# FARMING PRACTICES IN MOLDOVA FOR PREVENTING POLLUTION AND DEGRADATION OF THE ENVIRONMENT

**BORIS BOINCEAN**

Research Institute of Field Crops "Selectia" Balti, Calea Iesilor str., 28, 279200 Moldova, Republic of Moldova, selectia60@beltsy.md

**Abstract.** Agriculture of Moldova is at a crossroad. The technological approach to farm intensification based on increased inputs of nonrenewable sources of energy (mineral fertilizers, especially nitrogen, and pesticides) accompanied by reduced biodiversity in agroecosystems has led to many negative consequences in agriculture. Agriculture needs systemic changes at the level of the landscape and individual farms. Evidence is presented from long-term experiments carried out in Moldova since the 1960s at the Research Institute of Field Crops. "Selecţia" These results show the energy intensive nature of our agroecosystems and their long-term impacts in depleting soil organic matter. The use of fertilizers has covered up negative effects associated with intensive rotations on the productivity of crops. Gains due to breeding intensive varieties winter wheat have been less than expected. The use of crop rotations that include perennial forages, organic + mineral fertilizers can reduce the need for intensive agrochemical inputs. Only such changes can help to prevent, but not to control pollution and degradation of the environment. The key for a new approach to an intensive agriculture on a sustainable basis is the recognition of the soil as being a living organism and the crucial role of enhanced rotations and soil organic matter management.

**Keywords:** farming intensification, mineral fertilizers, soil management, crop rotation.

## 1. Introduction

The industrial approach to farm intensification taken since the 1960's in Moldova was based on increased inputs of nonrenewable sources of energy and their derivates (mineral fertilizers and pesticides). This development was supported by low prices for natural resources coupled with the lack of an economic mechanism for the evaluation of the negative consequences of human activity on the environment. Such consequences have aggravated the economic, ecological and social problems of our society. It neither possible to fully control such consequences without

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eradicating the causes of pollution and degradation of the environment, nor for the existing farming systems of Moldova to achieve sustainability without systemic changes. In order to make such changes in our agroecosystems we can choose to learn from natural ecosystems or, in other words, to use nature as a model. This means respecting a set of agricultural and ecological laws that have hitherto been largely ignored. A key issue for modern farming systems is to recognize soil as being a living organism and the significance of soil organic matter management and crop rotations. Soil revitalization programs would allow farmers to move toward more sustainable farming systems [1–5]. Experimental data obtained in the long term field experiments of the Research Institute of Field Crops "Selectia" (Balti, Republic of Moldova) has revealed some of the underlying principles of sustainability and the critical changes that are needed to transform our modern unsustainable farming systems.

## 2. Materials and methods

Research has been conducted in long-term field experiments with different crop rotations and permanent crops, with different systems of fertilization in crop rotation etc. on chernozem soils in the steppe region of Balti, located in the northern part of Moldova. These experiments have been conducted since 1962. They include eight, 10-field crop rotations which were unfolded in space and time. These crop rotations have a different level of saturation with row crops (from 40% up to 70%) including saturation by such crops as sugar beets ( from 10% up to 30%), corn (from 20% up to 40%), and sunflowers (from 10% up to 20%). The size for each experimental plot in crop rotation is 283 sq. m. The plots under permanent crops are without replications. They have been conducted since 1965. The size of the experimental plots under permanent crops is 450 sq. m. The systems of fertilization and soil tillage are different for different crop rotation, because they take into consideration the structure of each crop rotation.

An additional set of long-term experiments has been conducted since 1966. Different systems of fertilization in a six field crop rotation are studied. These are: no fertilization, three systems of mineral fertilization using increased rates of mineral fertilizers, six systems of organic + mineral fertilization using 10 and 15 tons of manure per hectare combined with similar increased rates of mineral fertilizers; and only manure fertilization and the residual action of manure in crop rotation. More details regarding the design of the experiments and conditions of conducting researches in these experiments can be found in our previous publications [6, 7].

## 3. Results and discussion

Compared with natural systems the agroecosystems have a deficit in their balance of energy. The annual deficit of energy even for crop rotation with perennial leguminous crop is 39.2%, compared with permanent black fallow on unfertilized plots (Table 3.1).

