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Resource Saving Basics in Potato Cultivation Technology within Far North Conditions.

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ABSTRACT

Current trends are presented in the field of soil treatment, the application of organic-mineral fertilizers and soil improvers in potato cultivation. Resource saving technologies for tillage prior to potato planting, the optimal dose of lime materials and organic fertilizers are proposed. It was proved that an economically viable potato cultivation should take into account agro-ecological conditions, choose the optimal tillage systems, the doses of organic and mineral fertilizers and lime materials aimed at soil fertility and potato plant productivity improvement.

Keywords: hydrolytic acidity, fertility, tillage system, organic and mineral fertilizers, liming, seed fraction of tubers.

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INTRODUCTION

Potato cultivation development requires the solution of urgent tasks concerning the development of advanced technologies. The basis of potato production is energy-saving trends where the energy deficiency is an urgent problem for the Far North (Khanty-Mansi Autonomous Area - Yugra). The creation of huge oil and gas facilities, the demographic growth of population requires a significant increase of potato production. The need for the development of modern resource-saving technologies is conditioned by existing region terms [1]:

- Firstly, the taiga zone soils are characterized by very high acidity (pH 3.5-4.0), and also by low levels of fertility.
- Secondly, a short vegetation period (80-90 days) for the potato crop development.

Tillage system within the conditions of the region should be aimed not only on the creation of a loose layer during an initial period of potato vegetation, but also on the preservation of an optimum mode during the period of intense tuber development [4,6]. The priority elements of resource-saving technology in cold soils are the following ones: the introduction of organic-mineral fertilizers and liming.

RESULTS AND DISCUSSION

Potatoes has increased demands on the availability of nutrients in a soil. On the basis of the Khanty - Mansi Experimental Station «Agricultural Research Institute of Northern Zauralye» the elements of resource-saving technology for podzolic soil fertility improvement in taiga. Pilot area soil is podzolic one, its mechanical composition is presented by loam. It is characterized by a very high actual acidity (pH - 3.9), low humus content (1.7%), the average content of mobile phosphorus (9,0-15,5 mg per 100 g of soil) and by exchangeable potassium (7,5 - 16.0 mg / 100 g).

The study of soil improver (dolomite flour with the neutralizing capacity of 87,6-103,8%) influence on soil fertility and potato productivity was provisioned at the doses of 0; 0.5 and 1.0 according to hydrolytic acidity; organic fertilizers (manure) within 0; 40; 80; 120 and 160 t/ha; mineral fertilizers $N_{90}R_{90}K_{90}$.

The study results showed that the use of dolomite flour for potatoes provided the decrease of all types of soil acidity. The experimental pH value of KCl decreased from 3.9 to 5,6-6,0 depending on ameliorant doses (Table 1).

Table 1. Liming effect on soil acidity (average value in 3 years)

Liming background	*pH*	Mg-eq per 100 g of soil			*Al,* in % to exchangeable acidity
		acidity		*A*	
		hydrolytic	*exchangeable*		
1. Without fertilizers and lime – *control*	3,9	7,23	1,78	1,54	86,5
2. Liming according to 0,5 of hydrolytic acidity.	5,6	7,10	0,44	0,38	86,0
3. Liming according to 1,0 of hydrolytic acidity.	6,0	6,26	0,12	0,09	75,0

The best values of *pH*KCl were held during first 2 years. Hydrolytic acidity value ranged from 4.7 to 5.5 mg-eq per 100 g of soil.

Organic fertilizers (manure 40-160 t/ha) did not significantly influence the change of pH (r = 0,400), but they influenced the value of hydrolytic and exchangeable acidity. Thus, on the backgrounds (120-160 t/ha) of manure, these figures made 10,15-10,32 and 2,20-2,41 mg-eq vs control 7.23 and 1.78 mg-eq / 100 g of soil.

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The changes of exchangeable acidity and moving AI content under the influence of dolomite flour was subject to the same laws as hydrolytic acidity. Half and full doses of liming completely eliminate the movable AI. Along with the decrease of acidity liming increased the amount and the degree of saturation by absorbed bases. On the average, during the year of influence the dolomite flour of 1.0 g.c. increased the amount of absorbed bases by 0.78 mg-eq per 100 g of soil and the degree of saturation increased by 26.04%. Organic fertilizers (80 t/ha) increased, respectively, by 6.28 mg-eq / 100 g soil, and by 25.2%.

