The CERES-MAIZE model as a potential tool for drought assessment in South Africa

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Abstract

An index to characterise drought in such a way that policy makers will have an objective measure to declare areas drought-stricken and to implement subsidy schemes on a fair basis has been sought. The Palmer Drought Severity Index (PDSI) has been found wanting in this respect and more crop specific indices are at present under investigation. A methodology employing the CERES-MAIZE model to assess drought impacts on maize at an early stage in the season has been developed.

The model was verified using South African yield data collected at a wide variety of localities ranging in mean annual rainfall from 550 to 870 mm and in yield from 986 to 8 600 kg/ha. Model sensitivity to soil water parameters and planting dates was evaluated. The profile available water (PAW) capacity should preferably be known to within 50 mm to make a good assessment while planting dates as far apart as two full weeks gave similar results.

In order to develop a methodology for predicting yield response to drought during the course of the growing season, temperature and rainfall data were analysed on a monthly basis. The month in the historical record which gave a monthly value nearest the median value of the record was identified and used to synthesise a "median year". To assess the impact of early season weather on the crop yield attained in a given season, the model was run with actual weather data up to a given date after which the median year's data were used for the remainder of the growing season. Excellent correlations were found between yield predictions based on the use of observed early season data (up to as early as the end of January) in combination with median data for the remainder of the season and yield predictions based on observed data over the entire season.

Introduction

Recent research has aimed at producing an index to characterise drought in such a way that policy makers will have an objective measure to declare areas drought-stricken and to implement subsidy schemes on a fair basis. A test of the index developed by Palmer (1965) in the USA initially appeared promising (Booysen, 1981), but later (during the winter of 1983) indicated an inability of the index values to correctly assess drought in the winter rainfall region.

Drought should be distinguished from aridity. Aridity is a characteristic of the climate of the region, i.e. there is generally a lack of rainfall and the vegetation and farming enterprises have (or should have) adapted to this natural aridity. Drought, on the other hand, is an abnormal condition caused primarily by below-normal rainfall or poor distribution of rainfall (or both). Drought is not only determined by the extent of the rainfall deficiency, but also by the duration of the deficit and the modification of the impact by the type of crop and the soil characteristics.

While some approaches use rainfall data only to describe drought, most approaches use some form of soil moisture balance which addresses the problem of rainfall distribution, crop type and soil type to a greater or lesser degree. The Palmer (1965) index uses a single index value to describe drought. It is improbable that a single index will suffice for describing drought conditions pertaining to dryland agriculture in South Africa because of the diversity of crops and possible growing seasons. A better approach would be to develop a series of crop-specific indices, which together would provide an assessment that would be more representative of agricultural drought in South Africa.

This paper discusses some initial results yielded by an alternative approach deriving a crop-specific drought index for maize which is representative of dryland summer grain crops.

Method

As a point of departure in the development of a methodology to assess real-time impacts of drought on maize yield the CERES-MAIZE model of Ritchie (1985) was selected. The CERES model is the most highly rated and used model in the USA. This model needs daily values of rainfall, maximum and minimum temperatures and solar radiation. Solar radiation data are usually not available at most weather stations, but this problem can be overcome by generating synthetic radiation data using the Richardson weather generator together with freely available temperature and rainfall data, according to the method of Hodges, French and Le Duc (1985).

Firstly it was necessary to validate the CERES model with South African data. During the 1983/84 season the same maize cultivar was planted by the Summer Grain Centre of the Department of Agriculture and Water Supply at places climatologically as different as Bloemfontein, Cedara, Potchefstroom and Bethlehem. Soil, phenological, planting density and yield data were made available by Mottram (Mottram, 1985). The CERES model also requires genetic information pertaining to the maize hybrid planted. Although only rough estimates were included in the original data set provided, it was possible to "construct" a set of genetic parameters in order to obtain good correspondence between observed and simulated phenology and yield (for yield r = 0,99 over a range of 986 to 8 600 kg/ha; mean difference between observed and calculated flowering dates was less than 3 d). This hypothetical hybrid (described by the calibrated parameter values) was used in all subsequent runs of the CERES model. The ability of the model to simulate both yield and phenology under South African conditions and its widespread use among the modelling fraternity gave the author confidence in using it further.

