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Influence of Nitrogen and Potassium Fertilizers on The Productivity of Spring Wheat

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ABSTRACT: Chemical fertilizers render effect on yield and quality of crops. Agricultural experts have been able to choose the right for crops, to optimal doses and ratios of nutrients that provide the maximum yield of good quality and be cost-effective. The purpose of the research is to determine the effect of doses of nitrogen-potassium fertilizers on the yield of spring wheat cultivated in Ural region. To determine the effect of doses of nitrogen and potassium fertilizers on wheat, yield field experiment was constructed in 2011. Results showed that the nitrogen-potassium fertilizers have increased the productivity of wheat from 30.0 zentner ha^{-1} (1 zentner = 100 kg) (N_0K_0) to 35.0-38.7 zentner ha^{-1}. Mathematical analysis of the results showed that wheat yield is more dependent on the dose of nitrogen (r = 0.82) and less – on the dose of potassium (r = 0.34). Designed a model dependent yield of wheat the growing on sod-podzolic soils from doses of potassium and nitrogen, which is as follows: $U = 30.00768+0.06009x-0.00035x^2+0.246852y-0.00192y^2-0.00069xy$. Using this model it is established that the optimum dose of fertilizer, where the yield has a maximum value of 38.16 zentner/ha, was found at K = 27.5 and N = 59.4 kg/ha, which is consistent with our experiment.

Keywords: Spring wheat, nitrogen, potassium, doses, the yield

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Azot ve Potasyumlu Gübrelerin İlkbaharlık Buğday Verimine Etkisi

ÖZET: Kimyasal gübreler bitkilerin ürün ve kalitesini etkilerler. Tarım uzmanları bitkiler için doğru, uygun maliyetli ve iyi kalitede maksimum ürün sağlayacak en uygun bitki besin maddeleri miktarı ve oranını belirleyebilirler. Araştırmanın amacı, ilkbaharlık buğday tarımı yapılan Ural Bölgesinde azot ve potasyumlu gübre dozlarının verim üzerine etkisini belirlemektir. Buğday verimine azotlu ve potasyumlu gübrelerin etkili dozlarını belirlemek amacıyla 2011 yılında tarla denemesi kurulmuştur. Verimlilik sonuçları gübrelerin verim artırıcı faktör olduğunu göstermiştir. Kontrol değişkeninde (N0K0) verim 30.0 zentner ha^{-1} (1 zentner = 100 kg), azot-potasyum gübreli 35.0-38.7 zentner ha^{-1} olarak bulunmuştur. Detaylı analiz sonuçlarına göre potasyum gübrelemesi yapılmayan, 30–60 kg ha^{-1} artan dozlarda azotlu gübre uygulaması ile verim 36.4 ile 37.5 zentner ha^{-1} arasında artırmıştır. Verimde benzer artışlar toprağa potasyum gübresi uygulandığında da gözlenmiştir. Sonuçlarım matematiksel analizi buğday veriminin azot dozuna (r=0.82), potasyum dozuna (r=0.34) oranla daha bağımlı olduğunu göstermiştir. Gübre uygulamalarıyla tarla denemelerinin sonuçlarına dayanarak tarımsal üretim için optimal gübre dozlarını belirlemek için yeni tekniklerle birlikte otomatik kontrol sistemleri kullanılarak yapılabilir. Bizim araştırmamız gübre dozları ile verim arasında matematiksel bir ilişki olduğunu göstermiştir. En uygun matematiksel model parabolik ilişki olarak bulunmuştur. Her iki gübre çeşidi kullanılarak (N, K) oluşturulan model aşağıdaki biçimde belirlenmiştir: $U=a0+a1x+a2y+b1x2+b2y2+cxy$. Deneme sonuçlarına bağlı olarak azotlu ve potasyumlu gübre dozlarının çimen-podzol topraklarda yetiştirilen ilkbaharlık buğday verimine bağlı geliştirilen model aşağıda verilmiştir: $U = 30.00768+0.06009\ x-0.00035\ x^2+0.246852\ y-0.00192\ y^2-0.00069\ xy$ ($\eta = 0.9547$; $\sigma T/t = 1.1981$; $\theta = 52.7987$; $\varepsilon = 1.4004$) Eşitlikte x: potasyum dozu, kg ha^{-1}; y: azot dozu, kg ha^{-1} dır. Bu model kullanılarak maksimum ürün verimi olan 38.16 zentner ha^{-1} verim için uygulanması gereken en uygun gübre uygulaması N = 59.4 kg ha^{-1} ve K = 27.5 kg ha^{-1} olarak bulunmuştur.

