QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 661

EFFECT OF PARTIAL AND COMPLETE PANICLE REMOVAL ON THE RATE OF DEATH OF SOME SORGHUM BICOLOR GENOTYPES UNDER MOISTURE STRESS

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SUMMARY

The effect of varying the grain yield of some sorghum genotypes by partial and complete removal of the panicle at flowering on their rate of death of leaves and subsequent onset of plant death under moisture stress was studied in two seasons. The rate of death, measured in terms of rate of death of leaves, and the onset of plant death were reduced as grain yield was reduced for all the genotypes. Some possible reasons for this apparent association and the implications of it are discussed.

Data showing the effect of the panicle treatments on the grain yield per plant and its components are presented for one season.

I. INTRODUCTION

Hybrid grain sorghum (*Sorghum bicolor* (L.) Moench) was introduced to Queensland farmers during the early 1960s. Acceptance by farmers was good at first, but worsened until at the present time approximately 80% of the Central Queensland grain sorghum crop is planted with the open-pollinated variety Alpha.

The major reason for this is that the hybrids in general have proved to be more susceptible to lodging than the variety Alpha. The lodging of concern is that experienced after the crop has been subjected to moisture stress during the period of grain filling. Stalk-rotting pathogens such as *Macrophomina phaseoli* (Maubl.) Ashby (Edmunds 1964) and *Fusarium moniliforme* Sheldon (G. S. Purss, personal communication) are probably responsible for at least some of the plant deaths which precede lodging.

A possible reason for the greater susceptibility of the hybrids than Alpha to plant death and subsequent lodging is their high grain yield. Koehler (1960) found that higher yielding corn varieties were more susceptible to stalk rots in Illinois. Edmunds and Voigt (1966) found that unpollinated, male-sterile grain sorghum plants produced no charcoal rot whereas plants which were developing grain had a high incidence of the disease after inoculation.

The purpose of this study was to determine if the grain yield of grain sorghum plants has any apparent influence on the rate of death of leaves and stalks and the occurrence of charcoal rot caused by *M. phaseoli* when moisture stress occurs during grain filling.

II. MATERIALS AND METHODS

The experiments were carried out in the field during the summers of 1968-69 and 1969-70 at Biloela Research Station. In 1968-69 the hybrids Texas 610, Pioneer 846, Pacific 222 and DeKalb E57 were used. In 1969-70 the hybrids DeKalb E57, Texas 610 and the variety Alpha were used.

Plots of each genotype were 3 m long in single rows 1 m apart, with plants 20 cm apart within the row. The experiment was planted on February 6 and 11 in 1969 and 1970 respectively.

Panicle treatments.—Grain yield was varied on each genotype by applying the following panicle treatments.— (A) none of the panicle removed, (B) an estimated one-third of the panicle removed, (C) an estimated two-thirds of the panicle removed, (D) the complete panicle removed. In 1968-69 these treatments were applied on March 31, which was at flowering or within 5 days after it. In 1969-70 they were applied at flowering, which occurred on March 31, April 3 and April 4 for Texas 610, DeKalb E57 and Alpha respectively. In both years the panicle treatments were replicated three times. In 1968-69 the genotypes were planted in separate blocks and no genotype differences could be determined. In 1969-70 the genotype and panicle treatments were randomized together within each of the three blocks.

Rate of death of leaves.—On April 23, May 9 and May 22, 1969, the number of green leaves on each plant was counted. A leaf was considered green if any part of the blade was green. The counts were expressed as a percentage of the number at April 23. In 1969-70 the counts were made on April 3, 15, 23 and 30; May 11 and 25; and June 5 and 18. Counts were expressed as a percentage of the number of green leaves at April 3.

Dead plants.—In 1968-69 on June 10, all plants whose stems were dead at the base were counted. The number of these dead plants which had charcoal rot was recorded.

Grain yield.—In 1969-70 the grain of individual plants was harvested, threshed and weighed. Two 100-seed samples were taken from each plant and weighed. The number of seeds per plant was then calculated.

