PUBLIC BREEDING OF COTTON IN THE SOUTHWEST HOST PLANT RESISTANCE

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Abstract

The first papers on host plant resistance given before the Improvement Conference was at the third meeting in Memphis. One was by Loden and Wilson on the effects of temperature on germination and seedling growth, and the other was by Brinkerhoff and Green on frequency of bacterial blight resistant plants in 20 varieties. The Southwest became the area for developing bacterial blight resistant cottons. Discoveries by Simpson and Weinding at Knoxville were utilized by Blank at College Station. This resulted in activity at Lubbock by Ray and Jones, at Paymaster (in Aiken, Texas) by Loden and Adams, and at Greenville, Texas by Hooton, and Porter. Moosberg initiated his blight resistance research at Greenville and continued it in Marianna, Arkansas. Brinkerhoff and Green's efforts in Oklahoma were productive. Blanks move to New Mexico resulted in resistant varieties in the Acala 1517 cottons. Blank was certainly the father of the first blight resistant varieties developed and released in the Southwest. To encourage breeding for bacterial blight resistance the College Station program maintained cultures of several races of the pathogen. The cultures were made available on request to the public and private programs across the belt.

In the early 1950's limited research for resistance to the Fusarium wilt-root knot nematode complex was underway in Texas and Oklahoma. The contributions of Smith and the Alabama nursery were supportive of these and subsequent research on wilt-nematode resistance in the Southwest. Bill Sappenfield's Missouri program for bacterial blight, Verticillium wilt and Fusarium wilt-nematode resistant strains contributed to host resistance research in the Delta and Southwestern regions. Waddle's efforts in Arkansas for evaluating strains and selecting for Verticillium wilt resistance; and with Bollenbacker and Fulton in identifying sources of resistance to seedling pathogen were significant.

Breeding Fusarium wilt-nematode resistance was centered in the southeast and east central states and much later in California. Breeding for blight resistance was centered more in the central states and emphasis on Verticillium wilt resistance began in the western states but spread rapidly to the central and some eastern states. Gaining high resistance to Fusarium wilt was slowed by the necessity of combining genes for wilt and nematode resistance. Similarly gaining high resistance to the blight pathogen was slowed by development of races necessitating pyramiding genes to get broad resistance to many races. Pyramiding genes for resistance to Verticillium wilt was used early and good resistance was gained in a relatively short period of time. A good lesson is; use different sources of resistance and some type of convergent improvement when dealing with host plant resistance. To emphasize, prior to World War II scientist found significant differences among varieties for an intermediate level of resistance to Phymatotrichum root rot. Pedigree selection was ineffective for gaining higher than intermediate resistance. We used a type of delayed convergent improvement in the MAR program. With this system we slowly gained higher than intermediate levels of resistance to root rot. Early on, except for identifying some sources of resistance little or no effort was directed towards breeding varieties for resistance to seed-seedlings pathogens. L. M. Blank transferred the gene for resistance to the Southwestern rust pathogen into Stoneville, Deltapine and Acala varieties. Its a simple single durable gene situation yet Blank's genetic stocks have not been used. The rust resistance gene is in MAR strains having a "U" in their designation. I should point out the need for *Gossypium barbadense* varieties having genes for resistance to pathogens causing bacterial blight, Southwestern rust and Alternaria leaf spot.

I was hired February 1, 1950 in a joint TAES, Cotton Branch USDA appointment to carry on the blight breeding initiated by L. M. Blank. My assignment was to develop cottons with resistance to bacterial blight and the Fusarium wilt-root knot nematode complex. On completing the Ph.D. degree in 1955 my superiors gave me the green light to breed cottons with resistance to all diseases. We began to evaluate 25 to 36 breeding lines for resistance to bacterial blight, Fusarium wilt-nematodes, Verticillium wilt, Phymatotrichum root rot and seedling disease. We also measured various seed, seedling and cold resistant traits. This also provided basic data for measuring genetic interrelations among genes for resistance to various diseases, seed-seedling, yield and earliness traits.

