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СЪДЪРЖАНИЕ НА ТЕЖКИТЕ МЕТАЛИ МЕД И ЦИНК В АКМОЛИНСКА ОБЛАСТ, СЕВЕРЕН КАЗАХСТАН ПРИ НУЛЕВА И ТРАДИЦИОННА ТЕХНОЛОГИЯ НА ОТГЛЕЖДАНЕ НА ЗЪРНЕНО-БОБОВИ КУЛТУРИ

CONTENT OF THE HEAVY METALS COPPER AND ZINC IN AKMOLINSKOJ DISTRICT OF NORTHERN KAZAKHSTAN IN RELATION TO ZERO- AND TRADITIONAL GROWING TECHNOLOGY OF GRAIN-LEGUME CROPS

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Abstract

Excessive heavy metal (HM) content in the soil and environment, caused by human activities such as the input of organic and mineral fertilizers and pesticides, may lead to suppression of plant growth. The present study, which is a part of a 3-year scientific project, aims at determining HM (Cu, Zn) content in the soils of Akmolinskoj district of Northern Kazakhstan, in order to conclude on the soil suitability when growing legumes (pea and chick-pea) and applying zero- and traditional technology, and to monitor certain plant growing characteristics. The study showed that HM content had changed under both zero- and traditional technology from the phase of 'pre-sowing' to the phase of 'pre-harvesting' but the content remained far below the Maximum Permissible Limits (MPL). According to the National Kazakhstan classification of the classes of toxic substances, the soils under the two technologies belong to class 3, i.e. very low toxicity that does not impact plants (quality) and animals as HM do not migrate in soil. Interestingly, the HM concentration in soils treated with P-fertilisers is lower than in the control (untreated) plots. Overall, the low HM content did not impact the pea and chickpea growth as the addition of 0.5 l/ha of Izagry Phosphorus and other combinations of Izagry P and Rizotorfin (N-fixing bacteria promoter) stimulated the growth of both legumes during almost all major plant phenophases, also reduced the main phenophases elapsing time as well as the length of the vegetation period which is important for farmers in utilising the short period of high temperatures.

Key words: traditional technology, zero-tillage technology, peas, chick-peas, Cu, Zn.

INTRODUCTION

Human impact on environment becomes a leading ecological factor by its importance and volume. Intensive use of natural resources for producing agricultural food leads to significant changes in biochemical cycles of most of chemical elements and compounds (Chulakov, 1993).

Accumulation of heavy metals (HM) in environment is also related to human activities. Significant part of heavy metals enters the environment with pesticides, organic and mineral fertilizers. Soils in this case become an important biochemical barrier, but in the same time suffer the biggest negative impact. The HM are accumulating in soil and adsorbing to soil particles, so therefore they have low biological uptake by plants. The high HM concentrations inhibit the plant growth and productivity but it depends on many factors. Therefore, the scientific research is directed towards identification of physiological response of plants to the stress caused by HM as well as identification of susceptibility of various crops and varieties. The HM stress impacts mainly plant photosynthesis, water regime, nutrient uptake and plant growth. These symptoms are profound mostly in very low temperatures during plant vegetation (Chernenok, 2009).

Accumulation of copper (Cu) in soil lead to inactivation of important enzyme systems in soil organisms, which in turn leads to disruption of mineralisation processes and restoration of organic matter. The Cu pollution leads also to soil acidification, disruption of nitrification and accumulation of ammonium ions instead of nitrates and manganese toxicity. The hormone regulation is suppressed as well as formation of biostructures that regulate breathing and photosynthesis. The Cu does not accumulate in plant leaves because it is held by the root system, which in turn becomes less developed. It reflects in Fe-chlorosis, suppressed growth and smaller roots and plants. Raykov et al. (1984) found that very high levels of Cu and Zn in soil suppress mostly the nitrogen mineralization.