III. RESULTS

In both years the plants were subjected to moisture stress during the period of grain filling, which occurs for approximately 30-35 days after flowering. The degree of plant stress was not measured, but Table 1 shows the amount of water (rain plus irrigation) received by the crop in both years from the time of planting until 35 days after flowering of the latest genotype.

TABLE 1

RAINFALL AND IRRIGATION (POINTS) RECEIVED AFTER PLANTING

Month	1968–69	1969–70	Average (45 years)
February	94	32	450
March	57+200*	99+150**	280
April	9	49	163
May (1st to 9th)	12	0	149
Total	172+200	180+150	1,042

100 points = 1 inch.

* Irrigation on 5.iii.69.

** Irrigation on 20.iii.70.

TABLE 2

PERCENTAGE GREEN LEAVES FOR EACH PANICLE TREATMENT AT THREE DATES FOR PACIFIC 222, DEKALB E57, PIONEER 846 AND TEXAS 610 IN 1968–69

Panicle Treatment	Percentage Green Leaves Measured at Three Dates											
	DeKalb E57			Pioneer 846			Pacific 222			Texas 610		
	23.iv.69	9.v.69	22.v.69	23.iv.69	9.v.69	22.v.69	23.iv.69	9.v.69	22.v.69	23.iv.69	9.v.69	22.v.69
(A) Full panicle	55a*	27a	14a	60a	34a	24a	43a	23a	10a	56a	20a	18a
(B) Two-thirds panicle	62a	29a	15a	59a	35a	27a	52b	37b	29b	61a	35b	23a
(C) One-third panicle	76b	64b	57b	75b	78b	69b	74c	70c	63c	79b	74c	69b
(D) No panicle	75b	71b	65b	72ab	70b	67b	77c	72c	61c	80b	78c	70b
Coefficient of variation (%) ..	8	10	16	12	20	25	7	10	17	7	8	10

* For each vertical column, numbers followed by the same letter do not differ at the 5% level of significance.

