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ONION
Tip-burn

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DONALD COMIN

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OHIO AGRICULTURAL
EXPERIMENT STATION

WOOSTER, OHIO

CONTENTS

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ONION TIP-BURN

DONALD COMIN

Onion tip-burn may be described as a physiological disorder affecting onion leaves, primarily at their tips or oldest portion. This disorder may also be observed on other monocots such as gladiolus. It is characterized by a dying back of the very tips of the oldest and largest leaves where it progresses down the leaf and eventually may result in the death of the entire leaf. In the early stages the leaf tips turn from green to yellow to white as the chlorophyll disappears and in a short time the tissues die and the color changes to a light brown. This sequence is progressive down the leaves and thus renders ineffective as a photosynthetic organ the affected portion of the leaf.

This disorder may be considered normal when occurring at the time the onion ripens or matures in the field for in this latter process the oldest portions of the leaves die first. It usually appears about the time the neck of the onion weakens and allows the top to fall over to the ground. In this respect, the disorder is not unnatural, but when it appears early in the life of the plant (May in Ohio) it causes a reduction in yield. It may not appear at all until the plant starts to ripen or mature and thus varies with the season and with the cultural environment. Its cause is not yet known. However, some workers (3) have likened it to tip-burn of lettuce. This disorder has been observed in many fields of onions and appears to be widespread. Many might describe it as premature senescence, particularly of the upper portion of the leaves. There is little question but what it has from slight to considerable effect on yields of this crop.

CONTRAST WITH ONION BLAST

Another term used interchangeably with tip-burn is "blast". (4). Undoubtedly, the two terms should not be used synonymously as the term "blast" denotes a sudden death of onion leaves which is not characteristic of tip-burn. In onion "blast" the tops turn white in a matter of a few days and the whole top, that is all the leaves, seem to be affected at once. Many leaves are afflicted simultaneously and over a large area of the leaves as in contrast with merely the tips of the leaves in the case of tip-burn. The term "blast" has been applied to sudden death of the onion tops due to mildew and due to the ecological factors of humidity, air temperature and insolation.[1] (4, 5).

PREVIOUS WORK

Very little work has been reported in the literature on onion tip-burn. Unfortunately, earlier workers have not distinguished between onion blast and tip-burn. Whetzel (6) and Clinton (1, 2) before 1916 published a few observations in regard to this or a similar type of injury. In 1944 Jones (4) of the Massachusetts Station reported his observations on the relation of weather conditions to onion blast. Through field observation and greenhouse experiments he claimed the injury was due to the inability of the onion plant to withstand bright sunshine, high temperature, and low relative humidity, following a period of cloudy wet weather occurring along with high temperature and high relative humidity. He was able to bring about the condition of severe blast under artificial conditions and set forth the composite of conditions which would invariably cause this disorder under field conditions. Although many of the conditions he described as causing blast probably are contributory to tip-burn as well, he did not recognize tip-burn, as described here, as separate from onion blast. Since blast occurs only occasionally and tip-burn every season, the author of this paper considers the two disorders as distinct and not necessarily due to similar causes.

Newhall and Rawlins of New York (5) claimed to have an excellent control measure for onion mildew and blast. Since they did not describe the malady or disorder it is not known if they included what is described as tip-burn in this paper. They did, however, distinguish between mildew damage and blast damage. They also pointed out that blast and mildew usually appeared after June 20 and for this reason never caused damage to onions grown from sets. They intimated that the carbamate fungicide in their spray formula was the ingredient responsible for blast control, although they used an insecticide-fungicide spray including Dithane D-14 plus zinc sulphate plus DDT. Since onions may be severely damaged by thrips and this damage appears as a blasted condition of the tops, the definition of blast becomes difficult and not at all clear. The above literature citations do strengthen the claim of this paper that tip-burn and blast are distinctly different in their manifestation but may be affected by many of the same environmental factors.

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[1]Insolation refers to the exposure to the rays of the sun.

OBJECTIVES

The objectives in this study were to investigate the influence of various factors of the environment on the incidence of onion tip-burn and to determine the effect of tip-burn on the yields of the crops. Also it was anticipated that the results of such studies might suggest methods to follow in partially or totally preventing this disorder in any onion plantings.

MATERIALS AND METHODS

The experiments were carried on in Huron County, Ohio, on the muck soils of the State Muck Crops Research Farm during the years from 1949 to 1954 inclusive. The Early Globe onion variety was used throughout the studies and all plantings were made with a Planet Jr. one row seeder employing the principle of various sized holes in a metal plate for the various seeding rates. Rows of onions were sown across a 330 foot strip of muck chosen for the studies, the rows running approximately in a north and south direction. Various rates of seeding and row spacings were employed depending upon the particular experiment. Replications of plots were some times in a north and south direction only but in several instances were also replicated in an east and west direction. The treatments were always randomized in the experimental area to allow the use of statistical methods in analyzing the data. In those instances where the treatments were various row spacings only, each spacing was repeated four times in an east and west direction and ten or more times in a north and south direction. This arrangement facilitated cultivation and spraying operations.

EXPERIMENTAL RESULTS

SHADING STUDY—1949

Since it had been suggested by other workers (4) that water relations might be responsible for the incidence of tip-burn, portions of an area planted to Early Globe onions were shaded by means of slatted composition board (Presswood) and snow fence placed horizontally three feet above the onions as they reached twelve inches in height and maintained in this position until harvest. In addition burlap formerly used as windbreaks for onions, was also supported over the crop. The wood slats were 6 inches wide and spaced 4 and 8 inches apart and 2 inch slats were spaced 2 inches apart (snow fence). No instrument was available for measuring the average foot candles of light received by the onions under the shades as compared with the unshaded controls.

