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# THE BIOENERGY EFFICIENCY OF THE APPLICATION OF VARIOUS FORMS AND DIFFERENT DOSE OF PHOSPHORUS FERTILIZERS (IN THE EXAMPLE OF COTTON, CORN AND VEGETABLE CROPS)

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**Abstract**

The bioenergetic efficiency of phosphorus-containing fertilizers based on Kyzylkum phosphates under the conditions of pasture and typical gray soils of the Zeravshan Valley has been determined. The highest bioenergy efficiency was found when cultivating cotton on pasture soils is 175 kg/ha of phosphorus ($P_2O_5$) against the background of $N_{250}K_{125}$, when using 120 kg/ha of phosphorus ($P_2O_5$) against the background of $N_{240}K_{100}$ when cultivating corn on eroded soils. On typical gray soils, the use of phosphorus-containing fertilizers in vegetable growing is bioenergetically inefficient.

**Key words:** Zerafshan valley, Kyzylkum phosphorite, nitrogen phosphorus fertilizer (NPhF), nitrocalcium phosphate fertilizer (NCPhF), PS-agro, cotton, bioenergetic efficiency, efficiency factor (EF).

## INTRODUCTION

Phosphorus is one of the most important nutrients for crops and plays an important role in increasing the growth, development, productivity and fertility of the soil. [4, 11, 23].

Since phosphorus reserves are very low in various types of soils around the world, phosphorus fertilizers play an important role in ensuring crop yields and global food security. Global demand for crops is likely to increase by 100-110% from 2005 to 2050, and global food security will require improved soil fertility and agricultural intensification [30], which will lead to increased demand for phosphate fertilizers. All phosphate fertilizers are produced from phosphate rocks (phosphorite and apatite), and it is assumed that by 2100 60% of this resource base may be depleted [38]. Given the lack of substitute products for phosphate fertilizers and the limited global supply of phosphate rock, which can increase the cost of phosphate fertilizers, it is important to increase the use of phosphate fertilizers [7].

Large reserves of about 8 phosphorite deposits have been discovered on the territory of the Republic of Uzbekistan. These include Gulyab (Surkhandarya region), Karakalpak, Central Kyzylkum (Navoi region) phosphorites of the Sariosi region and others. [9, 22, 27, 33].

These phosphorites contain very little phosphorus, between 10 and 20%. There is a lot of information about the production of various phosphorus-containing fertilizers from local phosphorite raw materials based on various new innovative technological

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processes that improve the production of fertilizers that are not inferior to previously used phosphate fertilizers. [15, 22, 24, 29, 31, 34, 39, 40, 41].

Today, 2.5-3.5 times less phosphate fertilizers are used in agriculture than the scientifically based norm, or 30-40% of agricultural phosphate fertilizers are provided on average. [2, 32].

A total of 1.45 million tons of mineral fertilizers (including: nitrogen fertilizers – 1105.4 thousand tons, phosphorus fertilizers - 133.4 thousand tons, potassium fertilizers - in 2021, increasing the production of mineral fertilizers in the country by 274.0 thousand tons. 216.0 thousand tons) are produced and delivered to agriculture[1].

Although the application of phosphate fertilizers improves the phosphate regime of the soil, the coefficient of absorption of phosphorus by plants from fertilizers remains low. One of the main reasons for this is the high content of calcium and magnesium cations in the absorbing complex of soils common in Central Asia [3, 13, 36, 37,]. This is also associated with the deposition of the reaction of the soil environment (pH) by calcium ions at high values, sorption by oxides (hydroxides) of iron and aluminum at low pH values [25], or immobilization by microorganisms [10].

The discrepancy in the change in soil phosphorus content after phosphorus application can be due to confusing factors such as soil types, soil physico-chemical properties, tillage and fertilization practices, especially phosphate fertilizer rates. [6].

The study of agricultural varieties, technologies for their cultivation, specific agrotechnical measures, norms of mineral fertilizers and the bioenergetic efficiency of their application in various proportions and norms is gaining popularity [17, 43]. Determining the use of energy technologies in the production of agricultural products and determining their energy efficiency when using mineral fertilizers to ensure energy efficiency is one of the important conditions. [16, 21, 40].

