Grain production technology in the USSR with minimal use of pesticides

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Abstract. The article examines the technological chain of grain production in the USSR with minimal use of pesticides. It was formed and improved throughout the existence of the USSR. Its components were: removal of organic fertilizers to the fields - deep plowing - sowing - treatment of fields and crops with pesticides - harvesting - cleaning and drying - grain storage. The article describes each of these elements in detail, using illustrations for clarity. The article examines the treatment of fields and crops with pesticides as a key element of this chain. If a necessary condition for the implementation of this technological chain was the increase in the number of livestock, as a result of which organic fertilizers were formed in large quantities, then the development of agricultural machinery and the production of pesticides was sufficient. The article emphasizes that the use of pesticides was limited. Many pesticides were banned completely, while others were used in small quantities and within certain periods. The main reasons for such restrictive measures, due to the social system of the USSR, were the production of high-quality bread products for the population and animal feed and the preservation of the environment.

1 Introduction

As is known, during its existence the Soviet Union has achieved considerable success in the production of agricultural products, including the production of grain, the collection of which, excluding legumes, increased from 86 million tons in 1913 to 209.1 million tons in 1990 and 156 million tons in 1991 [1]. The number of cattle, pigs and sheep compared to 1916 increased, respectively, from 58.4, 23.0 and 89.7 million heads to 115.7, 75.6 and 140.6 million heads in 1991 [2]. However, there were both ups and downs along the way. The following milestones can be highlighted:

- World War I and civil war and expropriation of landowners’ land [3]. These historical events threw Russian agriculture back into the past. Cultivated areas decreased in 25%. Agricultural production fell to 60% of pre-war levels. The main draft force at that time was the physical energy of peasants and animals (horses, cattle), and the main agricultural tools were plows and shovels.

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The New Economic Policy (NEP), carried out in 1921-1928, led to the restoration of abandoned crop areas and largely improved the situation in agricultural production [4]. In the last year of the NEP, grain production reached the pre-war 1913 level, and the number of livestock exceeded the pre-war level. Thanks to the growth in the production of agricultural machinery, many communes, artels and partnerships acquired horse-drawn carts, seeders, mowers and threshers. Higher technical equipment made possible to observe crop rotation to a greater extent and apply organic fertilizers to the soil. At the end of the 20-s. the New Economic Policy was repealed as contrary to the ideals of socialism.

Collectivization made serious adjustments to the agriculture of the Soviet Union. The creation of collective farms initially had a negative impact on agricultural production: grain harvest fell due to the reorganization of agricultural enterprises and lean years, the number of cattle decreased significantly, which led to famine in the country. But then the situation began to improve. For technical maintenance of collective farms, machine and tractor stations (MTS) were organized. The main feature of this period was the widespread use in agricultural production of tractors, cars and other agricultural machinery produced by industry created during the industrialization of the USSR. At the same time, the administrative-command system of collective farm management and low procurement prices for agricultural products hampered the economic development of agriculture [5].

During the Great Patriotic War, a significant part of the agricultural lands of the European territory of the country found itself under temporary occupation by the troops of Nazi Germany. Many rural settlements were destroyed and millions of villagers died. As a result of the losses, the level of labor mechanization in agriculture sharply decreased, grain production and the number of cattle decreased. Instead of tractors and other agricultural machinery, simple machines and mechanisms, draft power and manual labor began to be widely used [6].

After the end of the war and the restoration of the national economy, it became clear that without agrarian reform it was impossible to further develop agricultural production. In 1953, radical changes began in the country’s economy, in agricultural production, and its accelerated growth in order to provide the population with food and light industry with raw materials [7]. In 1954, the development of virgin and fallow lands began. To raise virgin soil in the Southern Urals, Siberia and Kazakhstan, over 350 thousand migrants (workers, peasants, specialists) arrived [8]. In 1958, MTS was reorganized. Collective farms received the right to buy equipment from MTS. Many collective farms were transformed into state farms. The economic measures have made possible to achieve certain successes in the development of agricultural production. But there was no fundamental improvement in the development of agriculture [9].

Agrarian reforms in the mid-60-s. didn’t stop the process of increasing difficulties in agriculture [10, 11]. Increasing the size of capital investments and supplies of equipment didn’t provide much economic effect. Many types of products were sold to the state at low prices. This was one of the reasons for the increase in the number of unprofitable farms that the state was forced to support. From the late 60-s and especially in the 70-s, in order to intensify agricultural production, integrated farms began to be created - agro-industrial associations, combines, agricultural firms, i.e. agricultural holdings. They included collective and state farms, processing enterprises agricultural raw materials, organization of transport and trade. New management structures have improved the situation in agriculture and livestock farming. In 1978, the gross grain harvest reached 213.7 million tons - the maximum for the entire Soviet period.

