Influence of Crop Rotation Fertilization System on Soil Ecology, Crop Yield and Quality of Vegetables in the South-east of Kazakhstan

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The parameters of soil fertility in the 3-field short rotary grain and vegetable crop rotation were relatively high. The humus content in the control was equal to 2,07%, for versions with organic-mineral fertilizers - 2,30-2,79%. Fertilized variants of nitrogen contained 30,8-37,8 mg/kg (control - 29,4 mg/kg), potassium - 380-540 mg/kg (control - 305 mg/kg). The absorption capacity of the soil is reduced bases - 15-17mg eq./100g at baseline - 20-21 mEq./100g. Amongst the predominant cations is calcium (85-87%). The content of heavy metals in the soil within the permissible limits, however, their level increases, which can lead to contamination of soil and products. Texture of the soil has changed for the worse (fraction <0,01 mm from 43-45% to 54-57%). Improvement of soil fertility parameters can only be achieved when organic and mineral fertilizers vegetable crop rotation system. Fertilizer increased the yield of potato tubers to the control (18,7 t/ha) at 17,11-51,34%. Increase crop of onions from fertilizers to the control (28,5 t/ha) was 6,2-15,6 t/ha (21,75-54,74%). Harvest of sugar beet from fertilizers increased from 26,5 t/ha (control) to 31,9-42,1 t/ha. Additionally received 20,38-58,87%. Most effective on potatoes N180P180K180, onions and beets - N150P90K120. In tubers increased solids content (24,86-25,18%) and starch (16,0-17,8%). Quality bulbs and roots varied little depending on the conditions of mineral nutrition.

Key words: Ecology, Soil, Fertility, Crop rotation, Ppotatoes, Onions, Beetroot, Productivity, Quality.

Vegetable growing is a very important branch of agriculture, designed to provide a year-round population of complete and balanced food at an affordable price. According to the Kazakh academy of nutrition, norm of consumption vegetables per 1 citizen of the republic is 120 kg, potatoes - 100 kg, melons - 26 kg.

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According to the statistics of 2013, in the republic area of potatoes totaled 184,8 thousand hectares, gross collection - 3,344 million tones with an average yield of 16,6 t/ha. Vegetable crops cultivated on 133,1 thousand hectares, 3,241 million tons of vegetables harvested, yield - 24,4 t/ha. Under melon fields allocated 82,3 thousand hectares, 1,248 million tons harvested, yield - 15,2 t/ha concentration.

Volumes of potatoes production, vegetables and melon fields fully cover domestic

needs of the country. However, there is disadvantages in the off season, the prices of many products vary considerably; still remain high, and the meager assortment of vegetables. Average crop yields are still low - 15-24 t/ha. Biochemical and environmental performance of products need to be improved.

Despite the availability of a sufficient number of domestic varieties (150) with high economically valuable features, advanced technology development, productivity of plantations is still low. One of the limiting factors of the implementation of the genetic potential of new high-yielding varieties of potatoes, vegetables and melons, the impact of new agricultural technology is the degradation of soil fertility due to nutrient depletion and erosion, failure of technology application of fertilizers. Declining soil fertility has also contributed to maintaining natural farming numerous small (peasant) farms. In the south and south-east of Kazakhstan soil is so depleted that it is very difficult for them to conduct a cost-effective sustainable vegetable production[1-3]. Along with the problems of preserving the fertility of irrigated land, increase yield and quality of vegetables, acute problems of soil contamination and toxins product still residues. A similar situation exists in other countries[4-10].

The foregoing determines the relevance of research on the development and improvement of crop rotation systems fertilizers, promote the restoration of soil fertility, increase productivity and improve the quality of vegetables and potatoes, reduce environmental load on the soil and the environment.

MATERIALS AND METHODS

Fields details: The study was performed in 2012 to 2014 in the experimental stationary KazRIPVF located in the Karasay district of Almaty region. Region - south-east Kazakhstan, foothill zone, 1000-1050 m above sea level. The climate is sharply continental. The warmer periods - 240-275 days frost-free, 140-170 days. The sum of the active temperatures, 3100- 3400^{0}C. 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% P_2O_5 - 33-35 mg/kg, K_2O - 340-360 mg/kg , pH 7,3-7,4, volumetric mass - 1,1-1,2 g/cm^3.