A clear direct link was established between the doses of lime and pH value. pH decreases with lime dose increase. So, the introduction of dolomite flour by 0.5 g.c. pH changed by 1.7 or the introduction of 1 tonne of CaCO3 changed the acidity by 0.21.

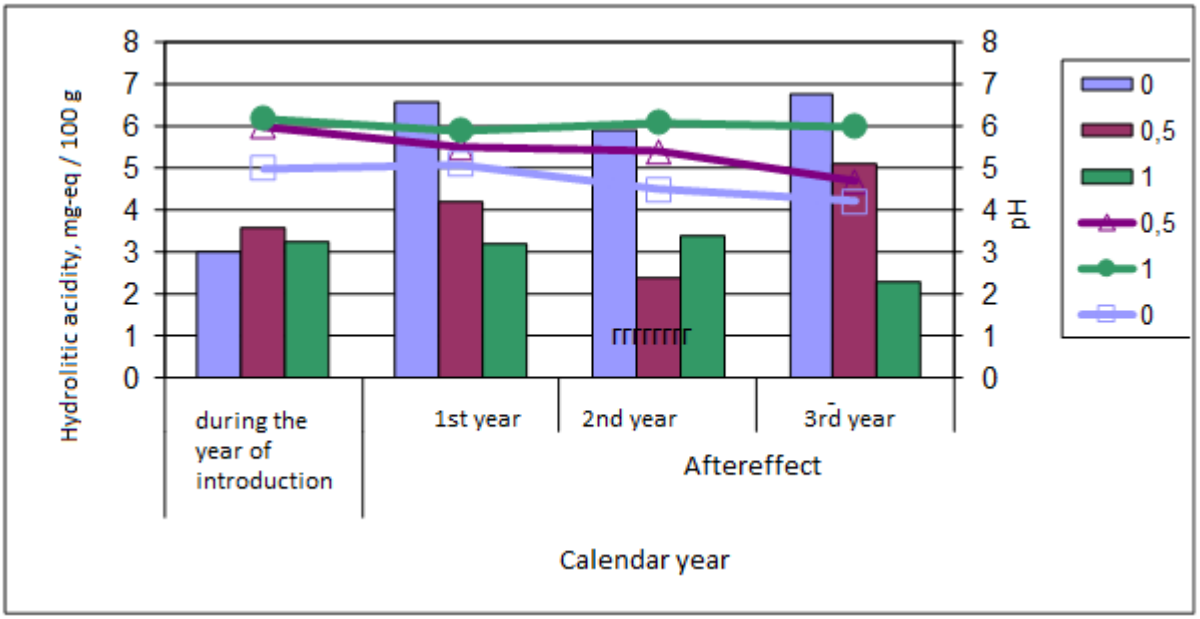

Figure 1: The influence of dolomite flour on the soil acidity during an aftereffect (background – 80 t/ha + N90P90K90)

At the increase of dolomite flour dose up to 1.0 g.c. the shift of the overall pH value made 1.6 times, and pH change from one ton of lime made from 0.27 to 0.19. The correlation coefficient is equal to 0.940. The correlation between pH, the hydrolytic acidity of soil and the content of mobile aluminum is negative one, equal to 0.519 and 0.666 respectively. In our studies, the correlation coefficient between the potato yield and a farm field pH value made 0,898 according to lime content, manure doses made 0,465, between the size of the crop and mobile aluminum content a negative correlation was obtained, - 0.898 and - 0.666 respectively.

In the aftereffect on the backgrounds of 0.5 and 1.0 g.c of dolomiteflour doses, where originally a practical neutralization of soil environment and the highest rate of acidity decline was observed during the year of introduction. On the background of liming at 0.5 g.c. the rate of change was the following one: from pH -5.8, the aftereffect: 1-st year - 5.2, 2nd year -5.0, 3rd year - 4.5. On the background of 1.0 g.c. the values made 6.4; 5.3; 5.1; 4.7 respectively. Half dose of dolomite flour did not cause such strong changes of hydrolytic acidity, compared to 1.0 g.c. Its value on this background during the whole aftereffect period fluctuated in the range of 5,28 ± 0,05 mg-eq / 100 g of soil, against 1.0 g.c.- 3,42 ± 0,78 -1,88.