In my opinion, significant findings concerning host-plant resistance in crops began in 1957. L. M. Blank reported that Al Smith's Fusarium wilt-nematode resistance lines were resistant to Verticillium wilt and Smith reported that Blank's Verticillium wilt resistant lines were resistant to the Fusarium wilt-nematode complex. This indicated presence of genes conditioning traits giving resistance to three pathogens. The reports by Blank and Smith stimulated Brinkerhoft and Hunter to make measurements indicating there were genes having to do with resistance to Fusarium wilt and bacterial blight. Bird et. al generated data by partitioning genetic variability indicating there were genes conditioning a mechanism causing resistance to pathogens causing bacterial blight, Verticillium wilt, Fusarium wilt-nematode complex, Phymatotrichum root rot and seedling disease. It was learned that reduced rates of germination

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and emergence were favorable for stand establishment, yield and earliness. During the 1955-1963 period many basic understandings of host plant resistance and seed-seedling cold resistance dealing with multiple diseases was gained. We extended the interrelationship studies among resistance to diseases, seed-seedling cold resistance, yield and earliness. Later, when it became apparent we were getting resistance to insects, the interrelationship studies included insect resistance. These studies showed we should expect insect resistance to occur with MAR selection.

About 1962-63, the state budget of the Texas Legislature directed the Agricultural Experiment Station to put a serious effort into developing cotton varieties having resistance to bacterial blight and seed-seedling cold resistance adapted to the Blackland and Trans-Pecos regions of Texas.

We knew how to deal with bacterial blight resistance but dealing with seed-seedling cold resistance was untested for obtaining genetic improvement. Results from the interrelationship basic studies (1955-1961) indicated that (1) selecting for rapid radical emergence and elongation led to increased susceptibility to seedling and Verticillium wilt pathogens (2) cotton had some seed-seedling cold resistance but this was lost as seed were exposed to moisture and heat (conditioning and deterioration) (3) as seed are exposed to moisture and heat the seed coat becomes sequentially more supportive of mold growth (4) seedlings from un- and partially conditioned seed are more likely to be attacked by primary pathogens such as *Rhizoctonia solani*, *Pythium* spp. and *Thielopsis basicola* and (5) seedlings from deteriorated seed are attacked more by saprophytic soil organisms such as *Fusarium* spp. and *Alternaria* spp. Based on this information we concluded that if gains were made in improving seed-seedling cold resistance it would be neutralized by seed conditioning and deterioration. Thus, we decided to select simultaneously for seed-seedling resistance to cold and resistance to (or slower rate of) seed conditioning and deterioration. The traits chosen for selection were slower radical emergence and elongation and seed coat resistance to mold growth on water agar after 8-days at 58°F. The radical emergence, seed coat mold growth, resistance to several races of the bacterial blight pathogen and absence of seedling disease lesions on the hypocotyle and radical became the traits we used to combine blight resistance and seed-seedling cold resistance as directed by the Texas Legislature. These traits later became the key for selecting for multi-adversity resistance (MAR).

The first varieties released using the MAR selection traits were from 1964 F_3 progenies and became SP21, SP23, and SP37. These were from the first hybrid pool. The genetic variability was due, in part, to genes from *Gossypium barbadense* (Knight's BAR Sakel lines). Empire WR, Blightmaster, Paymaster 105 and 39-11-20 (gl_1, gl_2 glandless strain). The initial MAR F_3 progenies were evaluated in 1965-66 and given the SP designations. These were increased with limited testing in 1966-67. Formal testing occurred in all areas of Texas in 1968-69. The results showed that the MAR types yielded 800 to 1200 pounds more lint per acre than non-MAR varieties where seedling disease was present, and worms and weevils could not be controlled. The MAR types yielded 200 to 300 pounds more lint per acre than susceptible types where seedling disease and bacterial blight were problems.

