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Agroecological Aspects of Chickpea Growing in the Dry Steppe Zone of Akmola Region, Northern Kazakhstan

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The aim of this study was to develop and offer technology for growing chickpea which comprises the application of stimulants for biological growth and mineral fertilizers adapted to conditions of dry steppe zone of Akmola region in Northern Kazakhstan. To achieve the goal, the study was focused on determining the combined effect of an integrated system of optimal agro-ecological conditions, soil cultivation technology (i.e. zero tillage versus traditional) and addition of nutrients (fertilizers, stimulants of legumes) on the growth and productivity of chickpea. This research shows that chickpea is well developed in growing season under traditional technology as compared to the zero-tillage technology, i.e. traditional soil cultivation improves germination and vitality of seeds and makes effective use of soil aeration and soil porosity in the soil layer of 0-20 cm. The results show that the combinations of mineral fertilizer $CaSO_4$ + $2H_2O_5$ + Rizotorfin (root inoculants) and the combination of Izagry Phosphorus + Rizotorfin can be recommended to farmers. The application of Izagry Phosphorus reduces the phenophases' elapsing time during chickpea growth and the total length (in days) of the chickpea growth. It gives farmers an opportunity to apply late sowing, for example in early June, and make use of higher temperatures during the main growing season that could have a positive impact on biological productivity of chickpea. It also improves chickpea morphological parameters (i.e. plant height) which produces a significant increase in biological productivity, i.e. yield, which was significantly higher under the traditional technology than under the zero-tillage. A remarkable increase of grain yield by 88% to 95% compared to the control variant, upon treatment with Izagry Phosphorus and Izagry Phosphorus + Rizotorfin, respectively, was observed. It provides new economic incentives for farmers that practice environmentally-friendly farming in Kazakhstan.

Keywords: chickpea, traditional technology, zero tillage technology Izagry Phosphorus, rizotorfin.

One of the modern directions of sustainable agriculture is ecological intensification of agroecosystems, including cultivation of leguminous plants and use of biological stimulants and bacterial preparations for increasing crop productivity and quality of grain[1].The application of biological stimulants helps to activate metabolism thus creating conditions for reducing the doses of mineral fertilizers, increasing their utilization, and accelerating mineralization of organic residues. Biostimulators increase the protective mechanism of plants against unfavorable factors. They do not disturb the ecological balance in the biosphere and play a significant role in anti-resistant strategy[2].

Currently, the agricultural production in the Republic of Kazakhstan (wheat and other grain crops) is carried out predominantly by application of synthetic mineral fertilizers and chemical pesticides. However, their unbalanced use may lead to environmental pollution as well as pollution of

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agricultural production with chemical residues, including heavy metals, nitrates and other elements that may be harmful to the people's health[3].

These negative effects require agro-technologies that should be based on sustainable crop rotations and application of biological preparations. The latter stimulates metabolism and reproduction of beneficial soil microflora, prolong the effect of the bacterial preparations, creates conditions to reduce rates of mineral fertilizers and accelerates mineralization of organic residues.

The development of biological methods of cultivation of agricultural crops is given great importance in the countries with the developed agriculture[4].According to the International Association of the biocontrol industry, 40% of all companies producing bio-preparations and bio-pesticides are in the US, 35% in Europe and 25% in all other countries. However, Kazakhstan is not mentioned in the list. The application of bio-pesticides based on exuded and purified natural biologically active substances used as bio-pesticides, bio-fungicides, and bio-herbicides and bio-nematocides increases annually in the world. In Kazakhstan, despite the significant potential, the application of bio-preparations in the production has received little attention[5].

