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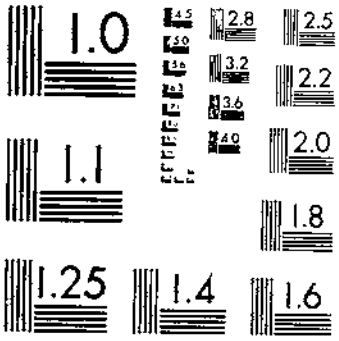

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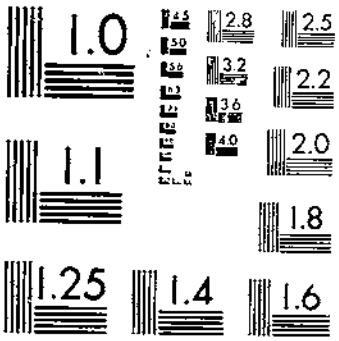

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CONTROL OF SOUTHERN CELERY MOSAIC IN FLORIDA BY REMOVING WEEDS THAT SERVE AS SOURCES OF MOSAIC INFECTION [1]

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CONTENTS

HISTORY AND IMPORTANCE OF THE DISEASE

During the early development of winter celery growing in Florida, little trouble seems to have been encountered with many of the diseases that have since become very destructive. With the concentration of the industry and intensification of cultural methods, diseases have become more and more important, and in the three winters of 1927–28, 1928–29, and 1929–30, the celery mosaic disease was especially severe. Mosaic diseases of celery have been reported from several portions of the United States (*5*),[2] Cuba (*11*), Hawaii (*3*), and Europe (*1*).[3] The celery mosaic herein discussed was first described in Florida in 1924 (*6*), though it was known to occur before this date. Experimental work in Florida was inaugurated in the winter of 1929–30 to study the control of this disease (*9*). Final results of these studies are presented in this bulletin.

DESCRIPTION OF THE DISEASE

Common celery mosaic in Florida is known as the southern celery mosaic and is caused by an infective virus (*10*). When examined in the field, plants affected with this mosaic at first appear stunted and severely yellowed with leaf blotches and bright, irregular markings of that color. As the disease progresses (fig. 1), many of the leaf stalks turn brown and have a water-soaked appearance, affected

[1] Acknowledgment is due S. P. Doolittle, of the Division of Fruit and Vegetable Crops and Diseases, for his suggestions and helpfulness during the course of these studies.
[2] Italic numbers in parentheses refer to Literature Cited, p. 16.
[3] Since preparing the manuscript of this publication, the author, while on a plant exploration expedition, has also found typical symptoms of virus disease on celery in Asia Minor (Turkey).

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tissues may be brittle and tear, leaves may die, and the result is a plant that is ragged and unfit for use.

The virus is easily carried from plant to plant by the common aphid (*Aphis gossypii* Glov.) (*5, 9, 10, 12*), which attacks cotton and

FIGURE 1.—Celery plant at harvest time severely diseased with the southern celery mosaic. Note irregular looking leaves and sickly appearing shriveled stalks.

melons in the South and is called the celery aphid in the Florida celery districts. The host range of the celery virus has been studied (*13*) and the virus was found capable of producing disease in a large number of species of weeds, flowers, vegetables, and other plants.

