AN ENVIRONMENTAL PROBLEM WITH GRAIN SORGHUMS

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SUMMARY

Problems experienced with grain set in sorghums in some New Zealand localities are probably caused by short periods of cool night temperatures at a critical stage in floral development. Chilling temperatures (<13 C) seem to restrict the nutrient supply to developing pollen grains from the degenerating tapetal layer. This results in male emasculation.

Meteorological data show that many northern semi-coastal areas should not experience these problems, but that more inland areas including the Waikato could be affected.

Chilling tolerant germplasm has been found and is being incorporated into acceptable agronomic types both at Palmerston North and by major U.S. seed companies.

INTRODUCTION

In the late 60's a number of grain and sugar sorghum yield trials were carried out by a group of Field Research Officers of the Research Division of Ministry of Agriculture and Fisheries.

These trials were generally in rather warm, semi-coastal areas such as Wairoa, Tauranga, Blenheim and Auckland. Grain hybrids used in the trials were usually early season Northrup-King types - NK 115, 220Y: and yields given in the Field Research Section Annual Report show a wide variation.

Hybrid NK 115

Trial No.	Site	Centals/acre	bu/acre (60lb/bushel)
N 80/19	Wairoa	29	48
N 80/13	Waikato	45	75
N 80/22	Papamoa	95*	158

*Assessment based on limited sampling.

This variability was put down to general agronomic problems coupled with losses to birds.

The trials were encouraging; suggesting that if good agronomic techniques were used, several early season types were capable of producing reasonable grain yields provided that head smut or birds were not a serious problem.

In 68-69, a private firm, A.M. Bisley Co. Ltd. also became involved; presumably because of a small specialised demand for sorghum starch and a genuine desire to develop new products. Largish plantings of 60-70 acres were put down near Gisborne and in the Waikato with disastrous results. As far as can be gathered, the Gisborne crops were mouldy and smut covered following a typical Gisborne "wet end to the season"; while the Waikato areas averaged 20% grain set or less.

As these results became known, grain sorghums developed a bad name in the Waikato and this coupled with severe "trial site bird problems" rather dampened M.A.F. and farmer interest.

There is an explanation for this lack of grain set in the Waikato, and the problem can be solved. It is intended to explain the phenomena in some detail because is is a good lesson in environmental adaptation.

