

## Optimization of Production and Realization of Main Types of Crop Products on the Basis of Modeling

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**Abstract:** In the study, the problems of optimization of production and implementation of crop culture of the Kyrgyzstan are considered. In order to solve this problem, the methods of economic and mathematical modeling are used. The estimates of the volumes of production and sales of crop products sales are shown. The ways of increase in production of high-quality domestic production its storage and conversion are offered.

**Key words:** Crop production, production, implementation, forecasting, optimization, domestic production

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### INTRODUCTION

At present there are not generally recognized methods that would allow forecasting the development of manufacture of products with satisfactory precision. It should be noted that strengthening of economic freedom of participants of the reproduction process at the level of regions predetermines probabilistic image or economic processes that take place in various spheres and leads to application of the scenario, approach and multi-variant alternative ways of search for solutions. In order to solve this problem it is offered to use the methods of economic and mathematical modeling and of multi-level statistical analysis-one of the main tools of economic mechanisms's progress, structural transformation of a regional market and forecasting of dynamics of production and realization of products. The changes that take place in modern economy lead to appearance of new and improvement of existing systems of economic and mathematical modeling. All this allows determining hidden reserves of economic growth of organizations at regional level. A variety of economic and mathematical models is optimization model. Its use allows analyzing the dynamics of development of region's organizations and using large volumes of real information. We offer the model of optimization of production of agricultural goods that will allow an enterprise to raise profitability of its production.

**Literature review:** Increasing the crop production is one of the most important tasks for development of the country's agriculture which is shown in the research (Sulaimanova, 2015). Increasing the quality of agricultural products is very important for the national economy. The

most important condition for increasing the economic effectiveness of production is improvement of the quality of agricultural products which is viewed by Sulaimanova (2015).

The issues of providing the population with high-quality food products and improvement of the sugar technology with the use of hybrids are viewed in the research (Mamaturdiyev *et al.*, 2015; Sulaimanova, 2015). The literature overview showed that the problem of crop production in agriculture in the globalizing economy was studied in a lot of research which lead to the decision that it is necessary to raise the sustainable development of crop-producing cultures that lead to increase of crop yield and quality of products. In the structure of the methodology of this research an important role belongs to economic and mathematical modeling.

### MATERIALS AND METHODS

At present, financial and economic state of agricultural organizations of various forms is rather complex. Negative influence on financial and economic state of agricultural organizations is performed by the following factors: increase of physical and moral ageing of main production funds reduction of yield of crops as a consequence of decrease of mineral fertilizers due to lack of money reduction of the volumes of production of various agricultural goods and their sales low volumes of investments into the infrastructure of production and social purpose insufficient provision by specialists, lack of qualification and use by production researchers; reduction of technical equipment of agricultural manufacturers.

Table 1: Production and realization of fruit and berries in Kyrgyzstan

Fruit and berries (thous.ton)	2010	2011	2012	2013	2014
Production	193.1	215.1	222.7	233.6	237.0
Realization	119.4	135.3	151.6	169.5	150.7

Compiled by the researcher according to the magazine "Agriculture of Kyrgyzstan", 2015

We receive maximum profit due to realization of agricultural goods it is a criterion of optimization. It is a targeted function. This preference is backed by the fact that profit is one of the significant indicators of financial and economic effectiveness in activity of agricultural enterprises. This allows ensuring optimal application of existing production resources and increasing profitability (Table 1).

Based on economic and mathematical modeling, socio-economic systems and processes are described in the form of economic and mathematical models that should be treated as a product of the process of economic and mathematical modeling; economic and mathematical methods are used as the main tools. Based on statistical data and the curve it is possible to see that dependence between the volume of fruit and berries and the viewed period of the environment is close to the power function. Based on the Least Square Method (LSM) we receive the trend equation of the type:

$$y = 194,38 * t^{0.128} \tag{1}$$

In this formula (Eq. 1), by substituting t by 1-5 we receive estimated values of the volume of production of fruit and berries:

$$y_{p(2010)} = 194.38; y_{p(2011)} = 212.4141; y_{p(2012)} = 223.7294; y_{p(2013)} = 232.1214; y_{p(2014)} = 238.847 \tag{2}$$