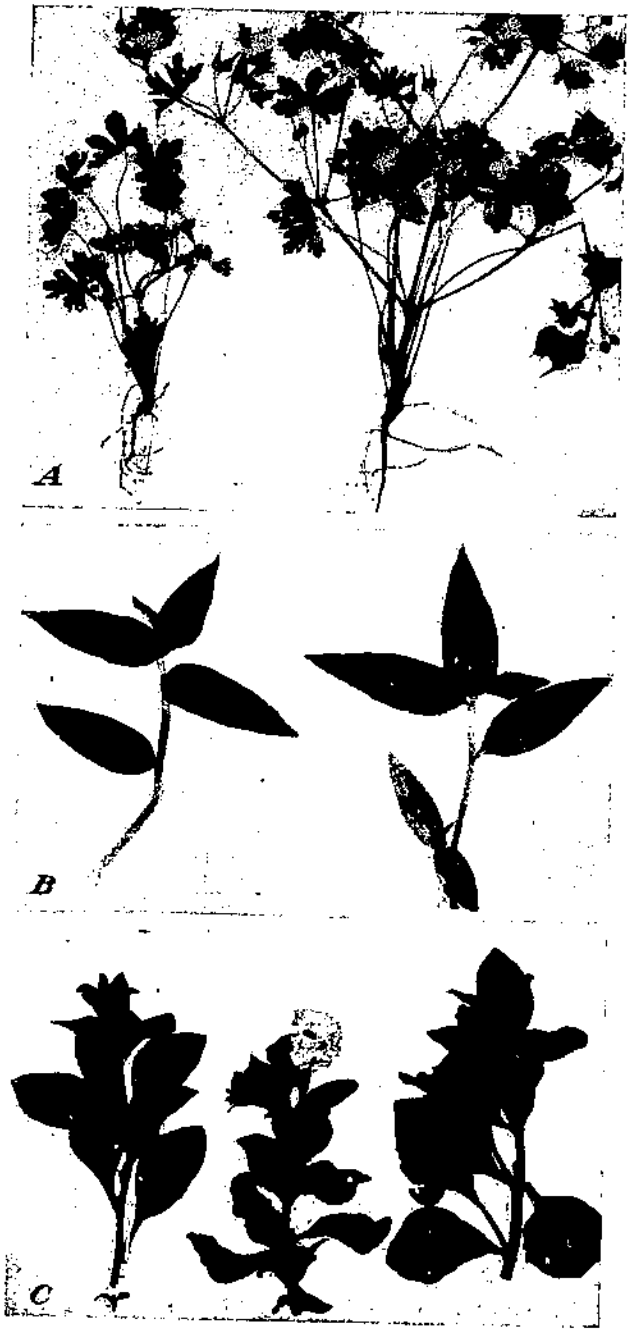

FIGURE 2.—Three hosts of the southern celery mosaic virus: *A*, A weed, Carolina cranesbill (*Geranium carolinianum* L.); diseased plant much stunted, but of same age as large healthy plant. *B*, The most important weed host of the virus in Florida, called wild wandering-jew (*Commelina nudiflora* L.). Diseased plant (at left) apparently of same size and vigor as healthy plant, but has yellowish markings and round translucent spots on the leaves. *C*, The common petunia (*Petunia hybrida* Hort.). Branch from healthy plant on left. Note irregular leaves, poor blossom, and unhealthy appearance of leaves of diseased plants on right.

Some of the important weeds affected in and around celery fields are the wild wandering-jew (*Commelina nudiflora* L.) (fig. 2, *B*), Carolina cranesbill (*Geranium carolinianum* L.) (fig. 2, *A*), plants called husk tomatoes by celery growers (*Physalis angulata* L. and *P. lagascae* R. and S.), the southern pokeweed (*Phytolacca rigida* Small), and common ragweed (*Ambrosia elatior* L.). The most commonly diseased weed is the wild wandering-jew, which grows promiscuously and is perennial throughout the celery districts in Florida. Many weeds were not affected by mosaic (*13*). In addition to certain weeds it is not uncommon to find a number of ornamental plants grown in flower gardens near celery fields that may be diseased with the celery mosaic virus. The most important flowers of this sort are marigold, larkspur, periwinkle, snapdragon, zinnia, and petunia (fig. 2, *C*). Of these the most commonly attacked are petunia, larkspur, and periwinkle. Many vegetables are also susceptible to attack by this mosaic, the most important of which are celery, beet, carrot, sweet corn, cucumber, eggplant, parsley, pepper, squash, sweetpotato, and tomato. Pepper, carrot, sweet corn, celery, cucumber, and squash are considered to be the most commonly and most seriously attacked.

SOURCES OF VIRUS INFECTION IN THE FIELD

When the experimental work on the southern celery mosaic was begun it was thought that the disease-producing virus might remain in the soil from season to season. This, however, was soon disproved (*5*). Celery plants were grown under insect-proof cages in soil from fields that were severely diseased with mosaic every year, and no mosaic developed in these plants. Methods of root inoculation were tried, but under none of these conditions did mosaic symptoms develop in the leaves of the treated plants.

Studies on the nature of the southern celery mosaic virus (*10*) showed that it was not infective when the juices were extracted from diseased plants and dried, or when it was held in a bottle at room temperature for 2 to 7 days. In addition, the virus was inactivated when the diseased plants died and decayed, or the infected tissues were air-dried sufficiently to crumble when rubbed between the fingers.

MEANS OF TRANSMISSION OF THE VIRUS

Greenhouse and field studies of the dissemination (*12*) of the celery virus showed that the common aphid carried the virus from weeds to celery, from celery to weeds and flowers, from flowers to weeds and vegetables other than celery, and from celery to celery and other vegetables, and back to weeds.

In some vegetables, notably tomato, pepper, cucumber, squash, and to a very minor degree in celery, the virus may be spread from plant to plant in the field by implements injuring and bruising first diseased then healthy plants. It is possible that disease-producing juices may be carried on clothes, hands, or tools. However, this type of disease spread was found (*12*) to be so infrequent as to be almost negligible. Practically all mosaic dissemination in celery is the result of aphid transmission.

CONTROL BY REMOVING SUSCEPTIBLE WEEDS

Commercially practicable measures to eliminate certain virus diseases of cultivated crops have been developed with reasonable success. They consist of the application to plant-virus problems of the well-recognized theory behind hygienic procedure in which sources of inoculum are destroyed and excluded, thus shielding the crop from disease losses. For example, Blodgett and Fernow (*2*) found that elimination of virus-infected potato seed pieces was of extreme importance in controlling potato virus diseases. Tuber-indexing methods have been developed by which virus-diseased tubers were discovered before planting time and excluded from the seed pieces that finally reached the field. Doolittle and Walker (*4*) developed practical commercial control of cucumber mosaic by destruction of wild host plants that acted as reservoirs of the virus.

