

## CONTROL OF THE COMMON MOSAIC DISEASE OF TOBACCO BY BREEDING<sup>1</sup>

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Fifteen years ago it was found that the common mosaic of tobacco could be controlled successfully by insisting that the hands of the workers who chewed or smoked barn-cured tobacco be freed from mosaic virus before weeding and pulling plants,<sup>2</sup> but, because of difficulties where hired help is used, growers are not always successful. It is, therefore, highly desirable that resistant varieties of tobacco, equal in other respects to those commonly grown, be produced. With this object in mind, the writer has conducted breeding studies on Burley and dark tobacco in an attempt to produce desirable mosaic-resistant varieties. Three promising lines are being followed: (1) hybridizing desirable varieties with *Nicotiana glauca* (seed obtained from R. E. Clausen, University of California), and repeatedly backcrossing; (2) hybridizing desirable varieties with Ambalema and repeatedly backcrossing; (3) repeatedly backcrossing the best Ambalema-type resistant plants (A) on glutinosa-type resistant plants (N) to combine the two types of resistance.

Recently, objections have been raised to the use of the N factor in control of tobacco mosaic,<sup>3</sup> but in the experience of the writer the conclusion that "it does not seem that the glutinosa type of mosaic resistance has any practical value" seems entirely unwarranted.

Theoretically, the glutinosa (N) type of resistance, when transferred to commercial varieties of tobacco, should be ideal. It is governed by a dominant gene; consequently, backcrosses can be made on selected plants in every generation. Thus it should be a relatively simple matter, if the N gene has been transferred to a tabacum chromosome, as Holmes seems to believe,<sup>4</sup> to introduce resistance of this type into any number of commercial varieties of tobacco. The backcrossed strains, after about the third or fourth backcross, usually appear nearly identical with the commercial variety used as the backcross parent. It should then be necessary only to self a strain that has been repeatedly backcrossed and select plants homozygous for the N factor. The original variety plus the resistance factors should result. The writer has isolated 3 homozygous strains from a fifth backcross strain prepared by Holmes in which Ky. 16 was used. Two of the NN strains were of lighter color than Ky. 16, had smaller upper leaves,

and bloomed much lower. The suckers were very tough and hard to remove. The third strain was of the same color as Ky. 16, grew nearly as large, but yielded about 25 per cent less tobacco. Several other homozygous strains of Burley of the writer's own breeding have been isolated but nearly all have been discarded because of slow growth, low yield, or other undesirable characters. These results seem to indicate that when the N factor from *Nicotiana glutinosa* is well established in the tabacum genome, it still carries with it other factors that, when in a homozygous condition, markedly affect the type of plant produced. Some NN strains appear desirable, suggesting that, eventually, satisfactory varieties may evolve.

As to the value of the N factor in the control of tobacco mosaic, there seems little doubt, in spite of objections that have been raised to it. There is no question that seedlings transplanted to thumb pots usually will be destroyed if heavily inoculated, making it necessary to remove the inoculated leaf soon after the necrotic spots develop, if the plant is to be saved. Rapidly growing plants in the field may likewise be destroyed if heavily inoculated. In the writer's field tests the past season, 27 strains of Nn or NN Burley tobacco were inoculated June 18, 1941, 25 days after setting. Inoculum used consisted of freshly crushed green leaves, applied with the thumb and fingers to the tip of one upper leaf. Of 441 N plants, 435 developed necrotic spots but otherwise remained healthy (Nn or NN); only 6 developed systemic necrosis (Nn or NN). Inoculation was undoubtedly heavier than would ordinarily occur in accidental inoculation by the farmer. In addition, 3 NN strains of Burley were tested extensively with farmers in 1940 and 1 strain in 1941. These strains were not introduced for general planting, but were used for the purpose of demonstrating that mosaic can be controlled by the use of a resistant variety. In some of these demonstrations, the grower inoculated both the resistant and susceptible plants, but in no instance has a case of systemic necrosis been reported. An occasional grower, who has been much troubled by mosaic in the past, has grown a crop of NN tobacco with complete success as far as mosaic is concerned.

Another point should be kept in mind in connection with the use of the necrotic response in mosaic control: Nearly all mosaic infection originates on the hands of the workers, either as a result of handling viruliferous dried tobacco or, in rare cases, handling diseased weeds in the plant bed.<sup>5</sup> Assuming, for argument's sake, that every plant, inoculated with tobacco mosaic virus at weeding, pulling, and setting time, develops systemic necrosis and dies, experience with susceptible varieties has shown that it would be rare indeed that 10 per cent of the plants in the field would be affected following setting. Field evidence indicates that there would be no further spread from necrotic plants the remainder of the season because of low virus content in necrotic plants that may survive. The crop at harvest time would be virtually virus-free, and would not, therefore, carry virus over winter.