Compared to Cu, the Zn does not accumulate in the surface soil layer, because it is loosely connecting to organic matter. The Zn in soil is sufficiently mobile. Its accumulation though suppresses soil biological activity which in turn disrupts mineralization of organic matter. The excess of Zn in soil disrupts mineralization of cellulose and disturbs soil microflora. Mineral and organic fertilisers and pesticides could also lead to Zn pollution, e.g. 36 years fertilisation of 175 kg/ha P per year (triple superphosphate) can increase Zn content in soil layer 0-15 cm from 118 to 250 mg/kg soil. *Nitrogen fertilisers could also acidify soils and could make Pb and Zn more available for plants*. In acidic soils, even normal Zn quantities may become toxic.

In the beginning of 90s, the state control on environmental safety increased in Kazakhstan. A compulsory environmental (OVOS) assessment was introduced. But problems with ecologically-susceptible territories still remain unsolved (Suleimenov, 2005). According to data by the Ministry of Agriculture of Kazakhstan in 2014 about 9993,3 thousand liters of pesticides were used and 84,3% of it in 3 districts of North Kazakhstan, i.e. Akmolinskoj - 3023,4 thous. l., Kostanajskoj - 2155,8 thous. l., and Severo-Kazakhstanskoj - 3156,0 thous. l. At present, production of cereals and other crops is almost 100% made with application of mineral fertilizers and chemical pesticides.

In the same time, modern biological preparations for soil fertility and plant protection increase defensive mechanisms in plants, decrease plant resistance to pesticides, but also do not impose a risk to environment. The turnover of organic production is today more than 70 billion US$ and increases 5-15% annually. Taking into account the new trends, agricultural production of Kazakhstan should undertake biological methods, use of agroecological services better crop rotations (including legume crops) instead of heavy mechanisation and chemical application (Cook and Baker, 1996).

Pea and chickpea are valuable and promising crops for Northern Kazakhstan. The growing interest to the cultivation of leguminous crops in Kazakhstan is determined by the volatile prices of grain on the international markets and the growing demand to legumes. Cultivation of legumes in the crop rotation can reduce the proportion of nitrogen fertilisers for main crops by 15-20% without damaging their productivity, and completely eliminate mineral fertilizer use in legume growing. In addition, a good balance of nitrogen and carbon left by the legume residues promotes their mobilization in the process of decomposition and mineralisation. After harvesting, legumes leave in the soil an average of 200-700 kg residues per 1 ha, which contain 45-130 kg N, 10-20 kg of phosphorus and 20-70 kg of potassium (Serekpaev, 1998). Legumes produce per unit of land much more protein which has good quality, low costs and good digestibility. Fixation of nitrogen by legumes saves significant amount of energy used to produce mineral fertilisers. They improve microbiological activity and soil structure which makes them suitable for organic production (Parincina, 1993).

At present, the growing of annual legumes in Northern Kazakhstan is done by using mainly traditional technology. Most of the areas of cultivation are under adverse climate conditions, i.e. sharp continental climate of Northern Kazakhstan. The region is exposed to wind and water erosion and degradation of soil organic matter. According to recent research (Dvurechensky and Gilevich, 2011), the rejection of conventional tillage and replacing it with zero-tillage can be justified by the need to save soil moisture, to maintain soil fertility and to prevent soils from erosion processes.

Based on experimental data from Northern Kazakhstan, Suleimenov (2005) notes that there cannot be a one-sided effect of the type of tillage for different soil and landscape conditions. Therefore, to reduce the intensity of tillage in dry-steppe zone with soils of southern chernozems, there is a need to know the impact of tillage on the soil and on the plant respectively.

Because of the afore mentioned problems and trends, and having regards to agroecological conditions of Akmolinskoj district, this research was focused on heavy metals, soil tillage technologies, legume crops and its future use in organic farming systems. Therefore, the research aimed at determination of heavy metals Cu and Zn in soils of Northern Kazakhstan and state conclusions on their suitability for legume crop production (peas and chickpeas) by application of zero-and traditional-tillage technology as well as to monitor certain plant growth parameters.

MATERIALS AND METODS

The experiment were conducted in Farm complex "Novokubansky" (p. Novokubanka), located in the Akmolinskoj region, Shortandy District in Northern Kazakhstan. Objects of research are the certified for use in the Akmolinsky region pea and chickpea varieties Aksaysky Usaty (2011) and «Yubileyniy» (1967) respectively. There was a rando-mized block design of experimental plots with three replications per plot in 2014. Area of a plot was 12 m^2 and experimental area was 400 m^2.

