THE EFFECT OF NITROGEN FERTILIZER ON DRY BEAN PRODUCTION UNDER RAINFED AND IRRIGATION CONDITIONS

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INTRODUCTION

In Brazil, dry beans are grown during three different growing seasons: the rainy season from August to November ("das águas"), the dry season from January to March ("da seca"), and the winter season from April to May ("de inverno"). In São Paulo, the most important growing season is the wet season, which accounts for more than 40% of total dry bean production in 2002 (IEA, 2003).

The production of dry bean during the wet season is practiced with or without irrigation, depending on the type of farmer. While the national average dry bean yield is about 780 kg ha^{-1}, the state of São Paulo reaches yield levels around 1500 kg ha^{-1}, mainly due to the differences in technology applied by the farmers, especially the apparent use of nitrogen fertilizers and irrigation.

Farmers have become more receptive to new technologies and have increased the amount of nitrogen (N) fertilizer that they apply. However, do farmers really need to increase N fertilizer to be able to maintain a sustainable production? In the state of São Paulo extension normally recommends an application of 30 to 40 kg ha^{-1} of N (Rosolem & Marubayashi, 1994). However, depending on the growing season and the farmer's technology level, it is common to apply N amounts that reach 90 to 120 kg ha^{-1}. For rainfed crops, normally less fertilizer is applied and in only one application, while for irrigated crops higher amounts are applied and split into two or three applications (Rosolem & Marubayashi, 1994; Dourado Neto & Fancelli, 2000).

The objective of this study was to analyze the impact of N fertilizer on the seasonal productivity of dry beans grown during the rainy season under both rainfed and irrigated conditions.

MATERIAL AND METHODS

Experimental data collected at the Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), São Paulo State University, Piracicaba, Brazil, were used for evaluation of the dry bean model CROPGRO (Hoogenboom et al., 1994). The experiment was conducted from April 1st. through July 2002 in a Typic Eutrudox soil and three levels of N fertilizer were applied (0, 60, and 120 kg ha^{-1}) (Tisot, 2002). The cultivar was IAC-Carioca Tybatã, type II (Pompeu et al., 2001) and plots were irrigated to avoid drought stress. Details on the evaluation of the performance of the simulation model CROPGRO-Dry Bean for conditions in the State of Sao Paulo can be found in Garcia et al. (2003).

The climate of the region is characterized as humid subtropical (Cwa). For the growing season used in this study, the monthly average rainfall was 170 mm, the maximum average temperature was 30ºC and the minimum average temperature was 17.3ºC.

For the simulations, the sowing date was defined as October 1st. and maize was assumed to be the previous crop. The CROPGRO Dry Bean model (Hoogenboom et al., 1994; Boote et al., 1998), included in the DSSAT Version 4.0 (Jones et al., 2003; Wilkens et al., 2003), was used to predict dry bean yield for 23 years from 1980 to 2002. The weather data were obtained from a conventional weather station located at ESALQ.

Crop yield was predicted for the rainy season for three different N fertilizer amounts and both rainfed and irrigated scenarios were used. The N fertilizer amounts were 40, 70 and 120 kg ha^{-1}, based on the typical extension recommendations. The seasonal analysis program of DSSAT Version 4.0 was used to examine the annual variation in productivity due to the seasonal weather variability and the amount of N fertilizer applied.

RESULTS

Simulated crop yield under rainfed conditions ranged from 300 kg ha^{-1} to 2000 kg ha^{-1}. There was no effect of the different N fertilizer amounts (Figure 1). In this scenario, the most

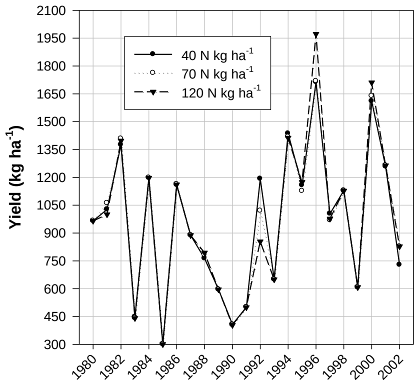

Figure 1 – Predicted Annual Yield Variability for the Rainfed Scenario.

