W. W. YOTHERS, A PIONEER IN CITRUS ENTOMOLOGY

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William Walter Yothers was born Sep 15, 1879 in Ashton, Illinois. The family moved to Idaho in 1889. Mr. Yothers attended the University of Idaho, receiving a BS in horticulture in 1903. He served as district horticultural inspector for northern Idaho during his last 3 years. Following his graduation from the University of Idaho, Yothers studied under Professor John Henry Comstock at Cornell University, receiving an AB in 1904. His first USDA assignment was in 1904 when he was asked to study the cotton boll weevil in Texas and develop methods for its control.

In Florida, meanwhile, citrus was recovering from severe freezes of 1894-95. A new generation of growers developed during this time. Many of these growers did not know how to handle many of the problems associated with growing citrus, particularly insect problems. The USDA had initiated citrus whitefly research in Orlando in 1906 with a $5,000.00 appropriation, and A. W. Morril and E. A. Back were initially assigned to conduct whitefly research. In 1907 the appropriation was increased to $10,000.00, and the USDA in Washington reassigned Yothers to the Orlando whitefly project. Another entomologist, E. Worsham, was also assigned to the project.

Yothers assisted A.W. Morrill in evaluating hydrocyanic gas as a fumigant for whitefly. He also studied the effect of the gas on other citrus pests. Although fumigation offered some degree of whitefly control, populations rebounded rapidly. Ultimately, he considered fumigation an unsatisfactory control treatment for whitefly. Yothers' interest increased rapidly in other pests of citrus including scales and mites. Citrus rust mites were a major pest of citrus at that time, and he devoted a great deal of research time on these mites.

Yothers was named Entomologist-in-Charge of the whitefly laboratory in 1910 and remained in this position until his retirement in 1935. W. W. Yothers, as he was known throughout his career, was an avid reader and collector of entomological literature. He accumulated an extensive collection of books and reprints to increase his knowledge. He was a careful and thorough researcher participating fully in all aspects of his research. He gave freely his time in talking with growers and in offering them advice. He felt there was a great need to educate growers and field workers in recognition of citrus pests. In one instance he took a binocular microscope to a grove and collected leaf samples from a series of trees, showing the grove personnel the various species and stages present. The demonstration was greatly appreciated and he was asked to repeat the demonstration so others could learn.

W.W. Yothers met 10 other entomologists at the University of Florida in 1916, forming the Florida Entomological Society. Officers for the society were President J. R. Watson (Exp. Station), Vice President William Newell (Plant Commissioner), Secretary Treasurer R. N. Wilson (U.S. Bureau of Entomology), Executive Committee Member H. S. Davis (Dept. of Zoology). Yothers was a charter member. The first volume of the *Florida Buggist* was issued in 1917, in which Yothers published an article entitled 'The effects of the freeze of Feb. 2-4, 1917 on the insect pests and mites on citrus.' He reported that, although pest populations were sharply reduced due to defoliation, populations generally rebounded fairly quickly. He noted that had chinaberry trees (a host of whitefly) not been present in the area, whitefly populations would have been more greatly reduced by the freeze. Another item of interest in Vol. 1 of the *Florida Buggist* was the announcement of the marriage of W.W. Yothers to Miss Ada Bumby on Dec. 6, 1917. Bumby is a prominent name in Orlando. Yothers was an active member of the Florida Entomology Society (Fig. 1) and served as president in 1927.

W. W. Yothers published USDA Farmers Bulletin 933 'Spraying for the Control of Citrus Insects and Mites Attacking Citrus Trees in Florida.' In this bulletin, he discussed the benefits of pesticides with respect to the quality and quantity of citrus fruit. In 1919, a conference was held at Orlando to develop a spray schedule for citrus. Participants were pathologists H. R. Fulton, J. R. Winston, J. J. Bowman, and H. E. Stevens, and entomologists W. W. Yothers, J. R. Watson (Exp. Station) and E. W. Berger (state plant board). This represented the beginning of the Florida Citrus Pest Management Guide, which is revised annually by the University of Florida, Institute of Food and Agricultural Service.