The magnitude of the hydrolytic acidity is influenced by a residual effect of dolomite doses (0,5 g.c.) in all variants of the experiment maintaining it at the level of 1,9-5,96 mg-eq / 100 g of soil. On the background of 1.0 g.c.- 2,3-6,4 mg-eq / 100 g of soil. The changes of mobile aluminum content under the influence of liming were subject to the following rates. On the background of 0.5 g.c., - the year of introduction 0.09, the aftereffect: 1st year -0.56; 2nd year -0.52; 3rd year -0.49 mg-eq / 100 g of soil. On the background of 1.0 g.c. at 0.02 - the year of introduction and the change in subsequent years made - 0.21; 0.14 and 0.55 mg-eq / 100 g of soil.

Aftereffect pH changes under the influence of organic fertilizers (40-160 t/ha) compared to its level, established in the year of introduction were the following ones: manure 40 t/ha - 4,6; 4.1; 4.0; 4.2: manure 80

t/ha - 4.6; 4.2; 4.2; 4.2 respectively and manure 160 t/ha - 4.8; 4.2; 4.9 and 4.6. Hydrolytic acidity changes (80 t/ha - 6.8; 7.3; 6.6; 6.9: 160 t/ha - 6.9; 6.2; 5.0; 4.8). Organic and mineral system of potato fertilizers Potato occupied an intermediate position by its action, and hydrolytic acidity increased by 59,1-77,4% on the average during the period of experiments in aftereffect.

The process of manure organic matter decomposition depends on soil acidity degree. The doses of manure (40-120 t/ha) on the background of liming at 1.0 g.c. had a significant influence on the change of acidity towards neutralization. It is seen more clearly in comparison with the year of introduction. The decrease of acidity values happens proportionally with organic fertilizer doses increase. For example, during the third year of aftereffect on the background of 1.0 g.c. of dolomite flour, with manure introduction of 40 t/ha pH made 4.4, hydrolytic acidity made 5.7 mg-eq / 100 g of soil, and in the version of 120 t/ha it made 6.2 and 2.0 mg-eq / 100 g soil.

Thus, common patterns of podzolic soil fertility change were established, depending on the studied techniques. The maximum shifts of agrochemical indicators in neutral area were recorded during the year of introduction, naturally changing with the increase of dolomite flour doses and a neutralizing effect decrease. In general, pH and hydrolytic acidity values on the background of 1.0 g.c. indicate that the introduction of a full dose of dolomite flour is more effective for AI ion content reduction during aftereffect compared to 0.5 g.c.

Organic fertilizers (40-160 t/ha) are also an effective measure for soil fertility increase. Their effectiveness is clearly manifested during the year of introduction for potatoes and during the 2nd year of aftereffect compared to an absolute control. Annual average displacements of pH during the 2nd year of aftereffect on the background of 40-160 t/ha of manure make 0.01-0.04 units, during the 3rd year on the background of 40-80 t/ha they make 0.025 pH units. At 120-160 t/ha of manure pH made 4.5 and 4.6 at pH index of 4.2; 4.8 during the year of introduction.

During the study of aftereffect studied techniques we noted that the organic-mineral system of fertilizers and dolomite flour caused the most significant acidification of the soil environment due to NPK. During the production of potatoes in podzolic soil the use of organic-mineral fertilizer system on a limed background provided by the stabilization of soil fertility indicators for a long time. Liming makes a long-term, positive effect on the fertility of acidic soil, where a significant enrichment by nutrients and the optimization of hydrolytic acidity takes place.

Studies showed that the organic-mineral system of fertilizers and liming makes a significant impact on soil food regime improvement.

Organic fertilizers (manure 40-160 t/ha) contribute to the phosphorus content increase by 6.9 on the average; potassium content increase by 4.5 and calcium content increase by 1.9 mg / 100 g soil compared to an absolute control. Mineral fertilizers ($N_{90}R_{90}K_{90}$) both in a pure form or in combination with manure increase the content of soil nutrient. Dolomite flour helps to reduce the content of easily hydrolyzable phosphorus and nitrogen in soil, especially at full introduction of hydrolytic acidity. On the background of 0.5 g.c. for manure 40-160 t/ha the increase in phosphorus, calcium and potassium content is noted.

During aftereffect an organic-mineral fertilizer system increases the content of easily hydrolyzable nitrogen, and then phosphorus and potassium most significantly [5,3]. This is apparently due to the fact that the decomposition of manure organic matter takes place most intensively during the second year of operation. Organic fertilizers (40-160 t/ha) increase the amount of soil nutrients: easily hydrolyzable nitrogen increases by 1,09-1,79; phosphorus and potassium content increases by 1,17-1,68 and 1,2-1,8. At the same time this rate is reduced without fertilizers by 0.9 (phosphorus) and 0.5 (potassium). This points to the need of nutrition level annual replenishment by the introduction of organic fertilizers.

