METHODS FOR DELAYING FLOWERING OF GRAIN SORGHUM, *SORGHUM BICOLOR* (L.) MOENCH, LINES

by 6408

JAMES CARL TRYBOM

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Major Professor

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INTRODUCTION

Grain sorghum, Sorghum bicolor (L.) Moench, tradition-bound to the Texas High Plains has fanned out to new areas. While Texas, Kansas, and Nebraska remain unchallenged as the top-ranking states in sorghum acreage, the crop is gaining polularity in other areas. Reasons for these developments can be summarized in three points. First, a market demand was created for grain sorghum. Second, grain sorghum can be adapted to a wide range of cropping systems. Third, hybrids adapted to the new areas were developed as the market grew.

In 1956, when hybrids were first released, the grain sorghum crop was 205 million bushels. A year later, as 95% of all grain sorghum growers switched to hybrids, production reached 568 million bushels.

Increased acreage, number of acres planted has doubled in the last 30 years, has required production of a large volume of good quality seed.

One of the problems facing breeders and producers of hybrid grain sorghum seed is utilization of lines differing in time of flowering. It is often necessary to cross lines of different maturity to obtain maximum hybrid vigor. Both lines must reach the reproductive stage at the same time in order to obtain good cross pollination and to prevent contamination from other pollen sources.

Several methods have been used to delay flowering of one of the parent lines. Delayed planting of the earlier maturing line is the method most often used. Other methods used include clipping the earlier maturing line in its early stages of growth, flaming the earlier maturing line, and fertilizing the later maturing line with an abundant supply of plant nutrients.

The need has been widely recognized for a technique for regulating the rate of early growth in order that an entire seed field may be planted at one time.

This study was undertaken to compare flaming, clipping, and use of a contact herbicide as methods to delay flowering of grain sorghum lines.

REVIEW OF LITERATURE

Lindstrom (9) clipped F_1 hybrid corn plants as part of a study of heterosis. His treatments designated as double, mid, and late decapitation produced delays of 6.0, 2.7, and 3.2 days in date of silking, respectively. Whole plant dry-weight yields showed reductions accompanying the delays in silking.

Dungan and Gausman (5) reported clipping single cross and inbred lines of corn in early stages of growth was a practical means of delaying reproductive development. Clipping plants early and severely gave the greatest delay in flowering and least yield reduction. Plants clipped below or slightly above the growing point did not recover. Three to six days delay were obtained without a significant reduction in grain yield. Pollen production was also reduced when delays were obtained.

Reece, Hurst, and Russ (11) reported that corn which had been flamed when the plants were less than twelve-inches tall was retarded in maturity.

Green (7) reported small significant delays of white inbred lines of corn when flamed. The most effective treatment was when the plants were flamed at two inches in height and flamed again when the regrowth reached two inches. Maximum delay obtained was 2.6 days for anthesis and 2.8 days for silking. A slight reduction in grain yield indicated

that it may be advisable to delay anthesis of the male parent rather than silking of the female parent. A significant line x treatment interaction indicated the advisability of testing the effects of flaming on different lines before attempting to flame on a field basis. He suggested that for greater delays, additional flamings at two inches could be used.

Register, Mahoney, and Minton (12) reported a delay in flowering and an extension of the pollination period for as long as one week when flame was used on several male-corn lines. The amount of delay could not be calculated because no check was left. Their results indicated very significant increases in yield by extending the pollination period.

Howard (8) reported no effects on yield or flowering period as a result of flaming at the pre-boot, boot, and flower stages of growth of a grain sorghum hybrid.

Price and Longnecker (10) reported "flaming off" grain sorghum resulted in a two-week delay in flowering over the original planting. Longnecker[1] later stated that sorghum could be flamed each time it grew back to a height of two inches for a total of three flamings without affecting stand or yield. Each flaming delayed maturity for three to five days.

Ball, Vanderlip, and Reece (2) reported that flaming RS 610 grain sorghum in the early growth stages significantly delayed flowering. They stated that the earlier and the more times the plants were flamed the greater the delay. Maximum delay, thirteen days, was obtained by flaming at all three growth stages tested; however, this treatment

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[1]Letter of communication from Dr. T. C. Longnecker, Chief Soil Scientist, High Plains Research Foundation, Plainview, Texas.

decreased the stand. They stated that even though the stand was reduced, possibly enough plants would be left for hybrid-seed production if the restorer line was flamed.

Banks (3) reported that flaming significantly delayed the flowering of six grain sorghum lines. The earlier and more times the plants were flamed, the greater the delay. Duration of bloom was increased and yield was decreased by the more severe flamings. He also stated that it may be difficult or impossible to obtain the same amount of delay from a line year after year, even though the same flaming combination is used. Although statistically significant, the magnitude of the differences in delay between the two years was not large, only one to two days.

Gohlke (6) reported that residue from a one-quart treatment of Treflan to a previous cotton crop delayed the growth rate of a succeeding grain sorghum crop. Plants headed ten days later than untreated plots. Yield was not affected.

Ball, et al. (1) tested 33 herbicides under field conditions. Although apparent differences occurred in the degree of injury as measured by grain sorghum stand counts, there were no consistent differences in date of flowering. Differences observed in early seedling growth had disappeared by flowering time.

METHODS AND MATERIALS

Two pollinator lines, Combine 7078 and Plainsman, and two male-sterile or female lines, ms Redlan and ms Combine Kafir 60, were planted in a split-plot design at the Kansas State University Agronomy Farm, Manhattan, Kansas, and at the South Central Experiment Field, Hutchinson, Kansas, in 1969 and 1970.

Plantings were made in 76-cm rows at the rate of 98,840 to 111,195 plants per hectare. This row spacing and plant population was used both years at the two locations.

Plantings at Manhattan were made on June 5, 1969, and June 17, 1970, in an unnamed alluvial silt loam. Fertilizer was applied preplant at the rate of 112 kg of nitrogen per hectare in 1969 and 1970.

Soil moisture conditions at planting time were good at Manhattan both years. In 1969, 6.86 cm of rain was received during the two weeks following planting. Above normal precipitation occurred during July, 19.84 cm, which is over 8.89 cm above normal. August precipitation was only 1.98 cm. This was 8.89 cm below normal. Over half of the August rainfall occurred on August 2, and only .64 cm was received the rest of the month. Although very little rainfall was recieved in August, grain sorghum was never under drouth stress because of the abundant moisture received early in the growing season. The rainfall for the six-month period, April through September, was normal.

The 1970 rainfall for the six-month period, April through September, was 17.78 cm above normal. In June, before planting time, 19.66 cm of rainfall was received. However, the plants were subjected to drouth stress in July and August as only 5.36 cm was recieved the 65 days following planting.

Nine of the ten days between July 29 and August 7 had temperature readings above 37.8 C. These high temperatures accompanied by hot, dry winds put the sorghum under stress during the latter part of July and the first three weeks in August.

Plantings at Hutchinson were made on June 10, 1969, and June 9, 1970, in a Clark-Ost complex soil to which no fertilizer was applied. Environmental conditions were similar to those at Manhattan in that the 1970 growing season was hotter and dryer.

Good soil conditions existed at planting time both years. Precipitation the first two days following planting in 1969 was 1.4 cm. Precipitation the six days following planting in 1970 was 10.92 cm. Rainfall during July and August in 1969 was 14.22 cm which was about normal. In 1970, only 4.9 cm of rainfall was received in July and August. Heavy rains in September were too late to be beneficial. Eighteen days in July and the first two weeks of August in 1969 and 17 days in August of 1970 were above 37.8 C.

Atrazine applied at the rate of 2.7 kg/ha was used to control weeds at Manhattan in 1969. Herban 21A at the rate of 2.7 kg/ha was used in 1970. Mechanical cultivation and hand hoeing were necessary to remove weeds, primarily grass, not killed by the herbicide applications. Weed control at Hutchinson consisted of several sweep cultivations early in the growing season and hand hoeing when necessary.

The flame equipment consisted of two Afco burners placed perpendicular to the row and offset front to rear so that the flame did not meet in the row. The burners were placed at a 30-degree angle with the horizontal and 15.2 cm above the soil surface. The burners were 61 cm apart or 30.5 cm from the row. Liquid LP-gas at 1.4 kg/cm^2 pressure was used. The tractor speed was 3.0 mph.

Clipping was done by hand with a pair of hedge trimmers. The plants were clipped at the first true leaf. The purpose of hand clipping was to remove the same amount of leaf area by clipping as was removed by flaming.

Dow-Premerge (2-sec-butyl-4,6-dinitrophenol, as the alkanolamine salts of the ethanol and isopropanol series), a dinitro weed killer, was the contact herbicide used. It was applied with a one-row sprayer using an 8003-E nozzle tip at the rate of 9.34 liters of Dow-Premerge in 187 liters of solution per hectare at 1.4 kg/cm^2 pressure. The recommended rate of Dow-Premerge used to control seedling grasses in corn and sorghum is "one to 1.5 gallons of Premerge in 30 gallons of water."[2] According to the herbicide label the activity of Dow-Premerge is affected by temperature. Less Dow-Premerge is required at higher temperatures. No recommended rates were given for use with a given temperature on grain sorghum, but recommended rates were given for use on soybeans. These rates were "four quarts per acre if temperatures were below 70 F; three quarts per acre for temperatures between 70 and 80 F; and two quarts per acre for temperatures between 80 and 95 F. If temperatures are above 95 F, do not apply Dow-Premerge for weed control in soybeans."[3]

Plants were treated at the three-leaf stage, five-leaf stage, or both. These stages are determined when the collar of the designated leaf is fully visible. When the plots were to be treated twice, the treatments were made when the check plots reached the five-leaf stage. The time when the plants reached the various leaf stages is recorded in Table 1.

The split-plot design consisted of lines as main plots and treatments as subplots. Each main plot contained the nine combinations of stages of

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[2]Dow Chemical Company's specimen label, 86-1110, for Premerge dinitro weed killer, July 1970.

[3]Ibid.

development and methods of leaf removal plus a no treatment plot. Each plot consisted of a single row 10.7 meters long, bordered by a single untreated row on each side. About 4.6 meters of the plot row was used as an alley for starting and stopping the tractor. Main plots or lines were separated by two untreated rows. All treatments were replicated four times at both locations.

Table 1. Dates of planting and dates plots were treated at the three- and five-leaf stages at Manhattan and Hutchinson.

		1969	1970
Manhattan			
	Plant	June 5	June 17
	3-leaf	June 25	June 30
	5-leaf	July 3	July 4
Hutchinson			
	Plant	June 10	June 9
	3-leaf	June 27	June 22
	5-leaf	July 2	June 28

Maturity was measured by days from planting to first, half, and full bloom. First bloom was defined as the time when any plant in the plot was in some stage of bloom. Half bloom occurred when 50 percent of the plants were in bloom. Full bloom occurred when 95 percent of the plants in a plot were in some stage of bloom. Days delay was obtained by subtracting the untreated plot values from those of the treated plots.

A 4.6-m section of each plot was harvested for yield. The number of heads in the 4.6-m section and the amount of threshed grain was recorded. Grain yield per acre was calculated and adjusted to 12.5 percent moisture.

Statistical analyses were made according to the methods outlined by Cochran and Cox (4). Least significant differences were calculated by the method outlined for the split-plot design.

RESULTS AND DISCUSSION

The treatments have been coded to show the leaf stages at which the plants were treated. Codes in Table 2 are used in presenting and discussing the results.

Days delay to half bloom is discussed in detail. Since half bloom is less affected by flowering of very early or very late plants, it is considered to be the best measure of maturity. There will be no discussion of first and full bloom; only the results will be presented. Hartley's homogeneity of variance test was used to determine data that could be combined over years. Individual years data are presented first and if statistically acceptable, later combined over years.

Table 2. Combinations of stages of growth at which the plants were treated. Plus indicates the plants were treated at that stage.

Combination Number	Stage	
	3-leaf	5-leaf
100	+	-
010	-	+
110	+	+

Days Delay to First Bloom

Hutchinson 1969. Table 3 shows lines, methods, stages, a line x stage interaction, and a method x stage interaction were highly significant.[4] A line x method interaction was significant.

The line x method interaction in Table 4 points out that flaming

[4]Significance at the 5% level will be termed significant and significance at the 1% level will be termed highly significant.

and clipping produced the same amount of delay within a line, while applying Dow-Premerge produced significantly less delay. The pollinator lines, Combine 7078 and Plainsman, were delayed more than ms Redlan and ms Combine Kafir 60 for all methods.

Table 3. Analysis of variance for days delay to first bloom at Hutchinson in 1969.

Source	d.f.	Ms	F
Replication	3	2.76	0.48
Line	3	75.87	13.08**[5]
Error (a)	9	5.80	
Method	2	111.58	91.56**
Stage	2	139.75	114.67**
Line x Method	6	3.34	2.74*
Line x Stage	6	4.56	3.75**
Method x Stage	4	26.27	21.56**
Line x Method X Stage	12	1.06	0.87
Error (b)	96	1.22	

Table 4. Days delay to first bloom as affected by lines and methods at Hutchinson in 1969.

	Method		
Lines	Flame	Clip	Herbicide
Combine 7078	6.00	6.25	4.33
Plainsman	6.00	6.33	2.83
ms Redlan	3.83	4.92	1.17
ms Combine Kafir 60	3.83	3.00	1.00

LSD Methods within a line = 0.90 day.[6]
LSD Lines within a Method = 1.13 days.

[5]Significance at the 5% level will be designated by one asterisk (*) and significance at the 1% level by two asterisks (**).

[6]All least significant differences are calculated at the 5% level.

The line x stage interaction in Table 5 also points out that the two pollinator lines were delayed more than the two male-sterile lines for all stages. There was no significant difference between stages 100 and 010 within a line. Treating the plants twice (110) produced significantly more delay than treating at either stage 100 or 010.