Since the suns rays continually shifted in direction, momentary light measurements would not be as valuable as some method of measuring average values. Two hundred plant samples were counted for tip-burned leaves under each treatment on July 17. The samples were selected at random over the entire area of sixty square feet for each treatment and control area. Since it was not feasible to adequately replicate the treatments, each pair of treated plots had an equal untreated or control area on either side. No yield values were secured.

The results shown in Table 1 reveal no significant effect of shading on the incidence of tip-burn. The figures show a very slight increase of tip-burn under the shade when compared with three of the control plots. There was no consistent different in the yields of onions with and without shade.

TABLE 1.—Percent of Tip-burn of Onions Under Different Amounts of Shade Compared to no Shade

Treatment (spacing)*	Percent of area opaque	Percent of total leaves tip-burned
Control	None	41.5
6–4	60	52.7
2–2	50	57.1
Control	None	56.0
6–4	60	50.4
6–8	43	54.6
Control	None	41.5
2–2	50	54.8
Burlap	Not known	47.5
Control	None	41.5

*First figure width of slat, second figure width of open space in inches.

MAJOR AND TRACE ELEMENT STUDIES

1950 Growing Season

During 1936 a personal communication from Dr. J. E. Knott of Cornell University stated that in his experiments with copper sulfate on onions that "on those portions of fields treated with this salt, little or no tip-burn appeared while the tops on the remainder of the field were fallen over and nearly dead". It is now customary to apply copper for onions to prolong their life, that is to keep them green longer although this treatment has not been recommended to control tip-burn specifically.

In order to gain some time in these studies and to test the possibility that one or more chemical substances might bear some relation to the incidence of tip-burn, various salts were distributed in 4 to 6 inch furrows opened on one side of each onion row which had reached a height of 6 inches. Later (1951) additional applications were made before the crop was planted. In this experiment, each treated plot consisted of 4 rows of onions spaced 13 inches apart and 25 feet long. Each plot was bordered on one side by a control plot of equal size.

TABLE 2.—Percentages of Tip-burn and Acre Yields of Onions from Plots Side-dressed with Various Salts and from Adjacent Control Plots

Treatments*	Percent Tip-burn		Percent Reduction	Yields, 100 Pound Sacks	
	Treatment	Control		Treatment	Control
Manganese Sulfate	64	91	29.7	336	378
Sulfur	73	100	27.0	378	477
Tecmangan†	68	87	21.9	297	411
Magnesium Sulfate	70	85	17.6	315	399
Ammonium Sulfate	68	82	17.1	294	357
Calcium Sulfate	80	95	15.8	396	378
Muriate of Potash	77	90	14.5	357	510
Copper Sulfate	85	95	10.5	303	432
Borax	89	98	9.2	396	477
Superphosphate	96	99	3.0	366	393
Mean	77	92	16.6	343	421

*All treatments except Borax (1/8 #) 1/2 pound per plot. Trreatments applied June 8, tip-burn count Aug. 24, 1950.

†A proprietary material containing 67% Manganese Sulfate.

In Table 2 are presented the results of this treatment. It will be noted that the yields were reduced by all treatments but Calcium Sulfate. This is explained by the cutting of some roots in making the furrow for receiving the various salts. It was impractical to apply the salts prior to the planting season in 1950. As for the effect of the treatments on tip-burn there appears to be some association between sulfur and the incidence of tip-burn. Since sulfur is essential for the persistance of the chlorophyll molecule these results could be explained on the basis of early destruction of the chlorophyll in the tips of the leaves of the control plants through a lack of sulfur. Since no replicates were employed, this hypothesis can not be proved.

1951 GROWING SEASON

In order to study the effect of trace elements on the incidence of tip-burn and expand the work started in 1950, sulfur, magnesium sulfate, iron sulfate and copper sulfate were applied to 1/800 acre plots replicated 10 times and at the rate of 100, 200, and 400 pounds per acre. Thus with three rates per salt and 5 salts there were 15 individual treatments. Each individual plot was 10 feet by 5 feet 5 inches and planted to 4 ten foot rows of Ohio Early Globe onions spaced 13 inches apart. The salts were incorporated with the soil before planting to a depth of 4 to 6 inches. No borders were left between treatments since the tip-burn counts were made on 100 leaves of middle two rows of each plot within 6 feet which was well within the borders of the plot. There were fifteen treated plots within each block well randomized and with 10 such blocks (10 replicates) there were a total of 150 plots. No untreated plots were included in the test.

In Table 3 are given the results of the treatments together with the least difference between treatment means (10 replicates each) required for significance at the 1 and the 5 percent levels. The means are also given for the individual salts (each mean representing three rates of application and 10 replications per rate). No statistical treatment was made of these means but they are included to aid in showing any differences between individual salts. All treatments were well randomized within the blocks. The standard differences are much too large to reveal any significance difference due to treatment. Since there were exceedingly wide differences in tip-burn percentage within the same treatment in different replications (blocks) yet the replicate averages showed little variation, it appears that other factors than the treatments were responsible for the large variation in tip-burn between individual plots.

Several other investigators have reported that copper has the effect of causing onions to remain greener and in an upright position longer than where copper was not used. However, no such effect was noted in these tests. The results indicate that neither the element copper nor any of the other elements used had any effect on either tip-burn or yield. The yields obtained from the various treatments were surprisingly uniform, the coefficient of variation of treatment means being only 5.75 percent.