During transition from factual value (y) of volume of production of fruit and berries to the estimated value, calculated with the formula (Eq. 2), the error is allowed that equals:

$$\varepsilon = \frac{1}{5} \sum \frac{|y_{\phi} - y_p|}{y_{\phi}} 100\% = \frac{1}{5} (0.006629 + 0.012487 + 0.004622 + 0.006329 + 0.007723) 100\% = 0.76\%$$

Due to smallness of the error of approximation, the Eq. 1 could be used for performing estimates for the next 10-15 years. Before determining the estimates it is necessary to show statistical substantiation of trend (Eq. 1). For this purpose, let us determine the index of correlation  $S_{yt}$  for linear regression with the following formula:

Table 2: Estimated volume of production of fruit and berries (thous.tons)

Years	Volume of production of fruit and berries (forecast)	Confidence intervals	
		Upper	Lower
2015	244.4865	246.3446	242.62850
2016	249.3588	251.2539	247.46380
2017	253.6571	255.5849	251.72920
2018	257.5109	259.4680	255.55380
2019	261.0067	262.9904	259.02302

Compiled by the researcher

$$S_{yt} = \sqrt{1 - \frac{\sum (y - \bar{y}_p)^2}{\sum (y - \bar{y})^2}} \tag{3}$$

where,  $\bar{y} = 220.3$  and  $\bar{y}_p$  is calculated with the Eq. 2.  $\sigma_y^2 = \sum (y - \bar{y}_p)^2$  total dispersion of resulting quality  $\bar{y}$ , a  $\sigma_{re}^2 = \sum (y - \bar{y})^2$  residual dispersion is calculated on the basis of regression Eq. 1 then, based on Eq. 3, let us calculate  $s_{yt} = \sqrt{0.9879} = 0.994$ . Knowing the determination coefficient  $s_{yt}^2 = 0.988$  let us determine factual value of the F-criterion:

$$F = \frac{S_{yt}^2}{1 - S_{yt}^2} (n - 2) = \frac{0.988}{1 - 0.988} 3 = 247$$

The F-criterion is compared to the table value.  $F_{table}(d; k_1; k_2) = F_{table}(0.05; 1.3)$ , hence,  $F_{\phi} = 247 > F_{table} = 10.13$  that's why trend Eq. 1 is statistically significant. That's why it is possible to perform estimates on the basis of this equation:

$$y_{pr(2015)} = 244.4865 \text{ (thous.ton)}; y_{pr(2016)} = 240.3588 \text{ (thous.ton)} \\ y_{pr(2017)} = 253.6571 \text{ (thous.ton)}; y_{pr(2018)} = 257.5103 \text{ (thous.ton)} \\ y_{pr(2019)} = 261.0067 \text{ (thous.ton)} \tag{4}$$

In view of approximation error it is possible to determine confidence intervals of the forecasted indicator of the volume and estimates of the volume of production of fruit and berries (Table 2). Thus, the resulting indicator of the volume of production of fruit and berries for the period of 2015-2019 can change in such interval. This allows for effective planning and management of the studied object.

Let us view optimization of the volume of realization of fruit and berries. According to the data of sales volume of fruit and berries in Table 3, the viewed 5 types of trend equation are statistically insignificant as all determination coefficients  $R^2$  are very low thus we applied the method of leveling, i.e., statistical method of forecasting. The most popular procedure of leveling is the method of simple sliding average. First of all leveling interval (g) is determined for the time row.