For operational use of the CERES model for regional drought impact assessment it is very important to know how changes in PAW-value and planting date would affect the assessment of the impact of any season's weather on yield and consequently a study was done to assess the importance of these

TABLE 1
CORRELATION OF YIELD ESTIMATES WITH THE CERES-MAIZE MODEL FOR DIFFERENT PAW-VALUES

Weather Station	Planting Date	PAW-value for Yield Comparison (mm)					
		50/100	50/150	50/210	100/150	100/210	150/210
Potchefstroom	1 Nov	0,008	0,24	−0,13	−0,02	0,58	0,16
	15 Nov	0,58	0,56	0,49	0,95	0,60	0,75
	1 Dec	0,48	0,44	0,32	0,90	0,50	0,78
	15 Dec	0,71	0,59	0,51	0,93	0,72	0,86
	PD 1	0,63	0,59	0,41	0,83	0,51	0,80
	PD 2	0,55	0,42	0,24	0,86	0,58	0,84
Cedara	1 Oct	0,53	0,41	0,23	0,93	0,63	0,77
	15 Oct	0,52	0,38	0,26	0,92	0,63	0,82
	1 Nov	0,48	0,30	0,09	0,93	0,59	0,74
	15 Nov	0,48	0,27	0,04	0,88	0,57	0,81
	PD 1	0,65	0,49	0,21	0,92	0,62	0,81
	PD 2	0,50	0,37	0,16	0,94	0,63	0,97
Glen	1 Nov	0,51	0,70	0,69	0,88	0,65	0,84
	15 Nov	0,58	0,57	0,57	0,97	0,90	0,96
	1 Dec	0,67	0,67	0,66	0,96	0,88	0,97
	15 Dec	0,72	0,70	0,56	0,85	0,62	0,85
	PD 1	0,61	0,55	0,50	0,96	0,78	0,88
	PD 2	0,76	0,73	0,70	0,96	0,86	0,95
Nooitgedacht	1 Oct	0,54	0,54	0,41	0,92	0,70	0,86
	15 Oct	0,47	0,49	0,47	0,95	0,81	0,93
	1 Nov	0,54	0,54	0,41	0,92	0,70	0,86
	15 Nov	0,29	0,35	0,36	0,96	0,76	0,86
	PD 1	0,34	0,40	0,35	0,92	0,68	0,88
	PD 2	0,42	0,48	0,42	0,92	0,71	0,87
Bethlehem	15 Oct	0,48	0,37	0,18	0,94	0,75	0,87
	1 Nov	0,39	0,39	0,36	0,94	0,78	0,92
	15 Nov	0,28	0,33	0,30	0,92	0,76	0,90
	1 Dec	0,34	0,32	0,19	0,83	0,61	0,90
	PD 1	0,54	0,47	0,28	0,94	0,73	0,89
	PD 2	0,38	0,35	0,24	0,92	0,73	0,89

parameters. Correlation coefficients were determined of simulated yields (for 30 growing seasons up to the 1983/84 season) for different PAW-values and planting dates. The model was run in the continuous mode for 32 seasons to allow calculation of the carry-over of soil moisture from the one season to the next. By discarding the first two seasons' yield data the problem of estimating the initial soil moisture value for the first season was avoided since by the third season a stable initial soil moisture value had been simulated. The model was run for five stations which represented a wide range of climatic conditions in the maize-growing area of the RSA. These were Potchefstroom, Glen, Cedara, Nooitgedacht (Ermelo) and Bethlehem.

The model runs were done for fixed planting dates for each year spaced around those planting dates considered to be the optimum for each of the five locations and also planting dates (labels PD1 and PD2) which emulate those dates which would be chosen by those farmers who waited for the spring rains to prepare the seedbed and then plant (PD1) or those who used the second good rains (25 mm or more in 5 d) to prepare the seedbed and plant (PD2).

