THE EFFECT OF ARTIFICIAL DEFOLIATION ON GRAIN YIELD OF DARSO GRAIN SORGHUM

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By

WAYNE W. HUFFINE

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APPROVED BY:

Frank Davies
Chairman, Thesis Committee

John B. Sieglinger
Member of the Thesis Committee

S. D. Murphy
Head of the Department

D. C. McIntosh
Dean of the Graduate School

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INTRODUCTION

Artificial reduction of the assimilatory surface of sorghum plants and its subsequent effect on grain yield simulates the effects resulting from a reduction of the photosynthetic surface of plants by foliar diseases, insects or hail.

Hail damage to crops in Oklahoma is a common occurrence. The severity of the damage varies with the intensity of the hail and the stage of development of the crop. If damaged in the early stages of growth, the grower is confronted with the problem of whether or not to replant the injured crop.

Infestation of crops with destructive insects, particularly grasshoppers, occasionally occurs throughout the central and western sections of Oklahoma and considerable foliage is destroyed.

There are several common foliage diseases in Oklahoma which generally present themselves each year and if in only a moderate amount, are considered by the grower as harmless.

The primary objective of this work is to determine as nearly as possible the quantity of grain lost from reduction of various amounts of the assimilatory surface of the sorghum plant and the stage of plant development when the loss of the photosynthetic surface has the most critical effect on the production of the grain.

In an attempt to establish a basis for the evaluation of the crop loss resulting from defoliation, Darso (Oklahoma strain number 1) was selected as a representative grain sorghum to be used in this experiment.

Darso is well adapted to Oklahoma conditions and is damaged less by birds than other grain sorghum varieties, because of tannin contained in the brownish-red seed. This astringent apparently is objectionable to birds.

The crop was subjected to three distinct treatments, as follows: (1) check, with no treatment, (2) ½ defoliation of the plant and (3) complete defoliation. These treatments were applied on a specified number of days after the crop was planted.

REVIEW OF LITERATURE

Numerous defoliation studies have been made with various crop plants and trees, to aid in estimating crop losses resulting from a reduction of the assimilatory surface of the plants by foliar diseases, insects or hail.

In studies with sorghum in China, Li and Liu (25)[/1] found defoliation of the plant prior to the dough stage resulted in a reduction of yield and kernel weight, with the yield reduction being directly proportional to the earliness of the defoliation.

More recently, Hoffmaster and Sieglinger (20) found that the complete defoliation of the sorghum plant at the time the leaves were near their maximum development resulted in the greatest reduction of yield. The reduction in yield resulting from defoliation of the plant was less as the leaves were removed before or after the period of maximum leaf development.

In Iowa, Eldredge (15) reported a reduction in the yield of wheat varying from 10 to 70% depending on the season and the stage of maturity of the plants. The greatest reduction in yield occurred when the plant was severely injured at the time the growing point of the plant was 1 to 2 inches above the surface of the ground. A reduction in the yield of wheat resulting from a decrease in the photosynthetic surface of the plant has been found by other workers (1,3,6,10,11,30,31,33,35,36,38) which corresponds approximately to the results Eldredge obtained.

Complete defoliation of barley reduced the yield a maximum of 60% (Kharitonov, 22); oats 72% (Eidelman, 11); and flax 49% (Klages, 24).

/1 Numbers in parenthesis refer to "Literature Cited", p. 25.

Defoliation is not limited to reduction in the quantity of yield in its harmful effects, but there is also observed a reduction in the quality of the crop. Artificial defoliation of wheat has effects comparable to those of leaf rust defoliation as was shown by Caldwell and Compton (6) and others (2,3,4). These investigators found that the grains contained less proteins and sugars, the 1,000 kernel weight and bushel weight were reduced, and the flour was of lower quality as was proved by time-test value and loaf volume of bread and cakes.

In addition, Caldwell and Compton (6) and Anonymous (1) found a significant lowering in the yields of straw and chaff from plants that were artificially defoliated.

In the preceding investigations with wheat, oats, barley and flax the most critical stage in the life of the plant, when defoliation expresses its maximum yield depressive effect was found to be when wheat, oats and barley were defoliated in the rosette stage, and flax in the bud stage.

In Russia, Shcherbinin (34) found in working with cereals a reduction of the assimilatory surface, either by artificial means or from natural causes, did not lead to reduced yields, but, on the contrary resulted in a considerable yield increase. Other Russian workers, Lubimenko (26) and Eidelman and Bankul (12), reported a reduction in the photosynthetic area of the leaves up to 50% had no appreciable effect on yield, and a reduction in the assimilatory surface had a stimulating effect on the photosynthetic activity of remaining portions of the leaves.

