Possibilities of Breeding for Tolerance Against Virus Yellows and Beet Eelworm

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Virus yellows causes serious losses in the beet growing areas of many parts of Western Europe, the Netherlands inclusive. On the other hand, in our country beet eelworm is present *in* many fields in our best beet growing areas.

As direct control of both diseases is very difficult, we have turned our attention to the possibilities of breeding tolerant plants. To prevent misunderstanding it should be mentioned that in Europe the term "tolerance" more or less covers the same idea as the term "resistance" in the U. S. Tolerant plants are plants which, although they are infected by a disease, have lower losses in yield and quality than other plants of the same species.

The work on virus yellows breeding started in 1944, but the first few years were not very encouraging. However, we improved our techniques and methods, and since 1950 we get satisfactory results. In those later years, all our breeding research work has been carried out under supervision of our pathologist, Dr. J. A. Hijner.

A problem with virus yellows under our conditions is that we never get all our plants in the field infected at the same time when we leave it to nature. This is due to the behavior of the vector (aphids) . It is necessary to get all plants infected in the same stage, as the stage of development of the plant at the moment of infection has great influence on the development of symptoms and on the final level of losses.

To overcome this trouble two methods were available:

1. Artificial infection with aphids in the greenhouse.
2. Artificial infection with aphids in the field.

Experiments showed us that greenhouse work was not sufficient. Under our conditions of light, humidity, etc., it is very difficult to get clear symptoms on all plants. Therefore, we abandoned the greenhouse-infection tests and relied fully upon the field work.

The plants to be tested are sown in square blocks, each containing 2,000-2,400 plants. These blocks are surrounded by a double row of oats to separate them from the farmer's field and from the other blocks. These rows of oats prevent the spreading of virus from our plots to neighboring beet fields. We have those plots always on the same farm, not far from Bergen op Zoom, and the fact that the farmer (Mr. A. Vos, Vinkenbroek, Roosendaal) is still fully cooperative shows that he has not suffered too much from the virus reservoir we build on his farm every summer.

Early *in* June all plants have to be infected with virus-carrying aphids. We keep our stock of virus in greenhouse plants infected with a known mixture of virulent strains, while the aphids are wintered over on sprouting tulips and in spring are put on the beet plants. We never use field plants as a source of infection, as then the virus strain is not sufficiently known and other viruses may also be present.

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All plants are infected on the same day. This certainly takes a lot of work, but we manage to get it done by sending out a whole group of our staff. The weather has to be chosen carefully. By preference we do this on a calm and dry day. In this way we practically always get a 100 percent infection. After a few days the plants are sprayed with an insecticide to kill the aphids.

As soon as symptoms appear on each plant, the total number of leaves and the number of yellow leaves is counted. This is repeated several times during the season. Also, the general aspect of each strain of beets in the experiment is described at regular intervals. In cases of doubt, symptoms are checked by means of the serological reaction.

The best plants are chosen as mother plants for single plant progenies. Weight, sugar content, noxious nitrogen and ash content are analyzed for each strain or progeny.

Even with this careful study, mistakes can be made, one of the main reasons we have found being the fact that there is no direct correlation between the intensity of the yellow color of the leaves and the losses in yield.

The progress we have made since 1948 is illustrated in Table 1. In this table M 17 is one of our inbreds highly susceptible to virus yellows. A, B and G are our best commercial varieties, while the others are our own inbred lines.

Table 1.

	Root weight per beet gms.	Sucrose %	Noxious N	Virus yellows (10 = green, 1 = total yellow)
M 17	226	15.07	51	3½
A	340	14.90	63	3½
B	326	15.15	69	3
C	346	14.60	47	3
76	372	15.42	48	7
94	475	13.85	53	7½
96	446	14.78	57	7
107	485	15.18	50	7
166	433	15.00	48	6½

These figures give some indication that, by breeding, plants can be obtained which suffer less from virus yellows. We have selected in this table a few numbers at random but could add quite a few other strains to this list.

Not much is known about the inheritance of this tolerance, but there are indications that this is a complex problem.

