DETERMINING OPTIMUM SOWING DATE FOR MAIZE USING MODELLING APPROACH

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ABSTRACT: The objective of this study was to determine the optimum sowing date for maize at Santo Antonio de Goiás, GO, Brazil. To optimize solar radiation and precipitation during the maize sowing period (from October to December) it was used the crop model CEREAL06 from Ecotrop plataform. To mimic the conditions of region, two scenarios were created: a) no restriction to root development (1.0 m effective root depth) and b) restrictions to root development (Al toxic in the subsoil – 0.5 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. Six different sowing dates (15/10, 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 for the reproductive period. The results obtained showed that the optimum sowing date for both scenarios was 15-Nov.
KEYWORDS: *Zea mays*, crop model, root depth

INTRODUCTION: Food shortage is becoming a serious global problem because the rate of world population growth currently exceeds the rate of increase in food production. Due to the competitive use of available water resources among industry, domestic and agriculture, the increase of irrigate land is became restrict. In this scenery, rainfed crop, such as maize cultivated at Brazil Central, can play an important role for increasing yield. Optimization of solar global radiation and precipitation based on the best sowing date may decrease the need of supplementary irrigation and increase yield. Maize 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. Crop simulation models can be an alternative research tool for determining optimum sowing dates and other management practices. 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 maize 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 CEREAL06 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 a reference maize (short cycle) cultivar (HEINEMANN et al. 2007). Two scenarios were created to mimic the region reality: a) no restriction to root development (1.0 m effective root depth) and b) restrictions to root development due to Al toxic in the subsoil and low inputs (0.5 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 15 of October to 31 of 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 the crop reproductive period 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:

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

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 (1.0 m effective root depth), the yield and water stress index variability for the six sowing dates is showed in Figure 1a and 1b. 01-Dec sowing date showed the worst median yield and the highest variation on the yield. Probably, the reason is associated to a decrease in the accumulated global radiation during the reproductive period due to clod weather (data not showed) in some years and an increase on the water stress index variability in other years (Figure 1b). The best median yield was observed for 15-Nov sowing date. This sowing date also showed the highest yield value for the probability of exceedance of 50% (8778 kg/ha, Figure 1c) and the lowest probability to have water stress index (low values of water stress index) (Figure 1d). For this sowing date there was the highest mean and the lowest standard deviation for yield and water stress index (Figure 1e and f). Based on that, 15-Nov was the optimum sowing date for maize when there is no root restriction.

For the scenario with soil restriction to root development, 01-Dec also showed worst median yield (Figure 2a). The best median yield was obtained for 15-Nov. The highest water stress index variations were observed for the sowing dates 15-Nov, 15-Dec and 31-Dec (Figure 2b). The 15-Nov sowing date showed the highest yield value for the probability of exceedance of 50% (7731 kg/ha, Figure 2c). This sowing date also showed the highest mean and the lowest standard deviation for yield and water stress index (Figure 2e and f). Grounded on this information, 15-Nov was the optimum sowing date for maize when there is root restriction.

CONCLUSION: The results showed that the optimum sowing date for both scenarios, with and without soil restriction to root development, was 15 of November.

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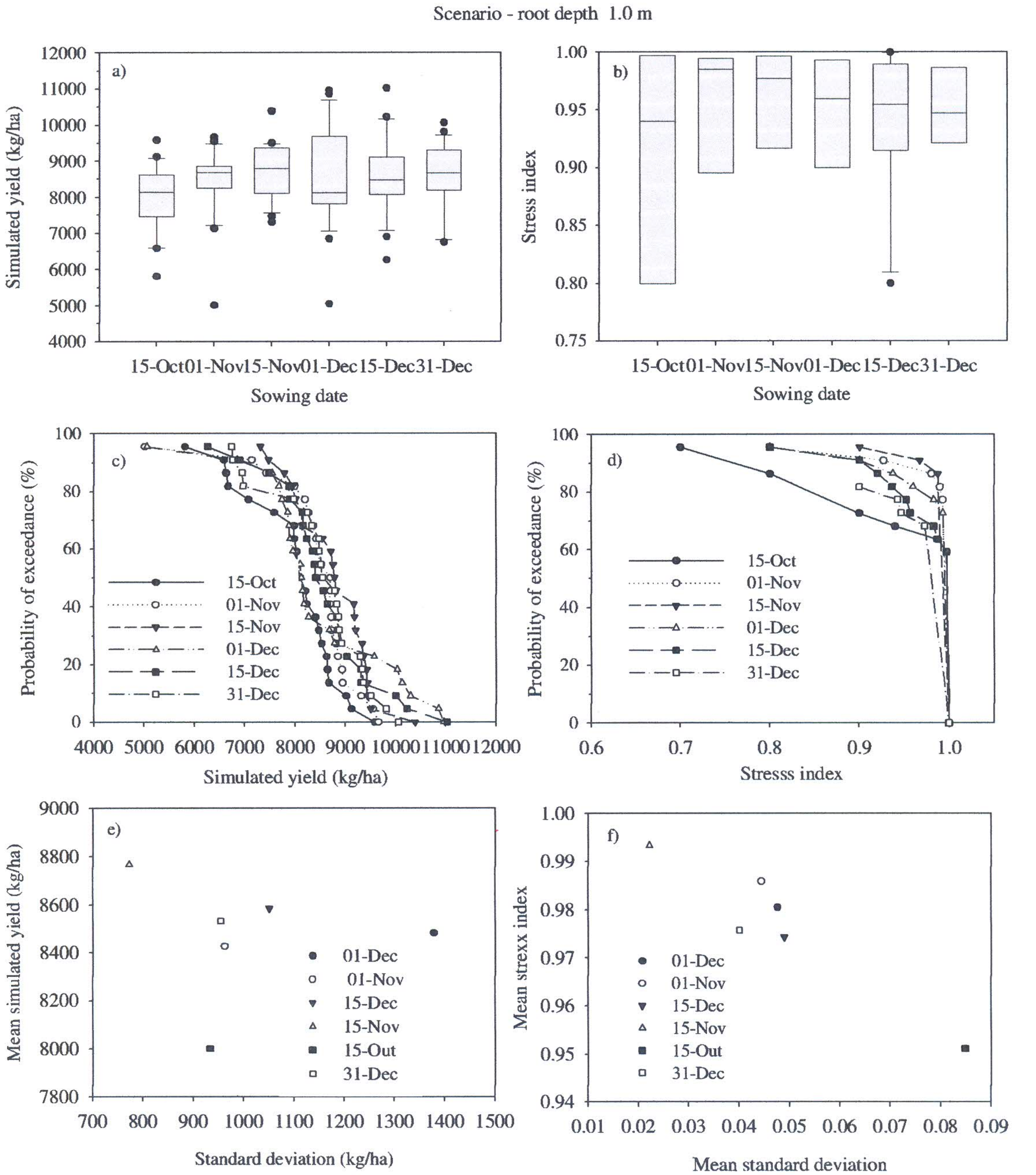