In Iowa, Eldredge (13,14) found in working with corn that 1/3 defoliation of the plant reduced yield 30%, 2/3 defoliation 70% and total leaf removal resulted in approximately 100% reduction in yield. Also, Dungan (7), Hume and Franzke (21), Kiesselbach and Lyness (23) working with corn report similar results to those of Eldredge. Other effects of defoliation in corn were a lowering of test weight and a production of more floury and chaffy seeds (Dungan 8).

Dungan (9) stated that the grain of corn made considerable growth after all the blades were stripped from the plant, which indicated that the green sheaths of the stalk were capable of considerable photosynthesis.

The consensus of the workers on corn were that defoliation reduced the yield of corn the greatest amount when the plant was in the tasseling stage.

Hawthorn (19) working with onions in Texas found that complete removal of the foliage when the plants were in the bulbing stage resulted in reduced yields of U. S. No. 1 jumbo and medium size onions an average of 76% and a resultant increase in the proportion of boilers and culls.

In California, Parker and Sampson (28) worked with several species of grass to determine the effect of clipping on the growth and yield of the plants. In all cases the smallest yields were obtained when the herbage was removed at the time when the growth rate was at its maximum.

Several workers in North Carolina, Gibson, Lovvorn and Smith (16), found that any degree of defoliation of soybeans resulted in a decrease in the weight of seed produced, and the yields tended to be inversely related to the amount of defoliation.

Defoliation studies have also been made with trees to provide an estimate of growth reduction by Graham (17) and by Wallace (37) and the effect on blossom bud formation by Roberts (29). Haller and Mayness (18) in a study with apples found that the fruit produced from trees with a large leaf area was of superior quality and was higher in dry weight, sugar and acids than the fruit produced from trees with a smaller leaf surface.

In South Carolina, Ludwig (27) working with cotton found that defoliation reduced the size and number of bolls produced, and that the fiber was seriously weakened if defoliation occurred long enough before maturity.

It is shown by Bailey (5) that controlled defoliation is very useful. Chemical defoliation of cotton reduced the crop loss due to boll rot as much as 50 to 60% in some years. With soybeans, artificial defoliation makes it possible to harvest the crop earlier in the season than if allowed to dry naturally, which enables the grower to prepare a seedbed in ample time for the fall seeding of wheat. The production of abundant foliage on tomatoes in the latter part of the season may prevent exposure of the fruit to bright and direct sunlight needed for quick, full red color ripening. Therefore, it is essential that the leaves be removed artificially to hasten ripening of the fruit and safeguard against possible loss by frost.

The total sugar content of the stem juice of both sweet and field corn has been increased as much as 50% after removal of the ears at canning time (Sayre, Morris, and Richey, 32). Therefore, under unfavorable conditions where natural barrenness is brought about, there is also an increase in total sugars due to an increase in sucrose. Consequently, where the stover is fed this increase in sugar compensates partially for the loss of grain.

MATERIAL AND METHODS

The plot selected for the experiment was located on the Oklahoma Agricultural Experiment Station farm at Perkins, Oklahoma. The soil was a Stidham loamy fine sand. Lime was applied to the south ½ of this plot April 26, 1944 while the north ½ was unlimed. The rows extending north and south were 100 feet long with ½ of the row in the limed and ½ in the unlimed portion. The rows were spaced 3½ feet apart as in normal culture.

Oklahoma Darso number 1 grain sorghum was selected for this experiment as it is well adapted to Oklahoma conditions and is less damaged by birds than other varieties. The Darso plantings were made May 18, 1946, and emerged May 24, 1946. The grain was hand dropped through a planter at a heavier than normal rate to insure a stand and was thinned to a 6 to 8 inch spacing between plants when they attained a height of approximately 4 inches.

The rows were treated on specific dates from the day of planting as follows:

ROW	TREATMENT	DAYS AFTER PLANTING OF TREATMENT
1	Check	
2	All leaves removed	40
3	do	40-60
4	do	40-60-80
5	Check	
6	½ leaves removed	40
7	do	40-60
8	do	40-60-80

ROW	TREATMENT	DAYS AFTER PLANTING OF TREATMENT
9	Check	
10	All leaves removed	60
11	All leaves removed	60-80
12	Check	
13	½ leaves removed	60
14	do	60-80
15	Check	
16	All leaves removed	80
17	½ leaves removed	80
18	Check	

Border rows were planted on each side of the plot.

