Ecological and agrochemical state of soil, productivity and quality of edible roots, depending on the system of vegetable fertilizers rotations in the south-east region of Kazakhstan

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Abstract. The results of researches of influence of fertilizers vegetable crop rotation systems on soil fertility and productivity of edible roots. Dark brown soil with prolonged use in vegetable production has changed significantly. Original humus content (3.0%) declined to 1, 60-2,46%. The total nitrogen content different - 0,112-0,168%. Gross phosphorus - 0,172-0,214%, gross potassium - 2, 61-3, 34% (at baseline). Readily hydrolysable nitrogen is very small - 20-34 mg / kg. P2O5 content is high (51-80mg/kg), which is associated with long-term use of phosphate fertilizers, K2O - low (240-295 mg / kg). Carbon content (CO2) differed sharply by type of crop rotation - 0, 33-2, 65%. Noted soil alkalization (pH from 7, 3-8,2). The cat ion exchange capacity (calcium - 85-87%) decreased from 20-21 to 15-17mg-eq./100g. Providing mobile microelements varies (mg / kg): Zn - 0,25-1,25; Cu - 0,85-1,55; Pb - 1,25-8,30; Cd - 0,25-0,75; Ni - 1,45-2,85; Mn - 62,0-90,9; Fe - 5,0-6,9. Noted weighting texture (fraction <0.01 mm, 48-57%). Fertilizers increased harvest carrots on 19, 7-67,6%, beet - by 22,8-69,3%. Nitrates in the roots are below the norm by 3-4 times, which indicates that, the ecological purity of the product.

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Abbreviations

N-nitrogen, P-phosphorus, K-potassium, As (nutrient)-active substance, t-ton, kg-kilogram, g-grams, mg- milligrams, t / ha- ton per hectare, m2-square meter, ha-hectare, %-percentage, mpc-maximum permissible concentration.

Introduction

Vegetable crops are the main sources of vitamins and minerals that are vital for the human body, an important place in the modern concept of the balanced nutrition. According to the Kazakh Academy of Nutrition, a year per 1 citizen of the Republic shall be at 126 kg of vegetables, including carrots - 9kg, beetroot - 8kg. By region consumption norms of different kinds of vegetables are slightly different.

Edible roots (carrots, beets) are very valuable, and the most popular year-round used in food vegetables. Owing to the high biological potential of edible root vegetable crops (40-50 t / ha or more), their level of yield remains low at an average of 20-22 t / ha. The main reasons for the low productivity of carrots and beetroots can be called deterioration of soil and crops of eating disorders.

Scientists point out many facts strong degradation of soil plane hydrogen. Much Research has established a decrease in soil fertility indicators, soil contamination by pesticides, heavy metals and other toxicants. Reduction in the supply of fertilizers in agriculture has led to a decrease in productivity fields. Non-compliance with technology application of fertilizers and plant protection led to the deterioration of the crop, the accumulation of toxic residues in the products [1-17].

In order to increase soil fertility and crop yields, while preventing soil contamination with toxic substances and products, it is necessary to develop science-based, ecologically safe technologies of application of fertilizers in crop rotations, to optimize the conditions of mineral nutrition of plants.

Taking into account these problematic issues, the scientists of the Kazakh Research Institute of Potato and Vegetable Crops (KazRIPVC) together with scientists from the Kazakh Research Institute for Soil Science and Agricultural Chemistry joined forces. U. Uspanova pursued the study (from 1991) in the indicated direction. Through these studies, experiments were established Kazakh National Agrarian University (2012, 2013) to study the agro-economic and environmental efficiency of fertilizers for edible vegetables crop rotations.

Materials and methods

Fields details: The study was performed in 2012 to 2013 in the experimental stationary KRIPH located in Karasai district of Almaty region. Region - south-east Kazakhstan, foothill zone, 1000-1050 m above sea level. The climate is sharply continental. The Warm periods - 240-275 days frost-free - 140-

170 days. Sum of active temperatures - 3100- 34000S . Hydrothermal factor - 0.7-1.0 . Annual rainfall - 350-600 mm during the growing season - 250-320 mm. Soil - dark chestnut , medium loam , humus content - 3% of total nitrogen - 0.18-0.20 % , total phosphorus - 0,19-0,20 % of total potassium - 2.4-2.7 % P2O5 - 33-35 mg / kg , K2O - 340-360 mg / kg , pH 7.3-7.4 , volumetric mass - 1.1-1.2 g/cm3.

