

## GENETIC STUDIES AT PBGI-NCSCI FROM “LYSENKOISM” TO NOWADAYS

**A.F.STELMAKH, Doctor in Biology**

**Plant Breeding and Genetics Institute – National Center of Seed and Cultivar Investigations**

*30-years period of “Lysenkoism” domination in “Soviet science” started just from PBGI. It was characterized by the negation of chromosomal theory of heredity and accompanied by obstruction of classical genetics supporters. Genetics revival started since late 60<sup>th</sup> with the author direct participation. Over time, the institute became the leading institution in the country again.*

For over 100 years the Institute had to pass intricate way which is described in publications of UAAS academician Lyfenko S.P. [1]. Founded in 1895, Southern Agricultural Company established the Management Committee of Odessa research field in 1912, instructed A.A.Sapegin to start breeding work on March 8<sup>th</sup>. And since that time the history of PBGI as a research institution originated. In 1918 on the basis of breeding department at Odessa research field, Odessa Breeding Station was established, which was reorganized to Ukrainian Genetics and Breeding Institute in 1928 (later – All-Union Plant Breeding and Genetics Institute, and now since Ukraine’s independence – Plant Breeding and Genetics Institute – National Center of Seed and Cultivar Investigations subordinating to NAAS of Ukraine). And the history of genetics department as an independent unit started just with the founding of UGBI, i.e. since 1928.

From the beginning of scientific institution establishment, A.A.Sapegin as one of the greatest scientists of his time realized fully that advances in breeding work were closely related to genetic researches as a basis for developing methods of selection. Already in 1912 he clearly stated that in published books [2, 3]. During all years of breeding work he (later together with his son and a number of employees) was heavily involved in genetic investigations which was confirmed with his separate publications [4]. Experimental work was directed to solving aims of the genetic and cytogenetic analyses, studies of intra- and interspecific wheat crosses, elaboration of backcross method, using X-rays for plant mutagenesis firstly in the world, studying the peculiarities of natural selection in hybrid populations. And in general, this period of the Institute activities was characterized by distinct realization that genetic researches preceded and should be the basis for future breeding achievements (the subsequent history of the Institute confirmed that, despite the explicit rejection of classical genetics).

In 1929 the Institute joined T.D.Lysenko as a senior specialist of physiology department (plant morphology) and the Institute became gradually the center of so-called “Michurin biology” supporters. Opinion differences of Institute director with the “vernalizators” team (as V.Soyfer determined T.D.Lysenko supporters in one of

the books [5]), gradual pressure of regional administrative and party apparatus, personal family troubles coincided with an invitation from N.I.Vavilov and forced to leave Sapegin to Leningrad in 1933. Actual scientific leadership at the Institute moved to Lysenko (in directorship of F.S.Stepanenko), who became later legal director. Experiments with classical genetics were suspended, and all experimental works were reoriented on tracks of “Michurin biology”.

The current generation of young scholars is barely aware of the main features of genetic trend evolution in biological and agricultural sciences during that and following periods. Therefore on the one hand, the main goal of this paper is to provide them with the opportunities to learn at least some basic “Lysenkoism” features for debunking certain myths. On the other hand, it will try to prove how in general the process of overcoming the “Lysenkoism” phenomenon consequences carried out in agricultural institutes.

**Methods.** Along with the analysis of information from some stocks of the literature, personal experience of the author is used first and most in this paper, because in 1968 I was personally engaged as the head of Genetics Department at this Institute with the main objectives: to convince Institute staff in actuality of chromosome theory of heredity and to reorient gradually scientific programs on the way of classical genetics.

**Results.** “Lysenkoism” period of biological science evolution in the country has been repeatedly described by researchers in the Soviet Union and beyond from various perspectives. Among recent publications, there are noted D.Ursu paper [6] and two chapters (pp. 25-43, 56-65) in S.P.Lyfenko book already mentioned [1]. In aggregate, these two publications can give almost complete picture of what happened from home biological sciences and agricultural production for 3 decades. But like most of previous works, each of them separately is not without significant drawbacks. The main defect among them is a subjective approach to the description of the facts: for the first author, it is underestimating (or omission) the main causes of “Lysenkoism” spreading as a phenomenon of the national scale, and for the other, it is the tendency not to focus on the negative.