Secondly, we determined that during the autumn ridge tillage it is impossible to plant potato in theses soils. There are several reasons of it. First of all these soils accumulate a lot of water and during spring time ridges are almost destroyed. Besides the soil between the rows and during autumn plowing usually has a higher moisture content than during spring plowing and it is impossible to perform the processing during early periods. At the same time, the tops of ridges have a lower humidity than the soil in a similar 10 cm layer at other variants. In autumn plowing the soil moisture is higher in all layers than at spring plowing variants, i.e. the ex-

cess moisture on a plowed field does not allow the tillage during spring time earlier compared with untilled soils since autumn.

During autumn ridge tillage the soil density is so high that it is not possible to perform a qualitative potato planting. In order to perform ridge tillage in autumn each year we had to perform their filling by hiller cultivator (KOH-2.8), but even after this work the soil density in these cases is always higher than during spring plowing. After the planting on the variants with autumn ploughing the soil density in the layer of 0-10 cm is 0,06-0,14 g/cm^3 higher than during spring plowing, and in the layer of 10-20 cm this excess reached 0.21 g/cm^3. A similar pattern is observed during the flowering stage. However, by the end of the growing season, these differences are smoothed in all variants, and the density values become almost identical.

A more intensive formation of vegetative mass of plants in the variants of spring plowing + spring ridge tillage + planting had a positive impact on crop formation. At that the highest yield of tubers is obtained, the excess over control (autum plowing + spring plowing + planting) made 9,5-10,1 t/ha, or 30-31%, labor costs, both in terms of money and man-hours are the lowest and a conditional net income per 1 ruble of production costs is the highest one.

The works [1, 3, 4] and others determined that at the thickening of planting to a certain limit the yield of seed tubers was significantly increased without the gross harvest reduction. At that, the maximum thickening depends on soil and climatic conditions and the level of feeding.

In order to test the effect of planting density in combination with different doses of fertilizers on the yield of potato seed fraction we carried out an experiment. Observations showed that the combined use of organic and mineral fertilizers made a positive impact for the assimilation surface of leaves. Thus, dense plantations (70 × 15; 70 × 20 cm) on the background of manure 40 t/ha + $N_{90}P_{90}K_{90}$ contributed to leaf area expansion (0,32-0,37 m²/bush). As the mass of tops and an assimilation leaf surface increases the productivity also increases. The decrease of feeding area results in the overall tuber yield increase from 1 ha. Besides, the yield of seed fraction tubers also increases (25-125 g).

The highest yield of seed fraction was obtained on the background of manure 40 t/ha + $N_{90}P_{90}K_{90}$ at the feeding area of 70 × 15 cm. The increase compared to the control group (70 × 30 cm) made 3.08 t/ha. At that, the practical application is presented by the tubers weighing 50-80 grams at regional farms.

The highest yield of seed fractions (50-80) per area unit was obtained at 70 × 20 cm planting on the backgrounds of manure 40 t/ha + $N_{60}P_{60}K_{60}$ and manure 40 t/ha + $N_{90}P_{90}K_{90}$. At that the yield of tubers from 157 thousand pieces is increased compared with a control group. This is not only due to the gross yield increase, but also due to the reduction of large tuber amount and the increase of the average ones. The maximum gross yield (14.3 t/ha) was obtained on the background of manure 40 t/ha + $N_{90}P_{90}K_{90}$ at the feeding area of 70 × 20 cm (71.5 thousand of bushes per hectare).

Thirdly, the analysis shows that the yield rate of experience accumulation year and three years of aftereffect differ significantly. These differences were determined not only by the doses of fertilizers and dolomite flour, weather conditions, and the duration the first two component action.

The direct effect of the studied factors showed that the potato yield is strongly dependent on fertilizers and liming. At the introduction of manure 80 t/ha for potato compared to the control variant without fertilizers tuber yield increased on the average from 26.9 to 36.5 t/ha. Besides, each ton of manure ensured yield increase up to 121 kg/ha.

Organic fertilizers at the dose of 120 and 160 t/ha provided the growth of tubers by 7.4 and 9.2 t/ha respectively against the unfertilized plots. 62 and 57.5 kg of tubers per hectare were obtained from 1 ton of manure.

