ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Selection of Winter Wheat Predecessors in Crop Rotations of the Volga Region Forest Steppe.

Alexander Leonidovich Toigildin*, Vladimir Ivanovich Morozov, ikhail Ilyich Podsevalov, Mikhail Yurievich Isaev, and Irina Aleksandrovna Toigildina.

Federal State Educational Institution of Higher Education "Ulyanovsk State Agricultural Academy named after P. A. Stolypin". Address: 1, Novy Venets Boulevard, Ulyanovsk, 432017, Russia.

ABSTRACT

The article is devoted to an evaluation of benefits and shortcomings of bare fallow in crop rotations. In practice its share is determined, first of all, by the intensification level and soil and climatic conditions. According to our data (on average for 12 years) winter wheat yielding capacity on bare fallow is higher than after peas by 0,7 t/hectare, but the grain yield "peas - winter wheat" increases in a crop rotation link by 1,02 t/hectare or 50,1%, besides it is necessary to consider ecological consequences from bare fallow. In this regard it is important to determine an optimum share ratio of bare and sown fallows in crop rotations. We offer a linear programming method with inclusion of indicators of production costs and productivity of links in grain yield in the model for the purpose of obtaining the maximum proceeds from sales of the products grown. The solution of a linear programming problem shows that an optimum ratio of predecessors for winter wheat in bare fallow: sown fallow according to our long-term data in the conditions of the forest-steppe of the Volga region was 0,4:0,6 respectively.

Keywords: winter wheat, selection of predecessors, modeling, linear programming.

***Corresponding author**

INTRODUCTION

Agricultural production is characterized as an open difficult dynamic system having a number of distinctive features the main of which is that it is a biological production and is connected with the soil, plants and live organisms.

Farming as system, is designed to solve a complex of the following problems: formation of yielding capacity of crops and production of plant growing output in amounts of public consumption, rational use of the land, management of soil fertility, environmental protection and creation of sustainable agrolandscapes.

A crucial element of the farming system is the structure of sown areas as it predetermines the specialization direction of the economy, production volumes and a variety of products of crop production, considering the situation on the market. The structure of sown areas is closely connected with the system of crop rotations. It should be noted that in modern farming a special function of a crop rotation consists in regulating a mode of organic substance at the expense of the biogenous resources created in agroecosystems. The crop rotation role increases in optimization of a phytosanitary condition of crops. The crop rotation is a succession analog – consecutive change of agrophyitocenosis in agrolandscape ecosystems. In this sense the crop rotation, from line items of an agroecosystem is considered as the main mechanism of its development, namely – biotic circulation of substance and transformation of energy. Here the ecological essence of a crop rotation is seen. The crop rotation is directly connected with the structure of sown areas that predetermines its economic essence [1, 2].

A grain farm - the leading industry of an agrarian sector of the economy the development of which determines success of the food market and food supply of the population. Grain production provides an essential part of proceeds from sales of products of agricultural industry therefore a rise in productivity, stability and efficiency of a grain industry - a priority objective in the farming systems of the region.

The purpose of this work was to develop an optimization approach of selecting predecessors for winter wheat as a leading grain crop for conditions of the Volga region forest-steppe of Russia.

RESEARCH TECHNIQUE:

Studying the yielding capacity of crops and efficiency of crop rotations was carried out in a stationary field experiment on the experimental field of the Ulyanovsk State Agricultural Academy. Experimental 6-course crop rotations (grain-fallow and grain-grass) have been studied since 2002, they are developed in space and in time, placed in 6 tiers by a method of split plots [3].

Long-term researches in stationary experiments allow us to use the modeling process entirely. To create a model the data were used by us which were obtained in experimental crop rotations on winter wheat which was placed after bare and sown fallows (in the article the data of a link are considered: bare fallow - winter wheat and peas - winter wheat).

Observations, accounting and analyses in the experiment were performed by commonly accepted techniques [4].

Mathematical processing of the obtained data was carried out by a method of linear programming [5, 6] and correlation and regression analyses.

RESULTS AND THEIR DISCUSSION

Formation of a grain yield of winter crops is substantially caused by timely emergence of seedlings and development of plants during the autumn period that is determined by a complex of factors. According to numerous data in the conditions of the Central Volga area the best predecessor for winter crops is bare fallow [7, 8, 9, 10].

