The exploitation of plant genetic information: Political strategies in crop development

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Chapter 3

The 1930s: Laying the Foundations for Industrial Crop Development

The international division of labour in agriculture that characterized the First Agro-Food Order was put under severe pressure during the economic depression of the 1930s. World market prices plummeted after 1929, both for temperate and for tropical foodstuffs, notably coffee, rubber and sugar, inducing protective measures in Europe and the colonies (Kindleberger, 1973:94-96). National food security was at stake and in a period of social instability, rural unrest had to be prevented. In those countries where protective measures already existed, such as France, Germany and Italy, national prices for agricultural products were sustained at a level up to two or three times the world market price (Tracy, 1982:130). Moreover, also in countries where a free-trade policy had prevailed, such as Great Britain, Denmark, the Netherlands, and the USA, farmers began to receive state support. Tariff and non-tariff barriers protected the national market from cheap, foreign agricultural products. The closing of the European market added to the crisis in the food exporting countries, notably the USA, which desperately tried to sell its cereals at any price abroad (Figure 3.1). Agricultural prices recovered from 1933 onwards but remained generally volatile throughout the decade.

The growing presence of the state in agriculture during the Great Depression was part of an overall economic interventionist policy by government pursued throughout the Western world. State intervention intended to save capitalist principles at a time when laissez faire policy had failed to revitalize the international economy. Also in agriculture, the existing, limited governmental involvement in agriculture was no longer appropriate. The economic crisis had put the main agricultural production and trade patterns under severe pressure and made alternative strategies to organize agricultural production necessary. In most countries, governments resorted to ad hoc and short-term protective measures (Tracy, 1982:138). There were two exceptions: Germany and the USA. In these two countries, for the first time, a more or less coherent, long-term agricultural production strategy was developed in which the state would play a central role.
role. The final objectives of the respective strategies, as well as the means to achieve them, differed entirely, however. The Nazi regime aimed at autarky in food production (Nahrungsfreiheit) in view of its envisaged territorial expansion by war, while in the USA, the Roosevelt administration intended to find a structural solution to surplus production and unstable food supply.

This chapter discusses the development of specific crop development policies against the background of emerging new agricultural production strategies in both Germany and the USA in the 1930s. Both in Germany and the USA the government became actively involved in plant breeding, plant collection and conservation, and the protection of plant breeders. These policies would set the trend for crop development policies followed by most Western countries during the Second Agro-Food Order.

We start this chapter, however, with an examination of crop development policy in the Soviet Union during the interbellum. Russian scientists, who were educated in Mendelian genetics, would leave their marks on Soviet plant breeding and conservation policies until their scientific paradigm was considered to contradict communist principles. While their scientific insights were neglected in the Soviet Union itself, they proved to be crucial to the plant conservation policy of Germany and the USA and other Western countries during the Second Agro-Food Order.

![Figure 3.1. Wheat and rye exports by main producing countries (1924-1938) (in million tonnes)](data derived from Tracy, 1982:143)

### 3.1 Mendelian genetics delinked from Soviet crop development

Like other wheat exporting countries in the world, the Soviet Union, in the early 1930s, was hit by plummeting world market prices (Kindleberger 1973:93). The problem was aggravated by crop failures in 1932 and 1933. The wheat crisis ignited a heavy scientific and political controversy on the position of Mendelian genetics as the prevailing scientific paradigm in crop development. A split occurred
between those scientists who had been educated in Germany and Great Britain on Mendelian genetics, and those who had not. According to the latter, the food crisis proved that Mendelian genetics had failed - a position supported by the Communist Party. The ‘Mendelians’ however argued that a boost in yields would require further elaboration of their theories and experiments. The outcome of this discussion would have a decisive impact on Soviet crop development policies.

Plant breeding activities had started already in the pre-Soviet era under the coordination of the Bureau of Applied Botany (established in St. Petersburg in 1884). Since 1930 the Bureau is known as the All-Union Institute of Plant Industry (in Russian initials V.I.R.). The VIR, with 20,000 staff in 1934, formed the nucleus of the All-Union Academy of Agricultural Sciences. The VIR was the major crop development institute in the Soviet Union. It had plant breeding programmes and maintained a national network of at least 40 satellite seedbanks and breeding stations. Special teams of taxonomists and botanists travelled around the world to extend the collections. The VIR seed collections in the 1930s contained the legendary number of 250,000 samples, collected from over 50 countries (Plucknett et al., 1987:162). Since then, only the U.S. National Seed Storage Laboratory (NSSL, established in 1957, see section 4.4.1) has contained a collection of that magnitude (James, 1961:322).

