ВЛИЯНИЕ НА ФОСФОРНИ ДОБАВКИ И СТИМУЛАТОРИ НА РАСТЕЖА И РАЗВИТИЕТО ВЪРХУ ЗЪРНЕНО-БОБОВИ КУЛТУРИ В ЗАВИСИМОСТ ОТ ТЕХНОЛОГИЯТА НА ОТГЛЕЖДАНЕ В СЕВЕРЕН КАЗАХСТАН
IMPACT OF PHOSPHORUS FERTILISERS ON THE GROWTH AND PRODUCTIVITY OF ANNUAL LEGUME CROPS IN RELATION TO THE AGRO-TECHNOLOGY APPLIED IN NORTHERN KAZAKHSTAN

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Резюме

Важен елемент на съвременните агротехнически мероприятия за растежа и развитието на растенията е използването на растежни стимулатори, които в малки дози влияят на обменните процеси и могат да доведат до значителни промени в растенията. Понастоящем липсват достатъчно изследвания за въздействието на стимулаторите на растежа в региона на Северен Казахстан. Настоящото проучване проведе полски експерименти в този регион върху южни черноземни почви и беше насочено към изследване на ефекта на традиционната и нулевата технология на отглеждане и прилагането на гранулиран суперфосфат, стимулатор на растежа *Изагрий фосфор* и микробиален препарат *Ризоторфин* върху растежа и производителността на избрани бобови култури – грах и нахут. Проучването показа, че комбинацията от *Изагрий фосфор* и *Ризоторфин* има най-голямо влияние върху всички изследвани параметри - височина, биомаса и биологична продуктивност на грах и нахут, и може да се препоръча за условията на Северен Казахстан. Ефектът основно се дължи на стимулирането на микробната активност в почвата и по този начин подобреното минерално хранене на бобовите. Тази комбинация спомага за по-ранно узряване на растенията с 4-6 дни, което е особено важно за условията на Северен Казахстан, характеризиращи се с къс вегетационен период.

Abstract

An important element of modern agronomic techniques in crop growing is the use of plant growth regulators which in small doses affect the metabolic processes in plants leading to significant changes in the growth of plants. There is insufficient research on the impact of growth regulators in the region of Northern Kazakhstan. Field experiments were conducted within the present study in the above region on southern chernozem soils. The aim was to investigate the effect of traditional and zero-tillage technology and the introduction of the granulated superphosphate growth regulator *Izagry Phosphorus* as well as the compound *Rizotorfin* on the growth and productivity of selected leguminous crops, namely peas and chickpeas. The study showed that the combination of *Izagry Phosphorus* and *Rizotorfin* had the strongest impact on all investigated parameters, i.e. height, biomass and biological productivity of peas and chickpeas and can be recommended for the conditions of Northern Kazakhstan. The effect can mainly be attributed to the stimulation of the microbial activity and thus an improved mineral feeding of pea and nut plants. That combination speeded up the maturing of the plants by 4-6 days, which is of particular importance for the conditions of Northern Kazakhstan characterized by a short vegetation period.

Ключови думи: традиционна технология, нулева технология, грах, нахут, фосфор, продуктивност.
Key words: traditional technology**,** zero tillage technology, peas, chickpeas, phosphorus, productivity.

INTRODUCTION

An important element of modern agronomic techniques in plant breeding is the use of plant growth regulators. In small doses they are capable to affect the metabolic processes in plants leading to significant changes in the growth and development of plants. A number of factors determine the practical importance of growth regulators using modern agro-technologies (Chulakov, 1993). They influence the processes of plant development and thus significantly accelerate the plant growth or increase yields of most crops. Growth regulators allow to realise the potential of plant organisms. Thus, the study of the influence of growth regulators on yield and quality of grain in accordance with the specific soil and climatic conditions is relevant.

In the region of Northern Kazakhstan, there is insufficient research on the impact of growth regulators. Currently, studies on the influence of plant growth regulators on the crop yield and product quality under the conditions of intensive agriculture is becoming increasingly important.

Peas and chickpeas 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 (Parincina et al., 1993). 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).

At present, the growing of annual legumes in Northern Kazakhstan is done by using 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.