With high farming standards, in the conditions of sufficient moisture supply, with optimization of the nutrient regime of the soil due to application of fertilizers, application of plant protection remedies, the role of bare fallow decreases, and from the point of view of economic efficiency its application is not reasonable. And though yielding capacity of winter crops on sown fallow in these conditions is lower, than on bare fallow, total efficiency of sown fallows is much higher than bare fallows, at the expense of fallow-grown crops.

Growing bumper crops of winter wheat on sown fallows is possible in the years with sufficient rainfall during the period July-August that provides timely and thick seedlings emergence therefore, the sowing of winter wheat can be made only on those sown fallows which accumulate enough moisture before sowing of winter crops.

Our calculations showed that yielding capacity of winter wheat in sown fallow (after peas) had a direct average dependence on the amount of rainfall during the period July-August of prior year (R=0,58) that is provided in fig. 1

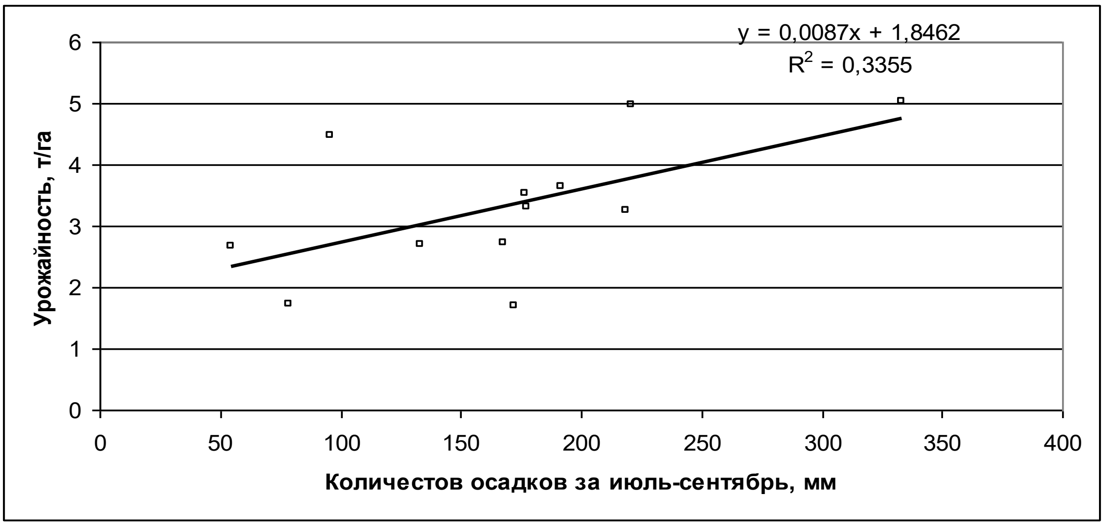

Fig. 1 - Dependence of winter wheat yielding capacity after peas on the amount of rainfall in a prior year (for 2003-2015)

In the conditions of the Volga region forest-steppe the valuable crops for growing in sown fallow are grain crops, leguminous crops , and one of the best is peas.

Crop succession is considered as a result from the general law of unity of plant organisms and their natural habitat. M. I. Sidorov [11] noted that "… crop succession in its influence on properties of the soil is similar to phytocenosis, but shows its action with time". On this basis of crop alternation the law of crop succession shall be based which is a scientific foundation of crop rotation.

Taking into account all the above-mentioned, it is possible to state that sown fallow should be considered as an alternative to bare fallow, and selection of species composition of predecessors will be determined by specific soil and climatic conditions.

The analysis of the obtained data in a stationary field experiment allowed us to reveal an average (r =-0,447) inverse relation of an increase of winter wheat yielding capacity on bare fallow (in comparison with peas) from the amount of rainfall during the period July-September. It has been found that with the amount of rainfall > 150 mm, for the specified period, distinctions in productivity of winter wheat on bare and sown fallow are minimized and do not exceed 0,6 t/hectare (fig. 2).