Yothers published USDA Farmers Bulletin 1011, which provided information on woolly whitefly on citrus. He noted that the pest had been reported on sea grape in Miami in 1900 and that it was first recognized as a potentially important pest of citrus when it was found infesting an orange tree in Tampa in 1909. In monitoring woolly whitefly populations, Yothers noted that populations were under severe attack by parasitic wasps. He concluded that control measures would rarely be required.

The USDA entomology laboratory in Orlando was moved from rented space to a new laboratory and facility at 415 N. Parramore St. in 1920 (Fig. 2). The entomology unit remained at this location until 1939 when it was moved to Ft. Pierce. The

Fig. 1. Picture of Florida entomologists, probably taken at the San Juan hotel and represents members of the Florida Entomological Society. Harold Denmark has provided names for some, but not all. Mr. Yothers is on the right hand side of the front row. Other familiar names to me include Tommy Thompson of Lake Alfred, Dr. John C. Creighton, head of entomology Univ. of Fla., Archie Tissot, head of entomology Exp. Station, and George B. Merrill, chief entomologist state plant board.

Fig. 2. USDA entomology unit facilities at 415 N. Parramore St., Orlando, Florida (1920).

staff at the Orlando entomology laboratory in 1922 consisted of five individuals (Fig. 3). Mr. A. C. Mason assisted Yothers in an extensive rust mite study. In 1924, the green citrus aphid *Aphis spireacola* became a serious concern. Yothers hired F. R. Coles to conduct research on the aphid. Mr. Coles had a talent for drawing and painting, and he provided oil paintings of several of the lady beetle predators of aphids. I found a copy of a letter to Washington requesting permission to spend $5 on oil paints and art supplies so that Mr. Coles could finish his paintings. Thus it would seem that red tape was part of the administration at that time also. Evidently permission was granted, as there were several canvases of lady beetles rolled up at the lab. I had them framed and displayed them before I retired.

I would like to digress briefly from the subject to give you a feel for general conditions during 1902-1935. First of all, it was the horse and buggy age at the beginning of this time. Telephone systems were in their infancy. The population of Orlando was less than 10,000 in 1907 and had grown to about 35,000 by 1935. The United States grew from 45 to 48 states with the addition of Oklahoma in 1907, and New Mexico and Arizona in 1912. U.S. presidents during this time included Theodore Roosevelt, William H. Taft, Woodrow Wilson, Warren G. Harding, Calvin Coolidge, Herbert Hoover, and Franklin D. Roosevelt. The U.S.A. endured WWI 1912-18, the stock market crash of Oct 1929, and resulting great depression 1929-39. A major international event in 1929 was the sinking of the Titanic Apr 14-15 1912 on its maiden voyage. The unsinkable ship struck an iceberg while traveling about 22 miles per hour. Of 2224 persons on board, 1513 were lost. These were W. W. Yothers' times.

The Mediterranean fruit fly was found in Orange County on Apr 10, 1929. An appropriation of $4,500,000.00 was made available to the USDA for an eradication attempt. A state quarantine prohibited movement of fruits and vegetables from the infected area of 15,000 sq. miles. All fruit from commercial groves and residential properties was removed and destroyed. This included all citrus fruit, guavas, peaches, and figs. Arsenical oil sprays were used to kill adult flies. Traps baited with kerosene were used to trap male flies. Mr. Yothers played a major role in the eradication program. As would be expected under the restrictions, public support for the project was not strong. Yothers' daughter, Jean, told me that her father received several death threats during the program. The USDA and The Florida State Plant Board were unable to continue this expensive program, and the inspection force was sharply reduced on Mar 26, 1930. Two infestations were found between Mar 26 and Sep 30, 1930.

Ralph Miller was hired during the med fly program, and he and Yothers evaluated lead arsenate sprays for control of adult med flies. They also measured the effects of lead arsenate sprays on citrus fruit. They found that arsenic sprays on foliage reduced acids slightly while increasing solids. Yothers was sent to Hawaii in Oct 1929 to study biology and control for medfly. The USDA laboratory in Orlando had increased to include other disciplines in 1930s, and additional facilities were built. A photograph of the staff at the field station taken about 1932 showed a staff of 22 people (Fig. 4).