Izagry phosphorus is a growth stimulator in a water soluble suspension containing phosphorus and having physiologically-active properties. It has been proven to enhance root growth and to promote development of above-ground plant biomass. In plants, Izagry phosphorus increases metabolism, increases the activity of soil microorganisms, which in turn contributes to improving the mineral feeding of plants (Artykov, 2000). In small doses, it stimulates the growth and development of plants, and accelerates their maturation with 7-10 days. This is especially important in Northern Kazakhstan where there is a short vegetative season. Izagry phosphorus increases efficiency of applied mineral fertilisers, improves mineral feeding of plants especially in extreme conditions (high or low temperature, insufficient or excessive moisture), increases resistance plants to diseases, leads to increased plant growth (plant height), increases yield, accelerates seeds' ripening and improves product quality.

The study used inoculation of legume seeds with bacteria of the genus *Rhizobium.* It was done by inserting a bacterial preparation Rizotorfin that is registered for seed treatment prior to sowing. Processing of seeds with Rizotorfin was done approximately 5 hours prior to seeding. The procedure was executed, because of the fact that new land planned for growing legume plants does not provide N-fixing bacteria. Considering this situation, seed inoculation with *Rhizobium* bacteria leads to significant increase of plant productivity, i.e. yield (Serekpaev, 1998).

Phenological observations were carried out in accordance with the method approved by State Commission for Variety Testing Crops in Kazakhstan (Almaty, 2002). Observations were made from sowing of legume seeds to ripening of legume plants on four permanent plots of 0.25 m^2 each by two non-adjacent replications. Beginning of the respective phenophase was considered when not less than 10% of the plants entered this phenophase and the total phase was marked when not less than 75% of the plants were inside this phenophase.

Germination of seeds was determined by the formula:

$$Пв = \frac{Г - 100}{Нв} \quad е:$$

where Пв is germination in %, Г is actual plant density on shoots in plants/м^2, and Нв is seeding rate in seeds/м^2.

Plant density was defined twice: after emergence and at harvest by counting the plants in all variants. For this purpose, four plots of 0,25m^2 each were randomly placed on two non-adjacent replicates. Number of seeds was determined by analysing the structure of the crop and the yield.

Other parameters such as laboratory germination, germination energy, purity and weight of 1000 seeds were also determined in accordance with State Standard GOST 9672-61.

Soil samples were taken two times a year, i.e. before sowing (in spring after snow melting, and before harvesting (in autumn few days prior to harvesting crops). Each variant was replicated 3 times in plots. Soil samples were taken with a drill from the top soil layer of 25 cm by intervals, i.e. 0-5, 5-10, 10-20 (25) см. Samples were distributed in a thin layer on a polyethylene film, and then were mixed up thoroughly and using approved methodology and then placed in plastic bags containing minimum 1 kg of soil. A label with necessary data on time, location, depth, address, name, etc. were attached to each sample bag then registered in the 'field journal'.

Determination of heavy metals in soil was done using atom-absorption spectrometer with flame or non-flame atomization.

Mobile forms of HM were extracted by using extractors (i.e. 1 M HCl and acetic-ammonium buffer solution with pH of 4.8) adopted by agro-chemical service for extracting available microelements for plants for chernozem soils. Extraction was done in replications for each sample.

The ratio soil to solution was 1:10; the impact time was 1 hour while stirring on the rotor apparatus or leaving for 24 hours (by method from Krupskii and Aleksandrova (1980) for chernozem and carbonate soils). A soil sample weighing 10 g. was placed in a 100-200 cm3 flask and then 50 cm^3 of acetic-ammonium buffer solution was added. Suspension was mixed up for 1 hour or placed for 24 hours. Then the solution was filtrated. Another 50 cm^3 acetic-ammonium buffer solution was added to soil in the flask and then the extraction was repeated. The solution was added to the first filtrated solution in the flask. With the entire filtrate in hand, the HM are determined using atom-absorption method in flame of acetilen-oxigen.