Legumes contain more nutrients per unit of harvest. Their needs of mineral elements are higher than these of cereals. At low levels of soil phosphorus and potassium, and at soil acidity, even high rates of externally added phosphorus fertilisers, potassium fertilisers and lime in legume fields do not provide for active nitrogen fixation and good harvest (Chernenyuk, 2009). If favorable conditions are assured for N symbiosis (i.e. pH corresponding to the biology of legumes, sufficient supply of N-fertilisers, an active strain of *Rhizobium*), there is no need for additional application of N-fertiliser in grain legume crops. Additional N-fertiliser may suppress the symbiosis, may reduce the amount of fixed nit-rogen from the air by the amount of nitrogen assimilated from the N-fertiliser and do not contribute for increase of seed production of grain legumes (Pryanichnicov, 1953).

Therefore, the present study conducted experimental studies under conditions of Northern Kazakhstan on soils of southern chernozems aimed to investigate the effect of traditional and zero-tillage technology and introduction of granulated superphosphate, growth regulator 'Izagry Phosphorus' and preparation Rizotorfin on growth and productivity of selected leguminous crops, i.e. pea and chickpea.

MATERIALS AND METODS

The experiment were conducted in Farm complex "Novokubansky" (p. Novokubanka), located in the Akmola 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 randomized 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. 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 (Articov, 2000).

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 (Chernenyuk, 2009).

Phonological 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 les than 75% of the plants were inside this phenophase.

Germination of seeds was determined by the formula

$$Пв = \frac{Г - 100}{Нв}$$

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.

Legume productivity was determined by the method of the State Variety Testing of Agricultural crops in Kazakhstan (Almaty, 2002), considering also the standard humidity, i.e.

$$X = \frac{У \times (100 - B)}{100 - CB},$$

where *X* - seed yield in kg/h; *У* – yield at harvest in kg/h; *B* - humidity of seeds at harvest in %; *Св* – standard moisture content for the respective crop in %.

Determination of seed protein content was done using standard methodology of laboratory of Kazakh Research and Applied Institute "Baraiev". Determination of seed quality was done in accordance with State Standard (GOST 9672-61). Other parameters such as laboratory germination, germination energy, purity and weight of 1000 seeds were also determined.

The data were processed statistically using ANOVA (STATISTICA, Statsoft, USA) and the multiple-range test of Duncan (1995).

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).

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 was 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 Shortandy Akmola 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