Sample preparation and analytical methods:

In experiments used conventional classical methods:

- Agrochemical methods of soil investigation (1975);
- F.A. Yudin «Method Agrochemical Research» (1980);
- B.A. Dospehov «Technique of field experience» (1985);
- V.F.Belika «Methods of experimental work in the Vegetables and Melons» (1992);
- Methodical instructions on determination of nitrates in production (1986).

Phenological observations were made by A.Rudenko (1950).

Qualitative indicators roots defined by methods:

Dry substance - gravimetric method (drying), the total sugar - according to Bertrand, vitamin C and carotene - by Murry; nitrates - potentiometric ally.

Soil researches carried out by the following procedures: pH - potentiometric ally; humus - by Tyurin, nitrate nitrogen - by Gryandval-Lyazhu; mobile phosphorus and exchangeable potassium - by Machigin with further definition of P2O5 per electro photo colorimeter, K2O - by flame photometer.

Farming equipment in experiments with root crops generally accepted to the region, carried out in accordance with the recommendations KRIPH. Used allowed for use in the Almaty region carrot varieties (Alau) and red beet (Kyzylkonyr).

Yields of carrots and beetroots with the definition of its structure were taken into account by a continuous method with all the options and re-experience. The statistical processing of the data, yielding carrots and beets conducted by dispersive analysis methods (B.A. Dospehov, 1985).

For assessing ecological and agro-chemical condition of dark chestnut soils foothill zone of the south-east of Kazakhstan carried out soil investigations under three very different rotations: 8-fields vegetable and herb (with grain sowing grasses, perennial herbs, potatoes, cabbage, cucumber, tomato, roots), 4-fields intensive vegetable (cabbage, cucumber, tomato, roots), 3-fields short rotation vegetable-grain (cereals, cabbage + tomato, onion + roots).

Results and discussion

The results showed that piedmont dark chestnut soils have different agrochemical and agro physical properties depending on the kinds of vegetable crop rotation systems and their fertilizer. At the same time a marked divergence of soil fertility parameters from baseline.

The original content humus in the soil, which is the main indicator of its fertility, was equal to 3.0%. After prolonged use (about 60 years) of these soils in irrigated vegetable humus content decreased on average by one-third, that is in our view an environmental disaster.

Depending on the types of crop rotation systems and their fertilizer humus content in the soil decreased from 3.03% to 1,60-2,46%, that is 0,47-1,57% (18,8-47,2%) . Under the influence of fertilizer was an increase of humus content relative to the control. To achieve baseline of humus requires prolonged use of large norms of organic and mineral fertilizers.

In the soil, except for humus, also it has also been noted an increase in total and mobile forms of macro-and micronutrients.

The total nitrogen (N) in topsoil sown vegetable crops depending on the type of crop rotation and fertilizer application systems varied widely - 0,112-0,168%, indicating that the various provisions of this valuable element of soil nutrition.

The content of total phosphorus (P) ranged between 0,172-0,214%, mainly - 0,19-0,20%), which corresponds to the original level.

The content of total potassium (K) was 2,61-3,34%. Most samples contained 2,5-2,6% of potassium, i.e. at baseline.

By moving forms of elements of fertilizes, easily digestible plants, marked the middle and higher levels.

Hydrolysable nitrogen content in the soil ranged between 20-34 mg / kg, which indicates that effective reduction of soil fertility.

It should be noted high security mobile forms of soil phosphorus. Depending on the kinds of vegetable crop rotations in the soil contained 51-80 mg / kg and over P2O5. This is due to long-term use of phosphate fertilizers on experimental plots KRIPH.

In contrast to the gross forms of potassium, which have a high content (2,6-3,3%) showed a significant decrease in the content of mobile forms of this macronutrient. In many soil samples analyzed the content of exchangeable potassium (K2O) was low - 240-295 mg / kg. Some samples K2O content was average - 300-350 mg / kg.