TABLE 3.—The Effect of Trace Elements on Onion Tip-burn and Yields Mean of 10 replications. Onions planted April 20, 1951

Treatment	Pounds per Acre	Percent Tip-burn July 5	Percent Tip-burn July 23	Yield per acre Bushels
Sulfur	100	17.0	37.6	636
	200	15.6	37.4	645
	400	16.9	41.2	714
Mean		16.5	38.7	665
Magnesium Sulfate	100	16.2	41.3	665
	200	16.8	38.6	622
	400	17.4	39.3	634
Mean		16.8	39.7	640
Manganese Sulfate	100	13.0	41.7	640
	200	13.5	36.9	665
	400	15.9	39.5	663
Mean		14.1	39.4	656
Iron Sulfate	100	13.0	38.3	658
	200	17.0	43.2	649
	400	12.7	38.8	620
Mean		14.2	40.1	642
Copper Sulfate	100	19.6	40.1	624
	200	13.2	36.6	602
	400	20.9	38.8	642
Mean		17.9	38.5	623
L.S.D. @ .05		7.4	4.9	73.4
@ .01		9.8	6.5	97.0

THE EFFECT OF SOME VARIABLES OF ENVIRONMENT ON ONION TIP-BURN AND YIELDS

1952 SEASON

In order to study further the effect of environment on tip-burn of onion, irrigation, fungicide and spacing of the onions were introduced as variables. The work of the New York Station (5) on the use of a fungicide-insecticide spray to extend the life of the onion was repeated, using basically the same formula. However, the insecticide (DDT) was eliminated in certain treatments, only DDT applied in some while others received both DDT and Dithane D-14 zinc sulfate. The first treatments were applied beginning June 15 and repeated at weekly intervals until August 15. The experimental area was planted to Ohio Yellow Globe onion in the following manner. Each individual plot was 10 feet (in the direction of the rows) by 2 2/3 feet. The plot was planted to 5 rows spaced 8 inches apart, the second plot was planted to 3 rows spaced 16 inches apart, the third was planted to 2 rows 24 inches apart and the fourth plot was planted to 2 rows 32 inches apart. Thus a given area (10 × 2 2/3 feet) supported different numbers of onion plants. Such a series of plots was repeated 8 times across the experimental area in a north and south direction. In addition each series of plots was repeated 6 times, one series of plots adjacent to another but separated by a 2 foot buffer strip, in an east to west direction. The only difference between each series of plots was that the rate of seeding was varied by using Planet Jr., seeder plate hole number 6 for the first series of plots, hole number 7 for the second series and hole number 8 for the third series of plots. Then this sequence was repeated to produce a duplicate planting. Thus the total experimental area included 192 individual plots. During the 1952 season one-half of the total area was irrigated and the remaining half was left unirrigated. The fungicide was applied to one-half of both the irrigated and unirrigated areas.

TABLE 4.—The Effect of Carbamate Fungicide on Tip-burn, Number, Size, and Yield of Onions

	Fungicide	No Fungicide	L.S.D. 5%	L.S.D. 1%
Average Percent Tip-burn, 48 Plots				
Irrigation	42.8	43.3	2.54	3.36
No irrigation	36.1	40.4	2.54	3.36
Number, Size and Yield				
Number of plots	96	96		
Average number of onions per plot	135	121		
Average weight per plot in pounds	27.7	25.1		
Average weight per onion in pounds	0.205	0.206		
Number of 50 pound bags per acre	403	365		

An examination of Table 4 shows that the carbamate fungicide had no effect on the incidence of tip-burn under irrigation while it significantly reduced it when no irrigation was applied. However, when the results obtained with and without irrigation were pooled, the average percentages of tip-burn for the fungicide and no fungicide treatments were practically the same, 39.5 versus 41.9 percent. It is also indicated in Table 4 that the fungicide had no effect on the average weight of onions or on the yield.

THE EFFECT OF SPACING ON THE INCIDENCE OF TIP-BURN

1952 SEASON

It was considered possible that the spacing of onions in the row and the row spacing might have an effect on the incidence of tip-burn. This was based on the fact that competition of the onions for water, nutrients and other essentials such as light and the humidity of the air surrounding their leaves might conceivably affect the incidence of tip-burn. That this is the case is shown in Table 5.

TABLE 5.—Correlations of Onion Tip-burn with Number of and Total Weight of Onions per Plot at Different Spacings Between Rows

Spacing Between Rows	With Number of Onions per Plot	With Total Weight of Onions per Plot
Inches	r value	r value
8	± 0.867*	± 0.484*
16	± 0.441*	± 0.443*
24	± 0.190	± 0.595*
32	± 0.865*	± 0.166

*Highly significant. With 48 comparisons the r value need be only 0.372 at the 1% level of significance and 0.288 at the 5% level.

In the case of both the 8 and the 16 inch row spacings the greater the number of onions per plot the higher the percentage of tip-burn. In the wider row spacings where the competition was less, i. e. 24 and 32 inch row spacings, the correlation coefficients were insignificant in two out of the four instances. The same held true with weight of onions as with their number per plot. Commercial growers of onions who have heeded the suggestion that wider row spacing would aid in tip-burn control have reported considerably less tip-burn in their fields. From the common practice of spacing their onion rows at 13 to 14 inches has developed the use of 16 inch spacing, and in a few instances even wider spacing.

1953 SEASON

The work on spacing of onions done during 1952 was repeated during 1953. For comparison, 1952 data are included in Table 6. It should be pointed out that although the actual count of number of seed dropped by the Planet Jr., seed drill per foot of row when using different sized holes in the plates, was not made, for purposes of the comparisons made here the plate hole number may be considered to be related to the number of seed per foot.

In Table 6 are shown the results of spacing of onions on the incidence of tip-burn.