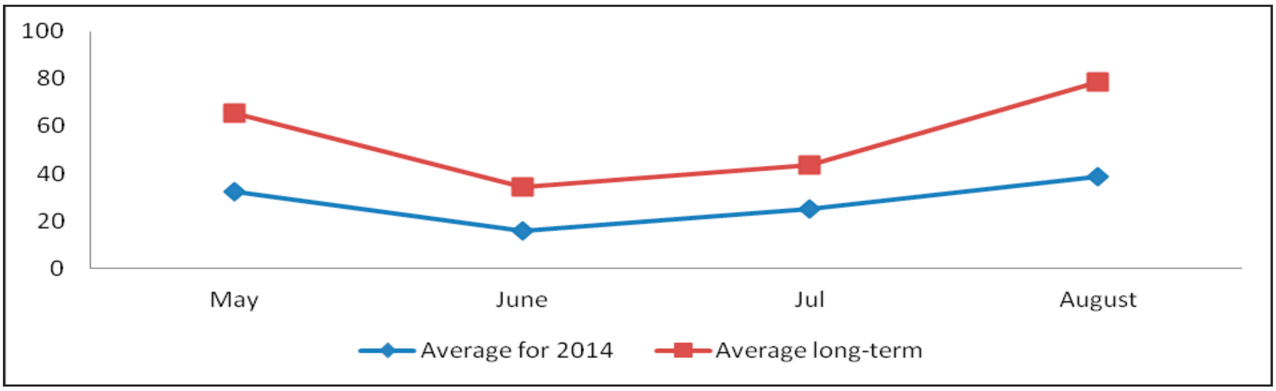

Fig. 1. *Quantity of rainfalls in the vegetation period of plant, mm*

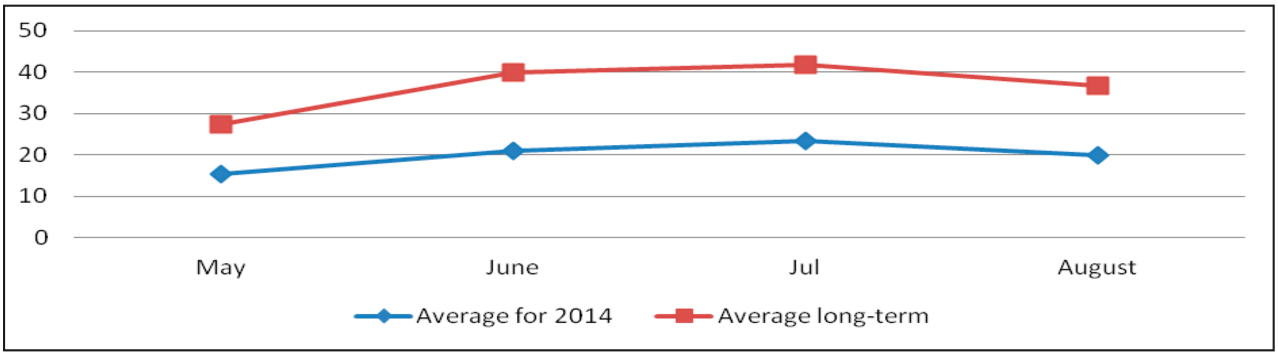

Fig. 2. *Mean monthly temperature in the vegetation period, ^0C*

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 Turin'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 Machigin'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.

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 2), 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 2).

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.

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 phenophases 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 2). It was not a case though when the combination of P_2O_5 and Rizotorfin was applied.

Table 1. The content of humus, soil nutrients and pH in soil layer of 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	8,22
	20-40	4.10	3.6	18.2	540.5	8,28
Traditional	0-20	4.46	4.1	22.8	635	7,73
	20-40	3.87	5.3	19.9	564.2	8,35

The length of vegetation season is one of the main indicators of the effect of growth stimulator Izagry Phosphorus. Growing technology also significantly influenced the dynamics of growth and development.

Analysis of Variance (ANOVA) (see Fig. 3 below) revealed also that impact of interactions of the three major factors investigated (i.e. technology of growing, addition of phosphorus and phenophase) on pea growth (lenght of plant, cm) is significant at p<0,05. This is especially profound at two early phenophases of pea growth i.e. rumification and blossoming. Similar trends were shown by chick-pea (Fig. 4 below), where differences between used technologies (plants under traditional show higher results compared to zero-tillage) were also profound, especially by those variant where additional P and Rizotorfin were applied.

Plant development involves also change in the overall plant biomass, which can signify quality and productivity changes at harvest.

Treatments with P-fertilisers stimulated the accumulation of pea and chickpea biomass (Table 3 below), which is shown by the significant differences shown between treated legumes compared to control variants (p<0,05) during all major plant phenophases. Differences between biomass of treated and untreated (control) plants were even more profound

Table 2. 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)

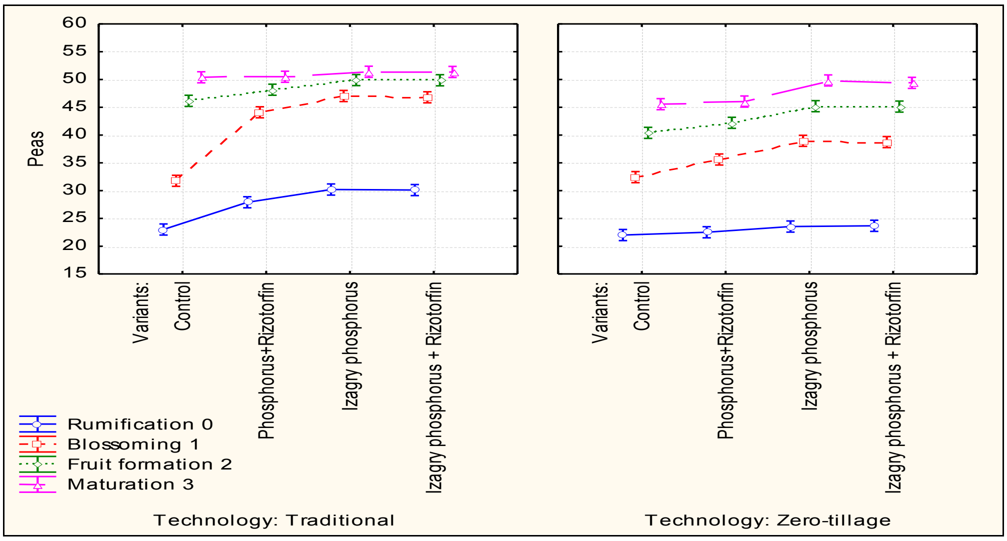

Fig. 3. *Impact of interactions of major factors, i.e. technology of growing, addition of phosphorus and phenophase, on pea growth (lenght of plant, cm), F(9, 64)=14,343, p=,00000*