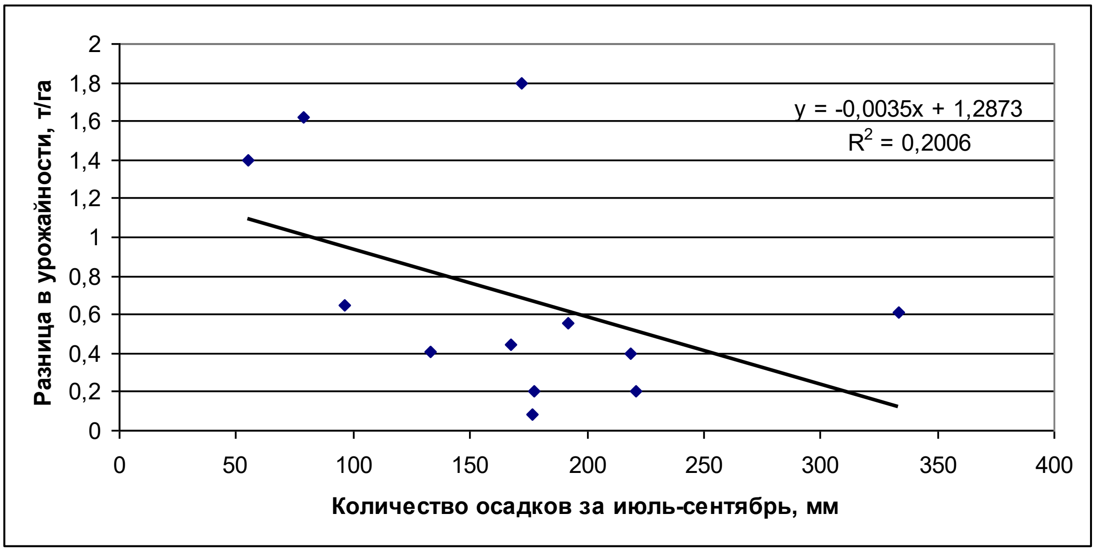

Fig. 2 Interrelation of winter wheat yielding capacity gain from bare fallow with an amount of rainfall in a prior year (for 2003-2015)

The analysis of winter wheat yielding capacity on bare fallow showed that it had changed from 3,09 to 5,65 t/hectare (there was a crop failure in 7,7% of years), at the same time the coefficient of variation was 19,7% that is characterized as an average variability. After peas the winter wheat yield varied from 1,72 to 5,04 t/hectare, with the coefficient of variation of 30,6%.

On average for 12 years of observations yielding capacity of winter wheat changed depending on predecessors from 3,31 to 4,01 t/hectare with an advantage of bare fallow by 0,7 c/hectare. Thus, yielding capacity of winter wheat on bare fallow was higher, than after sown fallow with peas and is steadier by years (table 1).

Table 1 – Yielding capacity of winter wheat and its variation on different predecessors for 2003-2015.

Predecessor	Average yielding capacity, 2003-2015	Variation of yields, t/ha		V, %
		min	max	
Not taking into account the year 2010 [1]				
Bare fallow	4,01	3,09	5,65	19,7
Sown fallow (peas)	3,31	1,72	5,04	30,6
Taking into account the year 2010				
Bare fallow	3,42	0,41	5,65	35,5
Sown fallow (peas)	2,86	0,16	5,04	43,7

[1]In 2009-2010 there was winter wheat crop failure in all predecessors. After re-sowing perished seedlings of spring wheat 0,16-0,41 t/ha of grain was harvested due to severe drought during vegetation of 2010.

This fact is explained by a higher moisture supply of winter wheat crops on bare fallow during sowing and autumn development. By means of correlation and regression analyses we established positive interrelation (r=0,633) between the content of productive moisture before sowing of winter wheat (x, mm) and grain yield of winter wheat (y, t/hectare) that is characterized by the regression equation: y = 0,025kh + 0,401.

Despite all that was mentioned, in an assessment of yielding capacity the essential advantage of crop rotation links with peas is emphasized. According to our data the yield of grain units in a link with peas was 3,02 thousand/hectare that it was more than in a link with bare fallow by 1,02 thousand/hectare (tab. 2).

