Effectiveness of mineral fertilizers in cultivation of maize for grain under conditions of the Central Chernozem region

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Abstract. The work is devoted to the actual topic related to the quality nutrition of corn grain. depending on the applied mineral fertilizers. Currently. the issue of increasing corn grain yield and its quality is particularly acute due to the increase in the number of farm animals and poultry. Increase in corn grain yield is currently impossible without the use of scientifically based technologies of its cultivation. Properly selected hybrid for the terrain and the use of rational doses of fertilizers together give good results of yield of this crop. Corn is such a crop that responds well to the use of various fertilizers. thereby increasing yield growth. The article considers the effectiveness of mineral fertilizers in the cultivation of maize for grain in the conditions of the Central Chernozem region.

1 Introduction

Corn is a high-yielding grain crop in the Central Chernozem region. It ranks first in terms of gross grain yields. Corn grain is the main component in the preparation of mixed fodder. In connection with the increase in the number of farm animals and poultry in Russia is a very urgent problem in farming is a sharp increase in the production of high-quality corn grain as the main ingredient in the preparation of mixed fodder. The production conditions require the improvement of technology elements in the cultivation of the most productive hybrids of corn for grain. increasing the level of their adaptation to the conditions of agrolandscapes of the forest-steppe of the Central Chernozem region. For effective cultivation of new hybrids of maize for grain it is necessary to predict their productivity. In this regard. the agrobiological substantiation of increasing the yield and quality of corn grain on gray forest soils in the conditions of forest-steppe of the Central Chernozem acquires special relevance and timeliness.

The relevance of the work consists in predicting the nutritive value of corn grain depending on the applied rates of mineral fertilizers on gray forest soils in the forest-steppe of the Central Chernozem region.

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2 Materials and methods

Is based on the inclusion of theoretical and general biological methods: analysis. comparison. generalization when working with scientific publications and with experimental data. Methods of empirical research - field experiments and observations. scientific basis of yield programming. laboratory analyses. dispersion and correlation-regression analyses of experimental research results. their processing and interpretation.

In field experiments we studied the effect of methods of basic tillage (moldboard tillage (depth 27-30 cm). no-tillage (27-30 cm) and minimum tillage 10-12 cm) on yield and grain quality. Pre-sowing tillage on all variants of the experiment was the same. Mineral fertilizers were applied at the rate of N30P30K30. N45P45K45. N60P60K60 kg/ha.

Experimental studies to improve the technology of cultivation of maize for grain are carried out in Kursk SAU and implemented in production in the districts of Kursk region.

The variants presented methods of intensive technology norms. NPK applied. calculated for the projected yield (100 c/ha of grain). using the normative method recommended by D.N. Pryanishnikov VNIIA. We took into account the removal by a unit of production and total NPK removal. their content in the soil. use of nutrients from the soil and fertilizers. Provision of plants with mineral nutrition elements was controlled using the results of soil and plant diagnostics on the basis of generally accepted methods in agronomic practice.

3 Results and discussion

Increasing the nutritive value of corn grain cultivated under intensive technology on gray forest soils of the forest-steppe of the Central Chernozem region is impossible without mineral fertilizers. Depending on different norms of mineral fertilizers and methods of basic tillage used in field experiments. we predicted the accumulation of nutrients (crude protein. BEV. crude fat. crude fiber). ash. total nitrogen. phosphorus and potassium in corn grain (Tables 1,2,3,4).

Prediction of crude protein accumulation in corn grain.

Crude protein: y=0.7168*-10.2882x+45.265

$$y = ax^2 + bx + cy_{min(7.17)}=8.35$$

represent the models of a solution to a system of linear equations using the Gaussian method

$$8.56=a*43.95+6.63b+c$$
$$8.44=a*56.55+7.52b+c$$
$$8.63=a*60.84+7.8b+c$$

$$\begin{cases} 43.95a+6.63b+c=8.56 \\ 56.55a+17.52b+c=8.44 \\ 60.84a+7.8b+c=8.63 \end{cases}$$

$$\left(\begin{array}{ccc|c} 43.95 & 6.63 & 1 & 8.56 \\ 56.55 & 7.52 & 1 & 8.44 \\ 60.84 & 7.8 & 1 & 8.63 \end{array}\right) \begin{array}{c} \begin{array}{ccc} c & a & b \end{array} \\ \left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 8.56 \\ 1 & 56.55 & 7.52 & 8.44 \\ 1 & 60.84 & 7.8 & 8.63 \end{array}\right) \end{array} \left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 8.56 \\ 0 & 12.6 & 0.89 & -0.12 \\ 0 & 16.89 & 1.17 & 0.07 \end{array}\right)$$