In 1927 Gilbert [4] and Brown [5] eradicated the weed hosts of mosaic (principally milkweed, pokeweed, and species of *Physalis*) in and around the cucumber fields of six growers in the vicinity of Salisbury, Md. The results demonstrated the adaptability of the method to eastern conditions. Doolittle and Gilbert,[6] following the successful trial of this method of eradication of wild host plants, published directions for the use of the method. Gilbert (*8*) also gave a report on the Maryland mosaic host eradication work, giving detailed figures on the results.

Gardner and Kendrick (*7*) met with some success in using the same method to control tomato mosaic in Indiana. Removal of virus-harboring weeds around celery fields was therefore attempted by the writer for the control of southern celery mosaic and preliminary results have been reported (*9*).

In the majority of cases the diseased plants of wild wandering-jew and southern pokeweed appeared to act as the main reservoirs of the virus causing southern celery mosaic. Other weeds and cultivated crops are frequently infected from these plants. Wild wandering-jew is not easily destroyed by being uprooted or hoed out, because the stems and leaves are not readily killed by drying. Plants of this species have been stored without water, on dry benches in a greenhouse, for over 2 months and, although the leaves died, the stems remained alive and were able to grow and develop new roots and shoots when planted in moist soil. This plant has remarkable facilities for withstanding adverse conditions, and it does not necessarily require deep planting to strike root and grow. Piles of the weed have been made on dry ground in the open and watched for wilting and death of the stems. Even when forked over many times the plants did not dry out enough to kill them after 4 months of this treatment.

A number of methods of removing weeds were attempted by the writer as well as by celery growers of the Sanford district. These methods all produced good results when carefully used, but all required repetition and some were expensive. Weeds were burned in the field by using a kerosene torch and by burning dry grass and trash thrown on overgrown areas. A few chemical weed killers, such as calcium

[4] GILBERT, W. W. CUCURBIT MOSAIC CONTROL A DEMONSTRATED FACT. Ext. Path. 6 (1): 4. 1928. [Mimeographed.]

[5] BROWN, J. P. CONTROL OF THE MOSAIC DISEASE OF CUCUMBERS IN WICOMICO COUNTY. Ext. Path. 6 (1): 1-2. 1928. [Mimeographed.]

[6] DOOLITTLE, S. P., and GILBERT, W. W. DATA FOR PLANS FOR EXTENSION WORK ON THE CONTROL OF CUCUMBER MOSAIC. Ext. Path. 6 (1): 5-10. 1928. [Mimeographed.]

chlorate and common salt, were used. In some cases attempts were made to eradicate the offending weeds by plowing and cultivation practices with mule-drawn implements, but in the majority of fields weeds were destroyed by hand hoeing. This latter method was considered fairly efficient and, considering the results obtained, the costs did not reach a figure which the growers felt would be prohibitive.

Merely cutting down the plants and removing the roots of pokeweed and most other weeds served to destroy them. With the wild wandering-jew, however, it was necessary to take the plants out, roots and all, mix them with dry trash, and burn or bury them or feed them to stock. This method of control is expensive where the weed is thick, but celery is grown season after season on valuable, especially fitted land and each season the process is less troublesome. Eventually it should require a minimum of labor.

To obtain definite evidence on mosaic control, seven fields were selected for control studies and the results are reported in table 1. These fields were surrounded with mosaic-diseased weeds and had suffered severe losses from celery mosaic for several years. All seedlings used for transplanting into these fields were known to come from seedbeds well removed from diseased weeds and which at all times appeared to be free from mosaic-infected plants. In fields 1, 2, 3, and 4 (table 1) mosaic had been severe through the three seasons of 1927–28, 1928–29, and 1929–30. The writer was not in Florida during these seasons, but farmers and other agricultural experts of the vicinity estimated that the fields then averaged between 60 and 70 and in some cases well over 70 percent of mosaic-infected plants. In 1930–31 the disease was less severe over the whole district. Late removal of weeds was tried this season on the edges of fields 1 and 2 where they were hoed out about 10 days after the transplanting date. Fourteen percent of mosaic developed in field 1, and 6 percent in field 2, whereas in the nearby unweeded fields (3 and 4) the percentages of disease were 26 and 48, respectively. In seasons subsequent to 1930–31, weeds were removed early from around fields 1 and 2. In these fields from 0 to 8 percent of mosaic plants occurred, whereas adjacent unweeded fields during the same seasons had from 27 to 81 percent of diseased plants.