Permanent crops reduce the deficit of energy relative to black fallow, fertilized and unfertilized plots, up to 64.6–64.8%, but, the deficit still remains substantial. The input of energy includes the content of energy in crop residues and farmyard manure. The output of energy includes the content of energy in the yield of crops removed from the fields and the content of energy in uncompensated mineralizational losses of soil organic matter.

**Table 3.1.** The annual balance of energy in long-term field experiment with crop rotation and permanent crops, Beltsy, Moldova, average for 30 years, thousands mdj/ha.

| Variants | | Output | Input | Balance | |
|---|---|---|---|---|---|
| | | | | +/–, mdj/ha | The annual deficit (%) |
| Crop rotation with perennial leguminous crop | | 109.7 | 66.7 | –43.0 | 39.2 |
| Permanent crop fertilized | Winter wheat | 95.5 | 33.8 | –61.7 | 64.6 |
| | Corn for grain | 157.8 | 55.5 | –102.3 | 64.8 |
| Permanent black fallow | Fertilized | 26.9 | 4.4 | –22.5 | 83.6 |
| | unfertilized | 32.7 | – | –32.7 | 100 |

As a result, the annual uncompensated mineralization losses of soil organic matter remain also very high (Table 3.2).

**Table 3.2.** Annual losses of soil organic matter in the long-term field experiment of the Research Institute of Field Crops “Selectia”, average for 30 years, 0–20 cm layer of soil, t/ha.

| Variants | | Annual losses of soil organic matter, t/ha |
|---|---|---|
| Crop rotation with 30% of perennial leguminous crops, fertilized plots | | 0.45 |
| Permanent crops, fertilized plots | Winter wheat | 0.66 |
| | Corn for grain | 0.73 |
| Permanent black fallow | Fertilized | 1.17 |
| | Unfertilized | 1.42 |

The highest uncompensated mineralization losses of soil organic matter are typical for permanent black fallow on unfertilized and fertilized plots – 1.42 and 1.17 t/ha, respectively. In black fallow mineralization losses predominate especially on unfertilized plots, because the input of fresh organic matter is very limited in the absence of crops, and soil is tilled by mold board plow and regularly by cultivation which stimulates the mineralization of soil organic matter. The lowest losses of soil organic matter are in a crop rotation with perennial leguminous crops (0.45 t/ha). On this plot the input of fresh crop residues was the highest, and the intensity of soil tillage was low. But even in crop rotation with 30% of perennial leguminous crop the losses of soil organic matter exceed the gains.

Monocultures have had an intermediate losses of 0.66 and 0.73 t/ha, respectively for winter wheat and corn for grain. It is important to mention that from the total annual mineralization losses of soil organic matter the share of fresh crop residues and animal manure consists in crop rotation with perennial leguminous crops – 89%, but in permanent black fallow on fertilized plots only 55%.

The quality of soil (agrophysical, agrochemical and biological properties of soil) is determined in great extent by the amount of fresh organic matter added to the soil.

Enriching soils regularly with fresh organic matter helps both to cover the deficit of soil organic matter, to improve the quality of soils and to increase the level of yields for majority of crops in our long-term field experiment. At one point we interrupted all the experiments and planted a crop of winter rye to examine residual effects of different rotations. We found a direct correlation between the content of labile fraction of soil organic matter and the level of yields for winter rye harvested for green mass for unfertilized plots [6, 7].

The longer is the crop rotation the higher the yields. The 10 field crop rotations yielded more than the seven field crop rotation and, especially more than the monocultures. In other words, the higher the diversity of crops in the crop rotation the higher the productivity of individual crops (Table 3.3).

The crops that are most receptive to increased diversity in rotations are winter wheat and sugar beets both on fertilized and unfertilized plots. Crops of corn for grain, winter barley and sunflower are less influenced by decreasing the diversity of crops in rotation both on unfertilized and, especially, on fertilized plots.

We determined “the rotation effect” (the difference in yields for crops in crop rotation and in permanent cropping) by using data from Table 3.3 (Table 3.4).

The highest rotational effect, both on fertilized and unfertilized plots, was noticed for winter wheat and sugar beets. The rotation effect is less on fertilized plots, but still significant for most crops.