$$\begin{array}{c} \begin{array}{ccc} c & a & b \end{array} \\ \left(\begin{array}{ccc|c} 1 & 0 & 3.5271 & 8.9775 \\ 0 & 1 & 0.0706 & -0.0095 \\ 0 & 0 & -0.0224 & 0.230455 \end{array}\right) \end{array}$$

$$a = -0.0095 - 0.0706*(-10.2882) = 0.7168$$

b=-10.2882;

c=8.9775-3.5271*(-10.2882) =45.265

$$y=0.7168*x^2-10.2882*x+45.265$$
$$y' = 0.1.4336x - 10.2882 = 0$$
$$y_{min}(7.17) = 8.34858.35$$
$$Y\ (6.63)=8.5625\approx 8.56$$
$$Y\ (7.52)=8.4331\approx 8.43$$
$$Y\ (7.8)=8.6272\approx 8.63$$

Table 1. Scheme for calculating the correlation coefficient between crude protein and mineral fertilizer application rate.

Factor	y_i	x_i	$(x_i - \overline{x})$	$y_i - \overline{y}$	$(x_i - \overline{x})^2$	$(y_i - \overline{y})^2$	$(x_i - \overline{x}) * (y_i - \overline{y})$
Crudeprotein	8.56	6.63	-0.69	0.02	0.4761	0.0004	-0.0138
	8.44	7.52	0.2	-0.14	0.04	0.0196	-0.028
	8.63	7.80	0.48	0.09	0.2304	0.0081	0.0432
∑	25.63	21.95	-		0.7465	0.0281	0.0014

$$r_{xy} = \frac{0.0014}{0.1448} = 0.0096$$
$$\overline{x} = 7.32$$
$$\overline{y}=8.54$$

$r_{xy} < 0.01$ →correlation between X and Y is not even approximately linear

Table 2. Scheme for calculating the correlation coefficient between BEB and mineral fertilizer rate.

	y_i	$y_i - \overline{y}$	$(y_i - \overline{y})^2$	$(x_i - \overline{x}) * (y_i - \overline{y})$
BEB	61.71	-3.19	10.1761	2.2011
	62.74	-2.16	4.6656	-0.432
	70.24	5.34	28.5156	2.5632
∑	194.69	-	43.357	4.3323

$$\overline{y}=64.90$$
$$r_{xy} = \frac{4.3323}{5.6871} = 0.7615 = 0.76$$
$$b_{xy}=\frac{4.3323}{0.7465} = 5.8035$$
$$y-64.9=5.8035-(x-7.32);$$
$$y=5.8035*x+22.4185;$$
$$y=5.80*x+22.42$$

There is a close relationship between BEV and NPK doses.
If fertilizer dose increases by 1 kg/ha. BEV will increase by 5.8 units
Crude fat: y=0.9346-13.5089*x+52.8206

$$y_{min}(7.23) =3.97$$
$$\begin{cases} 43.95a + 6.63b + c = 4.33 \\ 56.55a + 7.52b + c = 4.09 \\ 60.84a + 7.8b + c = 4.31 \end{cases}$$

$$\left(\begin{array}{ccc|c} 43.95 & 6.63 & 1 & 4.33 \\ 56.55 & 7.52 & 1 & 4.09 \\ 60.84 & 7.8 & 1 & 4.31 \end{array}\right) \sim \left(\begin{array}{c} 143.956.63 \vee 4.33 \\ 156.557.52 \vee 4.09 \\ 160.847.8 \vee 4.31 \end{array}\right) \sim \left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 4.33 \\ 0 & 56.55 & 7.52 & 4.09 \\ 0 & 60.84 & 7.8 & 4.31 \end{array}\right) \sim$$

$$\left(\begin{array}{ccc|c} 1 & 0 & 3.5271 & 5.1695 \\ 0 & 1 & 0.0706 & -0.0191 \\ 0 & 0 & -0.0224 & 0.3026 \end{array}\right)$$

b=-13.51;
a=-0.0262-0.0706*(-7.7017)=0.5175;
c=5.1695-3.527*(-13.51)=52.8206
y=0.5175*x^2-7.7017*x+30.3962