Calculation of HM content in soils and characterization of accuracy of analyses

The HM content in the analysed samples was calculated using the formulae:

$$X = \frac{V \times (A_1 - A_0)}{m}, \quad (1)$$

where:

x – amount of the analysed metal element in air-dry soil sample – part per million (mg/kg);

A_1- concentration of the metal element in the analysed acidic (buffer) soil solution, mg/dm^3;

A_0- concentration of the metal element in a control sample, mg/dm^3;

V – volume of analysed solution, см^3;

m – weight of air-dry soil sample, g.

Two laboratory sample analysis were done in parallel and then mean of the two was calculated for one soil sample. Parameters of correctness of the calculations of HM amount in soil were calculated in accordance with national standards, i.e. GOST (1983) (ГОСТ 8.505-84 and МИ 858-85).

At present, there are national standards for Maximum Permissible Limits (MPL) for individual elements such as Cu, Zn, Ag, Pb, etc. in soil as well as permissible level of their content considering their toxicity (Bespamatnov and Corotkov, 1985).

The data is processed mathematically according to them method ANOVA and the multi-ranking test of Duncan (1953).

RESULTS AND DISCUSSION

Results of the study show that growth and development of leguminous crops under dry steppe zone of the Northern Kazakhstan are strongly influenced by prevailing climate conditions during the vegetation period. The main factor is the soil moisture. During the vegetation period (May to August 2014), precipitation was 169 mm, which is less than the average annual rainfall. The distribution of rainfall during the vegetation season was uneven, i.e. 32,6 mm in May, 15,7 mm in June, 25,2 mm in July and 38,8 mm in August (Fig. 1).