TABLE 1.—*Results of removing mosaic-infected weeds in and around celery fields*

Winter season	Results in field [1] no.—													
	1		2		3		4		5		6		7	
	Weed removal [2]	Mosaic	Weed removal [2]	Mosaic	Weed removal	Mosaic	Weed removal [2]	Mosaic	Weed removal	Mosaic	Weed removal [2]	Mosaic	Weed removal [2]	Mosaic
		Percent		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*
1927-28 [3]	None	70	None	85	None	70	None	70						
1928-29 [3]	do	60 to 70	do	75	do	80	do	80	None	60				
1929-30 [3]	do	60	do	65	do	60	do	60	do	60	None	40	None	60
1930-31	Late	14	Late	6	do	26	do	48	do	47			Late	25
1931-32	Very early	0.6	Early	2	do	27	do	[4] 81	do	[4] 95	Late	1	do	20
1932-33	Early	2	do	8	do	64	Early	7	do	80	None		None	75
1933-34	Very early	2	Very early	0	do	29	do	3	do	74	do	65	do	77
1934-35	do	1	do	0	do	47	Late	5	do	[4] 82	do	[4] 90	do	[4] 96

[1] Fields were selected which were known to have been seriously affected year after year with the southern celery mosaic, and weed removal was practiced and counts made season after season over the same areas. These areas varied in extent from less than a quarter of an acre (8,000 plants) in field 4, to more than 1 acre (82,000 plants) in field 2.

[2] "Late" indicates weeds removed 1 to 3 weeks after transplanting crop into the field; "Very early" indicates weeds removed 10 days before transplanting crop into the field; "Early" indicates weeds removed 1 or 2 days before transplanting crop into the field.

[3] Percentages of mosaic plants estimated first 3 seasons by growers and agricultural experts of the vicinity.

[4] Field plowed under after counts were taken, no plants harvested.

In field 4 for the first five seasons mosaic in the plants varied between 48 and 81 percent (table 1). During this time no weed control was practiced. During the next three seasons a careful clean-up of mosaic-susceptible weeds was carried out around this field, and the mosaic in celery dropped to between 3 and 7 percent. That weed removal was the important factor in this drop in mosaic percentages is further indicated by the fact that during the same three seasons unweeded fields (5, 6, and 7) had percentages of mosaic that ranged from 65 to 96.

The data in table 1 for field 6 are of special note. The mosaic in this field was estimated as considerably less severe during the 1929–30 season than in the other fields noted. The next season no crop was planted in field 6, and Bermuda grass grew over the edges of the road and along the banks of the drainage ditch, choking out many weeds. In the fall and winter of 1931–32 all weeds and grasses were hoed out and burned around the edges of the field and in the drainage ditches. This work was begun about 10 days after the transplanting date for celery, and it was found at the time that the grasses had in some cases reduced the areas ordinarily covered with the wild wandering-jew. Only 1 percent of mosaic developed in this field during this season when weeds were removed. On the other hand, late weed control was practiced the same season around a fairly closely adjacent field (no. 7) and 20 percent of the plants were diseased.

In comparison with these two fields, an unweeded field (no. 5), which was surrounded by numerous mosaic-susceptible weeds and old mosaic-diseased pepper plants, had 95 percent of mosaic this same year, and the celery crop was plowed under by the owner because it was not worth harvesting.

The next summer wild wandering-jew grew rapidly over the areas around field 6 where no grass had been allowed to reestablish itself. Weed removal was not repeated in fields 6 and 7 the last three seasons of these studies, and mosaic percentages were higher there than formerly and about as severe as in field 5 in which no weed-control measures had ever been attempted.

Upon examination of the data presented in table 1, it is evident that weed-removal measures, when started early enough and continued season after season, as in fields 1, 2, and 4, acted as a fairly satisfactory control of southern celery mosaic. Even when weeds were destroyed at a late date, as in the case of field 7, reduction in mosaic was secured. However, to get the best results it is important that this treatment when once started be continued year after year. In one case (field 6) removal of weeds carried out during one season resulted in reduction in mosaic occurrence. However, when removal was not repeated the following seasons it was found that the clean-up prepared the waste land for a reinfestation of mosaic-susceptible weeds the following years and served to increase celery mosaic losses in succeeding years.

DISTANCE OF NATURAL SPREAD IN THE FIELD

In studies on dissemination of the southern celery mosaic virus, the writer has reported (*12*) that under certain conditions it was carried from infected weeds to celery plants as far as 75 to 150 feet away. While making these studies, an old weed-infested drainage ditch was encountered that was nearly a mile in length and ran along the

east side of eight especially interesting celery fields. Weeds[7] along this ditch were diseased with the celery mosaic virus and were fairly evenly distributed along its whole length. The celery fields near the ditch were at various distances from these infected weed sources and were studied for mosaic occurrence. Plots approximately 17 feet in width (6 rows deep) and 55 feet long, that contained 1,000 plants each, were laid out on the edge of each field, and mosaic was counted in the same plots during three successive seasons. The rows of the plots ran parallel with the ditch, and no weed eradication was practiced along this ditch nor close to the plot edges. The areas between the weeds on the ditch bank and the first rows of celery in these eight plots were occupied either by weed-free soil, wild grasses, cruciferous crops, or beds of narcissus and gladiolus plants, none of which were susceptible to celery virus attack. Three times each season counts were made of mosaic occurrence in these fields, twice during the time when the mosaic disease was the most severe in fields where other observations were being made, and the last time just previous to harvesting the crop. The totals from these data are presented in table 2.