Defoliation was accomplished by cutting the leaves off as near the collar as possible with a knife. Where ½ of the leaves were removed, the leaves were all cut from one side of the plant. Following the treatment the rows were undisturbed until harvest.

The final treatment was applied August 6, soon after maximum leaf development.

Figures 12 and 13 show the appearance of the plants after defoliation in comparison to untreated rows.

Harvesting was done September 27, from a representative section 25 feet long in each row, from both the unlimed and limed portion.

The heads were harvested by hand and cut approximately 1 inch below the last flowering branch. The heads from each 25 feet section were placed in individual sacks and tagged at that time as to location in the plot i.e., unlimed or limed portion, treatment and number of days after planting when applied. They were then placed under shelter

2 3 4

Fig. 1.—Rows 2, 3 and 4 of Darso completely defoliated 40 days, 40 and 60 days, and 40, 60 and 80 days after planting, respectively. Picture was taken August 6, 1946 after the 80 day treatment was applied.

9 10 11

Fig. 2.--Rows 9, 10 and 11 of Darso check, completely defoliated 60 days and completely defoliated 60 and 80 days after planting, respectively. Picture was taken on August 6, 1946 after 80 day treatment was applied.

and allowed to air dry for several months.

On February 7, 1947 each sack of heads was weighed and the weights recorded.

Threshing was done by hand and each head carefully handled to eliminate possible loss of grain. The grain from each sack of heads was placed in paper bags, then weighed on a gram scale and each weight recorded.

Soil and climatic conditions were conducive to normal development of the plants as is shown by the yield of grain of the check plots. The check average was 29.9 bushels per acre as compared to a 26-year production average of 26.8 bushels of grain per acre for the same variety.

The yields were analyzed by an analysis of variance in order to determine the exact significance of the various component factors. In Table 4, the yield of the check rows was adjusted by using the average of the check rows nearest the row receiving the treatment on a specified number of days after planting. This was done in order to have as nearly as possible a check row yield which could be used in comparing the yields from treated rows on specific dates after planting.

RESULTS AND DISCUSSION

The results presented in this paper are from only one year of study and specific recommendations cannot be made without further studies as to the effect defoliation has upon the sorghum plant.

Treatment, yield, percent of grain in the heads, and weight per bushel of the grain for the unlimed and limed rows of the plot are shown in Table 1. The yields from rows in the limed half of the plot were generally higher than those from the unlimed half and indicate that liming has influenced the yield and should show a significant difference, but the check row yields were adjusted (Table 4) in order to have a basis for comparison of the treated rows to a check row, for the various days after planting when treatment was applied. When the yields of the check rows were adjusted, there was no significant difference in the yield from the limed and unlimed portion when analyzed by an analysis of variance.

Plants from the unlimed half of the plot had a higher percentage of grain in the heads in most cases, than plants from the limed portion. However, in an analysis by Student's Method (Table 2) of the percentage of grain in the heads of plants from the unlimed and limed rows of the plot, a value of 2.055 was obtained and 2.110 is the value of t at the 5% point for 17 degrees of freedom; therefore, there is no significant difference in the percent of grain in the heads of the plants between the unlimed and limed portion of the plot.

The weight per bushel of grain produced in the unlimed portion of the plot shows a highly significant difference from that of the limed by Student's method of analysis at the 5% and 1% point for 17 degrees of freedom (Table 3).

Table 1.—Yields of heads and grain, per cent of grain in heads and weight per bushel of Darso for different defoliation treatments at Perkins Farm, Oklahoma, 1946.

Row*	Treatment**	Yield in Gms. of 25 ft. rows		Per cent Grain in Heads	Weight per Bushel in lbs.
		Heads	Grain		
1	None	1796	1272	70.82	55.8
1	do	2127	1544	72.59	52.0
2	40	1436	994	69.22	56.1
2	do	2018	1330	65.91	55.8
3	40-60	1240	963	77.66	59.7
3	do	846	605	71.51	59.5
4	40-60-80	415	244	58.80	49.0
4	do	443	250	56.43	51.7
5	None	2122	1582	74.55	58.0
5	do	3107	2332	75.06	55.8
6	40	2172	1578	72.65	58.8
6	do	2289	1632	71.30	56.0
7	40-60	1249	923	73.90	56.8
7	do	1367	961	70.30	56.0
8	40-60-80	1694	1276	75.32	59.7
8	do	1610	1108	68.82	49.2
9	None	1732	1309	75.58	58.5
9	do	2536	1897	74.80	54.8
10	60	1294	999	77.20	59.5
10	do	836	620	74.16	55.7
11	60-80	381	203	53.28	47.3
11	do	412	230	55.83	45.3
12	None	2024	1498	74.01	57.5
12	do	2648	1986	75.00	56.5
13	60	1240	933	75.24	55.5
13	do	1293	915	70.77	53.9
14	60-80	1192	880	73.83	56.7
14	do	1280	831	64.92	49.0
15	None	2222	1609	72.41	56.3
15	do	1619	1136	70.17	54.7
16	80	836	446	53.35	42.5
16	do	1095	671	61.28	43.8
17	80	1596	1134	71.05	56.0
17	do	1376	960	69.77	53.8
18	None	1462	1069	73.12	56.3
18	do	1395	978	70.11	55.8

