Table 5. Control of gray leaf spot of tomato with maneb and mancozeb alone and in combination with BCS.

Fungicide lbs/100 gal	Avg. no. lesions/leaflet[z] 1/13/64	1/24/64
Maneb, 1 + Anilazene, 1	1.6 a	2.6 a
Mancozeb, 1.5	3.8 ab	3.4 ab
Maneb + $ZnSO_4$	2.5 ab	3.9 bc
Maneb, 1.5	2.3 ab	4.1 bc
Maneb, 1.5 + BCS, 4	4.2 b	5.5 d
Mancozeb, 1.5 + BCS, 4	14.3 c	6.4 e
None (check)	30.2 d	—

[z]Differences between numbers followed by the same letter are not statistically significant according to Duncan's multiple range test.

velopment long enough, CEB combinations will be overwhelmed eventually.

Table 6. Control of late blight of tomato with fungicidal programs alternating or combining copper fungicides with maneb or zineb.

Fungicide lbs/100 gal	No. lesions/ 10 leaves	Total yield lbs/plot
1955-56 Experiment		
maneb, 1.5 alternated with zineb, 2	2.0	—
same but BCS 4 applied between each carbamate spray	11.0	—
None (check)	50.8	—
LSD @ 5% level	10.2	—
1956-57 Experiment		
maneb, 1.5 alternated with zineb, 2	7.0	127.2
BCS, 4	—	26.5
maneb, 1.5 + BCS, 4	22.0	68.4
None (check)	34.0	17.6
LSD @ 5% level	9.1	23.5
LSD @ 1% level	12.6	32.1

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FIFTY YEARS OF WATERMELON BREEDING AT ARC LEESBURG[1]

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Abstract. **The Leesburg unit of the Florida Agricultural Experiment Stations was established by an act of the 1929 legislature primarily to study and devise controls for Fusarium wilt of watermelon. A breeding program was begun in 1931. This program, with emphasis on the improvement of melon quality and the selection of disease resistant types, has continued till now, but goals of the program were changed from time to time to meet the changing problems of the Florida watermelon industry. This paper traces the history of those changes and summarizes the accomplishments of the program.**

The Leesburg unit of the University of Florida's Agricultural Experiment Stations system was established in 1930 as a field laboratory for the study of disease and insect problems on watermelons. One of its primary goals was to devise controls for Fusarium wilt, which was causing major losses to Florida watermelon growers, particularly those in the important production area in the central part of the state. A tract of land was leased near Leesburg and 104 varieties were planted in 1930 on 10 acres that had been planted in watermelons 3 times in the previous 11 years. Most of these plants died from Fusarium wilt, but seed from the survivors were planted in 1931 and the first crosses were made on them that year. Emphasis in the early years of the program was on resistance to Fusarium wilt, and many crosses and selections were made with the object of developing new wilt-resistant varieties. One of the most fortuitous was a 'Hawkesbury WR' x 'Leesburg' cross made in 1936. Selections from this cross were made available to many watermelon breeders. One of them, designated Florida Seedling 124, has been recognized as the source of high-level resistance to wilt in 'Calhoun Gray', 'Summit', and 'Calhoun Sweet' (1, 12). Four other cultivars with high level resistance to wilt ('Smokylee', 'Verona', 'Whitehope', and Texas W5) also have 'Hawkesbury' and 'Leesburg' in their genealogy (8). In 1936 anthracnose-resistant breeding lines were acquired and incorporated into the breeding program (9, 13). Lines incorporating anthracnose and Fusarium wilt resistances in horticulturally desirable types were widely distributed to other breeders, so that Florida lines are found in the genealogy of many of the watermelon varieties currently grown in this country and throughout the world. From these beginnings, the watermelon program at Leesburg has continued to the present time, with additional goals being added from time to time. Important goals over the years have been the development of varieties producing high yields of early maturing melons with desirable eating and shipping qualities on vigorous vines with multiple disease resistance (including resistances to Fusarium wilt, anthracnose, downy mildew, watermelon mosaic, and gummy stem blight).

Breeders and Cultivars

The Florida breeding program was begun at Leesburg in 1930 under the guidance of Marion N. Walker. He resigned in 1945 to assume duties with the U.S. Department

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of Agriculture. Walker was succeeded by G. Keith Parris, who conducted the breeding program until 1951. The author assumed leadership for watermelon breeding in 1952 and has continued in that capacity until the present time. Seven watermelon cultivars have been released during the 50-year program (Table 1).

