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CULTIVAR SELECTION FOR RAIN-FED MAIZE IN NORTHERN AUSTRALIA

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SUMMARY

Rain-fed cropping in the semi-arid tropics (SAT) of northern Australia is risky due to extreme environmental conditions. Crop simulation models are an appropriate means of quantifying the cropping potential and of assessing risk in this climatic zone. In this paper, a simulation model of maize is used to select the appropriate maize cultivar for early and late sowings at Katherine NT, by predicting grain yields of different cultivars over the historical climatic record. Of the commercial cultivars assessed at Katherine, the relatively short duration cultivar Dekalb XL82 (104 days to maturity) resulted in the highest mean yield (3,770 kg/ha) and lowest yield variability (CV 62%) for early sowings. We conclude that there was little benefit to planting later maturing cultivars or for later sowings at Katherine.

INTRODUCTION

Early assessments of land resources indicated a potential for dryland crop production in the SAT of northern Australia. However, this potential was not confirmed by early commercial efforts and recent research has shown cropping to have serious viability problems (Muchow, 1985). Uncompromising environmental conditions, such as variable within-season rainfall, extreme temperature, high evaporative demand, harsh seedbed conditions, low soil fertility and soils with high susceptibility to runoff and erosion, have been major contributors to poor crop yield in this climatic zone. It is feasible to quantify these risks to rain-fed crop production by simulating crop performance over a large number of seasons using a computer model, which mimics crop growth, development and yield, and historical climate records. Such an approach forms the basis of a project to assess cropping potential in the SAT of northern Australia (McCown, 1989).

Maize is well adapted to and is commonly grown in wetter SAT regions. Using a simulation model, the prospects of maize in northern Australia have been assessed in a number of studies which have simulated maize yields at different locations, for a range of planting times, for different tillage strategies and in comparison with sorghum (Cogle et al 1990, Carberry and Abrecht 1991, Muchow et al 1991). In this paper, we demonstrate, with a comparison between different maize cultivars, the utility of using a simulation model to assess risk to maize production in northern Australia.

METHODS

The maize model developed by Carberry and Muchow (unpubl. data, described by Carberry and Abrecht 1991) was used to simulate maize yields at Katherine NT over the period 1888/1988. Rainfall records for the 100 wet seasons were complete, but missing temperature and radiation data were generated using the method of McCaskill (1990). Agronomic conditions and values of input parameters used by the maize model were as described by Carberry and Abrecht (1991). Crops were planted conventionally at 70,000 plants/ha under non-limiting nutrient conditions on a soil with a plant extractable soil water content of 140 mm. Yields from two planting criteria were simulated: planting after 15 December and 1 January each year when 30 mm of rain occurred in a five day period.

The maize model was developed and tested principally around data collected for one cultivar, Dekalb XL82. Initial parameterisation of XL82 (Carberry et al 1989) used data from a 1983/84 experiment conducted at Katherine (Muchow, unpubl. data), which also included three other maize cultivars, Sargeant, Hycorn 9 and QK694. For this study, model predictions of phenology and grain yield for all cultivars were calibrated against this field data (Table 1). Yields were simulated for each of the four cultivars over the Katherine climatic record. Also included in the comparison is a hypothetical later maturing cultivar, "Late",

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with equivalent grain characteristics to XL82. Yield predictions for each cultivar are compared using mean values and cumulative probabilities, the level of which indicates the probability of achieving less than or equal to a specified yield value.

Table 1. Simulated duration (days) of cultivars between planting and maturity (P-M), planting and silking (P-S) and silking and maturity (S-M), averaged over 100 seasons and two planting criteria, and potential grain number/ear and grain growth rate (mg/d) used as inputs for each cultivar

	Duration				
Cultivar	P-M	P-S	S-M	Grain number	Grain growth rate
XL82	104	54	50	680	9.0
Sargeant	103	57	46	680	9.0
Hycorn 9	110	55	55	580	7.5
QK694	117	61	56	550	7.5
"Late"	120	59	61	680	9.0

RESULTS AND DISCUSSION

Rain-fed maize production at Katherine is risky, with predicted yields varying dramatically between seasons (Figure 1). For these situations, yield simulation provides a means of quantifying production risk by utilising the whole climatic record, whereas field experimentation is constrained to a relatively small number of sample years. The potential of maize at Katherine differed markedly between short runs of years; simulated mean yields for the periods 1958/1965 and 1973/1980 were 1,636 and 5,638 kg/ha respectively compared to 3,770 kg/ha for the complete period 1889/1988 (Figure 1). Low yields resulted from either poor crop establishment or soil water deficit, such that the mean yield potential of less than 4,000 kg/ha was considerablely less than the simulated potential for either irrigated maize or (assumed) well-established rain-fed maize at Katherine (compare with Muchow and Carberry, these proceedings).

Cultivar XL82, when simulated for Katherine under either planting criteria, performed better than the other commercial cultivars at all probability levels with the exception of the slightly higher yield potential of Hycorn 9 (Table 2). Despite its shorter maturity, the greater potential grain number and growth rate of XL82 (Table 1) resulted in higher grain yields than for the longer duration cultivars Hycorn 9 or QK694. Sargeant was of similar maturity to XL82, but XL82 had a longer potential grain filling period which was advantageous at Katherine. Variation in yields, measured using coefficient of variation (CV), was also lowest for XL82 compared to the other cultivars (Table 2). This comparison justifies XL82's preferred selection for maize grown at Katherine. Delayed planting until after 1 January, compared to after 15 December, resulted in lower yields and greater yield variability for all cultivars (Table 2). This result is related to more frequent occurrence of water deficit during grain filling. Planting earlier than 15 December results in severe problems with crop establishment (Carberry and Abrecht, 1991).