The importance of bioenergy assessment increases even more in the conditions of agricultural acceleration, as it increases the amount of energy consumption in the cultivation of crops, which in turn requires a complete calculation of the energy intensity of all technological processes. The proposed method allows you to accurately calculate and uniformly express the direct energy costs of technological activities, means of production, as well as the energy intensity of the product in energy equivalent. [17].

This, in turn, leads to the identification and introduction of energy-saving technologies, as well as an increase in energy efficiency in crop production. [8, 12, 28; 44].

In solving the above problems, i.e., the effective use of phosphate fertilizers to obtain high-quality crops, maintain and increase soil fertility, the determination of the bioenergetic efficiency of the applied phosphorus fertilizers is of scientific and practical importance.

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## MATERIALS AND METHODS

One of the urgent tasks is to study and improve the efficiency of mineral fertilizers, especially phosphorus, used in agriculture. In the country in 2009-2022, scientific research is being carried out to determine the effectiveness of the use of phosphorus-containing fertilizers for crops in various soil and climatic conditions.

Field and laboratory experiments are carried out in the conditions of the meadows of the Zeravshan valley, typical gray soils. In field experiments, the bioenergetic efficiency of types and norms of phosphorus-containing fertilizers obtained on the basis of local phosphorites is studied to maintain and increase soil fertility, along with obtaining high-quality crops of cotton, vegetables and potatoes, and corn.

Field experiments are carried out by "Methods of growing and vegetative experiments of cotton in growing conditions" [19], "Methods of field experiments" [5], "New phosphorus fertilizers based on Central Kyzylkum phosphorites and recommendations for their use in agriculture" [35]. ], "Methodology for determining the structure of the crop and the quality of grain" [18]. "Methods of field experiments in horticulture" [14], soil and plant analysis "Methods of agrochemical, agrophysical and microbiological research in polyvinyl chloride areas" [20], "Agrochemical methods of soil research" [1], "Practicum on agrochemistry" [26].

The bioenergetic efficiency of the obtained results was carried out according to "V.G.Mineev" [21].

The effective energy of application of mineral fertilizers (energy-consuming or bioenergetic efficiency) ($\eta$) was determined by the following formula.

$$\eta = \frac{V_{fO}}{A_O}$$

Here,

ŋ - effective energy or bioenergy efficiency FIK, unit.

$V_{fo}$ - the amount of energy in the main by-product obtained at the expense of mineral fertilizers, Mj.

$A_o$- energy consumed for fertilizer application, Mj.

$$V_f = U_p * R_i * l * 100$$

Here;

$V_{fo}$ - amount of energy in the main product (in terms of economic value), Mj.

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$U_p$ - additional yield at the expense of fertilizer, ts/ha.

$R_i$ - dry matter conversion unit of agricultural crops, ($R_i, l$ taken from the table).

$l$ - Total energy in 1 kg of dry matter, Mj.

100 - the conversion factor per centner per kilogram.

The energy consumption of mineral fertilizers was determined using the following formula.

$$A_O = (H_N * A_N) + (H_P * A_P) + (H_K * A_K)$$

Here;

$H_N, H_P, H_K$ - actual application of nitrogen, phosphorus and potassium fertilizers (as an active substance), kg / ha.

$A_N, A_P, A_K$ - Energy consumption per 1 kg of nitrogen, phosphorus and potassium fertilizers, per unit.

## RESULTS AND DISCUSSION

The bioenergetic efficiency of the use of phosphorus-containing fertilizers on the hayfields of the Zeravshan Valley was 1.18 for the cotton variety Omad in the variants of applying $N_{250}K_{125}$ kg/ha. The highest efficiency was observed on the variants of applying phosphorus-containing fertilizers in the form of 175 kg/ha $P_2O_5$. The subsequent increase in fertilizer rates led to a decrease in bioenergetic efficiency and turned out to be almost equal to the background $N_{250}K_{125}$ (Table 1).