Important Benchmark Dates Since 1952

1952-61. This period was one of evaluation of materials on hand from previous breeders and searching for accessions that might have value for future breeding purposes. During this period 10 accessions from the U.S. Regional Plant Introduction Station at Experiment, GA and several lines from the Dominican Republic with purported resistance to downy mildew (15) were found to be susceptible to this disease. Also during this period, 9 segregating progenies related to 'Garrisonian' were obtained from C. F. Andrus of the Southeastern Vegetable Breeding Laboratory at Charleston, S.C. The cultivar 'Jubilee' was developed from these lines after 4 generations of selection on soils heavily infested with the Fusarium wilt fungus.

1961. The development in 1960-61 of a reliable greenhouse testing procedure, using soil inoculum for infestation and seedling wilt as a criterion of Fusarium wilt resistance, led to a major change in the watermelon breeding program here. Using this procedure we were able to identify a high-level resistance in the cultivar 'Summit', and later also in Texas W5, 'Calhoun Gray', 'Calhoun Sweet', 'Verona', and 'Whitehope'. First crosses were made in 1961 to combine this high-level resistance to Fusarium wilt with anthracnose resistance (race 1) and other characters desirable in a high quality shipping-type watermelon. 'Smokylee', 'Dixielee', and 'Sugarlee' were developed from this program.

1962. Because of interest on the part of Florida growers and shippers in new varieties and numerous inquiries from them about the adaptability of the 'Klondike' and 'Peacock' cultivars grown commercially in California, we acquired a number of accessions of these types in the period 1962-64. None of them prove to be adapted to our conditions, but crosses made in 1962 to a wilt-resistant Peacock type led to the incorporation of an intense red flesh color and crisper-firmer flesh texture into many of our breeding lines. These 2 characters, along with small black seeds and higher soluble solids juice, are some of the most important improvements that have been developed in our lines since that time. They have markedly improved the appearance and eating quality of the watermelon flesh. These characters, along with a tough rind, and resistance to both anthracnose and Fusarium wilt are combined in 'Dixielee', and all but the intense red flesh color are in 'Sugarlee'.

1964. In the early 1960's watermelon mosaic built up quickly and caused severe damage in some south and central Florida watermelon fields. In our search for resistance to this disease, we obtained in 1964 all the accessions of *Citrullus* species that were then available from the the U.S. Regional Plant Introduction Station at Experiment, GA. The original 568 seed samples were sub-divided according to seed differences into 848 total accessions. These were planted in the field for several seasons and, under conditions of variable, but sometimes severe, natural infection, 3 accessions (P.I. 248178, P.I. 249010, and P.I. 255137) were selected for freedom from mosaic infection. A backcrossing program was initiated to incorporate this resistance into 'Charleston Gray', 'Jubilee', and 'Crimson Sweet', but the necessity for relying on natural infection for screening and the sporadic occurrence of mosaic in some seasons resulted in the loss of the clearly defined resistance demonstrated in the original PI's. Some lines with apparent tolerance to mosaic were distributed to Hawaii, where they reacted similarly to their performance here, but no variety releases have been made. Work in this project was discontinued in 1977, but recently an African accession named 'Egun', reported to have resistance to watermelon mosaic virus 2 (20), has been obtained, and crosses were made in 1981 between some of our better breeding lines and F_2, F_1, and parent lines of this accession.

1969. Another major facet of our breeding program was initiated in 1969, when crosses were made between several of our better large-fruited lines and a number of small-fruited cultivars, including 'New Hampshire Midget', 'Sugar Baby', and several from foreign countries (Japan, Israel, Hungary). Early in this program we aimed at the development of smaller-fruited cultivars of 4 fruit types: 1. a 'New Hampshire Midget' type (about 5 lb.); 2. a small (10 lb. average) round gray type, with and without stripes; 3. an intermediate size (about 20 lb.) round gray type; and 4. a 'Klondike' type (10-20 lb.). We have since discontinued efforts to select lines of the Klondike-Peacock types because of inability to eliminate uneven ripening characters from these lines, and recently we decided to discontinue efforts with the 'New Hampshire Midget' types because of a tendency for fruit splitting in these lines. Our present efforts toward the development of small-fruited cultivars are concentrated on several lines with small, round, gray fruits (8-15 lb. average) and several with intermediate size (about 20 lb.), round, gray, striped fruits.

We are seeking to develop varieties that might appeal

Table 1. Watermelon cultivars developed from 50-year breeding program at ARC Leesburg.

