Mark B. Tauger September 2014

Retrospective for Yale Agrarian Studies

This paper briefly presents the development of my ideas about Soviet agriculture and the famine of 1931-1933 and some of the issues that this research has raised. It omits my work on India and world agriculture, which I would be happy to discuss.

The standard view sees Soviet collectivization as a policy of exploitation, a view based on certain Marxist theories and a very selective use of evidence. The standard view also holds that the famine of the early 1930s was the result of collectivization. A related interpretation views the famine as genocide aimed against allegedly rebellious nationalists.

My research has shown that the famine resulted from drought, plant disease and pest infestations that caused two years of crop failures. I argue that this famine has to be understood in a broader context of earlier famines and Soviet agricultural sciences. I showed that the famines of the 1920s, not mentioned in previous studies, led Soviet leaders to resort to collectivization to restructure Soviet agriculture on the model of American mechanized farming, as an attempt to overcome its vulnerability to environmental disasters.

Another important context is the history of Soviet agricultural sciences. The literature is split over the ability of Trofim Lysenko to distort Soviet biological research. Some studies focus on Lysenko's victims such as N. I. Vavilov and overstate Lysenko's impact; others show that many scientists evaded his domination. The case of Pavel Luk'ianenko shows that there were scientists in the USSR who witnessed the famine, understood its environmental causes, and worked to improve Soviet agriculture to prevent these disasters despite Lysenko.

My research challenges the widely-held and publicized interpretation of the 1933 famine as a man-made famine that the Soviet regime allegedly imposed on Ukraine and other regions like Kazakhstan, to suppress political opposition or for other reasons. My work shows that these arguments usually misuse evidence, avoid contrary evidence, and misrepresent or ignore alternative interpretations.

I am working now on a project on the history of Russian and Soviet famines that addresses their causes, the relief efforts to deal with them, and the interpretations of them. I will discuss scientific attempts to explain and devise methods to avert them, include Luk'ianenko's work.

1. My work in this field began with my dissertation:

Commune to Kolkhoz: Soviet Collectivization and the Transformation of Communal Peasant Farming, 1930-1941. PhD dissertation, UCLA, 1991.

In this I was strongly influenced by James Scott's work on the "moral economy" and the arguments about peasant resistance. In working on this dissertation, however, I increasingly found the evidence for resistance to be isolated cases and not representative, and I also found other more concrete forms of evidence that suggested a different interpretation.

The key insight was in my first article:

2. "The 1932 Harvest and the Famine of 1933." *Slavic Review*, v. 50 no. 1, Spring 1991, 70-89. Exchanges with Robert Conquest on this article, *Slavic Review*, v. 51 no. 1, Spring 1992, 192-194; v. 53 no. 1, Spring 1994, 318-319.

This article presented the data from the kolkhoz annual reports, which were final harvest data and showed that the 1932 harvest was much smaller than indicated in the official harvest statistics. It discussed evidence that the famine affected large areas of the country, cities as well as rural areas, and concludes that the famine was the result of serious crop failures. The main work to which I responded in this article was Robert Conquest's *Harvest of Sorrow*, and my debates with him were published in *Slavic Review* as listed here.

As a result of this work Robert Davies, a well-known British historian of the USSR whom I met while doing dissertation research in the UK, invited me to participate in two projects, which resulted in the following articles:

3. "Soviet Grain Stocks and the Famine of 1932-1933," coauthored with R. W. Davies and S. G. Wheatcroft, *Slavic Review* v. 54 no. 3, Fall 1995, 642-657.
Republished in Christopher Read, *The Stalin Years*, London: Palgrave-MacMillan, 2003.

4. "Narkomzem SSSR and Economic Decision-Making in the 1930s." Chapter in E. A. Rees and R. W. Davies, eds., *Soviet Economic Decision-Making in the 1930s*, London: MacMillan, 1997, 150-175.

The grain stocks article documented that the Soviet regime accumulated grain stocks during 1932 and then distributed them as famine relief in 1933. It was a response to an unpublished paper by a Russian scholar that claimed that the USSR had large stocks that it withheld, which turned out not to be true.

The Narkomzem article discusses the policies of the Soviet agricultural commissariat during the 1930s, and some of the agricultural policies it implemented. At this point neither I nor any other historians knew about Luk'ianenko.

During my research for these articles in Moscow, I came across much other evidence that challenged components of the traditional interpretation of the 1931-1933 famine and Soviet agricultural history. My work with this evidence resulted in the following publications.

5. "Grain Crisis or Famine? The Ukrainian State Commission for Aid to Crop Failure Victims and the Ukrainian Famine of 1928-1929," in D. J. Raleigh, ed., *Provincial Landscapes: Local Dimensions of Soviet Power* (Pittsburgh: University of Pittsburgh Press, 2001).

This article documented the previously unknown famine of 1928-1929 in Soviet Ukraine, the Soviet relief effort for this famine, and some Soviet leaders' responses to it. This article also discussed the similarly overlooked 1924 famine, which affected Ukraine and the rest of the USSR, and for which the regime also provided relief using imported food.

6. *Statistical Falsification in the Soviet Union: A Comparative Case Study of Projections, Biases, and Trust*, The Donald W. Treadgold Papers in Russian, East European, and Central Asian Studies (Seattle: University of Washington, 2001), no. 34. 81pp.

This paper explained the differences between the official harvest statistics of 1932 and the much smaller harvests reported in the kolkhoz annual reports. It showed that the official data were forecasts, and were therefore different in kind and much less reliable as an indication of the causes of the famine than the annual reports, which the collective and state farms were required to submit every year.

7. *Natural Disaster and Human Actions in the Soviet Famine of 1931-1933*, The Carl Beck Papers in Russian & East European Studies (Pittsburgh: REES, University of Pittsburgh, 2001), no. 1506. 63pp.

This paper, based on my first paper for the Yale Agrarian Studies series, documented the environmental factors that reduced the 1932 harvest, especially the 1932 rust infestation, and argued that these factors were more important than labor, lack of draft forces or other factors in causing the crop failure and the famine. Previous historical studies never mentioned most of the environmental factors I discussed, which were based on Soviet, European, and American scientific studies and data.

8. "Soviet Peasants and Collectivization, 1930-1939: Resistance and Adaptation," *Journal of Peasant Studies*, v. 31 nos 3-4, April/July 2004, 427-546.
Republished in Stephen Wegren, ed., *Rural Adaptation in Russia*, New York: Routledge, 2005.

This article returned to the issue of peasant resistance that I had studied in my dissertation. It critical evaluated the idea of a "resistance interpretation," showing some of the problems in the data for that interpretation. It placed that evidence in a broader perspective that took into account a more comprehensive range of actions of peasants in the USSR in the 1930s. The article showed that peasant resistance was a much less common pattern than adaptation to the new system, and cannot be seen as a major cause of the system's problems.

9. "Stalin, Soviet Agriculture, and Collectivization," in *Food and Conflict in Europe in the Age of the Two World Wars*, ed. Frank Trentmann and Fleming Just, New York: Palgrave Macmillan, 2006, 109-142.

This article drew out the implications of my 2001 study of the 1928-1929 Ukrainian famine for the standard view of collectivization as a means to exploit peasants and facilitate "procurement" of food from villages. The economist James Millar questioned this view in the 1970s by showing that the regime invested more in collective agriculture than it extracted from it. My article argued that these larger expenditures were not accidental, as Millar thought, but intentional. I argued that the famines, famine relief and imports of the 1920s, and the weaknesses of Soviet agriculture (which neither the standard view nor Millar even mentioned), convinced Soviet leaders that Soviet farming was vulnerable to disasters because it was outdated and primitive. The leaders decided to restructure Soviet farming based on U.S. mechanized farming, which they saw as the most advanced farming system at the time. They began with a program of mechanized state farms in 1928 as a test project for collectivization.

10. "Modernization in Soviet Agriculture," in *Modernisation and Russian Society since 1900*, ed. Markku Kangaspuro and Jeremy Smith, Helsinki: SKS, 2006.

In this article I critiqued some widely-held negative views about Soviet agriculture by comparing certain aspects of Soviet agriculture to similar patterns in Western capitalist agriculture. This comparison also included a discussion of collectivization in light of Western farming.

11. "Famine in Russian History," *The Supplement to the Modern Encyclopedia of Russian and Soviet History*, v. 10 (Gulf Breeze, Florida: Academic International Press, 2011), 79-92.

This encyclopedia article was a first attempt to work out my idea of viewing Soviet famines in light of the long history of famine, famine relief, and views of famine in Russian history.

My ideas also developed in several so far unpublished papers on the 1924 famine, on American influences on Russian and Soviet agricultural scientists, and on Vavilov and Luk'ianenko.

Because my research challenged established views associated with Cold War anticommunism, some referees attacked my papers in reviewing them for publication, and some editors demanded I change them to conform to the old views. Three times my articles were rejected, but other journals or series always accepted them. A few scholars dealt with my work in ways that constituted academic malfeasance. I published one article about a particularly egregious case:

11. "Arguing from Errors: On Certain Issues in Robert Davies' and Stephen Wheatcroft's Analysis of the 1932 Soviet Grain Harvest and the Great Soviet Famine of 1931-1933," *Europe-Asia Studies* v. 58 no. 6, September 2006, 973-984.

Another case involves the Yale historian Timothy Snyder, who revived the old views of collectivization as exploitation and the 1933 famine as genocide in his recent book *Bloodlands*. Snyder asserted (on p. 41-42) that during the famine of 1932-1933, Stalin did not reduce exports and did not provide famine relief. He cited as evidence the article (number 3 above) on Soviet grain stocks. In fact our article documented (pp. 652-653) that the Soviet government reduced exports and distributed millions of tons of grain as famine relief. I had documented these points in my other articles, dating back to 1991. Snyder stated at the honorary Callahan Lecture at West Virginia University in February 2012 that he had read "everything" I wrote.

Snyder also asserted (on p. 395) that Stalin allowed grain exports in order to make a "profit," citing no evidence. My 1991 article, which Snyder asserted that he read, cited archival sources that the Soviet regime had fallen behind in paying its foreign debts and faced extremely punitive actions from foreign countries. According to German Chancellor Bruening, "their credit would be destroyed for good and all" if they did pay their foreign currency debts.