In Table 1 the results of the comparison are given where the impact of weather variability from year to year is assessed for maize planted on soils with different PAW-values ranging from 50 to 210 mm. In Table 2 the comparisons between different planting dates are given for the same four PAW-values, i.e. 50, 100, 150 and 210 mm.

From Table 1 it would seem that the yield expected with a PAW-value of 50 mm does not follow the same temporal pattern as that when the PAW-value is 100 mm or more. Once the PAW-value is 100 mm or more, the impact of seasonal weather on expected yield seems to stabilise somewhat, although differences still occur. The first impression when studying Table 2 is that the yield estimate seems to be less sensitive to differences in planting date than to PAW-values, although it is difficult to establish what variations in PAW and planting date would produce an equivalent impact on yield. It seems that ± 15 d around the "best" planting date does not interfere too much with an assessment. The PAW-value also does not seem to play a large role in determining the sensitivity to planting dates. As can be expected, the varying planting dates, PD1 and PD2, are correlated best with the earlier and later fixed planting dates, respectively.

It is of some use to be able to calculate the expected maize yield once the full growing season has elapsed, but more often it is required that an assessment of the current weather's impact be made as early as possible during the current growing season. It is therefore necessary to "run out" the growing season with daily meteorological data which is characteristic of the particular area.

According to Hodges (1985) it is not advisable to use the average value for each day on a day-by-day basis, since this leads to inflated yields due to the fact that the average daily rainfall used will mask the vagaries of rainfall distribution and will in effect contribute a small amount of rainfall every day. The following