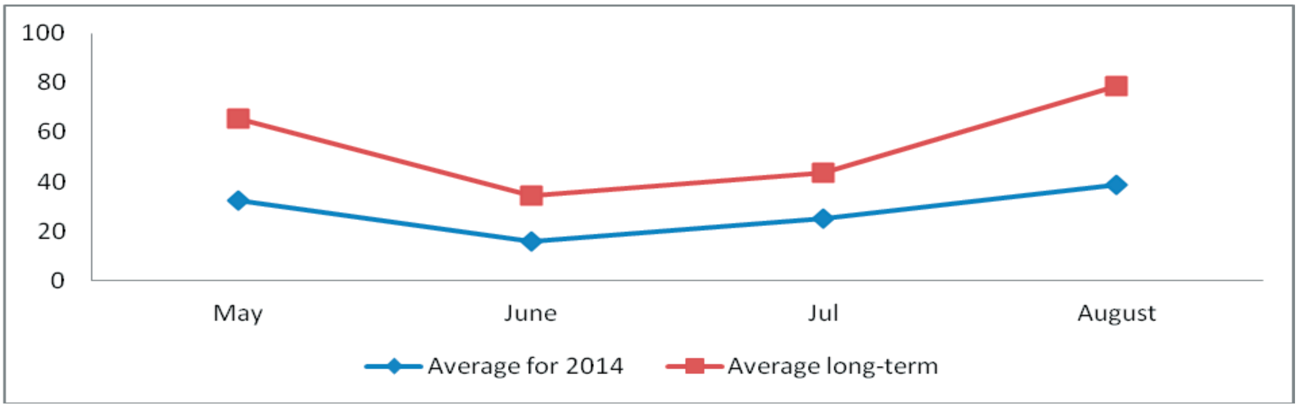

Fig. 1. *Quantity of rainfalls in the vegetation period of plants, mm*

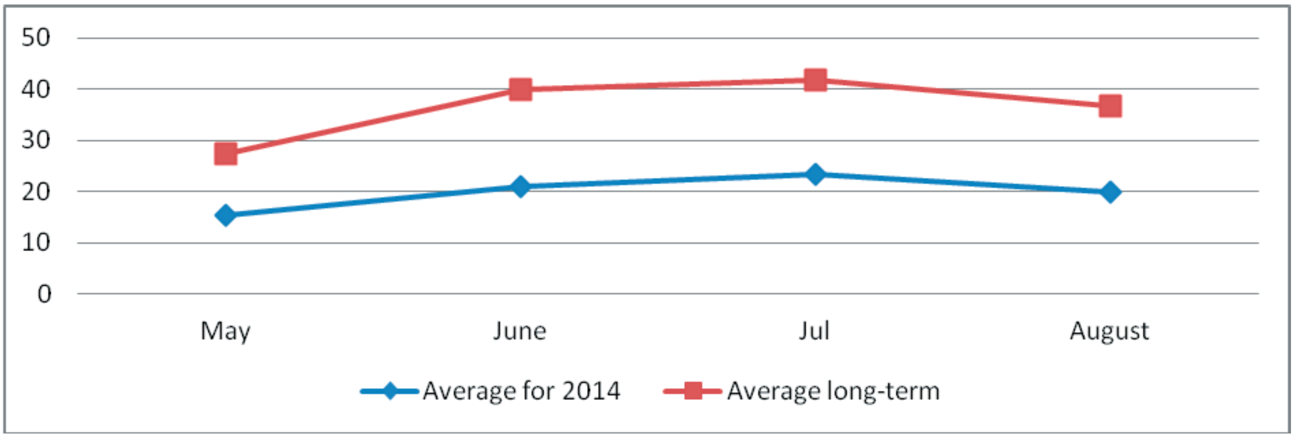

Fig. 2. *Mean monthly temperatures in the vegetation period of plants, ^{0}C*

Mean monthly temperature in the vegetation period of 2014 was below average long-term data and was 15,4^{0}C in May, 20,9^{0}C in June, 23,4^{0}C in July and 19,8^{0}C in August (Fig. 2 above). The amount of active temperatures during the 2014 vegetation season was 2213^{0}C, which was within the normal range. Considering the hydrothermal coefficient, the 2014 can be characterised as very dry (HTC=0,6).

Soil conditions

Soils are mainly calcareous southern. A soil sampling was performed and later an agrochemical analysis of soils was performed in a specialised agrochemical laboratory in Shortandinskij and Akmolinskoj region.

Previous studies determined that the humus content in the soil upper layer (down to 20 cm depth) was up to 6%, absorption capacity 41 mg/icv., CO_2 – 1,8-3,0%. Presence of absorbed sodium confirms the weak alkalinity of these soils. Absorption of sodium is about 2% in layer 0-10 cm. The relief characteristics determine the southern black vertosols (chernozems) as deposited on slightly undulating plain having typical steppe flora and having light clay content and deep underground water. Humus horizon (A+B_1) is about 40,5 cm deep and has a dark-gray color, often with slight brown tint, cloddy structure, but horizon B_2 reaches about 65 cm depth. Visible boundaries of the gypsum horizon are at a depth of 90-150 cm, as the line lies in the lower part of the horizon B_1 or at the boundary of the humus layer. Key indicators of soil fertility of the experimental site and their values are shown on Table 1.

According to the grouping of soils considering the humus content (determined by the Tyurin's method in %), and in regards to classification of content of mobile phosphorus and nitrate nitrogen in the soil (according to gradation of Chernenyuk (2009, in mg/кg), the humus content as well as N and P contents are low in the soil layer 0-20 cm and 0-40 cm. But exchangeable K (determined by Michigan's method in mg/kg) belongs to the high content group. The level of soil acidity (pH) determines the soil as neutral to medium-alkaline.

Dynamics of heavy metals

The dynamics of Cu and Zn in the experimental field are presented on Table 2 below.

The study showed that HM content has changed under both zero- and traditional technology from the phase of before sowing to the phase of before harvesting as it remained much below the Maximum Permissible Limits (MPL). According to the National Kazakhstan classification of the classes of toxic substances, the soils under the two technologies fall within class 3, i.e. very low toxicity that does not impact plants (quality) and animals as HM do not migrate in soil. Interestingly, the concentration in soils treated with P fertilisers is less than that in the control (untreated) plots.

Upon application of **traditional technology** to grow pea and chick-pea, the content of Cu does not change significantly between the phases ‘prior to sowing’ and ‘before harvest’, except the content in the Control (P and Rizotorfin untreated variant) (Table 2 above). However, a significant increase of Zink content can be seen in soils of both crops before harvest compared to the one detected prior to sowing in all variants. This is especially profound in the Control variant.