Most of these points are also documented in easily available sources. For example, the *Wall Street Journal* reported on 10 December 1932, p. 10, that the Soviets had cancelled grain exports to all but one of its foreign purchasers. Snyder's bibliography included other publications that documented famine relief in 1933. Robert Conquest's *Harvest of Sorrow*, a key book for the Holodomor interpretation, admits that Soviet famine relief ended the famine in a few months. He did not cite any of these publications in his book.

Snyder's claims that the USSR maintained large exports and withheld reserves are central to his book's argument, which views the 1933 famine as essentially the same as the Holocaust. If the regime reduced exports and distributed millions of tons of food from reserves as famine relief, then the image of the Soviet man-made famine is not correct. The Nazis in World War II obviously did not send millions of tons of food relief to alleviate conditions in the concentration camps. The famine affected most of the country, including 40 million people in towns dependent on a rationing system, which also distinguishes the Soviet case from the Holocaust.

Soviet leaders made bad decisions that worsened the famine, but the regime also provided relief and helped peasants produce a larger harvest that ended the famine. Their actions continued relief programs that date back to the 1920s and the Tsarist regime. Here is what one Ukrainian reader wrote to me about my 2001 article on the 1928-1929 famine in Ukraine.

"I was reading the first article you sent me on the way home and I'm glad you mention those famines in the late 20s because it seems that insofar as we can trust the evidence from that era, it creates a serious problem for those who would claim that the famine was "man-made" or "engineered". Obviously they made some mistakes in 31-32 in terms of policies, but it doesn't make sense that they would enact so many relief measures during several consecutive famines, only to start deliberately starving the same people shortly after."

Snyder explicitly told me that he read this article, but did not mention it or the 1928 Ukrainian famine in his book or his talk.

Overall, my work has brought to light an environmental and agrarian history that the older literature on Soviet collectivization has omitted. I think it is essential for anyone writing about agrarian topics to address this research, rather than ignore it in order to make a political point.

“Pavel Pantelimonovich Luk’ianenko and the Origins of the Soviet Green Revolution”

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Forthcoming in a collection of articles from the Second International Workshop on Lysenkoism, Vienna, Austria, June 2012.

INTRODUCTION:

The idea of a “Soviet Green Revolution” seems almost inconceivable: according to almost all scholarly and popular publications, the Stalinist policy of collectivization devastated Soviet agriculture, and the pseudoscientist Trofim Lysenko, supported by Stalin and Khrushchev, similarly destroyed Soviet genetics. Recent studies, however, have challenged this stereotype about collectivization.[2] This article deals with Soviet genetics and plant breeding, and also contributes to a revised view of collectivization, by describing and contextualizing the hybrid wheat-breeding work of Soviet scientist Pavel Panteleimonovich Luk’ianenko at the Krasnodar agricultural research institute in the Kuban region. Luk’ianenko and his associates -created wheat varieties resistant to several of the environmental threats that had long caused crop failures and famines in Kuban and elsewhere in the USSR. These varieties included semidwarf high-yielding varieties [HYV] of wheat - such as Bezostaia-1 - which achieved international recognition for their high quality.

Luk’ianenko’s work, which continued the work of the great Soviet biologist Nikolai Vavilov and was clearly on the forefront of world applied genetics, took place in the USSR during the peak period of Lysenko's power. This Soviet breeding program began before the plant breeding work of Norman Borlaug in northwest Mexico that was later called the "Green Revolution," and continued contemporaneously with it. The Soviet program had the same objectives, employed the same basic breeding methods based on standard genetic principles, and used many of the same sources of plant germplasm, including hybrid dwarf and semi-dwarf wheats from Japan, Italy, Argentina and the USSR. The concurrence of Lysenko's dominance and Luk'ianenko's initiation of a Green Revolution in the USSR, absent from the historical literature except for a single brief reference in one publication, raises important questions about the conventional interpretation of Lysenkoism and Soviet agriculture.[3]

This article outlines the main components of the Green Revolution outside the USSR, and describes and analyzes the main Russian and Soviet research that laid the basis for similar developments in the USSR. It then discusses the limits of Lysenko's attempts to stop Soviet genetics research: it was possible for an innovator to emerge despite Lysenko's administrative position and his efforts to control Soviet research in genetics and agricultural sciences. Finally, it reviews Luk'ianenko's work and discusses important issues that this history raises.

A. The International Green revolution

The usual story of the Green Revolution focuses on plant scientists from the United States.[4] According to this story, Mexican officials asked the Rockefeller Foundation for aid in 1942, after infestations of rust, a major fungal plant disease of wheat, devastated wheat crops and greatly reduced harvests three years in a row. The Foundation financed a group of scientists who began a research program in Mexico to breed wheat resistant to disease and drought. One of these scientists, Norman Borlaug, set up an experiment station in Ciudad Obregón in northwest Mexico, and in the 1950s introduced into its breeding program the partly Japanese dwarf wheat Norin 10. By the early 1960s, Borlaug's group had bred semi-dwarf high-yielding varieties [HYV] that produced much higher yields when used with a "package" of fertilizer, pesticides, and irrigation. These varieties inherited from Japanese wheat one or more "reduced height genes" (Rht), which caused the plants to grow short but very thick and sturdy straw much less likely to "lodge" or collapse.[5] This crucial phenotype transformed these plants into high-yielding varieties because it allowed farmers to use more fertilizer, so the plants could develop a larger ear of grain containing more and heavier seed without the risk that lodging would destroy the crops. In 1963, the Ciudad Obregón center was renamed the International Center for the Improvement of Maize and Wheat, known by its Spanish acronym CIMMYT.

Borlaug encouraged international exchanges of varieties to develop new ones, and proselytized among world leaders to adopt the high-yielding varieties. After two years of droughts, crop failures, and incipient famine in 1965-1966 in India, Borlaug persuaded Indian politicians to import high yielding varieties of wheat and begin breeding programs. By 1970 India dramatically increased its wheat production. For this success as well as his previous work Borlaug was awarded the Nobel Peace Prize in 1970. In 1971 CIMMYT and other recently formed research centers were unified under the Consultative Group on International Agricultural Research [CGIAR], which now includes 16 agencies working on a wide range of agricultural problems.

This narrative of the Green Revolution is incomplete and slightly misleading because it omits or minimizes plant breeding work done before Borlaug and outside the United States in an international effort to produce higher-yielding crops. A brief review of this earlier history provides the necessary background to Luk'ianenko's work and helps understand his unique contribution.[6] Japanese farmers obtained the short wheat varieties in the 16th century from Korea, where they had been grown since late antiquity.[7] In the 1920s, Japanese breeders crossed a short variety with varieties from the Mediterranean and Russia to produce 18-inch tall Norin-10.[8] Meanwhile, the first European to incorporate Japanese varieties and breed what were in essence the first HYVs was the Italian scientist Nazareno Strampelli (1866-1942).[9] Strampelli set out to breed high-yielding wheat because of Italy's dependence on imported wheat, as in 1904, when crop failures caused shortages in Italy while Argentina, its main source of imports, had an enormous harvest. Strampelli set out to make Italy self-sufficient in wheat years before Mussolini recruited him to lead his "Battle for Wheat" campaign of the 1920s.[10]

Strampelli and his co-workers at his research center in Rieti produced at least 65 new wheat varieties that substantially increased wheat production in Italy between 1900 and World War II. He specifically set out to breed wheat that had short stems to resist lodging, ripened early, and resisted rust, using the Japanese dwarf wheat Akakomughi. Two important results of these crossings were the varieties Ardito and Mentana, released in the 1920s, and used on millions of acres in Italy and elsewhere. In 1923, Strampelli went to Argentina with some of his new varieties and inspired agronomists there to breed new varieties based on the Italian ones. One breeder used Ardito and Mentana in crossings that produced rust resistant semi-dwarf varieties, named Klein 30, 31, and so forth, after the scientist who developed them. Borlaug used Mentana as one of his main breeding varieties in Mexico in the 1940s, and applied the same basic approaches as Strampelli. The work of Strampelli and the other Italian breeders was (as an Italian scholar put it) the 'first example' of the Green Revolution.[11]

As the examples of Italy and Mexico show, the Green Revolution was inspired by chronic low food production, vulnerability to crop failures and dependence on imported food. The efforts to develop new varieties involved cross breeding of diverse domestic and foreign varieties to create new types of wheat with short, sturdy stems to resist lodging and with resistance to plant diseases, severe weather, and other characteristics. These characteristics were necessary to enable these new varieties to produce much higher yields.

B. The Russian Background to the Green Revolution and the work of N. I. Vavilov

The history of plant breeding in Russia and the USSR followed more or less the same pattern as the Green Revolution in the west: it sought the same goals, used many of the same varieties, and anticipated Borlaug's work. Like Mexico and Italy, Russian breeding was also motivated by agricultural crises. The main difference was the interruption of Stalinism and Lysenko, discussed in the next section below.

Russia has a long history of famines: famines occurred in more than 400 of its 1,000 years of Russia's recorded history.[12] Environmental disasters almost always caused these famines: drought or heavy rain, extreme cold or heat, lodging from heavy rains or excessive plant growth, weeds, pests, and blights (plant diseases). Russians, from peasants to scientists, tried to alleviate and prevent these famines through rituals, food imports, elaborate relief systems, and use of resistant varieties of wheat and other crops. Some varieties were relatively resistant to certain environmental threats, such as the drought-resistant "Turkey Red," as well as other varieties that Mennonite immigrants from Russia and Mark Carleton of the USDA brought back to the United States in the 19th century.[13] But severe and complex environmental disasters continued to cause crop failures and famines in Russia into the 20th century.

From the 18th century, Russian nobles, scientists and officials established agricultural experimental stations in part to create new varieties of grains and other crops.[14] The number of stations and the competence of their personnel grew as biological knowledge expanded, and as the regime freed the serfs and founded the zemstvos, rural self-government agencies. Repeated famines, especially the 1891 famine in the Volga region, motivated the government to expand this network of experiment stations and other institutions for agricultural research and education. The trained personnel working in these institutions were educated in Western biological sciences, studied the research done in Western Europe and the U.S., and traveled there to observe farms and farming methods.