By utilizing crop rotations it is possible to reduce or even avoid use of mineral fertilizers and pesticides, which will prevent soil and water pollution.

**Table 3.3.** The yield of crops (t/ha) under the influence of their diversity in crop rotation in the long-term field experiments of the Research Institute of Field Crops "Selectia", 1994–2006, Balti, Republic of Moldova.

| Diversity of crops in crop rotations | Crops | | | | |
|---|---|---|---|---|---|
| | Winter wheat | Sugar beets | Corn for grain | Winter barley | Sunflower |
| | | | Fertilized | | |
| 10 field crop rotation | 5.3 | 44.6 | 5.8 | 4.1 | 2.1 |
| 7 field crop rotation | 4.5 | 41.0 | 5.9 | 3.6 | 1.8 |
| Permanent cropping | 3.1 | 20.6 | 5.6 | 3.8 | 1.5 |
| | | | Unfertilized | | |
| 10 field crop rotation | 4.9 | 36.2 | 5.4 | 3.3 | 2.0 |
| 7 field crop rotation | 4.0 | 26.9 | 5.3 | 2.5 | 1.5 |
| Permanent cropping | 2.2 | 10.2 | 3.9 | 2.0 | 1.5 |

**Table 3.4.** The "rotation effect" for different crops in the long-term field experiment of the Research Institute of Field Crops "Selectia", average for 1994–2006, t/ha and %.

| Crops | Without fertilizers | | With fertilizers | |
|---|---|---|---|---|
| | t/ha | % | t/ha | % |
| Winter wheat | 2.7 | 122.7 | 2.2 | 71.0 |
| Sugar beets | 26.0 | 254.9 | 24.0 | 116.5 |
| Corn for grain | 1.5 | 38.5 | 0.2 | 3.6 |
| Winter barley | 1.3 | 65.0 | 0.3 | 7.9 |
| Sunflower | 0.5 | 33.3 | 0.6 | 40.0 |

By increasing the diversity of crops in crop rotation and, especially, by using perennial crops with higher ability to restore soil fertility, it becomes possible simultaneously to prevent soil degradation under the influence of water and wind erosion. Keeping soil under permanent cover of living or dead mulch, as well as maintaining a good structure of the soil by less disturbance through soil tillage, are also crucial for sustainable land management.

We have expected a higher level of yields in the era of “green revolution” by increasing the production of new, more productive varieties and hybrids. Figure 3.1 shows the yields of one of the oldest varieties of winter wheat Odessa 51 and new, more productive varieties of winter wheat grown in different periods of time since 1962. The winter wheat varieties were grown side-by-side in a crop rotation after an early harvested predecessor (alfalfa on the third year, after first cutting). Each year one half of the field was sown with the variety Odessa 51 and the other half of the field was sown with new varieties registered in the Republic of Moldova. The difference in yield is very small. The fluctuations of yields under the influence of weather conditions are considerable higher for both types of varieties than the difference in yields between varieties.

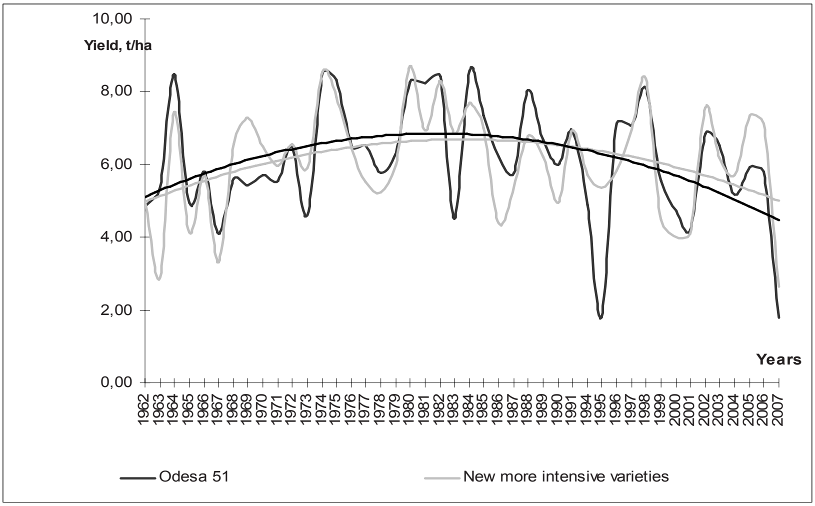


**Fig. 3.1.** The dynamics of yield for winter wheat (variety Odesa 51 and new more intensive varieties) in the long-term field experiment on crop rotations, 1962–2007, Research Institute of Field Crops “Selectia” Balti, Republic of Moldova (crop rotation N 5).