Soviet advances in genetics and taxonomy in the 1920s and 1930s had a great influence on the understanding of the value of landraces and wild relatives of cultivars for crop development. Key figure was Nicolai Ivanovich Vavilov, who formed the bridge between genetics and crop development in the Soviet Union. Vavilov received his education in genetics in the 1910s at Cambridge University from the world’s leading geneticists. Almost immediately after he had finished his studies he became the new director of the All-Union Institute of Applied Botany and New Crops (the forerunner of the VIR) and the Institute of Genetics of the Academy of Sciences. These functions allowed him to combine his knowledge of Mendelian genetics with a great botanical interest, which went far beyond the borders of the Union. In 1926 his many botanical expeditions abroad resulted in a theory on the “Universal centers of origin of the most important cultivated plants” (Vavilov, 1992), which held that the original ‘homeland’ of cultivated plants, as well as early forms of agriculture and human culture, were to be found in only seven specific geographical regions in the world (Figure 3.2).

Vavilov’s many travels to practically all continents, his frequent contacts with the most prominent geneticists of his time, his massive production of seminal books and publications, and his managerial and linguistic qualities contributed greatly to his international fame. Because of Vavilov’s work, Western agricultural scientists could greatly benefit from Soviet agricultural research. The extensive VIR botanical collection expeditions served as a guiding example for German and American scientists. In spite of the political barriers, plant material was continuously exchanged between the VIR and Western research institutes, at least until the late 1930s (Hyland, 1984:12). In the Soviet Union itself, however, Vavilov’s ideas, contacts and work were not appreciated. Despite his stature as the Communist
party's chief biologist, Vavilov's belief in the importance of genetics for agriculture brought him into serious conflict with the regime. Stalin's agricultural industrialization programme did not permit any dependence on basic Western science, notably genetics.

The communist agricultural policy of combining collectivization with the introduction of monocultures and mechanization, demanded cereal crops (especially wheat) which could be grown under the most adverse circumstances in the most remote corners of the Union. Stress-tolerant varieties were required that could thrive in the harsher climatic zones in the steppe fields, east of the Volga. Initially, the Soviet policy proved to be relatively successful, so that Stalin was able to claim that State farms would soon cover “as large an area under grain as the whole of Argentina [and] one million hectares more ... than ... Canada has to-day.” (Dobb, 1972:225-226). In reality, the increases in Soviet food production were far behind the projections. The food crises of 1932-33 led to a political controversy on the merits of Mendelian genetics and of its Soviet protagonist, Vavilov.

Mendelianism was questioned by members of the Soviet Academy of Science, notably by T.D. Lysenko, a personal friend of Stalin, and I.I. Prezent. The battle that emerged between them and Vavilov culminated at the 1936 Genetical Congress. Lysenko and Prezent declared that the early work of genetics, especially that of Bateson's school (see section 2.2.4), was subversive to Darwin's evolution theory and, in fact, a product of “clerical reaction against evolutionary biology.” (Hudson and Richens, 1946:70). In the eyes of Lysenko and Prezent, Darwinism was much more in line with marxist-dialectical interpretations of how plants (and other living organisms) adapt to changing environmental conditions (Hudson and Richens, 1946:18-20). Mendel's laws suggest that the adaptation of a plant to its environment was preordained by a genetic 'system' that could, or could not, express adaptational characteristics. It obliged breeders to sort out the desired genetic characteristics of a plant (e.g. the ability to grow on infertile tundra soil) by means of a long and complex system of crossing and selecting plants. This plant breeding method made Mendelian genetics, in the eyes of Lysenko and his comrades too complex, costly, and dangerously close to fascist ideas on genetic 'pureness'. In short, Mendelian genetics violated the public interest.

Lysenko and Prezent were convinced they could develop a much simpler and a more effective crop development strategy based on Darwin's observation that organisms are constantly adapting themselves to changing environments. In this theory, a plant subjected to a changing environment would, in order to survive, automatically change its internal genetic constitution within one or a few generations. Translated into breeding practice, this phenomenon, which was referred to as "assimilation", would have a tremendous advantage over Mendelian plant breeding (Hudson and Richens, 1946:18). It implied that a breeder could avoid a painstaking selection process to genetically adapt plants by simply exposing plants to adverse circumstances and waiting for their adaptive response. Lysenko and Prezent almost immediately gained wide political support for their ideas, especially when they claimed assimilation breeding could well form the basis for a steep
increase in agricultural production (Laird and Laird, 1970:51).

The Soviet rejection of Mendelian genetics reached a peak during the 7th International Genetical Congress in Edinburgh in 1939. Vavilov was appointed to chair the meeting, yet his supervisors in Moscow did not allow him to attend the congress (Dixon, 1993). A little later Vavilov was arrested because of alleged anti-Soviet activities. He died in prison in 1941 in unknown circumstances (Dobzhansky, 1949:227). Vavilov’s death signalled not only the final delinkage of Soviet agricultural science from its Western counterpart, but also of Mendelian genetics from crop development. Under Khrushchev’s leadership, after the Second World War, ‘Lysenkoism’ would be used to obtain the communist party’s support for what later turned out to be over-ambitious plans to boost agricultural production.