y(6.63)=4.3314=4.33 y'=0
y(7.52)=4.0774=4.08 1.8692x-13.51=0
y(7.8)=4.30366=4.30 x=$\frac{13.51}{1.8692}$=7.2276=7.23
y_{min}(7.23)=3.9664=3.97
At a fertilizer dose of 7.23 kg/ha we get a minimum value = 3.97 crude fat.
Crude fiber: y=0.5175x^2-7.7017*x+30.3962

y_{min}(7.44)=1.75

$$\begin{cases} 43.95a + 6.63b + c = 2.08 \\ 56.55a + 7.52b + c = 1.75 \\ 60.84a + 7.8b + c = 1.81 \end{cases}$$

c a b

$$\left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 2.08 \\ 1 & 56.55 & 7.52 & 1.75 \\ 1 & 60.84 & 7.8 & 1.81 \end{array}\right) \sim \left(\begin{array}{c} 143.956.63 \vee 2.08 \\ 012.60.89 \vee -0.33 \\ 016.891.17 \vee -0.27 \end{array}\right) \sim \left(\begin{array}{ccc|c} 1 & 0 & 3.5271 & 3.2315 \\ 0 & 1 & 0.076 & -0.0262 \\ 0 & 0 & -0.0224 & 0.1725 \end{array}\right)$$

b=-7.7017;
a=-0.0262-0.0706*(-7.7017) =0.5175;
c=3.23315-3.5271*(-7.7017) =30.3962
y=0.5175*x^2-7.7017*x+30.3962
y (6.63)=2.0816=2.08 y'=0
y (7.52)=1.744041=1.74 1.035x-7.7017=0
y (7.8)=1.80764=1.81 x=$\frac{7.7017}{1.035}$=7.4412
y_{min}(7.44)=1.75071=1.75

Ash: y=0.5805x^2-8.3457*x+31.1577

$$\begin{cases} 43.95a + 6.63b + c = 1.34 \\ 56.55a + 7.52b + c = 1.23 \\ 60.84a + 7.8b + c = 1.38 \end{cases} \quad y_{min}(7.19)=1.16$$

X∈[6.63; 7.8]

$$\left(\begin{array}{c} 143.956.63 \vee 1.34 \\ 156.557.52 \vee 1.23 \\ 160.847.8 \vee 1.38 \end{array}\right) \sim \left(\begin{array}{c} 143.956.63 \vee 1.34 \\ 012.60.89 \vee -0.11 \\ 016.891.17 \vee 0.04 \end{array}\right) \sim \left(\begin{array}{c} 103.527 \vee 1.7224 \\ 010.0706 \vee -0.0087 \\ 00 - 0.0224 \vee 0.1869 \end{array}\right)$$

b=-8.3457
a=-0.0087-0.0706*(-8.3457) =0.5805
c=1.7224-3.527*(-8.3457) =31.1577
y=0.5805*x^2-8.3457*x+31.1577
y'=0
1.161x-8.3457=0
X=$\frac{8.3457}{1.161}$=7.1884≈7.19
y_{min}(7.19) =1.1617

Y(6.63)=1.3426=1.34
Y(7.52)=1.2255=1.23
Y(7.8)=1.37886=1.38
Total nitrogen: y=0.1151*$x^2 - 1.6529 * x + 7.2703$
$y_{min}(7.18) = 1.34$

$$\begin{cases} 43.95a + 6.63b + c = 1.37 \\ 56.55a + 7.52b + c = 1.35 \\ 60.84a + 7.8b + c = 1.38 \end{cases}$$

$$\left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 1.37 \\ 1 & 56.55 & 7.52 & 1.35 \\ 1 & 60.84 & 7.8 & 1.38 \end{array}\right)\left(\begin{array}{ccc|c} 1 & 43.95 & 6.63 & 1.37 \\ 0 & 12.6 & 0.89 & -0.02 \\ 0 & 16.89 & 1.17 & 0.01 \end{array}\right)\left(\begin{array}{ccc|c} 1 & 0 & 3.5271 & 1.44032 \\ 0 & 1 & 0.0706 & -0.0016 \\ 0 & 0 & -0.0224 & 0.037024 \end{array}\right)$$