Table 5. Days delay to first bloom as affected by lines and stages at Hutchinson in 1969.

Lines	Stages		
	100	010	110
Combine 7078	4.58	5.33	6.67
Plainsman	3.83	3.67	7.67
ms Redlan	1.67	2.50	5.67
ms Combine Kafir 60	1.50	1.67	4.17

LSD Stages within a line = 0.90 day.
LSD Lines within a stage = 1.13 days.

Table 6. Days delay to first bloom as affected by methods and stages at Hutchinson in 1969.

Methods	Stages		
	100	010	110
Flame	3.75	2.88	7.75
Clip	2.88	5.06	7.38
Herbicide	2.06	1.94	3.00

LSD = 0.78 day.

The method x stage interaction (Table 6) also points out that treating the plants at both the three- and five-leaf stages resulted in the greatest delay for all three methods. Flaming and applying a contact herbicide produced more delay when the plants were treated at the three-leaf stage rather than the five-leaf stage, while clipping the plants at the three-leaf stage resulted in less delay than clipping at the five-leaf stage.

Hutchinson 1970. Table 7 presents the analysis of first bloom data at Hutchinson in 1970. Methods, stages, and a method x stage interaction were highly significant.

There was no significant difference in the amount of delay obtained between stages 100 and 010 for flaming and clipping as shown in Table 8. Treating the plants twice (110) gave significantly more delay than treating at either stage 100 or 010. Applying Dow-Premerge produced no significant delay in flowering for all three stages.

Hutchinson first bloom data can not be combined over years because Hartley's homogeneity of variance test was highly significant.

Table 7. Analysis of variance for days delay to first bloom at Hutchinson in 1970.

Source	d.f.	Ms	F
Replication	3	35.71	0.64
Line	3	39.62	0.71
Error (a)	9	55.68	
Method	2	369.25	36.23**
Stage	2	176.52	17.32**
Line x Method	6	15.78	1.55
Line x Stage	6	6.85	0.67
Method x Stage	4	47.58	4.67**
Line x Method x Stage	12	15.64	1.53
Error (b)	96	10.19	

Manhattan 1969. Methods, stages and a method x stage interaction were highly significant at Manhattan in 1969 as shown in Table 9.

The method x stage interaction is shown in Table 10. There was no significant difference in the amount of delay obtained for stages 100 and 010 when the plants were clipped or Dow-Premerge was applied. Flaming at stage 100 delayed flowering significantly more than flaming at stage 010.

Treating the plants twice (110) gave the greatest delay for all methods. Flaming and clipping caused more delay to first bloom than applying Dow-Premerge.

Table 8. Days delay to first bloom as affected by methods and stages at Hutchinson in 1970.

Methods	Stages		
	100	010	110
Flame	2.31	0.31	6.56
Clip	4.38	3.12	8.06
Herbicide	-0.81	0.06	-0.19

LSD = 2.26 days.

Table 9. Analysis of variance for days delay to first bloom at Manhattan in 1969.

Source	d.f.	Ms	F
Replication	3	0.76	0.03
Line	3	88.58	3.56
Error (a)	9	24.90	
Method	2	97.03	23.32**
Stage	2	409.59	98.45**
Line x Method	6	6.21	1.49
Line x Stage	6	8.69	2.09
Method x Stage	4	23.02	5.53**
Line x Method x Stage	12	5.90	1.42
Error (b)	96	4.16	

Manhattan 1970. Methods, stages, a line x method interaction, a line x stage interaction, and a method x stage interaction were highly significant at Manhattan in 1970. A line x method x stage interaction was significant at the 5% level (Table 11).

Table 10. Days delay to first bloom as affected by methods and stages at Manhattan in 1969.

Methods	Stages		
	100	010	110
Flame	7.25	4.25	12.06
Clip	6.62	6.31	11.12
Herbicide	3.69	4.56	8.19

LSD = 1.43 days.

Table 11. Analysis of variance for days delay to first bloom at Manhattan in 1970.

Source	d.f.	Ms	F
Replication	3	19.58	2.36
Line	3	16.14	1.95
Error (a)	9	8.28	
Method	2	451.90	128.54**
Stage	2	256.33	72.91**
Line x Method	6	13.16	3.74**
Line x Stage	6	11.24	3.20**
Method x Stage	4	58.95	16.77**
Line x Method x Stage	12	8.96	2.55*
Error (b)	96	3.52	

The line x method interaction is shown in Table 12. Flaming gave significantly more delay when used on Combine 7078. Flaming and clipping did not differ significantly for the other three lines. In all cases, applying Dow-Premerge produced significantly less delay than flaming or clipping. There was no significant difference between lines when Dow-Premerge was applied.

Days delay did not differ significantly when plants were treated at either stage 100 or 010 for all lines (Table 13). Treating the plants twice delayed all lines significantly more than treating at either the

three- or five-leaf stage. Treatment 110 gave significantly more delay when used on Combine 7078 and ms Combine Kafir 60. Differences were not significant among lines at stages 100 and 010.

Flaming delayed flowering more at stage 100 than at stage 010; however, clipping the plants at stage 100 produced less delay than clipping at stage 010 (Table 14). Flaming or clipping the plants twice (110) gave significantly more delay than treating at either stage 100 or 010. There was no difference in delay obtained among all three stages when Dow-Premerge was applied. Applying Dow-Premerge at either stage 100 or 010 produced no significant delay in flowering.

Table 12. Days delay to first bloom as affected by lines and methods at Manhattan in 1970.

Lines	Methods		
	Flame	Clip	Herbicide
Combine 7078	9.17	5.33	2.00
Plainsman	6.50	6.42	0.67
ms Redlan	5.92	4.83	1.67
ms Combine Kafir 60	7.58	7.25	1.42

LSD Methods within a line = 1.52 days.
LSD Lines within a method = 1.69 days.

Table 13. Days delay to first floom as affected by lines and stages at Manhattan in 1970.

Lines	Stages		
	100	010	110
Combine 7078	3.17	4.25	9.08
Plainsman	3.92	2.58	7.08
ms Redlan	3.42	3.42	5.58
ms Combine Kafir 60	3.42	4.33	8.50

LSD Stages within a line = 1.52 days.
LSD Lines within a stage = 1.69 days.

Table 14. Days delay to first bloom as affected by methods and stages at Manhattan in 1970.

Methods	Stages		
	100	010	110
Flame	5.94	4.12	11.81
Clip	3.44	5.81	8.62
Herbicide	1.06	1.00	2.25

LSD = 1.32 days.

Manhattan 1969-1970. Effects which were significant and highly significant when the data were combined over years at Manhattan are shown in Table 15.

Table 15. Analysis of variance for days delay to first bloom combined over years at Manhattan.

Source	d.f.	Ms	F
Year	1	355.56	21.44**
Replicate/Year	6	10.17	0.61
Line	3	33.94	2.05
Year x Line	3	70.78	4.27*
Error (a)	18	16.59	
Method	2	475.84	123.98**
Stage	2	652.00	169.88**
Method x Stage	4	67.76	17.66**
Year x Method	2	73.08	19.04**
Year x Stage	2	13.92	3.63*
Line x Method	6	13.44	3.50**
Line x Stage	6	1.73	0.45
Year x Method x Stage	4	14.20	3.70**
Line x Method x Stage	12	6.95	1.81*
Year x Line x Method	6	5.93	1.55
Year x Line x Stage	6	18.20	4.74**
Year x Line x Method x Stage	12	7.92	2.06*
Error (b)	192	3.84	

The line x method interaction is shown in Table 16. Flaming and clipping did not differ significantly within lines when used on Plainsman,

ms Redlan, and ms Combine Kafir 60. Combine 7078 was delayed significantly more by flaming. Applying Dow-Premerge resulted in significantly less delay. Differences were not significant among Plainsman, ms Redlan, and ms Combine Kafir 60 when flaming was used; however, Plainsman was delayed significantly more than Combine 7078, ms Redlan, and ms Combine Kafir 60 when the plants were clipped. When Dow-Premerge was applied, there was a significant difference in delay obtained between Combine 7078 and ms Combine Kafir 60.

Days delay was significantly larger in 1969 when averaged over methods and stages (Table 17). Delays did not differ significantly between years when plants were flamed at the three-leaf stage and when plants were clipped at the five-leaf stage. Delays were significantly larger in 1969 for the other methods and stages. In 1969, there was no significant difference in flaming at stage 100 and clipping at stages 100 and 010. Applying Dow-Premerge at either stage 100 or 010 produced no significant difference in delay. Treating the plants twice (110) gave the greatest delay for all methods. In 1970, flaming at the three-leaf stage and clipping at the five-leaf stage produced the same delay; however, flaming at the five-leaf stage and clipping at the three-leaf stage produced the same delay. No significant difference occurred between stages when Dow-Premerge was applied.

The year x line x stage interaction is shown in Table 18. No significant differences occurred between stages 100 and 010 within lines for both years. Treating at both stages (110) produced significantly more delay. There was no significant difference between years for Combine 7078 treated at the three-leaf stage and both stages, ms Redlan at the five-leaf stage, and ms Combine Kafir 60 at all stages. In all other cases, delays were significantly higher in 1969.

Table 16. Days delay to first bloom as affected by lines and methods combined over years at Manhattan.

Lines	Methods		
	Flame	Clip	Herbicide
Combine 7078	9.04	6.75	4.04
Plainsman	7.58	8.45	3.45
ms Redlan	7.20	6.42	3.70
ms Combine Kafir 60	6.46	6.33	2.62

LSD Methods within a line = 1.11 days.
LSD Lines within a method = 1.36 days.

Table 17. Combined data of days delay to first bloom as affected by years, methods, and stages at Manhattan.

Methods	Stages					
	100		010		110	
	1969	1970	1969	1970	1969	1970
Flame	7.25	5.94	4.25	4.12	12.06	11.81
Clip	6.62	3.44	6.31	5.81	11.12	8.62
Herbicide	3.69	1.06	4.56	1.00	8.19	2.25

LSD Methods and stages within a year = 1.36 days.
LSD Years within a method and stage = 1.67 days.

Table 18. Combined data of days delay to first bloom as affected by years, lines, and stages at Manhattan.

Lines	Stages					
	100		010		110	
	1969	1970	1969	1970	1969	1970
Combine 7078	6.58	3.17	6.00	4.25	10.58	9.08
Plainsman	6.92	3.92	6.75	2.58	11.75	7.08
ms Redlan	5.67	3.42	4.50	3.42	12.08	5.58
ms CK-60	4.25	3.42	2.92	4.33	7.42	8.50

LSD Stages within a line and year = 1.58 days.
LSD Lines and years within a stage = 1.93 days.

Days Delay to Half Bloom

Hutchinson 1969. Methods, stages, a line x method interaction, a line x stage interaction, and a method x stage interaction were highly significant (Table 19).

Table 19. Analysis of variance for days delay to half bloom at Hutchinson in 1969.

Source	d.f.	Ms	F
Replication	3	3.19	0.36
Line	3	13.27	1.51
Error (a)	9	8.78	
Method	2	157.30	93.73**
Stage	2	197.59	117.74**
Line x Method	6	6.75	4.02**
Line x Stage	6	10.04	5.98**
Method x Stage	4	31.68	18.88**
Line x Method x Stage	12	3.54	2.11
Error (b)	96	1.68	

Differences in the amount of delay obtained between flaming and clipping within a line were not significant (Fig. 1). Days delay ranged from 3.67 to 5.83 days. Applying Dow-Premerge produced less delay. Delays obtained for lines within a method were variable. There was a significant difference between ms Combine Kafir 60 and Plainsman when the plants were flamed and between ms Combine Kafir 60 and ms Redlan when clipped. Combine 7078 was the only line significantly delayed by applying Dow-Premerge.

Treating the plants at either stage 100 or 010 produced the same amount of delay to half bloom within lines (Fig. 2). Treating the plants twice (110) caused significantly more delay than treating at either stage 100 or 010. Combine 7078 was delayed significantly more than ms Redlan

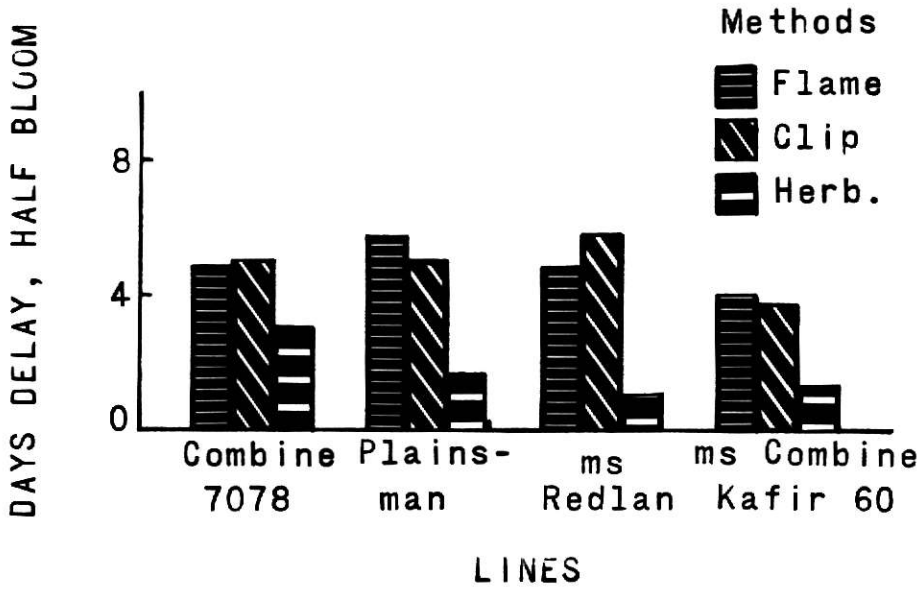

Fig. 1. Days delay to half bloom as affected by lines and methods at Hutchinson in 1969. LSD Methods within a line = 1.06 days. LSD Lines within a method = 1.35 days.