In my opinion, as a phenomenon in biological science during 30-60<sup>th</sup> years “Lysenkoism” is fully consistent with well-known “Rasputinism” phenomenon at late decline of Russian empire. Lysenko performed the role of Rasputin, and the roles of the tsar and his family advocates played all party and state administrative apparatus headed by I.V.Stalin (and then by N.S.Khrushchov, **i.e. the system!**) together with supporters and followers who “found” false evidences to erroneous ideas. In circumstances of free scientific discussions and objective methodologically flawless experimental testing, “Lysenkoism” phenomenon would not have any reason to rule in science. But only one Stalin’s expression at 1935 Congress of Collective Farmers (“Bravo, comrade Lysenko, bravo!”) was sufficient to eliminate any discussion and critic. The followers of classical genetics were fully implemented to obstruction and mass repressions with the graceful label of “weismanist-morganist”. “Ideological (philosophical) justification of socialist science” was given a foundation to “Michurin biology” which gave machine system a free hand.

The main initial Lysenko’s error was his rejection of chromosome theory of

heredity, denying its material carriers which might be recombined or changed by mutations. Heredity was considered as an integrated feature of an organism that was capable to be directly changed (= “brought up”) under the influence of environmental changes, adequate to the last once. It didn’t require any changes in material structures (which are diverse and non-directional at mutagenesis), didn’t require any selection action, and adaptation “could be immediately formed” under changed environment during “formation” of altered heredity. This main mistake had not only genetic consequences, but it changed also the views on the mechanisms of natural evolution in general.

Meanwhile, all genetic works were suspended at the Institute, studies were performed under the influence of “Michurin biology”. The main focus in the study was “directed” to heredity changes by “bringing up” plants in unusual environment, such as alteration of spring rye, bread and durum wheat, barley and even pea, sunflower, flax into winter-hardy of winter type ones and vice versa. There were also introduced studies of “intravarietal crossing effects”, “vegetative hybridization” by grafting or transplanting embryos of one species on the endosperm of the same or another species as well. And it was interesting and tragic that in the works on “bringing up” of spring crops into winter ones by sowing them in the fall “vernalizators” got the “desired” result not only in the Institute, but also in many other institutions of the country. Sometime, similar experiments with “heredity bringing up” acquires anecdotal form, such as breeding increase of sunflower seed oil content by irrigation of experimental plots with sunflower oil! The readers can find descriptions of such comedies and tragedies in the literature, and we get to the facts of when and how this orgy was stopped and the revival of classical genetics started.

At the end of 1964 N.S.Khrushchov was eliminated from the country’s leadership and relevant Resolutions and Decisions to overcome the lag in biological science were soon adopted. At the All-Union seminar of genetics teachers the new program of genetics course was developed in February-March 1965. It was compulsory for all higher education institutions and this process began next semester. Nevertheless, in the research institutes of biological and agricultural profile similar transition was carried slowly through the inertia of their long-term working plans, lack of appropriate qualified staff, and sometimes also through resistance etc. In PBGI genetics revival started partly already in 1966.

Along with some personnel changes in the genetics department there were initiated certain cytological work, chemical mutagenesis studies and others. However, the main research directions remained, like “heredity education” and “vegetative hybridization” (including “plant homogenates injection into immature grains of peas”). And the radical purposeful work for improving academic plans and implementation of genetic techniques began almost in 1969 after the appointment of a new head of genetics department from Byelorussian genetic school N.V.Turbin. Whose primary tasks were to increase the general genetic literacy of Institute employees and to transfer researches into genetic framework [7].

Within 3 years, lectures on general genetics course were given in PBGI and Odessa agricultural institute, for graduate students and other staff specialized seminars were conducted, discussions were submitted on contemporary scientific

issues. Meanwhile, in order to convince PBGI scientists of chromosomal theory of heredity being in accordance with the truth, researches on wheat aneuploidy were started by graduate students of the genetic department, when under a microscope everybody could see the absence of separate chromosome in specific lines, and in the field plots that effect could be accompanied by the absence or alteration of some traits. And it was convincingly! One of such type works with aneuploid lines was postgraduate's topic on monosomic analyses of genetic control for diversity in spectra of endosperm storage proteins. This work contributed to transferring researches of grain quality lab on a genetic bases, developing and spreading the biochemical genetics field (more exactly, the genetics of biochemical markers and traits). And later that lab grew in the department of genetic bases of breeding, which is currently headed by (after A.A.Sozinov and F.A.Poperelya) postgraduate student and now Doctor of Biological Sciences A.I.Rybalka.