In an article published in the Florida Entomologist Vol. X, Yothers reported observations made during a tour of the citrus growing areas of the United States. He noted that entomogenous fungi were an important pest management component in Florida citrus. The climate in Florida has many similarities to the climate in Southeast Asia, the original home of citrus. The Satsuma growing area of southern Alabama was similar to that of Florida for humidity and rainfall. Winter temperatures allowed purple mite to cause some damage in winter and spring. In Louisiana, rainfall occurs similar to that in Florida. The same complex of scales, whiteflies and mites in Florida were present in Louisiana, including the beneficial fungi. Yothers noted that growers relied almost entirely on entomogenous fungi to keep down scale and whitefly populations.

Yothers noted in Texas that entomogenous fungi did not thrive due to a lack of heavy and regular rainfall. He visited a 15-year-old grove that had never been sprayed or fumigated. Irrigation was by means of ditching and limited cultivation was practiced for weed control. He noted an unexpected lack of insects and mites in the grove and felt that a special study should be made to explain the lack of pests. Two citrus areas in Arizona were examined by Yothers, the Salt River area near Phoenix and the Mesa River Valley near Yuma. The most outstanding feature of Arizona noted by Yothers was the total absence of scale insects, whiteflies, and mites on trees and fruit. He surmised that the low humidity and high temperatures were the likely reasons for the lack of these pest problems. In California, Yothers found that aphid populations were confined to sections along the coast on low, cold locations in the Ontario district. He reported that black scale appeared to have developed a resistance to cyanide fumigation. He visited one pest free section in east highlands and noted that scale insects were absent or so scarce as to be of no economic importance. No one that Yothers contacted in this section suggested factors preventing infestations from developing.

Probably one of Yothers' most important contributions to citrus entomology was USDA technical bulletin 176 published in 1930. Mr. A. C. Mason is listed as a coauthor since he assisted Yothers in the study. The title of the bulletin is 'The Citrus Rust Mite' and its Control. In this bul-

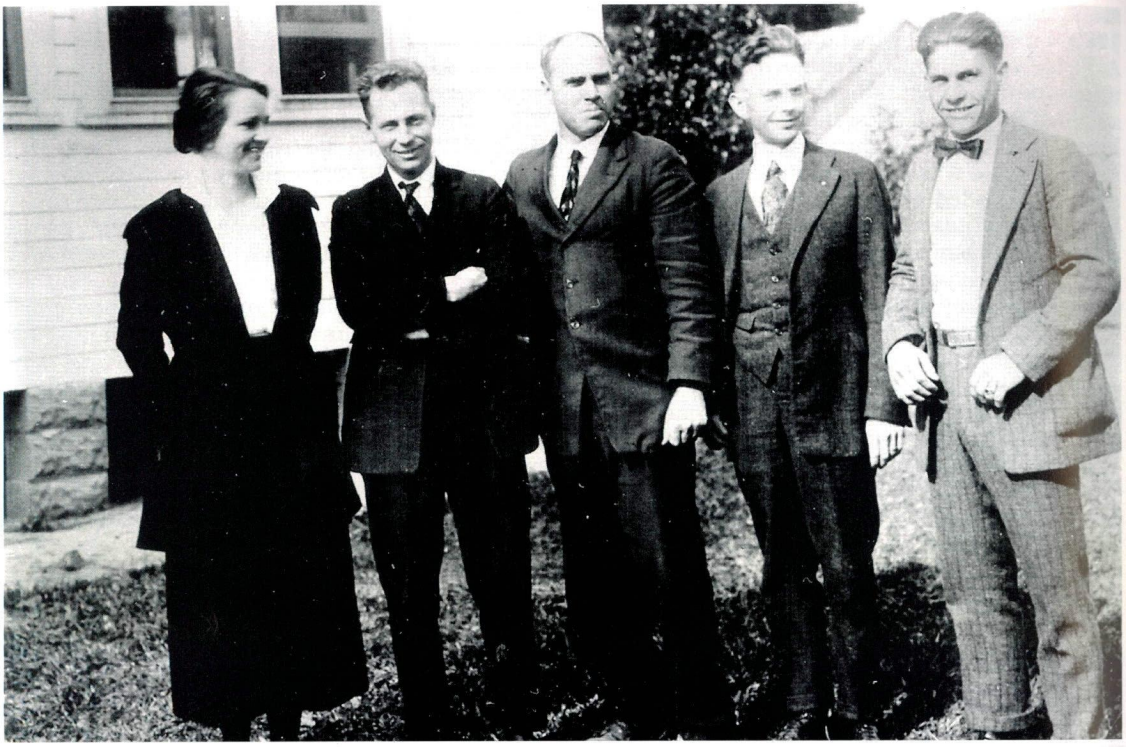

Fig. 3. The USDA Entomology staff at 415 N. Parramore St., Orlando, Florida (about 1922) Left to right: Miss Collicult, Mr. R. J. Cotton, Mr. W. W. Yothers, Mr. A. C. Mason, and Mr. H. H. Link.