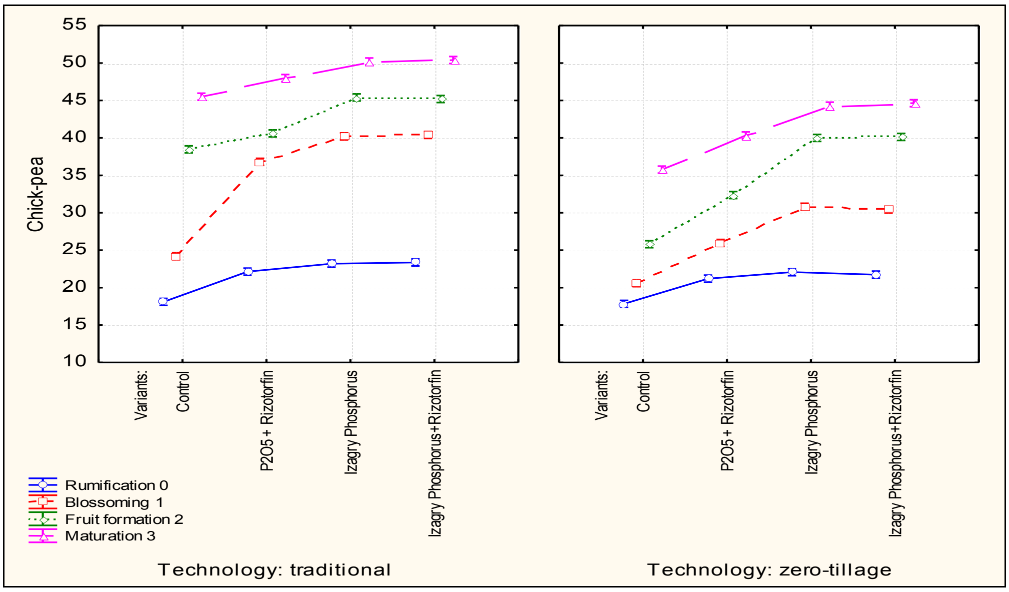

Fig. 4. *Impact of interactions of major factors, i.e. technology of growing, addition of phosphorus and the phenophase, on chick-pea growth (length of plant in cm), F(9, 64)=75,402, p=0,0000*

than those concerning the height of plants (see Table 2 above). They concerned almost all phenophases under the two contrasting technologies (traditional vs. zero-tillage).

Growing technology also significantly influenced the dynamics of growth and development.

Analysis of Variance (ANOVA) (see Fig. 5 below) revealed also that impact of interactions of the three major factors investigated (i.e. technology of growing, addition of phosphorus and phenophase) on pea growth (biomass, g/plant) is significant at p<0,05. This is especially profound at two final phenophases of pea growth i.e. fruit formation and maturation and between the two used technologies (plants under traditional show higher results compared to zero-tillage). Similar trends were shown by chickpea plants (Fig. 6 below). It was often not a case though when the combination of P_2O_5 and Rizotorfin was applied in zero-tillage technology (Fig. 5, right).