Upon application of **zero-tillage technology** to grow pea and chick-pea, similarly to traditional technology, the content of Cu does not change significantly between the phases ‘prior to sowing’ and ‘before harvest’, except the content in the Control (P and Rizotorfin untreated variant) (Table 2 above). However, a significant increase of Zink content can be seen in soils of both crops before harvest compared to the one detected prior to sowing in all variants. This is especially profound in the Control variant.

An interesting observation requiring more research is that the highest increase of Cu and Zn was shown by the Control variant compared to other variants. It could be most probably related to the P fertilizers in the soil and the Izagry P properties as well as the high humus content (Table 1) typical for chernozem soils and lower temperature than average for the vegetative season. All these factors in combination might prevent the heavy metal accumulation in soil and migration to legumes' vegetative parts.

Table 1. The content of humus, soil nutrients, pH in layer 0-20 cm

Technology	Soil layer, cm	humus, %	N-NO_3, mg/kg	P_2O_5, mg/kg	K_2O, mg/kg	pH
Zero tillage	0-20	4.25	2.3	23.6	670.0	5,2
	20-40	4.10	3.6	18.2	540.5	5,9
Traditional	0-20	4.46	4.1	22.8	635	5,5
	20-40	3.87	5.3	19.9	564.2	5,8

Table 2. Heavy metals dynamics (Cu, Zn,) in soils of experimental field Novokubanskoe

№	Variants	Phases of taking samples				Difference between heavy metal content in soil before sowing and before harvest, mg/kg**		Maximum permissible limit (MPL)*
Traditional technology								
		Before sowing, mg/kg**		Before harvesting, mg/kg**				
Pea growth								
		Cu	Zn	Cu	Zn	Cu	Zn	
1.	Control	0.002^{a}	0.011^{a}	0.015^{a}	0.050^{a}	0,013^{a}	0,039^{a}	Within limit
2.	P_2O_5+Rizotorfin	0.001^{a}	0.010^{a}	0.002^{b}	0.030^{b}	0.001^{b}	0,020^{b}	Within limit
3.	Izagry Phosphorus	0.004^{a}	0.034^{b}	0.005^{b}	0.042^{a}	0.001^{b}	0,008^{c}	Within limit
4.	Izagry Phosphorus + Rizotorfin	0.003^{a}	0.020^{b}	0.004^{b}	0.032^{b}	0.001^{b}	0,012^{c}	Within limit
Chick-pea								
1.	Control	0.003^{a}	0.016^{a}	0.010^{a}	0.054^{a}	0,007^{a}	0,038^{a}	Within limit
2.	P_2O_5+Rizotorfin	0.002^{a}	0.034^{b}	0.006^{a}	0.042^{b}	0,004^{a}	0,008^{b}	Within limit
3.	Izagry Phosphorus	0.005^{a}	0.024^{b}	0.007^{a}	0.034^{b}	0,002^{a}	0,010^{b}	Within limit
4.	Izagry Phosphorus + Rizotorfin	0.004^{a}	0.017^{a}	0.005^{a}	0.027^{c}	0,001^{a}	0,010^{b}	Within limit
Zero tillage technology								
Pea growth								
1.	Control	0.004^{a}	0.024^{a}	0.017^{a}	0.057^{a}	0,013^{a}	0,033^{a}	Within limit
2.	P_2O_5+Rizotorfin	0.005^{a}	0.020^{a}	0.006^{b}	0.035^{b}	0,001^{b}	0,015^{b}	Within limit
3.	Izagry Phosphorus	0.007^{a}	0.038^{b}	0.008^{b}	0.049^{a}	0.001^{b}	0,011^{b}	Within limit
4.	Izagry Phosphorus + Rizotorfin	0.009^{a}	0.026^{b}	0.010^{b}	0.036^{b}	0.001^{b}	0,010^{c}	Within limit
Chick-pea								
1.	Control	0.003^{a}	0.018^{a}	0.015^{a}	0.053a	0,012^{a}	0,035^{a}	Within limit
2.	P_2O_5+Rizotorfin	0.004^{a}	0.013^{a}	0.008^{b}	0.024b	0,004^{b}	0,011^{b}	Within limit
3.	Izagry Phosphorus	0.005^{a}	0.020^{a}	0.007^{b}	0.029b	0,002^{b}	0,009^{b}	Within limit
4.	Izagry Phosphorus + Rizotorfin	0.006^{a}	0.024^{b}	0.009^{a}	0.032b	0,003^{b}	0,008^{b}	Within limit