<sup>5</sup> Valleau, W. D., and E. M. Johnson. Tobacco mosaic—sources of infection and control. Kentucky Agr. Exp. Stat. Bull. 376. 1937.

<sup>1</sup> The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

<sup>2</sup> Valleau, W. D., and E. M. Johnson. Observations and experiments on the control of true tobacco mosaic. Kentucky Agr. Exp. Stat. Bull. 280, 143-174. 1927.

<sup>3</sup> Clayton, E. E., and H. H. McKinney. Resistance to the common mosaic disease of tobacco. Phytopath. 31: 1140-1142. 1941.

<sup>4</sup> Holmes, F. O. Inheritance of resistance to tobacco-mosaic disease in tobacco. Phytopath. 28: 553-560. 1938.

Therefore, any chewing or smoking tobacco from the crop, or any trash used for fertilizer from it, would be virus-free, and the second-year crop should be entirely uninjured by the virus. Granting that soil carry-over may sometimes be a minor factor in field infection, there should be none following an N-resistant crop because of the few plants affected and because of the very low virus content of the necrotic plants. In warm regions, where tobacco plants sometimes survive the winter and act as a source of mosaic for the succeeding crop, there is little likelihood that necrotic plants would survive. The mosaic disease in an N-resistant crop thus is self-eradicatory in contrast with its self-perpetuating habit in a susceptible crop.

With Burley tobacco it has been possible to backcross with a susceptible variety 4 consecutive times on Ambalema-resistant  $F_2$  Burley plants and still maintain resistance. There is some question as to whether resistance is of as high a degree as occurred in the original Ambalema selections. Backcross resistant seedlings develop some mottling 2 or 3 weeks after inoculation and may become slowly and nearly completely invaded if grown to maturity; yet the growing-point leaves of rapidly growing plants are unmottled and undistorted, indicating a high degree of resistance. When plants of this degree of resistance are grown in the field and inoculated with a bleaching strain of the mosaic virus as soon as rapid growth commences, the majority remain healthy, except for local chlorotic lesions, while a part develop an occasional chlorotic ring pattern on one or more lower uninoculated leaves. In commercial plantings where mosaic is abundant in a susceptible variety, these resistant varieties remain entirely free from any noticeable infection. The objections to these resistant Burley varieties, noted so far, are that they have a somewhat objectionable plant type, even after repeated backcrossing; yield has been lower than is obtained from the Burley parent (Ky. 16) used in backcrossing; and the majority of the hybrids wilt in hot weather, with the result that one or more leaves scald. Ky. 16 seems to be completely free from this trouble. It is possible that these objections may be overcome. The quality of certain of the resistant strains appears to be satisfactory.

Theoretically, there may be some objections to the A type of resistance in that resistant plants sometimes carry a slight amount of virus, which might act as a source of inoculum for tomatoes or other susceptible crops when the viruliferous tobacco is prepared and sold in commercial form. Actually such a large percentage of A-resistant plants escape systemic infection, when heavily inoculated in the field, that there is little danger of any resistant plants developing systemic infection under farm conditions. There is a real danger, however, that strains of the mosaic virus may develop that will become systemic in N plants and produce a mottle disease, rather than necrosis, as Blood and Watson report in *Datura meteloides*.<sup>6</sup> Both of these

<sup>6</sup> Blood, H. L., and R. D. Watson. A modification of the tobacco mosaic virus No. 1 occurring in *Datura meteloides*. Utah Acad. of Sci., Arts and Letters 15: 15-19. 1938.

theoretical difficulties can be overcome, and nearly immune strains of tobacco produced, if the N and the A types of resistance are combined in one variety. Ten such strains of Burley were set in the field in 1941 and inoculated 25 days after setting. All were heterozygous for N, and had not been selected for A-type resistance, except that A-type resistant plants were used in backcrossing. Of a total of 294 plants inoculated, 245 showed no evident signs of infection, 46 developed systemic mottle mosaic, and 3 developed a few chlorotic ring patterns on lower leaves. In tests later in the summer it was usually difficult to detect N plants because of slow development of local necrotic spots in plants in which the 4 recessive *a* factors also were present. In the greenhouse, tender *Nu aaaa* plants develop local necrotic spots but rarely manifest systemic necrosis under conditions where nearly all Nu plants would be destroyed. In a few instances *Nu aaaa* plants that developed systemic necrosis recovered completely when set in the ground bench.

From the writer's experience it seems safe to conclude that both the Ambalema (A) and the glutinosa (N) types of resistance, either singly or together, will prove satisfactory for practical control of tobacco mosaic if satisfactory commercial varieties containing these factors in a homozygous condition can be produced.

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