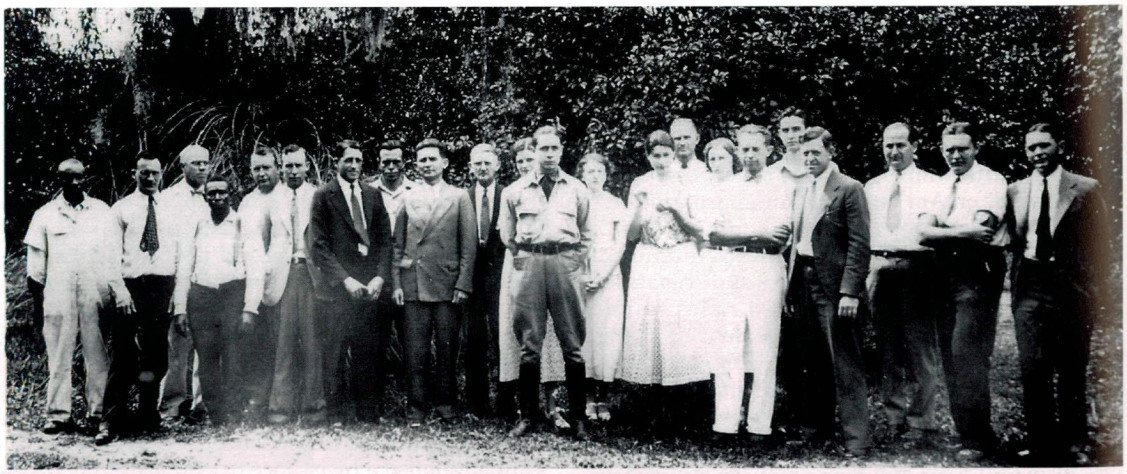

Fig. 4. Group photograph of USDA employees at the USDA Field Station at 415 N. Parramore St., Orlando, Florida, about. 1932. Left to right: Mr. Leonard Sligh, Mr. J. F. Wooten, Mr. W. W. Yothers, Dr. Alex Perkins, Mr. John R. Winston, Mr. T. E. McNeal, Dr. W. V. King, Mr. Taylor, Mr. George Bahrt, Mr. Harold E. Stevens, Miss Tucker, Col. Steward, Miss Ausley, Mrs. Billingsley, Mr. Lee Roberts, Miss Bassett, Dr. Ralph Miller, Mr. Ferguson, Mr. G. Bradley, Dr. Hambleton P. Traub, Dr. Ausker Hughes, and Mr. G. Serviss. This photograph is of particular interest to me. Leonard Sligh on the extreme left was hired by Mr. Yothers to assist in sprays and maintenance. He was still working at the citrus insect laboratory when I joined the laboratory in 1953. Yothers is 3rd from the left. Dr. W.W. King with insects affecting man and animals in the dark suit in position 7, and was in charge of the man and animal laboratory when I joined that laboratory in 1951. Mrs. Eugenia Parker, 11th from left (then Miss Tucker), was hired by Mr. Yothers on a short term position, but proved to be a capable and dedicated employee and finally was given a permanent position. She was still at the citrus insects laboratory when I joined in 1953. I think these 2 individuals demonstrate the good judgment of Mr. Yothers in selecting dependable employees.

letin, the authors bring together much of the known information on citrus rust mite. Studies by the authors gave valuable information on their biology. Rapid increases in summer populations of rust mites were thought to be due to their short life cycle of 7 d rather than a large reproductive capacity of the individual mite. Russeting of the fruit resulted in smaller size and reduction in quality over bright fruit. Contrary to general belief, the authors found that russeted fruit was not sweeter than bright fruit and keeping quality was impaired. An entomogenous fungus that causes a sharp reduction in rust mite populations was noted shortly after the beginnings of summer rains. Yothers and Mason found that rust mites infested all commercial species of citrus, lemons and grapefruit were infested more severely than orange. Tangerines were less severely infested than oranges. Rust mite injury resulted in lowering of the fruit grade, a reduction in size, increased water loss, and more rapid decay.