TABLE 2
CORRELATION OF YIELD ESTIMATES WITH THE CERES-MAIZE MODEL FOR DIFFERENT PLANTING DATES

Weather Station	Planting Dates Compared	Correlations for different PAW values			
		50	100	150	210
Potchefstroom	1 Nov/15 Nov	0,19	0,82	0,02	0,87
	1 Nov/1 Dec	0,26	0,49	0,01	0,63
	1 Nov/15 Dec	0,15	0,50	0,19	0,64
	1 Nov/PD 1	0,25	0,80	-0,10	0,87
	1 Nov/PD 2	0,38	0,49	0,01	0,63
	15 Nov/1 Dec	0,79	0,75	0,66	0,72
	15 Nov/15 Dec	0,71	0,66	0,71	0,74
	15 Nov/PD 1	0,62	0,80	0,74	0,81
	15 Nov/PD 2	0,83	0,71	0,65	0,73
	1 Dec/15 Dec	0,86	0,74	0,85	0,88
	1 Dec/PD 1	0,71	0,63	0,60	0,69
	1 Dec/PD 2	0,90	0,72	0,77	0,83
	15 Dec/PD 1	0,67	0,63	0,64	0,68
	15 Dec/PD 2	0,80	0,70	0,78	0,84
	PD 1/PD 2	0,69	0,76	0,80	0,82
Cedara	1 Oct/15 Oct	0,81	0,89	0,88	0,91
	1 Oct/1 Nov	0,68	0,79	0,76	0,81
	1 Oct/15 Nov	0,66	0,69	0,70	0,72
	1 Oct/PD 1	0,74	0,91	0,82	0,91
	1 Oct/PD 2	0,78	0,84	0,82	0,88
	15 Oct/1 Nov	0,80	0,87	0,90	0,87
	15 Oct/15 Nov	0,83	0,73	0,77	0,71
	15 Oct/PD 1	0,73	0,95	0,94	0,89
	15 Oct/PD 2	0,90	0,93	0,95	0,91
	1 Nov/15 Nov	0,81	0,87	0,84	0,76
	1 Nov/PD 1	0,67	0,86	0,90	0,86
	1 Nov/PD 2	0,85	0,94	0,93	0,93
	15 Nov/PD 1	0,67	0,72	0,77	0,68
	15 Nov/PD 2	0,88	0,83	0,80	0,72
	PD 1/PD 2	0,81	0,81	0,95	0,92
Glen	1 Nov/15 Nov	0,64	0,78	0,82	0,86
	1 Nov/1 Dec	0,68	0,62	0,75	0,84
	1 Nov/15 Dec	0,50	0,29	0,60	0,71
	1 Nov/PD 1	0,64	0,33	0,23	0,32
	1 Nov/PD 2	0,71	0,55	0,61	0,59
	15 Nov/1 Dec	0,61	0,80	0,81	0,83
	15 Nov/15 Dec	0,42	0,47	0,63	0,57
	15 Nov/PD 1	0,66	0,41	0,42	0,46
	15 Nov/PD 2	0,58	0,66	0,63	0,59
	1 Dec/15 Dec	0,90	0,59	0,67	0,67
	1 Dec/PD 1	0,56	0,25	0,27	0,30
	1 Dec/PD 2	0,80	0,77	0,73	0,68
	15 Dec/PD 1	0,33	0,10	0,11	0,17
	15 Dec/PD 2	0,75	0,74	0,74	0,68
	PD 1/PD 2	0,66	0,47	0,48	0,46
Nooitgedacht	1 Oct/15 Oct	0,85	0,89	0,92	0,96
	1 Oct/1 Nov	0,69	0,70	0,74	0,88
	1 Oct/15 Nov	0,54	0,62	0,65	0,71
	1 Oct/PD 1	0,73	0,88	0,92	0,93
	1 Oct/PD 2	0,60	0,79	0,83	0,88
	15 Oct/1 Nov	0,84	0,87	0,90	0,91
	15 Oct/15 Nov	0,62	0,79	0,81	0,76
	15 Oct/PD 1	0,82	0,89	0,91	0,93
	15 Oct/PD 2	0,75	0,93	0,91	0,91
	1 Nov/15 Nov	0,85	0,90	0,93	0,87
	1 Nov/PD 1	0,86	0,70	0,77	0,90
	1 Nov/PD 2	0,96	0,88	0,88	0,91
	15 Nov/PD 1	0,70	0,56	0,68	0,82
	15 Nov/PD 2	0,88	0,80	0,82	0,85
	PD 1/PD 2	0,79	0,81	0,85	0,92
Bethlehem	15 Oct/1 Nov	0,70	0,80	0,82	0,79
	15 Oct/15 Nov	0,71	0,61	0,62	0,54
	15 Oct/1 Dec	0,76	0,42	0,55	0,44
	15 Oct/PD 1	0,85	0,90	0,89	0,90
	15 Oct/PD 2	0,10	-0,22	-0,12	-0,17
	1 Nov/15 Nov	0,90	0,90	0,88	0,80
	1 Nov/1 Dec	0,88	0,71	0,73	0,61
	1 Nov/PD 1	0,73	0,85	0,84	0,77
	1 Nov/PD 2	0,12	-0,30	-0,23	-0,25
	15 Nov/1 Dec	0,86	0,84	0,84	0,75
	15 Nov/PD 1	0,72	0,68	0,66	0,53
	15 Nov/PD 2	0,09	-0,25	-0,17	-0,11
	1 Dec/PD 1	0,78	0,43	0,50	0,39
	1 Dec/PD 2	0,10	-0,22	-0,25	-0,34
	PD 1/PD 2	0,17	-0,17	-0,12	-0,12

scheme was followed to try to overcome this difficulty:

● The long-term climate for each of the locations uséd in this study was analysed on a monthly basis and various percentile values of probability were determined.

● For each weather element and each month, that year which produced the value nearest to the median value (50th percentile) was determined.

● For each weather element a median year was constructed using the month and year which coincided with the median value, e.g. rainfall for Potchefstroom is January, 1939; February, 1969; March, 1981; April, 1970; May, 1971; June, 1955; July, 1967; August, 1952; September, 1974; October, 1924; November, 1979 and December, 1936.