Anahtar kelimeler: İlkbaharlık buğday, azot, potasyum dozları, ürün verimi

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INTRODUCTION

Wheat is one of the leading food crops in Russia. On the territory both winter and spring wheats are cultivated. Winter wheat, as more winter hardy than spring wheat, grows in the warmer southern and central regions (North Caucasus, the Central Chernozem region, south Volga). In the northern areas mostly spring wheat is cultivated. In the Perm region in 2011, its cultivated area amounted to 117.7 thousand hectares or 46.7 % of the area of cereal crops. The average yield on the edge is not high – 11.9 zentner/ha, an increase of 2.4 zentner/ha less than in Russia.

The study of responsiveness to fertilizer crops has been carrying out for many years. The first results were obtained in Russia in the XIX century. Each year, breeders create new varieties that differ in their attitude to element food items and their ratios in soil and in fertilizers. To date, considerable material about the specificity of varietal reactions to mineral nutrition has been accumulated. Different varieties are able to varying extent to absorb and use nutrients from the soil and fertilizers and in differently pay increase in yield (Saffron S.A., 2006).

Summing up on the selection of basic grains to the beginning of the third millennium showed that in Russia as a whole assortment has been updated on spring wheat by 63 % (Nettevich E.D., 2002). To date in the Perm region the main variety of spring wheat is Irgina (64 % of the area sown wheat), testing of Gornoural'skaya variety only began in 2007. Therefore, the study of responsiveness of Gornoural'skaya spring wheat on mineral nutrition is an urgent question.

In the Perm region sowing is conducted on sod-podzolic soils of heavy granulometric composition, which occupy 69.6 % of arable land. These soils have low natural fertility, and therefore the productivity increase of agricultural crops is required in the first place to improve mineral elements supply. The application of mineral fertilizers does not have an equal effect on yield and quality of crops. Agricultural specialists need to choose the correct optimal doses and ratios of nutrients for each culture, which will provide not only the maximum yield of products of good quality, but will be economically and environmentally beneficial.

The purpose of research – to determine the optimal doses of nitrogen-potassium fertilizer to Gornoural'skaya spring wheat varieties in the Predural'e.

MATERIALS AND METHODS

Effect of doses of nitrogen-potassium fertilizer on yield of spring wheat has been studied in a field experiment on the basis of the educational and experimental field of the Perm State Agricultural Academy, which is located in the Perm region of the Permskiy Kray. The soil of the experimental area – sod-medium podzolic silty clay, characterized by the following agrochemical characteristics: pH_{KCl} 4.9-5.5, the content of available phosphorus 132.0-604.6 mg/kg soil, exchangeable potassium – 103.7-222.7 mg/kg soil. The content of mineral nitrogen in soil is very low. So when placing the wheat on this soils a priority is to provide plants with nitrogen and potassium.