These efforts to create new famine-resistant crop varieties included searching for unknown wild and cultivated crop varieties with resistance to environmental threats in Russia and in other countries. The most important Soviet scientist to undertake this phyto-geographical research was Nikolai Ivanovich Vavilov.[16] From early on in his work, including both his dissertation and his first expedition to Persia in 1916 under commission from the Russian government, Vavilov repeatedly dealt with insect infestations and crop diseases and searched widely to find resistant varieties.[17] Vavilov's expedition to Persia became the first of six large plant-prospecting expeditions in his career, followed by exploratory trips to the Mediterranean, East Africa, Afghanistan, East Asia, and the Americas. During 1923-1940, Vavilov and his associates went on 180 expeditions, 140 in the USSR and 40 abroad. By 1940, they had collected more than 250,000 plant varieties, and produced several substantial publications on plant resources in different world regions.[18] The plant and seed collections were stockpiled at a central government research institute dedicated to collecting plant varieties and plant breeding that underwent reorganizations and name changes until it became the All-Union Institute of Plant Production (VIR) in 1930s. Vavilov headed this agency from 1920 until 1940.[19] These collections, which Vavilov called the "world collection," comprised the first Russian large-scale stockpile of landraces (local native varieties) of many crops and their wild relatives in Russia and abroad, and included hybrid varieties created by plant scientists in many countries. In plant collecting, as in other areas, Russia and the early USSR lagged behind the major European powers and the United States. These efforts by Vavilov and his colleagues at VIR helped the USSR to catch up with Western countries in this area of plant research.[20] Their work also laid the basis for the Soviet Green Revolution, because later breeders used many varieties that Vavilov collected to create Soviet HYVs.

In 1920-1921, while Vavilov was establishing VIR, the USSR endured two extensive crop failures from drought and other environmental factors, exacerbated by the disruption of the Soviet civil war. The result was the largest famine in Russian history up to that time. Soviet leader V. I. Lenin responded by accepting aid from the American Relief Administration under Herbert Hoover, as well as by importing food independently and distributing it through a large

Soviet-run relief program to both rural and urban populations.[21] The Soviet government, specifically the People's Commissariat of Agriculture of the Russian Republic [NKZ RSFSR] also responded to the famine with a large-scale program to breed and introduce new drought-resistant and higher yielding grain varieties. It began with a decree issued by Lenin in June 1921 that ordered the agricultural agencies to compile a register of crop varieties, accumulate a stockpile of "selected seed" - seed of known origin that reliably produce good yields - and to expand the work and network of experimental stations to produce improved seed and crops.

This famine was the first of three major famines that struck the USSR in the 1920s. The vast famine of 1920-1923 encompassed the Volga valley, Ukraine, and certain other regions. In 1924-1925, a milder crop failure impacted the same regions and caused widespread starvation. In response the Soviet government again formed a relief commission, imported food, and fed more than 12 million peasants as well as part of the urban population. In 1928-1929, a major crop failure in Ukraine again required the government to import grain, set up a relief agency and feed hundreds of thousands of starving peasants. This famine was one of the events that pushed the Stalin regime to implement major changes in agricultural policy, including specifically collectivization.[22]

In response to these crises, the Soviet regime intensified its efforts to improve its agriculture scientifically. In 1921, Vavilov went to the U.S. and worked with the USDA to obtain American seed to help Soviet farmers increase their crops in the wake of the famine.[23] In December 1924, another government decision ordered the agricultural and trade commissariats to set aside about 900,000 tons of selected seed as reserves over the next five to ten years, and the complete replacement of all seed used in the USSR with improved varieties. This project turned out to be impossible to achieve in that period. In December 1927, the government prepared a five-year plan for seed production. Finally, in 1929, the regime established a central academy of agricultural sciences, VASKhNiL, headed by Vavilov, to coordinate and advance agricultural research.[24] In its objectives and its management of research institutes in multiple branches of agriculture, though not in its hierarchical and bureaucratic character, VASKhNiL anticipated CGIAR.[25]

The plant-collecting expeditions of Vavilov and his associates in VIR played a central role in expanding Soviet breeding programs. In their expeditions, Vavilov and his colleagues sought not only new varieties, but also clues to the geographical origins of cultivated plants. He believed that these centers of origin would be the most likely places to find diverse and productive varieties. With such varieties Vavilov envisaged a vast project to breed crops so productive and resistant to environmental threats that they could end famine in the USSR.[26] The regime also sent Soviet scientists abroad to obtain plant breeding information and collaborate with leading foreign scientists.[27]

Vavilov also published a small book, *The Scientific Basis of Wheat Breeding,* based on the VIR wheat collection.[28] This book surveyed the main wheat varieties grown in the major producing countries, the improved varieties developed in several of them, as well as various technical aspects of wheat breeding. To draw all these findings together, Vavilov included a chapter on "The Ideal Wheat Variety" that included a long list of characteristics that an ideal variety would have. These included high grain yield and quality, tolerance of drought and other weather threats, stiff straw to reduce lodging, resistance to plant diseases, and awn-less heads—because growing awns, the thin stalks protruding from the grain husk, diverted the plant's energy from growing grain.[29]

Soviet agriculture in the 1920s resembled that of Italy in the 1900s and Mexico in the 1940s. The USSR faced environmental crises that caused crop failures—in the Soviet case a series of famines—and repeatedly resorted to foreign relief and food imports at considerable expense. The USSR established and expanded institutions for agricultural research, recruited scientists and plant breeders, and promoted international collaboration and exchange of information and varieties. Most important, the Soviet government supported Vavilov's efforts to accumulate an extensive collection of plant varieties from around the world to use as a basis for a vast program of plant breeding. Vavilov's guidelines for "the ideal wheat variety" derived from Western as well as Russian and Soviet breeding goals. Soviet agricultural science thus by 1930 had both needs and preparations similar to those in Italy and Mexico, basically the same preconditions for launching a Soviet green revolution.

C. Stalinism and Lysenko

The Stalin regime began forcibly collectivizing peasant farms in 1929. This was in part a highly repressive policy, involving the "dekulakization" (expropriation and exile), and in some cases imprisonment or execution of peasants whom the regime and its personnel (on the basis of a Marxist theory of class struggle) considered to be a threat. This violence and the administrative control that collectivization extended over agriculture led some scholars to view collectivization as a new version of serfdom. Yet in the circumstances of repeated famines, famine relief, and other Soviet agricultural policies, collectivization was first of all part of a broader program to modernize and industrialize Soviet farming.[30] The regime accompanied collectivization with a large program to accelerate the development and impact of the agricultural sciences, including not only the establishment of VASKhNiL, but also of many new experimental stations (1300 existed officially by 1932). The government thus began to implement Vavilov's plans for plant breeding. But Soviet leaders also demanded much faster results than could realistically be expected.[31]

This was the setting for the political rise of Trofim Denisovich Lysenko and his followers.[32] The conventional view is that Lysenko was an incompetent scientist or a pseudo-scientist, possibly a fraud (in the sense that it is uncertain whether he actually believed what he wrote and said), who allegedly caused an unmitigated disaster for Soviet genetics and other branches of biological sciences. First, he and his cronies persecuted competent scientists in many fields of biology on the basis of politicized pseudo-scientific ideas. Many were forced out of their positions, many were imprisoned and ultimately executed, while others were driven to suicide or died in part from the stress of unjustified attacks, interrogations, and threats. Lysenko replaced them with his followers who were at least as incompetent as he was, if not worse.

Next, Lysenko rejected conventional genetics, dismissed any research or ideas from European and American scientists as "bourgeois science," and allegedly prevented Soviet scientists from conducting legitimate research in virtually all areas of biological sciences. He used his powerful position in the Soviet science administration to impose simple-minded, incorrect and often absurd views and approaches in virtually all aspects of biological research and education, until his ouster in 1965. Noël Kingsbury writes in his history of plant breeding: "The impact of Lysenko on plant breeding and other genetically based technologies was devastating. It has even been suggested that Lysenko's influence so damaged Soviet agriculture that it, more than any single factor, led to the demise of Communism."[33] Kingsbury also claims that Soviet genetics lost three decades because of Lysenko. Valerii Soyfer, in his detailed and substantial study of Lysenkoism, similarly describes Lysenko's impact as devastating.[35]

In this discussion I do not seek to minimize the suffering and injustices endured by those whom Lysenko and his followers victimized. Nonetheless, several studies have presented substantial evidence that qualify the impact of Lysenkoism on Soviet scientists and on research in agricultural sciences.

In his impact on scientists, while some victims of Lysenko suffered tremendously, other Soviet scientists and agronomists opposed Lysenko openly without suffering significant consequences, and many others managed to evade his sanctions. Joravsky conducted a prosopographical study of Soviet biologists and agricultural scientists and found that only a small percentage of these scientists were subjected to "repression."[37] Most of Lysenko's opponents were not arrested, though some lost their jobs.[38] Many if not most of the scientists whom Lysenko had removed from posts found work in scientific fields, and some even continued publishing through various subterfuges.[39] Krementsov argued that scientific and political considerations, such as patronage of powerful individuals, protected many biologists and geneticists from dismissal. They often managed to continue their work in conventional genetics by writing research plans in ways that deceived bureaucratic censors. They could publish their work because journals carried brief articles on Lysenkoist themes as camouflage.[40]

A significant literature has also qualified earlier extreme views regarding Lysenko's impact on the ideas and practice of the agricultural sciences. Lysenko's early ideas were not particularly extreme in the context of biological sciences in the late 19th and early 20th centuries. Roll-Hansen showed that many biologists and agricultural scientists, in the USSR and outside, questioned "neo-Darwinian" conceptions of incremental evolution and suspected that environment did play a role in evolution, even if neo-Lamarckism seemed unacceptable to most of them.[41] Vavilov encountered these disputes as a student in the 1890s-1900s.[42] From the 1930s onward, when Lysenko rejected "Western" biology and advocated extreme anti-scientific views, Joravsky, Krementsov, Roll-Hansen, and others document how several scientists and officials resisted his ideas and his politicization of science. Ethan Pollock notes that even Stalin, in a late publication, condemned the "Arakcheev" [dictatorial] practices in science, implied that Soviet scientists should learn from foreign science, and called for open debate.[43] Stalin's essay clearly challenged Lysenko, and gave rise to further challenges. Even while Lysenko was in power, some of his programs failed so visibly that they were openly criticized and reversed, as for example his idea of cluster planting trees (planting saplings close together in groups rather than separately and widely spaced) in the Soviet shelter-belt program of 1949-1952.[44] After Stalin's death, Lysenko and his followers steadily lost power and posts while legitimate geneticists staged a comeback, which implied that many of these scientists and their ideas survived.[45]

Lysenko's dominance thus did not expel all legitimate scientists, stop all legitimate research in Soviet biology, or eliminate opposition to his ideas (much less cause the collapse of the USSR). In order to provide a more specific context for Luk'ianenko's work, the following section presents two concrete examples of these limitations on Lysenko's influence. First, the conflict between Lysenko and Vavilov provides an example of how legitimate scientific ideas could survive such a scientist's death even under Lysenko. Second, Lysenko's pet project of vernalization was not quite as absurd as it is ordinarily portrayed.