The five locations reflected in Tables 1 and 2 were used to study the effect of replacing part of the growing season's weather with data from this median year. It was decided to see whether it would be possible to assess climatic impact at the ends of the months December, January and February using the CERES-MAIZE model.

The same 30-year period was used as before and the current season's weather data were replaced with the median year's data for the months of:

● January to May;

● February to May;

● March to May; and

the yields calculated by the CERES-MAIZE model and the 30-year records of yields correlated in each case with the yields obtained with the full season's weather data. Planting dates and PAW-values were the same as before.

In Table 3 the correlation coefficients are given for the yields calculated for the 30 seasons 1954/55 to 1983/84 simulating assessments at the end of the months December, January and February and the calculated yields using the full season's weather data.

The data in Table 3 suggest that for four of the five locations used in this study, a good assessment can be made (r = 0,7 or more) at the end of February, and in most cases even at the end of January. The only location which seems way out of line is Cedara (Table 3b) where correlation coefficients are very low. This phenomenon was studied in some depth because one of the features of the assessment yield was the zero yields which were consistently calculated for the last four seasons. A new set of assessments was made substituting only the months until April instead of May so that less of the median year's data were used in calculating the carry-over of moisture from the one season to the next. It should be borne in mind that, due to time constraints while doing this study during a visit to the USA, the simulated assessments are not true representations of an actual assessment, since blocks of five, four or three months data were replaced by median data in every year and used as such, instead of actual data up till the assessment year and median data only from the assessment month onwards. Table 3(c) shows little improvement over 3(b) but subsequently the Cedara data were rerun doing the assessment as it would be done in real time using actual data for all seasons up to the assessment date and median data from that

month onwards. The results are given in Table 3(g) and show a marked improvement. It is encouraging that the method suggested seems to do well over a wide range of climatic conditions, especially in the OFS and Transvaal. This is a much simpler approach than that used by Dugas in Texas (Dugas *et al.*, 1983) and the NOAA group at Columbia, Missouri (CIAM, 1985) during the 1985 growing season for the US Corn Growers Association. The method used by Dugas would necessitate at least thirty ''run-out'' years to establish limits of confidence, while the NOAA approach necessitates a separate study to establish seasons with weather patterns similar to that of the current season and running out the simulation with each of these seasons to give a range of expected yields. This is something which might be worth

TABLE 3(a)

CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Potchefstroom				
		Planting Date				
		15 Nov	1 Dec	15 Dec	PD 1	PD 2
50	December	0,22	0,51	0,62	0,13	0,33
	January	0,92	0,84	0,66	0,97	0,88
	February	0,98	0,99	0,96	0,99	0,996
100	December	0,46	0,48	⌐ 0,43	0,42	0,27
	January	0,95	0,79	0,74	0,87	0,85
	February	0,97	0,97	0,91	0,91	0,95
150	December	0,38	0,36	0,39	0,19	0,22
	January	0,94	0,79	0,75	0,79	0,75
	February	0,96	0,88	0,92	0,82	0,86
210	December	0,22	0,19	0,37	0,15	0,12
	January	0,68	0,58	0,61	0,75	0,66
	February	0,80	0,76	0,84	0,84	0,85

TABLE 3(b)

CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Cedara					
		Planting Date					
		1 Oct	15 Oct	1 Nov	15 Nov	PD 1	PD 2
50	December	0,01	0,17	0,13	0,32	0,05	0,09
	January	−0,01	0,12	0,13	0,31	0,04	0,07
	February	−0,02	0,23	0,23	0,39	0,09	0,15
100	December	0,15	0,08	0,01	−0,06	−0,03	−0,01
	January	0,10	0,12	0,01	−0,08	−0,06	−0,03
	February	0,13	0,12	−0,02	−0,04	−0,05	−0,03
150	December	0,12	0,20	−0,04	0,03	0,10	0,12
	January	0,13	0,22	0,10	0,01	0,13	0,10
	February	0,09	0,21	0,06	0,01	0,10	0,09
210	December	0,28	0,41	0,29	0,23	0,35	0,35
	January	0,31	0,41	0,29	0,24	0,37	0,36
	February	0,20	0,39	0,30	0,23	0,34	0,35