Carbon content (CO2) in topsoil varied widely - from 0.33-0.6 to 1,32-2,65%, indicating a significant difference by type of crop rotation as well as the initial content of CO2.

Soil reaction (pH) in the initial cut was alkaline soil (pH 7,3) and is close to neutral (pH 7,1). In soil samples in 2012, 2013 marked alkalization of soil (pH 8,02-8,20).

The cat ion exchange capacity decreased from 20-21mg-eq. 15-17 mEq. per 100g of soil. Additional soil cat ion predominant calcium (85-87%).

Microelements, along with macro elements, play an important role in the life of plants. So the study of of issues related to security of soil and plant micronutrient nutrition is very impotent essential.

Our results show that the soils of different kinds of vegetable crop rotations have different levels of security on mobile forms of trace elements. The difference between the variants of experiments and experimental plots reach from 2 to 5 times. So , by type of trace elements in soils of experimental plots indicated the following content of mobile forms of zinc (Zn) - from 0.25-0.40 to 0.75-1.25 mg / kg, Copper (Cu) - 0,85-1,55 mg / kg; Lead (Pb) - up to 1,25-3,50 5,60-8,30 mg / kg; Ccadmium (Cd) - 0,25-0,75 mg / kg; Nickel (Ni) - 1,45-2,85 mg / kg; Marganese (Mn) - 62,0-90,95 mg / kg; Iron (Fe) - 5,0-6,95 mg / kg.

The gross forms of micronutrient differences between experimental plots are less pronounced. In the analysis of soil samples collected vegetable crops sown at different crop rotations, they contain the following number of gross forms of trace elements (mg / kg): Zn-70,2-73,2; Cu-27,8-35,8; Pb-28,8-30,6; Cd-2,2-3,2; Ni-34,0-44,6; Mn-639,6-701,4; Fe-27896-35260.

Mechanical compositions the soil in different crop rotations was close. Content of the clay fraction less than <0.01 mm ranged from 42-48% to 54-57%, which corresponds to an average loam. At the same time, the data indicate a significant increase in weight of the mechanical composition of the soil. Mechanical composition of the original soil samples was middle loam. Contains fractions <0.01 mm within 43-45%. That is, in the process of agricultural use has changed mechanical composition dark brown soil on the downside. Heavy texture makes it difficult soil treatment tools, increases Fuel consumption and deterioration of equipment, has an adverse effect on the formation of grocery intra soil vegetables (roots).

Thus, on the basis of soil studies, we can conclude that the dark brown soil zone foothills southeast of Kazakhstan for a long period of use in irrigated vegetable production have undergone significant changes. On soil fertility parameters significantly affect species and vegetable crop rotation system of fertilizer.

Plant productivity largely depends on the level of soil fertility and their conditions of mineral nutrition. Were therefore studied the effect of fertilizers on the growth and development of edible root plants, the accumulation of the crop. This article presents data on two types of rotations.

To determine the intensity of formation of vegetative biomass and product of carrot and beet on experimental plots were held biometric research. Found that the conditions of mineral nutrition have a significant impact on the growth and development of the edible root plants.

Table 1. Influence of fertilizers on biomass formation beet plants, technical maturity (2012, 2013)

Variants of experience	The total mass of 1 plant, gram	The leaves mass with petioles gram	The leaves length with petioles, cm	The total number of leaves pcs.	Leaf Total area, cm2	The Root length, cm	The diameter of root crops	Weight of 1 root crop, gram
$N_0P_0K_0$	429	196	40	12,3	304	9,5	8,7	233
$N_{50}P_{30}K_{40}$	497	235	45	12,8	341	10,0	9,1	263
$N_{100}P_{60}K_{80}$	556	266	47	14,5	375	10,7	9,9	291
$N_{150}P_{90}K_{120}$	628	315	48	15,3	414	11,2	10,8	312

Biometric counts beetroot plants confirm the high responsiveness of culture conditions on mineral nutrition. On the unfertilized control and fertilized with rising standards for all nutrition elements variants metrics marked significant differences.

