

CYTOGENETICS OF *NICOTIANA TABACUM* VAR. *VIRII* RESISTANT TO THE COMMON TOBACCO MOSAIC VIRUS*

DONTCHO KOSTOFF

(Central Agricultural Research Institute, Sofia, Bulgaria.)

THE cytogenetics of plant forms obtained from interspecific and intergeneric crosses is of great significance in evolutionary and plant-breeding problems. Unfortunately very few of such crosses have been studied thoroughly. I have made such studies in the crop plant genera *Triticum*, *Secale*, *Nicotiana*, etc., and wish to deal here with the inheritance of a physiological character for virus resistance in *Nicotiana*.

The work was started with the aim of producing form of *Nicotiana tabacum* resistant to the common tobacco mosaic virus. This was to be secured by interspecific hybridisation of *N. tabacum* with a species which resists the virus, by producing localised necrotic reaction, and deriving from the hybrid a resistant tobacco plant with $2N = 48$ chromosomes. The expectation was that gene or genes causing resistance could be transferred to chromosomes of *N. tabacum*. This was accomplished in two ways. Firstly by crossing two hybrids, (a) *N. rustica* RL \times *N. tabacum* Basma and (b) amphidiploid *N. glutinosa-tabacum*, and the F_1 of this cross, was back-crossed to *N. tabacum* twice and selections selfed for homozygosity. Secondly, *N. tabacum* was repeatedly back-crossed to the amphidiploid, *N. glutinosa-tabacum*, and again selections selfed for homozygosity. Virus-resistant tobacco plants thus produced were called var. *virii*².

N. glutinosa and a particular variety of *N. rustica* used in the crosses, show resistance to virus by localisation of virus around the source of infection. In all *N. tabacum* varieties, and in other varieties of *N. rustica* the virus spreads and kills the plants.

In this and other wide crosses, detailed cytogenetical analysis is essential to learn the evolutionary and plant-breeding value of the crosses.

In the present instance the cytogenetic problem can be stated in the following terms. The dominant gene which restricts the spread of the virus (here termed *Vr*) has been transferred from another species to *N. tabacum*. Has the transfer been accomplished by transfer of a segment of a chromosome or by addition or substitution of an entire chromosome? The latter alternative means that in the resistant plant there are 23 pairs of *N. tabacum* chromosomes and one pair of foreign chromosomes (*glutinosa* or *rustica*) or even possibly 24 pairs of *N. tabacum* and one pair of foreign chromosome (designated *Nch*) making a total $2N \approx 50$. This last possibility, that is production of a stable form, with an additional chromosome pair of another species, was first suggested by the Russian worker M. Ternovsky³ in 1935 and again by Gerstel⁴ in 1946.

The present investigation supports the explanation given first. Our conclusion is, that resistant plants are usually produced by the cross-

over of a segment of chromosome *Nch*, containing gene for resistance to *N. tabacum* chromosomes. Gerstel studying Holmes' material and his own material assumes the other possibility, namely entire *Nch* chromosomes has been substituted or added. He had at hand my statement upon this problem, but did not consider it.

The cytological observations supporting the explanation offered is therefore important. Primary evidence is this. My observation is that in an interspecific cross, two to six chromosomes of *N. glutinosa* conjugate frequently with those of *N. tabacum*, contradictory to the observations of some other investigators. It is evident that conditions under which the F_1 develops influences the degree of chromosome conjugation. Occurrence of conjugation is responsible to a great extent for the inconstancy in the amphidiploid *glutinosa-tabacum*, which was shown by Muntzing.⁵ Gerstel holds the view that "the transfer of genes from one species to another is impossible, because of failure of chromosomes to conjugate and to cross over in the hybrid," and also that there is lack of homology between the chromosomes concerned. However, Gerstel's view that a substitution of homologous chromosomes can occur, contradicts his own arguments, and supports the present observation.

The meiotic stages in hybrids between the virus resistant tobacco, *N. tabacum virii*, with closely related susceptible varieties of tobacco have been studied by me, and supports my interpretation. Two examples are given here. In the F_1 hybrids of *N. tabacum virii* 'alba' and *N. t.* 'Nevrocop Basma' the complete regular pairing was observed in 108 P.M.C. and only in 7 P.M.C. did 23 pairs and two univalents appear. In the F_1 of another cross *N. t. virii* 'alba' with *N. t.* Serska Basma regular pairing was seen in 84 P.M.C. and univalents only in 4 P.M.C. These data show that in the majority of the cases, the chromosome carrying the dominant gene *Vr* for virus resistance, conjugates readily with its pure *N. tabacum* partner. Only in a few cases (7.4% and 4.8%) the conjugation fails, which can be accounted for by the non homologous segment carrying *Vr* gene. These data can be interpreted by assuming that the chromosome segment controlling virus resistance has been transferred from one species to another, by cross-over in the interspecific cross. In other words we have a transfer of an important physiological character from one species to the background of another, preserving the chromosome number and homology of the economic species. This factor facilitates further breeding work, i.e., the transfer of the resistance gene to any other economic variety. Cytogenetic work appears here as distinctly separated from plant-breeding work. On the one hand study of cytogenetics

This Article by Dr. Kostoff which is likely to be of interest to all plant breeders, has been altered from its original form, the editing having been done to make it conform to accepted standard of English diction and idiom.—(Editor's note)

of species and their hybrids gives a background for accomplishing the transfer of a desirable gene or gene-complex from one species to another, preserving the genom of the latter plant. At this stage cytogenetic work ends and the plant-breeding work begins, using the derived form for transferring the new characteristic to such economic varieties, as desired, for different localities and purposes.