The large yield improvement of the notional "Late" cultivar over XL82 in good seasons (Table 2) would initially suggest some benefit from selection of a later maturing cultivar in this environment. However, this cultivar yielded worse than XL82 in 47% of seasons when planted after 15 December and was worse in more than 61% of seasons for the later planting criteria (Figure 2). Given these results, and the operational difficulties in early plantings, we conclude that little benefit would be gained from cultivars of later maturity than XL82 in this environment.

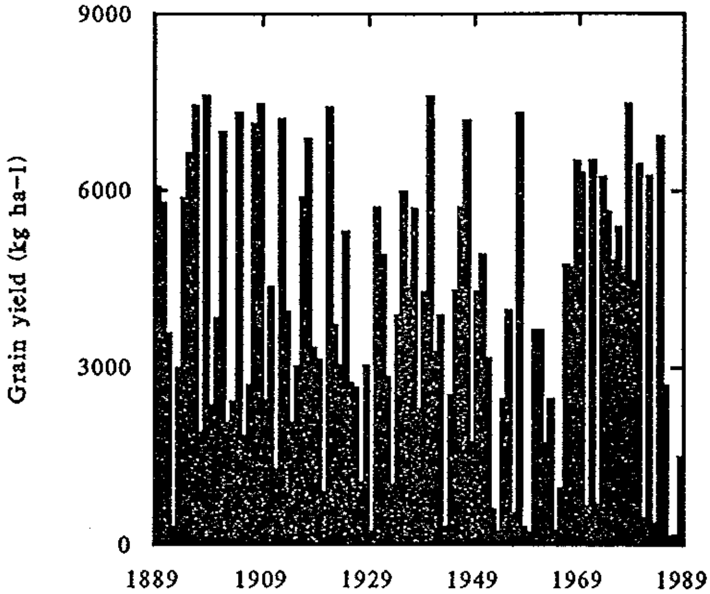

Figure 1. Simulated grain yield of cultivar XL82 from 1889 to 1988 when sown after 15 December when 30 mm of rain occurred in any five day period

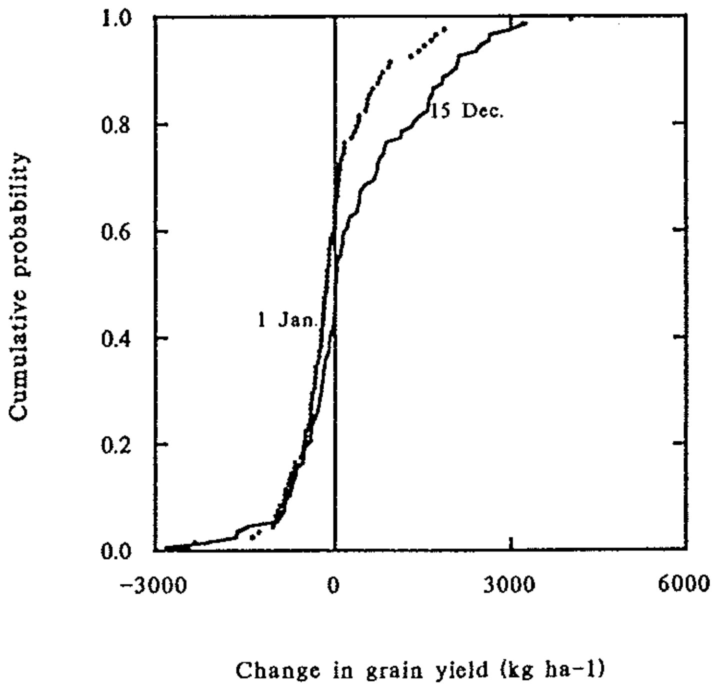

Figure 2. Cumulative distribution function for change in grain yield relative to cultivar XL82 for a later maturing cultivar when sown after either 15 December or 1 January

Table 2. Mean and CV (%), and quartile cumulative probabilities for grain yield (kg/ha dry weight) simulated for cultivars over 100 seasons with planting after either 15 December or 1 January when 30 mm of rain occurred in a five day period

			Cumulative Probability				
Cultivar	Mean	CV	0.00	0.25	0.50	0.75	1.00
Planting after 15 December							
XL82	3770	62	134	1920	3676	5838	7605
Sargeant	3578	63	120	1591	3441	5510	7644
Hycorn 9	3555	64	128	1836	3237	5449	7813
QK694	3214	68	0	1293	2991	4838	7597
"Late"	4108	72	0	1704	3688	6432	10237
Planting after 1 January							
XL82	3271	69	0	1360	3036	4876	7461
Sargeant	3076	73	0	1064	2831	4543	7576
Hycorn 9	3053	71	0	1255	2846	4455	7646
QK694	2612	83	0	558	2302	4062	7248
"Late"	3237	83	0	936	2726	5073	9654

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