**Table 3: Result of time row leveling (thous.ton)**

Variables	2010	2011	2012	2013	2014
Leveled time row	119.3	135.4	152.2	157.3	156.85

Compiled by the researcher

For first (g) levels of the time row their average arithmetic value is determined. This will be a leveled value of the row level in the medium interval of leveling then the interval moves by one level to the right. Calculation of mean average, etc. is repeated. As a result of such procedure we obtain a range of leveled values at that, depending on Eq. 2, first and last levels are lost. Performing leveling for the interval  $g = 3$  and applying the method of simple leveling we have good results in dynamic rows with linear tendency. The result of time row leveling is given in the following Table 3. Based on this data, only the linear trend equation  $\bar{x}_t = a+bt$  is used. Applying the least square method as to  $a$  and  $b$  we receive the system of two equations with two variables in the general form after certain calculation we receive a normal system of equations and determine that  $a = 115.055$ ;  $b = 9.715$ . Then, the linear trend equation has the following form:

$$\bar{x}_p = 115.055+9.715t \tag{5}$$

Based on this equation, let us determine the following estimated values:

$$\begin{aligned} \bar{x}_{p(2010)} &= 124.775; \bar{x}_{p(2011)} = 134.485; \bar{x}_{p(2012)} = 144.2; \\ \bar{x}_{p(2013)} &= 153.915; \bar{x}_{p(2014)} = 163.63 \end{aligned} \tag{6}$$

Let us determine errors of approximation (Eq. 6) with the following equation:

$$\begin{aligned} \epsilon_n &= \frac{1}{n} \sum \frac{|x_\phi - \bar{x}_p|}{x_\phi} 100\% = \frac{1}{5} \\ &\left( \frac{0.0458+0.006758+0.05256+}{0.0215194+0.043226} \right) 100\% = 34\% \end{aligned}$$

So, the approximation error equals 3.4%. The number 3.4% shows that such approximation could be used during forecasting of efficient indicator. The theory proves that if approximation error deviates from 0-10% they could be used in practical calculations. It is possible to determine projected values in practical calculations. It is possible to determine projected values of the resulting indicator volume of realization of fruit and berries for 2015-2019. For that let us put 6-10 into Eq. 6 instead of  $t$ , we receive the following estimates for 2015-2019:

$$\begin{aligned} x_{pr(2015)} &= 173.34 \text{ (thous.ton)} \\ x_{pr(2016)} &= 183.06 \text{ (thous.ton)} \\ x_{pr(2017)} &= 192.775 \text{ (thous.ton)} \\ x_{pr(2018)} &= 202.495 \text{ (thous.ton)} \\ x_{pr(2019)} &= 212.205 \text{ (thous.ton)} \end{aligned} \tag{7}$$

We see that the volume of realization of fruit and berries will grow by 9.715 thous.ton for these years. According to the determined volumes of production and realization of fruit and berries, let us determine the estimated volume of consumption of fruit and berries which will equal:

$$\begin{aligned} z_{pr(2015)} &= 71.1225 \text{ (thous.ton)} \\ z_{pr(2016)} &= 66.7988 \text{ (thous.ton)} \\ z_{pr(2017)} &= 608821 \text{ (thous.ton)} \\ z_{pr(2018)} &= 55.02 \text{ (thous.ton)} \\ z_{pr(2019)} &= 48.8 \text{ (thous.ton)} \end{aligned}$$

Hence, the consumption volume in 2019 as compared to 2015, decreases by 68.6%. This means that if fruit and berry are realized in such form, food security will not be provided for these types of products. Production of fruit and berries constitutes 220, 300 tons on average. Ways of increase of domestic gardens and berry beds, preservation and processing of fruit and berries. Under the conditions of market economy it is necessary to reconsider the direction of the Sphere's development in favor of quicker return of investments by means of realization of organizational and economic measures that provide increase of production volumes of fruit and berries for manufacturers. It is necessary to do the following: develop adapted sorts and technologies of fruit and berries increase volumes of production and improve qualities of planting material implement highly specialized fruit farms and nurseries of market direction.