Laying of two-factor field experiment was carried out using standard techniques described by B.A. Dospekhov (1985) on the following scheme: N_0K_0; $N_{30}K_0$; $N_{60}K_0$; $N_{30}K_{30}$; $N_{60}K_{30}$; $N_{30}K_{60}$; $N_{60}K_{60}$; $N_{30}K_{90}$; $N_{60}K_{90}$. In the Predural'e dose of 60 kg ai/ha is medium recommended for growing spring crops. Since in the current economic conditions farms are not able to apply adequate amounts of fertilizer for the plants and to reduce the anthropogenic impact on agroecosystem dose of nitrogen and potassium, we reduced it by ½ (30 kg/ha). In addition in the soil experimental area on 42 plots (of 66 plots), the potassium content below the optimum level for crops, so it became necessary to introduce in the scheme of additional options with an increased dose of potassium, relative to the optimum, at ½ (90 kg/ha). Ammonium nitrate, (containing N = 34.4 %) and potassium chloride (containing K_2O = 60.0 %) fertilizer were applied. Fertilizers have been applied under presowing cultivation. The area of experimental plots – 150 m^2, accounting – 80 m^2. Wheat cultivation technology is common to the Perm region. Accounting for yields was carried out in the phase of full ripeness by the direct method. The weather conditions of the growing season can be characterized as quite favorable for the growth and development of wheat.

RESULTS AND DISCUSSION

In 2011 wheat has formed a high enough level yield for Perm region (Table 1).

The results of experiment show that the difference in wheat yield between the control and doses of nitrogen-potassium fertilizer was substantial. The yields in the control variant (N_0K_0) was 30.0 zentner/ha (1 zentner = 100 kg), on variants with nitrogen-potassium fertilizers – 35.0-38.7 zentner/ha. Maximum grain yield

Table 1. The effect of fertilizers on the productivity of spring wheat

Variants	The yield, zentner/ha	Return 1 kg of NK increase in yield, kg/kg	The costs NK on increase yields grain, kg/zentner
N_0K_0	30.0	–	–
$N_{30}K_0$	36.4	21.3	4.7
$N_{60}K_0$	37.5	12.5	8.0
$N_{30}K_{30}$	35.0	8.3	12.0
$N_{60}K_{30}$	38.7	9.7	10.3
$N_{30}K_{60}$	37.7	8.6	11.7
$N_{60}K_{60}$	37.9	6.6	15.2
$N_{30}K_{90}$	36.3	5.3	19.0
$N_{60}K_{90}$	36.5	4.3	23.1

of spring wheat was obtained in the embodiment $N_{60}K_{30}$ and it amounted to – 38.7 zentner/ha.

Applying of nitrogen fertilizers has been effective technique to improve the yield of spring wheat. Overall the experience, yield increase with nitrogen doses ranged from 6.4 to 7.5 zentner/ha. Detailed analysis showed that with increasing doses of nitrogen with 30 kg/ha to 60 kg/ha has been some increase in yield in all experimental variants. For example, when applying 30 kg/ha of nitrogen yield of wheat increased compared to the control of 6.4 zentner/ha, with a dose of 60 kg/ha – 7.5 zentner/ha.

Additional application of potash fertilizers has different impact on productivity of spring wheat. The positive effect of potassium on the variations observed with a doses of potassium, 30 and 60 kg/ha, application of a higher dose leads to lower yields. It is interesting to note that with increasing dose of potassium the grain yield is reduced. For example, in the variant of $N_{60}K_{30}$ yield of spring wheat was 38.7 zentner/ha, applying $N_{60}K_{60}$; it decreased to 37.9 zentner/ha, and in the $N_{60}K_{90}$ – to 36.5 zentner/ha. Perhaps this can be explained by applying higher doses of potassium results in damaged the optimum ratio between of nutrients and wheat plants.

Mathematical processing of the results confirms that in conditions high of provision plants phosphorus yield of spring wheat to a greater extent dependent on the doses of nitrogen (r = 0.82) and less – on the doses of potassium (r = 0.34). This dependence is explained by the fact that sod-podzolic soils contain little of mineral nitrogen and so plants primarily responsive to nitrogen fertilizers.