Here the total mass of beet plants was 497-429g and 628g, length of leaves and petioles - 40cm and 45-48 cm, number of leaves - 12.3 items and 12,8-15,3 pcs., leaf surface - and 341-304sm2 414sm^2 . There were significant differences and on the formation of roots. Thus, their average weight was 233g in control and fertilized variants - 263-312g (Table 1).

Table 2. Influence of fertilizers on biomass formation plant of carrots, technical maturity (2012, 2013)

Variants of experience	The total mass of 1 plant, gram	The leaves mass gram	The leaves length with petioles, cm	The total number of leaves on 1 plant, pcs.	The diameter of root crops	The root length, cm	The average weight of 1 root crop, gram
$N_0P_0K_0$	209	48	36,9	8,6	4,5	12,9	161
$N_{50}P_{30}K_{40}$	232	55	39,4	9,7	4,9	14,4	177
$N_{100}P_{60}K_{80}$	267	65	43,5	11,1	5,5	15,6	202
$N_{150}P_{90}K_{120}$	300	77	43,0	12,1	5,8	16,2	223

In experiments with carrots fertilizers have more effective influence on the formation of vegetative biomass and product culture. Carrot plants were very big, had a total weight of 1 plant within 232-300g at 209g at checkout. Number of leaves was 9,7-12,1 items, that 1,1-3,5 items larger than control plants.

Options on of experience depending on security nutrients formed roots with different parameters: diameter - 4.5 cm and 4,9-5,8 cm, length - 12.9 cm 14,4-16,2 cm, average weight - 161g and 177 - 223g (Table 2). Best carrot plant development was observed in treatments with double and triple standards fertilizers.

Table 3. Yields carrots depending on fertilization rates 4-fields intensive vegetable crop rotation

Variants of experience	The root crops yield t/ha (2012)	The yield increase of carrot		The root crops yield, t/ha (2013)	The yield increase of carrot	
		t/ha	%		t/ha	%
1. $N_0P_0K_0$	17,5	-	-	18,0	-	-
2. $N_{50}P_{30}K_{40}$	20,9	3,4	19,4	21,6	3,6	20,00
3. $N_{100}P_{60}K_{80}$	25,2	7,7	44,0	26,3	8,0	46,11
4. $N_{150}P_{90}K_{120}$	29,0	11,5	65,7	30,5	12,5	69,44
P,%	2,84			3,21		
HCP05, t/ha	2,64			2,51		

Thus, the use of fertilizers, improving nutritional conditions, promotes more intensive development of plants. Accumulation of more powerful plant bio-mass ultimately ensured shaping of relatively high yields of edible roots.

In the 4-fields crop rotation fertilizer application provided substantial productivity gains carrot fields (Table 3). On the unfertilized control root crops average yield for 2 years was the minimum -17.75 t / ha. Significant growth harvest carrots marked fertilized variants - 21,25-29,75 t / ha, which is 19,72-67,61% of the control. The highest yields of carrot roots in the experience were obtained by introducing a culture N150P90K120.

In 3-fields short rotation vegetable and grain crop rotation improved mineral nutrition conditions by applying fertilizers has a positive effect on the productivity of beetroot (Table 4).

Table 4. Yield beetroot depending on fertilizer norms in 3-fields short rotation vegetable and grain crop rotation

Variants of experience	The root crops yield t/ha (2012)	The yield increase of beetroot		The root crops yield t/ha (2013)	The yield increase of beetroot	
		t/ha	%		t/ha	%
1. $N_0P_0K_0$	24,4	-	-	26,0	-	-
2. $N_{50}P_{30}K_{40}$	30,5	6,1	25,0	31,4	5,4	20,77
3. $N_{100}P_{60}K_{80}$	35,8	11,4	46,7	37,5	11,5	44,23
4. $N_{150}P_{90}K_{120}$	41,6	17,2	70,5	43,7	17,7	68,08
P,%	2,87			2,29		
HCP05, t/ha	3,81			2,57		

The beetroot yield when fertilizing culture increased from 25.20 t / ha (control) to 30,95-42,65 t / ha (average 2 years). In addition to the control obtained by 5.75 t / ha (22.82%), 11.45 t / ha (45.44%) and 17.45 t / ha (69.25%), respectively root crops variants field experiences.