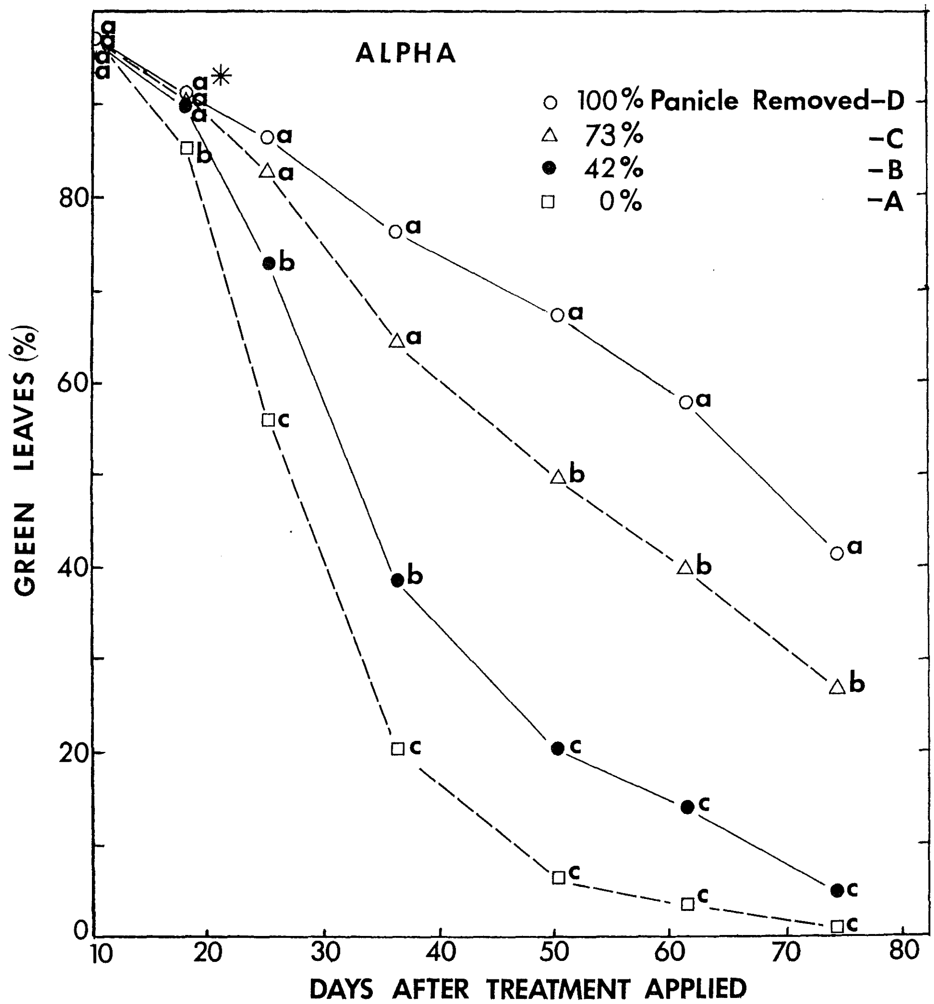

Fig. 1.—Effect of panicle treatment on the death of leaves for Alpha in 1969-70.
*At a particular date, points followed by the same letter do not differ at the 5% level of significance.