**In soil, national MPL for heavy metal content of Rep. of Kazakhstan: Cu-3,0 мг/кг, Zn-23,0 мг/кг*
***Different letters near the values in the table show statistical significance between means compared to control (Duncan multiple range test, at p<0,05)*

Parameters of plant growth

Overall, the low HM content did not impact the legume crop growth.

The study showed that the addition of 0,5 l/ha of Izagry Phosphorus as well as the other combination of Izagry Phosphorus and Rizotorfin stimulated the growth of pea and chickpea plants (Table 4), which is shown by the significant differences between height of treated legumes variants compared to control variants ($p<0,05$) during all major plant phenophases, with some exceptions i.e. pea mean height during maturation phenopphase and use of traditional technology (Table 4).

The results of phenological observations after treatments during the vegetation period showed that addition of growth stimulators such as Izagry Phosphorus as well as the combination of Izagry Phosphorus and Rizotorfin reduces the time of passing the main phenophases of pea and chickpea, i.e. vegetation period in days was significantly lower ($p<0,05$) compared to control. Its use has reduced the vegetation period of plants in traditional cultivation technology from 92 to 86 days in pea, and even more significantly from 96 to 88 days in chickpea (Table 2). It was not a case though when the combination of P_2O_5 and Rizotorfin was applied.

Table 3. Level of toxicity of HM (for Cu, Zn) (according to GOST, 1983)

Parameters	Norms for each level of toxicity		
	1st	2nd	3rd
Toxicity, LD_{50}*	Up to 200	above 200	Up to 1000
Persistence in soil, in months**	**	above 12	from 6 to 12
MPL in soil, mg/kg	Less than 0,2	From 0,2 to 0,5	above 0,5
Migration	migrate	Lower migration	No migration
Persistence in plants, in months	3 and more	from 1 to 3	Less than 1
Impact on nutrient value of agricultural produce	higher	lower	none

**LD_{50} - lethal dose of a chemical, i.e. when leads to death of 50% of animals, mg/kg liveweight.*
***Persistence in soil – time (days, months) in which a chemical maintains its biological activity and polluting impact in soil; it is characterized by resistance of the chemical to mineralization processes.*

Table 4. Effect of technology of growing (traditional vs. zero tillage) and addition of phosphorus on growth parameters of pea and chick-pea (length of biomass in cm) and on the length of vegetation period (days)

№	Variants	Phenophase				Vegetation period, day*
		Rumification*	Blossoming*	Fruit formation*	Maturation*	
	Traditional technology					
	Pea length (cm)					
1.	Control	$23,1^a$	$37,0^a$	$46,3^a$	$50,8^a$	92^a
2.	P_2O_{5+}Rizotorfin	$28,0^b$	$44,2^b$	$48,4^b$	$51,4^a$	92^a
3.	Izagry Phosphorus	$30,1^b$	$47,2^b$	$50,0^b$	$51,9^a$	86^b
4.	Izagry Phosphorus + Rizotorfin	$30,2^b$	$47,1^b$	$50,1^b$	$51,4^a$	86^b
	Chickpea length (cm)					
1.	Control	$18,2^a$	$24,4^a$	$37,8^a$	$45,5^a$	96^a
2.	P_2O_{5+}Rizotorfin	$22,3^b$	$36,8^b$	$40,6^b$	$48,0^b$	96^a
3.	Izagry Phosphorus	$23,4^b$	$40,2^b$	$45,2^b$	$50,2^b$	88^b
4.	Izagry Phosphorus + Rizotorfin	$23,4^b$	$40,4^b$	$45,2^b$	$50,4^b$	88^b
	Zero-tillage technology					
	Pea length (cm)					
1.	Control	$22,0^a$	$32,5^a$	$40,2^a$	$45,7^a$	92^a
2.	P_2O_{5+}Rizotorfin	$22,4^a$	$35,6^b$	$42,3^a$	$46,2^a$	92^a
3.	Izagry Phosphorus	$23,5^a$	$38,9^b$	$45,0^b$	$49,0^b$	86^b
4.	Izagry Phosphorus + Rizotorfin	$23,6^a$	$38,9^b$	$45,1^b$	$49,4^b$	86^b
	Chickpea length (cm)					
1.	Control	$17,9^a$	$20,6^a$	$25,6^a$	$35,5^a$	96^a
2.	P_2O_{5+}Rizotorfin	$21,2^b$	$25,7^b$	$32,5^b$	$40,2^b$	96^a
3.	Izagry Phosphorus	$22,0^b$	$30,8^b$	$39,8^b$	$44,3^b$	92^b
4.	Izagry Phosphorus + Rizotorfin	$22,4^b$	$30,4^b$	$39,7^b$	$44,7^b$	92^b