3.2 Nazi German agricultural autarky

When the National Socialists came to power in 1933, they had a well-elaborated agricultural policy designed by Walther Darré, Hitler’s first National Socialist Minister of Agriculture. Capitalizing on the rural dissatisfaction in Germany, the Nazis offered farmers the prospect of relief from the high debt burden, taxes, and decreasing agricultural prices. This policy was embedded in the Blut und Boden ideology, which considered the German farmers descendants of Germanic settler tribes, with a close relationship to the soil. The farmer was therefore not only the source of food, but also the “blood source” of the country (Darré quoted in Tracy, 1982:202). Initially, a combination of measures did improve subsistence in the countryside, but after 1935 agriculture downgraded in favour of the armament programme at the expense of the farmer’s income (Koning, 1986:118-119). Agricultural production and trade were put under total state control by the National Socialist Food Corporation (in German initials R.N.S.), while agricultural imports were drastically reduced, except for maize, because of the shortage of home-grown fodder.

The Nazi regime, more seriously than previous governments, also tackled the problem of fragmentation of the land. To this end the “Erbhofgesetz” was designed, a racial farm legislation that included elements of a structural agricultural production strategy. For the first time, a law indicated the minimum size of a potentially viable farm: farms had to be large enough to support a family (Tracy, 1982:207). Farms that could not meet this requirement could not be registered under the law and were doomed to disappear. One of the intentions of the legislation was to reduce the number of people whose income depended on agricultural production. As shown below, this policy was also an essential element of the American agricultural policy under the New Deal. After 1945, the distinction between ‘viable’ and ‘non-viable’ farms would become the cornerstone for agricultural policy in all industrialized countries.
3.2.1 Conservation as a scientific military operation

As in the Soviet Union, the German interest in developing a crop development policy formed an essential part of the long-term agricultural production strategy. During the First World War, German agro-industry had lost most of its capacity to produce seed. This loss, and the memory of the “Hungerblockade” by the English navy in 1916-17, fed National Socialist ideas for a strong and new autarkic agricultural sector. Credos such as accomplishing “Food Liberty” (Nahrungsfreiheit) and the closing of the “protein and fat gap” (Eiweiss und Fettlücke) became part of the National Socialist programme (Flitner, 1995:68-74). In 1933, 3.6 billion Reichsmark (RM) had to be spent on food imports, mainly fats. After a poor harvest in 1934-35 the agricultural programme was incorporated in Göring’s Four Year Plan (1936), which was designed to prepare the country for war. Indeed, Germany entered the war with a healthy agricultural sector and a grain reserve of some 6-7 million tonnes (Cecil, 1979:29).

Achieving self-sufficiency in food and fodder also became the central aim of the crop development policy of the Nazi regime. The regulation of the seed market, the support for plant breeders, the interest in collecting and conserving genetic resources of plants, all this served the function of reducing the dependence on food imports. The quest for food autarky tied political, scientific and military elements together, a tendency which was probably best expressed in the search for seed and plants. The expeditions of Nazi taxonomists evolved into scientific-military operations in which occupied territory was effectively screened for new seed.

The interest in botany and crop development materialized in the establishment of the Kaiser-Wilhelm-Institut (KWI), in Müncheberg, near Berlin. During the war, the KWI rapidly became the key scientific institute for agricultural research in Germany. In 1944, the KWI housed six sections, with a division very similar to today’s research centres: genetics, cytology, systematics, physiology, cultivars, and horticulture. Extensive financial support was offered by the chemical and fertilizer industry and the banking sector, allowing the Institute’s annual budget to rise from 120,000 RM in 1930 to 1,5 million RM in 1939 (Flitner, 1995:87). These investments helped Germany to regain its leading position in Mendelian genetics, which had been seriously affected after the First World War.

Extensive genetic resources collection activities became part of the German scientific programmes to reach food autarky. One of the most significant initiatives of the KWI in this realm was the 10 months trial to the Hindu Kush mountains (predominantly Northeast Afghanistan), financed by the German scientific society named Deutsche Forschungsgemeinschaft in 1935 (Flitner, 1995:74-86). Military successes of the German army during the Second World War allowed the KWI to extend its crop development and collection efforts to occupied territories in Central and Eastern Europe, particularly the Balkan. Direct military or paramilitary back-up was received for plant collecting expeditions in Spain during the Civil War, and in Abyssinia (Ethiopia) in cooperation with the Italian army. In spite of (or perhaps due to) the close contacts between the VIR under Vavilov and the KWI in the 1920s
and 1930s (Loskutov, forthcoming), a special SS-unit for Collection in Russia (the "Russland-Sammelkommando") was established, to take charge of the "systematic robbery" of the seed collections (Flitner, 1995:113-121). Many collections were captured, with the exception of the large collection at the VIR in Leningrad. Some of the collections that arrived in Germany were lost at the end of the war, some fell into British, and some into Soviet hands. A substantial part was brought over to Gatersleben, where it formed the basis of the East German seedbank after 1946 (Hammer, 1993:1).