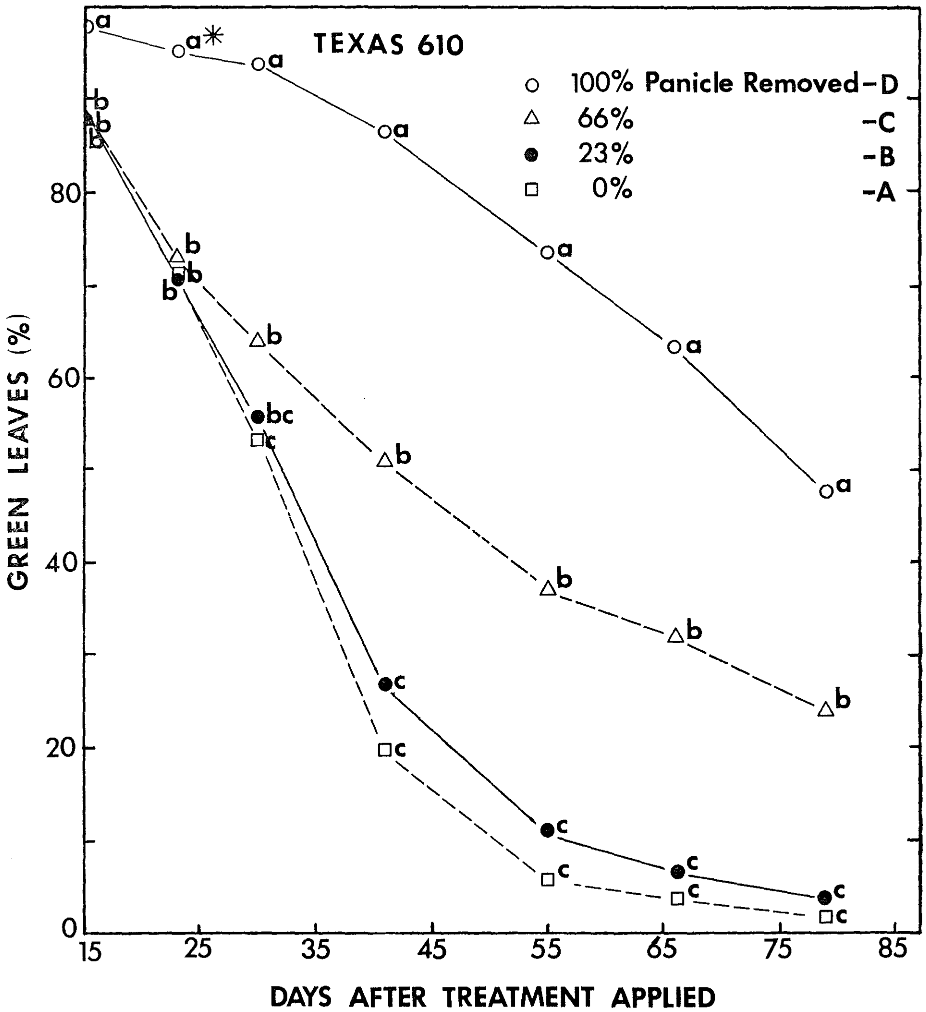

Fig. 2.—Effect of panicle treatment on the death of leaves for Texas 610 in 1969-70. *At a particular date, points followed by the same letter do not differ at the 5% level of significance.

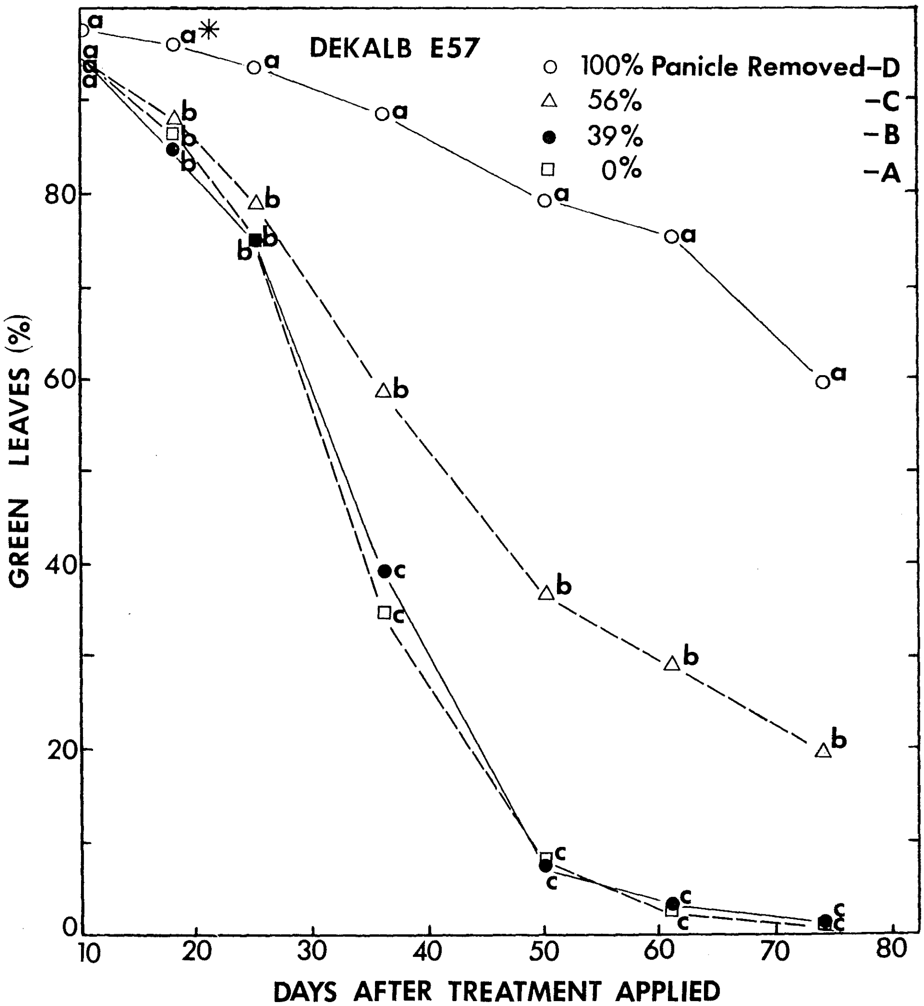

Fig. 3.—Effect of panicle treatment on the death of leaves for DeKalb E57 in 1969-70. *At a particular date, points followed by the same letter do not differ at the 5% level of significance.