Vavilov initially supported Lysenko, who rose from the peasantry, obtained a limited agronomic education, and was championed by the Soviet press for his early research. Vavilov could see Lysenko's ignorance but was impressed by Lysenko's energy and commitment. He also thought that Lysenko's artificial vernalization (see below) could facilitate plant breeding.[50] Initially Lysenko sought and accepted Vavilov's support, but by late 1935, Lysenko came to see Vavilov as an obstacle to his advancement and began a campaign to discredit Vavilov and his associates. Lysenko's sycophantic promises to Stalin to breed new varieties rapidly, even when he failed and pleaded for more time, sounded better to Stalin than Vavilov's cautious but accurate warnings that progress would take time.[51]

After a series of public disputes between Lysenko and Vavilov and their followers, and conspiratorial politics behind the scenes, the government removed Vavilov from the presidency of VASKhNiL in 1936 and appointed Lysenko to the post in 1938. Lysenko attacked Vavilov publicly and behind his back in meetings with Stalin and other leaders. Vavilov defending himself and finally attacked Lysenko in 1939, but by then fewer scientists supported Vavilov while increasingly key politicians, including Stalin, supported Lysenko.[52] In 1940, the NKVD unexpectedly arrested Vavilov while he was on an expedition to western Ukraine, newly acquired under the Molotov-Ribbentrop Pact. The NKVD interrogated him, and the Military Collegium of the Soviet Supreme Court sentenced him to execution. Several leading scientists, including the agrochemist Dmitrii Nikolaevich Prianishnikov, appealed to the Soviet leadership to spare Vavilov. In 1941 NKVD Commissar Lavrentii Beria decided not to execute Vavilov but allow him to continue work as an imprisoned scientist. When the Nazi invaders reached Moscow, Vavilov and many other prisoners were dispatched to the Volga region, where in January 1943 Vavilov died in prison, ironically of starvation.[53]

Yet despite Vavilov's tragic death, Soviet scientists at VIR revived his program of expeditions to find new plant varieties in 1946, despite the Nazi's destruction of some VIR laboratories and fields. From 1946 to 1965, in other words during the period of Lysenko's rise to dominance and his fall from power, the Institute conducted 130 domestic and (from 1954) foreign expeditions, from 1963 often in collaboration with foreign scientists, and its staff members collected some 200,000 more new plant specimens. In addition, the Institute revived in 1952 the practice of geographical plantings, to test varieties from the world collection, that Vavilov had begun in 1923. VIR also revived Vavilov's programs of research and publications on the characteristics and genetics of different categories of plants (with a large book on perennial leguminous grasses in 1950).[55] This incomplete list of VIR's postwar work indicates that enough of Vavilov's colleagues and students survived the peak of Lysenkoism (at least in part by means of the subterfuges discussed above) to maintain VIR's core components, especially its world plant collection, and restore its scientific role along the lines Vavilov had laid out in his two decades of leadership between the wars.

As for vernalization, Lysenko understood the importance of this widespread growth phenomenon in plants but misunderstood its causes. Most grain plants (as well as many other plants) fall into one of two "habit" categories: spring habit and winter habit. A winter habit plant like winter wheat or winter barley, planted in fall, needs a period of cold weather within a certain range of temperature in order to mature and produce flowers and seed the next spring. "Vernalization" is the term for this process. Lysenko first acquired recognition by reporting on his experiments of wetting and cooling winter wheat seeds in early spring to induce them to sprout, and then planting the sprouted seed in spring. They would then, in some cases, flower and produce grain. Strictly speaking, this "technique" should be called "artificial vernalization." European and Russian scientists and even peasants had also discovered this technique and developed a theoretical understanding of it long before Lysenko, and since Lysenko referred to only a small part of this earlier work and only in his first publication on it, his advocacy of this technique as his own represented a kind of plagiarism.[56]

Nonetheless, Lysenko managed to convince the Soviet press and Soviet leaders that this technique was his idea, and that it would greatly benefit agriculture. Because at this phase so little was known about genetics, Lysenko and many other specialists and observers believed that this technique of artificial vernalization actually changed the "inheritance" of the plants and represented an example of the inheritance of acquired characters.[57] Lysenko and his followers thus used artificial vernalization as a justification for their commitment to what they called "Neo-

Lamarckism," which is usually viewed as a mistaken evolutionary theory that preceded Darwin, and that claims that organisms can pass on to their offspring characteristics they acquired during their lives.[58] Lysenko and some of his followers explicitly defended Lamarckism and Neo-Lamarckism at the infamous VASKhNiL conference in July-August 1948.[59]

In fact Lysenkoists misunderstood what they observed. Recent genetics research shows that grain and other plants have specific genes that regulate their responses to changing temperatures and photoperiods, which these studies call VRN genes. Plants have multiple VRN genes and different versions or alleles of them, and their relationships can determine plants' reaction to vernalization.[61] The VRN genes also interact with other genes, making plants' ability to mature with or without a cold spell the result of complex polygenic interactions.[63]

Thus the patterns that Lysenko and others saw in their artificial vernalization experiments were in virtually all cases the result of the plants' genetic potential rather than of any "change" of winter into spring wheat, both because of the complexity of plants' responses to vernalization and because significant genetic changes are rare events.[64] Lysenko's artificially vernalized plants may also have grown because of overlooked environmental conditions that had nothing to do with any change in the plants themselves.[65] Lysenko and his followers thus misinterpreted their experiments by jumping to the conclusion that they had changed what they called the "inheritance" of the plant, when they actually observed variations among individual plants in their genetic make-up, that affected their responsiveness to changing conditions.

Yet Vavilov and other scientists in the USSR saw artificial vernalization as potentially very useful (and initially supported Lysenko, despite his ignorance, for this reason). Vavilov and his colleague Nikolai Maksimov in 1932 both argued that artificial vernalization could help breed plants with shorter growth periods. Vavilov also argued that the technique could allow the use of tropical and subtropical varieties in breeding by allowing crossing of varieties that normally had entirely different growth patterns. In 1933 Vavilov referred to grain varieties from Spain and North Africa that ripened in Saratov experimental plots to assert that the "simple technique of vernalization" allowed southern varieties to produce normal harvests in northern regions where they ordinarily could not ripen. Most notably, in 1934 Vavilov argued that artificial vernalization would facilitate the use of the enormous array of varieties in VIR's world collection in crossings to make new varieties.[68]

Later research and breeding practices have vindicated Vavilov's predictions. Artificial vernalization is used as technique to transfer genetic characteristics between winter and spring crops. At CIMMYT, the Green Revolution center in Ciudad Obregon, Mexico, plant breeders routinely use "vernalization growth chambers" to allow "winter x spring crosses" which allow the transfer of important genetic characteristics between plants of different growth habits.[69] In this case, therefore, the technique that Lysenko advocated was actually legitimate and useful, even though he misunderstood it and caused pointless confusion and worse by imposing his interpretations of these processes on Soviet science.

Lysenko damaged but did not destroy the field of genetics in the USSR. Despite the tragic and unnecessary loss of Vavilov and several other leading scientists, the projects that Vavilov began resumed after the war. Some Lysenkoist ideas resulted from ignorance that would not be overcome for decades even in the west. Lysenko also subscribed to the same goals as the Soviet government and the scientists of the 1920s and before - to increase yields and production and protect the country from famine – even though he claimed that genetics and geneticists could not achieve these goals. It is unclear what Lysenko actually thought: Roll-Hansen describes Lysenko as "sincere in his beliefs" but also refers to his "egotism." He cites a Soviet scientist who knew Lysenko, and described him as a cynic who would "run down everything and everyone who obstructed his purpose."[70] These and other descriptions suggest that Lysenko may have been a sociopath who mercilessly victimized others to advance himself.[71] This also implies that his crank ideas were for him a means to achieve power in science by deceiving Soviet officials. This in turn suggests that scientists who did their work in ways that would not attract his notice, or provoke his fear or hostility, could continue to do legitimate work. At least one scientist managed to do this in a dramatic way.

D. Lukianenko and the Soviet Green Revolution

Pavel Pateleimonovich Luk'ianenko was a Soviet scientist who navigated the shoals of Lysenkoism, and achieved a great deal using conventional genetics-based plant breeding during Lysenko's ascendancy. For the Soviet Green Revolution, he played a role comparable to Strampelli in Italy or Borlaug in the Mexican plant breeding program.

Luk'ianenko was born in stanitsa Ivanovskaia to a Kuban Cossack family in 1901.[73] He farmed, but he also gained basic education before the war. Luk'ianenko endured famine and deprivation during his childhood (including the famine of 1911), and then again during the world war and the civil war. His own and his family's experiences led him to side with the Bolsheviks. He served briefly in the Red Army after the Civil War, and then enrolled in the Kuban agricultural institute in Krasnodar in 1922.