**Table 1:Bioenergetic efficiency of phosphorus-containing fertilizers in cotton growing (BEF)**

| No | Varieties | Additional yield obtained at the expense of fertilizer application, ts/ha | The energy in the additional product, Mj | The energy expended for the application of fertilizers, Mj | Bioenergetic efficiency (BEF) |
|---|---|---|---|---|---|
| 1 | $N_{250}$ $K_{125}$ - background | 14.9 | 26817.02 | 22687.7 | 1.18 |
| 2 | Background + $P_{175}$ ammophos | 23.3 | 41935.34 | 31700 | 1.32 |
| 3 | Background + $P_{125}$ NPhF | 17.8 | 32036.44 | 29125 | 1.09 |
| 4 | Background + $P_{150}$ NPhF | 20.9 | 37615.82 | 30412.5 | 1.23 |
| 5 | Background + $P_{175}$ NPhF | 23.3 | 41935.34 | 31750 | 1.32 |
| 6 | Background + $P_{200}$ NPhF | 21.7 | 39055.66 | 33037.5 | 1.18 |
| 7 | Background + $P_{125}$ NCPhF | 18.6 | 33549.94 | 29175 | 1.14 |
| 8 | Background + $P_{150}$ NCPhF | 21.3 | 38335.74 | 30462.5 | 1.26 |
| 9 | Background + $P_{175}$ NCPhF | 23.7 | 42655.26 | 31750 | 1.34 |
| 10 | Background + $P_{200}$ NCPhF | 22.7 | 40855.46 | 33087.5 | 1.23 |

The introduction of phosphorus-containing fertilizers NPhF and NCPhF in the form of 175 kg/ha $P_2O_5$ against the background of $N_{250}K_{125}$ when cultivating the “Omad” cotton

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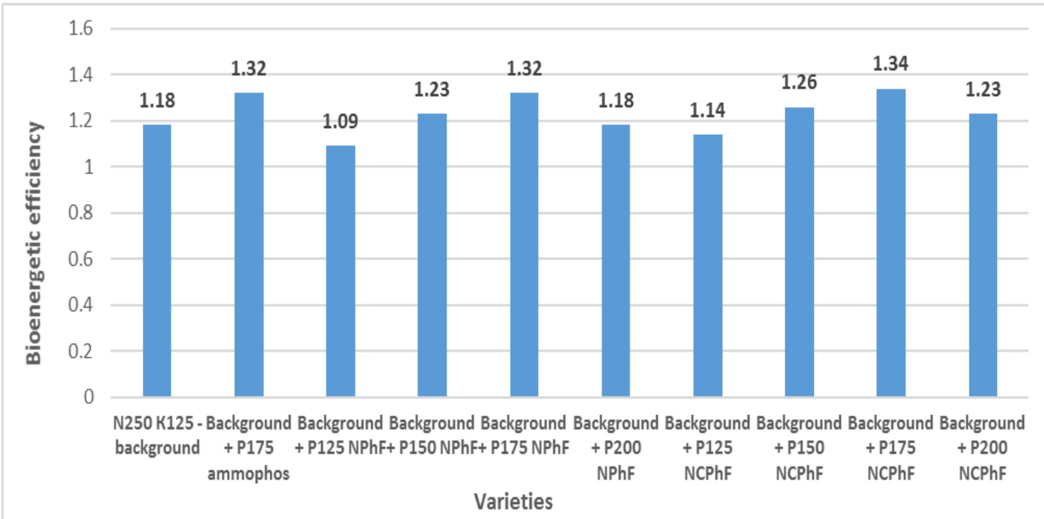
variety under conditions of magnesia-carbonate saline meadow soils is bioenergy efficient. The highest bioenergy efficiency was 1.32–1.34 (Fig. 1).

**Figure 1. Bioenergetic efficiency of phosphorus-containing fertilizers in cotton growing (BE)**




Analysis of the data obtained in the study of the bioenergy efficiency of the types and norms of phosphorus-containing fertilizers in the conditions of typical gray soils of the Zeravshan Valley is presented in Table. 2. In the $N_{240}K_{100}$ variant, the bioenergy efficiency was 2.11, while the bioenergy efficiency also increased with the increase in the rates of various phosphorus-containing fertilizers. Phosphorus-containing fertilizers against the background of $N_{240}K_{100}$ were 2.24-2.33 in the variants of application at 90 kg/ha, and in the variants with an increased fertilizer rate of 120 kg/ha, the bioenergetic efficiency was almost the same 2.33-2.34. An increase of 150 c/ha led to a decrease in productivity.