In fruit cropping, the most important resource potential is variety assortment of fruit plants which is used with insufficient effectiveness as profit of certain sorts of a hectare of plants could differ by 2-3 times and more together with good ecological adaptation to local conditions and high quality of products, the sorts should have a complex of economic and biological qualities that stimulate satisfaction of people with fruit all year long. For the purpose of increasing the level of self-provision with fruit and product of their processing and provision

**Table 4: Production u realization of vegetables and gourds in Kyrgyzstan**

Vegetables and gourds (thous.ton)	2010	2011	2012	2013	2014
Production	969.400	972.50	1059.200	1077.300	1119.900
Realization	628.815	778.68	678.621	707.203	764.808

Compiled by the researchers on the basis of the journal "Agriculture of Kyrgyzstan" (2015)

of manufacturer’s protection from Foreign rivals, the measures of state support for national production and creation of a specialized market are necessary.

The market of fruit and berries starts to form in the country but the level of economic effectiveness of manufacture of fruit and berry products should influence the development of the processing industry of juice and canned fruit and stimulate expansion of assortment of fruit and berry infant food. Let us view the task of optimization and forecasting of vegetables and gourds. The following Table 4 was developed on the basis of statistical data of the committee "Agriculture of Kyrgyzstan" (2015). Based on statistical data on the plane  $to_{x_1}$ , let us built a curve consisting of five points. Analyzing 5 production functions, we see that the most convenient is the linear trend equation of the type:

$$x_1 = a+bt \tag{8}$$

For determining the parameters let us use the least square method the results are  $b = 40.58$ ;  $a = 917.92$ . Then, the trend equation has the following form:

$$\hat{x}_{1p} = 917.92+40.58t$$

We have to show statistical significance of this equation. In order to evaluate the quality of selection of the linear function, square of the linear coefficient of correlation  $s_{x_1}^2$  is calculated which is called determination coefficient then we calculate the share of dispersion of the resulting quality  $x_1$ , explained by regression in the total dispersion of resulting quality  $x_1$ . For this purpose, let us determine estimated values of production of vegetables and gourds for the viewed period of 2010-2014:

$$\begin{aligned} \hat{x}_{1p(2010)} &= 958.5; \hat{x}_{1p(2011)} = 999.08; \hat{x}_{1p(2012)} = \\ &1,039.66; \hat{x}_{1p(2013)} = 1,080.24; \hat{x}_{1p(2014)} = 1,120.92 \end{aligned} \tag{9}$$

Knowing factual value  $x_{1\phi}$  and estimated values  $\hat{x}_{1p}$ , we calculate:

$$\begin{aligned} S_{res}^2 &= \frac{1}{n} \sum (x_{1\phi} - \hat{x}_{1p})^2 = \frac{1}{5} \\ &\left( 118.81+702.25+442.6816+ \right. \\ &\left. 8.6436+0.8464 \right) = 254.6432 \end{aligned} \tag{10}$$

Then let us calculate:

$$\begin{aligned} S_{x_1}^2 &= \frac{1}{n} \sum (x_{1\phi} - \bar{x}_1)^2 = \frac{1}{5} \\ &\left( 4,933.6576+4,507.7796+ \right. \\ &\left. 382.5936+1,418.275+6,441.6676 \right) = 3,536.8548 \end{aligned}$$

Then the determination coefficient will have the following form:

$$S_{bx_1}^2 = 1 - \frac{r_{OCT}^2}{r_{x_1}^2} = 1 - \frac{254.6432}{3,536.8548} = 0.93$$

Accordingly, the value  $1-s_{bx_1}^2$  characterizes the share of dispersion  $x_1$  caused by other factors of the model. After the equation of the linear regression is determined, significance of the equation and its parameters is assessed. In order to have an idea on the quality of the model based on relative deviations, let us determine average error of approximation:

$$\begin{aligned} \epsilon_n &= \frac{1}{n} \sum \frac{|x_{1\phi} - \hat{x}_{1p}|}{x_{1\phi}} 100\% = \frac{1}{5} \\ &\left( 0.0112445+0.027382+0.018448+ \right. \\ &\left. 0.002729+0.000822 \right) 100\% = 1.21\% \end{aligned} \tag{11}$$