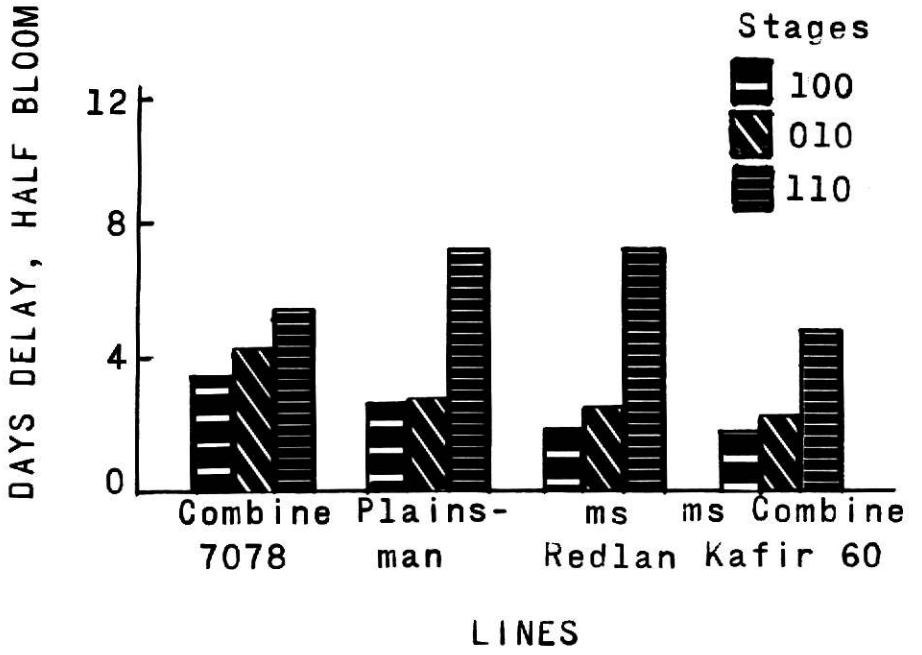

Fig. 2. Days delay to half bloom as affected by lines and stages at Hutchinson in 1969. LSD Stages within a line = 1.06 days. LSD Lines within a stage = 1.35 days.

and ms Combine Kafir 60 at stage 100; however, there was no significant difference among Plainsman, ms Redlan, and ms Combine Kafir 60. Combine 7078 was delayed significantly more than Plainsman, ms Redlan, and ms Combine Kafir 60 when the plants were treated at stage 010. Plainsman and ms Redlan were delayed significantly more than Combine 7078 and ms Combine Kafir 60 when the plants were treated at both the three- and five-leaf stages (110).

These two interactions show how differently individual lines can react to the same treatment. These interactions emphasize the importance of testing each line before trying to delay its flowering on a field basis.

The method x stage interaction is shown in Fig. 3. Flaming early, the three-leaf stage (100), delayed flowering more than flaming at the five-leaf stage (010). Clipping was the reverse; more delay was obtained when the plants were clipped at stage 010. Apparently, clipping the plants at the first true leaf at the three-leaf stage (100) did not remove as much leaf area as flaming at this stage. Flaming killed all exposed plant material above ground level. Clipping the plants at the five-leaf stage was the reverse of the above. Apparently, flaming at stage 010 did not burn or kill plant material within the whorl, while clipping removed this plant material. Therefore, clipping produced more delay. There was no difference between stage 100 and 010 when Dow-Premerge was applied. Treating the plants twice (110) gave the greatest delay for all methods. Flaming and clipping produced more delay than applying Dow-Premerge for all stages. Very little delay was obtained when the plants were treated with Dow-Premerge.

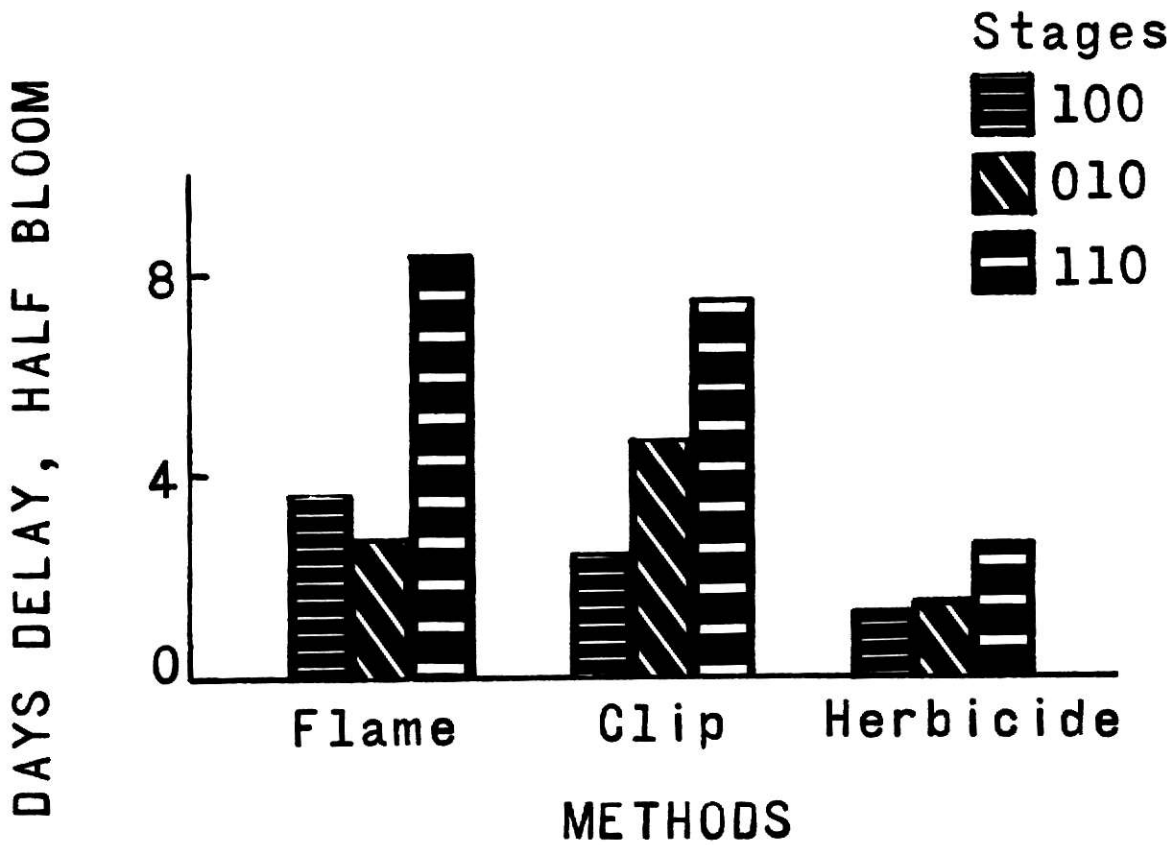

Fig. 3. Days delay to half bloom as affected by methods and stages at Hutchinson in 1969. LSD = 0.92 day.

Hutchinson 1970. Methods, stages, a line x method interaction, and a method x stage interaction were highly significant at Hutchinson in 1970 (Table 20).

Table 20. Analysis of variance for days delay to half bloom at Hutchinson in 1970.

Source	d.f.	Ms	F
Replication	3	118.10	2.74
Line	3	58.12	1.35
Error (a)	9	43.03	
Method	2	747.15	74.49**
Stage	2	231.81	23.11**
Line x Method	6	36.49	3.64**
Line x Stage	6	8.71	0.87
Method x Stage	4	92.24	9.20**
Line x Method x Stage	12	16.07	1.60
Error (b)	96	10.03	

Flaming and clipping Combine 7078 and Plainsman resulted in no significant difference between the two methods, but clipping ms Redlan and ms Combine Kafir 60 produced more delay than flaming these lines as shown in the line x method interaction in Fig. 4. Applying Dow- Premerge caused no significant delay in flowering for any of the lines. In fact, applying Dow-Premerge to Plainsman and ms Redlan appeared to accelerate flowering. The treated plots bloomed before the untreated plots due to moisture stress caused by a severe weed infestation in the untreated plots. Plots that received Dow-Premerge were relatively free of weeds. Therefore, the untreated plots may have been delayed because of weed competition for the small amount of moisture that was present. Applying Dow-Premerge is a relatively mild treatment as very little leaf area is killed compared to flaming or clipping. Apparently the lack of weeds more than offset the small delays obtained with Plainsman and ms Redlan, thus resulting in

negative delays.

Combine 7078 and Plainsman were delayed significantly more by flaming than were ms Redlan and ms Combine Kafir 60. There was no significant difference between lines when the plants were clipped. Again, this emphasizes that individual lines may react differently to the same treatment.

The method x stage interaction (Fig. 5) also points out that very little delay or negative delay was obtained when Dow-Premerge was applied. The reasons for the negative delays are the same as above, moisture stress and a severe weed infestation. Also, flaming at stage 010 produced very little delay. Some of the individual plots that had been flamed also bloomed before the check. Again, these negative delays were due to the weed infestation problem. Flamed plots were also free of weeds which tended to reduce the amount of delay obtained. Flaming delayed maturity even though the plots were free of weeds because its effects are more severe than applying Dow-Premerge. These flaming effects more than offset the effects of the weeds and lack of moisture.

Whereas flaming and applying Dow-Premerge produced less delay because of the lack of weeds, delays from clipping were probably increased over what they would have been if no weeds were present. Clipped plots, like the untreated plots, were also weed infested. The plants in these plots had to compete with the weeds for moisture and also had to regrow after clipping under these conditions. Flaming or clipping at both stages (110) delayed flowering significantly more than treating at either stage 100 or 010.

Hutchinson 1969-1970. Although statistically the Hutchinson data cannot be combined over years, the author believes it is important to look at the data. These methods of delaying flowering are impractical if the

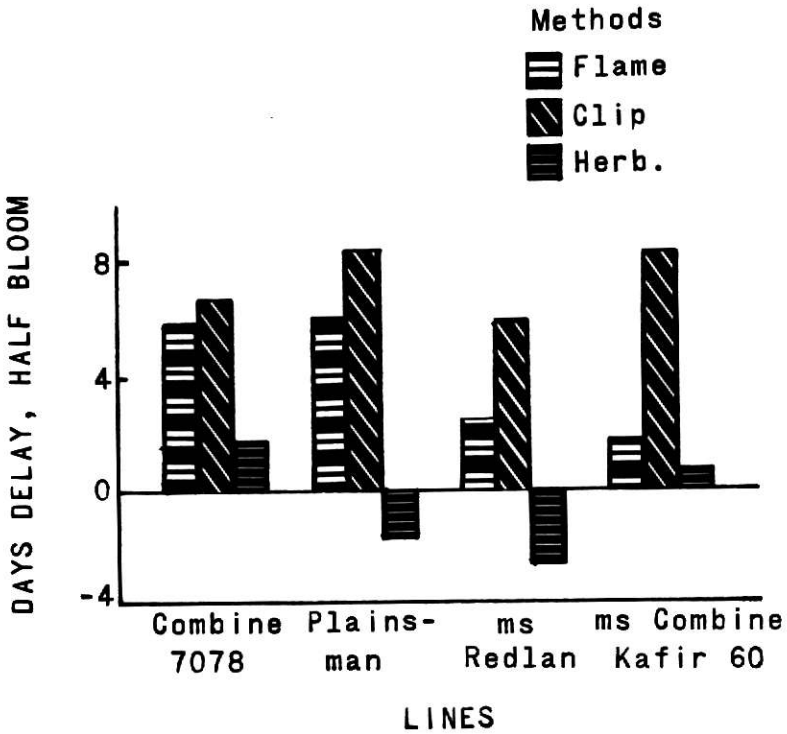

Fig. 4. Days delay to half bloom as affected by lines and methods at Hutchinson in 1970. LSD Methods within a line = 2.59 days. LSD Lines within a method = 3.16 days.

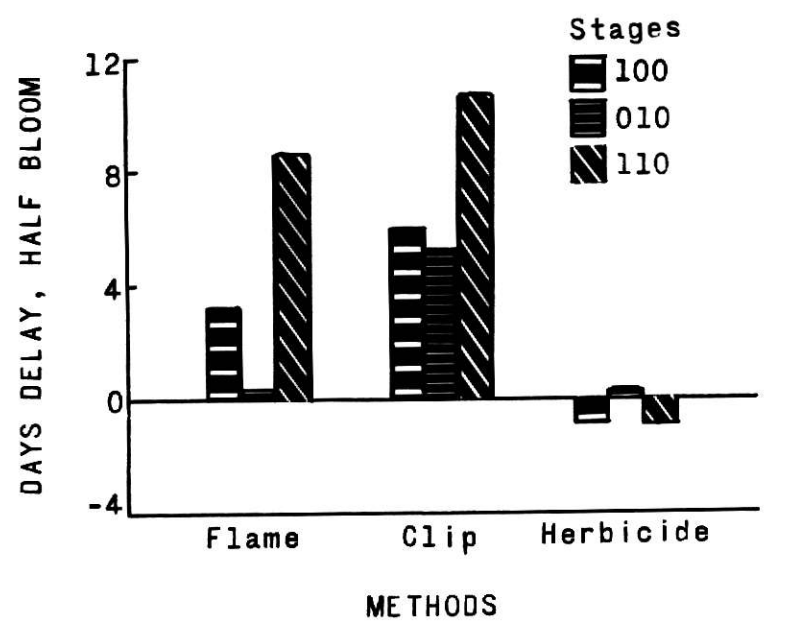

Fig. 5. Days delay to half bloom as affected by methods and stages at Hutchinson in 1970. LSD = 2.24 days.

same delays cannot be produced year after year. For this reason, the data are combined to see if there are significant differences between the two years from a practical viewpoint.