Works with "converting spring crops into winter ones" were not terminated but subjected to testing in methodological perfect experiment: genetic homogeneity of the initial material (disomic descendants of spring monosomic lines which were maintained for decades with artificial isolation), minimization (and taking into account the intensity) of the selection accompanied with the protection from negative temperatures, pedigree analysis of each descendant etc. That work was performed by A.I.Sinkevich as a scientist from the same school of N.V.Turbin. And within 3 years of such "heredity education" significant "alterations" were not received! However, it was shown that such extreme "unusual" environment could act as a mutagenic factor (by the test of reverse *waxy* mutation in barley), but the frequency of that mutations were sufficiently lower than "autumnization" ones stated by "vernalizators". And another important fact: wheat introduction from other regions or sowing it at inappropriate environment led to a significant increase of open flowering, which increased the opportunity of cross-pollination. Since sown in the fall spring wheat lines flowered at the same time with the ordinary winter stocks (which was usually sown close by), segregation of winter descendants as a result of such spontaneous hybridization didn't not surprise in the absence of artificial isolation. That was confirmed by analysis of storage proteins spectra in 10 samples of the so-called Mironovskaya spring which were developed in different regions "through alteration" of winter Mironovskaya 808: in each of them the presence of separate protein blocks were revealed, which were usual for winter wheat cultivars of those regions. So the major causes of "getting results in alteration" could be heterogeneous initial material, and/or increased possibility for cross-pollination (note: even during typical spring wheat stocks with non-allelic dominant *Vrn* genes to be crossed, winter descendants segregated in the following generations [8]), and mutagenesis with a minimal probability only.

That work initiated further studies on genetic diversity of growth habit (winter / spring) and rate of development of wheat. It should be noted here, that in terms of plant physiology Lysenko's position on the theory of phasic development (although he was not a pioneer of vernalization and photosensitivity properties) was mostly correct and not denied until now. After receiving from A.T.Pugsley (Australia) the seed stocks of 5 isogenic by *Vrn* genes Triple Dirk lines the works in that direction

were broadly developed, and aimed later also on *Ppd* (photosensitivity), *Vrd* (vernalization requirement duration) and *Eps* (earliness *per se*) genetic systems. Those works were widely published [9], known in the world, and are continued now in identifying effects of mentioned genes on economically valuable traits (including the levels of winter hardiness and frost resistance).

At that time analogous studies of the causes and mechanisms of genetic variation after “injection” were instructed to postgraduate S.F. Lukyanyuk (again, a graduate of Department of genetics in Minsk). First of all it was shown that the frequencies of chromosomal aberrations and rearrangements (as mutagenic factor) increased significantly after “injection”. However the frequency of marker trait “directed transfers” from donor to recipient was found to be significantly higher. And after fractionation of homogenates on carbohydrate, protein and nucleic fractions and putting them into recipient seeds separately, such effect was detected in the variant with nucleic fraction only. That fact served as an additional justification for organizing special Molecular Biology lab (by Yu.M.Syvolap who had just returned from Bonner’s training in the USA) which became later the leading Biotech Agricultural Center in Ukraine.

Further work on the “injections” stimulated the idea of transferring research from the level of intact organisms to the level of cell culture *in vitro*. And after training in IPP of AS USSR, Lukyanyuk started to work on that direction (meristem culture, regeneration, suspension culture, selection *in vitro*, haploproduction *etc.*). Over time the special biotechnology lab was organized in the department, which had become one of the best Ukrainian institutions of agricultural profile. After premature death of S.F.Lukyanyuk that lab was headed by her companion (doctor of Biology S.A.Ignatova).

By that way, overcoming the consequences of “Lysenkoism” started in the Institute. Meanwhile, other research areas were deployed in the department. More detailed information is covered in summarizing paper devoted to 100<sup>th</sup> anniversary of the Institute [10]. Here are just some directions of such studies. Among them not last place were occupied with works on studying the causes and mechanisms of cytoplasmic male sterility of different types used in breeding for heterosis in many crops, and the identification of specific diagnostic marker traits of sterilizing cytoplasm. Researches on cytogenetics of wheat and their alien hybrids were gradually expanded for introgression of remote genes and creation of primary and secondary triticales. Various sets of alloplasmic, isogenic, recombinant inbred and marker lines were created for genetic analysis and molecular marker development.