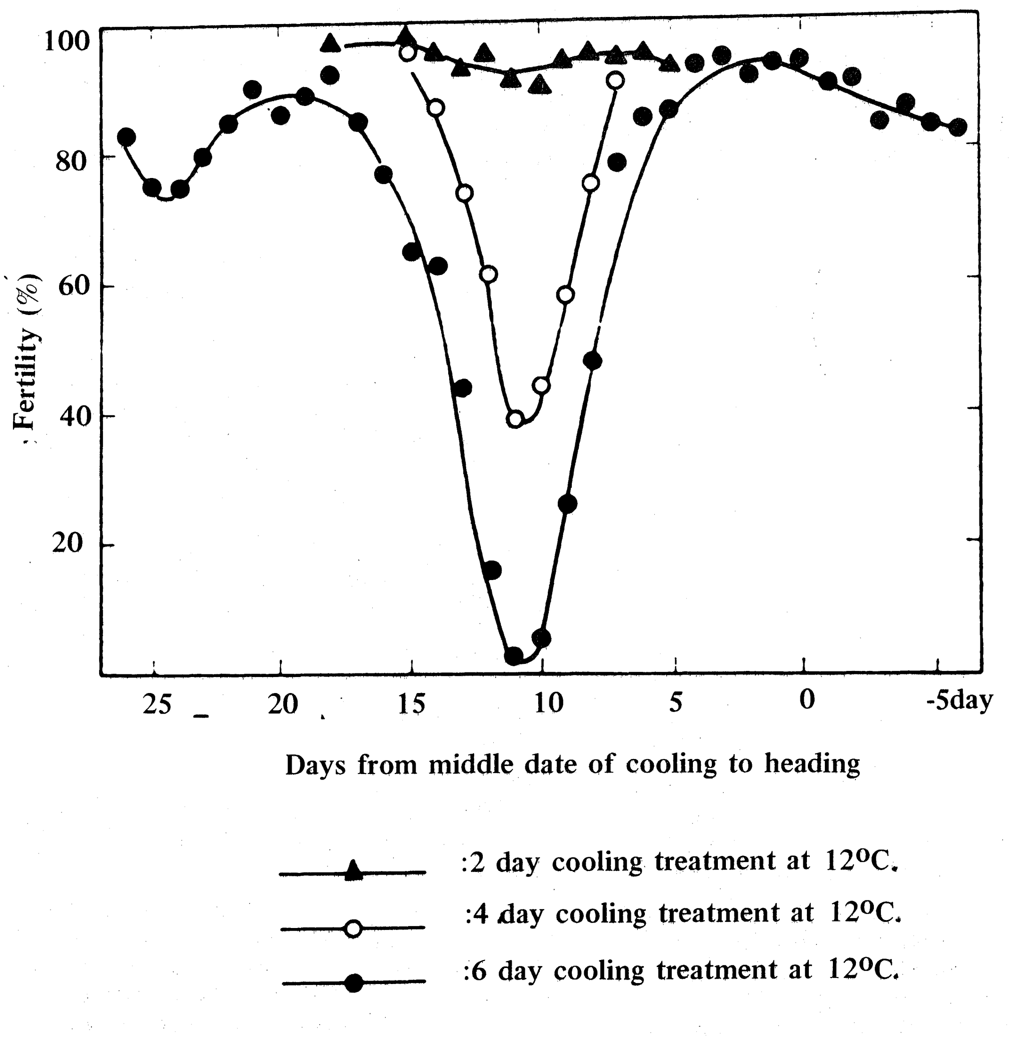
DESCRIPTION AND DISCUSSION

Rice

It has been known for a number of years that short periods of cool weather during the boot stage can cause severe yield depressions in rice. This is quite common in Hokkaido, where it is a serious social and agronomic problem.

It has been shown that a period of 5 to 6 days of 12 C or lower temeratures approximately 11 days before heading can completely emasculate a crop(see Figure 1).

Figure 1: Effects of cool treatment on male fertility of rice (Satake, 1969).



This sensitive period corresponds rather closely to the time that the pollen mother cell is undergoing its reduction or meiotic division. When developing heads are given low temperature treatment, anthers do not develop their respiratory activity, proline does not build up in the pollen grains, and at a time when the anthers should be dehiscing, they remain stunted and contain immature pollen. Styles are fully receptive and ovules fully fertile, however, because viable pollen shaken on the head will restore full fertility.

These features resemble rather closely those found in cytoplasmic male sterile types of Sorghum.

Reasons for cytoplasmic male sterility or for this stress induced emasculation are not known, however, although there are indications that nutrient supply to the developing pollen grains from the degenerating tapetal layer is restricted.

Varieties of rice have been found which differ quite substantially in tolerance to this stress, although no truly insensitive types have been found. Nevertheless, breeding for enhanced tolerance is possible, and is proving quite successful.

Sorghum

It has been reported quite recently that the same phenomenon occurs in Sorghum and that cool night temperatures are all that are required to produce emasculation (Figure 2).

Downes also showed that mean day/night temperature treatments of 18.5 C, set up as 21/16 C or 27/10 C had very different effects; only that treatment with the low night temperature (10 C) caused male sterility. It seems that short periods of low night temperatures around 13 C cause the same type of pollen sterility in Sorghum as they do in rice.

Fig. 2: Effects of cool nights (13 C) on male fertility in sorghum. Treatments were started at the time of floral initiation (Downes *et al.* 1971).

Variation in seed number per panicle with increasing periods of exposure to low temperatures.

Treatment	Mean	Range
0	961 a†	690-1327
4 days+	1217 a	804-1518
8 "	275 b	189-375
12 "	88 c	34-177
16 "	29 c	0-102
20 "	16 c	0-49

† Values followed by the same letter do not differ ($P > 0.05$). Analyses on natural log transform.