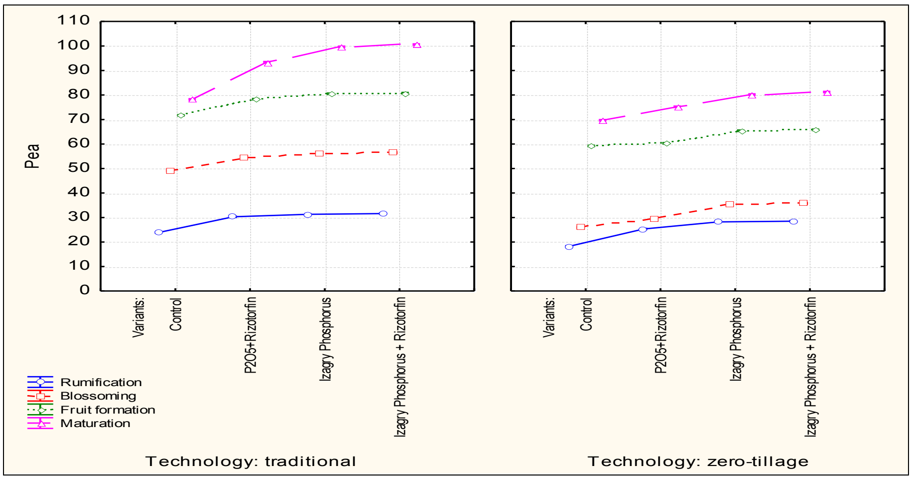

***Fig. 5.** Impact of interaction of major factors, i.e. technology of growing, addition of phosphorus and phenophase on pea biomass, g/plant, F(9, 64)=253,02, p=0,0000*

Table 3. Impact of addition of phosphorus (superphosphate and Izagry Phosphorus) and Rizotorfin on pea and chickpea biomass, g/plant

№	Variants	Phenophase			
		Rumification	Blossoming	Fruit formation	Maturation
Traditional technology					
Pea biomass, g/plant					
1.	Control	23,7[a]	49,2[a]	71,7[a]	78,2[a]
2.	P_2O_{5+}Rizotorfin	30,3[b]	54,7[b]	78,3[b]	93,4[b]
3.	Izagry Phosphorus	31,3[b]	56,2[b]	80,5[b]	100,0[b]
4.	Izagry Phosphorus + Rizotorfin	31,6[b]	56,4[b]	80,8[b]	100,6[b]
Chickpea, g/plant					
1.	Control	28,4[a]	50,7[a]	73,4[a]	90,2[a]
2.	P_2O_{5+}Rizotorfin	31,5[b]	55,6[b]	77,9[b]	93,5[b]
3.	Izagry Phosphorus	32,2[b]	59,2[b]	79,3[b]	103,5[b]
4.	Izagry Phosphorus + Rizotorfin	32,5[b]	59,5[b]	79,6[b]	104,2[b]
Zero-tillage technology					
Pea growth, g/plant					
1.	Control	18,2[a]	25,9[a]	59,2[a]	69,7[a]
2.	P_2O_{5+}Rizotorfin	25,3[b]	29,2[b]	60,3[a]	75,2[b]
3.	Izagry Phosphorus	28,0[b]	35,6[b]	65,4[b]	80,2[b]
4.	Izagry Phosphorus + Rizotorfin	28,5[b]	35,8[b]	65,7[b]	81.0[b]
Chick-pea, g/plant					
1.	Control	19,7[a]	45,2[a]	65,2[a]	85,4[a]
2.	P_2O_{5+}Rizotorfin	26,5[b]	47,2[a]	67,9[a]	87,3[b]
3.	Izagry Phosphorus	29,2[b]	50,3[b]	70,0[b]	90,2[b]
4.	Izagry Phosphorus + Rizotorfin	29,7[b]	50,6[b]	70,8[b]	90,8[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)