The significance of equation of regression is determined on the basis of F-criterion:

$$F_F = \frac{r_{bx_1}^2}{1-r_{bx_1}^2} (n-2) = \frac{0.93}{0.08} 3 = 39.86$$

This factual value of F-criterion is compared to  $F_{table} = 10.13$ . As  $F_F = 39.86 > F_{table} = 10.13$ , trend Eq. 8 is statistically significant as based on this equation we can perform estimates based on trend Eq. 8, let us determine projected values:

$$\begin{aligned} x_{1pr(2015)} &= 1,161.4; x_{1pr(2016)} = 1,201.98 \\ x_{1pr(2017)} &= 1,242.56; x_{1pr(2018)} = 1,283.14 \\ x_{1pr(2019)} &= 1,323.72 \end{aligned} \tag{12}$$

Hence, production of vegetables and gourd in 2019 as compared to 2010 will grow by 36.6% and starting from 2014 by 18.2% for the planned period, the growth rates constitute 3.7, 3.5, 3.4, 3.3 and 3.2%. Increase of production of vegetables and gourd depends on certain factors: increase of crop of vegetables and gourds takes

Table 5: Volume of production of cereal crop and potato in Kyrgyzstan (thous.ton)

Production	2010	2011	2012	2013	2014
Cereal cultures	1,583.8	1,580.7	1,438.3	1,813	1,443.9
Potato	1,339.4	1,379.2	1,312.7	1,332	1,320.7

Compiled by the researcher on the basis of journal "Agriculture of Kyrgyzstan" (2015)

Table 6: Confidence intervals of the forecasted indicator

Years	Confidence intervals	
	Lower	Upper
2015	1,466.740	1,666.319
2016	1,465.730	1,665.167
2017	1,464.850	1,664.171
2018	1,464.080	1,663.290
2019	1,463.385	1,662.505

Compiled by the researcher

place with application of Zirkon to the seeds. This product allows increasing crop by 7 ton/ha, thus, increasing yield by 18.6%. Zirkon can be used for processing seeds and plants also in many countries, seeds and plants are treated with Epin-extra and Zircon. Application of these products allows weakening negative influence of pesticides on plants. The main role in increase of yield of agricultural crops belongs to correct treatment of plants, timely preparation of soil, application of organic and mineral fertilizers, irrigation, tillage, further use of high-quality seeds, favorable climatic conditions and wise location of areas for planting some or other agricultural crops. One should not underestimate the roles of bees in increase of yield pollination is required for 150 cultures including vegetables, gourd, cotton and cereal plants, etc. (Table 5). Based on the cereal crop presented in Table 6, we see that out of five various functions the most optimal one is logarithmic function. We studied the trend equation of the form:

$$\hat{y}_p = a + blnt$$

Bringing this equation to the linear type and applying the least square methods while passing to the initial trend equation, let us determine trend equation of the type:

$$\hat{y}_p = 1,579.1 - 7.016lnt \tag{13}$$

With the help of this equation, let us determine the following estimated values:

$$\begin{aligned} y_{p(2010)} &= 1,579.1; y_{p(2011)} = 1,574.237 \\ y_{p(2012)} &= 1,571.392; y_{p(2013)} = 1,569.374 \\ y_{p(2014)} &= 1,567.808 \end{aligned} \tag{14}$$

Knowing factual and estimated values, let us determine evaluations of approximation:

$$\begin{aligned} \epsilon_n &= \frac{1}{n} \sum \frac{|y_\phi - \hat{y}_p|}{y_\phi} \cdot 100\% = \frac{1}{5} \\ &\left( \frac{0.002968 + 0.004089 + 0.092534 + 0.134377 + 0.084313}{0.134377 + 0.084313} \right) 100\% = 6.37\% \end{aligned} \tag{15}$$