TABLE 2.—*Percentages of mosaic-infected celery plants found in eight plots (1,000 plants each) located at various distances from a ditch lined with weeds infested with aphids and mosaic*

Plot	Distance between diseased weeds and celery fields	Southern celery mosaic in—			Plot	Distance between diseased weeds and celery fields	Southern celery mosaic in—		
		1930–31	1932–33	1934–35			1930–31	1932–33	1934–35
	Feet	*Percent*	*Percent*	*Percent*		*Feet*	*Percent*	*Percent*	*Percent*
A	3	.....	90	88	E	75	7	12	44
B	5	60	91	94	F	120	7	4	16
C	15	67	91	13	G	170	.....	1	0
D	29	.....	84	.....	H	243	0	0	0

In plots A, B, C, and D (table 2) which were from 3 to 29 feet from mosaic-infected weeds, large numbers of mosaic-diseased plants occurred during the three seasons of study. The 1930–31 season was cool, and mosaic was less abundant than usual over a large part of the celery-growing district. Between 60 and 70 percent of the plants were diseased in the plots whose edges were 15 feet and less from the sources of infection.

In 1932–33 mosaic was severe over the Sanford district and about 90 percent of the plants in these four plots were diseased. In 1934–35 the severity of mosaic varied considerably, but plants in plots closely adjacent to mosaic-infected weeds were severely diseased. In plot C, located with one edge only 15 feet from infected weeds, 13 percent of mosaic plants occurred. This was practically the same as that occurring in plot F (16 percent) that was 120 feet from diseased weeds. Plot E, located 75 feet from diseased weeds, had 44 percent of mosaic plants in it. Aphids were less numerous every season on plot C than

[7] The weeds susceptible to celery virus found along this ditch were: Wild wandering-jew, Carolina cranesbill, southern pokeweed, and two *Physalis* species (*P. angulata* L. and *P. lagascae* R. and S.). These weeds were all naturally infested with the common aphid, which attacks celery in Florida.

on plots A, B, or D, and it is possible that whatever was responsible for this smaller number of insects was perhaps reflected in the smaller percentage of mosaic found in 1934–35. In plots E and F, growing 75 and 120 feet, respectively, from diseased weeds, there was a marked falling-off in percentage of mosaic compared with the most severely diseased plots. However, plot G, 170 feet from diseased weeds was almost completely free from mosaic (only 1 percent in 1932–33 and none in 1934–35). In plot H, 243 feet away from diseased weeds, no mosaic occurred during any of the seasons.

DISTANCE AND METHODS OF WEED REMOVAL

In the specialized vegetable-growing district about Sanford fields may be closely adjacent with only roads, hedges, or drainage ditches between them. Under these conditions, celery is grown in one field after another for a few miles in all directions. In such fields it is difficult to obtain clear-cut responses to local weed-control measures because of the proximity of weed-free fields to farms where weeds are not regularly removed. It was desirable, therefore, to determine if possible the distance over which it was necessary to remove the weeds around the fields in order to insure adequate control of mosaic.

Where actual presence or absence of weed removal was studied by the writer (table 1) every effort was made to eliminate the maximum amount of susceptible weeds about fields rather than to attempt varying the width of strips of weeded areas. As a consequence, this type of study had to be made by observing results on a number of farms where the growers used several methods and distances of weed removal to control mosaic. Observations were duplicated two seasons and results were secured on the same farms during the seasons of 1933–34 and 1934–35, and are presented in table 3.

TABLE 3.—*Results of observations made during two seasons (1933–34 and 1934–35) of methods used on various farms for weed removal to control southern celery mosaic*

Farm	Field	Area from which weeds were removed	Method of weed treatment	Barrier between weeds and celery	Distance between weeds and celery	Presence of mosaic in celery	
					Feet		
A	1	Ditch and field edge	None	None	5	+	
	2	Ditch and bank	Hoe	Weed-free soil	25	+	
B	1	Farm garden	do	Weed-free soil, shrubs	45	[1]+	
	2	Ditch and bank	do	Weed-free soil and ditch	15	[1]+	
	3	do	None	None	5	+	
	4	Edge of field	Hoe	Weed-free soil	15	+	
	5	do	None	None	5	+	
C	1	Ditch and bank	Planted Para grass	Para grass	20		0
	2	do	None	None	10	+	
	3	do	Hoe	Weed-free soil	20	+	
D	1	Roadside	do	do	50	[1]+	
	2	do	None	None	10	+	
	3	do	Planted Bermuda grass.	Bermuda grass	15		0
E	1	do	Hoe	Weed-free soil	50		0
F	1	Farm garden	do	Weed-free soil, shrubs	75		0
	2	do	None	None	5	+	
G	1	Ditch and bank	Hoe	Weed-free soil and ditch	25	[1]+	

[1] Less than 1 percent mosaic plants.