Significant and highly significant effects when the data were combined over years at Hutchinson are shown in Table 21.

The year x method x stage interaction is shown in Fig. 6. Differences were not significant between flaming and clipping at stage 100 or both stages (110) in 1969. Also, there was no significant difference between flaming and applying Dow-Premerge at stage 010 in 1969. Other results were variable. Applying Dow-Premerge resulted in significantly less delay than flaming or clipping.

Table 21. Analysis of variance for days delay to half bloom combined over years at Hutchinson.

Source	d.f.	Ms	F
Year	1	3.34	0.13
Replicate/Year	6	60.65	2.34
Line	3	45.23	1.75
Year x Line	3	26.15	1.01
Error (a)	18	25.91	
Method	2	763.38	130.40**
Stage	2	416.94	71.22**
Method x Stage	4	107.25	18.32**
Year x Method	2	141.06	24.10**
Year x Stage	2	12.46	2.13
Line x Method	6	28.79	4.92**
Line x Stage	6	6.97	1.19
Year x Method x Stage	4	16.67	2.85*
Line x Method x Stage	12	10.69	1.83*
Year x Line x Method	6	14.45	2.47*
Year x Line x Stage	6	11.78	2.01
Year x Line x Method x Stage	12	8.91	1.52
Error (b)	192	5.85	

Flaming at stages 100 and 110, clipping at stage 010, and applying Dow-Premerge at stages 100 and 010 produced no significant difference in delay between the two years. Other results were variable between the two years. Clipping in 1970 caused significantly more delay than clipping in 1969, while flaming and applying Dow-Premerge in 1970 gave significantly less delay than in 1969. The reasons for these differences were discussed in presenting the 1970 Hutchinson data. In 1970, there was a severe drouth and a severe weed infestation in the plots. Plots that had been flamed or plots to which Dow-Premerge had been applied were free of weeds. Weed infested untreated plots tended to reduce the amount of delay in 1970.

Differences between flaming and clipping were not significant except for Plainsman and ms Combine Kafir 60 in 1970. This is shown in the year x line x method interaction in Fig. 7.

Differences were not significant between the two years for all three methods on Combine 7078, flaming Plainsman, clipping ms Redlan, and flaming or applying Dow-Premerge to ms Combine Kafir 60. Other results were variable between the two years. Clipping delays were higher in 1970; however, flaming and applying Dow-Premerge resulted in signficantly less delay in 1970. The reasons for these differences were discussed above.

The year x line x method x stage interaction will be discussed as follows: the methods and stages that look practical on a field basis will be the only treatments discussed. These treatments are flaming at stages 100 and 010, and clipping at stages 100 and 010. These treatments resulted in delays up to 7.5 days, (Fig. 8). Clipping Plainsman at the three-leaf stage (100), flaming ms Redlan at the five-leaf stage (010), flaming ms Combine Kafir 60 at stage 010, and clipping ms Combine Kafir 60 at stage 100 were the only treatments that were different between the two

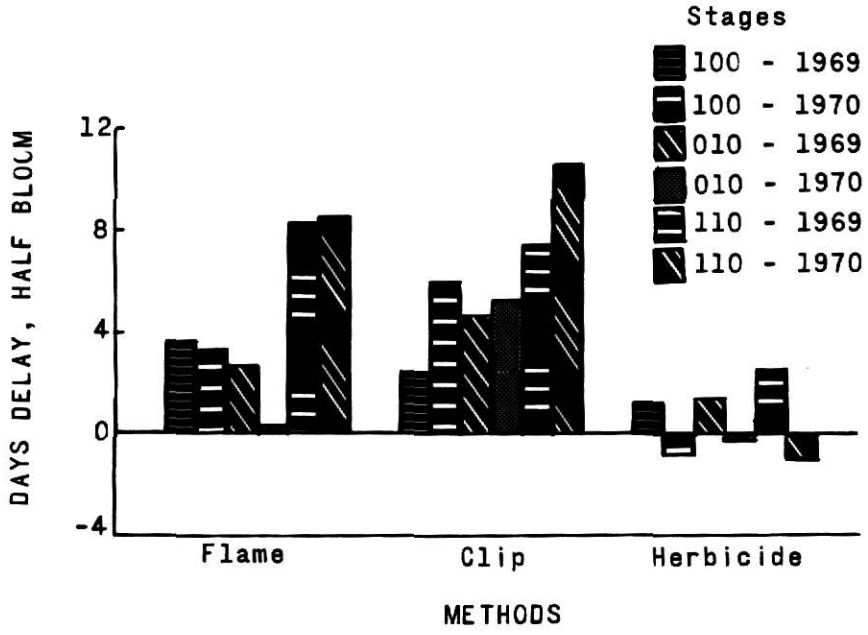

Fig. 6. Days delay to half bloom as affected by years, methods, and stages at Hutchinson. LSD Methods and stages within a year = 1.69 days. LSD Years within a method and stage = 2.03 days.

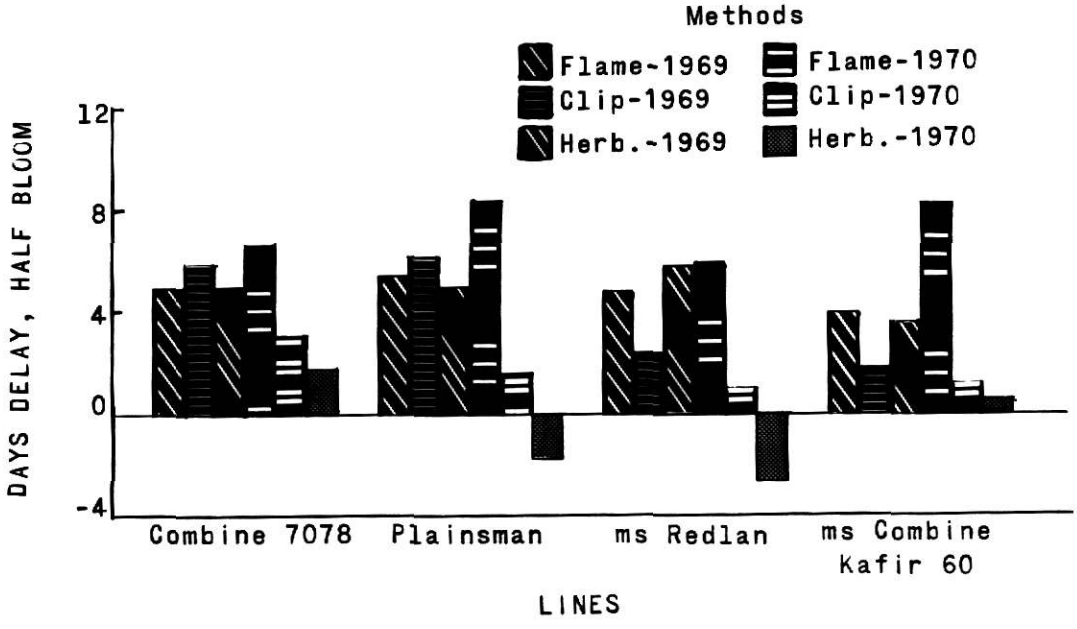

Fig. 7. Days delay to half bloom as affected by years, lines, and methods at Hutchinson. LSD Methods within a line and year = 1.95 days. LSD Lines and years within a method = 2.34 days.

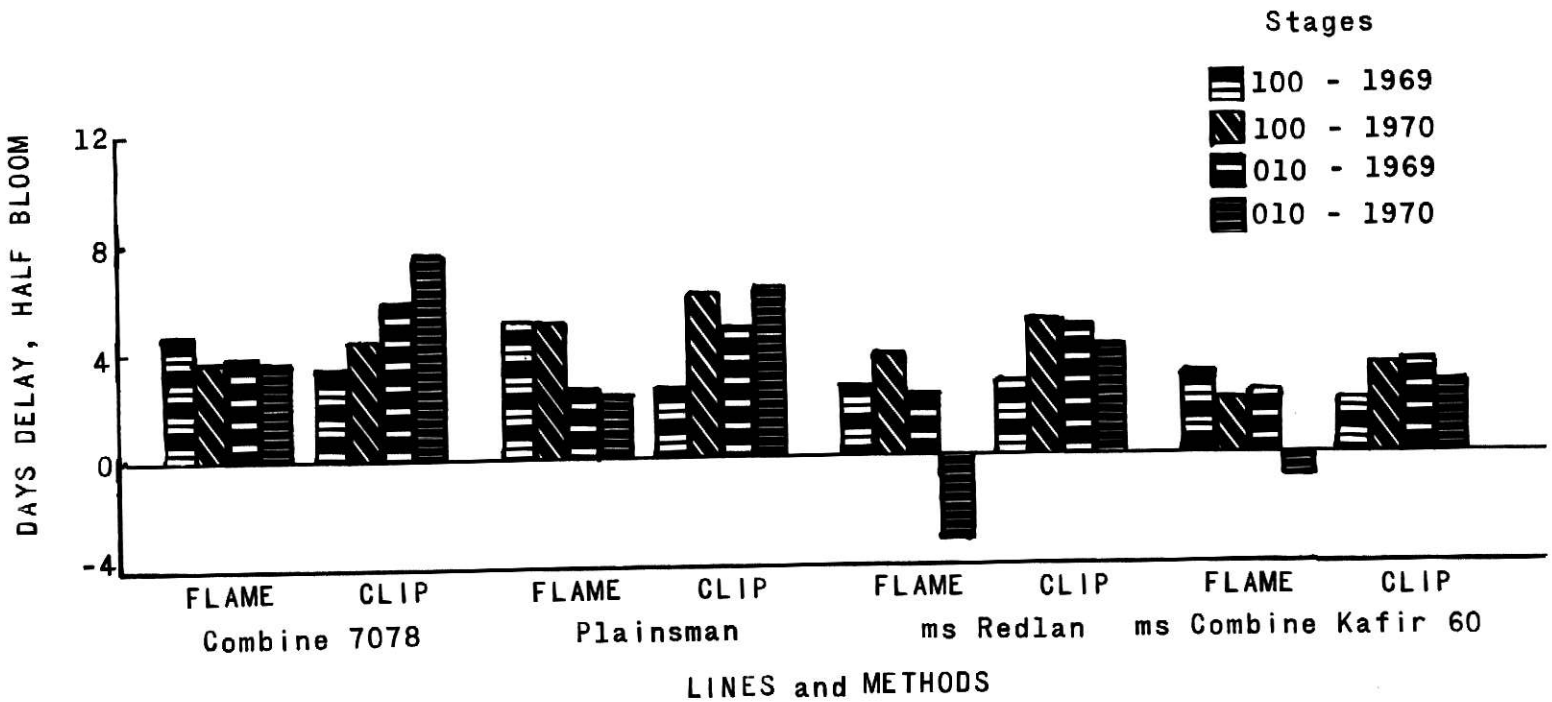

Fig. 8. Combined data of days delay to half bloom for four treatments as affected by years, lines, methods, and stages at Hutchinson. LSD Methods and stages within a line and year = 3.37 days. LSD Lines and years within a method and stage = 4.06 days.

years. All other treatments produced no significant differences between years. Therefore, flaming and clipping at the three or five-leaf stage would appear to give the same amount of delay year after year.

Manhattan 1969. Lines, methods, and stages were highly significant as shown in Table 22. A line x stage interaction was significant at the 5% level.

Differences were not significant between flaming and clipping, while applying Dow-Premerge resulted in significantly less delay to half bloom. Days delay were 7.6, 7.56, amd 5.71 for flaming, clipping, and applying Dow-Premerge, respectively. Apparently delays obtained from flaming were due primarily to leaf removal because clipping and flaming resulted in the same amount of delay. Delays from Dow-Premerge were less because less leaf area was removed.

The line x stage interaction is shown in Fig. 9. Treating the plants twice (110) significantly delayed flowering more than treating at either stage 100 or 010. Differences were not significant between stages 100 and 010 within lines when combined over methods. Plainsman and ms Redlan were delayed significantly more than Combine 7078 and ms Combine Kafir 60 for all stages. There is a difference in the magnitude of delay when going from stage to stage within a line. This accounts for the interaction. The line x stage interaction points out than individual lines can react differently when treated at the same stage of growth. This emphasizes the importance of testing each line before trying to delay its flowering on a field basis.

Table 22. Analysis of variance for days delay to half bloom at Manhattan in 1969.

Source	d.f.	Ms	F
Replication	3	9.08	0.57
Line	3	132.32	8.32**
Error (a)	9	15.90	
Method	2	56.27	22.03**
Stage	2	179.52	70.30**
Line x Method	6	3.42	1.34
Line x Stage	6	6.51	2.55*
Method x Stage	4	6.23	2.44
Line x Method x Stage	12	5.93	2.32
Error (b)	96	2.55	

Manhattan 1970. Table 23 presents the analysis of half bloom data at Manhattan in 1970. Lines, methods, stages, a line x method interaction, a line x stage interaction, a method x stage interaction, and a line x method x stage interaction were highly significant.

The line x method interaction is shown in Fig. 10. Flaming delayed the flowering of Combine 7078 and ms Combine Kafir 60 more than clipping, while there was no difference between flaming and clipping with Plainsman and ms Redlan. Applying a contact herbicide, Dow-Premerge, produced significantly less delay for all lines.