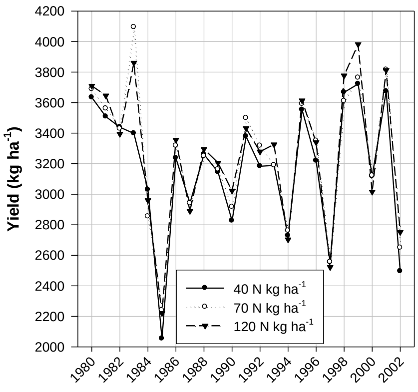

Figure 2 – Predicted Annual Yield Variability for the Irrigated Scenario.

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constraining factor is water, which limits the absorption of fertilizer by the plant. Therefore, no differences in yield were predicted for the three levels of N applied. In 50% of the years yield was less than 900 kg ha^{-1} while in 10% of the years the expected yield can be great than 1400 kg ha^{-1} (Figure 3).

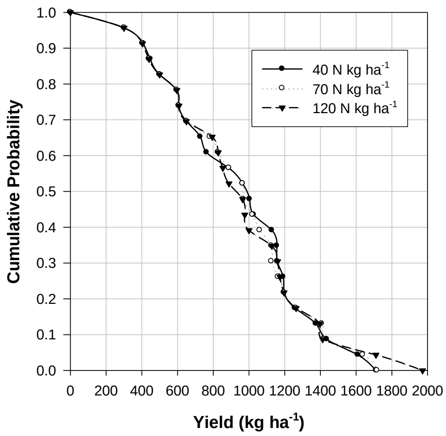

Figure 3. Cumulative Yield Probability for the Rainfed Scenario.

Under irrigated conditions, the simulated yield ranged from 2000 kg ha^{-1} to 4100 kg ha^{-1}. However, the amount of N applied did not significantly affect crop yield (Figure 2). For this scenario, the 70 and 120 kg ha^{-1} of N treatments showed a slight difference when compared with the 40 kg ha^{-1} of N treatment. However, for 70% of the years yield was similar and independent of the amount of N fertilizer that was applied (Figure 4).

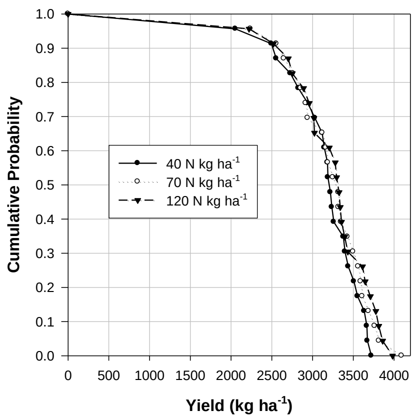

Figure 4 – Cumulative Yield Probability for the Irrigated Scenario.

The average yield for rainfed conditions was 960, 960, and 970 kg ha^{-1} while for the irrigated conditions it was 3170, 3250, and 3270 kg ha^{-1} for 40, 70, and 120 kg ha^{-1} of N, respectively. For both, the rainfed and irrigated scenarios, higher standard deviations for yield (420 and 454 kg ha^{-1}) were observed when 120 kg ha^{-1} of N was applied, and lowest standard deviations (390 and 420 kg ha^{-1}) were found when 40 kg ha^{-1} of N was applied. Under rainfed conditions, the standard deviation for 70 kg ha^{-1} of N was 389 kg ha^{-1}, and 449 kg ha^{-1} for the irrigated scenario.

Also, it was found that the higher amounts of N fertilizer had a negative impact on the environment and the net income of the farmer due to N-leaching and higher production costs. Thus, an accurate knowledge of the local weather conditions is critical for developing a sustainable technology while at the same time maintaining high productivity levels.

CONCLUSION

An increase from 40 to 120 kg ha^{-1} in the amount of N fertilizer applied did not result in an increase in dry bean yield for either rainfed or irrigated conditions.

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