Sample preparation and analytical methods

In experiments used conventional classical methods:

a) Agrochemical methods of soil investigation (1975);
b) F.A. Yudin «Method Agrochemical Research» (1980);
c) B.A. Dospehov «Technique of field experience» (1985);
d) V.F.Belika «Methods of experimental work in the Vegetables and Melons» (1992);
e) Methodical instructions on determination of nitrates in production (1986).
f) Phenological observations were made by A.Rudenko (1950).

Qualitative indicators potato, onion and red beet defined by methods

Dry substance - gravimetric method (drying), the total sugar - according to Bertrand, vitamin C - 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 KazRIPVF. Used allowed for use in the Almaty region potato varieties - Aksor, onion varieties - Tabys, red beet - Kyzylkonyr.

Yields of potato, onion 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 potato, onion and beets conducted by dispersive analysis methods (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 3-fields short rotation vegetable-grain (cereals, potato, onion + red beet).

RESULTS AND DISCUSSION

To assess the state of dark chestnut soils foothill zone of the south-east of Kazakhstan, heavily used in irrigated vegetable production from the 50 years of XX century, soil investigations carried out fewer than 3 different rotations. This article presents data on the 3-field short rotational vegetable crop rotation (barley, potatoes, onions + beet). Laboratory analytical work was performed at the Kazakh research institute for soil science and agricultural chemistry U.Uspanova.

According to the soil survey, foothill dark chestnut soils have different agrochemical and agro properties depending on the kinds of vegetable crop rotation systems and their fertilizer. At the same time was a significant difference of soil fertility parameters from the original.

Knowing that the main indicator of soil fertility is the content and humus reserves, the initial content of humus in the dark chestnut soils foothill zone of the south-east of Kazakhstan (soil experienced hospital KazRIPVF, 1981) was 3,0%. Here in the topsoil (0-30 cm) contained 3,03% of humus, 0,16-0,19% of total nitrogen, total phosphorus 0,18-0,20% and 2,3-2,4% of total potassium. High value had other initial parameters of the soil. After 30 years of operation of these soils in irrigated vegetable production, has been a significant deterioration of the basic properties of the foothills of dark brown soil.

Table 1. The humus content and mobile forms of nitrogen, phosphorus and potassium in the soil

Experience options	Depth, cm	Humus, %	Mobile forms, mg/kg			CO^2, %	pH
			N	P_2O_5	K_20		
$N_0P_0K_0$	0-20	2,07	29,4	143	305	1,35	8,14
	20-40	1,86	23,8	82	265	1,83	8,16
	40-60	1,16	21,0	32	205	3,46	8,18
$N_{60}P_{60}K_{60}$	0-20	2,30	30,8	98	300	1,28	8,11
	20-40	1,85	26,6	58	255	1,25	8,10
	40-60	1,51	23,8	26	215	2,11	8,08
$N_{120}P_{120}K_{120}$	0-20	2,69	37,8	153	380	1,09	8,04
	20-40	2,56	30,8	70	285	1,13	8,07
	40-60	2,32	25,2	27	230	1,25	8,08
$N_{180}P_{180}K_{180}$	0-20	2,79	37,8	100	540	1,06	8,05
	20-40	2,48	33,6	110	545	0,94	7,99
	40-60	2,27	35,0	65	410	1,44	8,12

Three field crop rotation was developed and recommended by KazRIPVF for small (peasant) farms with small landholdings (3-10 ha). In the first field crop rotation crops are placed (in the experiment - barley). After harvesting the grain milled (combine) straw scattered over the field. The average rate of straw is 2 t/ha (with the grain yield of 2 t/ha), which is equivalent to 3,4 tons of manure. Over the straw manure, which, together with the straw is plowed into the soil. This creates an organic background for the next two cultures: the second field - the potatoes, the third - vegetables (two vegetable crops - a consolidated field). In this case, under the succeeding crops on two fields are made complete fertilizer. Such a system (decomposition, organic-mineral) can significantly improve soil fertility and crop productivity in the 3-pole rotation.

Our results show that by agrochemical properties of soil parameters in 3-field short rotary grain and vegetable crop rotation significantly exceeded that of other crop rotations (Table 1).