Rate of death of leaves.—The percentage green leaves at each count for 1968-69 is shown in Table 2 and for 1969-70 in Figures 1, 2 and 3. The behaviour of each genotype in both years was basically the same. Rate of death of leaves was clearly much greater for plants with full and two-thirds panicle than for those with no panicle or one-third panicle. The difference in the no-panicle and one-third panicle treatments was larger in 1969-70 than in 1968-69. Rate of death of leaves was less (non-significant except for Pacific 222 in 1968-69) for the two-thirds panicle treatment than for the full panicle treatments for each genotype in both years.

The percentage green leaves at each counting date in 1969-70 for the no-panicle treatment for DeKalb E57, Texas 610 and Alpha is shown in Table 3.

TABLE 3

PERCENTAGE GREEN LEAVES ON THE NO-PANICLE TREATMENT FOR DEKALB E58, TEXAS 610 AND ALPHA IN 1969–70

Date of Count	Percentage Green Leaves		
	DeKalb E57	Texas 610	Alpha
15.iv.70	98a*	98a	97a
23.iv.70	96a	95a	91a
30.iv.70	93a	93a	86b
11.v.70	88a	86a	77a
25.v.70	79a	73a	67a
5.vi.70	75a	63a	57b
18.vi.70	59a	47b	41b

* At each counting date, numbers followed by the same letter do not differ at 5% level of significance.

Dead plants and charcoal rot.—The percentage dead plants and the percentage of the dead plants with charcoal rot are shown in Table 4. The apparent effect of the higher grain yield is clearly seen and is similar to the effect on rate of death of leaves (Table 2).

TABLE 4

DEAD PLANTS (%) AND CHARCOAL ROT DISEASED PLANTS (PERCENTAGE OF DEAD PLANTS) FOR EACH PANICLE TREATMENT FOR PACIFIC 222, DEKALB E57, PIONEER 846 AND TEXAS 610 IN 1968–69

Panicle Treatment	DeKalb E57		Pioneer 846		Pacific 222		Texas 610	
	Dead Plants	Rot	Dead Plants	Rot	Dead Plants	Rot	Dead Plants	Rot
(A) Full panicle	58a*	4	21a	11	82a	12	50a	9
(B) Two-thirds panicle	52a	0	5b	0	37b	29	36a	13
(C) One-third panicle	1b	..	0b	..	0c	..	0b	..
(D) No panicle	0b	..	0b	..	0c	..	0b	..

* Numbers followed by the same letter do not differ at 5% level of significance.

Grain yield.—No grain was harvested in 1968-69. The average weight of grain per panicle, the average weight of 100 seeds and the calculated average number of seeds per panicle for each panicle treatment on DeKalb E57, Texas 610 and Alpha in 1969-70 are presented in Table 5. The average reduction in the number of seeds per panicle caused by the treatments was calculated and the results are shown in Table 5 and Figures 1, 2 and 3. For example, in Figure 1 treatment C actually had 42% of the grain removed from each panicle and treatment B had 73% removed.

TABLE 5

WEIGHT OF GRAIN PER PLANT (Wt.Gr.P.), WEIGHT OF 100 SEEDS AND NUMBER OF SEEDS PER PANICLE FOR EACH PANICLE TREATMENT ON DEKALB E57, TEXAS 610 AND ALPHA IN 1969–70

Panicle Treatment	De Kalb E57			Texas 610			Alpha		
	Wt.Gr.P. (g)	Wt. 100 Seeds (g)	Seeds/ Panicle	Wt.Gr.P. (g)	Wt. 100 Seeds (g)	Seeds/ Panicle	Wt.Gr.P. (g)	Wt. 100 Seeds (g)	Seeds/ Panicle
(A) Full panicle ..	20·0a	1·38a	1,447a	23·2a	1·71a	1,395a	16·1a	1·17a	1,437a
(B) Two-thirds panicle	17·8a (89)*	2·03b (47)†	878b (61)‡	20·1a (87)	1·91a (12)	1,069b (77)	13·7a (85)	1·64b (40)	829b (58)
(C) One-third panicle	17·4a (87)	2·75c (100)	637b (44)	14·2b (61)	3·08b (80)	464c (33)	7·5b (47)	1·93b (66)	388c (27)

* Percentage of full-panicle yield.