In the 80-s. stagnation began in USSR agriculture. The collective and state farm organization of agriculture had reached the limit of its capabilities and began to fail. If
in 1971-1975 the volume of gross agricultural output was 13% of the total social product, then in 1981-1985 only 6% [12, 13]. This happened despite the fact that at that time the USSR was implementing a policy of intensifying agriculture, large livestock complexes were built, including under the program for the development of the Non-Black Earth Region. A slight rise was observed only during the years of perestroika. In 1987, several years before the collapse of the USSR, the peak of the cattle population for the entire Soviet period was reached - 122.1 million heads.

2 Research methods

The study used a historical approach to research the development of agriculture in the USSR from 1918 to 1991. The starting point for consideration was the agriculture of Tsarist Russia in 1913-1917. Through methods of analysis, synthesis and generalization, a technological chain of grain production with minimal use of pesticides was identified, starting from the preparation of fields for plowing and ending with the storage of the harvest, and the dependence of grain production and yield on the use of organic fertilizers was established in order to obtain natural agricultural products. Thanks to the processing of statistical data, tables were compiled indicating the main indicators of grain production and the number of cattle, pigs, sheep and goats. Photographs were used as visual illustrations to explain the text and reveal the components of the technological chain of grain production with minimal use of pesticides: applying organic fertilizers to the soil, deep plowing, sowing, using pesticides, harvesting, cleaning, drying and storing grain. An important point in the study was the personal experience of the author, who worked in 1983-1984 in the collective farm "Red Banner" - one of the lagging farms in the Sovietsky district of the Kursk region of the RSFSR.

3 Research results

The technological chain of grain production with minimal use of pesticides is as follows: application of organic fertilizers – plowing – sowing – treatment of fields and crops with pesticides – harvesting – cleaning and drying – storage. In the first years of Soviet power, due to the devastation, fields were fertilized mainly with manure, slurry, and bird droppings. Despite the subsequent creation of a powerful chemical industry that produced mineral fertilizers, with the development of livestock farming and an increase in peat production, the use of organic fertilizers in agriculture increased. By the end of the 1980s, annual peat extraction reached 50 million tons, of which approximately half was used in agriculture. The bulk of organic fertilizers came from developing livestock farming, thanks to which huge amounts of organic fertilizers were exported to the fields of the Soviet country (Table 1). So, for example, in 1950 348 million tons were exported, in 1960 428 million tons, and in 1974 already 626 million tons.

Table 1. Number of cattle, pigs and sheep in the USSR (millions of heads).

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Including cows</th>
<th>Pigs</th>
<th>Sheep and goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>50.8</td>
<td>28.8</td>
<td>19.3</td>
<td>86.7</td>
</tr>
<tr>
<td>1928</td>
<td>60.1</td>
<td>29.3</td>
<td>22.0</td>
<td>107.0</td>
</tr>
<tr>
<td>1941</td>
<td>54.5</td>
<td>27.8</td>
<td>27.6</td>
<td>91.7</td>
</tr>
<tr>
<td>1951</td>
<td>57.1</td>
<td>24.3</td>
<td>24.4</td>
<td>99.0</td>
</tr>
<tr>
<td>1961</td>
<td>75.8</td>
<td>34.8</td>
<td>58.7</td>
<td>140.3</td>
</tr>
<tr>
<td>1971</td>
<td>99.2</td>
<td>39.8</td>
<td>67.5</td>
<td>143.4</td>
</tr>
<tr>
<td>1981</td>
<td>115.1</td>
<td>43.4</td>
<td>73.4</td>
<td>147.5</td>
</tr>
<tr>
<td>1991</td>
<td>115.7</td>
<td>41.5</td>
<td>75.6</td>
<td>140.6</td>
</tr>
</tbody>
</table>
Organic fertilizers, in particular manure, were usually applied for plowing, but sometimes also for cultivation (Figure 1). As a result of the introduction of organic matter, the increase in grain yield reached 6-7 centners per 1 ha [14].

![Fig. 1. Manure transported to the field.](image)

After applying organic fertilizers, the fields were plowed with tracked tractors, since they compact the soil less than wheeled ones (Figure 2). For better productivity, it was very important to choose the right plowing depth, since it depends on many factors, such as climate, soil type, type of crop grown, etc. When there is a deep plowing with a plow and skimmer, the loose (bottom) layer of soil is turned to the surface, increasing humidity in the soil. This type of plowing reduces the number of vegetative organs of weeds in the soil and evenly distributes organic matter. At the bottom of the furrow, the upper part of the plowed soil layer, which is more clogged with weeds, is mixed. In this case, the weed seeds die. Deep plowing is also an excellent way to control diseases and insects. Pests from the upper layers of the soil fall into the lower layers and die there due to their inadaptability to living conditions underground. The optimal plowing depth is about 20 cm [15].