For life history studies, Yothers reared rust mites on green detached fruit ½ inch to 2 inches in diameter. Gelatin capsules size 0 were found to be satisfactory rearing cages and were attached to the fruit with melted paraffin (Fig. 5). Ends of the capsules were removed for ease of observation. Yothers and Mason determined that the egg stage lasted 3 d in the summer and 5 d in the winter. Rust mites have 2 larval periods, the first lasting 1.8 d in the summer and 4.3 d in the winter. The second larval period lasted 1.3 d in the summer, and 6.4 d in the winter. A pre-oviposition period of from 2 to 5 d was observed. Adults lived 6.9 d in the summer and 11.3 d in the winter. Numbers of eggs laid by female mites were estimated due to difficulty in keeping the mites alive for only limited times. They did record a record of 29 eggs deposited over 20 d. They recorded a maximum of 5 eggs laid in one day. The short period of time for development in from 7-10 d allows for several generations per month and accounts for the vast numbers of mites during the summer. The authors did not report finding any male rust mites. Reproduction did occur by parthenogenesis. Single female mites reared alone from single eggs laid eggs that developed normally. Male rust mites are known to occur, and their method of reproduction has only been reported by Israel entomologists in the last 25+ years. These researchers found that sperm packets placed on short stalks above the leaf or fruit surface were picked up by female mites crawling across them.

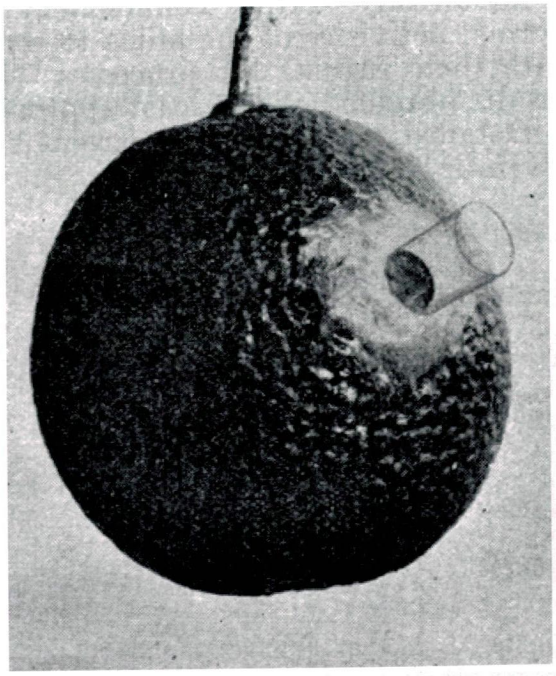

Fig. 5. Rust mite study arena used by W. W. Yothers.

For control of rust mites, sulfur as sprays or dusts were the best agent found by Yothers, but other materials evaluated for rust mite control included oil emulsions, nicotine sulfate, and sulfur (liquid lime sulfur or sulfur dust). Oil emulsions were not commercially available, but Yothers made his own locally using iron kettles over an open flame with whale oil soap as an emulsifier (Fig. 6). Water for sprays was obtained generally from lakes near citrus groves (Fig. 7). Spray equipment consisted of horse drawn spray rigs (Fig. 8). Hand nozzle sprayers of 2-3 nozzles were used by 2-3 spray hands to spray trees (Fig. 9). Research by Yothers indicated oil emulsions of 1% were considered only partially effective for rust mites. Nicotine dusts and sprays were ineffective for rust mite control, but sulfur as liquid lime sulfur or sulfur dusts (Fig. 9) provided satisfactory control. I found in the course of spray tests I conducted from 1970-80 in which I compared miticides for rust mite control that oil sprays at 1% gave control equal to or better than standard miticides in use at that time. Yothers and Mason acknowledged that oil at 1% was partially effective and speculated that had spray coverage been more complete, control would have been better

W. W. Yothers retired from the USDA in 1935, but this did not mark the end of his career in providing advice and assistance to Florida citrus growers. Following retirement, he became a citrus consultant for Chase and Company, Wilson Toomer Fertilizer, and Rhome and Haas Chemical Company.