The number 6.37 shows that such error could be used during forecasting of the efficient indicator volume of cereal crop production for 5 years. Let us determine projected values of the resulting indicator volume of cereal crop production for 2015-2019 for that, we insert Eq. 6-10 into the trend Eq. 11 instead of t:

$$\begin{aligned} y_{pr(2015)} &= 1,566.529 \text{ (thous.ton)} \\ y_{pr(2016)} &= 1,565.447 \text{ (thous.ton)} \\ y_{pr(2017)} &= 1,564.511 \text{ (thous.ton)} \\ y_{pr(2018)} &= 1,563.684 \text{ (thous.ton)} \\ y_{pr(2019)} &= 1,562.945 \text{ (thous.ton)} \end{aligned} \tag{16}$$

In view of approximation error it is possible to determine confidence intervals of the forecasted indicator (Table 6). Thus, the resulting indicator volume of cereal crop production for the planned period of 2015-2019 can change in these intervals. This shows that manufacturers have to use this effect in further planning and management. For the planned period, the volume of cereal crop production reduces very slowly. Growth rates of the volume of cereal crop production constitute: 0.069; 0.053; 0.075%, i.e., they decrease annually by 1.082; 0.936; 0.83; 0.79 thous.ton. Hence, it is necessary to develop measures for increase of cereal crop yield. Increase of corn production has been the main task of agriculture. Implementation of new progressive technologies allows receiving stable yields of cereal crop even under unfavorable climatic conditions as most crop areas in Kyrgyzstan are situated in the zones of risky agriculture. Cereal cultures require a lot of mineral and organic fertilizers.

## RESULTS AND DISCUSSION

It is necessary to increase sustainable development of cereal crop that leads to growth of yield and quality of products as well as increase of sustainability of plants to abiotic processes. According to many scholars, application of growth regulators that stimulate increase of non-specific immunity of agricultural crops is very

important among such regulators, the most popular ones are Epi-extra and Zirkon. It is recommended to apply these products to Spring and Winter wheat treatment of plants at the stage of wheat growth raises field survival by 10-12% increases the number of efficient stalks, number of grains and their weight by 0.5-2.8 g which leads to increase of yield by 12-20% (Winter wheat 17-57 hundred W/ha).

For Spring wheat (15-29 hundred W/ha), share of protein and fibrin grows by 1.5-2.5% its quality grows, number of empty grains decreases, vulnerability to root rots reduces and plant's sustainability to brown rust grows. Let us view the main ways of increase of production and cheapening of corn production. The main ways of increase of effectiveness of corn production are the following: reserves of increase of production increase of corn quality and measures for their use. Determination of reserves of increase of plant production should be done for the following directions: expansion of plant areas, improvement of their structure and increase of yield of agricultural crops.

The next step is increase of quality of plant products and increase of commodity qualities which allows selling the products for higher price and receiving additional profit. Application of intense technologies of production leads to growth of yield of agricultural crops and increase of its gross output. Reduction of grain losses at the stages of production and processing leads to growth of grain production. Based on crop rotation it is possible to increase grain yield. A significant factor influencing the yield of agricultural cultures is implementing high-yield zones sorts and high-quality seed material and optimal selection of seeds allows for a 15% increase of crop.

Another important factor that increases the yield of agricultural crops is science-based method of effective application of mineral and organic fertilizers, equipment, work force and other production means. An important condition of obtaining high and stable crops is conduct of agro-technical measures within optimal terms. Lack of technology and professionals leads to crop losses. Let us view optimization and forecasting of potato on the basis of statistical data of the volume of potato production Table 4. According to these data, we performed research and determined results of trend logarithmic equations of the following type:

$$\bar{x}_p = 62.06 - 6.89 \cdot \ln t \tag{17}$$

Out of these 5 viewed equations, the most optimal is the following. Based on this equation, estimated values of the following types are calculated:

$$\begin{aligned} \bar{x}_{p(2010)} &= 1,354.4; \bar{x}_{p(2011)} = 1,341.674 \\ \bar{x}_{p(2012)} &= 1,334.229; \bar{x}_{p(2013)} = 1,328.948 \\ \bar{x}_{p(2014)} &= 1,324.851 \end{aligned} \tag{18}$$