*First figure refers to unlimed part of row, and second figure to limed part of row.

**Number of days after planting when treatment was applied and severity of treatment. Example: $\frac{1}{2}$ defoliated at 40 days as 40; all defoliated at 40 days as 40.

Table 2.--Determination of significance of mean difference in the per cent of grain in the heads of plants from the unlimed and limed portion of the plot.

Per cent of grain in the heads		Difference		Mean difference	Deviation from mean difference		Square of deviation
Unlimed portion	Limed portion	Unlimed	Limed				
		−	+		−	+	
70.82	72.59	1.77			3.62		13.1044
69.22	65.91		3.31			1.46	2.1316
77.66	71.51		6.15			4.25	18.0625
58.80	56.43		2.37			0.52	0.2704
74.55	75.06	0.51		$\frac{+33.26}{18}$	2.36		5.5696
72.65	71.30		1.35		0.50		0.2500
73.90	70.30		3.60	$= \pm 1.85$		1.75	3.0625
75.32	68.82		6.50			4.65	21.6225
75.58	74.80		0.78		1.07		1.1449
77.20	74.16		3.04			1.19	1.4161
53.28	55.83	2.55			4.40		19.3600
74.01	75.00	0.99			2.84		8.0656
75.24	70.77		4.47			2.62	6.8644
73.83	64.92		8.91			7.06	49.8436
72.41	70.17		2.24			0.39	0.1521
53.35	61.28	7.93			9.78		95.6484
71.05	69.77		1.28		0.57		0.3249
73.12	70.11		3.01			1.16	1.3456
		13.75	47.01		25.14	25.05	248.2391
		+33.26			0		

Standard deviation of differences $= \sqrt{\frac{248.2391}{17}} = \sqrt{\frac{248.24}{17}} = \sqrt{14.60} = 3.82$

Standard error of mean differences $= \frac{3.82}{\sqrt{18}} = \frac{3.82}{4.24} = 0.90$

The mean difference = 1.85

$$t = \frac{D}{E_D} = \frac{1.85}{0.90} = 2.055$$

Table 3.—Determination of significance of mean difference in the weight per bushel of grain from the unlimed and limed portion of the plot.

Wt. per bu. in lbs.		Difference in wt.		Mean difference	Deviation from mean difference		Square of deviation
Unlimed portion	Limed portion	Unlimed	Limed				
		-	+		-	+	
55.8	52.0		3.8			1.5	2.25
56.1	55.8		0.3		2.0		4.00
59.7	59.5		0.2		2.1		4.41
49.0	51.7	2.7		$\frac{+40.7}{18}$	5.0		25.00
58.0	55.8		2.2	$= \pm 2.3$	0.1		0.10
58.8	56.0		2.8			0.5	0.25
56.8	56.0		0.8		1.5		2.25
59.7	49.2		10.5			8.2	67.24
58.5	54.8		3.7			1.4	1.96
59.5	55.7		3.8			1.5	2.25
47.3	45.3		2.0		0.3		0.90
57.5	56.5		1.0		1.3		1.69
55.5	53.9		1.6		0.7		0.49
56.7	49.0		7.7			5.4	29.16
56.3	54.7		1.6		0.7		0.49
42.5	43.8	1.3			3.6		12.96
56.0	53.8		2.2		0.1		0.10
56.3	55.8		0.5		1.8		3.24
		4.0	44.7		19.2	18.5	
		+40.7			0		

Standard deviation of differences $= \sqrt{\frac{135.25}{17}} = \sqrt{7.96} = 2.82$

Standard error of mean differences $= \frac{2.82}{\sqrt{18}} = \frac{2.82}{4.24} = 0.67$

The mean difference = 2.3

$$t = \frac{D}{E_D} = \frac{2.3}{0.67} = 3.43$$

The reason the unlimed portion had a higher percentage of grain in the heads and a higher test weight, possibly can be explained by the fact that liming of the other portion of the plot caused an increase in vegetative growth which prolonged development and filling of the grains, thus it did not escape the effects of high temperatures and droughty conditions which prevailed for approximately six weeks during the latter part of the summer, whereas the unlimed portion began producing and filling the grains in the heads before the hot, dry weather retarded the plant development.