W. W. Yothers acquired a great deal of information during his career either from first hand experience or from literature. His daughter, Eleanor Y. Fisher, told me of one instance when a grower in Cuba asked for assistance in solving a problem of dry fruit. Yothers went to Cuba and examined the grove where the affected fruit occurred. He could

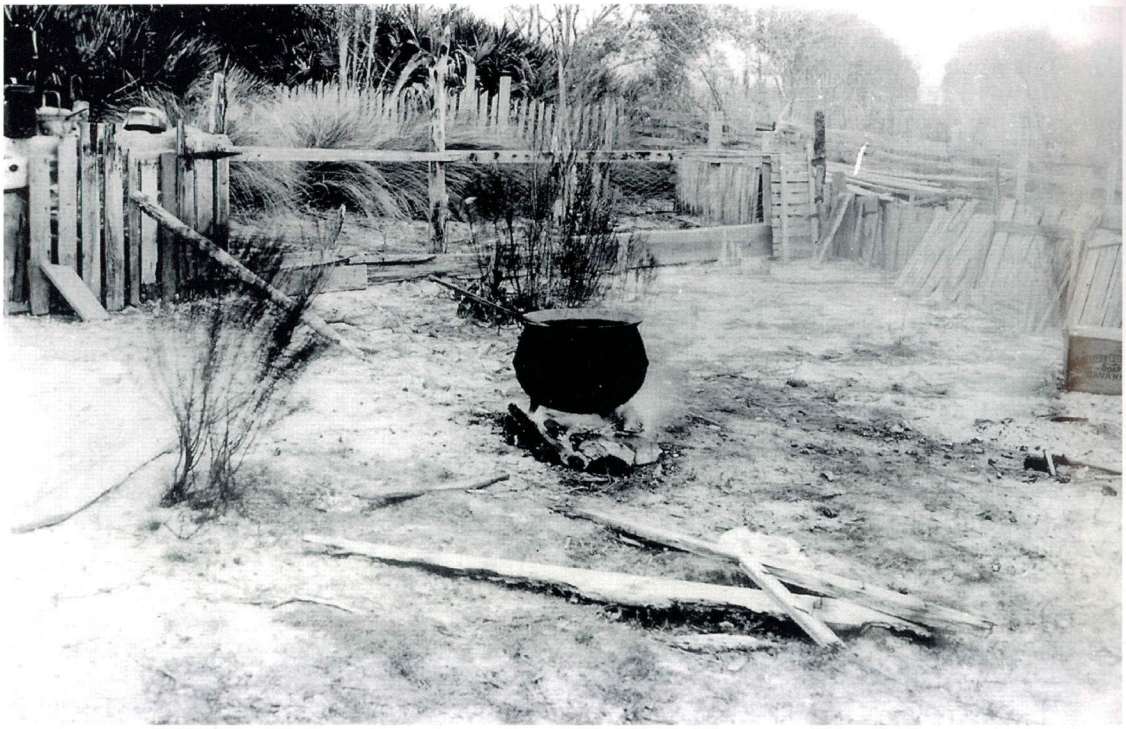

Fig. 6. A 9-gallon iron kettle used by W. W. Yothers to boil oil and water preparatory for emulsification by a bucket pump. Photo by W. W. Yothers, 1910.

Fig. 7. Horse-drawn spray rig for spraying orange trees with experimental insecticides used by W. W. Yothers, about 1910. Yothers, in the boat at the right of the picture, is seen with a suction hose for obtaining water from the lake to fill the spray tank.