Table 2 – Efficiency of crop rotation links with winter wheat for 2003-2015. (according to the data of the field experiment)

№	Crop rotation link	Yielding capacity of peas, t/ha	Yielding capacity of winter wheat, t/ha	Grain yield units, thous./ha	V, %
1	Bare fallow – winter wheat	-	4,01	2,00	19,7
2	Peas – winter wheat	1,95	3,31	3,02	26,0

Modeling of farming systems and its elements is based on economic-mathematical methods, however they are applied not often, though there is a certain experience of their development and deployment [12].

One of the optimization methods of the structure of sown areas is the linear programming problem solution [13].

Goal setting reduced to determination of an optimum crop rotation link (with bare and sown fallows), a share of bare fallow as a predecessor of winter wheat which would provide the maximum cash revenue from grain products produced in a crop rotation link.

The economic-mathematical model was developed for the solution of this problem. The values to be found in it were acreage of winter wheat in links with bare fallow and sown fallow (x_1, x_2).

x_1-acreage of bare fallow - winter wheat;

x_2 -acreage of peas - winter wheat;

Restrictions of the problem were made up of the conditions describing the structure of sown areas of grain crops and reflecting cultivation conditions and also in calculation of technical and economic indicators. The general size of a problem consisted of two variable and the most significant conditions-restrictions. The indicator - receipt of proceeds from sales of grown products in crop rotation links was taken as the objective function. Such indicators as production costs, yielding capacity of winter wheat and grain yield in a crop rotation lin, loss of humus, accumulation of moisture before sowing, a projective cover of the soil (table 3), was taken as limiting factors.

Table 3 – Original data for constructing an optimization model of a crop rotation link with winter wheat

№	Indicators	Bare fallow – winter wheat	Peas – winter wheat	Scopes of restraints
1	Production expenditures, thous.rub./ 1 ha	15,1	27,5	Not more 25,0
2	Grain yield, t/ha	2,00	3,02	Not less 2,5
3	Income from the output sale, thous. rub. from1 ha	23,6	40,8	Objective function tends to max

The purpose of a problem reduced to determination of such share of bare and sown fallows as predecessors for winter wheat which would provide the maximum value of the function:

$F(X) = 23{,}6\ x1+40{,}8\ x2 \rightarrow \max$
under following conditions:
on total area of the arable land:
$x1+x2=1$
on addition of production costs:
$15{,}1x1+27{,}5x2\leq 25{,}0$
on production of grain products:
$2{,}00x1+3{,}02x2\geq 2{,}5$
$4{,}01x1+3{,}31x2\geq 3{,}65$

As a result of the problem solution the area of admissible decisions was constructed, i.e. the system of inequalities is solved graphically. Straight lines have been constructed for this purpose and half-planes set by inequalities have been determined.

As a result of the straight line creation answering the value of function F = 0: F = 23,6x1+40,8x2 = 0 and creation of the vector gradient constituted from coefficients of the objective function the direction of maximization F(X) is specified.