The humus content in the soil on the control of an experienced hospital equaled 2,07%, which is below the initial level (3,03%), marked in 1981 by 31%. That is 30 years of heavy use in irrigated vegetable production without compensation removal of nutrients stocks of soil organic matter significantly reduce. On versions with organic-mineral fertilizers decrease of humus was less dramatic - 2,30-2,79%. Application of complete fertilizer for potatoes and vegetables (onions, beets) in the triple norm against the backdrop of 20 t / ha of manure and 2 t/ha of straw

(1 time for crop rotation) as much as possible to stabilize the process of decreasing soil fertility. In this embodiment, the experience of the humus content was 2,79%, which is only 7,9% less than the original figure.

In a 3-field crop rotation was a significant increase in the content of mobile forms of nutrients. Thus, nitrogen contained fertilized embodiments 30,8-37,8 mg/kg (Control - 29,4 mg/kg), potassium - 380-540 mg/kg (control - 305 mg/kg). Noticeable differences between the variants of experience in humus content of the soil in a relatively short period of our study (2012-2014 years) associated with the initial level of soil fertility.

Found that in the irrigated dark chestnut soils foothill zone of the south-east of Kazakhstan, heavily used in potato and vegetable for a long time (about 60 years), humus content decreased by an average of one-third, which causes great concern, is very alarming.

Determined by the capacity of the absorbed bases (cation exchange), the carbon content in the soil and the reaction of the soil solution (pH), which is an important indicator of soil fertility.

CO^2 content in the soil fluctuated greatly on options experiments and soil horizons. On the control of the carbon content was 1,35-3,46%, fertilized variants - 1,25-2,11%; 1,09-1,25% and 0,94-1,44%.

To determine the response of the soil environment has shown that there has been a significant leaching of soil: pH 8,14-8,18 at checkout; pH 7,99-8,12 and 8,08-8,11 fertilized variants of the experiment.

According to soil analyzes, reduced cation exchange capacity of dark brown soil. Absorbed bases (calcium, magnesium, sodium, potassium) in the soil of experimental plots in total amounted to 15-17 mg equivalent per 100 g of soil. This is significantly lower than baseline (20-21 mEq/ 100 g). Among the cations largest value (85-87%) is calcium, i.e. active cation prevails compared to other cations (magnesium, sodium, potassium).

The textures of the soil in different crop rotations were close. Content of physical clay (clay fraction less than <0,01 mm) is 44-45%, which corresponds to an average loam. In some samples,

Table 2. Yields of potatoes and vegetables, depending on fertilization rates

The experiment variants	Yields, t/ha	Increase crop yields t/ha	%
Potato			
1. $N_0P_0K_0$	18,7	-	-
2.$N_{60}P_{60}K_{60}$	21,9	3,2	17,11
3.$N_{120}P_{120}K_{120}$	25,1	6,4	34,22
4.$N_{180}P_{180}K_{180}$	28,3	9,6	51,34
m,	3,18-3,26		
min.$yield_{095,}$ t/ha	2,30-2,60		
Onion			
1.$N_0P_0K_0$	28,5	-	-
2.$N_{50}P_{30}K_{40}$	34,7	6,2	21,75
3.$N_{100}P_{60}K_{80}$	40,0	11,5	40,35
4.$N_{150}P_{90}K_{120}$	44,1	15,6	54,74
m, %	1,88-2,76		
min.$yield_{095,}$ t/ha	2,67-3,35		
Beetroot			
1. $N_0P_0K_0$	26,5	-	-
2.$N_{50}P_{30}K_{40}$	31,9	5,4	20,38
3.$N_{100}P_{60}K_{80}$	36,9	10,4	39,25
4.$N_{150}P_{90}K_{120}$	42,1	15,6	58,87
m, %	1,98-2,87		
min.$yield_{095,}$ t/ha	2,26-3,81		

the content of the clay fraction (<0,01 mm) greater than 45% and reached 46-48%, indicating that the weighting of the mechanical composition of the soil. Mechanical structure of the original samples of soil was medium loam with a content of particles <0,01 mm in the range 43-45%. That is, in the process of agricultural use has changed texture of dark brown soil to the downside.