**Table 2: Bioenergetic efficiency of different types of phosphorus fertilizers and norms of corn cultivation (BEF)**

| No | Varieties | Additional yield obtained at the expense of fertilizer application, ts/ha | The energy in the additional product, Mj | The energy expended for the application of fertilizers, Mj | Bioenergetic efficiency (BEF) |
|---|---|---|---|---|---|
| 1 | $N_{240}K_{100}$ - background | 30 | 45408 | 21614 | 2.11 |
| 2 | Background + $P_{90}$ ammophos | 39.1 | 59181.7 | 26249 | 2.25 |
| 3 | Background + $P_{120}$ ammophos | 42.8 | 64782.1 | 27794 | 2.33 |
| 4 | Background + $P_{150}$ ammophos | 43.2 | 65387.5 | 29339 | 2.23 |
| 5 | Background + $P_{90}$ polyammophos | 40.4 | 61149.4 | 26249 | 2.33 |
| 6 | Background + $P_{120}$ polyammophos | 42.9 | 64933.4 | 27794 | 2.34 |
| 7 | Background + $P_{150}$ polyammophos | 43.5 | 65841.6 | 29339 | 2.24 |
| 8 | Background + $P_{90}$ supraphos | 38.8 | 58727.7 | 26249 | 2.24 |
| 9 | Background + $P_{120}$ supraphos | 42.6 | 64479.4 | 27794 | 2.32 |
| 10 | Background + $P_{150}$ supraphos | 42.9 | 64933.4 | 29339 | 2,21 |

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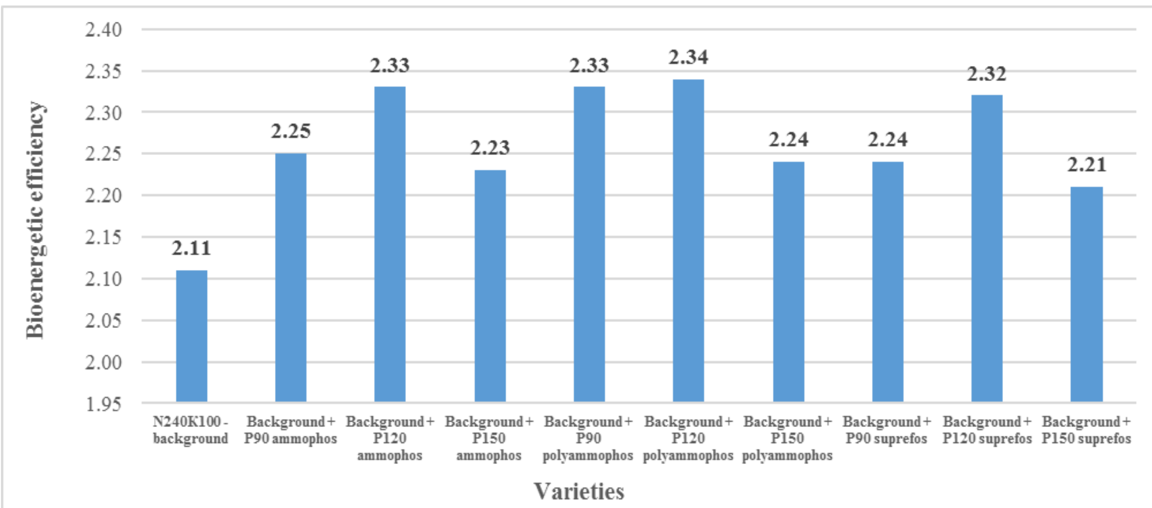
In the conditions of typical gray soils of the Zarafshan valley, the application of phosphorus-containing fertilizers at 120 kg/ha against the background of $N_{240}K_{100}$, and among the applied fertilizers, polyammophos fertilizers were found to have the highest bioenergetic efficiency (Fig. 2). In the variants applied to 150 kg/ha of phosphorus-containing fertilizers, it was equal to and less than the variants applied to 120 kg/ha (Fig. 2).