Thus, the improvement of the conditions of mineral nutrition of plants by fertilizing promotes productivity of crop rotation fields planted with root vegetables.

In vegetable growing product quality are very important, because directly linked to the health of the population. Vegetables are very important to ensure balance of power supply, used every day, and therefore the importance of the quality factor and environmental safety.

Almost all kinds of vegetables are used fresh in food, and after superficial processing. Therefore, products must be grown with safe all vitamins inside and ecologically pure, not to hurt the body by the toxins.

Given the importance of product quality, we have carried out biochemical analyzes harvest carrots and beets. Found that the effect of fertilizers on the quality of the product is markedly different depending on fertilizer norms and meteorological conditions of the year.

In experiments with carrots influence of fertilizers on quality of roots was different (Table 5). In 2012, there was some decrease in the content of dry matter and total sugar, increased nitrate levels. In 2013 there was an increase in dry matter 12.10% (control) to 12,70-12,94% (fertilized variants), with a decrease in sugar, from 9.76% (control) to 8.75 - 9.48%. Also noted a decrease in vitamin C in the roots - from 8.4 mg% to 6,3-7,8 mg%. Nitrate levels in carrots were low both in control (75 mg / kg) and fertilized variants (69-75 mg / kg), indicating that the ecological purity of the product (MPC carrot - 400 mg / kg of fresh weight). Relatively low nitrate content in products is explained by a moderate rate of fertilizer application.

Table 5. Effect of fertilizers on the quality of carrot

Variants of experience	Dry substance, %		Overall sugar, %		Vitamin C, mg/%		Nitrates, mg/kg	
	2012	2013	2012	2013	2012	2013	2012	2013
1.$N_0P_0K_0$	13,88	12,10	10,10	9,76	8,14	8,4	90	75
2.$N_{50}P_{30}K_{40}$	13,64	12,70	8.75	8,75	7,83	7,8	106	79
3.$N_{100}P_{60}K_{80}$	12,94	12,94	9,25	9,48	8,24	6,9	161	73
4.$N_{150}P_{90}K_{120}$	13,30	12,76	9,40	9,30	8,14	6,3	216	69

In experiments with beet noted the positive impact of fertilizers on the quality of root crops (Table 6). In 2012 the introduction of a beet field and N50P30K40 N100P60K80 significantly increased sugar content in the roots. Was an increase in the dry matter production. Only on version with triple standards fertilizers (N150P90K120) slightly decreased the total solids, sugars and vitamins. In 2013 fertilized variants in beet roots accumulated more dry matter (17,50-18,12%) and total sugar (13.75%), and vitamin C content was at the control level or slightly decreased (22,5-24, 6 mg%).

Nitrate was greater in 2012 beetroot crop, due to adverse weather conditions (extreme heat, drought) in the growing season. On the controlled by the roots contained 400 mg / kg NO3-, fertilized variants - 420-524 mg / kg, an increase of 5-31%. In 2013 the nitrate level was significantly lower. Nitrate accumulation was minimal in the beet crop grown without fertilizers (265 mg / kg) and with the introduction of single fertilizer norms (N50P30K40) - 247 mg / kg. Application under beet double and triple fertilizer norms increased the nitrate content in roots in relation to the control 20,75-69,81%. If we consider that the permissible limits for beetroot are 1400 mg / kg, the whole grown products are environmentally safe.

Table 6. Effect of fertilizers on the quality beet of root crops

Variants of experience	Dry substance, %		Overall sugar, %		Vitamin C, mg/%		Nitrates, mg/kg	
	2012	2013	2012	2013	2012	2013	2012	2013
1.$N_0P_0K_0$	18,02	16,80	12,25	12,10	30,8	24,2	400	265
2.$N_{50}P_{30}K_{40}$	17,94	17,50	12,75	13,75	30,8	24,6	420	247
3.$N_{100}P_{60}K_{80}$	18,72	18,04	13,45	13,75	30,8	23,8	483	320
4.$N_{150}P_{90}K_{120}$	17,16	18,12	11,45	12,00	28,6	22,5	524	450

Thus rational fertilizer has positive effect on the biochemical composition of the product. Fertilizer in moderate-optimal standards improves quality of roots, increasing their content of dry matter, sugars and vitamins.