Within the terms of Khanty-Mansi Autonomous Area - Yugra the manure efficiency during the year of introduction in the dose of 120 and 160 t/ha slightly decreases versus the dose of manure 80 t/ha. This is determined by the basic parameters of crops photosynthetic activity. Overall productivity of photosynthesis depends on the leaf surface, the duration and the intensity of the process in potato plants. The joint introduction

of fertilizers ($N_{90}R_{90}K_{90}$) and organic fertilizers increases the yield of tubers 1.5 times compared to their separate use. At the introduction of 80 t/ha of manure and $N_{90}R_{90}K_{90}$ the crop increases from 26.9 to 40.9 t/ha. Compared with other variants the gain makes 1,5-13,1 t/ha.

The liming according to 0.5 g.c. and complete hydrolytic acidity increases tuber yield by 5.7 and 4.8 t/ha. A ton of dolomite lime at the rate of 0.5 g.c. increases the yield by 0.71 t/ha, and on the background of 1.0 g.c. liming - 0.30 t / ha. During a dry season liming does not reduce the yield of tubers compared with more rainy years.

The efficiency of organic and mineral fertilizers on the background of liming increases significantly. This allows you to receive extra 6,4-7,9 tonnes of tubers per hectare. The maximum yield of tubers makes 46.7 t/ha, develops potatoes on the background of liming at 0.5 g.c. at the introduction of organic fertilizer at the dose of 80 t/ha, together with $N_{90}R_{90}K_{90}$.

The increase of liming doses in organic-mineral system of potato fertilizers decreases the effectiveness of manure. Against the background of organic fertilizer high doses strong tops was developed, the period of maturity delayed, and thus a lot of tubers did not reach their potentially possible level.

Studies showed high efficiency of fertilizers and liming during an aftereffect. During the first year of aftereffect organic fertilizers in the dose of 40-160 t/ha increase the yield of tubers compared with the control variant without fertilizers by 2,2-9,9 t/ha. Each ton of manure during an aftereffect provides the increase - 55,0-82,5 kg of tubers. There is a proportional relationship between yield and the dose of organic fertilizers during an aftereffect. However, against the year of introduction the manure aftereffect efficiency decreases: against 40, 80, 120 and 160 t/ha, respectively, by 6.3; 12.2; 5.6 and 6.0 t/ha. A sharp intensity of crop decrease on the background of manure 80 t/ha is explained by high yield during the year of its introduction. The largest harvest during the aftereffect period (28,4-27,3 t/ha) form the plants grown on manured plots at 120 and 160 t/ha. During the aftereffect of manure at 40 t/ha the potato yield during the first year increased only by 2.2 t/ha.

The role of mineral fertilizers during the aftereffect in obtaining potato yields is of little significance. During aftereffect the value of increase in comparison with the variant without fertilizers amounted to: 0.4 during the first year; 0.3 t/ha during the third year at the reduction against the year of NPK introduction by 12.7 and 14.9 t/ha of tubers respectively.

The effectiveness of liming depends mainly on the time of its introduction. It was revealed that during the 1 st year of aftereffect liming increases the yield of tubers by 5.3 - 6.7 t/ha, which is higher than during the year of its introduction by 1.2-1.8 t/ha compared to the variant without liming. Each ton of dolomite flour in the aftereffect produces 150-112 kg of tubers. Liming improves potato yield and increases the efficiency of introduced organic and mineral fertilizers in the aftereffect. Moreover, it was the largest one during the 1st year of aftereffect.

Organic fertilizers for 80 t/ha of manure and $N_{90}R_{90}K_{90}$ on the background of liming present a more effective influence system on potato yield throughout the whole study period. It was found that the impact of fertilizers and liming on potato yield during the 1st year of after-effect was stronger than during the second one. Favorable weather conditions for vegetation favored this case.

During the third year of aftereffect organic fertilizers (40-160 t/ha) ensure potato yield increase compared to the variant without fertilizers by 4.3; 4.5; 6.3 and 10.5 t/ha respectively. There is a relationship Between the doses of fertilizers: at 80-40 t/ha the yield increase made 0.2 t/ha, at 120-80 t/ha the yield increase made 1.8 and at 160-120 t/ha the yield increase made 4.2 t/ha of tubers. This demonstrates the effectiveness of high doses of manure during an aftereffect. However, in comparison with the year of their introduction the efficiency reduced by 1.5 -2.1 times.

At the introduction of mineral fertilizers $N_{90}R_{90}K_{90}$ there is no influence of dolomite flour on the yield. During the liming at 0.5 and 1.0 of hydrolytic acidity the yield decrease is observed by 2.1 and 1.8 t/ha. The variants of organic and mineral fertilizer joint introduction do not reveal a negative effect of liming.