**Figure 2: Bioenergetic efficiency of different types and norms of phosphorus containing fertilizers in corn cultivation, (BEF)**




The highest bioenergetic efficiency in the cultivation of white cabbage in the conditions of typical gray soils of the Zarafshan valley was obtained in the variant applied to the type and norms of phosphorus-containing fertilizers $N_{200}K_{90}$ kg/ha. Phosphorus fertilizer and its norms do not show bioenergetic effect in the cultivation of white cabbage. Phosphorus fertilizers were found to have the same (1.26-1.28) bioenergetic effect in the variants applied per 100 kg/ha. Decrease in bioenergetic efficiency was observed with increase of NCPhF oil standards by 140 and 180 kg/ha (Table 3)

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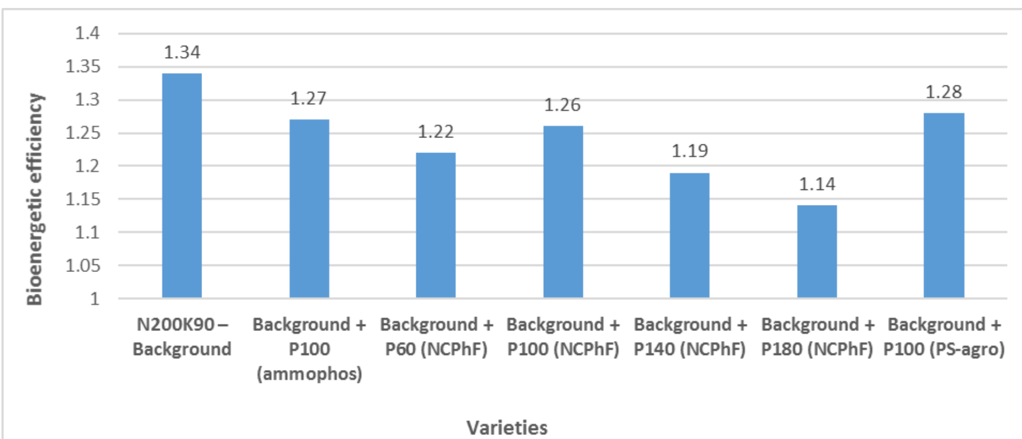
**Table 3:Bioenergetic efficiency of mineral fertilizers in the cultivation of white cabbage (BEF)**

| No | Varieties | Additional yield obtained at the expense of fertilizer application, ts/ha | The energy in the additional product, Mj | The energy expended for the application of fertilizers, Mj | Bioenergetic efficiency (BEF) |
|---|---|---|---|---|---|
| 1 | N200K90 – background | 168.1 | 24206.4 | 18067 | 1.34 |
| 2 | Background + P100 (ammophos) | 204.9 | 29505.6 | 23217 | 1.27 |
| 3 | Background + P60 (NCPhF) | 179.1 | 25790.4 | 21157 | 1.22 |
| 4 | Background + P100 (NCPhF) | 203 | 29232 | 23217 | 1.26 |
| 5 | Background + P140 (NCPhF) | 208.2 | 29980.8 | 25277 | 1.19 |
| 6 | Background + P180 (NCPhF) | 216.1 | 31118.4 | 27337 | 1.14 |
| 7 | Background + P100 (PS-agro) | 206.2 | 29692.8 | 23217 | 1.28 |

The lowest bioenergetic efficiency was obtained against the background of $N_{200}K_{90}$ in the variant applied NCPhF fertilizer 180 kg / ha, while the highest efficiency was obtained in the variant applied $N_{200}K_{90}$ kg/ha. Bioenergetic efficiency is inversely proportional to the increase in fertilizer standards. (Fig. 3)

**Figure 3 : Bioenergetic efficiency of mineral fertilizers in the cultivation of white cabbage (BEF)**




Data on white cabbage cultivation were also obtained in onion cultivation under typical gray soil conditions, and the highest bioenergetic efficiency was 1.88 in the variant applied to $N_{200}K_{90}$ kg/ha (Table 4).