3.2.2 Breeders benefit from authoritarian seed market control

The power shift in 1933 in favour of the National Socialists brought about a radical change in the organization of plant breeding and the seed market. Initiatives to establish a Plant Breeders’ Protection Law, and the tendency to protect plants under patent law, were set back for political and technical reasons.

Political opposition to plant patenting came especially from the RNS which was “decidedly anti-patent” (Bent et al., 1987:45). The RNS considered plant patent monopolies detrimental for plant breeding and therefore also for the Nazi agricultural production strategy. This opposition left breeders little other option than to withdraw their patent applications filed in Germany, although they maintained their applications abroad (Lange, 1985:31).

Apart from the political opposition, plant patents proved to be impracticable because it was difficult to meet the requirements of patent protection (Lange, 1985:31). A major obstacle was that breeders had to show that their ‘invented’ plant was applicable in industry. Also the requirement that the invention had to be replicable was too demanding at that time. Before cloning techniques became available in the 1970s, the exact replication of sexually reproducing plants was impossible. Furthermore, a patent is granted on an ‘invention’, but inventiveness was generally not involved in plant breeding. The National Socialist regime came up with an alternative crop development policy, which involved the complete restructuring of the German seed sector. The main legal instrument was the Ordinance on Seed Material, promulgated in 1934, putting seed production and trade under strict state control. In order to raise agricultural production, the RNS intended to “protect German farmers ...[from]... inferior, contaminated, hereditary-diseased seed material” (translation RP/JvW) (Flitner, 1995:81). The Ordinance, therefore, prevented the use of on-farm saved seed, and obliged farmers to purchase approved seed from breeders only. In addition, the Ordinance offered a solution for the ‘varietal jumble’ which, according to the agricultural establishment, had already disturbed the seed market for too long. Around 1935, the registration of plant varieties in a national variety list became obligatory. The national list was a useful tool to start a drastic “varietal cleaning” operation removing 90 per cent of the plant varieties on the market (Flitner, 1995:82).
According to Flitner (1995:85,130-131), the restructuring of the national seed market by the Nazi regime supported the German plant breeders, even though private exploitation rights were not granted. By obliging farmers to purchase breeder's seed, and by reducing the number of marketable varieties, the 1934 Ordinance offered private breeders a good opportunity to eliminate unauthorized reproduction of their varieties.

3.3 Stabilization of food production under the American New Deal

The Great Depression hit not only farmers in Europe, but also their main competitors on the other side of the ocean. Burdened by the low food prices of the early 1930s, the American farming community called for active government support. The political elite thought it wise to take this call very seriously, as farmers were important allies against the threat of emerging socialism. This was the situation when the USA witnessed a shift of power from Republicans to Democrats in 1933, the same year in which the National Socialists took over government in Germany. The Democrats would develop a production strategy for agriculture with the intention of strengthening the linkage between agriculture and industry, and to ease social unrest in the countryside.

The Roosevelt Administration presented a series of policies for restructuring and reviving the economy, known as the 'New Deal'. The programme of the Democrats was historically unique, and contrasted with contemporary policies in Germany and the USSR in that it envisaged a central role of the state in organizing the national economy without violating the basic principles of the market economy. The new role assumed by the U.S. government was clearly expressed in agriculture.

The New Deal contained an important agricultural element, composed of a series of interrelated programmes, initiated over a number of years. These programmes, of which the Agricultural Adjustment Act (AAA) is the best known, were often contradictory as they reflected the different social-economic interests involved in agriculture. Nevertheless, the Roosevelt Administration succeeded in developing a more or less coherent strategy for tackling the problems in agriculture. The New Deal policies created the foundation for the agricultural production strategy of the Second Agro-Food Order, not only in the USA but also, as we will see in chapter four, in the entire Western world. Basically, the New Deal strategy encompassed the stabilization of food supplies by establishing food reserves and offering income guarantees for farmers. This raised the purchasing power of farmers, enabling them to undertake investments and subsequently raise farm productivity. To prevent a boost in production and a corresponding collapse of agricultural prices, it was considered crucial that the minimum income standard was only applied to the wealthier ('viable'), middle-sized and large farms. Non-viable farms, in fact, were given up.

The implementation of this aspect of agricultural production strategy under the New Deal was greatly supported by the events of the time. An expanding industry,
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the mis-croppings in the mid-1930s, and the outbreak of the Second World War, encouraged or forced a large number of share croppers and tenants to find jobs in an urban industrial environment, or in the U.S. army (Saloutos, 1982:266).

The new production strategy succeeded in raising agricultural productivity by specific crop development policies, designed by the USDA under guidance of the U.S. Secretary of Agriculture, Henry A. Wallace. Traditionally, agricultural research in the USA had been directed at production increase through area extension, rather than yield increase per hectare. But when marginal land began to be cultivated, spending on fertilization and irrigation rose. Labour costs rose as well, because the low population density in the agricultural areas could only partly be compensated by mechanization (Cochrane, 1979:185). Under these circumstances an increase of yield per hectare came within sight as a means to cut down input and labour costs. This induced the Democrats during the New Deal drastically to reverse reductions in public research expenditure, a trend set by the Republicans. The aim was to raise productivity in American agriculture by creating new, high yielding varieties.