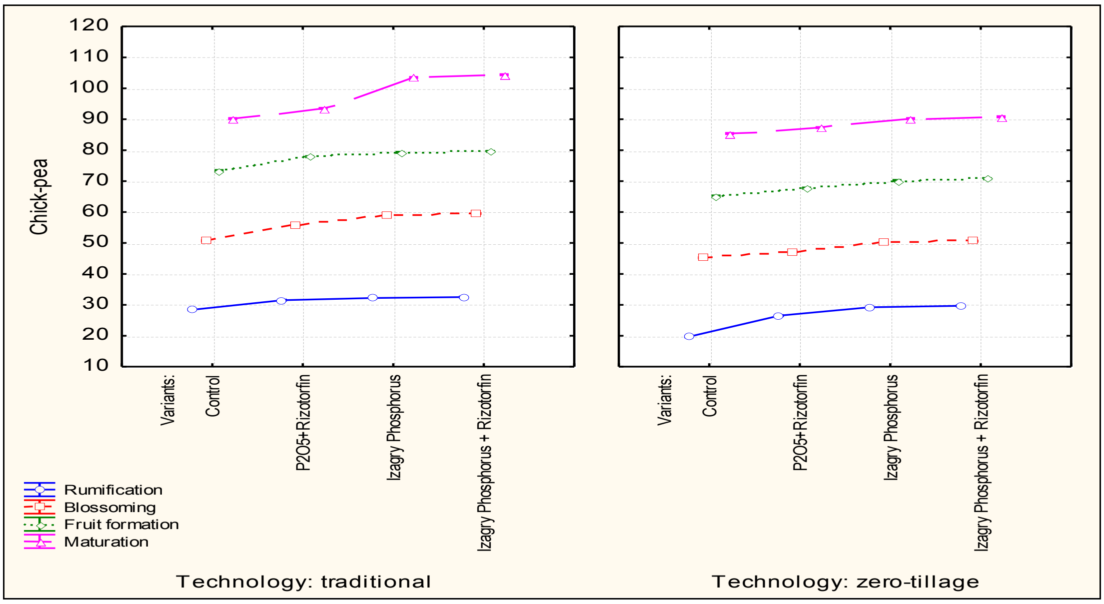

Fig. 6. *Impact of interaction of major factors, i.e. technology of growing, addition of phosphorus and phenophase on chickpea biomass, g/plant, F(9, 64)=451,86, p=0,0000*

One of the most important indicators for the efficacy of P-stimulators such as Izagry Phosphorus is the productivity of plants. It is the result of the cumulative impact of the structural elements of the crop productivity.

The result show that Izagry Phosphorus and the combination of Izagry Phosphorus and Rizotorfin had a positive impact on all structural elements of yield of the selected leguminous crops and on overall biological productivity (yield) of plants (Table 4 below).

Table 4 results show that the number of plants at harvest is higher in variants treated with phosphorus stimulators compared to control variants (at $p<0,05$). It also reflected in higher number of beans per plant ($p<0,05$) and higher number of seeds in 1 bean per plant ($p<0,05$).

One of the key quality parameters of the pea and chickpea harvest is height of the lower attachment of first bean. The higher the level of attachment of the 1st bean, the lower losses one can anticipate during harvest of beans. Table 4 shows that this parameter was significantly higher in treated plants compared to control (at $p<0,05$).

As a consequence, a significantly higher productivity of pea plants (at $p<0,05$) was shown by those grown under **traditional technology**, i.e. addition of Izagry Phosphorus and Rizotorfin yielded 1682 kg/ha compared to 1010 kg/ha of the control. Similarly, chick-pea showed 1568 kg/ha after addition of Izagry Phosphorus and Rizotorfin compared to 1110 kg/ha of the control.

Similarly, a significantly higher productivity of pea plants (at $p<0,05$) was shown by those grown under **zero-tillage technology**, i.e. addition of Izagry Phosphorus and Rizotorfin yielded 1590 kg/ha compared to 1000 kg/ha of the control. Similarly, chickpea showed 1580 kg/ha after addition of Izagry Phosphorus and Rizotorfin compared to 1050 kg/ha of the control.

Analysis of Variance (ANOVA) (see Fig. 7 below) revealed that impact of interactions of the two major factors investigated (i.e. technology of growing and addition of phosphorus) on pea biological productivity (yield, kg/ha) is significant at $p<0,05$. This is especially profound after addition of single Izagry Phosphorus and after combination of Izagry Phosphorus and Rizotorfin. These two applications 'produce' higher yields when traditional technology was used compared to zero-tillage one.

Similar trends were shown by chickpea biological productivity (Fig. 8 below), but here differences in yields between traditional technology and zero-tillage technology and after addition of single Izagry Phosphorus and after combination of Izagry Phosphorus and Rizotorfin were minimal. Even the combination of P_2O_5 and Rizotorfin in both technologies 'produced' higher yield compared to control (at $p<0,05$) (Fig. 7 and 8).

Table 4. Impact of Izagry Phosphorus and Rizotorfin on structural elements of the crop productivity in relation to the applied technology, i.e. traditional and zero-tillage