There was a significant difference between lines in the amount of delay obtained within a method. Combine 7078 and ms Combine Kafir 60 were delayed significantly more than Plainsman and ms Redlan when flaming was the method used. Plainsman and ms Combine Kafir 60 were delayed more than Combine 7078 and ms Redlan when the plants were clipped. Differences were not significant among lines when Dow-Premerge was applied. This interaction points out that individual lines react differently to the same method.

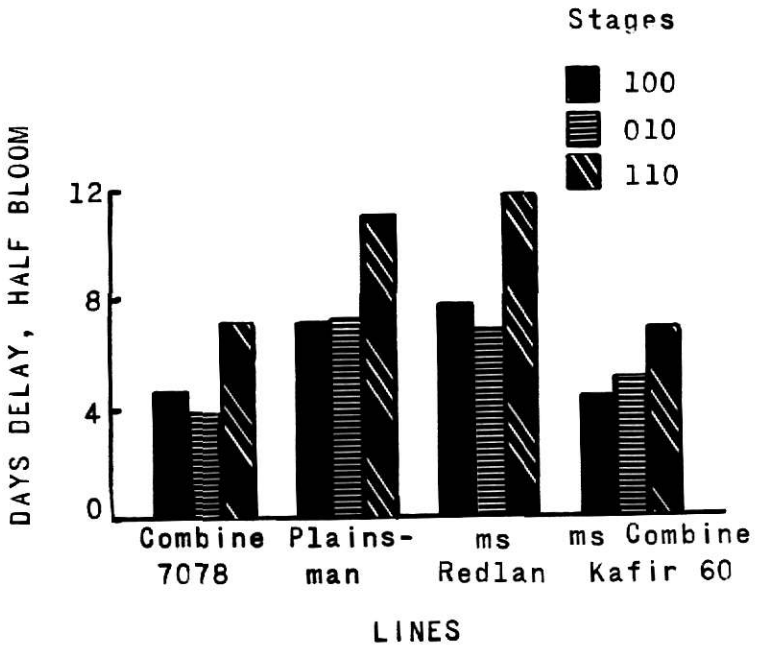

Fig. 9. Days delay to half bloom as affected by lines and stages at Manhattan in 1969. LSD Stages within a line = 1.30 days. LSD Lines within a stage = 1.73 days.

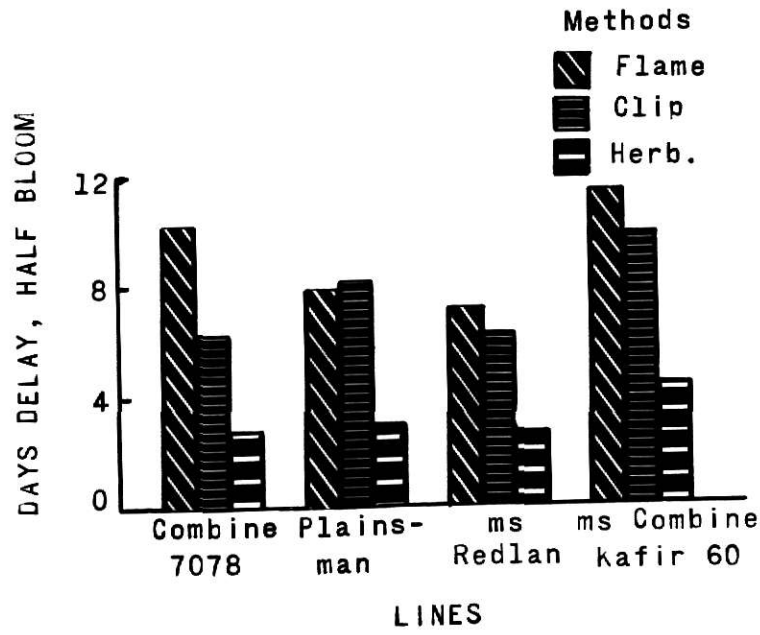

Fig. 10. Days delay to half bloom as affected by lines and methods at Manhattan in 1970. LSD Methods within a line = 1.08 days. LSD Lines within a method = 1.25 days.

The line x stage interaction showed there was no significant difference between stage 100 and 010 for all lines except Combine 7078 (Fig. 11). Combine 7078 was delayed more when the plants were treated at stage 010 than when treated at stage 100. Treatment 110 gave significantly more delay than treating at either stage 100 or 010 for all lines. The amount of delay obtained between lines within a stage was variable. Generally, Combine 7078 and ms Combine Kafir 60 were delayed more than Plainsman and ms Redlan. The line x stage interaction is due to the differences in the magnitude of the delays when going from stage to stage within a line. Also, some stages produce significantly more delay than another stage on one line, i.e., Combine 7078 stages 100 and 010, while the same stages may not differ when used on a different line.

The line x method and line x stage interactions point out the importance of testing each line before trying to delay its flowering on a field basis.

The method x stage interaction is shown in Fig. 12. Very little delay was obtained when Dow-Premerge was used at either stage 100 or 010. Flaming or clipping at either stage 100 or 010 produced delays one would be looking for on a field basis. A method and a stage can be chosen which will give the desired amount of delay.

The line x method x stage interaction will be discussed in detail when the data are combined over years.

Manhattan 1969-1970. Effects which were significant and highly significant when the data were combined over years at Manhattan are shown in Table 24.

The year x line x method interaction is shown in Fig. 13. Differences in the amount of delay between flaming and clipping within a line, except for ms Combine Kafir 60 in 1970, were non-significant. Flaming delayed

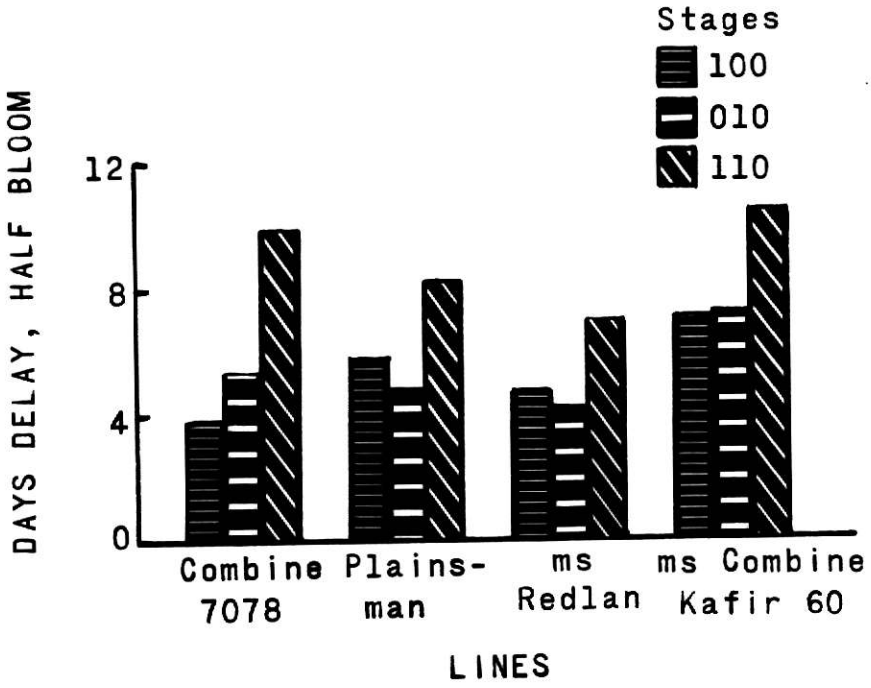

Fig. 11. Days delay to half bloom as affected by lines and stages at Manhattan in 1970. LSD Stages within a line = 1.08 days. LSD Lines within a stage = 1.25 days.

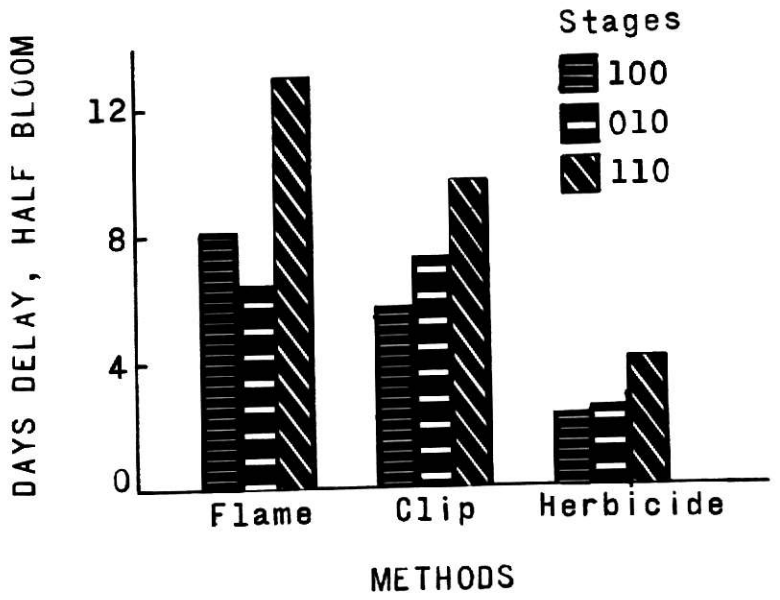

Fig. 12. Days delay to half bloom as affected by methods and stages at Manhattan in 1970. LSD = 0.94 day.

ms Combine Kafir 60 significantly more than clipping in 1970. Applying Dow-Premerge produced less delay both years for all four lines.

Table 23. Analysis of variance for days delay to half bloom at Manhattan in 1970.

Source	d.f.	Ms	F
Replication	3	19.67	3.57
Line	3	55.54	10.09**
Error (a)	9	5.51	
Method	2	509.39	289.93**
Stage	2	199.52	113.56**
Line x Method	6	16.43	9.35**
Line x Stage	6	9.81	5.58**
Method x Stage	4	32.54	18.53**
Line x Method x Stage	12	7.84	4.46**
Error (b)	96	1.76	

Table 24. Analysis of variance for days delay to half bloom combined over years at Manhattan.

Source	d.f.	Ms	F
Year	1	11.28	1.05
Replicate/Year	6	14.38	1.34
Line	3	34.11	3.19*
Year x Line	3	153.76	14.37**
Error (a)	18	10.70	
Method	2	447.70	207.71**
Stage	2	378.38	175.55**
Method x Stage	4	27.32	12.67**
Year x Method	2	117.97	54.73**
Year x Stage	2	0.66	0.30
Line x Method	6	12.82	5.95**
Line x Stage	6	4.58	2.13
Year x Method x Stage	4	11.45	5.31**
Line x Method x Stage	12	8.67	4.03**
Year x Line x Method	6	7.03	3.26**
Year x Line x Stage	6	11.73	5.44**
Year x Line x Method x Stage	12	5.09	2.36**
Error (b)	192	2.15	

Flaming Plainsman, clipping Combine 7078, and applying Dow-Premerge to Combine 7078 and ms Combine Kafir 60 produced no significant difference in delay between the two years. Other results were variable between the two years. Applying Dow-Premerge in 1970 caused significantly less delay than in 1969, due primarily to temperature. Temperatures were 8 to 11 C higher in 1969 when Dow-Premerge was applied at stage 010. According to the specimen label, less herbicide is required at higher temperatures. Dow-Premerge is more effective at higher temperatures; that is, more leaf area is burned.

There was no significant difference between days delay obtained for stages 100 and 010, except for Combine 7078 in 1970 as shown in the year x line x stage interaction in Fig. 14. Treating the plants twice (110) delayed flowering significantly more than treating at either stage 100 or 010. Days delay were not consistent between the two years. There was no significant difference in delay between years when Combine 7078 and Plainsman were treated at stage 100. Results of the other lines and stages were variable. Combine 7078 and ms Combine Kafir 60 were delayed significantly more in 1970; however, Plainsman and ms Redlan were delayed less in 1970, possibly due to maturity. Days to half bloom for the untreated plots of Plainsman and ms Redlan were higher than Combine 7078 and ms Combine Kafir 60 which may explain why delays were smaller for Plainsman and ms Redlan.

The year x method x stage interaction is shown in Fig. 15. There was no significant difference between flaming and clipping at stages 100 and 010, and clipping at both stages (110) between the two years. Applying Dow-Premerge in 1970 produced significantly less delay than in 1969. These smaller delays were due to the difference in temperature when the herbicide was applied. Temperatures were 8 to 11 C higher in 1969; therefore, more

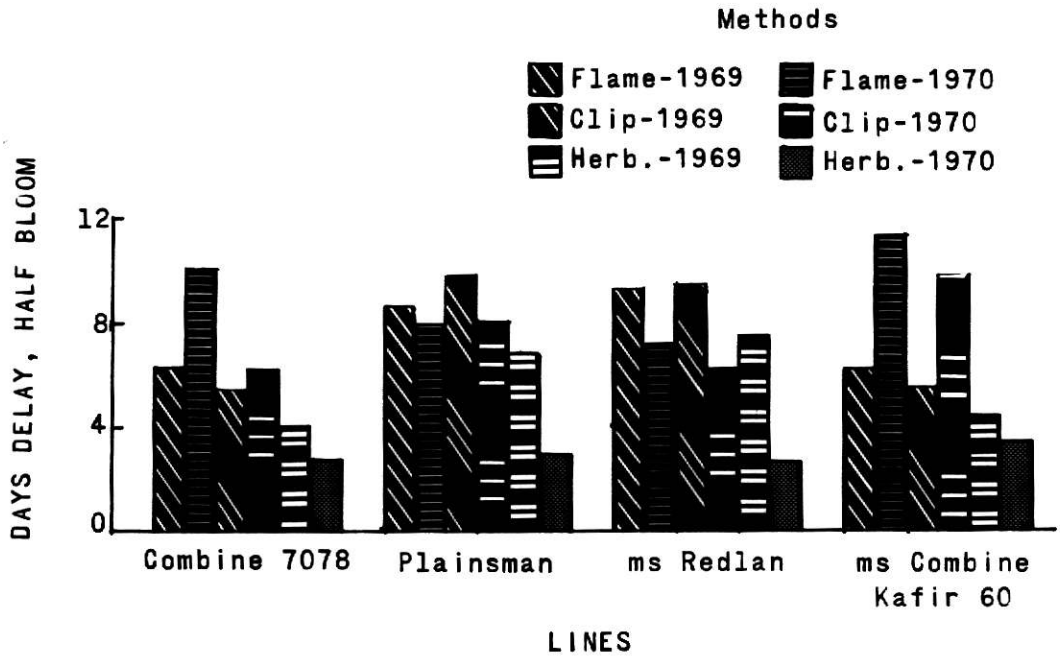

Fig. 13. Combined data of days delay to half bloom as affected by years, lines, and methods at Manhattan. LSD Methods within a line and year = 1.18 days. LSD Lines and years within a method = 1.45 days.