Luk'ianenko decided to become a plant breeder, or *selektsioner*, based on certain early life experiences. When he was an adolescent, a village elder described to him the effects of a plant disease the peasants called 'zakhvat' that blackened wheat stems and allowed the plant to produce only depleted, 'empty' grain. This infestation was stem rust, and this description of it was his first encounter with the plant disease that would be a major focus of his plant breeding work.[74] At the agricultural institute, one of his teachers described the difficult, but potentially very rewarding life of a plant breeder. This career required intelligence, stamina, and persistence, not to mention years of work to produce new varieties.[75] Luk'ianenko was by this time quite familiar with the chronic problems in Kuban farming, including rust and other plant diseases, lodging, drought, and the skepticism and resistance of local peasants to scientific advice. The prospect of creating crop varieties to overcome these problems persuaded him to commit his life to this career in the 1920s.[76] During this period he also married Polina Aleksandrovna, a fellow plant science student, who collaborated with him in this work.[77]

After graduating, the Luk'ianenkos worked at research institutes in the Crimea and Chechnya, and in the late 1930s returned to Kuban.[78] During these years they increasingly focused on developing varieties resistant to rust, lodging, and the extremes of cold and dry weather. The Kuban institute had a variety called 'dvuruchka' that was both a spring and a winter wheat, and was very resistant to cold, but not rust.[79] The Luk'ianenkos' breeding efforts expanded from local varieties to varieties from remote parts of the USSR such as Central Asia, and from abroad, including India, Germany, Canada, the USA and Argentina. They obtained most, if not all, of these varieties from the collections gathered by Vavilov and his personnel at VIR.[80] Aleksandr Fedorchenko, Luk'ianenko's biographer, repeatedly states that Lukianenko knew and greatly respected Vavilov's work.

The Luk'ianenkos' breeding efforts were motivated by their own knowledge of chronic problems of Kuban wheat varieties, but collectivization and the Soviet famine made these problems even more urgent. With farm collectivization, the Soviet government commissioned plant specialists to develop varieties that could withstand machine harvesting. Such varieties should ripen simultaneously and be resistant to lodging and shattering (bursting of the ear and scattering of grain during harvesting), both chronic problems for grain growers in the Kuban and elsewhere in the USSR.

The famine of 1931-1933 also resulted fundamentally from another set of environmental problems with which Luk'ianenko was familiar, but which neither Stalin nor most observers at the time and since have understood. Stalin did admit that crops in many areas of the USSR endured a severe drought in 1931, and Soviet authorities returned procured grain back to regions that suffered from that drought.[81] Yet Stalin in a speech in January 1933 stated that the 1932 harvest was not reduced by a crop failure because there was no major drought in 1932. Based on similar considerations, numerous publications have claimed that the famine was "man-made," or even genocide.[82] In fact, however, the USSR did have serious crop failures in 1932 caused by environmental factors. Agronomists described and analyzed a series of infestation of crop diseases, insects, and rodents. The most significant was a vast and severe infestation of rust. Agronomists estimated that in 1932 rust caused losses of more than seven million tons of grain. In an extremely important study of the rust infestation in the Northern Caucasus in 1932, Luk'ianenko estimated that leaf rust destroyed at least 25 percent of the winter wheat harvest in Kuban alone, the top wheat-growing region in the USSR. The other infestations also caused substantial losses.[83]

This infestation of leaf rust began with the 1931 crop. It was caused by a new race of rust to which almost no local varieties of wheat were resistant. Luk'ianenko, very apprehensive about the effects of this new rust, undertook to find or create wheat that would resist it. He crossed Soviet varieties, especially Ukrainka, with North American varieties including Marquis and Kitchener. Yet this rust strain affected almost all of the 49 different hybrid crosses he was breeding at the Krasnodar experimental station in 1931-1932.[84]

Luk'ianenko and the other agronomists at his institute worked intensively on breeding rust resistant varieties in the wake of the 1931-1933 crises. By 1937, they produced 10,000 tons of hybrid seeds of wheat that were resistant to rust and cold, many of which could be planted both in fall and spring. This seed stockpile may have been a factor in the large harvest of 1937. These plant breeders also continued to focus on short-stemmed varieties to prevent lodging, with larger consequences a few years later.[85]

World War II disrupted this work when the Nazi invaders reached the Northern Caucasus. Luk'ianenko and his wife and staff had to pack up their main materials very rapidly and flee the invaders. In the process the Luk'ianenkos lost one of their children, a son, captured and killed by the Nazis in 1943. They also had to transport substantial amounts of grain, mostly hybrids they had produced over the previous decade, avoiding Nazi ground attacks and bombing raids, and then maintain their stocks while in evacuation in Central Asia. Polina Aleksandrovna was mostly responsible for this work, which resembles the story of the workers at VIR in Leningrad who starved rather than eating the grain that Vavilov's expeditions had brought to the USSR.[86]

Upon the staff's return to the Krasnodar station in 1944, Luk'ianenko and his wife and associates resumed the projects of developing rust and cold resistant crop varieties. They also conducted many experiments in planting winter wheats in spring and spring wheats in fall. These projects apparently reflected the influence of Lysenko, but also the limited understanding of genetics and the uncertainties about the effects of environment on inheritance that Roll-Hansen showed were prevalent at that time. According to Luk'ianenko's biographer, the breeder performed these experiments to find "universal" wheat varieties that could be planted both in fall and spring, with the goal of having high-yielding spring varieties that could replant winter wheat fields destroyed by winterkill. They also continued cross breeding Soviet and foreign varieties, including U.S. and Argentine varieties, resulting in an early-ripening variety, Skorospel'ka, that could yield four tons per hectare, which was three to four time the normal yield of the time. By this time Luk'ianenko had compiled a list of 26 characteristics of the ideal wheat variety, perhaps influenced by Vavilov's list of characteristics of an ideal variety in his book on wheat breeding.[87]

The most important result of the station's breeding efforts was Bezostaia-1, a semidwarf variety that has repeatedly been recognized as one of the best winter wheat varieties ever produced.[88] Bezostaia means 'awnless,' and there was at least one natural awnless variety of wheat found in the 1920s in the Northern Caucasus. This may have been involved in the development of Bezostaia-1.[89] The breeding steps that led to this variety began in 1935 when Polina Aleksandrovna crossed Kanred-Fulcaster, an American variety, with Klein-33. Klein-33 was hybrid wheat from Argentina that derived partly from Spanish rust-resistant varieties and partly from Ardito, one of the short-stemmed varieties produced by Strampelli in the 1910s and 1920s using Japanese dwarf wheat.

Polina Aleksandrovna had to quit this work in 1952 because of her health, but in 1953 the original crossing produced Bezostaia-4, which was a semidwarf variety 110 cm tall, resistant to lodging, rust, and cold. The Soviet government authorized use of this variety in 1955, and by 1957 it was planted on 350,000 hectares. Meanwhile, Luk'ianenko and his staff had crossed this with other types of wheat and came up with an even better variety, which they first called Bezostaia-4/1, and later changed to Bezostaia-1. This variety had higher yields than Bezostaia-4, was rust and cold resistant, and had very good plasticity, which mean that it was a good basic variety for crossbreeding. According to a Hungarian scientist, many later crossings would have been impossible without Bezostaia-1 as a basis.[90]

Luk'ianenko predicted early on that Bezostaia-1 could become the main wheat type for the Northern Caucasus. It grew a heavier head of grain than previous varieties, but because it was a dwarf variety with a sturdy stem, even when mature the plant stood straight up like a broom.

This made it highly resistant to even the heaviest rain and strongest wind, and very easy to harvest with low losses. Usually mature wheat in Kuban stood bowed over and had a strong tendency to fall over into the ground, or lodge, which could cause large harvest losses. Farms growing Bezostaia-1 obtained harvests routinely double the size of harvests from earlier varieties, up to six metric tons per hectare.[91] This yield is in the order of magnitude of the highest yields achieved in Mexico at the peak of the Green Revolution in the 1990s. Even if this six tons per hectare came only from the best-supplied farms, and the others had yields only half that level, that yield of three tons per hectare was still the average wheat yield in Mexico in the 1960s and 1970s, during the expansion of the Green Revolution there.[92] On the basis of this work, Luk'ianenko was promoted to full KPSS membership without a candidate stage, and also made an active member of the Academy of Sciences.

Bezostaia-1 was planted on large areas: at least 13 million hectares (32 million acres) by the late 1960s in the USSR and Eastern Europe, as well as in Iran, Turkey, and in other arid regions. By 1972, it was reportedly planted on 18 million hectares (45 million acres).[93] Western scientists consistently noted its high yields and plasticity, and recognized Lukianenko as one of the major wheat breeders of the world.[94] At an international meeting on plant breeding organized by Norman Borlaug in 1971, one questioner asked about "the Russian variety which yielded well at high latitudes in Turkey in the international winter wheat trials." Virgil Johnson and Norman Borlaug answered as follows:

V. A. Johnson: This winter wheat, Bezostaia, has been the highest yielding variety in the international winter wheat performance nurseries since the project was established in 1969. It is in a performance class by itself and it has wide adaptability. Morphologically, it is similar to the CIMMYT wheats.

N. E. Borlaug: Although this variety was developed in a local program, it has tremendous yield stability built into it.[95]

Clearly Bezostaia-1 demonstrated that Soviet wheat breeding could reach the highest western scientific standards. Perhaps the nearest comparison among Green Revolution varieties was the "Miracle Rice" IR8, bred by Henry Beachell and his co-workers at the International Rice Research Institute [IRRI], and widely distributed throughout Asia.[96]

Connections between the Soviet and Mexican breeding programs grew, and scientists from Mexico visited the Krasnodar institute.[98] In 1971, after Borlaug was awarded the Nobel Prize, *Literaturnaia Gazeta* asked Luk'ianenko to write about the Green Revolution, and Luk'ianenko praised Borlaug as an inexhaustible worker and organizer.[99] Lukianenko met Johnson at an international conference in Turkey in 1972. In February 1973, Borlaug wrote Luk'ianenko, apologizing for missing the Turkey conference, and invited him to CIMMYT, but Luk'ianenko's heart condition prevented him from travelling. Luk'ianenko died in June from a heart attack while traveling around fields in Kuban to observe the growth of new wheat varieties.[100]

E. Luk'ianenko, Lysenkoism, and Soviet genetics.

Certainly Lysenko and his associates harmed many legitimate Soviet scientists and misled Soviet biology students for several decades. In this discussion I do not intend to minimize these losses.

Yet clearly Luk'ianenko's work was not "thirty years behind" the leading western workers in applied genetics.