Different letters near the values in the table show statistical significance between means compared to control (Duncan multiple range test, at p<0,05)

Similar trends were observed in zero-tillage variants, i.e. addition of Izagry Phosphorus as well as the combination of Izagry Phosphorus and Rizotorfin reduces the time of passing the main pheno-phases of pea and chickpea, i.e. vegetation period in days was significantly lower ($p<0,05$) compared to control as from 92 to 86 days in pea and from 96 to 88 days in chickpea (Table 4). It was not a case though when the combination of P_2O_5 and Rizotorfin was applied.

The length of vegetation season is one of the main indicators of the effect of growth stimulator Izagry Phosphorus. Technology of cropping (zero-tillage vs. traditional tillage) also significantly influenced the dynamics of growth and development.

CONCLUSIONS

In the conditions of North Kazakhstan, characterized by typical continental climate with low winter temperatures and lack of sufficient soil moisture, legume plant growth is impacted. Application of zero-tillage technology could safe soil moisture; however the soil is getting compacted, and as a result the seed emergency suffers and penetration of oxygen in the soil is deprived. Application of traditional technology helps in loosening soil, improves the aerobic processes, and as result nutrient exchange and access of oxygen and fertilizers is made easier. Latter stimulates the growth of legume seeds and overall growth of plants.

The study aimed to detect the so called “background content” of HM. It shows that this content is in conjunction with national norms that are set for chernozem soils, i.e. up to 80 mg/kg in soil with pH=5.1 to 6.0. The study also showed that HM content has changed under both zero- and traditional technology from the phase of before sowing to the phase of before harvesting but it remained far below the Maximum Permissible Limits (MPL). According to the National Kazakhstan classification of the classes of toxic substances, the soils under the two technologies fall within class 3, i.e. very low toxicity that is far below MPL and does not impact plants (quality) and animals as HM do not migrate in soil. Also, HM persistency in soils falls within norms of i.e. from 6 to 12 and does not have an impact on agricultural foodstuff.

An interesting observation requiring more research is that the highest increase of Cu and Zn was shown by the Control variant compared to other variants. It could be most probably related to the P fertilizers in the soil and the Izagry-P properties as well as the high humus content (Table 1) typical for chernozem soils and lower temperature than average for the vegetative season. All these factors in combination might prevent the heavy metal accumulation in soil and migration to legumes’ vegetative parts.

Overall, the low HM content did not impact the legume crop growth. The treatment of seeds with Rizotorfin stimulates the work of root nodules and increases consecutively seed productivity, shortens the period of vegetation (i.e. days) and impacts positively the overall growth. It signifies that legume crops could be grown without heavy doses of mineral fertilizers. The study showed that the addition of 0,5 l/ha of Izag-ry Phosphorus as well as the other combination of Izagry Phosphorus and Rizotorfin (N-fixing bacteria promoter) stimulated the growth of pea and chickpea plants during almost all major plant phenophases. Addition of P growth stimulators and Rizotorfin reduces the time of passing the main phenophases of pea and chickpea, i.e. reduces the length of vegetation period in days, which gives the farmers opportunity to apply late sowing, e.g. in the beginning of June and use the higher temperatures during vegetation period.

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