b= 1.6529;
a=-0.0016-0.0706*(-1.6529)=0.1151;
c=1.44032-3.5721*(-1.6529)=7.2703;
y=0.1151*x^2-1.6529*x+7.2703
$y' = 0; 0.2302 * x - 1.6529 = 0.$
x=$\frac{1.6529}{0.20302}$=7.1803=7.18
$y_{min(7.18)=1.3366=1.34}$
Phosphorus: y=0.1987x^2-2.8593*x+10.5557
y_{min} (7.195) =0.27

$$\begin{cases} 43.95a + 6.63b + c = 0.33 \\ 56.55a + 7.52b + c = 0.29 \\ 60.84a + 7.8b + c = 0.34 \end{cases}$$

$$\begin{pmatrix} 143.956.63 \vee 0.33 \\ 156.557.52 \vee 0.29 \\ 160.847.8 \vee 0.34 \end{pmatrix} \sim \begin{pmatrix} 143.956.63 \vee 0.33 \\ 012.60.89 \vee -0.04 \\ 016.891.17 \vee 0.01 \end{pmatrix} \sim \begin{pmatrix} 103.527 \vee 0.47064 \\ 010.0706 \vee -0.0032 \\ 00 - 0.0224 \vee 0.0640 \end{pmatrix}$$

b=2.8593
a=-0.0032-0.0706*(-2.8593) =0.1987
c=0.47064-3.5271*(-2.8593)=10.5557
y=0.1987*x^2-2.8593x+10.5557
y'=0. 0.3974x-2.8593=0
X=$\frac{2.8593}{0.3974}$=7.1950=7.20
y_{min} (7.195)=0.2693=0.27
Y(6.36)=0.3327=0.33
Y(7.52)=0.2903=0.29
Y(7.8)=0.3421=0.34
Potassium y=0.4

Table 3. Programmed models of nutrients depending on the mineral fertilizer rateson mineral fertilizer rates.

Nutrients substances	**Predictive | model Minimum cost model**	**S error**
Crude protein	Y=0.7168*x^2-10.2882*x+45.265 y_{min}(7.17)=8.35	0.01
Raw fat	Y=0.9346*x^2-13.5089*x+52.8206 y_{min}(7.23)=3.97	0.01
BEB	Y=5.80*x+22.42 rxy=0.76	60.01
Raw fiber	Y=0.5175*x^2-7.7017*x+30.3962 y_{min}(7.44)=1.75	0.01
Ash	Y=0.5805x^2-8.3457*x+31.1577 y_{min}(7.19)=1.16	0.01

Total nitrogen	Y=0.1151*x^2-1.6529*x+7.2703 y_{min}(7.18)=1.34	0.01
Phosphorus	Y=0.1987*x^2-2.8593*x+10.5557	0.01
Potassium	Y=0.4	

The correlation coefficient calculations showed that the relationship between mineral fertilizer application and nutrient is non-linear. except for BEB.

4 Conclusion

According to the constructed models. the following conclusions can be drawn: on the interval (6.63 kg/ha - 7.8 kg/ha) of any study:

1. The minimum value of crude protein is obtained at 7.17 kg/ha. which is less than at 6.63.so from the economic point of view it is advisable to follow the conditions of optimization in the application of mineral fertilizer doses.
2. As for crude fat. the minimum is at 7.23 kg/ha and is 3.97. We recommend the production dose of 6. 63 kg/ha
3. BEV when fertilizer dose increases by 1 kg/ha. BEV increases by 5.8 kg/ha. The relationship of obtaining is close and therefore at x>7.8 kg/ha higher BEB values can be obtained.
4. Crude fiber. The nonlinearity of crude fiber depending on fertilizers allows us to calculate the minimum value. which is 7.44 kg/ha and equal to 1.75 units of crude fiber. The optimal variant is 6.63 units.
5. Ash. The minimum value is 7.19 kg/ha of fertilizer and is 1.16 units (7.19 is inside the study interval).
6. The minimum value for total nitrogen by fertilizer is 7.18 kg/ha and is 1.34 kg/ha
7. Phosphorus. Regarding phosphorus. the minimum value of 7.2 kg/ha is 0. 27. based on nutrition. then at least 7.8 kg/ha can be recommended.
8. Potassium y = 0.4 is a constant value. We believe that this is due to the movement of the soil-plant balance.
9. So in the development of intensive technologies of cultivation of maize for grain on the predicted level of nutrition should apply a strategy to optimize the applied doses of fertilizers.

References

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