The data for both years indicate that the wider spacings, both between rows and plants in the row decrease the incidence of tip-burn. The effect of wide spacing was slightly more pronounced during 1952 than 1953 for in the former year each 8-inch increase in row spacing

TABLE 6.—The Effect of Differential Spacing Between Rows and Within Rows on the Incidence of Onion Tip-burn for the Years 1952 and 1953

Spacing Between Rows*	Percent Tip-burn	
	1952	1953
Inches		
8	48.5	33.3
16	44.7	31.2
24	40.6	29.2
32	38.7	27.3
L.S.D. 5 %	3.27	2.41
1 %	4.33	3.19

*Forty-eight replications.

Spacing Within Row*		
(Plate Hole No.)		
6	39.6	36.8
7	43.9	37.2
8	45.9	40.8
L.S.D. 5 %	2.84	3.11
1 %	3.75	4.88

*Sixty-four replications.

except between 24 and 32 inches, produced a significant (5% level) reduction in tip-burn. It required an increase of 16 inches to produce a reduction of tip-burn significant at the 5 percent level in 1953.

An effect similar to that of increasing the space between rows was obtained where the spacing between plants in the row was increased. Thus, less competition between plants within the row had the desired effect of reducing the incidence of tip-burn within limits.

In reducing competition between plants it might be expected that each onion bulb would be larger. At the same time, the number of bulbs per acre would be reduced. The question arises as to how effectively and completely can increased bulb size compensate for the decrease in number of bulbs in maintaining total per-acre yields. To answer this question both number and weigth of bulbs was obtained and the weight per bulb calculated. Bulbs less than the minimum allowable for U. S. No. 1 onions were graded out before the records were taken.

1954 SEASON

The data for the 1954 season is presented in Table 7 together with that for 1952 and 1953 for comparison. In interpreting the results of these spacing experiments it is well to keep in mind that during 1952 and 1953 the area of each plot was kept constant while the number of rows necessarily varied in order to determine the effect of competition and other related factors on size of onion and total yields from a given area. Thus, some plots contained 5 rows of onions spaced 8 inches apart, 3 rows for the 16-inch spacing and 2 each for the 24 and 32-inch spacing. In spite of the wide variation in the number of seed sown per plot (because of variation in number of rows per plot) the number of U. S. No. 1 onions harvested was surprisingly close, especially in 1953.

In the interpretation of the data in Table 7, numerous comparisons between the various average values (16 replications) given could be made. L.S.D. values were calculated for most of the differences in such comparisons. They were calculated for the differences in average total weights of onions per plot (column 3) only. Only a few comparisons are of value in this discussion or obviously represent insignificant differences. For this reason none of the numerous L.S. D. values calculated are shown here. Where comparisons are of value in this discussion the significance of the differences will be stated in the customary manner i. e., "highly significant" when the L.S.D. is above the 1 percent level, "significant" when it is above the 5 percent level and "not significant" when it is below the 5 percent level.

The first comparison of interest is that between the 8-inch and the 16-inch row spacings at all seed plate hole numbers given. During 1952 the 8-inch spacing between rows resulted in a greater yield of onions than the 16-inch spacing in all instances (seed plate holes 6, 7, and 8). These differences were all highly significant. However, the size of the onions (weight per onion) was small in the closer row spacings. However, during 1953 and 1954 the 16-inch row spacing resulted in larger yields than did the 8-inch spacing, although these differences were not significant. Thus it may be concluded that 16-inch row spacing will most often produce as large or larger yields of larger onions than the 8-inch row spacing and at the same time reduce the incidence of tip-burn.

Another comparison is that between the yields of onions from rows spaced 16 and 24-inches apart. During 1952 the wider spacing (24 inches) produced a significantly lower yield. When the rows were widened out to 32 inches there resulted a highly significant reduction in yield. Again the weight per onion (size) increased with the increase in row spacing. During 1953 the differences in yields between the 16-inch and 24-inch row spacings were insignificant as they were between the 16- and 18-inch row spacings during 1954. This relation between yields and row spacing held true at all seed plate hole numbers employed. Although the yields continued to lower slightly all three years by still wider row spacings (to 32 inches in 1952 and 1953 and to 20-inches in 1954) the differernces were highly significant only during 1952. It is well to point out that the plots were all uniform in size but contained 5 rows with the 8-inch row spacing, 3 rows with the 16-inch spacing, and 2 rows with the 24 and 32-inch spacing. It is doubtful if much difference in yields or size of onion could be expected from the same number of rows per plot when the only difference is the 8-inch wider row spacing in the 32 over the 24-inch row spacing. This is borne out in the data in Table 7 and the discussion above. Thus it may be concluded that 16-inch to 24-inch spacing between onion rows should be selected as the practical limits for spacing onion rows to maintain good yields, good onion size and low incidence of tip-burn.

Another method by which yields and onion size may be affected is by the seed sown per foot of row. During 1952 and 1953 seed plate hole numbers 6, 7, and 8 were used, and these were changed to 7, 8, and 9 during 1954. Increasing the seed sown per plot did increase the yields in all row spacings employed, Table 7. It also increased the number of onions per plot and reduced the average size (weight) per onion in all instances. Statistical analysis of the data reveals, however, that the