FIGURE 1. Variation and median of a) simulated yield and b) stress index as function of sowing date, probability of exceedance for c) simulated yield and d) water stress index, and mean variance of e) simulated yield and f) water stress index for scenario 1.0 m effective root depth.

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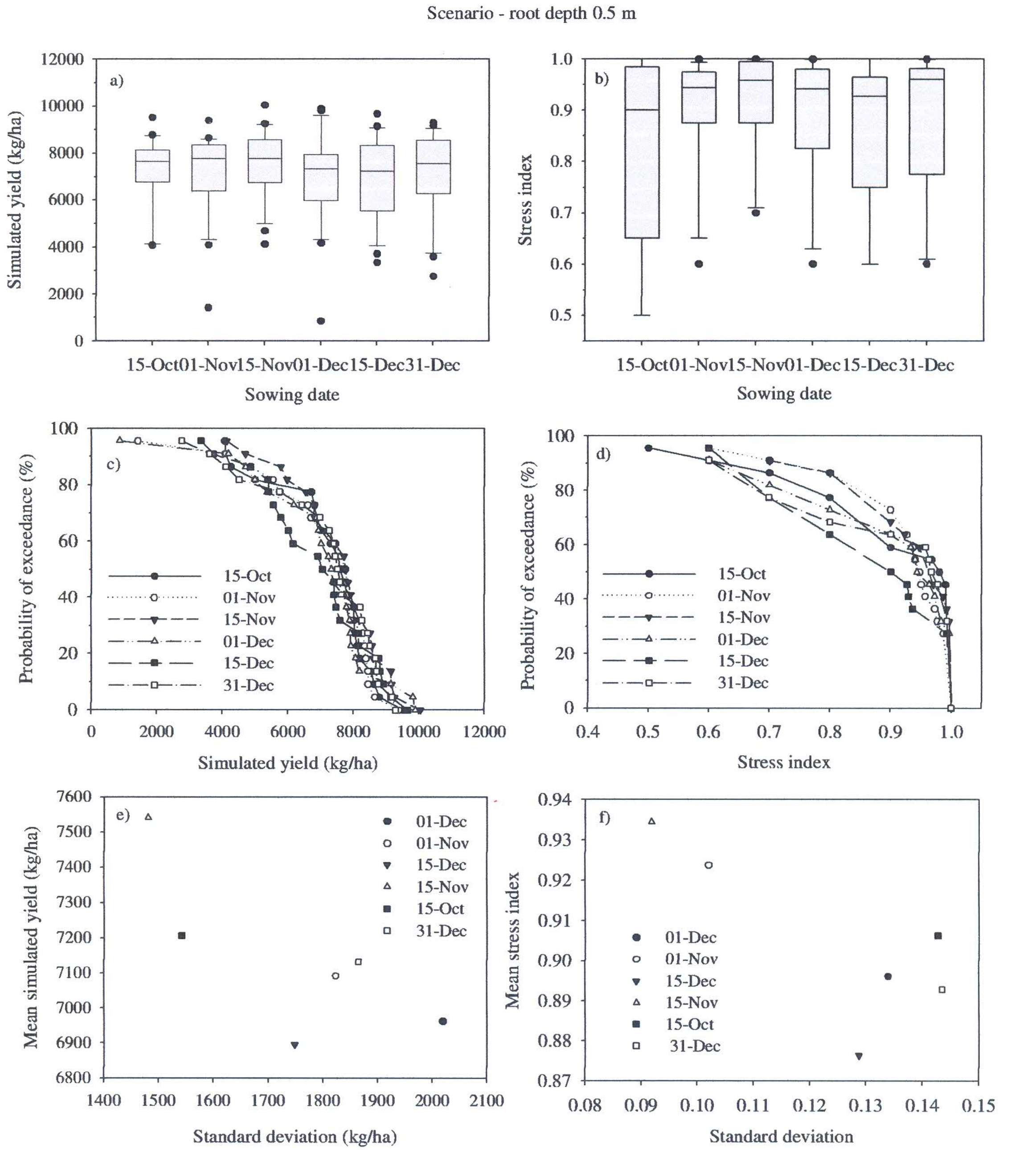

FIGURE 2. Variation and median of a) simulated yield and b) stress index as function of sowing date, probability of exceedance for c) simulated yield and d) water stress index, and mean variance of e) simulated yield and f) water stress index for scenario 0.5 m effective root depth.