In compiling system of fertilizers of no small importance has agronomic efficiency of applied fertilizers, which shows how much each kilogram applying element nutrition will provide the kilogram increase in yield. Our experiments showed that the applied fertilizer provide different increase in yield grain of spring wheat. Each kilogram applying of nitrogen-potassium fertilizer provide a receipt depending on the variants from 4.3 to 21.3 kg of grain. Maximum response (12.5-21.3 kg/kg) was observed in the variants with applying a single nitrogen, potash fertilizers reduce this figure. In addition, there has been a trend of decreasing return fertilizers with increasing use the total fertilizer doses. For example, at applying 90 kg ai/ha ($N_{60}K_{30}$) return in fertilizer was 9.7 kg of grain, and in a variant with a dose of 120 kg ai/ha ($N_{60}K_{60}$) – 6.6 kg of grain.

Due to the fact that in determining the needs of culture in fertilizer basic indicators are costs of nutrients on the formation of a unit of harvest. We found it is necessary to determine this value (Table 1). As the table shows, the cost of nitrogen-potassium fertilizer to obtains 1 zentner increase in yield also greatly changeable depending on the variants, the range of variation was 4.7-23.1 zentner/ha. The value of costs nitrogen-potassium fertilizers on obtain 1 zentner a gain of yield wheat show same trend, but in reverse order. At a higher return nitrogen-potassium fertilizers decreased its consumption on formation of a unit accretion in yields.

Based on the results of field experiments with fertilizers to determine optimal doses of fertilizer in agricultural production are implementing automated control systems (ACS), associated with the use of new techniques. For this purpose, special empirical mathematical models are used widely, which contain concise information on the quantitative relationship between yield and fertilizer doses at specific soil and climatic conditions. These models are called production functions or "productivity functions".

Production functions contain information that can be used for the following tasks agrochemical services in agriculture:

- clarification patterns of the influence of soil properties, dose fertilizers and weather conditions on crop yield and quality of the product;
- calculation of optimal, cost-based norms of fertilizers;
- determination of agronomic and economic efficiency of fertilizer;
- prediction of crop yields;
- development of standards in planning the distribution of fertilizers.

To address these challenges and build these models it is needed to have experience with a large number of variants (Mikayilov F.D., 2010).

Our research has shown that in the experiment for establishing quantitative relationships between yield and fertilizer doses could be explained by parabolic equation mathematical model. At applying two types of fertilizers (N, K) general view of such a function is expressed by the polynomial: $U=a_0+a_1x+a_2y+b_1x^2+b_2y^2+cxy$.

According to the results of experience a model of dependence of wheat yield on potassium and nitrogen doses has been developed:

$U = 30{,}00768+0{,}06009x-0{,}00035x^2+0{,}246852y-0{,}00192y^2-0{,}00069xy$

where x – the dose of potassium, kg/ha, y – the dose of nitrogen, kg/ha.

The obtained model has the following values of statistical parameters that show a very high reflection model experiment:

- the correlation ratio ($\eta = 0.9547$);
- the mean square deviation ($\sigma_{T/t} = 1.1981$);
- the criteria reliability ($\theta = 52.7987$);
- the relative absolute error of the experiment ($\varepsilon = 1.4004$).

Using this model it has been established that the optimum dose of fertilizer, where the yield has a maximum value of 38.16 zentner/ha, was found at K = 27.5 and N = 59.4 kg/ha, which is consistent with our experiment.

CONCLUSION

Gornoural'skaya spring wheat variety differently responded to application of nitrogen and potassium fertilizers doses. Increase in yield of wheat on sod medium podzolic soils with a high content of available phosphorus from applied fertilizers was 6.3-8.7 zentner/ha. Yields of spring wheat to a greater extent dependent on the doses of nitrogen (r = 0.82) and less – on the dose of potassium (r = 0.34).

Maximum return on 1 kg of fertilizer is marked on variants with nitrogen and was 12.5-21.3 kg of grain. For 1 zentner return in yield grain of spring wheat costs of nitrogen-potassium fertilizers varied from 4.7 to 23.1 kg.

The developed model of dependence of wheat yield on potassium and nitrogen doses allows us to plan the yields of spring wheat grown on sod medium podzolic soils.

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