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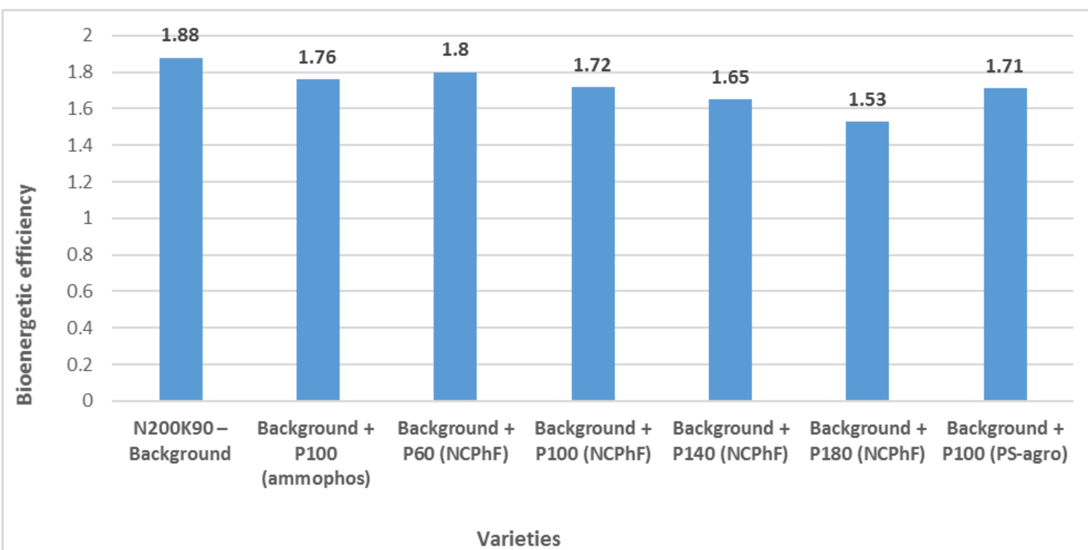
**Table 4: Bioenergetic efficiency of different phosphorus fertilizers in onion cultivation (BEF)**

| No | Varieties | Additional yield obtained at the expense of fertilizer application, ts/ha | The energy in the additional product, Mj | The energy expended for the application of fertilizers, Mj | Bioenergetic efficiency (BEF) |
|---|---|---|---|---|---|
| 1 | N200K90 – background | 236.7 | 33990.1 | 18067 | 1.88 |
| 2 | Background + P100 (ammophos) | 284.7 | 40882.9 | 23217 | 1.76 |
| 3 | Background + P60 (NCPhF) | 265.9 | 38183.2 | 21157 | 1.8 |
| 4 | Background + P100 (NCPhF) | 278 | 39920.8 | 23217 | 1.72 |
| 5 | Background + P140 (NCPhF) | 289.5 | 41572.2 | 25277 | 1.65 |
| 6 | Background + P180 (NCPhF) | 292 | 41931.2 | 27337 | 1.53 |
| 7 | Background + P100 (PS-agro) | 276.1 | 39647.9 | 23217 | 1.71 |

Bioenergy efficiency also declined as NCPF increased fertilizer rates. Against the background of the lowest value of $N_{200}K_{90}$, NCPF turned out to be 1.53 in the variant used at the rate of 180 c/ha. Fertilizers NCPF and PS-agro were equally effective and amounted to 1.71–1.72 in the variants applied at the same dose, and ammophos fertilizer - 1.76 when applied at the same rate (Fig. 4).

**Figure 4: Bioenergetic efficiency of different phosphorus fertilizers in onion cultivation (BEF)**




## CONCLUSION

A high additional yield and high energy efficiency (1.32-1.34) can be achieved by applying 175 kg/ha of phosphorus-containing fertilizers (ammophos, AFU and NCPF) obtained on the basis of Kyzylkum phosphorites against the background of $N_{250}K_{125}$ under cotton crops in meadow soil conditions Zeravshan valley. On typical gray soils with various phosphorus-containing fertilizers (ammophos, polyammophos and suprefos), when cultivating typical gray soils, the high bioenergy efficiency of wool in variants using norms of 120 kg/ha was 1.32 - 1.34, when using polyammophos fertilizer 90 kg/ha and the coefficient efficiency 1.33. High efficiency is achieved when applying ammophos and suprefos fertilizers up to 120 kg/ha and polyammophos fertilizers up to 90 kg/ha. Phosphorus-containing fertilizers are bioenergetically inefficient in the cultivation of vegetables (white cabbage and onions) on typical gray soils. However, against the background of the obtained additional yield of $N_{200}K_{90}$, it is recommended to apply phosphorus-containing fertilizers (ammophos, NCPF and PS-agro) at a rate of 100 kg/ha.

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