In Table 4, the yield from rows treated at a specified number of days after planting is compared with that of a corresponding check yield. In all cases, with the exception of $\frac{1}{2}$ defoliation of Replication 1 at 40 days after planting, the yields were lower in the treated rows on any date than that of the corresponding check. This indicates that defoliation of any amount during any stage of development will cause a reduction in yield to some extent.

Analyses of variance for the grain yields are given in Table 5, with a highly significant difference being shown between the number of days after planting when treatment was applied and the treatment itself; but since there is no significant interaction between the number of days and the treatment, it appears that the number of days after planting when treatment was applied has no measurable effect on the treatment of the plants.

A further analysis of the average yield for $\frac{1}{2}$ defoliated and all defoliated plants in relation to average yield of corresponding checks (Table 6) shows that plants completely defoliated at each of the specified number of days after planting suffer a significant reduction in

Table 4.—Grain yields of Darso in grams for one-half and complete defoliated plots at specified times after planting compared with check plots. Perkins Farm, Oklahoma, 1946.

No. of days after planting of treatment	Check* (No treatment) Replication 1	Check* (No treatment) Replication 2	Check* Total for check	Treatments 1/2 Defoliated Replication 1	1/2 Defoliated Replication 2	Total for 1/2 defoliated	Complete defoliated Replication 1	Complete defoliated Replication 2	Total for complete defoliated	Total for all treatments
40	1427	1938	3365	1578	1632	3210	994	1330	2324	8899
60	1404	1942	3346	933	915	1848	999	620	1619	6813
80	1339	1057	2396	1134	960	2094	446	671	1117	5607
40-60	1388	1924	3312	923	961	1884	963	605	1568	6764
60-80	1554	1561	3115	880	831	1711	203	230	433	5259
40-60-80	1446	2115	3561	1276	1108	2384	244	250	494	6439
Total	8558	10,537	19,095	6724	6407	13,131	3849	3706	7555	39,781

* Yields for replications 1 and 2 of check plot were obtained by taking the average of the check rows nearest the treated rows. Two checks were used to determine yield of each of the check replications, with the exception of rows treated on 40-60 days after planting, where 3 checks were used.

Example: Rows treated 40 days after planting were nearest check rows 1 and 5, therefore, weight for replication one is shown by the average of first grain weight of rows 1 and 5 (Table 1).

1272 + 1582 = 2854

2854 ÷ 2 = 1427

1427 check row weight for replication 1.

Table 5.--Analysis of variance of 1946 grain yields.

Factor	Degrees of freedom	Sum of squares	Mean square	F
Total	35	8,992,973		
Replications	1	65,241	65,241	1.28
No. of days	5	1,360,410	272,082	5.33**
Treatments	2	5,550,908	2,775,454	54.35**
Treatments x No. of days	10	1,148,320	114,832	2.25
Error	17	868,094	51,064‡	

**Significant at 1% point.

‡ $S.E._D = \sqrt{\frac{\text{Mean square for error x 2}}{N}}$

$= \sqrt{\frac{51,064 \times 2}{2}}$

$= 226$

Table 6.--Mean yields in grams of rows treated at specified times after planting, compared with the limits of the average weights for check rows at 5% and 1% levels.

No. of days after planting	Check nos.	Limits of average weights for checks at		Average of 2 replications	
		5% point†	1% point†	½ defoliated	All defoliated
40	1-5	1206 -- 2160	1028 -- 2338	1605	1162*
60	9-12	1196 -- 2150	1018 -- 2328	924**	810**
80	15-18	721 -- 1675	543 -- 1853	1047	559*
40-60	1-5-9	1179 -- 2133	1001 -- 2311	942**	784**
60-80	12-15	1081 -- 2035	903 -- 2213	856**	217**
40-60-80	5-9	1304 -- 2258	1126 -- 2436	1192*	247**

† t values for 17 degrees of freedom equals 2.110 at 5% and 2.898 at 1% point. $S.E._D$ (226) times t values used to determine limits.