The rising outlays for crop development were controversial among farmers. Pointing to the surplus production and low agricultural prices at the time, they questioned the benefit of research directed at higher production, rather than higher prices (Kloppenburg, 1988a:85,87). Secretary Wallace, however, held the view that not less but more science would be the remedy for the agricultural crisis (Kloppenburg, 1988a:86).

A financial boost for agricultural research, basically through the 1935 Bankhead-Jones Act, was not the only characteristic of the New Deal crop development policy. Also significant was the type of research that was supported. Wallace had his roots in the seed industry. He was the founder of the Pioneer Hi-Bred Corn Company (which would develop into one of the world’s largest seed companies), and a strong advocate of the ‘pure-line’ plant breeding approach. Wallace appointed a Secretary’s Committee on Genetics, the results of which were reported in the 1936 and 1937 Yearbooks of Agriculture. Kloppenburg (1988a:88) argues that these reports marked the coming of age of ‘agricultural genetics’. The reports focused on Mendelian genetics for the understanding of practical problems in crop development, and considered hybridization as the main breeding tool.

3.3.1 Conservation becomes the cornerstone of crop development

The crop development policy of the New Deal also increased support for conservation of landraces and wild relatives. The support was expressed in the Bankhead-Jones Act of 1935, which called for an expansion of the U.S. conservation and collection capacity. The rising interest in plant collection in the 1930s resulted from advances in Mendelian genetics. The insight that landraces and wild relatives should be assessed on genetic criteria, rather than outward characteristics, greatly expanded the number of plants that were potentially useful. Two problems had to
be addressed, however: the loss of landraces because of their replacement by newly
developed varieties, and the limited seed storage capacity in the USA.

The growing value attributed to genetic information in crop development in the
1930s provoked concern about the speed at which ‘modern’ varieties were rapidly
replacing ‘traditional’ landraces. Plant breeders began to realize that genetic in­formation contained in landraces would be valuable for breeders in the future. The
danger of a deadlock in breeding was first realized by J. Harlan and M.L. Martini.
In their seminal article on the rapid replacement of old barley landraces of 1936,
they summarized the problem as follows:

“In the hinterlands of Asia there were probably barley fields when man
was young. The progenies of these fields with all their surviving variations
constitute the world’s priceless reservoir of germ plasm. It has waited
through long centuries. Unfortunately, from the breeder’s standpoint, it is
now being imperiled. When new barleys replace those grown by the farm­
ers of Ethiopia or Tibet, the world will have lost something irreplaceable.”
(Harlan and Martini, 1936:303).

Harlan and Martini not only revealed their concern for the loss of a ‘common good’,
but also their awareness of the long-term interests of the plant breeding industry.

“The plant breeder has every reason to feel gratified and undoubtedly the
time is not too far distant when the entire acreage will be planted to pure­
line varieties. There is, however, one rather disconcerting problem raised
by the plant breeder’s success. In a way, we lose whenever we gain ... The
breeder is helpless without living material of diverse character.” (Harlan
and Martini, 1936:315-316).

Very likely this was the first time plant breeders themselves publicly expressed the
paradox of the success of the spread of improved, genetically more uniform crops.
Harlan and Martini were frequent travellers and had personally witnessed the gradu­al replacement of traditional landraces by new varieties. Their global scope on the
"irreplaceable" loss of diverse germplasm, however, also reflects an American bias.
Knowing that the USA traditionally is a large ‘net importer’ of landraces and wild
relatives of food crops, the authors realized that the American breeding industry
would be one of the first to suffer from the replacement of traditional plants. The
fact that Harlan and Martini published their article in the same 1936 Yearbook of
Agriculture in which Wallace reported on his New Deal crop development policy,
contributed to the political impact of their call for more conservation capacity.

While the necessity to collect landraces and wild relatives was increasingly
emphasized, the capacity to store and conserve the seed collected in remote areas
of the world reached it limits. During the 1920s and early 1930s, American collec­
tion efforts were at a peak. “Hundreds of collections were brought together at the
nursery centres throughout the country for screening ... [and] ... contributed more
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to crop improvement and production than any other time of U.S. agricultural history” (Hyland, 1984:10). Until in the mid-1930s political conditions prevented joint conservation efforts, the USDA was in frequent contact with Vavilov and his staff (Hyland, 1984:12). The call for more storage capacity was voiced in the late 1930s by the U.S. National Academy of Sciences Committee on Plant and Animal Stocks. The committee expressed its concern over the high loss-rate of the U.S. seed collections due to inadequate storage facilities. It would not be until after the Second World War before the USDA was allowed to build four new Plant Introduction Stations with extensive conservation facilities (Busch et al., 1995:93) (see section 4.4.1).

