of a) simulated yield and b) stress index as function of sowing date, probability of exceedance for c) simulated yield and d) water stress index, and mean variance of e) simulated yield and f) water stress index for scenario 0.4 m effective root depth.