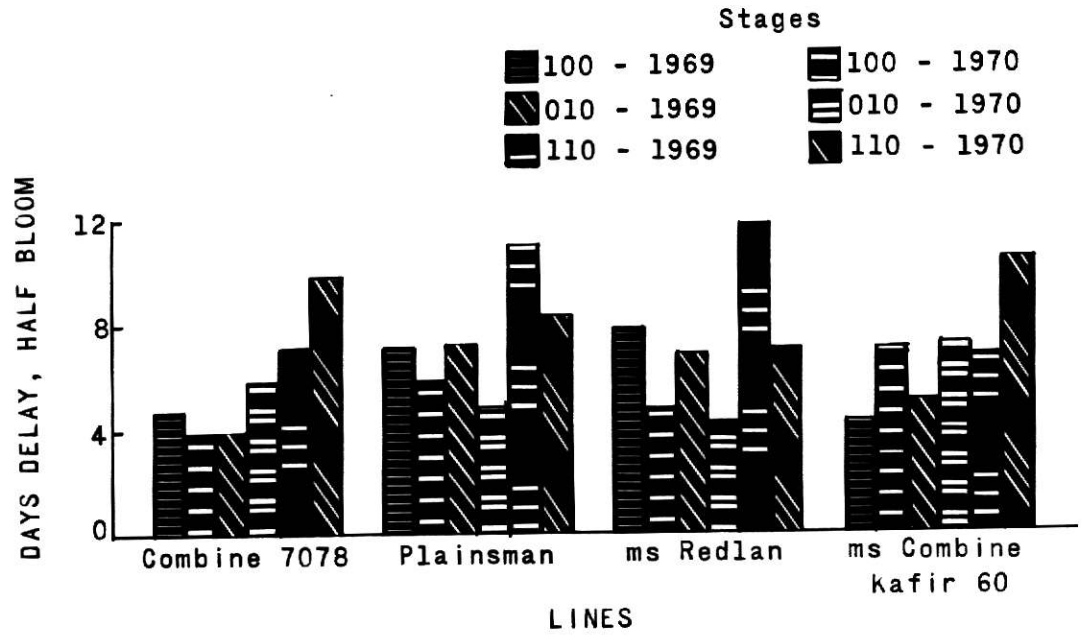

Fig. 14. Combined data of days delay to half bloom as affected by years, lines, and stages at Manhattan. LSD Stages within a line and year = 1.18 days. LSD Lines and years within a stage = 1.26 days.

leaf area was burned in 1969 producing more delay. Differences were not significant between flaming and clipping except for treatment 110 in 1970 when flaming significantly delayed flowering more than clipping. Applying Dow-Premerge resulted in significantly less delay.

The line x method x stage and year x line x method x stage interactions are presented as follows: The methods and stages that look practical on a field basis are the only treatments discussed. Therefore, only those treatments that delayed flowering from three to ten days are discussed. These are the magnitude of delays that would be practical on a field basis. First, treatment 110 was omitted because this treatment reduced stands and yields. Also, all herbicide treatments were omitted because the results were too variable between years and delays were too small. Applying Dow-Premerge seems to be highly temperature dependent; therefore, this method is not practical because the temperature cannot be controlled. The following four treatments are discussed: flaming at the three-leaf stage, flaming at the five-leaf stage, clipping at the three-leaf stage, and clipping at the five-leaf stage. These treatments produced 3.5 to 10.5 days delay to half bloom which is the magnitude of delay that would be practical. Also, there was very little stand reduction with these treatments.

These treatments produced small differences in delay between the two years (Fig. 16). Clipping ms Redlan at stage 100, flaming ms Combine Kafir 60 at stage 100, and clipping ms Combine Kafir 60 at stage 010 were the only treatments that were significantly different between the two years.

Flaming at the three-leaf stage (100) produced more delay than flaming at the five-leaf stage (010); however, clipping at stage 100 produced less delay than clipping at stage 010. Apparently, clipping the plants at the first true leaf removed less leaf area at the three-leaf stage than flaming;

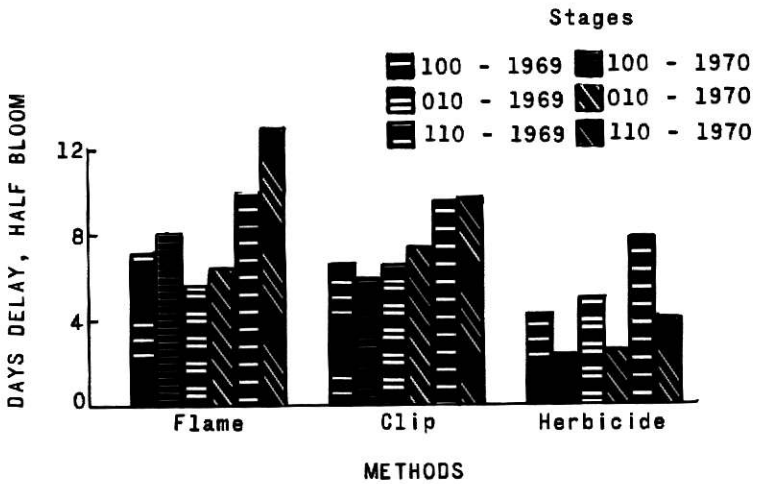

Fig. 15. Combined data of days delay to half bloom as affected by years, methods, and stages at Manhattan. LSD Methods and stages within a year = 1.02 days. LSD Years within a method and stage = 1.26 days.

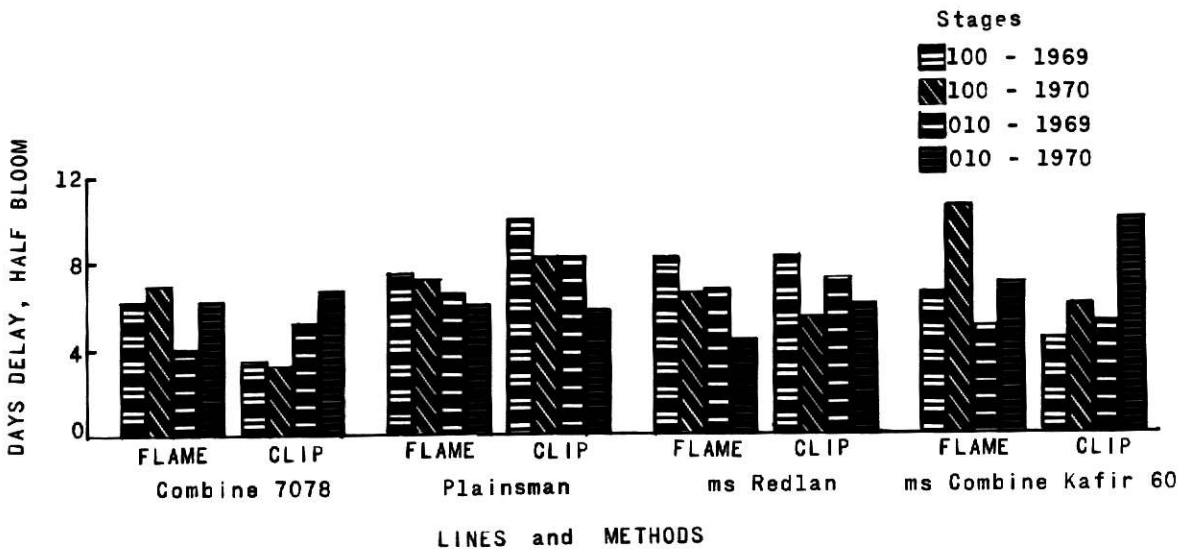

Fig. 16. Combined data of days delay to half bloom for four treatments as affected by years, lines, methods, and stages at Manhattan. LSD Methods and stages within a line and year = 2.04 days. LSD Lines and years within a method and stage = 2.52 days.

however, clipping at the five-leaf stage removed more leaf area than flaming at the five-leaf stage.

The magnitude of the differences in delay for the two years is small. Therefore, it appears that the same amount of delay can be obtained from year to year using the same treatment.

Days Delay to Full Bloom

Full bloom is easily affected by the flowering of very late plants; therefore, it is not considered the best measure of maturity. There will be no discussion of full bloom data, only the results will be presented.

Hutchinson 1969. Effects which were significant and highly significant at Hutchinson in 1969 are shown in Table 25.

Table 25. Analysis of variance for days delay to full bloom at Hutchinson in 1969.

Source	d.f.	Ms	F
Replication	3	15.89	1.83
Line	3	34.48	3.97*
Error (a)	9	8.69	
Method	2	383.31	76.01**
Stage	2	438.52	86.96**
Line x Method	6	29.27	5.80**
Line x Stage	6	16.97	3.37**
Method x Stage	4	114.83	22.77**
Line x Method x Stage	12	10.67	2.12
Error (b)	96	5.04	

The line x method interaction is shown in Table 26. Plainsman was delayed significantly more by flaming than the other lines; however, ms Redlan was delayed significantly more by clipping than Combine 7078, Plainsman, and ms Combine Kafir 60. There was a significant difference

between Combine 7078 and ms Combine Kafir 60 when Dow-Premerge was applied. Flaming and clipping Combine 7078 produced no significant difference in delay. Plainsman and ms Combine Kafir 60 were delayed significantly more by flaming than clipping; however, ms Redlan was delayed more by clipping. Applying Dow-Premerge produced significantly less delay than flaming or clipping. Combine 7078 was the only line significantly delayed by applying Dow-Premerge.

Differences in the amount of delay obtained between stages 100 and 010 were not significant for all lines (Table 27). Treating twice (110) delayed flowering significantly more than treating at either stage 100 or 010. Combine 7078 and Plainsman were delayed significantly more than ms Combine Kafir 60 when treated at the three-leaf stage (100). Male-sterile Combine Kafir 60 was delayed significantly less than the other lines when the plants were treated at stage 010. When the plants were treated twice (110), the flowering of Plainsman and ms Redlan was delayed significantly more than Combine 7078 and ms Combine Kafir 60.

Flaming at stage 100 delayed flowering significantly more than flaming at stage 010; however, clipping at stage 100 delayed flowering significantly less than stage 010 (Table 28). Also, treating the plants twice (110) produced the greatest delay of flowering. There was no significant difference between stages when Dow-Premerge was applied. Applying Dow-Premerge at both stage (110) was the only herbicide treatment to significantly delay flowering.

Hutchinson 1970. Methods, stages, a line x method interaction, and a method x stage interaction were highly significant at Hutchinson in 1970 as shown in Table 29.

Male-sterile Combine Kafir 60 was delayed significantly more by clipping than by flaming, while treating the other three lines produced no significant difference between flaming and clipping (Table 30). Flaming significantly delayed Combine 7078 and Plainsman more than ms Redlan and ms Combine Kafir 60; however, clipping Plainsman and ms Combine Kafir 60 produced greater delay than clipping Combine 7078 and ms Redlan. Combine 7078 was the only line significantly delayed by applying Dow-Premerge.

Table 26. Days delay to full bloom as affected by lines and methods at Hutchinson in 1969.

Lines	Methods		
	Flame	Clip	Herbicide
Combine 7078	6.33	5.25	3.33
Plainsman	8.83	6.33	1.42
ms Redlan	6.83	9.25	1.50
ms Combine Kafir 60	6.08	4.00	0.83

LSD Methods within a line = 1.81 days.
LSD Lines within a method = 1.93 days.

Table 27. Days delay to full bloom as affected by lines and stages at Hutchinson in 1969.

Lines	Stages		
	100	010	110
Combine 7078	3.67	4.50	6.75
Plainsman	4.08	2.92	9.58
ms Redlan	2.75	4.58	10.25
ms Combine Kafir 60	1.58	2.00	7.33

LSD Stages within a line = 1.81 days.
LSD Lines within a stage = 1.93 days.

Table 28. Days delay to full bloom as affected by methods and stages at Hutchinson in 1969.

Methods	Stages		
	100	010	110
Flame	5.25	2.94	12.87
Clip	2.50	6.06	10.06
Herbicide	1.31	1.50	2.50

LSD = 1.57 days.

Table 29. Analysis of variance for days delay to full bloom at Hutchinson in 1970.

Source	d.f.	Ms	F
Replication	3	29.73	0.42
Line	3	152.17	2.17
Error (a)	9	70.10	
Method	2	1015.18	56.63**
Stage	2	339.81	18.95**
Line x Method	6	69.41	3.87**
Line x Stage	6	13.67	0.76
Method x Stage	4	236.22	13.18**
Line x Method x Stage	12	25.11	1.40
Error (b)	96	17.93	

Table 30. Days delay to full bloom as affected by lines and methods at Hutchinson in 1970.

Lines	Methods		
	Flame	Clip	Herbicide
Combine 7078	8.41	8.75	4.08
Plainsman	9.58	13.00	-0.50
ms Redlan	3.75	6.33	-1.25
ms Combine Kafir 60	3.33	11.25	0.50

LSD Methods within a line = 3.42 days.
LSD Lines within a method = 4.12 days.