Cultivar	Release date	Description of fruit	Seed color	Disease resistance[z]	Parentage
Leesburg	1936	Long, solid green	White	WR	Kleckley Sweet (18)
Blacklee	1944	Long, solid green	Black, stippled	WR	Leesburg, Hawkesbury (19)
Ironsides	1950	Long, solid green	Black, stippled	WR	Leesburg, Hawkesbury, Garrison (14)
Jubilee	1963	Long, striped green	Black, stippled	WR, AR	Africa 8, Iowa Belle, Leesburg, Hawkesbury, Garrison (2)
Smokylee	1971	Long, solid green	White	WR, AR	Texas W5, Charleston Gray (3)
Dixilee	1979	Round, striped green	Black, stippled	WR, AR	Texas W5, WR Peacock 132, Summit, Fairfax, Graybelle (5, 6)
Sugarlee	1981	Round, striped green	Black, stippled	WR, AR	Texas W5, Summit, Charleston Gray, Fairfax, Crimson Sweet, Graybelle (7)

[z]WR, wilt resistant; AR, anthracnose resistant.

to consumers for their easier handling from market to home and their more convenient storage in the home refrigerator. We are also considering their adaptation to shipping in cartons, a prime requisite for overseas shipment. Our test plantings and limited distributions of our small-fruited selections to consumers indicate a reluctant acceptance on the part of growers and distributors but an enthusiastic endorsement by many consumers.

1972. Greenhouse and field tests in 1971-72 and later (4) confirmed the suspicion that commercial seed stocks of 'Jubilee' no longer had the same degree of resistance to Fusarium wilt as that found in original "breeder" seed of 'Jubilee'. Increases of seed from breeder stocks were made here and distributed through the Florida Foundation Seed Producers, Inc. to seedsmen so they could produce "registered"[2] grade seed for sales to growers. Growers willingly paid a premium price for such seed because of its greater resistance to wilt, but practical problems in the production of sufficient quantities of "registered" seed have limited the success of this approach to the problem. Therefore, 2 other approaches to a solution were initiated. A selfing program was conducted for several years in an attempt to eliminate any possible loss of wilt resistance that might be occurring because of heterozygosity at one or more wilt-resistance–governing loci, but since no apparent progress was being made it was terminated. A backcrossing program to incorporate the high-level wilt resistance of 'Smokylee' and 'Calhoun Gray' into 'Jubilee', 'Charleston Gray', and some other varieties was also started in 1972. This was a comprehensive program that required continued selfing, backcrossing, and greenhouse testing in a specific sequence, but it seemed to be the most promising method for getting improved wilt resistance in 'Jubilee' and other commercial cultivars. Test results with backcross lines of 'Jubilee' and 'Charleston Gray' in 1978 were encouraging enough to warrant increasing seed for replicated and grower testing. Tests since 1978 have shown that backcross lines are superior to the recurrent parent lines not only in resistance to Fusarium wilt but in many other characteristics.

1973. Crosses were made beginning in 1973 between some of our more promising selections and several Kentucky short-internode (dwarf) lines. This exchange of breeding materials was facilitated on a sabbatical visit here by H. C. Mohr. Two dwarf mutants in watermelon are governed by single, nonallelic, recessive genes, and the F_2 from the cross between them segregates in a 9:3:3:1 ratio, with the double recessive being expressed in a pronounced bush-like plant (10, 11). Work on dwarf lines has been somewhat limited, but recurrent backcrosses with our better lines have been made to both of the single dwarf types and to the double dwarf.

1981. In addition to the re-initiation of work on mosaic resistance this year, we also initiated work on gummy stem blight resistance. An earlier attempt to utilize resistance found in wild *Citrullus* accessions was abandoned because of lack of facilities and personnel to carry out the procedures necessary for controlled inoculation experiments. In 1981 we obtained *Citrullus* species accessions P.I. 189225 and P.I. 271778, both of which have been reported to have resistance to gummy stem blight (16, 17). Crosses between these 2 lines and some of our better lines were made this season.

Current Program and Future Outlook

Our current program is concentrated in 4 major areas. It is in these areas that we might anticipate releases of new cultivars in the reasonably near future: 1. small fruit size types, 2. large round striped fruit types; these include selections for earlier maturity and higher yield from lines similar to 'Dixielee' in appearance and fruit quality, 3. backcross 'Jubilee' types; similar in appearance to 'Jubilee', but with a higher level of resistance to Fusarium wilt, improved fruit quality, and higher yields, 4. backcross 'Charleston Gray' types; similar in appearance to 'Charleston Gray', but with a higher level of resistance to Fusarium wilt, improved fruit quality, and higher yields.

In the longer range future we might look for cultivars of dwarf types, with more compact vegetative growth and the potential for higher yields of melons per given area of land. We might anticipate, also, development of cultivars with resistance to mosaic (at least that one caused by watermelon mosaic virus 2) and resistance to gummy stem blight. Resistance to mosaic would remove one of the major threats of severe losses of yield and profits to individual growers in Florida from a disease for which we presently have no control. Resistance to gummy stem blight would not only lessen the losses suffered each year from this disease, but it would also greatly lower production costs by reducing the number of fungicidal sprays needed, with concomitant environmental benefits.

[2]Registered grade seed is defined by federal and state laws as seed produced from foundation grade seed.

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