TABLE 7.—The Effect of Row and Plant Spacing on Onion Size and Yield*

Spacing between rows (Inches)	Number of onions per plot	Total weight of onions per plot (Pounds)	Weight per onion (Pounds)	Number of 50 lb. bags per acre
		1952		
		Seed Plate Hole Number 6		
8	147	31.9	0.216	1041
16	92	23.8	0.258	778
24	65	16.9	0.258	553
32	61	15.8	0.258	514
		Seed Plate Hole Number 7		
8	201	36.3	0.180	1186
16	117	25.3	0.215	827
24	87	21.6	0.246	706
32	74	17.7	0.239	579
		Seed Plate Hole Number 8		
8	283	41.9	0.148	1369
16	171	33.0	0.192	1076
24	122	27.7	0.226	906
32	112	24.6	0.218	802
		1953		
		Seed Plate Hole Number 6		
8	147	26.8	0.182	876
16	152	30.2	0.198	985
24	156	31.9	0.205	1043
32	162	31.9	0.197	1041
		Seed Plate Hole Number 7		
8	191	30.7	0.160	1003
16	209	35.6	0.170	1163
24	212	37.1	0.175	1211
32	191	34.7	0.182	1135
		Seed Plate Hole Number 8		
8	225	36.2	0.160	1182
16	277	42.7	0.154	1395
24	255	40.8	0.160	1334
32	265	40.6	0.153	1327

TABLE 7.—The Effect of Row and Plant Spacing on Onion Size and Yield*—Continued

Spacing between rows (Inches)	Number of onions per plot	Total weight of onions per plot (Pounds)	Weight per onion (Pounds)	Number of 50 lb. bags per acre
		1954		
		Seed Plate Hole Number 7		
14	54	17.3	0.321	566
16	71	23.4	0.325	764
18	70	22.4	0.318	730
20	63	19.3	0.304	629
		Seed Plate Hole Number 8		
14	83	24.0	0.286	784
16	85	24.9	0.290	812
18	81	23.4	0.287	763
20	79	21.9	0.277	717
		Seed Plate Hole Number 9		
14	120	29.5	0.246	964
16	109	29.6	0.270	966
18	108	29.7	0.273	969
20	105	27.1	0.257	884

*Average of sixteen replications. Individual plot size 10 X 2 2/3 feet, 1/1634 acre. Number of rows per plot, 5 with 8-inch spacing, 3 with 16-inch spacing and 2 with 24 and 32-inch spacing during 1952 and 1953. Three rows per plot for all spacings during 1954.

seed plate hole number must be increased two numbers, i. e., 6 to 8 (1952-1953) or from 7 to 9 (1954) to result in a highly significant increase in yield. Increasing the hole number by one produced no significant increase in yield except in two instances where the increase was significant only at the 5 percent level. It appears from the data in Table 7 that since it is desirable to choose a minimum of 16 inches between onion rows, using the larger seed plate hole number will tend to maintain yields as row spacings are increased. Many examples could be cited. During 1952, yields in 50-pound bags per acre at the 16-inch row spacing and seed plate hole number 6 were 778 as compared to 906 bags of the same U. S. No 1 Grade onions when the row spacing was increased to 24 inches and the seed plate hole number to 8. Comparable figures for 1953 are 985 and 1334 bags, respectively. One other example might be given. During 1954, if 16-inch row spacing was chosen using seed plate hole number 7, the average yield was 764 bags per acre. By increasing the row spacing to 20 inches and the seed plate hole number to 9, the yield would increase to 884 bags per acre. It would appear that if widening out onion row spacing provides some measure of control for tip-burn, this procedure may be followed with no sacrifice in yields. It should be pointed out that following such a procedure will invariably increase the number of onions harvested per acre at a possible sacrifice in size of individual onions. This factor could become important, particularly if too many onions fell below the minimum size (1½ inches) for a Northern U. S. No. 1 onion. This could be avoided, at least to a degree, by maintaining a high level of fertility, by the use of irrigation and by other means.

FURTHER STUDIES ON ENVIRONMENTAL FACTORS, 1954

Two things seemed clear in this work up to 1954. The incidence of tip-burn was always rather high regardless of treatment and there appeared to be a positional effect in the field. This is clearly shown in figure (1). During the 1953 season the tip-burn percentage dropped from over 40 percent at the north end of the field to 10 percent at replicate 6 which was slightly south of the center of the field. The same tendency for low tip-burn near the center of the field occurred to a less extent during 1952 but was not evident in 1954. The only treatment

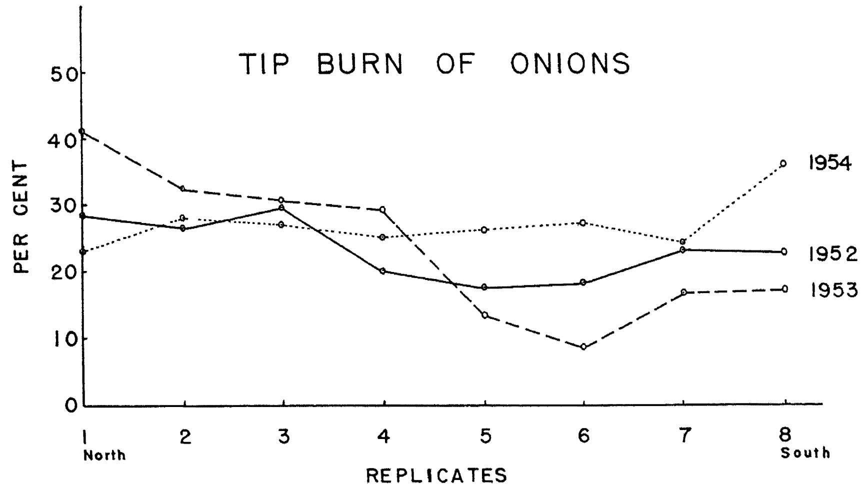

Fig. 1.—Percentage tip-burn of onions at eight locations on experimental area during 1952 to 1954 inclusive.

that could affect these results was irrigation which was applied to the north half of the field (first 4 replicates) during 1952 and the south half (second four replicates) during 1953, page 8.