Luk'ianenko and his associates at the Krasnodar institute bred semidwarf HYVs of wheat in the late 1940s and 1950s, at the peak of Lysenko's dominance, to create varieties that would be resistant to diseases, to extreme weather conditions, and to lodging. These were all the same objectives that Borlaug and his associates pursued in their work in Mexico at the same time or later, using some of the same source varieties as Luk'ianenko and his group, including Strampelli's from Italy and Klein's from Argentina. Luk'ianenko's work was based on established concepts of genetics and inheritance. None of the Western specialists refer to him or his work in a negative way or as compromised by Lysenkoism. Luk'ianenko clearly saw his work as part of an international effort. He consistently used varieties from outside the USSR in his breeding, seeking new genetic material from them. His publication on the rust infestation of 1932 had a title page and section and table headings in English as well as Russian. Perhaps this was routine for agronomic publications at the time, but it seems also to reflect a desire to make this information available to western researchers.

Where was Lysenko in all of this? Luk'ianenko's biographer repeatedly wrote that Luk'ianenko greatly respected Vavilov's work, and did not mention Lysenko at all. In 1989, however, five years after the publication of that biography, the Soviet journal *Molodaia Gvardiia* published a long interview with I. A. Benediktov, Minister of Agriculture from Stalin to Khrushchev (1938-1958).[101] In this interview (about halfway through), Benediktov responded to a question about Lysenko as a charlatan in part by saying: "A dedicated student of Lysenko, who esteemed him to the end of his days, was Pavel Panteleimonovich Luk'ianenko, who was perhaps our most talented and productive *selektsioner*…" Benediktov named several of the wheat varieties that Luk'ianenko created, and also some bred by Lysenko, and added: "however one may criticize Lysenko, the cropland of our country to this day has dominant agricultural crops introduced by his students and people who sided with him." Soyfer, a critic of Soviet agricultural policy, in a one-paragraph biography of Luk'ianenko in his book on Lysenkoism, wrote that Luk'ianenko "[R]ose to high administrative position in agricultural science by toadying to Lysenko, but then left administrative work to take up wheat selection in earnest."[102]

At this point I cannot document directly Luk'ianenko's attitude toward Lysenko, and sources for determining his attitude may not exist. Yet according to Fedorchenko's biography, Luk'ianenko spent virtually his entire career in Krasnodar (he seems to have been absent only during the war), and worked "in earnest" on wheat breeding also throughout his career. Luk'ianenko's crucial study of the 1932 rust infestation in the North Caucasus cites works by Vavilov, Artur Iachevskii, one of the founders of Russian and Soviet plant pathology, and L. F. Rusakov, another leading plant pathologist, but no publications or ideas from Lysenko.[103] The breeding of Bezostaia-1 began in 1935, before Lysenko had reached any significant position of control in Soviet science.

Perhaps something of Luk'ianenko's attitude to Lysenko can be inferred from the two articles he published in Lysenko's journals: one in *Iarovizatsiia* in 1941, after Lysenko had taken over VASKhNiL, the other in *Agrobiologiia* in1948, at the peak of Lysenko's dominance.

The earlier article, "On the methodology of breeding winter wheat varieties resistant to leaf rust," examined how rust resistance in wheat varied in relation to environmental conditions. The article cited American studies and its research data employed American varieties, which Lysenko would not have favored. In the article's last paragraph, discussing the process of selecting a new variety for larger-scale testing, Luk'ianenko wrote the only reference in the whole article to Lysenko: "At the same time we use the intravarietal crossing by means of castration and wind pollination proposed by Academician T. D. Lysenko."[104] This referred to one of Lysenko's irrational schemes to use open-air pollination instead of the controlled breeding that Luk'ianenko and other scientific breeders used. Luk'ianenko followed this with the last sentence of the article that referred to "maximum selectivity in fertilization" to preserve resistance, completely the opposite of Lysenko's method. It appears that Luk'ianenko cited Lysenko in this minimal, perfunctory and dismissive way because he had to for some reason, perhaps as a polite gesture to Lysenko in return for publishing the article. Lysenko's approach was not an important part of Luk'ianenko's research, if he even used it at all; the article did not cite or list any publication or research by Lysenko. This article was clearly not the work of a "devoted student of Lysenko."

The title of the second article, "Changing the nature of varieties of winter and spring wheat by means of changing the conditions of the process of vernalization," appeared to follow Lysenko's theories because it refers to a neo-Lamarckian approach of changing these plants' "nature" through inheritance of acquired characteristics from artificial vernalization.[106] In this article Luk'ianenko discussed the results of experiments in planting winter wheat in spring and vice versa, which as noted above was one of the experiments that Lysenko misinterpreted. In passing Luk'ianenko even referred to Lysenko's interpretation of "destabilized heredity." Yet this article also honestly and clearly reported how most of these experiments either failed or had limited success. More important, most of the article was oriented toward Luk'ianenko's main project of finding varieties resistant to rust and other threats, with multiple tables detailing the extent of rust resistance of every different spring-planted winter variety line. While this article seemed to accept, at least implicitly, Lysenkoist claims such as "destabilized heredity" and the idea that planting winter wheat in spring "changed the nature of the variety," which were still plausible given the limited development of genetics at that time, it also presented (as typical for Luk'ianenko) much straightforward evidence on disease resistance that had practical application for planting and breeding. It should be noted that agronomists in other countries have also crossed winter and spring wheat and planted wheat varieties in the wrong season to find varieties resistant to cold spells in spring and unusually mild winters.[107]

Luk'ianenko may have cited Lysenko as "protective coloration," as Douglas Weiner described loyal statements conservationists made to distract the Soviet regime from their real values and motives.[108] Perhaps whenever he had to deal with Lysenko or his associates, Luk'ianenko played the role of a dedicated follower, and thereby misled Benediktov. In his work, however, he remained in Krasnodar, some 1200 km from Moscow, and did his research his own way. Luk'ianenko's 1948 article can also be seen as an example of the scientific manipulation and evasion of Lysenkoism described by Krementsov. Luk'ianenko's article is in part "Lysenkoist" research, but it presents its evidence honestly, and contains potentially useful data from additional experiments that were Luk'ianenko's own focus, and not strictly speaking "Lysenkoist" in orientation. Luk'ianenko's article, from this perspective, was a "pseudo-

Lysenkoist" article, written with sufficient scholarly integrity to imply relatively clearly to an alert reader that a Lysenkoist approach was inadequate.

E. Conclusions

The work of Luk'ianenko and certain other grain breeders led to an explosion of research on HYVs in Russia from the 1960s onward, as well as substantial genetics research and greatly improved education that began even before Lysenko's removal from power. These topics, however, lie outside the scope of this article.[109] This study of Luk'ianenko challenges the prevailing view that Lysenko held back Soviet genetics for a generation. While certainly during the heyday of Lysenkoism, the Soviet regime victimized many excellent Soviet geneticists and wasted money and time on fraudulent Lysenkoists' "research," many other scientists conducted valid, substantial, and important work—particularly in the area of plant breeding. Luk'ianenko was not the only agricultural scientist who did such research in these years, but his work had more national and international significance than that of any other Soviet agricultural scientist in this period.

This work differed greatly from the conventional view of scientific research in the time of Lysenko: Luk'ianenko's work began before Lysenko's rise and continued despite his dominance. Luk'ianenko's work relied substantially on plant varieties from outside the USSR, in many cases brought into the USSR through the work of Nikolai Vavilov. He also relied on conventional principles of genetics, including the guidelines for plant breeding published by Vavilov, as well as some breeding theories and techniques from outside the USSR. In particular he and his co-workers independently sought and achieved the same goals as the Italians around Strampelli in the early 20th century and Borlaug in the Green Revolution of the 1950s-1960s.

Luk'ianenko's work during Lysenko's time and afterwards produced several extremely important wheat varieties that had the same characteristics as the Green Revolution varieties created by Borlaug. Luk'ianenko's Bezostaia-1, a semi-dwarf rust resistant HYV earned the highest praise from European and American breeders including Borlaug as one of the best of the HYVs. This finding thus goes beyond even Krementsov's points about scientists' evasion of Lysenko. The work of Luk'ianenko and his colleagues, more than simply continuing previous genetics-based work in plant breeding, achieved breakthroughs that put it at the forefront of world wheat breeding, both in their methods and their results. Because of the accomplishments of Luk'ianenko and his co-workers in Krasnodar, a post-Soviet Russian symposium on breeding of wheat and triticale commemorating Lukianenko was entitled "The Green Revolution of P. P. Luk'ianenko."[111] Thus despite Lysenko, Soviet agronomists and agriculture thus participated in the international Green Revolution under Lysenko's dominance as well as afterwards.

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[2] See especially Mark Tauger, "Stalin, Soviet Agriculture, and Collectivization," in Trentmann and Just, eds., *Food and Conflict in Europe in the Age of the Two World Wars*, New York and Basingstoke: Palgrave MacMillan, 2006, 109-242, and Mark Tauger, "Modernization in Soviet Agricuture," in Kangaspuro and Smith, eds., *Modernization in Russia since 1900*, Helsinki: Finnish Literature Society, 84-103. Both of these can be read at the website: http://history.wvu.edu/faculty/current-faculty/mark-b-tauger/soviet-agriculture-and-famines .

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[3] Valerii Soyfer, *Lysenko and the Tragedy of Soviet Science* (Camden: Rutgers University Press, 1994), has a one-paragraph somewhat inaccurate biography of Luk'ianenko in an appendix (p. 306) containing brief biographies of historical figures in the history of Lysenkoism. In particular, Soyfer describes Luk'ianenko as "He could well be placed in the category of people who laid the foundations of the 'green revolution,' which so greatly increased crop yields." Luk'ianenko did more than lay the foundations for the Green Revolution, as will be discussed below.

[4] This discussion relies on John Perkins, *Geopolitics and the Green Revolution* (New York, 1997), Lennard Bickel, *Facing Starvation* (New York, 1974), and Susan Dworkin, *The Viking in the Wheat Field* (New York, 2009). My focus here is on wheat; the pattern for the Green Revolution in rice was similar, but involved the International Rice Research Institute [IRRI] and the work of the American rice breeder Henry Beachell.