Another interesting phenomenon is that in our infection plots the plants suffering badly from virus yellows often are attacked heavily by Cercospora, even strains which in virus-free conditions are not very susceptible to this disease.

For sugar beet eelworm tolerance breeding there are at least two possibilities. With virus yellows no immune plants have been found, but the wild species *Beta patellaris, B. procumbens* and *B. Webbiana* are im-

mune to beet eelworm and we should try to introduce this immunity in commercial beets. On the other hand, the possibility should not be overlooked that variations in susceptibility might be found in our normal beet varieties.

Numerous crossings were made between sugar beet and the three wild species mentioned above. Although thousands of viable seeds were obtained, the seedlings mostly died *in* or shortly after the cotyledon stage. The same difficulty has already been described by Dewey Stewart (1) [2]. Various treatments were tried on the seedlings, but without success. Finally in 1952 Hijner succeeded in grafting the young seedlings on stems of *B. procumbens.* Some died, some survived and started growth. One plant formed several flowering branches in 1953. The cross had been made with a male sterile sugar beet and the flowers of the F_1 also proved to be male sterile. Although this plant was pollinated with various types of pollen, no viable seed was formed.

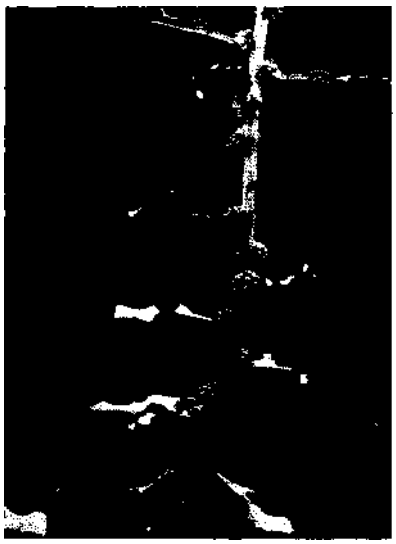

Figure 1.—Sugar beet x B. Webbiana, flowers on F_1 plant.

The leaves of this plant are more or less intermediate between sugar beet and B. Webbiana. The flowers more or less are formed in clusters and not as single flowers as in the wild parent.

[2] Numbers in parentheses refer to literature cited.

Other graftings have been made in 1953 and several of these are growing vigorously, but have not yet reached the flowering stage.

We will continue this work and hope others will do the same, as introduction of immunity would be the best solution of the nematode problem. Under an immune crop the nematode population gradually dies, while under a tolerant crop the population will remain constant or even build up.

We have, however, not neglected the search for eventual tolerance in commercial beet varieties. Here again the technique to be applied gives difficulties, for in the field, even when there is a heavy infestation, the distribution of cysts is too irregular to get a teliable test for individual plants.

Figure 2.—Sugar beet x B. Webbiana, typical intermediate leafshape of F_1 plants.

Den Ouden, a young collaborator of Dr. Hijncr, now lias worked out a test method which can be used in the greenhouse. First, seedlings are grown in pans with silversand, while to each seed the same number of cysts is added. After 6 weeks all these young plants (several thousand in a few square yards) are carefully taken out of the sand. Those plants on which only a few cysts have been formed are planted again in small pots (2-inch diameter) in sandy soil and cysts added for a second time. After 6-8 weeks the development of cysts on the roots is checked again and the best plants then are planted in large pots, **again with** cysts. Per **10,000**

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plants tested, 6-10 plants are left after passing the third test. Those are used for producing single plant progenies which come into the test again. The outcome of this work is not yet clear, for apart from the number of cysts on the roots, other factors have to be taken into consideration also.

This method seems to be cumbersome, especially as enormous quantities of cysts of good quality have to be stocked. But it has the great advantage that in a short time large numbers of plants can be tested under conditions which guarantee an equal chance of infection for each individual plant.

Further improvements of this system are in development and will be applied in 1954.

Literature Cited

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1950. Sugarbeet X Beta procumbens, the F, and backcross generations. Proc. Amer. Soc. Sugar Beet Tech. pp. 176-179.