† Percentage increase over full-panicle seed size.

‡ Percentage of full-panicle number.

For each vertical column, numbers followed by the same letter do not differ at 5% level of significance.

IV. DISCUSSION

When the grain yield of DeKalb E57 plants was reduced by 13% (treatment 6, Table 5), a marked reduction in the rate of death of leaves resulted (Figure 2). Likewise, a 39% reduction in the grain yield of Texas 610 plants (treatment 6, Table 5) resulted in a marked reduction in the rate of death of leaves (Figure 3). The effect of the reduced grain yield on the percentage dead plants for DeKalb E57, Texas 610 and Alpha follows the same trend.

On the basis of these results, the lower grain yield of Alpha could well cause its relative resistance to the effects of moisture stress experienced as the grain is filling. The grain yield per plant for the full panicle treatment of Alpha was 20 and 30% less than that of DeKalb E57 and Texas 610 respectively in this test (Table 5). In performance tests (Moore and Harbison 1965-70) Alpha's yield is usually of this magnitude relative to that of most hybrids.

It is of interest to note that, with the effect of grain yield completely removed (the no-panicle treatment), Alpha's rate of leaf death (41% green leaves at April 18, 1970) was greater than that of Texas 610 (47% green leaves) and DeKalb E57 (59% green leaves) (Table 3).

The causes of this apparent effect of grain yield on the death of plants in response to moisture stress experienced during the grain filling period are not known and can only be speculated upon. The real explanation may include one or more of the following:

(i) Koehler (1953), Michaelson (1957), Pappelis (1970) and Gates and Mortimore (1972) have all shown that by reducing the photosynthetic capacities of corn plants by removing or damaging leaves or damaging roots, the incidence of stalk rots caused by *Diplodia zeae* and *Gibberella zeae* is increased. Death of the pith parenchyma cells in the stem is accelerated by these treatments. The reduced photosynthetic rate of plants in the present study resulted from moisture stress and it is possible that it is this reduction in photosynthesis that contributed to the plant death experienced. Photosynthetic rates were not measured, so the reduced rate of death of leaves on plants with a lower grain yield may have resulted from these plants having a higher photosynthetic rate. On the other hand, the effect of a reduction in photosynthetic rate may be less when the photosynthate demand is less, as is the case when the "sink", represented by the developing grain, is reduced. The effect may result from a preferential distribution to the panicle of the photosynthate that is produced, which occurs commonly in plants (Meyer *et al.* 1973) and/or a redistribution of photosynthate from the stem to the panicle.

(ii) The glumes in a sorghum panicle contain stomata. The removal of some of these glumes may have significantly reduced the rate of transpiration from the plant. Also, the developing grain is a water sink, although not a large one, which would be reduced along with the grain yield. However, plant water status was not measured so it is not known if the panicle treatments affected it.

(iii) Removal of part or all of a panicle may upset the hormone balance of the plant and this may result in the differences observed in this study. For example, Phillips (1971) reviewed some literature which indicated that fruits accelerate the senescence of other plant parts because they produce auxin which "directs" the flow of photosynthate to the developing fruit. The increased rate of death of leaves of high-grain-yielding sorghums under moisture stress may be no more than an accelerated senescence phenomenon.

The implications of this apparent relationship between grain yield and the rate of death of leaves, percentage dead plants and stalk rots under moisture stress are of considerable importance. It makes the selection and utilization of higher yielding grain sorghums more difficult and apparently should be taken into account in breeding programmes aimed at selection for resistance to stalk rots.

V. ACKNOWLEDGEMENTS

Statistical analysis of the data was carried out by the Biometry Branch of the Department of Primary Industries, whose assistance is gratefully acknowledged.

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(Received for publication July 4, 1973)

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