Variants	Number of plants at harvest, pieces per m²	Height of the lower attachment of 1 bean, cm	Number of beans on 1 plant.	Weight of beans per plant, g	Number of seeds in 1 bean per plant	Mass of the seeds in 1 plant, g	Mass/ 1000 seeds,g	Biological productivity (yield), kg/ha
Traditional technology								
Pea growth								
Control	45,3[a]	22,7[a]	13,8[a]	5,4[a]	16,8[a]	3,3[a]	192,8[a]	1010[a]
P_2O_{5+}Rizotorfin	48,8[b]	25,4[b]	16,0[b]	7,4[b]	19,6[b]	4,1[a]	209,4[b]	1540[b]
Izagry Phosphorus	50,0[b]	25,7[b]	18[b]	8,2[b]	20,2[b]	5,2[b]	215,4[b]	1680[b]
Izagry Phosphorus + Rizotorfin	52,1[b]	25,9[b]	18.2[b]	8,4[b]	20,4[b]	5,4[b]	215,6[b]	1682[b]
Chick-pea								
Control	42,3[a]	18,9[a]	10,8[a]	4,9[a]	13,9[a]	2,0[a]	180,0[a]	1110[a]
P_2O_{5+}Rizotorfin	45,6[b]	20,4[a]	12,3[a]	5,6[a]	14,7[a]	2,7[a]	182,1[b]	1390[b]
Izagry Phosphorus	50,3[b]	23,5[b]	14,1[b]	7,5[b]	16,9[b]	3,4[a]	200,3[b]	1560[b]
Izagry Phosphorus + Rizotorfin	52,4[b]	23,7[b]	14,2[b]	7,6[b]	17.2[b]	3,8[b]	200,6[b]	1568[b]
Zero tillage technology								
Pea growth								
Control	42,3[a]	20,7[a]	11,8[a]	4,4[a]	15,2[a]	3,0[a]	188,0[a]	1000[a]
P_2O_{5+}Rizotorfin	44,8[b]	24,4[b]	15,0[b]	6,4[b]	17,6[b]	3,9[a]	190,4[b]	1490[b]
Izagry Phosphorus	49,0[b]	25,7[b]	16.0[b]	7,9[b]	19,2[b]	4,4[a]	200,2[b]	1570[b]
Izagry Phosphorus + Rizotorfin	50,0[b]	25,9[b]	16.4[b]	8,2[b]	19,8[b]	4,8[b]	210,4[b]	1590[b]
Chick-pea								
Control	39,3[a]	18,9[a]	9,2[a]	4,4[a]	12,2[a]	2,0[a]	178,2[a]	1050[a]
P_2O_{5+}Rizotorfin	44,7[b]	20,4[a]	12,6[b]	5,0[a]	13,9[a]	2,2[a]	180,0[b]	1300[b]
Izagry Phosphorus	49,2[b]	23,5[b]	13,4[b]	7,0[b]	15,2[b]	3,0[a]	191,2[b]	1520[b]
Izagry Phosphorus + Rizotorfin	50,4[b]	23,9[b]	13,8[b]	7,4[b]	15,6[b]	3,5[a]	192,8[b]	1580[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)

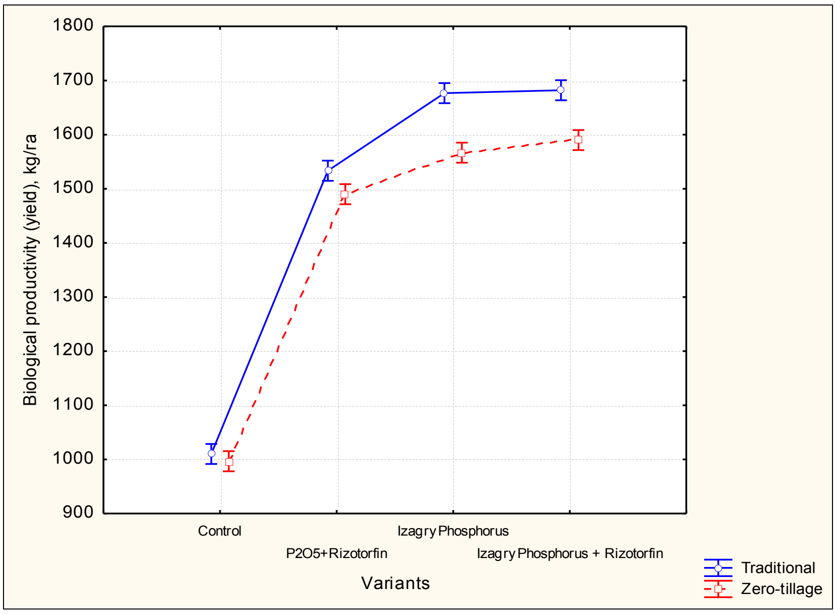

Fig. 7. *Effect of interactions of major factors, i.e. technology of pea growing and addition of phosphorus on pea yield, kg/ha, F(3, 16)=12,800, p=,00016*