In general, the Institute became a leading genetics and breeding establishment on the territory of all the USSR once again. Since 1971, he was the main center directing the State scientific and technical program on the theoretical basis of plant breeding in the country (and later in the independent Ukraine after the USSR collapse) and the Coordinating Center of international scientific cooperation on the theoretical basis of cereal breeding in the CMEA countries. Institute reached its peak in the second half of the 80<sup>th</sup> of the last century. For example, at that time 17-18 scientists were employed at the department of genetics with a total staff over 50 people (and over 1200 workers in the Institute).

Unfortunately, the situation with plant genetics changed significantly not only in our Institute, but in all state institutions during Ukraine's independence (financial constraints, staff reductions with eliminating theoretical studies in the first turn). From the 90<sup>th</sup> beginning, the number of institutions cooperating in the State program on theoretical basis of plant breeding decreased gradually each 5 years from 32 to 23, 11, 7, and 6, respectively. Yet even nowadays, PBGI retains its breeding and theoretical potential keeping its scientific schools on developmental genetics, biochemical genetics, resistance genetics, biotechnology and molecular genetics.

And at present in the department, the main directions of genetic studies are:

- search for new genetic systems associated with the adaptive response control in wheat, and study the allele effects of known systems as components or markers of complex frost resistance trait;
- molecular marker technology development for identification and selection of genotypes carrying certain genes (alleles) of qualitative or quantitative traits;
- studying the cytogenetic mechanisms of chromosome fragments and remote traits inheritance during alien introgression into wheat genome;
- introduction of new initial material of cereals and forming basic and character collections.

**Conclusions.** Institute founder A.A.Sapegin realized clearly the role of genetic studies for plant breeding. Since joining the Institute T.D.Lysenko, a period of “Michurin biology” (= “Lysenkoism” or “Rasputinism in biology”) came in the “Soviet science” under strong pressure from the whole country administrative and party apparatus. All the theses of chromosomal theory of heredity were rejected, it was considered a property of the whole organism without any material carriers and being able “to be grown up” adequately under variable environment. Every supporter of classical genetics was exposed to obstruction and harassments. In the late 60<sup>th</sup> genetic direction revival started in the Institute with the direct participation of the author. To convince the employees that chromosomal theory of heredity was in accordance with the truth, the researches of wheat aneuploidy were started (along with lectures, seminars, presentations). The works on “heredity alteration” and “vegetative hybridization” were verified in methodologically correct experiments. All those led to the development of new fields of genetic studies such as genetics of growth habit, grain quality genetics (biochemical genetics), cell and tissue culture *in vitro*, and even molecular genetics. And the Institute became again the leading center among the agricultural institutes, it functioned as State Coordinator on the theoretical basis of plant breeding and Coordinating Center of scientific cooperation within the CMEA countries. During the years of Ukraine independence, the number of institutions cooperating theoretic program reduced sufficiently, nevertheless the Institute tried to keep all scientific schools.

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**Стельмах А.Ф.**

***Генетические исследования СГИ-НЦСС от «лысенкоизма» до настоящего времени.***

*Период 30-летнего господства «лысенкоизма» в «советской науке» начинался именно со СГИ. Для него были характерными отрицание хромосомной теории наследственности и преследования сторонников классической генетики. Возрождение генетики началось с конца 60-х годов при непосредственном участии автора. И со временем институт вновь стал ведущим научным учреждением страны.*

***Ключевые слова:*** Сапегинский период, «лысенкоизм», возрождение генетики, современное состояние.

**Stelmakh A.F.**

***Genetic studies at PBGI-NCSCI from “lysenkoism” to nowadays.***

*30-years period of “lysenkoism” domination in “Soviet science” started just from PBGI. It was characterized by the negation of chromosomal theory of heredity and pursuit of classical genetics supporters. Genetics revival started since late 60-th with the author direct participation. In course of time, the institute became the leading institution in the country again.*

***Key words:*** Sapegin’s period, “lysenkoism”, genetics revival, modern state.