3.3.2 Hybrids as alternative protection paradigm

The New Deal encouraged the breeding of plant varieties that would raise productivity of agriculture through various means, although not by enacting specific intellectual property rights legislation. Of course, the USA was the first country that had established a specific plant patent system, but that was not related to the New Deal policy for agriculture. The Plant Patent Act (PPA) of 1930 had been established before the Roosevelt Administration entered into office and was specifically designed to protect asexually reproducing varieties: fruit and nut trees and ornamental plants. For the American seedsmen it had little to offer.

The absence of legal protection did not seem to be a big problem for the seed industry, however. While German seed firms were demanding - and were given - state protection against unauthorized reproduction of their varieties in the 1930s, legal protection was not a big issue for the American seed industry (Bugos and Kevles, 1991:11). American plant breeding in field crops was predominantly carried out by state-funded institutions that did not seek legal protection for their innovations. The existence of ‘traditional’ protective measures may have played a role too. Breeders still enjoyed some protection from seed certification, purchase contracts, and trademarks. Most important, however, was the coming of age of agricultural genetics, which made available hybrid plant varieties that rendered legal protection superfluous.

By developing hybrids, breeders took advantage of a natural phenomenon, called ‘heterosis’ or ‘hybrid vigour’, which is the tendency for offspring of genetically diverse plants to perform better than their parents. By deliberate crossing two different parental lines which contain specific characteristics, the first filial generation (F1) of this cross can express these desired characteristics along with the hybrid vigour. Yield potential is very important. In some cases, the F1 hybrids yield significantly more than ‘open-pollinated varieties’ (OPVs).13

Hybrids offer built-in protection against propagation. Unlike OPVs, the second generation of which gives yields similar to the first, the second generation of hybrid varieties is highly variable and significantly lower in yield than that of the first generation. This phenomenon has two consequences. When using hybrid varieties, farmers have to buy fresh, first generation seed every year in order to maintain the
high yields, and other desirable characteristics of the hybrid varieties. Additionally, the lower yields and high variability of the second-generation seed eliminate the incentive of farmers and professional seed producers, to re-use seed from a hybrid. Only the breeder who holds both parental lines is able to produce economically viable hybrid seeds. In other words: hybrid varieties effectively prevent the double use value of plants; hybrids produce grain or fruit rather than useful seed.

This unique property of hybrids was very clearly realized right from the outset of their development. Two of the early promoters of hybrid varieties, Edward East and Donald Jones, in their classic book Inbreeding and Outbreeding (1919) explained the advantages of hybrids for commercial breeders.

"It is not a method that will interest most farmers, but is something that may easily be taken up by seedsmen; in fact, it is the first time in agricultural history that a seedsman is enabled to gain full benefit from a desirable origination of his own or something that he has purchased. The man who originates devices to open our boxes or shoe polish or to autograph our camera negatives, is able to patent his product and gain the full reward for his inventiveness. The man who originates a new plant which may be of incalculable value benefit to the whole country gets nothing - not even fame - for his pains, as plants can be propagated by anyone. There is correspondingly less incentive for the production of improved types. The utilization of first generation hybrids enables the originator to keep the parental types and give out only the crossed seeds, which are less valuable for continued propagation."

(East and Jones quoted in Bugos and Kevles, 1991:12)

For economic and technical reasons, maize was the crop for which hybrid varieties were developed first. By the end of the 19th century, livestock experts favoured the improvement of especially maize, which was the prime feed crop in the USA (Crabb, 1947:15), while the physical structure of the maize plant facilitates control of the pollination process, which is the key to inbreeding and hybridization. Moreover, the chromosome structure of maize turned out to be favourable for cytogenetic studies (Mayr, 1982:767). The first commercial maize hybrids were marketed in the 1920s, but their breakthrough came two decades later. In 1934, only 0.4 per cent of the total American maize area was planted to hybrids; by the 1940s the percentage had risen to 60 per cent (Dowswell et al., 1996:55).

The seed industry welcomed the potential of the built-in protection in hybrid varieties. The initiator of the Plant Patent Act, Stark, explained later that, when Congress was considering the PPA in 1930, maize breeders thought they might get better and quicker protection from hybrid maize than from plant patents. Their optimism spread to other breeders who expected that hybrid varieties would also be developed in other seed crops (Bugos and Kevles, 1991:12).

The positive expectations of the inbred-hybrid breeding method were strengthened by very strong political support of this breeding strategy by Secretary of Agriculture Wallace. Wallace had conducted inbreeding experiments himself, and
his company, the Pioneer Hi-Bred Corn Company, had been the first to grow commercial hybrid maize in Iowa in the 1920s (Crabb, 1947:109,152). It was also Wallace who had been instrumental in a drastic change of breeding policy within the maize section of the USDA in 1922. He advised his father, the then Secretary of Agriculture, to replace the principal maize agronomist at the USDA, who opposed the inbreeding technique, by a declared supporter (Crabb, 1947:99). This shift in personnel marked the beginning of a massive 15-year hybrid maize programme, subsidized and coordinated by the USDA (Berlan, 1997:8).