Place the figure as close as possible after the point where it is first referenced in the text. If there is a large number of figures and tables, it might be necessary to place some before their text citation.

![Fig. 2. Plowing land with crawler tractors.](image)

Sowing of grain crops was carried out using crawler tractors for the same reason: to avoid compacting of the soil (Figure 3). Harrows were attached behind the seeders to loosen the soil and remove large roots and weed shoots from it. This was the last mechanical tillage of the soil before the growth of grain crops.

A special place in the agricultural production of the USSR was occupied by the treatment of collective and state farm fields with pesticides. Issues of permitting or banning pesticides have not always been resolved from the perspective of the interests of people and nature. Sometimes “expediency,” a tradition of ignoring scientific data, prevailed.
Fig. 3. Sowing grain crops.

Each pesticide essentially had the same story: permission - recognition of the mistake made - ban. As a rule, the difference was only in the duration of the period of use of certain pesticides. Ultimately, almost all pesticides were banned in the USSR. Bans were sometimes introduced not only in relation to individual pesticides, but also to entire batches [16]:

- March 30, 1978: anabasine sulfate (neonicotine), calcium arsenate, sodium arsenate, galeclectron, intrathion (M-81), nemagon (fumazone), nicotine sulfate, octamethyl, Paris green, phencapton, ziram, cyanplav, keelval.
- March 21, 1986: aphos (FS-UMO), butiros, heptachlor, mercurbenzene, technical HCH, DDB, dichloroethane, linuron, mane (dithane M-22), methyl mercaptophos, monolinuron, nitazine (a mixture of ramrod and atrazine), nitrochlor (nitrophen), PCNB, rubigan (fenarimol), aldicarb.
- August 29, 1988: Cartex M (mixture of ramrod, monolinuron and prometrin), Curb mix B and Curb ultra (mixtures of propyzamide and diuron).
- March 13, 1990: lindane (gamma-HCH), hexachlorane (meaning its mixture with phosphate rock), acrex (isophene).

At the same time, not only many pesticides were prohibited, but also the regularity of their use was limited. For example, it was forbidden to treat fields with them before harvesting. The volume of pesticides applied to the soil or poured onto crops was also negligible compared to what is happening today (Figures 4 and 5).

Fig. 4. Treating a field with pesticides in Soviet times.

The criterion for determining the advisability of applying pesticides was the economic threshold of harmfulness - the minimum density of the pest population (actual or predicted), at which the costs of combating them are recouped by the income from the saved harvest.
To calculate the average economic threshold of harmfulness, a standard value of yield loss was adopted - 3% for cereal crops [17]. The main purpose of using pesticides was to kill pests, not weeds.

![Fig. 5. Currently treating the field with pesticides.](image1)

The limited use of pesticides in Soviet times did not allow us to completely get rid of weeds and wildflowers: thistle, horsetail, wheatgrass, cornflowers, daisies, etc. Often the fields were overgrown and, before harvesting, they had time to ripen the seeds of weeds in large quantities [18].

Harvesting grain crops in the USSR also had its own characteristics. It occurred, as a rule, in two stages. Since the ripening of standing grain led to large losses due to the insufficient number of high-performance combine harvesters and cars, grain crops were mowed into windrows at the first stage. As soon as the grain ripened in the windrows, the second stage began - threshing (Figure 6). This cleaning technology had both advantages and disadvantages. The advantage was that the grain ripened in the windrows and there was no need to artificially speed up this process. The main drawback was an external reason - rains, which not only prevented the harvest from being harvested, but also made the grain wet and caused it to germinate. Therefore, during rainy harvesting, the losses of already grown crops were enormous. It is no coincidence that harvesting was then called “the battle for the harvest” [19]. Another drawback was that when picking up the windrows with the header of a combine harvester, various impurities got into the threshed grain: soil, stems, leaves, husks, weed seeds, pests, unripe, damaged and sprouted grains.

![Fig. 6. Threshing grain crops.](image2)

The grain harvested from the fields was taken to grain storage facilities, where it was cleaned from impurities and dried if it arrived wet (Figure 7). An important purpose of grain cleaning units, which were production lines, was to automate the work of receiving
grain delivered from the field (unloading, transportation, loading), cleaning it and bringing it to the required quality. Mass introduction of grain cleaning units and grain cleaning and drying complexes with a capacity of 5, 10 and 20 t/h, seed cleaning attachments for them (5 t/h), and then grain cleaning units (10 t/h) and a grain drying complex (5 t/h) began in 1962 [20].