A synthetic species alike to *N. tabacum* was produced by me^{6,7} in 1936, using two genoms of *N. silvestris*, and two genoms of *N. tomentosiformis* and similar work has been done by Greenleaf⁹ in 1941. Stebbins⁸ gives the data, but gives priority to Greenleaf, however. This data, and observations in other *Nicotiana* species hybrids, done by me, show the chromosome homologies in the different species. In *glutinosa* × *silvestris* 1-5 bivalents, in *glutinosa* × *tomentosiformis* 5-8 bivalents and in *glutinosa* × *tabacum* 2-6 bivalents are formed frequently. This behaviour suggests possibilities in breeding by transfer of a segment or entire chromosome from one species to another.

Even Gerstel's data are in favour of this conception, as he suggests possibility of a exchange transfer of an entire chromosome.

From plant-breeding point of view, substitutions of an entire chromosome pair from a wild into a cultivated species is not desirable, as the entire chromosome can contribute undesirable characters. In the present work, *N. tabacum* var *virii* enabled me to produce by hybridisation and selection, virus-resistant plants having good yield and excellent quality. It is doubtful if such quality can be obtained if an entire chromosome pair had been substituted.

From evolutionary and plant breeding point of view, chromosome substitution has restricted possibilities in production of new forms, as compared to possibilities by a transfer of a gene or small group of genes. The genomic background of a species is less affected by the transfer of a small portion of a chromosome. In addition, fertility of the new hybrid is not much affected. In plant breeding, such forms can be used to transfer the new character to other varieties. I shall not be surprised if in a short time all cultivated tobacco varieties are corrected in this respect, i.e., all of them made resistant to the common tobacco mosaic virus with the use of *N. t. virii*.

This paper is to show once more that cytogenetics both stimulates the development of other biological sciences and gives a real background for the development of applied sciences—in this case contributing to the production of newer and better crop plant.

Thanks are due to R. Georgieva and D. Tzikov for help throughout this work.

1. Kostoff, D., *Phytopath. Zeitschr.*, 1937, 10, 578-93.
2. Kostoff, D., "Resistant tobacco varieties against mosaic virus experimentally produced, Sofia", 1944.
3. Ternovsky, M., *Zeitschr. f. Zuchtung, Reihe A. Pflanzensuchtung*, 1935, 20, 268-89.
4. Gerstel, D. U., *Genetics*, 1946, 31, 42-427.
5. Muntzing, A., *Hereditas*, 1935, 20, 251-72.
6. Kostoff, D., *Curr. Sci.*, 1936, 4, 872.
7. Kostoff, D., *Compt. Rend. (Doklady) Acad. Sci., USSR*, 1938, 18, 7.
8. Stebbins, G. L., *Advance in Genetics*, 1947, 1, 403-29.
9. Greenleaf, W. H., *Genetics*, 1941, 26, 301-24.
10. Kostoff, D., *Cytogenetics of the Genus Nicotiana, Sofia*, 1941-43, 1-28, 1-1071.

FELLOWSHIPS TO FRENCH GRADUATES

WITH a view to strengthening the cultural bonds between India and France, the Ministry of Education, Government of India, propose to award nine Fellowships to suitable French graduates for research work and teaching in Indian Universities in 1949. This is in response to the interest shown by the French Government in cultivating the study of the Indian languages and literature amongst the French people.

Last year the French Government awarded nine scholarships to Indian students. They have awarded another ten scholarships in the current year. They have also sent out three French students to India to study Hindi and another student is coming shortly to study Sanskrit literature.

The value of the Fellowships to be granted by the Government of India has been fixed at Rs. 500 per month for a period of two years plus the cost of second-class return passage. Each Fellow would be expected to undertake teaching in the French language and literature at an Indian University in addition to his own work. The actual number of Fellowships granted will depend on the response from the Universities.

In a letter addressed to the Vice-Chancellors of Universities in India, the Ministry of Education have proposed that the cost of each Fellowship may be shared equally between the Government of India and the University at which the Fellow will be placed. By this means, the University will secure an efficient tutor of French language and literature at a cost of about Rs. 250 per month and half the share of the passage.

There has been a rapid development of our foreign contacts and there is a growing demand in Indian Universities for instruction in foreign languages. It may even be possible to secure as Fellows French students competent to give instruction in French as well as other European languages.

From the cultural view-point also, it is felt that India should adopt a wider outlook and should take all possible steps to encourage the promotion of reciprocal cultural exchanges with foreign countries.

The Government of India have asked each University to let them know if it would be willing to accept one or two Fellows and would be prepared to meet half the expenses as proposed by the Government.