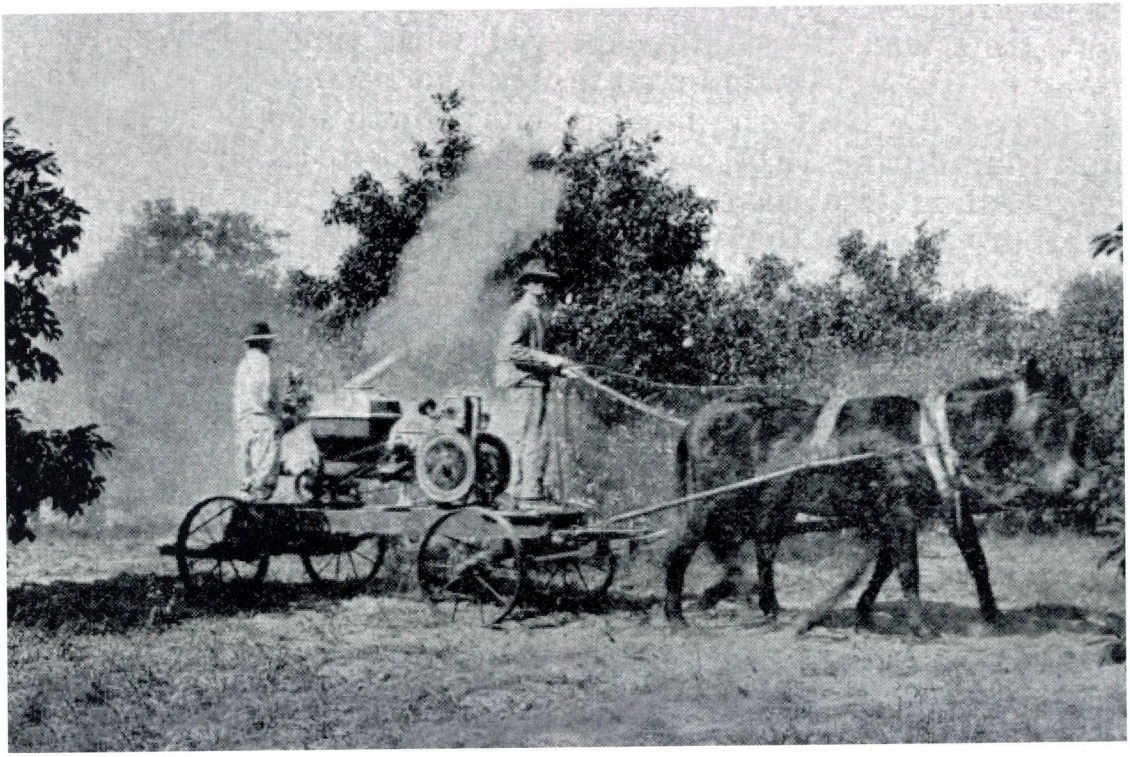

Fig. 8. Horse-drawn dusting rigs used by W. W. Yothers in citrus.

Fig. 9. Spraying orange trees with hand nozzles in a grove at Micanopy, Florida, about. 1909. Photo taken by W. W. Yothers.

Fig. 10. W. W. Yothers (right) receiving from Hendry H. True an award from the Florida Entomological Society for his contributions to entomology (48th Annual Meeting, 1965).

Fig. 11. W. W. Yothers, USDA retired, at home with his dogs.

find nothing during his inspection in daylight, so he decided to visit the grove after dark using a flashlight. He soon discovered the problem was caused by fruit piercing moths. I didn't learn what he suggested as a control measure, but this pointed out his broad knowledge of citrus problems.

After retiring, Yothers remained an active member of the Florida State Horticultural Society and served in several offices. He was able to compile a complete set of the proceedings of the Florida State Horticultural Society and donated them to the Albertson Public Library in Orlando. He donated much of his accumulated collection of books, periodicals, and reprints on citrus and its problems to the University of Florida Research and Education center at Lake Alfred. He was elected an honorary member of the Florida State Horticultural Society in 1955 and was inducted into the Citrus Hall of Fame. These honors reflect the many years of service to the industry by one pioneer in citrus entomology.

I am honored to have served the same laboratory that W. W. Yothers served. He was the second entomologist to head that lab, and I was the sixth entomologist to be in charge. I have always felt a sense of pride to have had a part of this bit of history. I never formally met Yothers, but I remember seeing him at several meetings of the Florida Entomological Society and the Florida State Horticultural Society.

W. W. Yothers (Figs. 10, 11) was a true pioneer of citrus entomology, and I compliment the Florida Entomological Society for selecting him as the honoree in this lecture. I have greatly appreciated the opportunity to compile this brief overview of the life and times of W. W. Yothers.