TABLE 3.—*Results of observations made during two seasons (1933–34 and 1934–35) of methods used on various farms for weed removal to control southern celery mosaic*—Continued

Farm	Field	Area from which weeds were removed	Method of weed treatment	Barrier between weeds and celery	Distance between weeds and celery	Presence of mosaic in celery
					Feet	
H	1	Roadside	do	Weed-free soil and road	100	0
	2	do	Hoe and cultivator	do	200	0
	3	do	do	Weed-free soil	200	0
	4	do	Hoe	do	5	+
	5	do	do	do	25	+
	6	do	None	None	10	+
I	1	Ditch and bank	Hoe and burning	Weed-free soil and ditch	25	0
	2	do	Let wild grasses grow.	Wild grasses	40	0
J	1	do	Hoe and burning	Weed-free soil and ditch	15	[1]+
	2	do	Hoe	do	25	+
K	1	Roadside	do	Weed-free soil	50	[1]+
	2	do	Hoe and planted grass.	Weed-free soil and Bermuda and wild grass.	75	[2]0
	3	do	do	do	20	[1]+
	4	Ditch bank	None	None	10	[2]+

[1] Less than 1 percent mosaic plants. [2] Results obtained only 1934–35 season.

In 8 fields on the 11 farms studied, the weeds adjoining the celery were left untouched and occurred within 5 to 10 feet of the celery. These were used as check fields. Mosaic was always severe in the celery next to these weeds. In five other cases all weeds were removed from strips 25 feet or less in width around the fields. In these five fields mosaic occurred in adjacent celery plants as severely as in the eight untouched fields. Along the edges of five additional fields, grasses were planted or allowed to grow in strips 15 to 75 feet wide. Para grass (*Panicum purpurascens* Raddi) was planted in moist soils, Bermuda grass (*Cynodon dactylon* (L.) Pers.) in well-drained soils, and wild grasses were allowed to grow in some cases for at least 2 years, crowding out the diseased weeds. No mosaic was found in celery plants adjacent to these grasses.

In eight fields mosaic-infected weeds were removed in strips over 25 feet in width, and extending in two cases as far as 200 feet. In fields cared for in this way mosaic was completely eliminated in some cases; in others it occurred occasionally, though to the extent of less than 1 percent. All weeds were removed on the edges of five other fields, where they adjoined a drainage ditch, but the weeds were untouched on the other side of the ditches. These strips varied from 15 to 25 feet in width, including the width of water in the ditch and the areas where weeds were hoed out, and yet celery mosaic occurred only in extent comparable to that in fields where weeds were eliminated from border areas of more than 25 and up to 200 feet. In these cases it appeared that the strip of water lying between insect- and mosaic-infested weeds and the celery plants probably acted as an effective barrier to travel by virus-carrying, wingless aphids. While these data are not extensive, they give some idea of the success of certain methods of field treatment in eliminating transmission of mosaic virus to celery fields.

In these observations (tables 2 and 3) it was found that the most successful measures employed to prevent spread of mosaic from infected weeds to celery were as follows: (1) Weeding a strip more than 25, probably more nearly 50 or 75 feet in width between the

celery plants and infected weeds; (2) establishing grasses where infected weeds had previously flourished (Para grass in wet soils and Bermuda grass as well as native species in well-drained areas), also gave good results; and (3) the maintenance of a clean open ditch between weeds and celery plants was also effective. The weeding of strips 25 feet or less in width between the celery and infected weeds did not prevent development of southern celery mosaic.

FREQUENCY OF REMOVAL OF WEEDS

In the field experiments (table 1) weeds were hoed out as many as 8 to 10 times a season. Some of this was unnecessary, though no attempt was made to determine experimentally the exact number of times required to eliminate weeds. In this work it was evident that the most practical number of such treatments might be placed at approximately four or five. This, of course, varied with conditions, and did not include hygienic measures about seedbeds.

Weeds were first removed from around fields a week to 10 days before the seedlings were transplanted. Often the places where weeds had been removed were revisited the day before transplanting and any new seedlings or sprouts of susceptible weeds were taken out. It was usually necessary to repeat these measures in about 30 days. Usually a survey of areas near the field edges made a week or so after the last weeds had been destroyed, served to determine how soon further weed removal was needed. When the previous work had been carefully carried out it was usually found that the next weed removal was a minor operation and was not necessary for about 3 weeks. On the whole this sort of program proved fairly adequate for practical control of the southern celery mosaic. Great variation was noted, however, and much depended upon weather conditions and the thoroughness of weed-control measures.

SPRAYING WITH APHICIDES TO CONTROL SPREAD

It has been stated (p. 4) that, practically speaking, aphids are the only means of dissemination and spread of the celery virus in the celery fields. The writer has reported (*9*) that in field tests, sprays and dusts applied in an unusually thorough manner, beyond commercial practicability, did not stop the spread of mosaic by aphids. Comparatively few aphids are required to spread mosaic from plant to plant. They apparently migrate during the season from weeds at some distances away from fields to those on the edges of fields, and from there to celery or other crops.