In order to study the positional effect, soil stations were established at the north end (station number 1) in the middle (station number 2) and the south end (station number 3). At these stations Hygro-Thermographs recorded air temperature and relative humidity approximately one foot above the soil surface and two-bulb soil thermographs recorded the muck soil temperatures at the 6- and 12-inch levels. Six inch drain tiles were used to sink wells to the bottom of the muck for weekly measurements of the water table. Soil moisture tensiometers (Irrometers) were also installed at the same locations at a depth of 6 inches. Rainfall was recorded daily within 10 feet of the experimental area.

Soil Temperatures. In figures 2 and 3 are given the soil temperatures for station 1 (north end of experimental area) and station 3 (south end of experimental area). Station 2 temperatures (in middle of experimental area) were not graphed due to frequent interruptions of record through a faulty clock mechanism. The sensitive bulbs were placed at the 6- and 12-inch levels and the graphs show the maximum and minimum temperatures recorded for each week during the growing season. Daily or hourly fluctuations in soil temperatures at these levels (6 and 12 inches) were not great and of little significance.

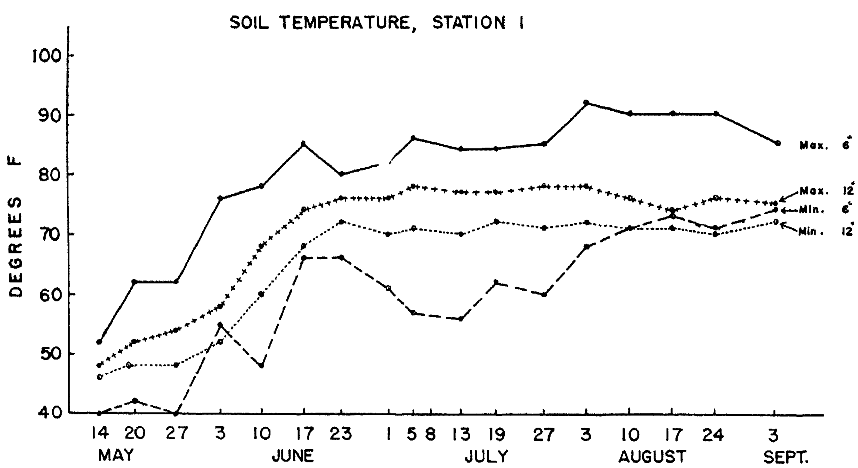

Fig. 2.—Weekly maximum and minimum soil temperatures at the six and twelve inch levels in °F., at Station One, 1954.

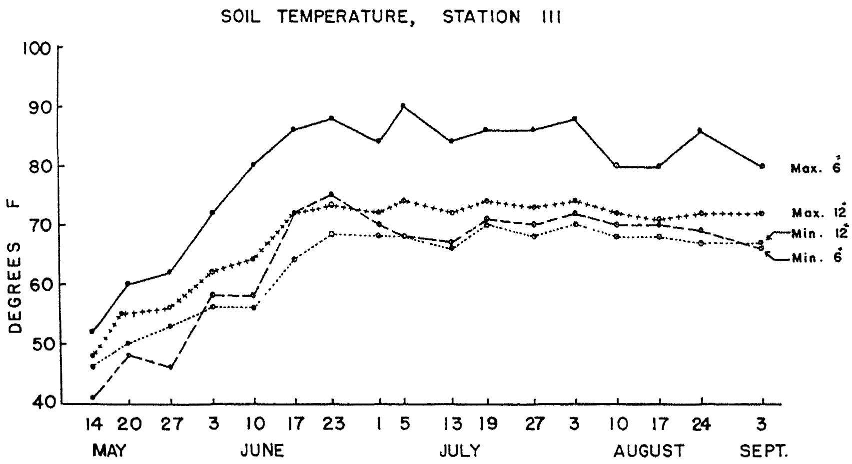

Fig. 3.—Weekly maximum and minimum soil temperatures at the six and twelve inch levels in °F., at Station Three, 1954.

In general, the maximum and minimum temperatures for the 12-inch depth were intermediate or between the curves for those of the 6-inch depth. This would be expected for soil temperatures are much more uniform at greater depths and not as much affected by high or low air temperatures as are soil locations closer to the surface of the muck.

Although no actual measurements were made, examination showed that the great majority of the fibrous roots of the onion plants were in the top 6 inches of soil. This black soil horizon absorbed considerable heat during the periods of sunshine and, although close to 50° F. on May 14, rose rapidly to weekly maximums close to 90° F. in July and August. This horizon also dropped in temperature at night to levels approximately 20 to 30° F. below the daytime maximum. The differences between maximums and minimus at the 12-inch depth was considerably less; about one-sixth or 5° F.

When the two graphs (2 and 3) are compared, it may be seen that they are virtually the same although soil temperatures are slightly lower at station 3. This could be due to more shade or more moisture. Station 3 was about 30 feet from a willow windbreak about 20 feet in height. One notable difference was the consistently higher temperatures recorded for minimum values at the 6-inch level (horizon) at Station 3. No explanation can be offered for this discrepancy unless it may be considered due to the protection afforded by the windbreak.

Since the curves in figures 2 and 3 show no correlation with those curves in figure 1 it is not likely that soil temperature was a contributing factor to the incidence of tip-burn.

Soil Water Table. In figure 4 is shown a continuous graph of the water table at the three stations. Measurements were made once a week. With the exception of the weeks of June 17 and August 19 when rain fell to the extent of 3.86 and 1.73 inches respectively, the water stood at close to an average of 28 inches from the surface. Although the graphs indicate there were some differences at the three stations, these differences could very well be attributed to differences in elevation of the muck surface at the three stations. These differences are thus not significant. Differences of the magnitude exhibited here are about the same as many differences in surface elevation recorded when measurements were made from a single permanent bench mark.