The inbreeding-hybridization route was extremely costly. Inbreeding in maize depresses yields, while heterosis occurs in only a few combinations of inbred lines. To find the right combinations, hundreds of thousands of plants had to be tested. This job could only be carried out through an “unprecedented venture” in which the brightest research leaders in the USA were investigating one of the ten gene linkage groups then known in maize (Kloppenburg, 1988a:103). The programme made available hybrid varieties of maize that marked the beginning of an ongoing period of continuous yield increase. Pointing to the maize yields, Wallace would later compare the power of heterosis with that of atomic energy by drawing an analogy between the hybrid maize programme and the ‘Manhattan project’ (Berlan, 1997:8; Kloppenburg, 1988a:91).

The choice of the inbreeding-hybridization technique has proved to be very influential in plant breeding. The American funds devoted to the hybridization programme supported the formation of a new approach in breeding research, at the expense of others – and this is what makes the inbreeding-hybridization technique controversial. It has been pointed out by Kloppenburg (1988a:101) and Lewontin and Berlan (1990:616-617) that the choice of this breeding strategy was political rather than scientific. The real aim would have been the abandonment of on-farm seed production. To this end, the development of cheaper alternative breeding methods was deliberately put aside. One such alternative was ‘recurrent selection’, a plant population improvement method which involves the self-fertilization of plants, the selection of those lines for desired characteristics, and finally the intercrossing of these superior lines. This method also involves inbreeding and heterosis, and may also result in hybrid varieties. However, this type of hybrid can be replanted by farmers and does not help the breeder to increase his return on investment.

Berlan (1997:20), and Lewontin and Berlan (1990:626) argue that the higher yield of hybrids was based on a self-fulfilling prophecy. In the mid-1930s, American farmers began to shift over to maize hybrids because they out-yielded open-pollinating maize varieties. But since hybrid development was made the only breeding strategy in maize, the open-pollinating varieties had not undergone any improvement for several years. The yield performance of hybrids was thus compared to that of maize plants that were in the same genetic state as they had been in the 1910s, when plant improvement was still directed towards aesthetic characteristics rather than to yield. In short, if alternative plant breeding techniques had been developed concurrently with the inbred-hybrid method, the yield advantage of hybrids may have been less significant.
Conclusions

During the 1930s, the state started to intervene in agriculture in all of the then industrializing countries, but most forcefully in the USA and Germany. These countries were unique, in the sense that they gradually developed a long-term and state-led strategy for a structural transformation of agricultural production. The strategies entailed specific policies on plant breeding, plant collection and conservation, and the protection of private plant breeding firms.

The spread of Mendelian genetics in the first decade of the 20th century provoked breakthroughs both in breeding and conservation. As science disclosed how genes control specific traits in plants, the search for useful genes from a broad range of plants intensified. The new genetic knowledge greatly expanded the scope of plant material with potential economic value. Not only cultivated varieties, but also landraces, and to some extent wild relatives were increasingly seen as ‘resources’ for breeding. This development opened the door for a new type of scientific activity of which the Russian geneticist Vavilov was the exponent: the world-wide collection of plants as germplasm resources in their centres of origin.

The strategic value of germplasm of temperate crop plants was realized by the main economic and military powers of the time: the Soviet Union, Germany and the USA. During the interbellum they became the key players in the worldwide collection and conservation of plant germplasm. However, geopolitical developments would lead to the Soviet Union and Germany being left behind. The Soviet communist party caused the Soviet adherents of Mendelian genetics to play down their ideas as well as their Western contacts. The outcome of the Second World War terminated the political drive in Germany to establish agricultural autarky and a strictly national germplasm collection.

The newly emerging crop development policies in Germany and the USA did not entail further intellectual property protection for plant breeders. The Nazi regime terminated the tendency of plant patenting in Germany. Instead, German breeders enjoyed de facto protection from an authoritarian control of the seed market in which the marketing of seed other than that of plant breeders was not allowed. In the USA, the coverage of the Plant Patent Act would remain limited basically to fruit and ornamental plants. The production of hybrid varieties was strongly developed by the Democratic government as a new protection paradigm for plant breeders.

Notes

1 Grain exports made up 36 per cent of Russia's export in the 1910s and 1920s (Kindleberger, 1973:93).
2 The exact number is not known. Some sources spoke of over 400 seedbanks and breeding stations, but this number is contested by Frankel, a contemporary of Vavilov (personal communication Otto Frankel, Australian Commonwealth Scientific and Industrial Research Organization, CSIRO, Canberra, Australia, 1994).
Vavilov’s ideas were first published in 1926 as Studies in the Origin of Cultivated Plants (Vavilov, 1926). The study became widely available only in 1951 when it was translated and republished as The Origin, Variation, Immunity and Breeding of Cultivated Plants: Selected Writings of N.I. Vavilov (Vavilov, 1951).