The overall rate of liming in a pure form during an aftereffect is more effective than 0.5 g.c.: tuber growth rate makes 112.5 kg per ton of soil improver, while on the background of 0.5 g.c. only 50.0 kg.

The dose of organic fertilizers 160 t/ha of manure together with mineral fertilizers $N_{90}R_{90}K_{90}$ on the background without liming provided the greatest yield. In comparison with the control variant without fertilizers the yield increased from 12.1 to 28.2 t/ha, the increase amounted to 16.1 t/ha. On the average, during the period of research a high efficiency of organic fertilizer 40-160 t/ha and organic-mineral system of fertilizers at 80 t/ha of manure + $N_{90}R_{90}K_{90}$ was observed during potato plant liming. In a mineral system ($N_{90}R_{90}K_{90}$) potato provides the increase of tubers by 58.8 kg per 1 kg of an active ingredient NPK.

The liming of plants proved to be an effective measure, as during the year of introduction, so as during the year of aftereffect. Less organic fertilizers were used during soil liming in order to achieve an equivalent level of productivity, obtained on an acidic soil. So, in order to obtain potato yields in the range of 34.3 t the manure was required to be introduced annually at the dose of 120 t/ha, against the background of liming by 0.5 g.c. of dolomite flour the application of the background - manure at 40 t/ha helps to achieve the same level of yield (33.2 t/ha).

The effectiveness of mineral fertilizers ($N_{90}R_{90}K_{90}$) shall be noted in potato plantings. Thus, in order to obtain approximately equal values of harvest at 39.4 - 38.3 t/ha (background manure 160 tons/ha), it is necessary to use NPK + dolomite flour at 0.5 and 1.0 g.c. or to use the combination of manure at 40 t/ha + $N_{90}R_{90}K_{90}$. Such results were also observed in the cases of organic-mineral fertilizer system. Thus, in the Far North terms, for the economical use of organic fertilizers on acid podzolic soils, liming should be applied directly for potato planting.

With the increase of organic fertilizer doses the efficiency of liming decreases. So, the performance of liming in combination with high doses of organic fertilizers (120-160 t/ha) was not covered by additional products. The application of manure 80 t/ha + $N_{90}R_{90}K_{90}$ with liming ensures maximum yield (46,7-42,1 t/ha). However, the greatest effect was observed only on the background of 0.5 g.c. of soil improver.

In general, dolomite flour in aftereffect reduces tuber yield: against the background of liming at 0.5 g.c. by 6 t during the first year and by 11.3 t/ha during the third year. Against the background of liming at 1.0 g.c. the yield reduction made 5.4 and 11.3 t/ha respectively. Thus, the effectiveness of liming during the third year of after-effect is sharply reduced, regardless of meliorant doses. The maximum increments of tuber yields from liming were obtained during the 1st year of aftereffect, then the magnitude of increases reduced approximately by 3.5 - 4 times.

CONCLUSION

Thus, in the terms of taiga zone on podzolic soils the basic element of resource-saving technology is the processing of soil - spring plowing followed by ridge tillage and planting in ridges. It provides the obtaining of 41.6 t/ha, 30% more than the autumn plowing + spring plowing + tuber planting. At that, power consumption is reduced significantly.

Autumn ridge tillage on plowed fields leads to soil density increase in ridges and to waterlogging between the rows, which adversely affects the terms of potato planting.

- An optimal density, providing a maximum output of certified seed potato tubers is the planting of 71.5 thousand tubers per 1 ha (70 × 20 cm) at the introduction of 40 t/ha + N90P90K90;
- Liming, the introduction of organic-mineral fertilizers improves the agrochemical properties of soil, thereby creating favorable conditions for the growth and the development of potato plants, which ultimately impacts the increase of tuber yield. It is necessary to introduce annually to 80 t/ha of manure + N90R90K90 on acid podzolic soils at the creation of background liming at 0.5 Gc, which allows to obtain high yields of potatoes (up to 46.7 t/ha) without a significant deterioration of product quality;
- Repetition of liming in 3-4 years.

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SUMMARY

Thus, these indicators allow to evaluate objectively the possibility of soil fertility increase by using moderate doses of organic and mineral fertilizers and their effectiveness on the background of liming. Resource-saving technology is a spring soil treatment before the planting of potatoes.

According to the abovementioned info we may conclude about the prospects of offered technological elements and the possibility of its application.

CONFLICT OF INTEREST

The authors confirm that the presented data do not contain any conflict interests.

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