Although there was some definite lowering of the water table as the season progressed, it did not change drastically except during the two periods of exceptionally heavy rainfall described above. Rainfalls of less than one inch (figure 5) had no measureable effect. It seems apparent then that water table had no effect on the incidence of tip-burn during the 1954 growing season.

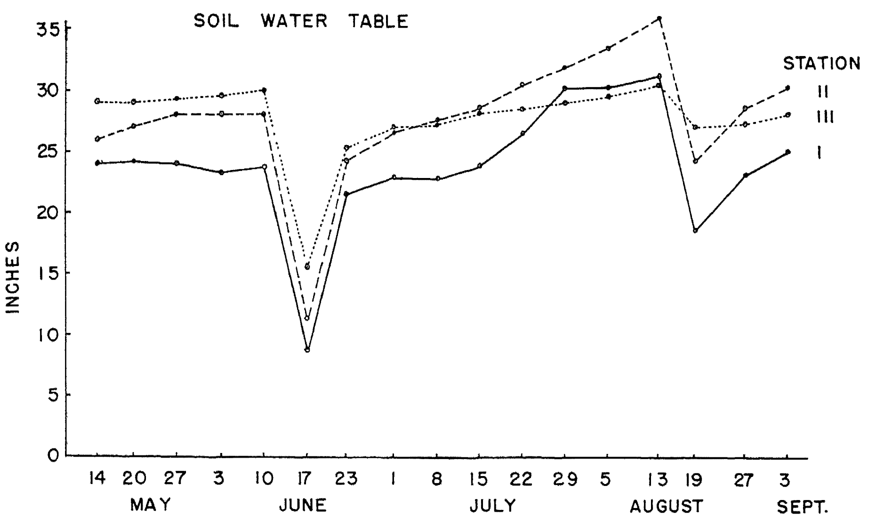

Fig. 4.—Soil water table in inches from the surface at weekly intervals at Stations One, Two and Three, 1954.

Soil Water Tension and Rainfall. In order to follow the moisture in the soil at the three stations, tensiometers were employed, one at each location. The porous bulb of each instrument (Irrometer) was buried at the 6-inch level and readings taken once each week. In figure 5 are given the readings in centimeters of mercury divided by 1.47, that is each division on the tensiometer vacuum gauge represented 1.47 centimeters of mercury. Thus to convert to gauge readings as given on the graph to centimeters of mercury, merely multiply any gauge reading by 1.47. The graph was constructed in this way to emphasize that actual gauge readings are perfectly satisfactory for comparative purposes and growers need only learn between which readings it is desirable to maintain the tension and thereby the soil moisture. The inches of rainfall are also represented graphically at the top of figure 5.

The most interesting feature of this graph is the rise and decline of the soil water tension which is directly related to the periods of rainfall. An inspection of the graphs will show that they invariably fall after each rainy period. These rainy periods happened to occur almost every two weeks and thus the soil water tension is seen to fall and rise again in the same two-week cycle. Since the tension readings were taken only once a week the lines indicating the fall in tension show an apparent fall

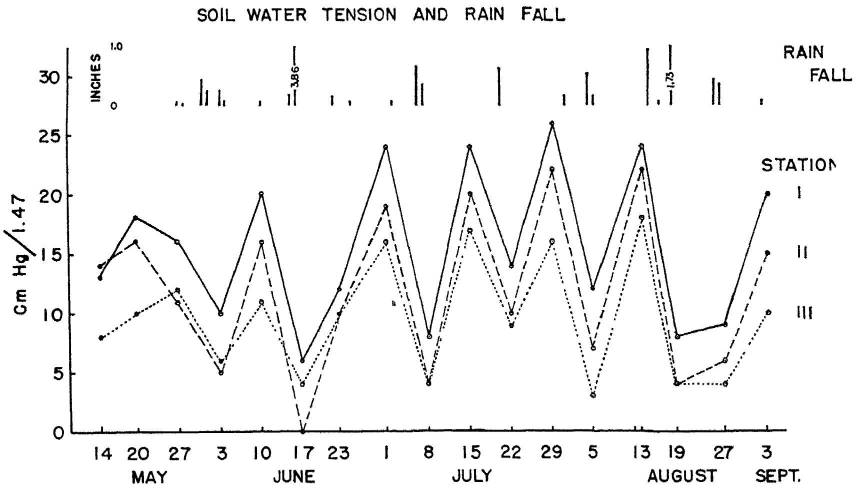

Fig. 5.—Soil water tension in vacuum gauge readings (cm.Hg./1.47) recorded weekly and rainfall recorded daily at Stations One, Two and Three, 1954.

ahead of the actual rainfall that causes it. This cycle pattern is characteristic of all tensiometer installations as might be expected. It is very evident that the pattern followed by the soil water tension is the same for each station and, therefore, it is impossible to draw any correlations between the incidence of onion tip-burn and soil water tension. The fact that the curves for the three stations are not superimposed is not significant as the differences existing are largely due to inaccuracies in the water tension measurements. For example, on June 17 the tensiometer at station two read zero as the soil was saturated due to the heavy rainfall (3.86 inches) occurring a few hours previous to the reading of the instrument. The tensiometers at the other two stations should probably have read zero also and slight inaccuracies in the instruments at these low tensions may explain this discrepancy. On the other hand this does not preclude the possibility that the soil water tension at any one time was not slightly higher at station one than at station two and at station two than at station three. The differences, however, are probably not significant.