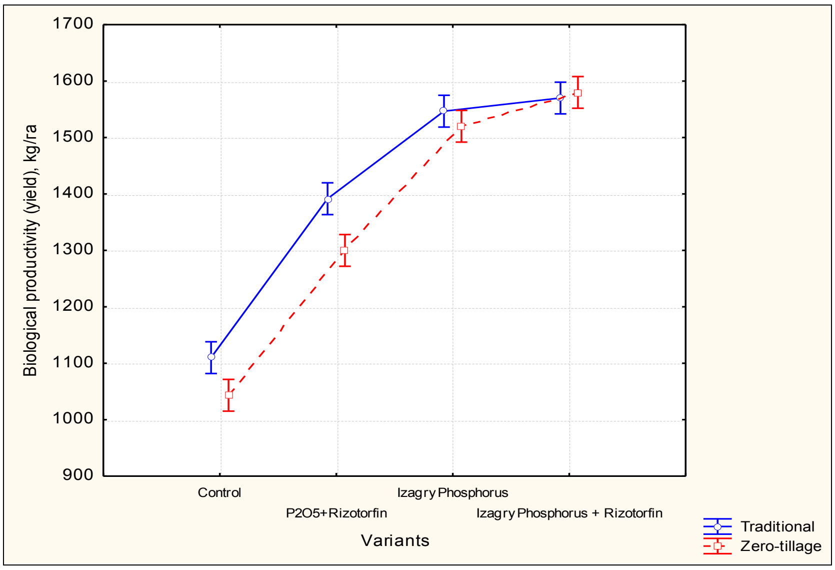

Fig. 8. *Effect of interactions of major factors, i.e. technology of pea growing and addition of phosphorus on pea yield, kg/ha, F(3, 16)=5,6664, p=,00769*

CONCLUSIONS

The climate conditions of Northern Kazakhstan are characterised with lower than average monthly temperatures and insufficient soil moisture for legume growth. These conditions impact the legume biometric parameters. Application of zero-tillage technology may hold some soil moisture, but it may increase soil compaction and as a consequence the seed emergence. The traditional technology helps to initiate backwashing of soil, penetration of oxygen, improvement of aerobic mineralization of organic matter, stimulation nutrient exchange and thus oxygen and fertilisers become available to seeds and roots.

The above characteristics can explain the trends found by this study. It revealed that addition of Izagry Phosphorus as well as the other combination of Izagry Phosphorus and Rizotorfin stimulated positively the growth of pea and chickpea plants. It was clearly shown by the significant differences between height and biomass of treated legumes compared to control variants (p<0,05) during all major plant phenophases. Here, the treatment of seeds of the two crops with Rizotorfin (strains of *Rhizobium*) increases the seed productivity of crops and the accessibility of the nitrogen released by the root nodules in the soil. These processes lead to the possibility of growing grain-legume crops without mineral fertilisers.

Differences between pea and chickpea biomass of treated and untreated (control) plants were even more profound than those concerning the height of plants. They concerned almost all phenophases, but especially at the two final phenophases of pea growth i.e. fruit formation and maturation and between the two used technologies (plants under traditional show higher results compared to zero-tillage). It was, however, often not a case when the combination of P_2O_5 and Rizotorfin was applied in both technologies.

The result show that Izagry Phosphorus and the combination of Izagry Phosphorus and Rizotorfin had a positive impact on all structural elements of biological productivity of plants of the selected leguminous crops and the overall yield of both leguminous crops (Table 4). Analysis of Variance (ANOVA) (Fig. 7) revealed a significant (at p<0,05) impact of interactions of the two major investigated factors (i.e. technology of growing and addition of phosphorus) on pea and chick-pea biological productivity (yield, kg/ha). The two applications Izagry Phosphorus and the combination of Izagry Phosphorus and Rizotorfin ‘produce’ higher yields after application of traditional technology compared to zero-tillage one.

Overall, the study showed that combination of Izagry Phosphorus and Rizotorfin have the strongest impact on all investigated parameters, i.e. height, biomass and biological productivity of pea and nut and can be recommended for the conditions of Northern Kazakhstan. It can be mainly attributed to the stimulation of microbial activity and thus and improved mineral feeding of pea and nut plants. This combination speeded up maturation of plants with 4-6 days, which is especially important for the conditions of Northern Kazakhstan characterized with short vegetation period.

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