Knowing factual and estimated values of the volume of potato production, let us determine the approximation error:

$$\begin{aligned} \epsilon_n &= \frac{1}{n} \sum \frac{|x_\phi - \bar{x}_p|}{x_\phi} 100\% = \frac{1}{5} \\ &\left( \frac{0.011199 + 0.027209 + 0.016401}{+0.002292 + 0.003143} \right) = 1.20\% \end{aligned}$$

These corresponding statistical parameters show that the built equation of regression Eq. 15 could be used before forecasting the resulting indicator. Based on trend logarithmic equations, let us determine projected values of the volume of potato production:

$$\begin{aligned} x_{pr(2015)} &= 1,321.503 \text{ (thous.ton)} \\ x_{pr(2016)} &= 1,318.673 \text{ (thous.ton)} \\ x_{pr(2017)} &= 1,316.221 \text{ (thous.ton)} \\ x_{pr(2018)} &= 1,314.059 \text{ (thous.ton)} \\ x_{pr(2019)} &= 1,312.125 \text{ (thous.ton)} \end{aligned} \tag{19}$$

For the planned period, the volumes reduce annually by: 3.35; 2.83; 2.452; 2.162; 1.934 (thous.ton). Let us perform a study for optimization of the volume of potato and grain production in Zhalal-Abad Oblast (Table 7). Compiled by the researcher according to the magazine "Agriculture of Kyrgyzstan", 2015. Based on statistical data of the volume of potato production and as a result of application of least square method we have determined coefficients of trend equations as a result, the trend equation will have the following form:

$$x_{ip} = 1.2321t^2 - 2.3936t + 104.84 \tag{20}$$

Inserting 1-6 instead of t into Eq. 17 estimated values of are calculated:

$$\begin{aligned} x_{1pr(2010)} &= 103.6785; x_{1pr(2011)} = 104.9812 \\ x_{1pr(2012)} &= 108.7481; x_{1pr(2013)} = 114.9792 \\ x_{1pr(2014)} &= 123.6745; x_{1pr(2015)} = 134.834 \end{aligned} \tag{21}$$

Table 7: Volume of potato and grain production in Zhalal-Abad Oblast (thous.ton)

Production	2010	2011	2012	2013	2014	2015
Potato	104.2	102.5	111.8	115.5	120.8	136.1
Grain	239.3	199.9	236.1	254.5	259.7	291.6

Compiled by the researcher according to the magazine "Agriculture of Kyrgyzstan", 2015

Knowing the factual and  $(x_{1f})$  estimated  $(x_{1p})$  values, we determined the approximation errors:  $\varepsilon = 1.57$  also, we determined determination index  $R^2 = 0.97$ . F-criterion is calculated:  $F_f = \frac{R^2}{1-R^2} (n-2) = \frac{0.97}{0.03} 3 = 97$  and  $F_{table} = 10.13$ ; That's why  $F_f 97 > F_{table} = 10.13$ . Hence with the help of trend equations it is possible to perform estimates of the volume of potato production for 2016-2020:

$$\begin{aligned} x_{1pr(2016)} &= 148.458; x_{1pr(2017)} = 164.5456 \\ x_{1pr(2018)} &= 183.0977; x_{1pr(2019)} = 204.114 \\ x_{1pr(2020)} &= 227.736 \end{aligned} \quad (22)$$

For the planned period of 2016-2020, the volume of potato production grows annually by 2.6-3 thous.ton grows rate constitutes 10.1; 10.8; 11.3; 11.5; 11.6%. The factors of increase of potato yield are the following: the longer the potato leaves stay green, the higher the yield. For this purpose, it is necessary to use mineral fertilizers and select the best means of crop production. Number and quality of stalks has a key value the larger is the number of stalks, the larger is the yield. Stalks that grow out of eyes of potato are the main ones they are sources of a new crop.

Irrigation is a key stage in growing potato. Of course it's better to irrigate during the whole cycle of growth, especially in dry weather. Treatment with copper sulfate. Potato should be treated with copper sulfate 1-2 weeks prior to harvesting, thus, nutrients will pass to tubers which will raise the yield and improve the quality of potato. Besides there's another means of increase of potato yield treatment with super phosphate which increases transition of nutrients from leaves to tubers and thus, increases potato yield (Mamaturdiev and Turdubaev, 2011; Mamaturdiev and Zhorobaev, 2015; ULIF., 2016).