+ Days at 18/13^{o}C, day/night temperature.

Bisleys used a DeKalb hybrid C45. This hybrid is described as early-mid season for the Australian environment, so we could guess at developmental times close to:

30-40 days from sowing to floral initiation, and
35-45 days from floral initiation to anthesis.

This would make the most temperature sensitive phase about 6-8 weeks after planting. Not enough work has been done to be fully certain of the temperature conditions required to produce almost complete emasculation; but one would guess that a sequence of 3-5 nights with minimums close to 10 C would be enough.

Weather records for January 1969 show an interesting picture (Fig. 3) any minimums below 52 F have been marked.

Fig. 3: Daily temperature minimums for January 1969. (Data from N.Z. Meteorological Service).

Temperature Minimums

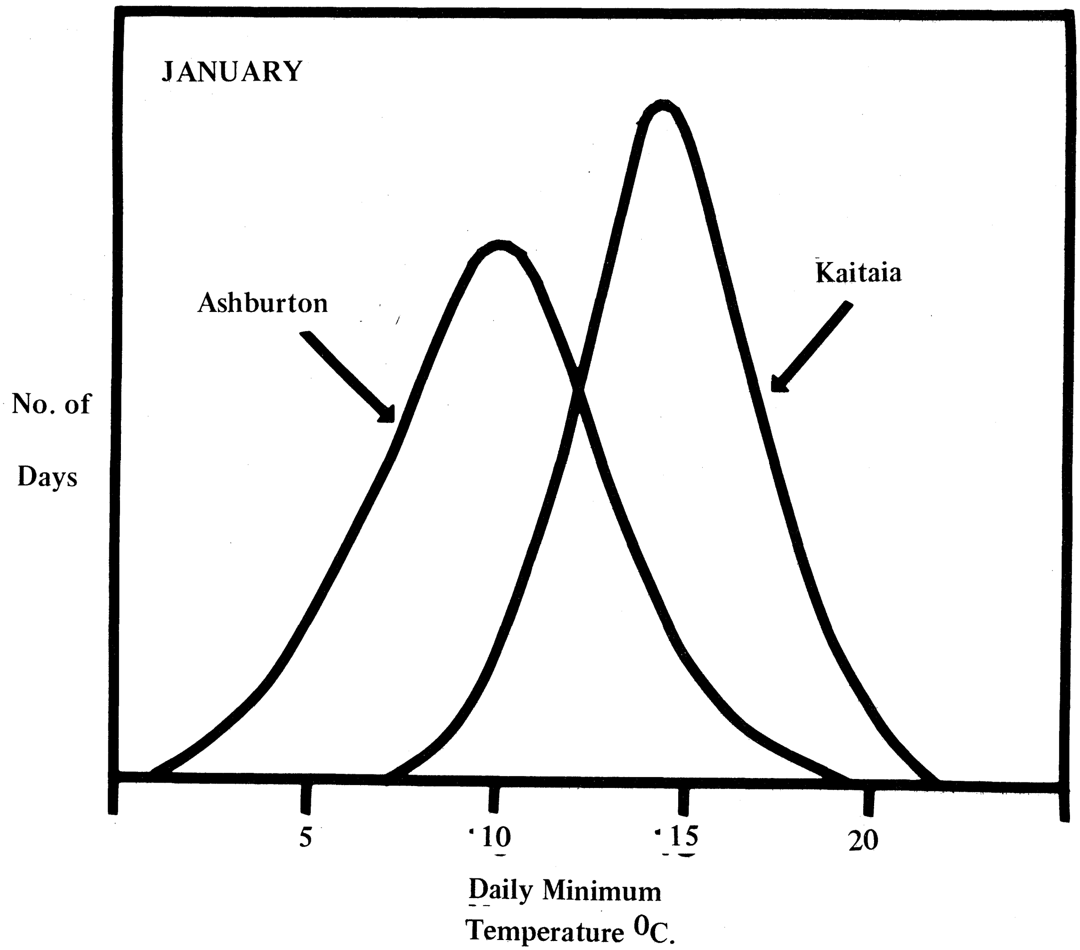
(Screen)