The writer suggested to three farmers, who found it difficult to eliminate weeds in brushland about their fields (fig. 3, *A* and *B*), that they might reduce their losses from mosaic by regular and continued use of nicotine sulphate in their spray program. These growers combined bordeaux mixture and nicotine sulphate and a good aphid kill resulted. However, although they started using the aphicide in December when aphids first appeared in numbers that season (1933–34), in February after 10 applications a large number of mosaic-infected celery plants occurred and the disease continued to increase. The expense of purchasing the aphicide was an impressive item in the cost of growing the crop, and the farmers abandoned its further use as impractical for the results obtained.

The practical impossibility of a perfect kill of aphids by spraying the matted weed patches along field edges was recognized. The

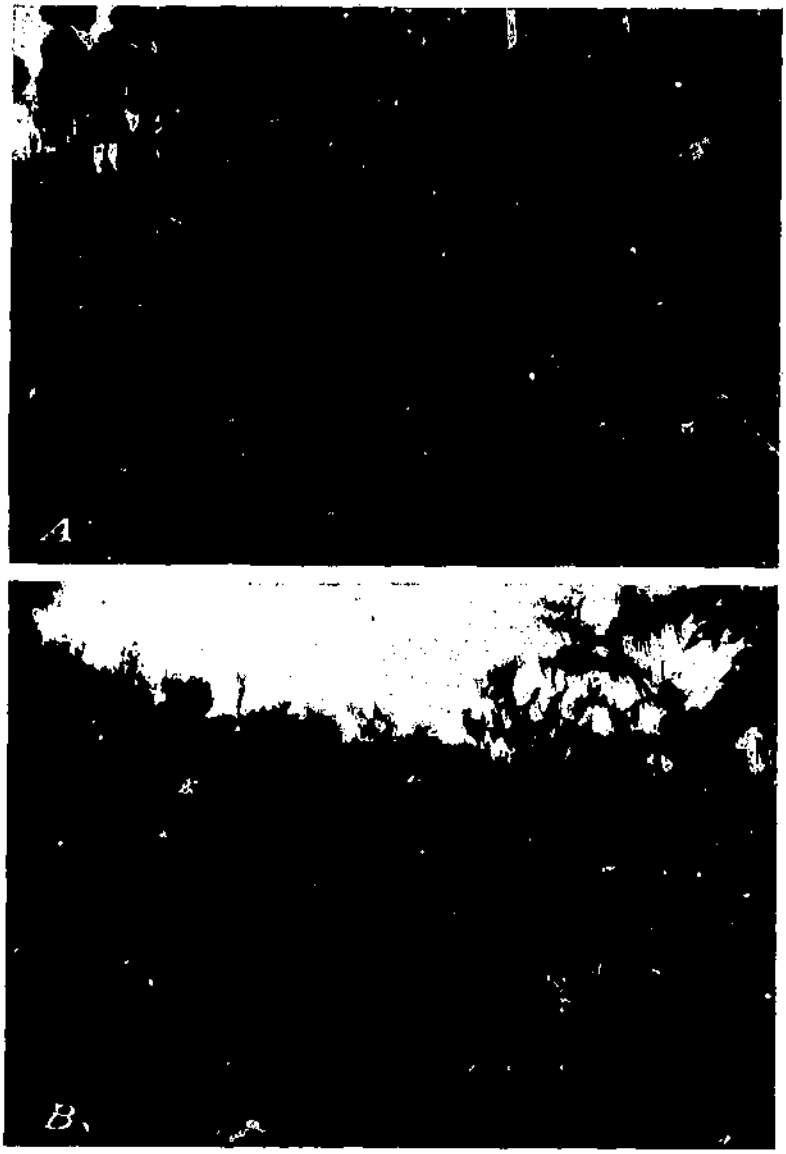

FIGURE 3.—Weed-infested areas that served as sources of southern celery mosaic virus infection in adjacent celery fields near Sanford, Fla.: *A*, View at edge of severely diseased field. Note how weeds extended over soil between trees and bushes. Weeds were eventually removed from the edge of this field for 75 feet into the underbrush, and losses from mosaic were completely eliminated. *B*, View in swampy area close to severely diseased celery field. No weed removal was attempted. However, a strip of Para grass, which is not affected by mosaic, was planted along the fence between the celery and the swampy area, and the grower reported considerable reduction of losses.

continuous multiplication of aphids under Florida conditions and their spread from local points of infestation also required considera-

tion. During the season of 1934–35, an attempt was made to demonstrate the continual reinfestation of weed hosts of southern celery mosaic by aphids. A limited area of weeds that was continuously open to reinfestation by aphids was selected, and the aphids were removed at regular intervals. A strong solution of Black Leaf 40 was applied with a hand sprayer to these weeds during the warmest part of the day. On some plants this spraying was supplemented by the use of the aphicide in a small atomizer, to reach inside of curled leaves and into flower bracts and calyxes. The bed of diseased weeds measured 3 by 15 feet, and was an old one composed of a thick growth of wild wandering-jew and two species of *Physalis*. These plants were adjacent to an abandoned celery field grown up to grass and other weeds. The weeds in this experimental area were sprayed five times at about weekly intervals. The plants were examined before each spraying and aphids were always found on them. Four to six hours after spraying, the plants were washed with water and no living aphids were found. These plants were visited again 5 to 7 days after each spraying. Except during one 9-day period which was cold, wet, and windy, the weeds were always reinfested with aphids. This continual reinfestation of weeds by aphids is apparently a common feature during the winter celery-growing season.