Table 31. Days delay to full bloom as affected by methods and stages at Hutchinson in 1970.

Methods	Stages		
	100	010	110
Flame	4.75	1.18	12.87
Clip	9.12	6.94	13.44
Herbicide	-0.50	3.00	-0.37

LSD = 2.96 days.

Flaming at stage 100 produced significantly more delay than flaming at stage 010, while clipping at stage 100 or 010 produced no significant difference in delay of flowering (Table 31). Treating the plants twice (110) caused the greatest delay in flowering. Applying Dow-Premerge at the five-leaf stage (010) was the only herbicide treatment that significantly delayed flowering.

Manhattan 1969. Methods and stages were highly significant and a method x stage interaction was significant at the 5% level at Manhattan in 1969 (Table 32).

Table 32. Analysis of variance for days delay to full bloom at Manhattan in 1969.

Source	d.f.	Ms	F
Replication	3	13.83	0.25
Line	3	113.94	2.08
Error (a)	9	54.84	
Method	2	17.84	6.54**
Stage	2	115.47	42.32**
Line x Method	6	5.95	2.18
Line x Stage	6	5.27	1.93
Method x Stage	4	7.69	2.82*
Line x Method x Stage	12	4.94	1.81
Error (b)	96	2.72	

The method x stage interaction is shown in Table 33. Differences in the amount of delay obtained between stages 100 and 010 were not significant when clipping or Dow-Premerge was used. Flaming at stage 100 produced significantly more delay than flaming at stage 010. Delays from treatment 110 were the greatest for all methods.

Differences were not significant between flaming and clipping at stage 100. Clipping at stage 010 produced significantly more delay than flaming or applying Dow-Premerge at stage 010. There was no significant difference between methods when the plants were treated at both the three and five-leaf stages.

Table 33. Days delay to full bloom as affected by methods and stages at Manhattan in 1969.

Methods	Stages		
	100	010	110
Flame	6.00	4.12	7.94
Clip	5.06	5.68	7.62
Dow-Premerge	4.00	4.12	6.94

LSD = 1.15 days.

Manhattan 1970. Effects which were significant and highly significant at Manhattan in 1970 are shown in Table 34.

Flaming delayed Combine 7078, Plainsman, and ms Combine Kafir 60 significantly more than flaming ms Redlan. This is shown in the line x method interaction in Table 35. Plainsman and ms Combine Kafir 60 were delayed more than Combine 7078 and ms Redlan when clipped or when Dow-Premerge was applied. Flaming delayed flowering significantly more than clipping for all lines. Applying Dow-Premerge produced significantly less delay than clipping.

Treating Plainsman and ms Combine Kafir 60 at stage 100 produced significantly more delay than treating Combine 7078 and ms Redlan at this stage (Table 36). Male-sterile Redlan was delayed significantly less than the other lines when treated at either stage 100 or treated twice (110).

Treating Plainsman, ms Redlan, and ms Combine Kafir 60 at either stage 100 or 010 caused no significant difference in delay of flowering. Combine 7078 was delayed significantly more at stage 010. Treating the plants twice (110) gave the greatest delay for all lines.

Flaming, clipping, or applying Dow-Premerge at either stage 100 or 010 produced no significant difference in delay within methods. This is shown in the method x stage interaction in Table 37. Also, there is no significant difference in days delay when Dow-Premerge was applied at either the five-leaf stage or both stages. Flaming or clipping at both stages produced the greatest delay of flowering. Applying Dow-Premerge produced significantly less delay than flaming or clipping.

Number of Heads per Plot

The number of heads per plot is a more reliable indicator of the severity of the treatment than grain yield. Plots where flowering was severely delayed were also severely reduced in yield. Reduction of grain yield was primarily due to a reduced stand but also could be due to the lack of other plants at the flowering stage at this time. Also, environmental conditions varied during seed set because not all plots bloomed at the same time. Therefore, yield data are not discussed, but are included in the appendix for future reference (Tables 49 and 50).

Table 34. Analysis of variance for days delay to full bloom at Manhattan in 1970.

Source	d.f.	Ms	F
Replication	3	34.01	1.29
Line	3	92.69	3.52
Error (a)	9	26.36	
Method	2	527.21	160.45**
Stage	2	221.36	67.37**
Line x Method	6	8.29	2.52*
Line x Stage	6	14.57	4.44**
Method x Stage	4	35.94	10.94**
Line x Method x Stage	12	6.13	1.87*
Error (b)	96	3.29	

Table 35. Days delay to full bloom as affected by lines and methods at Manhattan in 1970.

	Methods		
Lines	Flame	Clip	Herbicide
Combine 7078	10.67	5.58	2.33
Plainsman	10.17	8.58	4.25
ms Redlan	7.42	5.17	1.75
ms Combine Kafir 60	11.33	9.00	4.83

LSD Methods within a line = 1.47 days.
LSD Lines within a method = 2.09 days.

Table 36. Days delay to full bloom as affected by lines and stages at Manhattan in 1970.

	Stages		
Lines	100	010	110
Combine 7078	3.08	5.50	10.00
Plainsman	6.92	6.92	9.17
ms Redlan	4.00	3.17	7.17
ms Combine Kafir 60	7.42	7.17	10.58

LSD Stages within a line = 1.47 days.
LSD Lines within a stage = 2.09 days.

Table 37. Days delay to full bloom as affected by methods and stages at Manhattan in 1970.

Methods	Stages		
	100	010	110
Flame	8.12	7.44	14.12
Clip	5.44	6.50	9.31
Dow-Premerge	2.50	3.12	4.25

LSD = 1.27 days.

Hutchinson. Tables 38 and 39 show that lines were highly significant in 1970 and treatments were highly significant both years.

Table 38. Analysis of variance for the number of heads per plot at Hutchinson in 1969.

Source	d.f.	Ms	F
Replication	3	2.33	0.04
Lines	3	26.67	0.49
Error (a)	9	53.89	
Treatment	9	270.67	12.35**
Line x Treatment	27	27.52	1.26
Error (b)	108	21.92	

Table 39. Analysis of variance for the number of heads per plot at Hutchinson in 1970.

Source	d.f.	Ms	F
Replication	3	181.67	12.98*
Line	1	4687.00	335.50**
Error (a)	3	14.00	
Treatment	9	164.67	5.45**
Line x Treatment	9	46.44	1.54
Error (b)	54	30.20	

In 1970, only the pollinator lines were harvested because the male-sterile lines set very little seed due to the hot, dry weather in July and August. The difference in lines was due to differences in establishment. Also, the 1970 difference in lines was due to variations in drouth tolerance of the lines.

Differences between treatments are shown in Table 40. Flaming at both stages (110) severely reduced the stand. Clipping the plants in 1970 reduced the stand more than in 1969 due to the drouth stress. Generally, stand was reduced only slightly and those plants in the treated plots where stands were reduced tillered more than plants in the untreated plots.

Table 40. Number of heads per plot as affected by treatments at Hutchinson in 1969 and 1970.

Treatments	Number of heads	
	1969	1970
Untreated	33.50	31.88
Flame, 100	25.56	26.00
Flame, 010	31.38	28.00
Flame, 110	19.56	18.75
Clip, 100	29.62	22.25
Clip, 010	28.31	25.12
Clip, 110	26.12	22.12
Dow-Premerge, 100	30.50	26.50
Dow-Premerge, 010	30.81	27.75
Dow-Premerge, 110	29.94	33.25

LSD 1969 = 3.28 heads.
LSD 1970 = 3.85 heads.

Manhattan. Table 41 shows that lines and treatments were significant or highly significant at Manhattan both years.

Differences between lines were due to differences in establishment. All the lines were seeded at the same rate, but probably differed in stand establishment.

Table 41. Analysis of variance for number of heads per plot at Manhattan in 1969 and 1970.

Source	d.f.	Manhattan 1969		Manhattan 1970	
		Ms	F	Ms	F
Replication	3	76.00	0.89	68.33	1.43
Line	3	506.00	5.95*	1065.67	22.30**
Error (a)	9	85.11		47.78	
Treatment	9	816.89	19.66**	413.33	16.03**
Line x Treatment	27	25.96	0.62	48.19	1.87*
Error (b)	108	41.55		25.79	

Differences between treatments are shown in Table 42. In 1969, there was no significant difference among the no-treatment, Dow-Premerge at stages 100 and 010, and clip at stage 010. In 1970, differences were not significant among the untreated plot, clip at stages 100 and 010, and flame are stage 010. In both years flaming at both stages (110) was the only treatment that severely reduced stands. All other treatments, even though they were significantly different from the untreated plot, did not severely reduce the stand.

When the stand was thinned by these treatments, the plants in these plots tillered more than the plants in the untreated plots. Apparently these treatments caused the plants to initiate more tillers than were initiated by the plants in the untreated plots. Only the main head was harvested; therefore, the reduction in the number of heads is not as severe as the data indicate.

Table 42. Number of heads per plot as affected by treatments at Manhattan in 1969 and 1970.

Treatments	Number of Heads	
	1969	1970
Untreated	33.44	33.38
Flame, 100	24.06	28.25
Flame, 010	27.12	30.00
Flame, 110	9.31	14.94
Clip, 100	28.75	31.12
Clip, 010	30.56	30.50
Clip, 110	23.56	28.69
Dow-Premerge, 100	31.56	30.50
Dow-Premerge, 010	33.25	30.06
Dow-Premerge, 110	24.88	30.38

LSD 1969 = 4.51 heads.
LSD 1970 = 3.55 heads.

SUMMARY AND CONCLUSIONS

Flaming, clipping, and possibly Dow-Premerge can be used to delay the flowering of grain sorghum lines. Generally flaming and clipping produced the same amount of delay; however, applying Dow-Premerge produced significantly less delay. Flaming or clipping at the three-leaf stage or the five-leaf stage produced about three to eight days delay at Manhattan and two to six days delay at Hutchinson. Generally applying Dow-Premerge did not delay the flowering very much, if any.

Treating the plants at both the three- and five-leaf stages gave the greatest delay for all three methods. These treatments would be impractical on a field basis because they reduced stands and did not produce consistent delays over the two years. Also, these treatments would be twice as expensive because the plants were treated twice.

The significant line x stage and line x method interactions pointed out that individual lines can react differently to the same treatment. These interactions emphasize the importance of testing each line before trying to delay its flowering on a field basis.

When the data were combined over years, the following four treatments gave the most consistent results: flaming at the three-leaf stage, flaming at the five-leaf stage, clipping at the three-leaf stage, and clipping at the five-leaf stage. These results indicate that it will be possible to obtain the same delays year after year using the same treatments. This is contrary to the results Banks (3) obtained with his work on grain sorghum.

The number of heads was slightly reduced using these four treatments, but this reduction was probably made up by the extra tillering in the plots where the stands were thinned.

If the above four treatments produce the same amount of delay each year, than flaming or clipping at these two stages would be as equally good, if not better, as delayed planting.

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LITERATURE CITED

1. Ball, J. D., P. J. Banks, R. L. Vanderlip, and S. J. Clark. 1967. Influencing grain sorghum maturity. Progress Report on Project 5-760. pp. 8-9.

2. Ball, J. D., R. L. Vanderlip, and F. N. Reece. 1967. Flaming to delay flowering in grain sorghum. Proceedings Fourth Annual Symposium on Thermal Agriculture. pp. 58-59.

3. Banks, P. J. 1969. Flaming to delay flowering of inbred lines of grain sorghum. Master's Thesis. Kansas State University. Manhattan, Kansas.

4. Cochran, W. G. and G. M. Cox. 1968. Experimental Designs. John Wiley & Sons, Inc., New York.

5. Dungan, G. H., and H. W. Gausman. 1951. Clipping corn plants to delay their development. Agron. J. 43: 90-93.

6. Gohlke, A. F. 1966. Residual Treflan effect on grain sorghum yields. High Plains Research Foundation Report No. 166. pp. 620-621.

7. Green, J. M. 1949. Effect of flaming on the growth of inbred lines of corn. Agron. J. 41: 144-146.

8. Howard, D. 1967. The effect of flaming at different stages of growth on yield of grain sorghum. Proceedings Fourth Annual Symposium on Thermal Agriculture. pp. 73-74.

9. Lindstrom, E. W. 1935. Genetic experiments on hybrid vigor in maize. Amer. Naturalist 69: 311-322.

10. Price, D., and T. C. Longnecker. 1962. The use of flame to control weeds in row crops. High Plains Research Foundation Report No. 47. pp. 101-103.

11. Reece, F. N., H. Hurst, and O. Russ. 1966. Comparison of flame, mechanical, and chemical weed control in corn and grain sorghum. Proceedings Third Annual Symposium on Thermal Agriculture. pp. 34-35.

12. Register, O., W. Mahoney, and R. Minton. 1968. Delay and extension of pollination period in male seed corn parentage. Proceedings Fifth Annual Symposium on Thermal Agriculture. pp. 71-73.

APPENDIX

Table 43. Days delay to first, half, and full bloom for all lines and treatments at Hutchinson in 1969.