January 1969 Date	Ruakura	Kaitaia	Blenheim
1	57.5	61.3	43.3*
2	57.2	57.9	47.8*
3	51.0*	55.9	50.7*
4	53.9	58.5	53.9
5	55.8	63.3	62.5
6	61.9	63.0	61.5
7	53.2	55.6	51.1*
8	42.1*	50.6*	44.9*
9	49.0*	57.1	49.2
10	50.0*	55.3	61.0
11	42.8*	57.0	49.5*
12	48.2*	57.8	48.3*
13	50.8*	54.6	53.9
14	55.8	53.2	51.9*
15	52.3	62.7	51.0*
16	44.9*	57.7	46.0*
17	56.5	61.6	54.0
18	56.5	59.8	59.0
19	51.8*	55.2	50.9*
20	48.9*	53.7	59.9
21	56.0	57.9	54.8
22	56.2	57.4	53.9
23	53.1	56.6	43.9
24	50.2*	56.0	52.4
25	50.9*	57.4	52.1
26	46.4*	58.2	49.2*
27	48.6*	56.5	53.9
28	48.9*	54.1	61.2
29	61.1	60.5	57.7
30	57.6	59.7	53.0
31	55.4	58.2	57.0
Mean minimum	52.4	57.5	52.9
Mean maximum	73.1	72.4	74.2

These records show clearly that two 5-day cool night sequences were experienced in the Waikato at a time when this critical development stage could have been occurring. No problems would have been experienced in Kaitaia in 1969, while at Blenheim, problems may have occurred especially with early plantings. Maximum temperatures are of little use in considering zones of adaptability of grain Sorghums, because mean maximums were actually lowest in Kaitaia.

If one considers two sites within New Zealand of rather comparable maximal summer temperatures and summer drought problems and, then looks at long-term meteorological data on daily minimums, site differences in Sorghum adaptability become much clearer (Figure 4).

Fig. 4: Distribution of January minimum temperatures over a 10 year period (data from N.Z. Meteorological Service).



On average, daily minimums below 10 C will be experienced on half the days in January at Ashburton, while at Kaitaia, they almost never occur.

This then is a partial solution to the problem; and it should shortly be possible to predict the chances of experiencing drastically reduced grain set in Sorghum at different locations. It would be better, however, if one could solve the problem completely.

On a recent trip overseas, I found that similar problems to ours were experienced with grain Sorghum at high altitudes in the tropics. U.S. hybrids are, for example, almost completely male-sterile when grown close to Mexico City at an altitude of approximately 8,000 feet. The large "International Maize and Wheat Improvement Centre" is sited in this area, however, and Elmer Johnson, their maize and Sorghum breeder, is fully confident that the problem can be solved.

Sorghums are thought to have evolved in north-eastern Africa, which probably explains their tolerance to high temperatures and drought; but they are also grown by native tribes at higher altitudes in Ethiopia, Kenya and Uganda. Dr. Johnson has collected populations from these high altitude sites and found two that produced viable pollen at high altitudes in Mexico.

These populations have now been incorporated into breeding programmes by CIMMYT and by major U.S. seed companies. Professor Eastin, who has been working at the Plant Physiology Division, D.S.I.R. has also done some selection and breeding work. The Plant Physiology Division, D.S.I.R. will largely supply detailed physiologic information to the U.S. in exchange for advanced breeding stocks.

In conclusion it is suggested that green-chop forage Sorghums or sugar Sorghums are likely to be of considerable use in some situations; especially for larger scale beef fattening enterprises in areas where summer droughts are a problem. Grain Sorghum, and more especially multipurpose grain/forage types, may also have a role if starch rich feed is required and provided sufficient acreages can be planted to lessen bird depredations.

Problems involving low seed set can be solved and more open heads may help the mold problems which have been reported to develop in some areas.

REFERENCES

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