It has been suggested that spraying with sufficient care to eradicate all the aphids on the weeds at one time would control spread of the celery virus to susceptible cultivated crops. However, the areas covered by susceptible weeds along the edges of vegetable fields near Sanford are often large, in some cases extending many rods into the underbrush (fig. 3, *A*), also along edges of rivers, lakes, and marshland (fig. 3, *B*). Under such conditions spraying with sufficient care to kill all the aphids and thereby inhibit spread of the virus is not a practical possibility.

RESISTANCE OF CELERY VARIETIES TO MOSAIC

During 4 seasons, tests were made including 77 strains and varieties of celery, some of them foreign strains, the majority, however, being in common commercial use in the United States. All plants whether in field or greenhouse were individually inoculated and without exception all became diseased. In these tests, both field (fig. 4) and greenhouse studies were made and over 10,000 plants were inoculated, those escaping infection on the first trial becoming diseased when reinoculated. Of the 77 varieties and strains tested a very few poor types showed signs of some tolerance to the disease. Certain foreign strains showed marked ability to grow in spite of the disease, but these were all types far removed from that demanded by Florida growers.

SUMMARY AND RECOMMENDATIONS

The southern celery mosaic disease is caused by an infective agent or virus, which is able to cause disease in a large number of weeds, flowers, and vegetables. The most commonly attacked weeds are cranesbill, two species of *Physalis* called locally husk tomato, southern pokeweed, ragweed, and wild wandering-jew. The most commonly attacked flowers are periwinkle, snapdragon, zinnia, larkspur, and petunia. The most commonly attacked vegetables are beets, carrot, sweet corn, cucumber, eggplant, parsley, pepper, squash, sweetpotato, tomato, and celery.

The southern celery mosaic virus normally persists from one celery season to the next in weeds that surround celery fields. The most important weeds in this regard are southern pokeweed and wild wandering-jew. It appears that the virus does not remain from season to season in seeds or soil. It does, however, exist in the sap of living plants and is perpetuated almost entirely in the field by the feeding action of aphids that commonly attack celery and other vegetables in Florida. It is known that the mosaic virus is carried by insects (aphids) and exists from season to season most frequently in certain perennial weed hosts. The common method of spread of the virus is for these aphids to feed on mosaic-diseased weeds, then travel to healthy cultivated plants in the fields where they feed and

FIGURE 4.—Portion of 1 season's field trials of varieties and strains of celery for resistance to southern celery mosaic. Note in the background toward the center the Para grass which had been planted the previous season to act as a barrier between the weed-grown tangle of bushes and trees in the background and the celery field in front.

thus carry the mosaic to these plants. After the mosaic is once in the celery field, it is spread rapidly by the aphids and causes severe losses. It is evident, therefore, that complete removal of weeds, or, failing that, removal of weeds for a distance sufficient to prevent the aphids that feed on these diseased weeds from reaching the susceptible cultivated plants, will eliminate or greatly reduce losses from this disease.

Celery mosaic was controlled in the Sanford district by removal of weeds, especially wild wandering-jew and southern pokeweed, from around celery fields. These fields were known to be severely affected with the disease year after year, but when the weeds around the fields were removed mosaic losses were reduced to a minimum. Fields in the neighborhood continued to be severely diseased where no attempts were made to destroy weed hosts of mosaic.

Spraying was practiced in fields and in weedy areas to destroy the aphids that carry the celery mosaic. However, it was not practical to spray thoroughly enough over a sufficiently large area of weeds

and celery plants to control the spread of the virus by mere aphid-killing methods.

Tests were made to determine whether any varieties or strains of celery were resistant to mosaic. Over 10,000 celery plants, comprising 77 varieties or strains, were inoculated, and all became diseased when properly inoculated. None of the commercial varieties of celery commonly used in Florida, or any foreign varieties resembling these in type, were found to be resistant to celery-virus attack.

It appears from these results that this particular mosaic virus exists most frequently from season to season in perennial weeds, and is largely spread by insects which, however, do not carry it to extreme distances. Measures for the control of southern celery mosaic consist of weed removal as follows:

1. Complete eradication of all weeds for a distance of 75 or more feet around seedbeds before planting.
2. Removal of weeds, especially wild wandering-jew, from around fields for a distance of 75 or more feet.
3. Complete the first weed removal around celery fields before seedlings are transplanted.
4. Remove weeds about five times during the celery-growing season.

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