Vavilov was increasingly put under pressure. In a desperate attempt to defend himself, he managed to meet Stalin on 20 November 1939. This is how the meeting is described by Vavilov’s confederate at the VIR, E.S. Yakushevsky: ... [H]e (Vavilov), after several attempts, reached his goal and was granted admission to Stalin at 10 p.m. After he arrived, he spent two hours in the reception room and at long last, after midnight, he was allowed in. Vavilov entered and greeted Stalin: “Good evening, Iosif Vissarionovich”, and bowed. (Later he was told that Stalin hated being called by his first name and patronymic, but preferred being addressed as Comrade Stalin). Stalin did not answer the greetings and said: “So you are the Vavilov who fiddles with flowers, leaves, grafts and other botanical nonsense instead of helping agriculture like Academician Lysenko, Trofim Denisovich”. Vavilov was not invited to sit down. Stalin walked up and down the office and left Vavilov standing. In the first instance Vavilov was taken aback, but then regained his spirit and read him a lecture about the problems of the Institute, the assemblage of the VIR seed collection, and ... everything that was done for the development of plant science, and for the development of plant breeding and seed production in this country ... After Vavilov had told all this, he calmed down, but noticed that he was like talking to a stone wall, After an hour, Stalin cut him short, saying: “You are free to go now, Mr. Vavilov”. Vavilov bowed and left.” (Loskutov, forthcoming)

The verdict against Vavilov of 5 July 1941 was formulated as follows: “Preliminary and fullscale investigations have determined that since 1925, Vavilov has been one of the leaders of an antiSoviet organization called Peasants’ Party of Labour. Since 1930 he has actively participated in a rightwing antiSoviet organization that functioned within the Peoples’ Commissariat of Agriculture of the USSR and several scientific institutions of the USSR... Pursuing interests of antiSoviet organizations, he performed acts of sabotage on a wide scale aimed at the undermining and liquidation of the collectivefarm system, and at the breakdown and decline of Socialist agriculture in the USSR...” (Loskutov, forthcoming)

The incorrectness of Lysenkoism was indirectly admitted when Vavilov’s work was officially reassessed by the Communist Party in 1955.

The Erbhofgesetz was a legislative elaboration of the Nazi ideology and provided that farms, once registered as Erbhof, literally translated as ‘entailed farm’, could not be disposed of by the current owner and had to pass intact to a single heir. In 1938, half of the agricultural area was registered under the law (Tracy, 1982:207).

Flitner (1995) points out that the Hindu Kush expedition was not only organized for agricultural reasons. The search for ‘pure’ seeds also served as an opportunity to test quasi-scientific eugenic hypotheses on the ‘purity’ of the Aryan race. The criterion “purity” was not only applied to the more than four thousand landraces and wild relatives collected (mostly wheat, barley and legumes), but also to the physiological characteristics of several hundred local inhabitants. It was assumed that both plants and men had hardly been exposed to racial blending, leading to what in Nazi ideology was called “softening” (Verweichlichung), because of their long-term geographical and cultural isolation (Flitner 1995:74-80). How close plant breeding and eugenetics were related is illustrated by the following quote from the dissertation (1934) of Herman Kuckuck of the KWI: “An application of plant improvement methods to improve the human race cannot be carried out right away. These methods will nevertheless increase our insight and understanding of the necessity to take strong measures to preserve the human race, as already convincingly initiated by the sterilization law”, (translation RP/JvW) (Kuckuck quoted in Flitner, 1995:114).

The drastic reduction of varieties was undoubtedly also related to the relatively late introduction of the national variety list in Germany. In the Netherlands, a comparable - albeit advisory - list had been
introduced in 1924. Like the German list, the Dutch variety list had also initiated the abandonment of many varieties that were considered to be inferior, as well as varieties that were traded under synonymous names. The Dutch “cleaning” process, however, developed more gradually. By 1935, synonymous denomination no longer occurred (De Haan, 1949:23). From the 353 crop varieties that had been included in the Dutch national variety list in the period 1924-1939, 154 (44 per cent) had been abandoned (De Haan, 1940:12). In 1949, 415 (48 per cent) out of a total of 871 varieties had been eliminated from the Dutch list, including 40 landraces (De Haan, 1949:42).

10 Pointing to the explosive situation in rural America, the president of the American Farm Bureau Federation O’Neil warned in 1933: “[U]nless something is done for the farmers, we will have a revolution in the countryside in less than 12 months” (O’Neil quoted in Saloutos, 1982:43).

11 The New Deal policies “...more or less set the pace for [agricultural] policy-making in the post-World War Two decades for Republicans and Democrats alike” (Saloutos, 1982:254).

12 The support for specific layers of the agricultural community under the AAA was not entirely new. In fact, during the years prior to the New Deal, research, teaching and extension work had been concentrated almost exclusively on the well-managed farm (Saloutos, 1982:261-261).

13 In order to produce hybrids, a group of parental lines must be formed. This is done by repeated self-pollination of individual plants - a process called inbreeding. Each inbred line is (almost) genetically uniform and different from each of the other inbred lines.
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