The three SP MAR types were released as varieties. Seed supplies were limited in 1973 but were adequate from 1974 forward. Their performance in the Coastal Bend of Texas illustrated their importance. As the MAR types replaced Stoneville, Lankart and other non-MAR varieties the average yield for the area increased from about 300 pounds to about 650 pounds per acre. A new gin had to be built at Odem, Texas to handle the added volume of seed cotton. These results indicate why MAR varieties were credited with saving the cotton industry in the Coastal Bend of Texas. The MAR varieties gave similar results in the Rolling Plains of Texas where seedling disease, bacterial blight and the Fusarium wilt-nematode complex were problems.

We intercrossed the first hybrid pool material and produced the second hybrid pool which gave added improvement indicating the MAR gains were under genetic control. The F_3 progenies of the second pool were planted in 1967. The presence of cabbage loopers showed a number of progenies were uniformly resistant, some segregating and others were fully susceptible. Thus the first insect resistance became apparent in hybrid pool two. After further testing, the hybrid two strains became CAMD-E, SP21S and SP37H. In addition to measuring improved resistance to diseases, resistance to fleahoppers, boll weevils and worms was measured. We established a set of host differentials to use in estimating levels of insect resistance. CAMD-S is SP21S, CAMD-H is SP37H, OR-S is an okra leaf frego bract smooth strain and SP37 had no insect resistance. The fleahopper resistance was confirmed by Ring, Benedict, et al. in 1996. They measured high resistance to fleahoppers in hairy SP37H, partial resistance in glabrous SP21S and no resistance in hairy SP37. These data are similar to results reported in 1976.

The fiber of the original Tamcot SP varieties was high quality for their time. They were criticized for having genetically low micronaire values. Yet, with length, strength and elongation equal to the Delta varieties and better than Texas varieties the SP varieties with mature micronaires of 3.8 to 4.2 were producing high quality fiber. They came along at a time when mature low micronaire fiber was needed.

Hybrid pool three was primarily to bring additional variability into the broad pool of genetic variability. Pools four and five gave additional improvement in total yield, early yield, resistance to diseases, insects and environmental stresses. I should point out now that MAR progress for yield and earliness is best measured when tests are in a field surrounded by a MAR variety. Under these conditions insect scouting indicates needs of a MAR type which is usually about half the insecticide required for a non-MAR variety. A MAR test in a non-MAR field of cotton usually gets twice as much insecticide. Under these conditions benefits of insect resistance in MAR cottons is partly neutralized. The MAR varieties have storm resistant bolls and they are two to four weeks earlier in maturing. Consequently to be fair in comparing in tests with later maturing open boll varieties using picking machines; (1) the picker must be adjusted for efficient picking of a storm resistant boll and (2) the storm resistant varieties should be picked when they are fully mature not waiting until the later open boll varieties are ready.

At the end of 1985 the strain CDP37HH had the highest level of MAR resistance through hybrid pool four. It had the best average resistance over five diseases and over four insects. It had the highest early and total yield over four locations in the coastal bend of Texas and the highest early, mid and total yield in a test where no insecticides were applied.

The better MAR strains of each hybrid pool were systematically released to public and private breeders. This resulted in a number of private varieties being developed by selection from MAR strains and others from crosses with MAR strains. These activities resulted in more farmers benefiting from the favorable traits of MAR germplasm.

Measured performance data over four hybrid pools and the projected pool five show a progressive gain as one would expect for a genetically controlled trait. This indicates the total MAR trait is under genetic control and further improvements should be made. Delayed convergent improvement proved to be a perfect breeding procedure for MAR gains.

Drs. Kamal El-Zik and Peggy M. Thaxton are continuing the MAR program and additional gains have been made. The varieties HQ95 and Sphinx, and breeding strains have been released.

The hypothesis of the MAR mechanisms of broad resistance is: “MAR genes cause selective colonization of plant tissues by certain symbiotic bacteria and fungi. These organisms act to prevent successful invasion by plant pathogens and alter tissues so they become unattractive to insects”. Results have been given elsewhere showing that by applying symbiotic bacteria and fungi from MAR cotton tissues makes cotton plants resistant to pathogens and insects.