DISCUSSION

No one prior to this study had reported on tip-burn of onion except in relation to onion blast as described in this paper. This author believes these two maladies to be entirely distinct in nature, although they may occur concurrently and may have one or more causes in common. However, tip-burn occurs very commonly (in this crop), while "blast" occurs very infrequently. It has been felt by the author that tip-burn of onion may be very similar to tip-burn of lettuce, although there is no proof that this is true.

The experiments performed and reported here were based on the assumption that one or more environmental factors would be found as the cause, or at least contributing to the incidence of tip-burn. It was impossible to show that light or direct radiation from the sun had any significant effect under the conditions of these experiments. It should be noted that the percent tip-burn was relatively large under all shade treatments. This suggests that more shade than used here would not reduce tip-burn to a low percentage without also reducing yields. Therefore, light and direct sun radiation may logically be ruled out as directly affecting the incidence of tip-burn of onions.

All experiments with various salts showed no significant results. Copper in many instances, reported elsewhere (page 4), had delayed the maturity of onions and thereby increased yields. This effect is not one of reducing the incidence of tip-burn, however, Tables 2 and 3. There is some evidence that sulfur may play some part in preventing the premature death of the oldest portions of onion leaves, Table 2. This phase of tip-burn control should be investigated further.

Others have reported a beneficial effect of a carbamate fungicide (5). The results reported here, though not conclusive either way, support this contention. It is suggested that the zinc sulfate added to Dithane D-14 may have been responsible for any reduction in tip-burn noted in light of the work with sulfur discussed above.

There seems little doubt but that allowing more space per onion in plantings of this crop does reduce the incidence of tip-burn. This fact in no way explains or points out the cause for this disorder. It does, however, offer a practical control for tip-burn, Tables 5, 6, and 7. The reason for this effect of more space per onion must await further research before a clear understanding is made available. It has been proved, however, that widening the row spacing and decreasing the number of onions per foot of row will not decrease yields too greatly due to the obvious compensation in onion size which results from the greater space per onion. This is particularly true for 16-inch row spacing compared to closer spacing (8 inches). The increase beyond 16 inches sometimes will increase yields and sometimes decrease them, but the changes in yield did not prove to be great. It would be interesting in this connection to study the effects of more vigorous strains of onions (hybrids) and larger fertilizer applications, or the use of under-row placement of fertilizer on the yields and incidence of tip-burn of onions under the wider row spacings. A study of planting rates is badly needed at this time.

The fact that some significant differences in tip-burn were exhibited due to positional effects in the field gave rise to other studies such as are reported here, pages 11-17. Unfortunately, it was impossible to discover any significant differences in the experimental area by the methods employed in these experiments. It is believed a more micro approach to this problem would be required to determine the individual effects of the environmental factors.

SUMMARY AND CONCLUSIONS

Tip-burn of onions has been here defined as a dying back of the tips or oldest portion of onion leaves in a progressive manner until ten to twenty percent of the leaf's length may be affected. Tip-burn usually appears during the middle to latter part of June and usually terminates in the death of the affected portion. It is imperative to be aware that onion leaves may be affected by other pests or physiological disorders which may cause the death of the leaves such as thrip damage, mildew damage and blast. The latter is apparently caused by adverse ecological or environmental conditions associated with weather. However, it is in no way connected with tip-burn, although the symptoms at times may appear similar. A definite distinction between blast and tip-burn has been drawn in this discussion.

Light and direct sun radiation apparently have no direct effect on the incidence of tip-burn. Different amounts of shading of onion plants in the field throughout most of their growth period resulted in no significant differences in the percent of tip-burned leaves. This does not preclude the possibility that light and direct sun radiation may have an effect through their influence on other environmental factors.

The addition of major and trace elements to the soil in which onions were subsequently grown had no significant effect on the incidence of tip-burn when compared with ample controls. No plots with known deficiencies of these elements were used in this study. Under the soil conditions encountered here, there were apparently no deficiencies of the elements used for the yields of onions were unaffected by the salt applications. This does not preclude the possibility that other elements might affect the incidence of tip-burn.

There was some evidence obtained that a carbamate fungicide (Dithane D-14 plus zinc sulfate) reduced tip-burn. The New York Experiment Station found a similar reduction in the death of onion leaves where this fungicide was used (5). The evidence was not conclusive, however, in the tests reported here, Table 4. In the light of the number of replications employed in this work it appears that this fungicide had little effect on the incidence of tip-burn.

Considerable evidence accumulated in this study to show that the spacing of onions in the field (between rows and in the rows) had an effect on the incidence of tip-burn, Table 5 and 6. Although the reasons why more space as well as more soil per onion plant had such an effect in reducing tip-burn are not now known, it may be assumed that it has to do with a group of factors, all interrelated. These factors are suggested as, freer air movement and its effect on temperature and humidity, more soil moisture, major nutrient and trace elements, and finally less competition between plants and all that this may imply. Based on the data presented here, commercial growers are now using a minimum of 16-inch row spacing for this crop and several have claimed a noticeable reduction in tip-burn. This has occurred with no reduction and in some cases actual increases in acre yields. This may be attributed to better weed control and to other factors, as well as to less tip-burn.

Another observation supported by data (Figure 1) indicates that tip-burn may appear in different degrees in different parts of a field. No specific explanation is offered here, although considerable data on soil temperature and moisture (tensiometer) as well as air temperature, relative humidity, rainfall and depth of the water table were obtained for the purpose of determining any differences which might account for variations in tip-burn. No correlations of value were obtained.

Although no specific cause for tip-burn of onion was found, the results of these investigations seem to point towards a combination of environmental factors as influencing this disorder. More space per plant than has been the common practice has definitely reduced the incidence of tip-burn. Therefore, it is recommended for control of this malady that onions be planted in rows at least 16 inches apart with no more than one onion per inch in the row.

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