Trace elements nutrition has a very important role in the life of plants. They complement the macronutrients, increase their efficiency. Studies have shown that different types of soil have different rotations levels of security (2-5) in the mobile forms of trace elements (mg/kg), zinc (Zn) - from 0.25-0.40 to 0,75-1,25 ; Copper (Cu) - 0,85-1,55; Lead (Pb) - from 1,25-3,50 to 5,60-8,30; Cadmium (Cd) - 0,25-0,75; Nickel (Ni) - 1,45-2,85; Manganese (Mn) - 62,0-90,95; iron (Fe) - 5,0-6,95.

It should be noted that a number of trace elements are heavy metals that must be considered from the point of view of soil ecology.

Fertilizers have a definite influence on the content of trace elements (heavy metals) in the soil. It is necessary to pay special attention to the high level in the soil two most dangerous heavy metals - cadmium and lead. The total content of lead (Pb) in the soil was 28,8-30,6 mg/kg at the maximum permissible concentration of 30 mg/kg. The content of the gross forms Cadmium (Cd) in the soil reached 2,4-2,8 mg/kg at approximately allowable concentration of 2,0 mg/kg.

In general, the content of heavy metals in the dark brown soil south-east of Kazakhstan is within the permissible limits. However, the level of heavy metals may increase over time, leading to contamination of the soil and products.

Based on soil studies, we can conclude that the dark brown soil zone of the foothills southeast of Kazakhstan for a long period of use in irrigated vegetable production have undergone significant changes. Parameters of soil fertility are largely determined by species of vegetable crop rotation systems and their fertilizer.

In irrigated horticulture great attention has been paid to the productivity of vegetable plantations. Each hectare of irrigated land is very valuable, especially in the foothill region south-east of Kazakhstan, where there are highly fertile land and sufficient water resources. Therefore, selection of research and technological development are mainly aimed at increasing the productivity of vegetable crops. Yield of vegetable crops has been and remains the main indicator of the effectiveness of new scientific developments. With this in mind, we are in our studies measured levels of harvest of vegetables depending on the type of crop rotation systems and their fertilizer.

Table 2 shows the experimental data on the productivity of the 3-field short rotary grain and vegetable crop rotation. In terms of rotation

Table 3 . In a 3-field short rotary grain and vegetable crop rotation fertilizers on the background of organic fertilizers (manure, straw) had a positive impact on the quality of the products

The experiment variants	The dry substance, %	Vitamin C, mg %	The total sugar, %	The starch, %	Nitrate, <g/:g
Potato					
1. $N_0P_0K_0$	22,12	14,95	2,04	15,7	76
2.$N_{60}P_{60}K_{60}$	25,18	13,65	2,00	16,02	92
3.$N_{120}P_{120}K_{120}$	24,86	14,95	1,86	17,8	130
4.$N_{180}P_{180}K_{180}$	24,92	15,60	1,84	16,9	225
Onion					
1.$N_0P_0K_0$	11,49	6,46	8,13	-	36
2.$N_{50}P_{30}K_{40}$	11,94	7,26	8,20	-	41
3.$N_{100}P_{60}K_{80}$	12,35	7,58	8,07	-	44
4.$N_{150}P_{90}K_{120}$	11,65	6,89	7,75	-	58
Beetroot					
1.$N_0P_0K_0$	16,59	28,4	12,65	-	220
2.$N_{50}P_{30}K_{40}$	16,51	28,4	13,23	-	230
3.$N_{100}P_{60}K_{80}$	16,91	28,0	13,40	-	281
4.$N_{150}P_{90}K_{120}$	16,41	26,5	11,98	-	409

defined yields of potatoes, beetroot and onions. This rotation is a precursor of spring barley (the first field). After cereals (barley) located potatoes (second field). Third crop rotation is vegetable culture, and here it is possible to place on the same field a variety of vegetable crops by botanical families or household purposes, and based on the demand for crops on the market. In our studies on the third floor (summary field) cultivated two valuable vegetable crops year-round use - onions and beetroot.

It should be noted that the system of fertilizer 3-field rotation decomposition combines two kinds of organic fertilizers and mineral fertilizers. After harvesting, the precursor (barley) in this field is left in the autumn, chopped straw with the addition of 20 kg/ha of nitrogen fertilizer for accelerated mineralization. In addition to the straw were made organic fertilizer rate of 20 t/ha. This ensures decomposition, organic-mineral fertilizer system 3-field short rotational crop rotation.

