before anthesis may be related to rapid anther dehiscence. A relationship between mean minimum temperatures 5-9 days before anthesis and pollen production also exists, but the cause of this relationship is not clear. The relationships between pollen production, maximum relative humidity and precipitation suggests that significant rainfall during panicle development increases pollen production.

Conclusions

The models developed in this study may be useful for predicting male fertility characteristics under environmental conditions that commonly occur on the Central Great Plains of the US. Previous studies have evaluated the effects of cool temperature stress, high humidity and rainfall on male fertility; however, only a few studies have evaluated the effects of high temperature and drought stress on these traits. Heat and drought stress are much more common than cool temperature stress in most sorghum-producing environments. These models should provide some guidance for predicting male fertility responses of sorghum under hot dry conditions.

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Timing of Anthesis in the Sorghum Hybrid MR Buster and the Elite Line 31945-2-2

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Introduction

The flowering biology of sorghum [*Sorghum bicolor* (L.) Moench] is an important factor in hybrid seed production. A possible resistance mechanism to sorghum midge [*Stenodiplosis sorghicola* (Coquillett)] consists of resistant genotypes completing their daily flowering before sorghum midge begin ovipositing (Diarisso 1997). Flowering biology is important in interactions with sorghum ergot (caused worldwide by three species of *Claviceps*), because a successfully pollinated spikelet is no longer able to be infected by ergot (Bandyopadhyay et al. 1998). Additionally, both Frederickson et al. (1993) and Ryley (personal communication) have trapped airborne conidia of *C. africana* and found peak conidial release occurred during daylight hours. Flowering outside this period may result in avoidance of peak times of airborne spores.

Preliminary studies were undertaken to determine the nature of flowering in two sorghum genotypes, sorghum midge-resistant MR Buster® (Pacific Seeds Australia Pty Ltd), a sorghum hybrid grown widely in Australia, and 31945-2-2, an elite inbred line used in the sorghum breeding program of the Department of Primary Industries.

Materials and Methods

In January 2001, preliminary experiments were conducted in a controlled environment cabinet (12 h photoperiod; day/night temperature 26°C/21°C; relative humidity 70%) to simulate mid-summer conditions in Australia. Because of space limitations, plants were grown in a glasshouse until the flag-leaf stage, and then moved into the controlled environment cabinet. The timing of the cabinet day-night cycle was set the same as the glasshouse to avoid potentially interfering with the true flowering behavior.

A preliminary investigation was conducted to determine the best method of observing flowering behavior, therefore the results on these nights are not presented. On the other nights, insufficient numbers of spikelets flowered to interpret flowering behavior. The data presented in this paper is a composite of the flowering behavior of each genotype during two nights.

Observations were made on the flowering behavior on individual spikelets, so on the afternoon before each of the nights, several rachis branches were tagged in that part of the panicle that were expected to flower. Spikelets that had previously flowered were removed. The handling of panicles was minimized and the target spikelets were not touched, because any disturbance was found to artificially stimulate flowering.

Observations were taken hourly from 0100h to 0800h. The flowering stage of each spikelet was assessed at hourly intervals, using the following six categories [modified from the 10-stage scale of Ayyangar and Rao (1931)]:

FS1: Glumes begin to open
FS2: Staminal column visible
FS3: Stamens separate
FS4: Anthers tilt down, and then become pendent
FS5: Glumes begin to close
FS6: Glumes completely closed

A number of spikelets at flowering stages 1 through 5 were combined to determine the percentage of spikelets that had commenced flowering but not finished. Flowering stage 6 is presented separately as the percentage of spikelets that had completed flowering.

Both the number of spikelets assessed per panicle and the number of panicles per night varied because of the availability of flowering material and limitations in the number of spikelets that could be assessed at any one time. Not all spikelets on all marked panicles flowered within the period of observation. The total numbers of assessed spikelets were 291 for MR Buster* and 133 for 31945-2-2.

Results and Discussion

MR Buster® started flowering from 0100-0300h (Fig.1). All spikelets that flowered that night opened in this two-hour period, gradually closed during the next five hours. More than 90% of the spikelets had closed by 0600h.

By contrast, the line 31945-2-2 started flowering before 0100h (Fig. 1), and less than 10% had closed by 0800h. Although the end of flowering (stage FS6) was not observed for this line it is possible that these flowers would still be open for some time after ()8()0h.

Analysis of the flowering data using ANOVA (Genstat v6) found highly significant differences between the genotypes for flowering hour, as well as highly significant interactions for both beginning and end of