[5] Katarina Borojevic, Ksenija Borojevic, "The Transfer and History of "Reduced Height Genes" (Rht) in Wheat from Japan to Europe," Journal of Heredity 2005(96)4:455-459.

[6] The excellent popularized history by Susan Dworkin does discuss part of this earlier history.

[7] Borojevic and Borojevic, "The Transfer and History of "Reduced Height Genes" (Rht) in Wheat from Japan to Europe," 455.

[8] Dworkin, *Viking*, 38-39.

[9] Gian Tommaso Scarascio Mugnozza, "The contribution of Italian wheat geneticists: From Nazareno Strampelli to Francesco D'Amato," in R. Tuberosa et al., eds., *Proceedings of the International Congress: "In the wake of the Double Helix: From the Green Revolution to the Gene Revolution," May 2003*, Bologna, Italy: Avenue Media, 2005; Borojevic and Borojevic, "The Transfer and History of "Reduced Height Genes" (Rht) in Wheat from Japan to Europe," 455.

[10] Roberto Lorenzetti, *Wheat Science: The Green Revolution of Nazareno Strampelli* (Rome: Journal of Genetics and Breeding, 2000), 120-122. On Strampelli, plant breeding, and fascist agrarian policies, see Tiago Saraiva, "Fascist Landscapes: Geneticists, Wheat, and the Landscapes of Fascism in Italy and Portugal," *Historical Studies in the Natural Sciences*, v. 40, no. 4, Fall 2010, 457-498.

[11] Lorenzetti, *Wheat Science*, 112ff.

[12] Mark Tauger, "Famine in Russian History," *The Supplement to the Modern Encyclopedia of Russian and Soviet History* [SMERSH] v. 10 (2011), 79-92.

[13] Tauger, *Agriculture in World History* (London: Routledge, 2011), 103.

[14] A recent excellent study is Ol'ga Elina, *Ot Tsarkikh sadov do Sovetskikh polei: Istoriia sel'skokhoziaistvennykh opytnykh ucherzhdenii XVIII-20-e gody XX veka*, 2 vols., Moscow: Russian Academy of Sciences, 2008.

[16] On Vavilov, see Peter Pringle, *The Murder of Nikolai Vavilov*, New York: Simon and Schuster, 2008, and numerous Russian-language studies and sources, some to be cited below.

[17] Soyfer, *Lysenko and the Tragedy*, 44-48, and Vavilov, *The Origin, Variation, Immunity and Breeding of Cultivated Plants: Selected Writings of N. I. Vavilov*, translated by K. Starr Chester (Waltham: Chronica Botanica, 1949).

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[18] S. R. Mikulinskii, ed., *Nikolai Ivanovich Vavilov: ocherki, vospominaniia, materialy*, Moscow: Nauka, 1987, 39. The publications include: S. M. Bukasov, *Vozdelyvaemye rasteniia Meksiki, Gvatemaly i Kolumbii*. Leningrad: Institute Rastenievodstva, 1930, 553 pp.; N. I. Vavilov, D. D. Bukinich, *Zemledel' cheskii Afghanista. Agricultural Afghanistan. Sostavlen po materialam ekspeditsii Gos. in-ta opytnoi agronomii i Vses. in-ta prikladnoi botaniki v Afghanistan*, Leningrad: Institute Rastenievodstva, 1929 610 pp. ; N. I. Vavilov, *Pshenitsy Abissinii i ikh polozhenie v obshchei sisteme pshenits : K poznaniiu 28 khromozomnoi gruppy kul'turnykh pshenits*, 236 pp. Leningrad : Institut Rastenievodstva, 1931.

[19] E. I. Kolchinksii, A. A. Fedotova, Naiuchyi Sankt-Peterburg: Biologiia v Sankt-Peterburge, 1703-2008: entsiklopedicheskii slovar', St. Peterburg, Russia: Nestor-Istoriia, 2011, 83, 114. The compilers are both historians at the Institute of History of Natural Sciences and Technology of the St. Petersburg branch of the Russian Academy of Sciences.

[20] See Lucile Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens*, New York: Academic Press, 1979, and Richard A. Walker, *The Conquest of Bread: 150 Years of Agribusiness in California*, New York: New Press, 2004, p. 111.

[21] Tauger, "Famine of 1921-1922," *Encyclopedia of Russian History*, edited by James Millar; E. M. Khenkin, *Ocherki istorii bor'by sovetskogo gosudarstvo c golodom* (1921-1922), Krasnoiarsk 1988.

[22] See Tauger, "Grain crisis or famine?" in Raleigh, ed., *Provincial Landscapes: Local Dimensions of Soviet Power*, Pittsburgh: University of Pittsburgh Press, 2001; Tauger, "Stalin, Soviet Agriculture and Collectivization," in Frank Trentmann, Fleming Just, eds., *Food and Conflict in Europe in the Age of the two World Wars*, Basingstoke, Palgrave MacMillan, 2006, and Tauger, *Natural Disaster and Human Action in the Soviet Famine of 1931-1933*, Carl Beck Papers, Pittsburgh: REES, 2001. These are available at my website: http://history.wvu.edu/faculty_staff/current_faculty/dr_mark_tauger

[23] Vavilov, *Polevye Kul'tury Iugo-Vostoka* (Petrograd: Novaia Derevnia, 1922), 7.

[24] S. K. Chaianov et al., *Opytnoe delo Narodnogo Komissariata Zemledeliia RSFSR: rezultaty, organizatsiia, programmy i plan na 1927-28-1931-1932 gg.* , Moscow: Novaia Derevnia, 1929, 13ff.

[25] On VASKhNiL's 35 subordinate institutes that resembled CGIAR, and on its bureaucratic character, see Nils Roll-Hansen, *The Lysenko Effect* (Amherst, New York: Humanity Books, 2005), 77-78, 90.

[26] Pringle, *Murder*, 167; Vavilov, *Polevye Kul'tury*, 9-10.

[27] Pringle, *Murder*, describes Vavilov's frequent travels to Europe and the US for collaboration, often with other Soviet scientists. These scientists often published articles and books about their travels and collaborative work; one article by the Soviet drought specialist N. M. Tulaikov on the huge Tom Campbell farm in Montana persuaded Stalin that large scale farming, and hence collectivization, was possible; Tauger, "Stalin, Soviet Agriculture, and Collectivization," 129.

[28] Vavilov, *Origin, Variation, Immunity and Breeding*, 170-314.

[29] Vavilov, *Origin, Variation, Immunity and Breeding*, 257-258.

[30] On dekulakization, see N. A. Ivnitskii, *Kollektivizatsiia I raskulachivanie* (Moscow, 1994); on collectivization as "serfdom," see Sheila Fitzpatrick, *Stalin's Peasants* (New York: Oxford University Press, 1994); on collectivization as part of a larger modernization program, see Tauger, "Stalin, Soviet Agriculture, and Collectivization," and idem., "Modernization in Soviet Agriculture."

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[31] Joravsky, *Lysenko Affair*, 77.

[32] My main sources include Soyfer, *Lysenko and the Tragedy*; Krementsov, Soviet Science (Princeton: Princeton University Press, 1997); Roll-Hansen, *Lysenko Effect*; Ethan Pollock, *Stalin and the Soviet Science Wars* (Princeton: Princeton University Press, 2006); Joravsky, *Lysenko Affair*,; Zhores Medvedev, *The Rise and Fall of T. D. Lysenko*, New York: 1969; Pringle, *Murder*.

[33] Noël Kingsbury, *Hybrid: The History and Science of Plant Breeding* (Chicago, University of Chicago Press, 2009), 209.

[35] Soyfer, *Lysenko and the Tragedy*, xviii, 5-7, passim.

[37] Joravsky, *Lysenko Affair*, appendix.

[38] Joravksy, *Lysenko Affair*, 112-130.

[39] Professor Steve McCluskey, personal communication, based on graduate work with Loren Graham.

[40] Krementsov, *Stalinist Science*, 239-253.

[41] Roll-Hansen, *Lysenko Effect*, 22-24. Neo-Lamarckism refers to theories alleging the inheritance of acquired characters.

[42] Pringle, *Murder*, 26-28.

[43] See Ethan Pollock, "From Partiinost' to Nauchnost' and Not Quite Back Again," Slavic Review v. 68 no. 1, Spring 2009.

[44] Joravsky, among others, narrates the main examples of Lysenko's projects. See Soyfer *Lysenko and the Tragedy of Soviet Science*, 208-209 and 341 fn. 12 on the public exposure and rejection of cluster-planting.

[45] See Soyfer, *Lysenko and the Tragedy*, ch. 13-15, for a survey of Lysenko's decline.

[50] See Soyfer, *Lysenko and the Tragedy*, 53-59, and Roll-Hansen, *Lysenko Effect*, 56-58, 94-95, 135-137, 160-163.

[51] See Soyfer, *Lysenko and the Tragedy*, 135, for Vavilov's last meeting with Stalin, and in general his chapters 8-9 for Lysenko's attack on Vavilov. According to this source, it seems clear that Stalin was exasperated with Vavilov's attempt to explain rationally the inevitable lag in plant breeding, and Soyfer documents repeatedly Lysenko's slavish promises to Stalin of fast work.

[52] Pringle, *Murder* , 155-156; Soyfer, *Lysenko and the Tragedy*, 134-140, Roll-Hansen, *Lysenko Effect*, 254.

[53] Mark Popovsky, *The Vavilov Affair*, Hamdon, Connecticut: Archon, 1984, 165-178; Pringle, *Murder of Nikolai Vavilov*, 266-279.

[55] I. G. Loskutov, *Vavilov and his institute: A history of the world collection of plant genetic resources in Russia* (Rome: IPGRI, 1999), 117, 119, 124, 127, 130. The book is: *Kul'turnaia flora SSSR. Mnogoletnye bobovye travy* (Moscow & Leningrad, 1950), 526 pages.

[56] See Soyfer, *Lysenko and the Tragedy*, 12-20, Roll-Hansen, *Lysenko Effect*, 29-32, 55-57.

[57] For example Lysenko described the results of an experiment in planting winter wheat in spring in 1936 and 1937, in which the spring-planted varieties produced very few maturing plants in 1936 and even fewer in 1937, as having changed the plants' heredity. Lysenko, "Heredity and its Variability," in Lysenko, *Agrobiology* (Moscow, 1954), 427-428.