Treatment	Days Delay			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
First Bloom				
Flame, 100	5.50	4.75	2.00	2.75
Flame, 010	4.75	3.50	1.75	1.50
Flame, 110	7.75	9.75	7.75	5.75
Clip, 100	4.25	3.75	2.25	1.25
Clip, 010	7.00	6.00	4.75	2.50
Clip, 110	7.50	9.25	7.50	5.25
Dow-Premerge, 100	4.00	3.00	0.75	0.50
Dow-Premerge, 010	4.25	1.50	1.00	1.00
Dow-Premerge, 110	4.75	4.00	1.75	1.50
Half Bloom				
Flame, 100	4.50	5.00	2.50	3.00
Flame, 010	3.75	2.50	2.25	2.25
Flame, 110	6.50	10.00	10.25	6.75
Clip, 100	3.25	2.50	2.75	2.00
Clip, 010	5.75	4.75	4.75	3.50
Clip, 110	6.00	8.50	10.00	5.50
Dow-Premerge, 100	2.50	1.00	1.00	0.50
Dow-Premerge, 010	3.00	1.00	0.50	1.00
Dow-Premerge, 110	3.75	3.00	1.50	2.25
Full Bloom				
Flame, 100	4.75	9.50	3.25	3.50
Flame, 010	4.00	3.00	3.25	1.50
Flame, 110	10.25	14.00	14.00	13.25
Clip, 100	3.75	1.75	3.25	1.25
Clip, 010	6.00	5.00	9.75	3.50
Clip, 110	6.00	12.25	14.75	7.25
Dow-Premerge, 100	2.50	1.00	1.75	0.00
Dow-Premerge, 010	3.50	0.75	0.75	1.00
Dow-Premerge, 110	4.00	2.50	2.00	1.50

Table 44. Days delay to first, half, and full bloom for all lines and treatments at Hutchinson in 1970.

Treatment	Days Delay			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
First Bloom				
Flame, 100	1.75	5.25	1.25	1.00
Flame, 010	1.25	0.00	-0.50	0.50
Flame, 110	8.25	6.25	5.75	6.00
Clip, 100	2.00	1.75	5.25	8.50
Clip, 010	5.25	5.00	-0.50	2.75
Clip, 110	6.75	9.00	7.25	9.25
Dow-Premerge, 100	1.00	-1.75	-2.75	0.25
Dow-Premerge, 010	1.25	-0.50	-1.75	1.25
Dow-Premerge, 110	2.50	-0.50	-3.75	1.00
Half Bloom				
Flame, 100	3.50	5.00	3.75	2.00
Flame, 010	2.75	2.25	-3.00	-0.75
Flame, 110	11.50	11.25	6.50	5.00
Clip, 100	4.25	6.00	5.00	7.25
Clip, 010	7.50	6.25	4.00	2.75
Clip, 110	8.50	13.00	8.00	13.00
Dow-Premerge, 100	1.25	-1.25	-3.25	0.00
Dow-Premerge, 010	1.00	-2.00	-0.50	2.00
Dow-Premerge, 110	3.00	-2.00	-4.25	-0.25
Full Bloom				
Flame, 100	5.75	7.75	5.00	0.50
Flame, 010	2.75	3.75	-1.25	-0.50
Flame, 110	16.75	17.25	7.50	10.00
Clip, 100	6.25	13.50	3.75	13.00
Clip, 010	8.25	10.00	5.25	4.25
Clip, 110	11.75	15.50	10.00	16.50
Dow-Premerge, 100	3.75	-0.50	-4.25	-1.00
Dow-Premerge, 010	3.50	2.25	3.25	3.00
Dow-Premerge, 110	5.00	-3.25	-2.75	-0.50

Table 45. Days delay to first, half, and full bloom for all lines and treatments at Manhattan in 1969.

Treatment	Days Delay			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
First Bloom				
Flame, 100	8.00	6.75	7.50	6.75
Flame, 010	5.50	6.00	3.75	1.75
Flame, 110	13.25	13.25	14.25	7.50
Clip, 100	6.50	9.75	5.50	4.75
Clip, 010	7.25	9.50	5.50	3.00
Clip, 110	10.75	12.25	13.00	8.50
Dow-Premerge, 100	5.25	4.25	4.00	1.25
Dow-Premerge, 010	5.25	4.75	4.25	4.00
Dow-Premerge, 110	7.75	9.75	9.00	6.25
Half Bloom				
Flame, 100	6.25	7.50	8.25	6.50
Flame, 010	4.00	6.50	6.75	5.00
Flame, 110	9.00	12.00	12.25	7.00
Clip, 100	3.50	10.00	8.25	4.50
Clip, 010	5.25	8.25	7.25	5.25
Clip, 110	7.25	11.25	13.00	7.00
Dow-Premerge, 100	3.75	3.75	6.75	2.00
Dow-Premerge, 010	2.75	6.75	5.75	5.00
Dow-Premerge, 110	5.00	9.75	10.25	6.50
Full Bloom				
Flame, 100	3.75	7.25	7.50	5.50
Flame, 010	2.75	3.75	6.75	3.25
Flame, 110	6.00	10.00	9.25	6.50
Clip, 100	2.75	7.75	7.00	2.75
Clip, 010	4.25	7.25	6.75	4.50
Clip, 110	4.75	9.25	11.25	5.00
Dow-Premerge, 100	4.75	3.50	6.00	1.75
Dow-Premerge, 010	3.00	4.25	5.25	4.00
Dow-Premerge, 110	4.50	8.75	8.50	6.00

Table 46. Days delay to first, half, and full bloom for all lines and treatments at Manhattan in 1970.

Treatment	Days Delay			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
First Bloom				
Flame, 100	5.25	6.50	5.25	6.75
Flame, 010	6.50	2.75	3.75	3.50
Flame, 110	15.75	10.25	8.75	12.50
Clip, 100	3.00	5.25	3.25	2.25
Clip, 010	5.50	4.50	5.50	7.75
Clip, 110	7.50	9.50	5.75	11.75
Dow-Premerge, 100	1.25	0.00	1.75	1.25
Dow-Premerge, 010	0.75	0.50	1.00	1.75
Dow-Premerge, 110	4.00	1.50	2.25	1.25
Half Bloom				
Flame, 100	7.00	7.25	6.50	10.50
Flame, 010	6.00	6.00	4.50	7.00
Flame, 110	13.75	10.50	10.50	14.75
Clip, 100	3.25	8.25	5.50	6.00
Clip, 010	6.75	5.75	6.00	10.00
Clip, 110	8.50	10.25	7.00	13.00
Dow-Premerge, 100	1.25	2.00	2.25	3.50
Dow-Premerge, 010	2.00	2.75	2.00	3.00
Dow-Premerge, 110	5.00	4.00	3.50	3.75
Full Bloom				
Flame, 100	6.75	8.75	6.75	10.25
Flame, 010	8.75	9.25	3.50	8.25
Flame, 110	16.50	12.50	12.00	15.50
Clip, 100	2.00	9.25	3.75	6.75
Clip, 010	5.75	6.50	5.00	8.75
Clip, 110	9.00	10.00	6.75	11.50
Dow-Premerge, 100	0.50	2.75	1.50	5.25
Dow-Premerge, 010	2.00	5.00	1.00	4.50
Dow-Premerge, 110	4.50	5.00	2.75	4.75

Table 47. Average number of heads per plot for all lines and treatments at Hutchinson in 1969 and 1970.

Treatment	Number of heads per plot			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
1969				
Flame, 100	30.75	23.50	26.25	21.75
Flame, 010	32.25	31.00	29.50	32.75
Flame, 110	21.00	18.50	19.75	19.00
Clip, 100	27.50	29.75	28.25	33.00
Clip, 010	24.50	31.75	26.75	30.25
Clip, 110	25.75	27.00	24.75	27.00
Dow-Premerge, 100	29.00	29.75	29.25	34.00
Dow-Premerge, 010	28.25	30.00	33.25	31.75
Dow-Premerge, 110	27.00	27.00	29.75	36.00
No Treatment	36.00	32.00	34.00	32.00
1970				
Flame, 100	33.50	18.50	*	*
Flame, 010	34.75	21.25		
Flame, 110	23.00	14.50		
Clip, 100	30.75	13.75		
Clip, 010	35.50	14.75		
Clip, 110	33.75	10.50		
Dow-Premerge, 100	36.50	16.50		
Dow-Premerge, 010	33.25	22.25		
Dow-Premerge, 110	38.75	27.75		
No Treatment	38.50	25.25		

* The two male-sterile lines were not harvested in 1970.

Table 48. Average number of heads per plot for all lines and treatments at Manhattan in 1969 and 1970.

Treatment	Number of heads per plot			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
1969				
Flame, 100	24.25	21.50	24.25	26.25
Flame, 010	22.00	26.25	28.25	32.00
Flame, 110	4.75	9.50	7.75	15.25
Clip, 100	28.00	25.00	28.50	33.50
Clip, 010	22.00	30.75	31.75	37.75
Clip, 110	23.25	20.00	18.25	32.75
Dow-Premerge, 100	29.75	30.25	31.25	35.00
Dow-Premerge, 010	29.25	30.25	36.25	37.25
Dow-Premerge, 110	19.00	25.25	25.75	29.50
No Treatment	31.75	32.50	32.25	37.25
1970				
Flame, 100	39.50	24.75	21.50	27.25
Flame, 010	34.25	33.00	28.25	24.50
Flame, 110	16.75	11.00	11.75	20.25
Clip, 100	39.75	30.75	30.00	24.00
Clip, 010	39.50	31.75	26.50	24.25
Clip, 110	40.50	24.50	23.50	26.25
Dow-Premerge, 100	39.75	31.00	25.25	26.00
Dow-Premerge, 010	35.25	29.00	28.00	28.00
Dow-Premerge, 110	35.50	32.00	25.75	28.25
No Treatment	40.50	38.00	26.75	28.25

Table 49. Grain yield (kg/ha) for all lines and treatments at Hutchinson in 1969 and 1970.

Treatment	Grain Yield (kg/ha)			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
1969				
Flame, 100	3,080	2,075	875	745
Flame, 010	3,412	3,213	940	1,854
Flame, 110	1,727	1,776	306	400
Clip, 100	3,886	3,249	1,252	2,293
Clip, 010	2,549	2,465	403	1,122
Clip, 110	2,231	1,893	432	654
Dow-Premerge, 100	3,503	3,685	1,877	3,073
Dow-Premerge, 010	3,529	3,249	2,489	2,407
Dow-Premerge, 110	3,252	2,732	1,684	1,753
No Treatment	4,160	3,171	2,784	2,810
1970				
Flame, 100	1,385	764	*	*
Flame, 010	1,604	796		
Flame, 110	566	497		
Clip, 100	1,295	364		
Clip, 010	1,226	393		
Clip, 110	666	241		
Dow-Premerge, 100	1,607	950		
Dow-Premerge, 010	1,913	1,295		
Dow-Premerge, 110	1,971	1,236		
No Treatment	2,026	1,216		

* The two male-sterile lines were not harvested in 1970.

Table 50. Grain yield (kg/ha) for all lines and treatments at Manhattan in 1969 and 1970.

Treatment	Grain Yield (kg/ha)			
	Combine 7078	Plainsman	ms Redlan	ms CK-60
1969				
Flame, 100	3,302	3,080	2,309	2,260
Flame, 010	3,984	4,196	3,753	2,592
Flame, 110	572	1,421	946	800
Clip, 100	3,568	3,497	3,230	3,090
Clip, 010	2,964	3,676	2,566	2,904
Clip, 110	2,429	2,579	676	1,512
Dow-Premerge, 100	4,410	4,423	3,864	3,503
Dow-Premerge, 010	3,903	4,625	3,965	2,901
Dow-Premerge, 110	2,065	3,187	1,935	1,879
No Treatment	4,937	4,781	5,555	3,476
1970				
Flame, 100	2,316	2,579	702	1,252
Flame, 010	2,897	2,904	895	1,457
Flame, 110	940	1,011	312	816
Clip, 100	3,405	2,759	1,054	1,406
Clip, 010	2,706	3,032	827	989
Clip, 110	2,690	2,072	1,028	1,161
Dow-Premerge, 100	3,152	3,379	1,339	1,230
Dow-Premerge, 010	2,651	3,012	1,327	1,389
Dow-Premerge, 110	2,996	3,327	1,266	1,122
No Treatment	3,246	3,505	1,678	1,203

METHODS FOR DELAYING FLOWERING OF GRAIN SORGHUM, *SORGHUM BICOLOR* (L.) MOENCH, LINES

by

JAMES CARL TRYBOM

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Grain sorghum, Sorghum bicolor (L.) Moench, tradition-bound to the Texas High Plains has fanned out to new areas. Increased acreage has required production of a large volume of good seed. One of the porblems facing breeders and producers of hybrid grain sorghum seed is utilization of lines differing in time of flowering. It is often necessary to cross lines of different maturity to obtain maximum hybrid vigor. Delayed planting or some other method must be used on the earlier flowering line so that both the male- and female-parent plants reach the reproductive stage at the same time.

This study compared flaming, clipping, and applying a contact herbicide, Dow-Premerge, as methods to delay flowering of grain sorghum lines.

Two pollinator lines (Combine 7078 and Plainsman) and two male-sterile lines (ms Redlan and ms Combine Kafir 60) of grain sorghum were planted at Manhattan and Hutchinson in 1969 and 1970. A split-plot design with lines as main plots and treatments as subplots was used. The plots were treated at the three-leaf stage, five-leaf stage, or both.

Generally flaming and clipping produced the same amount of delay, while applying Dow-Premerge produced significantly less delay. Flaming or clipping at the three-leaf stage or five-leaf stage produced about three to eight days delay at Manhattan and two to six days delay at Hutchinson. Applying Dow-Premerge did not delay the flowering very much, if any. Treating the plants twice gave the greatest delay for all three methods.

The line x stage and line x method interactions pointed out that individual lines react differently to the same treatment. These interactions emphasize the importance of testing each line before trying to

delay its flowering on a field basis.

When the data were combined over years the following four treatments gave the most consistent results: flaming at the three-leaf stage, flaming at the five-leaf stage, clipping at the three-leaf stage, and clipping at the five-leaf stage. These results indicate that it will be possible to produce the same amount of delay each year.

The number of heads and yield were slightly reduced using these treatments, but this reduction was probably made up by the extra tillering of the plants where the stands were thinned.