Found that the fertility of dark chestnut soils foothill zone southeast of Kazakhstan for a long period of use (over 60 years) in irrigated vegetable growing has changed significantly. Humus content in the soil decreased from 3.03% (baseline) to 1,60-2,46%, which should be noted as a significant environmental problem. The total nitrogen content (0,112-0,168%) indicates a weak security of this valuable element of soil nutrition. The content of total phosphorus (0,172-0,214%) and total potassium (2,61-3,34%) was at baseline or above it. Hydrolysable nitrogen is very small - 20-34 mg / kg, which shows a decrease in the effective soil fertility. P2O5 content is high (51-80mg/kg and more), which is associated with long-term use of phosphate fertilizers, K2O content - low (240-295 mg / kg). The carbon content (CO2) in the soil ranged from 0.33-0.6 to 1,32-2,65%, which indicates a significant difference for both types of rotations and the initial content of CO2. Soil reaction (pH) in the initial state was slightly alkaline (pH 7,3) and is close to neutral (pH 7,1). In soil samples in 2012, 2013 marked alkalization of soil (pH 8,02-8,20). The cat ion exchange capacity decreased from 20-21mg-eq. 15-17 mEq. per 100g of soil. Among soil predominant cat ion calcium (85-87%). Providing mobile trace elements varies (mg / kg): Zn - 0,25-1,25; Cu - 0,85-1,55; Pb - 1,25-8,30; Cd - 0,25-0,75; Ni - 1,45-2,85; Mn - 62,0-90,9; Fe - 5,0-6,9. Under the influence of fertilizer intensive development edible root plants, the formation of a strong biomass. Fertilizers increased the productivity of 19,7-67,6% carrot, beet - by 22,8-69,3%. Moderately optimal mineral nutrition improved the quality of root crops, increasing their content of dry matter, total sugar and vitamin C. The accumulation of nitrate in the roots was minimal (3-4 times lower than the MPC), which indicates that the ecological purity of the product.

Conclusions

It was established that the fertility of dark chestnut soils foothill zone southeast of Kazakhstan for a long period of use (over 60 years) in irrigated vegetable production has changed significantly. Humus content in the soil decreased from 3.03% (baseline) to 1,60-2,46%, which should be noted as a significant environmental problem. The total nitrogen content (0,112-0,168%) indicates a weak security of this valuable element of soil nutrition. The content of total phosphorus (0,172-0,214%) and total potassium (2,61-3,34%) was at baseline or above it. Hydrolysable nitrogen is very small - 20-34 mg / kg, which shows a decrease in the effective soil fertility. P2O5 content is high (51-80mg/kg and more), which is associated with long-term use of phosphate fertilizers, K2O content - low (240-295 mg / kg). The carbon content (CO2) in the soil ranged from 0.33-0.6 to 1,32-2,65%, which indicates a significant difference for both types of rotations and the initial content of CO2. Soil reaction (pH) in the initial state was slightly alkaline (pH 7,3) and is close to neutral (pH 7,1). In soil samples in 2012, 2013 marked alkalization of soil (pH 8,02-8,20). The cat ion exchange capacity decreased from 20-21mg-eq. 15-17 mEq. per 100g of soil. Among soil cat ions predominant calcium (85-87%). Providing mobile microelements varies (mg / kg): Zn - 0,25-1,25; Cu - 0,85-1,55; Pb - 1,25-8,30; Cd - 0,25-0,75; Ni - 1,45-2,85; Mn - 62,0-90,9; Fe - 5,0-6,9. Under the influence of fertilizer intensive development edible root plants, the formation of a strong biomass. Fertilizers increased the productivity of 19,7-67,6% carrot, beet - by 22,8-69,3%. Moderately optimal mineral nutrition improved the quality of root crops, increasing their content of dry matter, total sugar and vitamin C. The accumulation of nitrate in root crops was minimal (3-4 times lower than the MPC), which indicates that the ecological purity of the product.

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