TABLE 3(c)
CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA
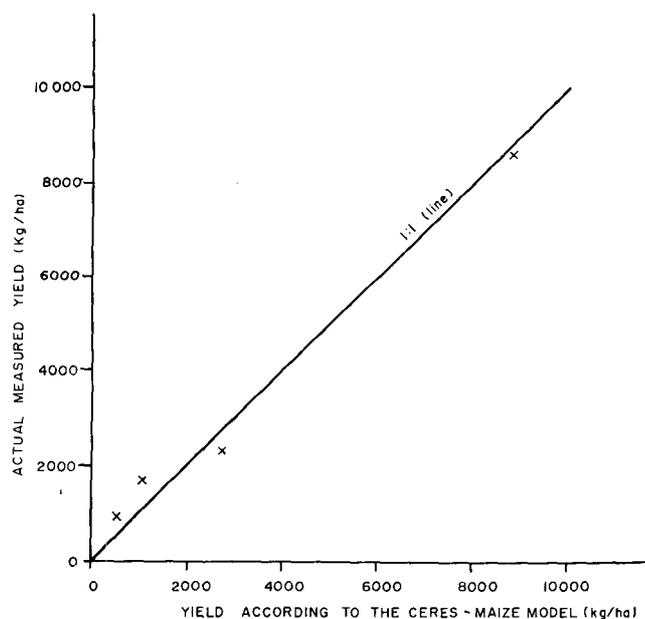
PAW (mm)	Assessment End of:	Locality: Cedara (April) Planting Date					
		1 Oct	15 Oct	1 Nov	15 Nov	PD 1	PD 2
50	December	0,02	0,24	0,19	0,28	0,07	0,25
	January	−0,02	0,10	0,12	0,36	0,04	0,15
	February	−0,04	0,10	0,02	−0,01	0,10	0,01
100	December	0,14	0,08	0,03	+0,02	0,07	0,05
	January	0,17	0,13	0,01	−0,02	0,08	0,01
	February	0,16	0,14	0,02	−0,01	0,10	0,01
150	December	0,08	0,17	0,10	0,09	0,13	0,18
	January	0,12	0,21	0,09	0,02	0,12	0,11
	February	0,11	0,21	0,10	0,04	0,12	0,10
210	December	0,30	0,40	0,33	0,24	0,39	0,39
	January	0,30	0,41	0,28	0,23	0,37	0,35
	February	0,28	0,41	0,29	0,22	0,34	0,34

TABLE 3(e)
CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Nooitgedacht Planting Date					
		1 Oct	15 Oct	1 Nov	15 Nov	PD 1	PD 2
50	December	0,79	0,85	0,80	0,75	0,81	0,80
	January	0,93	0,92	0,86	0,79	0,91	0,81
	February	0,97	0,99	0,98	0,96	0,96	0,97
100	December	0,43	0,18	0,01	−0,05	0,36	0,18
	January	0,83	0,75	0,65	0,52	0,73	0,64
	February	0,97	0,93	0,88	0,85	0,88	0,87
150	December	0,56	0,33	0,15	0,06	0,43	0,29
	January	0,87	0,75	0,62	0,53	0,73	0,59
	February	0,96	0,92	0,84	0,83	0,83	0,82
210	December	0,43	0,47	0,45	0,33	0,43	0,55
	January	0,85	0,86	0,74	0,56	0,74	0,69
	February	0,93	0,95	0,87	0,77	0,86	0,85