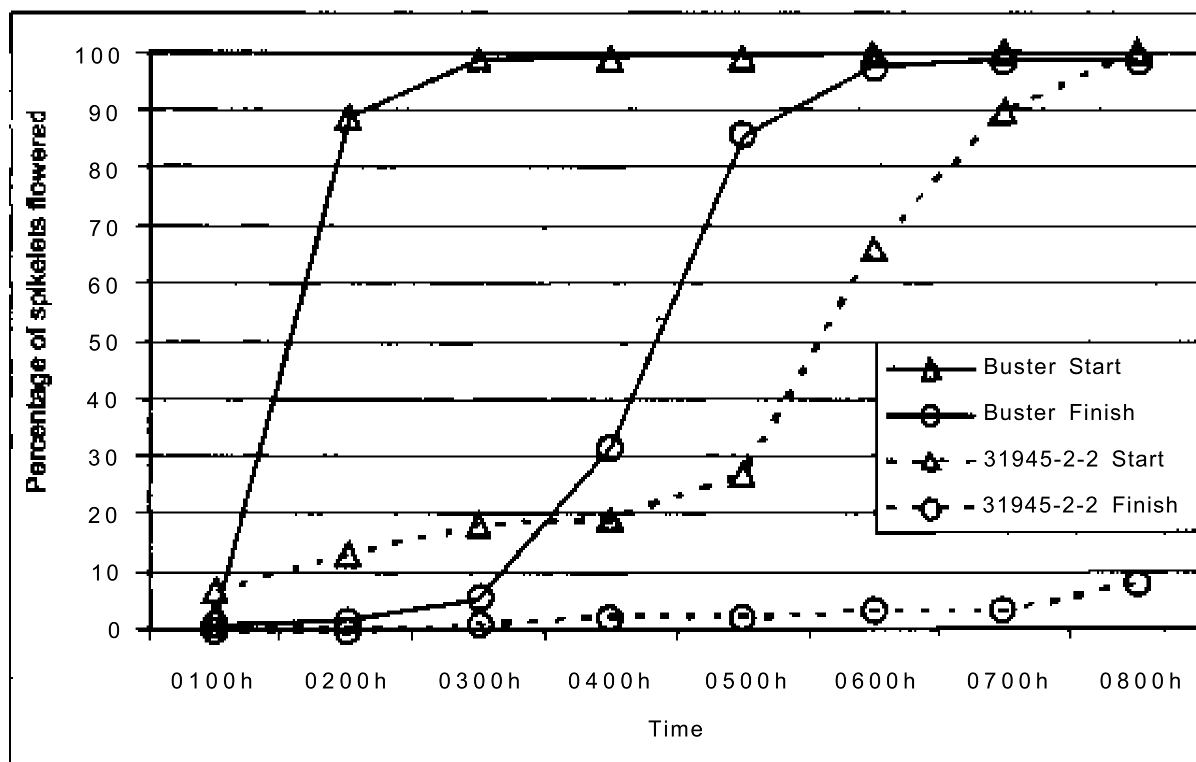

Figure 1. Average hourly percentage of flowering spikelets (FS1-5) and spikelets that had finished flowering (FS6) for two sorghum genotypes.

flowering time. These results indicated that the flowering behavior of the two genotypes over time were markedly different.

In a separate study more than 75% of the pollen grains of MR Buster® were trapped between 0300h and 1000h during the Australian mid-summer (MJ Ryley, unpublished data), which corroborates the Findings of these experiments. In the controlled environment cabinet, anther dehiscence was generally observed after the anthers had been completely exserted, at FS4. This stage corresponds to a pollen peak occurring from 0200 to 0400h for MR Buster® under the conditions of the experiments. There would theoretically be a less obvious pollen peak for 31945-2-2, which commenced flowering during a much longer period.

The results of this investigation demonstrate that flowering behavior differs between sorghum genotypes, and therefore must be considered in studies on the biology of pollen, ergot and sorghum midge. In particular, the relationship between flowering biology and resistance to the latter two pests needs to be recognised.

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Evidence for Apomixis and its Inheritance in the Sorghum Line SSA-1

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Introduction

Apomixis is a method of asexual reproduction in plant seeds that is of great significance in the evolution and formation of species and in plant breeding. Because apomixis can fix hybrid vigor, it has aroused wide attention among plant breeders (Zhao Shixu 1990). Poaceae, to which the sorghum species belongs, is a major family possessing this trait. Rao and Narayana (1968) were the first to report apomixis in the sorghum [*Sorghum bicolor* (L.) Moench] line R473 and it was considered to be apospory. Hanna et al. (1970) identified a facultative apomictic line PGY in sorghum. Because of the low frequency of apomictic progeny, cross infertility, and male sterility in PGY, it was difficult to evaluate genetically and consequently has seen little use in breeding programs. Niu Tiantang et al. (1994) have developed the apomictic line SSA-1 and made detailed studies of its embryology. The line showed a high frequency of apomixis with no cross infertility and has been a good basic material to research inheritance of apomixis and for use in fixing heterosis.

Evidence for apomixis. During 1992-1993, SSA-1 was evaluated for its apomictic behavior through hybridization and emasculation for four generations based on the methods suggested by Murty (1982) in Yuci, Shanxi province and Huangliu, Hainan province. The results showed SSA-1 could set seeds autonomously both in Yuci, Shanxi Province and Huangliu, Hainan Province, when it was emasculated and bagged (Table 1), indicating the evidence for apomixis. However, there were large differences in the frequency of apomictic seed-set in different locations and years. After analyzing experimental conditions, it was hypothesized that this differential frequency of apomixis could be due to temperature variations in different locations and years. A perusal of results clearly indicated a large influence of temperature on the apomictic frequency. High temperature appeared to increase the frequency of apomictic seed-set in SSA-1. These results are in line with those of Murty et al. (1982) in apomictic line R473 in sorghum.

In order to further confirm apomictic seed-set in SSA-1, experiments were conducted involving emasculation and