Effect of climate variability on frequency of sorghum ergot outbreaks in Australia

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Abstract

A method was developed to use historical weather data from 53 locations throughout the sorghum growing areas of Australia to analyse likely outbreak events of sorghum ergot with climate variability. The five SOI phases were used for probabilistic forecasting of the frequency of such events. Results showed that the number of potential events varied strongly depending on time of the year and locations. For a given location, there were significant differences in the probability of exceeding the median number of potential monthly events between different SOI phases.

Key Words

Sorghum ergot, event frequency, climate variability, modelling

Introduction

The significant impact of the ovary disease, sorghum ergot caused by *Claviceps africana* Frederickson, Mantle & deMilliano, on the Australia sorghum industry has led to considerable research on the biology, epidemiology and management of the disease (Wang et al., 2000a; Ryley et al., 2001). A previous climatic analysis indicated that there were increasing gradients of potential ergot events in eastern Australia from south to north as well as from west to east between December and March. Later in the growing season (April to May) the number of potential monthly events increased, particularly in the southern areas (Wang et al., 2000b). In this paper we report on the effect of climate variability, based on Southern Oscillation Index (SOI) phases, on the number of potential ergot events during the year. The analysis was conducted using the methodology of Wang et al. (2000b) for the prediction of ergot events for different phases of the SOI (Stone et al., 1996).

Methods

Long-term historical climatic data from 01/01/1887 to 30/05/1998 at 53 localities throughout the sorghum growing areas of Australia were used for ergot prediction and SOI phases. No humidity or vapour pressure data were available for these long term climate records, so the relative humidity component in the prediction rules developed by Wang et al. (2000b) was replaced with daily maximum vapour pressure deficit (VPD, hPa). VPD was estimated using daily maximum (T_x) and minimum (T_m) temperature (?C) based on the relationship between temperature and saturated vapour pressure as proposed by Goudriaan and van Laar (1994) (Eq. 1). This calculation assumes that the daily minimum temperature equals dew point and that the dew point does not change during any one day.

$$VPD = 6.107\left(e^{\frac{17.4Tx}{239+Tx}} - e^{\frac{17.4Tm}{239+Tm}}\right) \quad (1)$$

where T_x and T_m are daily maximum and minimum temperature (?C) respectively. The stages of sorghum development, which are critical in ergot epidemiology (start and duration of the flag leaf stage and flowering), and the ergot infection factor were simulated according to Wang et al (2000a,b). A threshold of VPD<1800hPa was selected because it gave similar predictions when substituted for the relative humidity factor in the original ergot risk analysis (2000b).

For the prediction of ergot outbreaks, the following conditions had to be met before it was deemed likely that an ergot outbreak could occur:

a. The mean of daily maximum VPD during flowering was less than 1800hPa.

b. The mean infection factor during flowering was >0.30 for male-fertile sorghum and >0.05 for male-sterile sorghum.

If the mean daily minimum temperature during the flag leaf stage was less than 13?C male sterility in hybrid grain sorghum was assumed to occur. For each selected location, the calculated potential number of daily events using the above method was accumulated every month to determine the total number of monthly events in each year. Based on the SOI phases (Stone et al., 1996) in the previous month, all months in the 111 years were separated into 5 classes as follows:

a. Months with SOI consistently negative in the previous month (phase 1)

b. Months with SOI consistently positive in the previous month (phase 2)

c. Months with SOI rapidly falling in the previous month (phase 3)

d. Months with SOI rapidly rising in the previous month (phase 4)

e. Months with SOI consistently near zero in the previous month (phase 5)

The median number of potential monthly events and the probability of exceeding a certain number of events for each month with each of the SOI phases in the previous month was then calculated.

Results

The effect of the SOI phase on the number of potential events differed strongly in different months of the year, and between locations. With a SOI phase 1 in the previous month, the probability of exceeding the median number of potential monthly events (PEME) was lower than 50% for almost all locations every month from October to February. In March, PEME at most locations in New South Wales was higher than 60%. In April, some coastal regions in Queensland had a PEME>50% with a PEME<50% in all other regions. In May, PEME in east Queensland and north New South Wales was > 60-75%, compared with very low values (<15%) in north Queensland and south New South Wales.

With an SOI phase 2 in the previous month, the PEME was much higher than that with an SOI phase 1 at all locations, for all months except in May. This result implies that a higher ergot risk would be expected in the next month if the SOI phase were consistently positive in the current month, especially from August to October. At most locations from December to March, when the most commercial sorghum are flowering, an SOI phase 2 in the previous month could result in the highest ergot risk than that from the other SOI phases.

With an SOI phase 3 in the previous month, the PEME was, for most locations, intermediate between the PEME with a SOI phase 1 and 2 for all months except November. In that month, the PEME in coastal Queensland and New South Wales was the highest (>60%). With SOI phases 4 or 5 in the previous month, the PEME was similar except that the PEME in the coastal regions of Queensland during March and August was higher with SOI 4 than SOI 5.

Conclusion

The number of potential events that are conducive to ergot outbreaks in any particular year differed greatly, depending on the season type. In general a positive or rising SOI in the previous month tended to result in a higher number of potential events. However, this varies depending on the time of year and the geographic location. Clearly climate variability plays an important role for ergot outbreaks. There appears to be some potential to probabilistically forecast the risk of such events occurring, based on phases on Southern Oscillation index.

References

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