In experiments with potato tuber yield on the control variant was minimal experience - 18,7 t/ha. Fertilizer potatoes different norms NPK-fertilizers on the background of organic fertilizers (chopped straw and semi rotted manure under autumn plowing) helped to increase crop yields to 21,9-28,3 t /ha. In addition to the control formed 17,11-51,34% yield of tubers. At the same time showed the highest efficiency rate N180P180K180.

In experiments with potato tuber yield on the control variant was minimal experience - 18,7 t/ha. Fertilizer potatoes different norms NPK-fertilizers on the background of organic fertilizers (chopped straw and half rotted manure under autumn plowing) helped to increase crop yields to 21,9-28,3 t/ha. In addition to the control formed 17,11-51,34% yield of tubers. At the same time showed the highest efficiency rate N180P180K180.

In experiments with onions revealed sufficiently high fertilizer efficiency. Productivity of commodity onions on the control was low and on average over 3 years was 28,5 t/ha. Adding complete fertilizer normally provided N50P30K40 receive 34,7 t/ha, N100P60K80 - 40,0 t/ha, N150P90K120 - 44,1 t/ha. Increase in yield of onion turnip from different fertilization rates was 6,2-15,6 t/ha (21,75-54,74%). Relatively better performance productivity onions marked when making triple norms of nutrition elements.

In experiments with beet root yield levels are determined by the conditions of mineral nutrition culture. Harvest of sugar beet plants with fertilizer NPK-increasing rate of fertilizer increased from 26,5 t/ha (control) to 31,9; 36,9 and 42,1 t/ha. In addition to the control received 5,4 t/ha (20,38%); 10,4 t/ha (39,25%) and 15,6 t/ha (58,87%), root yield, respectively according to the norms of fertilizers. What remains is a high responsiveness beet fertilizer. Enhancing mineral nutrition of plants responded to the increase in root yield 20,38-58,87%.

In the vegetable product quality is important, as directly linked to the health of the population. Vegetables like "pantry vitamins" make a certain part of the daily human diet, it is very important for a full balanced diet.

It was established that the biochemical composition of fruits to some extent depends on the system of fertilizer application in vegetable crop rotations.

In experiments with onion quality onion turnip positively varied depending on the conditions of mineral nutrition. The dry matter content and increased vitamin C for all embodiments fertilized. Total sugar content in the bulbs was at the control level or slightly deviated in the direction of increasing or decreasing. There was a trend of gradual increase of nitrates in production with an increase in fertilization rates under the bow. In the control group of products contained 36 mg/kg nitrate, and crop fertilized variants - 41-58 mg/kg of MPC 80 mg/ kg (table 3).

In experiments with beetroot quality parameters of the control and fertilized variants were very close. Thus, the solids content (16,41-16,91%) and vitamin C (26,5-28,4 mg%) varied slightly. The improvement of sugar beet and potatoes rose, (13,23-13,40%). Compared with the control nitrates roots grew from 220 mg/kg (control) to 281-409 mg/kg of MPC - 1400 mg/kg.

According to the research we can conclude that a rational fertilizer has a positive effect on the biochemical composition of the product. Application of NPK-fertilizers in moderately-optimal standards improves the quality of potatoes and vegetables, increasing their content of dry matter, starch (tubers), sugars and vitamins.

CONCLUSION

Mineral fertilizers vegetable crop rotation system does not provide the preservation, reproduction and improvement of soil fertility, respectively, and the levels of harvest vegetables, low. This is due to the depletion of nutrients in the soil due to intensive use of vegetable crops for multiple crop rotations, crop rotation in the absence of annual and perennial legumes, non-use of organic fertilizers. The most effective organic-mineral fertilizers vegetable crop rotation system would create optimal conditions of mineral nutrition of plants by organic and mineral fertilizers contributes to the formation of a strong vegetative biomass and productivity of potato and vegetables. Rational fertilizer has a positive effect on the biochemical composition of the product. Application of NPK-fertilizers in moderately-optimal standards improves the quality of potatoes and vegetables, increasing their content of dry matter, starch (tubers), sugars and vitamins.

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