* Significant at 5% point.

** Significant at 1% point.

yield when compared to the average of the corresponding check row yield. This indicates that complete defoliation causes a significant reduction in yield regardless of the time after planting when it occurs. One-half defoliation of the plants shows a significant reduction in yield when compared to the check row yield only when it occurs near 60 days after planting. If ½ defoliation occurs before or after this period there appears to be no significant reduction in the yield.

In comparing the mean yields of all defoliated to ½ defoliated plants (Table 7) a significant difference is obtained when the plants are completely defoliated near 80 days after planting, and if completely defoliated before this critical period the plant can compensate partially by production of new leaves without suffering a significant reduction in yield as is shown when compared to the yield of ½ defoliated plants at the same time.

In comparison of the average yield for all ½ defoliated and complete defoliated rows to that of all the checks (Table 8) there is found a significant difference, and the mean total yield of both treatments shows a highly significant difference when compared to the mean total yield of the checks. Consequently, it can be said that defoliation of any amount lowers the yield of grain, with complete defoliation expressing the greatest depressive effect.

The average yield for all of the completely defoliated rows is of no significant difference from the average yield of all ½ defoliated rows, indicating that either ½ or complete defoliation results in a reduction in yield practically to the same extent.

Table 7.--Mean yields in grams of all defoliated rows treated at specified times after planting, compared with limits of the average weights for one-half defoliated rows at 5% and 1% levels.

No. of days after planting	Limits of weights for ½ defoliated at		All defoliated
	5% point	1% point	
40	1128 -- 2082	950 -- 2260	1162
60	447 -- 1401	269 -- 1579	810
80	570 -- 1524	392 -- 1702	559*
40-60	465 -- 1419	287 -- 1597	784
60-80	379 -- 1333	201 -- 1511	217*
40-60-80	715 -- 1669	537 -- 1847	247**

*Significant at 5% point.

**Significant at 1% point.

Table 8.—Mean total yields in grams for one-half and complete defoliated plots compared with the limits of mean total weight for check plots, and mean total yield in grams of complete defoliated compared with the limits of the average total weight for one-half defoliated at 5% and 1% levels.

Treatment	Limits of weights at		Average for all ½ defoliated rows	Average for all complete defoliated rows	Average for total of Both Treatments
	5% point	1% point			
Check	1114 - 2068	936 - 2246	1094*	630**	862**
½ Defoliated	617 - 1571	439 - 1749		630	

*Significant at 5% point.

**Significant at 1% point.

SUMMARY AND CONCLUSIONS

Defoliation studies of Darso grain sorghum were conducted on the Oklahoma Agricultural Experiment Station farm at Perkins, Oklahoma in 1946 in an attempt to establish a basis for evaluation of crop loss in grain due to a reduction in the assimilatory surface of the plant either by diseases, insects or hail.

On April 26, 1944 the south ½ of the plot used in this experiment was limed, the north ½ was unlimed. The rows extending north and south were half in the limed and half in the unlimed portion.

The plants were subjected to three distinct treatments, (1) check, (2) ½ defoliated and (3) complete defoliation, at a specified number of days after planting.

Defoliation was accomplished by cutting the leaves off as near the collar as possible with a knife. In the case of ½ defoliation, all the leaves were removed from one side of the plant.

Heads were harvested from a representative 25 foot section in both the limed and unlimed portion of the rows, which represents 1/500 of an acre.

Threshing was done by hand and each head carefully examined to assure complete threshing. The grain was then weighed on a gram scale.

The test weight of the grain from the unlimed portion of the plot showed a significant difference from that of the limed portion.

In analysis of variance of the grain yields, the component factors such as, treatment and the number of days after planting when the treatment was applied, had a highly significant influence on the quantity of grain produced.

Complete defoliation on any of the specified days after planting resulted in a significant reduction of yield when compared to the yield from the check row for the same period.

One-half defoliation of the plants showed a reduction in yield in comparison to the corresponding check row yield, when the treatment was applied on or near 60 days after planting. With defoliation before or after this period, there was no significant difference from that of the check.

Complete defoliation shows a significant reduction in yield over ½ defoliation when the leaves are removed on or near 80 days after planting, when the plants are in the stage from first headed to full headed.

The average yield for all ½ defoliated and completely defoliated rows and the mean yield of both treatments combined show a significant variance from the average of the yield of all checks, suggesting that defoliation of any amount will lower the yield significantly from what the crop would have produced if it had not been mutilated.

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TYPIST: Mary Wallace Spohn