Let us view the conduct of the issue of optimization and forecasting of the volume of cereal crop production in Zhalal-Abad Oblast. Based on the data on the volume of cereal crop production for 2009-2015 we build a curve going through 6 points  $((t, x_i) (i = 1..6))$  we draw five lines (linear, degree, logarithmic, polynomial and exponential) the most optimal is polynomial line  $-x_2 = a_0 + a_1 + a_2 t^2$ . Using the least square method to this function as to  $a_0, a_1, a_2$ , we receive a system of three equations with three variables after certain transformations we receive a normal system of three linear equations with three variables. As a result,  $a_0 = 239.67$ ;  $a_1 = -15.94$ ;  $a_2 = 4.151$ . Then non-linear trend equation is presented in the form:

$$\hat{x}_{2p} = 239.62 - 15.94t + 4.1518t^2 \quad (23)$$

Based on this trend equation, let us determine the following estimated values:

$$\begin{aligned} x_{2pr(2010)} &= 227.8813; x_{2pr(2011)} = 224.3972 \\ x_{2pr(2012)} &= 229.2162; x_{2pr(2013)} = 242.3888 \\ x_{2pr(2014)} &= 263.765; x_{2pr(2015)} = 293.4948 \end{aligned} \quad (24)$$

Let us determine approximation error when we go from  $x_{2f}$  to  $x_{2p}$ :

$$\varepsilon = \frac{1}{6} \left( \frac{0.047715 + 0.122547 + 0.029156}{0.047785 + 0.015653 + 0.006498} \right) = 4.49\%$$

Closeness of connection is assessed through the correlation index  $S_{bx_2}$ :

$$\begin{aligned} S_{bx_2} &= \sqrt{1 - \frac{\sum (x_2 - \hat{x}_{2p})^2}{\sum (x_2 - \bar{x}_2)^2}} = \sqrt{1 - \frac{1,015.2031}{7,627.7726}} \\ &= \sqrt{0.867} = 0.93 \end{aligned}$$

Knowing the determination index  $s_{bx_2}^2 = 0.867$  let us determine F-criterion:

$$F_f = \frac{S_{bx_2}^2}{1 - S_{bx_2}^2} (n-2) = \frac{0.93}{0.07} 3 = 39.857$$

$$\begin{aligned} x_{1pr(2016)} &= 331.5282 \text{ (thous.ton)} \\ x_{1pr(2017)} &= 377.8682 \text{ (thous.ton)} \\ x_{1pr(2018)} &= 432.5058 \text{ (thous.ton)} \\ x_{1pr(2019)} &= 495.45 \text{ (thous.ton)} \\ x_{1pr(2020)} &= 566.551 \text{ (thous.ton)} \end{aligned}$$

This result is compared to  $F_{table}$  but  $F_{table} = 10.13$ . Hence,  $F_f = 39.857 > F_{table} = 10.13$ . That's why trend Eq. 20 is statistically significant, so, trend equation is the basis for estimates.

### CONCLUSION

Sustainable economic growth of Kyrgyzstan is closely connected to further effective development of the agriculture which accounts for more than 30% of GDP.

Increase of crop production is one of the most important tasks of Kyrgyzstan's agriculture development and a factor of satisfying the growing needs of the country's population for food products and further development of the cattle breeding sphere. Optimal development of crop products is ensured by: development of seed breeding increase of seed efficiency and accessibility increase of the level of chemical and biological protection of plants increase of land fertility, preservation of land fund increase of production of ecologically clean crop products. The tools for development of agricultural production include establishment of guarantees prices for agricultural products regulation of the assortment of agricultural products by including the products manufactured by the economic subjects of the agricultural territory targeted subsidizing within the program of support for agricultural entrepreneurs stimulation of nature protection activity development of the social and production infrastructure, etc.

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