In another long-term field experiment with different systems of fertilization and crop rotations it was established that combined organic + mineral fertilization systems increased the yield of winter wheat by 1.5 t/ha, or 25–27% more yield than the control (Fig. 3.2). This means that 73–75% of the yield for winter wheat on the best fertilized plots was supported by basic soil fertility, mainly by mineralization of soil organic matter. On unfertilized plots 100% of the yield is derived from soil fertility. The fluctuations of yields under the influence of climatic conditions are significantly higher than the influence of fertilization.

These results show the importance of crop rotations and soil fertility for modern farming systems. Wise utilization of rotations and fertility would allow farmers not only to maintain and increase productivity of crops but also to cut the production expenditures, to prevent soil degradation and pollution of the environment.

Proper soil organic matter management can prevent also drought, which recently become a recurrent problem in the Republic of Moldova. Accomplishing this kind of change probably entails a change in mindset with a greater focus on sustaining a healthy, living soil through organic matter management and crop diversity.

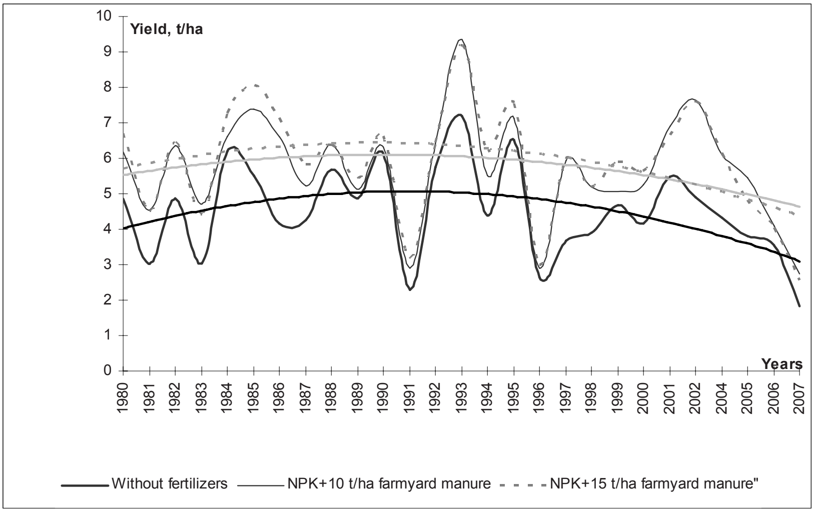


**Fig. 3.2.** The dynamics of yield for winter wheat (t/ha) in the long-term field experiment with different systems of fertilization, Research Institute of Field Crops "Selectia", 1980–2007.

## 4. Conclusions

The deficits of energy and soil organic matter associated with agroecosystems that include annual field crops and even perennial leguminous crop are very high. This makes these systems dependent on external inputs and vulnerable to unfavorable weather conditions.

The uncompensated annual losses of soil organic matter even in crop rotation with 30% of alfalfa consists in 0.5 t/ha. The higher the diversity of crops in crop rotation the higher the yields for the majority of crops.

"The rotation effect" is higher on unfertilized than on fertilized plots. Fertilization reduces the rotational effect, but it remain still high, especially for such crops as winter wheat, sugar beets and sunflower.

The share of basic soil fertility in yield formation on plots with optimal rates of organic + mineral fertilization on chernozem soils, is 73–75%.

The fluctuation of yields for winter wheat under the influence of climatic conditions are significantly higher than the influence of organic + mineral fertilization in crop rotation and especially more than the influence of new, more productive varieties of winter wheat.

Sustainable development of agriculture is possible only by restoring soil fertility and, in particular, soil organic matter as the integral index of soil fertility.

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