TABLE 3(d)
CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Glen Planting Date					
		1 Nov	15 Nov	1 Dec	15 Dec	PD 1	PD 2
50	December	0,74	0,75	0,42	0,36	0,63	0,26
	January	0,77	0,81	0,69	0,76	0,70	0,52
	February	0,99	0,99	0,94	0,93	0,95	0,83
100	December	0,30	0,60	0,54	−0,01	0,48	0,55
	January	0,88	0,79	0,72	0,26	0,74	0,57
	February	0,97	0,97	0,93	0,73	0,85	0,83
150	December	0,50	0,55	0,56	0,26	0,54	0,48
	January	0,67	0,74	0,81	0,50	0,72	0,65
	February	0,95	0,95	0,90	0,76	0,86	0,80
210	December	0,59	0,56	0,67	0,33	0,53	0,53
	January	0,53	0,70	0,77	0,39	0,59	0,60
	February	0,85	0,89	0,86	0,58	0,82	0,77

Figure 1
Scatter diagram of actual and modelled yields

following up at a later stage, but which is beyond the scope of the present study.

Conclusion

The CERES-MAIZE model, used with an appropriate set of standardised genetic parameter values (see Table 4) proved capable of accurate simulation of observed maize yields for a given season over a wide range of climatic conditions in South Africa and therefore lends itself most promisingly to the assessment of drought impacts on maize production. (See Figure 1 for a scatter diagram of actual and simulated yields).

The model suggests a considerable measure of yield sensitivity to values of plant available water capacity in the soil; thus careful thought would have to be given to the choice of appropriate values when using the model for regional drought assessment.

Yield appears to be less sensitive to planting date, the choice of which does not appear to be too critical as long as it is within a fortnight of the actual date.

From preliminary results, the impact of drought on maize

TABLE 3(f)

CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Bethlehem					
		Planting Date					
		15 Oct	1 Nov	15 Nov	1 Dec	PD 1	PD 2
50	December	0,93	0,84	0,84	0,83	0,92	0,23
	January	0,99	0,95	0,91	0,90	0,99	0,12
	February	0,999	0,996	0,99	0,93	0,998	0,16
100	December	0,69	0,47	0,29	0,34	0,45	0,24
	January	0,98	0,95	0,85	0,65	0,96	−0,03
	February	0,98	0,96	0,89	0,87	0,97	−0,17
150	December	0,72	0,67	0,49	0,39	0,61	0,33
	January	0,94	0,93	0,83	0,66	0,94	0,01
	February	0,96	0,96	0,91	0,81	0,96	−0,08
210	December	0,72	0,54	0,55	0,23	0,47	0,38
	January	0,89	0,84	0,68	0,50	0,89	0,15
	February	0,92	0,90	0,84	0,72	0,92	0,08

TABLE 3(g)

CORRELATION BETWEEN CALCULATED YIELDS FOR SIMULATED ASSESSMENTS AT THE END OF DECEMBER, JANUARY AND FEBRUARY WITH CALCULATED YIELDS USING THE WHOLE SEASON'S DATA

PAW (mm)	Assessment End of:	Locality: Cedara (May, Realistic Simulation)					
		Planting Date					
		1 Oct	15 Oct	1 Nov	15 Nov	PD 1	PD 2
50	December	0,72	0,43	0,62	0,47	0,68	0,54
	January	0,83	0,63	0,80	0,70	0,77	0,74
	February	0,79	0,49	0,80	0,69	0,73	0,62
100	December	0,64	0,37	0,35	−0,03	0,37	0,46
	January	0,76	0,77	0,66	0,35	0,66	0,72
	February	0,77	0,77	0,77	0,48	0,73	0,78
150	December	0,56	0,31	0,37	0,01	0,27	0,52
	January	0,69	0,68	0,72	0,23	0,57	0,73
	February	0,70	0,78	0,78	0,46	0,68	0,79
210	December	0,41	0,30	0,38	−0,06	0,43	0,48
	January	0,49	0,57	0,50	−0,02	0,47	0,57
	February	0,56	0,67	0,64	0,30	0,55	0,61

TABLE 4

GENETIC PARAMETERS USED IN THE CERES-MAIZE MODEL RUNS

P1 = 168,0
P2 = 0,0
P5 = 525
G2 = 18,0
G3 = 6,6

yield should be predictable to within acceptable limits up to four months prior to harvest (assuming harvest takes place at the end of June) using the median year method to run out the current season.

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