[58] Roll-Hansen explains Lysenko's commitment neo-Lamarckism and the viewpoint that environmental events could change plants' heredity, *Lysenko Effect*, 165-173. Apparently the concept of Lamarckism, especially as opposed to "Darwinism," is a myth, since such views were very widespread at least in the 19th century, and even Darwin accepted some of them. See Roll-Hansen, *Lysenko Effect*, 22-24, and Michael Ghiselin, Research Fellow at the California Academy of Sciences, "The Imaginary Lamarck," *The Textbook Letter*, September/October 1994, online at: http://www.textbookleague.org/54marck.htm

[59] Lysenko's speech is in *The situation in biological science; proceedings of the Lenin Academic of Agriucltural Sciences of the USSR* (Moscow, 1948), and is available online: http://www.marxists.org/reference/archive/lysenko/works/1940s/report.htm.

[61] Winter habit can result from an epistasis or interaction of vernalization or VRN genes at different loci in the genome. The VRN-1a gene has two alleles, for spring habit and winter habit, and the spring habit allele is dominant. For at least some wheat varieties to have winter habit, all the loci or sites for this gene on the chromosomes must have the recessive, winter-habit alleles. Some plants even have multiple versions of the recessive allele. A. E. Limin, D. B. Fowler, "Developmental Traits Affective Low Temperature Tolerance Response in Near-isogenic Lines for the Vernalization Locus VRN-1a in Wheat (triticum aestvum L. em Thell), *Annals of Botany* 89, 2002, 579-585; A. T. Pugsley, "A genetic analysis of the spring-winter habit of growth in wheat," *Australian Journal of Agricultural Research*, 22 (1), 21-31, 1971.

[63] Winter and spring habits can be polygenic traits in which several genes interact. Some studies show the existence of multiple VRN genes (VRN-2a, VRN 4, and so forth) that affect a plant's need for a period of cold, or vernalization, for flowering, while genes that determine a plant's response to photoperiod also affect habit. See among several works, Y. Y. Klaimi, C. O. Qualset, "Genetics of Heading Time in Wheat (Triticum aestivum L.). II. The Interitance of Vernalization Response, Genetics 76: 119-133, January 1974; D. K. Santra et al., "Genetic and Molecular Characterization of Vernalization Genes Vrn-A1, Vrn-B1, and Vrn-D1 in Spring Wheat Germplasm from the Pacific Northwest Region of the U.S. A., Plant Breeding, 2009;

[64] According to Martin A. J. Perry et al., "Mutation discovery for crop improvement," *Journal of Experimental Botany*, v. 60 n. 10 (Oxford University Press: 2009), 2817-2825: "Whilst mutations occur spontaneously in nature, the frequency of such mutations is too low to rely on alone for accelerated plant breeding." Many other scientific publications document the rarity of major genetic changes and mutations.

[65] Artificial vernalization produces sprouted seed which will grow into a plant if, for example, it is planted before mold starts to grow on the seedlings. One website describes a method to sprout wheat berries to produce wheatgrass that resembles Lysenko's artificial vernalization, and warns about the spread of mold if the sprouts are not removed from the sprouting process in time: http://wheatgrassgrower.blogspot.com/2009/11/planting-your-wheat-berries-to-sprout.html . Also winter wheat planted in spring, for example in March or April, may become cold enough in the soil or because of a cold spell to mature, without any change in "inheritance."

[68] Roll-Hansen, *Lysenko Effect*, 136, 159-162.

[69] See for example the image and mention of a vernalization growth chamber at CIMMYT, used to grow winter wheat to develop resistance to the rust epiphytotic Ug99: http://www.flickr.com/photos/cimmyt/4809668488/. See also A. I. Morgounov et al., *Wheat Breeding: Objectives, Methodology, and Progress*. Proceedings of the

Ukraine/CIMMYT Workshop, June 1995, Wheat Program Special Report, WPSR no. 37, Sonora Mexico: CIMMYT, 1995, p. 11ff "Importance of winter x spring crosses."

[70] Roll-Hansen, *Lysenko Effect*, 58, 73, 106.

[71] See the discussion of the characteristics and widespread incidence of sociopathy in society in Martha Stout (professor of psychology, Harvard University), *The Sociopath Next Door* (New York: Random House, 2005). On Lysenko's psychology, see Soyfer, *Lysenko and the Tragedy of Soviet Science*, passim.

[73] The following biographical discussion is based on Aleksandr Fedorchenko, *Luk'ianenko*, M: Molodaia Gvardiia (Zhizn' zamechatel'nykh liudei), 1984; Vitalii Vardadym, "Pavel Panteleimonovich Luk'ianenko, 1901-1973," *Radeteli zemli kubanskoi*, http://kuban-xxi.h1.ru/favourite/508.shtml ; I. N. Elagin, "Vydaiushchii uchenyi-selektsioner. K 80-leiiu so dnia rozhdeniia P.P. Luk'ianenko," Zhurnal RAN, 1981 no. 11, 104-111.

[74] Fedorchenko, *Luk'ianenko*, 49-50.

[75] Fedorchenko, *Luk'ianenko*, 104-105.

[76] Fedorchenko, *Luk'ianenko*, 105ff describes several agricultural threats with which Luk'ianenko and his fellow farmers struggled in the early 1920s, including lodging from rain, plant diseases and insects, drought, heavy rains, and cold. Late imperial Russian publications even mentioned soil exhaustion in Kuban (108).

[77] Fedorchenko, *Luk'ianenko*, 111.

[78] Fedorchenko, *Luk'ianenko*, 113-115.

[79] Fedorchenko, *Luk'ianenko*, 114-115.

[80] A. A. Romanenko, "Bezostaia 1 - triumf nauki i iskusstva." *Bezostaia 1 - 50 let triumfa*. Sbornik materialov mezhdynarodnoi konferentsii, posviashchennoi 50 letiiu sozdaniia sorta ozimoi miagkoi pshenitsy Besostoi 1. Krasnodar: 2005, p. 8.

[81] Iurii Moshkov, *Zernovaia problema v gody sploshnoi kollektivizatsii* (Moscow, 1966), 191.

[82] I. V. Stalin, *Sochinenniia*, v. 13 (Moscow, 1954), 216-233. On the genocide interpretation, see for example Robert Conquest, *Harvest of Sorrow* (New York, Oxford University Press, 1986), and for a critique showing that the 1932 harvest was in fact a small harvest, Tauger, "The 1932 Harvest and the Famine of 1933," *Slavic Review*, v. 50 no. 1, Spring 1991, 70-89.

[83] Tauger, *Natural Disaster and Human Action*, 17; Lukianenko, *O stepeni ugneteniia gibridov ozimoi pshenitsy buroi rzhavchinoi v 1932 g*. (Rostov na Dony, 1934), 14.

[84] Elagin, "Vydaiushchii uchenyi-selektsioner, " 106.

[85] Fedorchenko, *Luk'ianenko*, 122.

[86] Fedorchenko, *Luk'ianenko*, 125-145.

[87] Fedorchenko, *Luk'ianenko*, 149-152.

[88] The following section is based on Fedorchenko, *Lukianenko*; Elagin, "Vydaiushchii uchenyi-selektsioner," and Vardadym, "Pavel Panteleimonovich Lukianenko."

[89] P. Grebennikov, *Tverdaia bez'ostaia pshenbitsa v estestvennykh usloviiakh*, RnD, 1925.

[90] Fedorchenko, *Luk'ianenko*, 164.

[91] Fedorchenko, *Luk'ianenko*, 165-172.

[92] David B. Lobell et al., "Analysis of wheat yield and climatic trends in Mexico," Field Crops Research 94 (2005) 250-256, citing FAO data on Mexican wheat production.

[93] Dworkin, *Viking*, 90.

[94] Elagin, "Vydaiushchii uchenyi-selektsioner," 108.

[95] Borlaug, N. E. "Breeding wheat for high yield, wide adaptation, and disease resistance." In *Rice Breeding*, IRRI, Philippines, 1972, p. 590.

[96] On Beachell's breeding of IR8 see http://www.livinghistoryfarm.org/farminginthe50s/crops_17.html and the pages that follow this one.

[98] Fedorchenko, *Luk'ianenko*, 202.

[99] Fedorchenko, *Luk'ianenko*, 202-204.

[100] Fedorchenko, *Luk'ianenko*, 217-219, 235, 260-261. According to an interview with an American plant breeder, Luk'ianenko died after seeing a major new infestation, Dworkin, *Viking*, 50-51. This story is problematic because it describes Luk'ianenko as "at his home near the Odessa Institute of Plant Breeding" but Luk'ianenko's home was in Kuban and he did his research at the Krasnodar institute, several hundred miles from Odessa. Perhaps this source confused Luk'ianenko with another person.

[101] I. A. Benediktov, *O Stalin i Khrushchev*, Molodaia Gvardiia, 1989 no.4, 12-65. Obtained from the internet: http://rksmb.org/get.php?143 .

[102] Soyfer, *Lysenko and the Tragedy*, 306.

[103] Luk'ianenko, *O stepeni ugneteniia*, pp. 45-46.

[104] P. P. Luk'ianenko, "O metodike selektsii sortov ozimoi pshenitsy, ustoichivykh k buroi rzhachiny," *Iarovizatsiia*, 1941 no.3, pp. 38-47, quote from p. 46.

[106] Luk'ianenko, "Izmenenie prirody sortov ozimoi I iarovoi pshenitsy putem izmeneniia uslovii prokhozhdeniia stadia iarovizatsii," *Agrobiologiia*, 1948 no. 2, 1948, 40-50.

[107] See for example International Winter Wheat Improvement program (Turkey-CIMMYT-ICARDA) http://www.iwwip.org/files/iwwip-website-info.pdf , apparently from 2008 or later.

[108] Douglas Weiner, *A Little Corner of Freedom* (Berkeley: University of California Press, 1999), 41 and passim.

[109] I am preparing a study of famines in Russia and the USSR that will address many of these issues.

[111] *Pshenitsa i tritikale: materialy naucho-prakticheskoi konferentsii 'Zelenaia revoliutsiia P. P. Luk'ianenko'*, Krasnodar, 2001 (799 pgs).