![Image of grain cleaning and drying](image1)

**Fig. 7.** Cleaning and drying grain by sorting (in the foreground) and a grain cleaning unit (in the background).

The grain brought to condition was then stored in collective and state farm warehouses and elevators, the construction of which was actively carried out in the post-war period. In agricultural areas, new reinforced concrete elevators were erected, which ensured the acceptance, processing and storage of food grain intended for processing at flour mills (Figure 8). The capacity of such elevators reached 25 thousand tons. Unlike collective and state farm warehouses, grain at elevators retained its quality characteristics for a long time. Elevators provided agricultural producers with a full range of services: cleaning, drying, protection from moisture, insects and microorganisms, maintaining the required temperature, improving marketable condition, etc. [21]. The optimal option for storing grain was to comply with the following conditions: air humidity should be at the level of 60-75%, and the temperature should be within 12-15 °C or lower.

![Image of reinforced concrete elevator](image2)

**Fig. 8.** Reinforced concrete elevator.

## 4 Discussion

A complex technological chain: application of organic fertilizers – plowing – sowing – treatment of fields and crops with pesticides – harvesting – cleaning and drying – storage, which ensured grain production with minimal use of pesticides, was due to both technical
and technological reasons and the socio-political system of the USSR. Technical and technological reasons include the fact that the transfer of agricultural production to an industrial basis was slow. Wars, devastation, and a radical change in the peasant way of life and activity hampered the production and introduction of agricultural machinery, tools and mechanisms. This was especially true for the years 1918-1953, when the muscular strength of people and animals was often used. Only after the restoration of the national economy, a series of agrarian reforms, the production of heavy agricultural machinery and the construction of large agricultural structures, a mechanized “field-current-elevator” system was formed. Among the socio-political reasons, it is necessary to note the desire not only to catch up and surpass the United States and other capitalist countries, but also, most importantly, to provide our own population with high-quality bread and bakery products, and livestock farming with clean feed, free of chemical impurities, and preserve the environment.

These reasons restrained the growth of grain production in the USSR. As a result, the USSR gradually lagged behind China and the USA in terms of gross grain harvest (Table 2). The yield of grain crops in the USSR was significantly lower than in China and developed countries. So, in 1990 it was (c/ha): in China - 43.2, in the USA - 47.5, in Germany - 54.1, in Japan - 58.5, in France - 60.8, and in USSR - 20.1.

Table 2. Grain production (excluding legumes) in the largest countries of the world, million tons.

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>USA</th>
<th>USSR</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>107.0</td>
<td>163.6</td>
<td>118.8</td>
<td>87.4</td>
</tr>
<tr>
<td>1965</td>
<td>159.1</td>
<td>183.6</td>
<td>106.7</td>
<td>79.7</td>
</tr>
<tr>
<td>1970</td>
<td>197.6</td>
<td>186.9</td>
<td>167.0</td>
<td>113.9</td>
</tr>
<tr>
<td>1975</td>
<td>241.2</td>
<td>249.3</td>
<td>125.5</td>
<td>127.8</td>
</tr>
<tr>
<td>1980</td>
<td>277.2</td>
<td>269.9</td>
<td>170.4</td>
<td>140.5</td>
</tr>
<tr>
<td>1985</td>
<td>336.8</td>
<td>347.1</td>
<td>169.7</td>
<td>165.7</td>
</tr>
<tr>
<td>1990</td>
<td>401.9</td>
<td>312.4</td>
<td>209.1</td>
<td>193.9</td>
</tr>
</tbody>
</table>

5 Conclusions

The use of grain production technology in the USSR with minimal use of pesticides and chemical fertilizers was possible due to the following factors:

- Developed livestock farming (the number of animals in different years exceeded 100-200 million heads, which made it possible to annually produce and transport hundreds of millions of tons of organic fertilizers to the fields).
- Deep plowing (the use of crawler tractors with plows and skimmers made it possible to plow the soil to a depth of 20 cm, which led to the death of many roots and seeds of weeds and insects).
- Sowing on seeders with harrows (harrors loosened the soil and removed large roots and weed sprouts from it).
- Dosed spraying of soil and plants with pesticides (the rationing of the use of pesticides was due to the limitation of the scale of chemical treatments to the minimum level necessary to prevent product losses).
- Grain cleaning (harvested grain from the fields was cleared of plant stems and seeds, husks, soil and other impurities).
- Storage in warehouses and elevators (compliance with natural conditions was the main task of preserving the grain harvest).
External factors for the use of this technology were to provide the Soviet people with high-quality bread and bakery products, and livestock farming with clean feed without chemical impurities and the preservation of the environment.

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