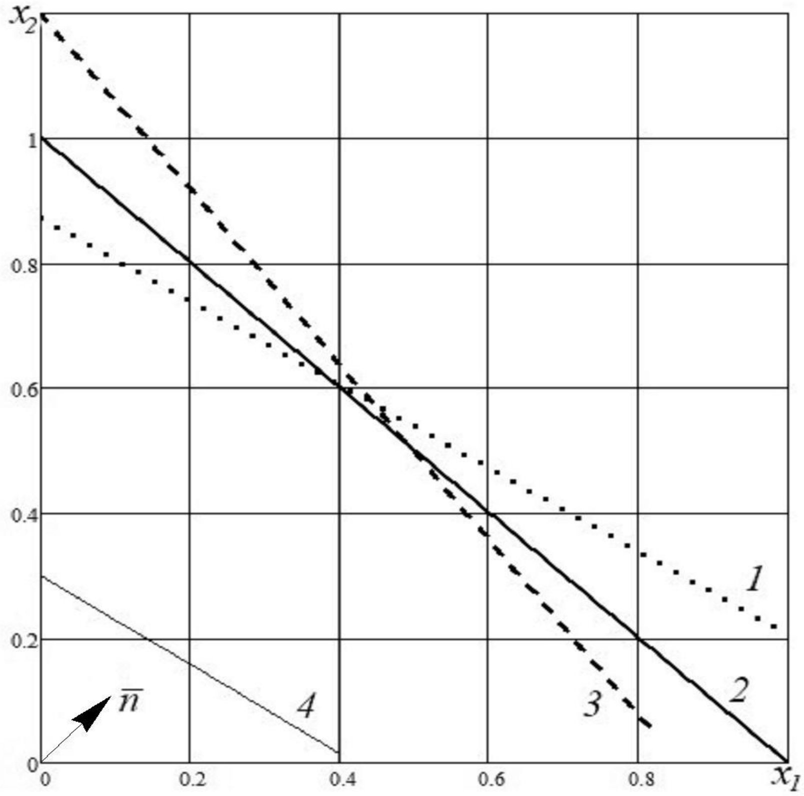

Fig. 3 – Graphic representation of the problem solution

1 solution of the equation on optimization of production costs.
2 share x_1 – of bare fallow; x_2-fallow sown with peas.
3 solution of the equation on production of grain products from the unit area

Straight line F(x) = const crosses the area in point A. Since point A has been obtained as a result of crossing the straight lines (1) and (3), its coordinates satisfy the equations of these straight lines (fig. 3):

x1+x2=1
2,00x1+3,02x2≥2,6
Having solved the system of equations, the values have been obtained: x1 = 0,4, x2 = 0,6
From where the maximum value of the objective function is found:
F(X) = 23,6*0,4 + 40,8*0,6 = 33,9

The amount of the planned cash revenues from sales of grain products can be 33,9 thousand rubles from 1 hectare.

Thus, the solution of a linear programming problem shows that the optimum ratio of bare and sown fallow as predecessors of winter wheat according to long-term field studies in the conditions of the Volga region forest-steppe is 0,4:0,6 respectively.

ISSN: 0975-8585

REFERENCES

[1] Morozov V. I. Biologization of crop rotations and their synergetic efficiency in fertility management of the Volga region forest-steppe / V. I. Morozov//the Bulletin of the Ulyanovsk State Agricultural Academy. 2012. No. 1. pp. 36-40

[2] Loshakov V. G. Crop rotations and fertility of the soil / V. G. Loshakov//-M.: Publishing house VNIIA, 2012. - 512 pages.

[3] Morozov, V. I. Field experiment as a method of knowledge and practical development of innovative technologies / V. I. Morozov, A. L. Toigildin//the Bulletin of the Ulyanovsk State Agricultural Academy. –2012. – No. 1. – (17). – pp. 40-44.

[4] Kiryushin, B. D. Fundamentals of scientific research in agronomy / B. D. Kiryushin, R. R. Usmanov, I. P. Vasilyev//M.: Kolos S, 2009. - 398 pages.

[5] Svetlov N. M. Stochastic models of dynamic programming for crop rotation optimization and their use in the system of models of advance planning of production structure of agricultural enterprises. M, 1997. – 8 pages.

[6] Orlova, I.V. Economic-mathematical modeling: Practical manual for problem solution. - M.: High school textbook, 2004. – 144 pages.

[7] Potushansky, VA. Winter wheat in the forest-steppe of the Volga region / I. F. Timergaliyev, S. N. Nemtsev//-Ulyanovsk, 2003, 86 pages.

[8] Asmus, A. A. Biologization of crop rotations and productivity of fallow links with winter wheat on leached black soil of the Volga region forest-steppes / A.A Asmus// Abstract of the PhD thesis/ the Samara State Agricultural Academy. Kinel, 2009.

[9] Adaptive and landscape system of farming of the Ulyanovsk region. – Ulyanovsk: LLC Kolor-Print, 2013. - 354 pages.

[10] Pleskachev, Yu.N. About crop rotations in Nizhny Volga region / Yu.N. Pleskachev, A. N. Sukhov//Agriculture, 2013, No. 2, pp. 3-5

[11] Sidorov, M. I. Scientific and agrotechnical bases of crop rotations / M. I. Sidorov, N. I. Zezyukov//Voronezh, 1993. - 104 pages.

[12] Frumin Igor Lazarevich. Modeling of farming in Southern TransUrals: Abstract of the doctoral thesis in agriculture:06.01.01- General farming: / I. L. Frumin//Chelyabinsk, 2004, 40 pages.

[13] Obraztsov, A. S. A systemic method: application in farming/A.S. Obraztsov, A. V. Obraztsov//– M.: Agropromizdat, 1990.