In this context, the agricultural production in the Republic of Kazakhstan cannot be carried out by 0 simplified system of mechanization, irrigation and application of chemicals. It should incorporate ecologisation processes of agroecosystems involving more efficient and intensive use of natural resources as well as improving the structure of cropped areas by crop rotations and inclusion of legumes. The advantage of legumes over the most common cereals (i.e. in Kazakhstan more than 16.0 mln ha of grain, or 80% of the total cultivated area) is that they produce much more protein with higher quality and accessibility per unit of area. The cultivation of legumes helps to optimize the microbial environment in soil, to improve a number of soil physical and chemical properties resulting in significantly increased soil fertility[6]. Chickpea is a promising legume, which is suited to the agroecological conditions of arid regions with sharply continental climate. It easily withstands drought and breaks with lack of moisture, and provides good grain yield. Due to its deep root system and resistance to water stress, the crop is well adapted to the drier areas[7], and, along with a favorable ratio of protein, fat, carbohydrates, minerals, vitamins, biologically active substances in the seeds resulted in its wide spread in India, Pakistan, Afghanistan, Iran, Iraq, Syria, Ethiopia, Mexico and other countries with arid climate [8]. There, from 9 to 10 million hectares are annually sown with chickpea[7,8]. In North Kazakhstan chickpea can grow even at relative humidity of 25-33%, which is impossible condition to other crops[9]. Despite the number of valuable biological properties of this crop, technologies of chickpea cultivation involving biological stimulants such as seed inoculants have not been developed. Therefore, the present study of agroecological aspects of the cultivation of chickpea plants, including the impact of application of biological stimulants and seed inoculants in the dry steppe zone of Akmola region is important to solve the problems of ecologisation in the agricultural sector of the Republic of Kazakhstan.

MATERIALS AND METHODS

Experimental studies (variants) were carried out in the period from 2014-2015, in three replications under laboratory and field conditions of the permanent study area of the Department of Agriculture and crop production of S.Seifullin Kazakh Agrotechnical University (KATU) and in the laboratory of the Republican Scientific Research Guidance Center of Agrochemical Service (RSRGCACHS). The field experiments were setup in "Novorybinskoe and K" agricultural production unit in Akkol district. The field plots were selected on the basis of existing soil and agrochemical maps as well as on field-history book and on a survey about preceding crops, agricultural techniques, the applied organic and mineral fertilizers. Following the traditional technology of cultivation of legumes, chemicals and fertilizers have not been applied on the selected pilot area prior to the experiment . The preceding plants were perennial grasses grown for more than 25 years. The object of study was the chickpea variety *Jubilee* with economic vitality of 92.0% and that is approved for planting in Akmola region. Experimental plot area was 12 m^2 and the registration plot area was

10 m^2. The total experimental plot area was 1,000 m^2. The allocation of experimental variants was systematic with sequential replication. The field experiments were made according to the following scheme:

Variant 1

Study of the influence of biological stimulant plus innoculant on the growth and development of chickpea plants according to the traditional technology

1. Control (single-crop sowing);
2. Izagry Phosphorus (biological stimulator);
3. Izagry Phosphorus + rizotorfin

Variant 2

Study of the influence of mineral fertilizers plus innoculant on the growth and development of chickpea plants according to the traditional technology

1 Control (single-crop sowing);
2. Double superphosphate (mineral fertilizer) ($CaSO_4 + 2N_2O_5$);
3. Double superphosphate ($CaSO_4 + 2N_2O_5$) + rizotorfin

Variant 3

Study of the influence of biological stimulant plus innoculant on the growth and development of chickpea plants according to the zero-tillage technology

1. Control (single-crop sowing);
2. Izagry Phosphorus (biological stimulator);
3. Izagry Phosphorus + rizotorfin

Variant 4

Study of the influence of mineral fertilizers plus innoculant on the growth and development of chickpea plants according to the zero-tillage technology

1. Control (single-crop sowing);
2. Double superphosphate (mineral fertilizer) ($CaSO_4 + 2N_2O_5$);
3. Double superphosphate ($CaSO_4 + 2N_2O_5$) + rizotorfin

Location of experimental area

The experimental plot is located in the village Novorybinka of Akkol region. The area is located in the central part of Akmola region. It borders Bulandy region, Shortandy in the south, Astrakhan in the west and Yereimentau region in the east.

Climate and soil conditions during study period

The climate of the region is sharply continental, dry. The average annual precipitation is 300-350 mm. About 200-250 mm fall during the warm period that lasts from mid-April to mid-September. According to the long-term average annual data for 2014-2015, the absolute maximum temperature is in June, July and August and it is ranging from $+16^0$ to $+22^0$.

The lowest temperatures were detected in December, January and February. The increase of mean daily temperature above 0^0C takes place in the first decade of April. The warm period lasts from 75 to 90 days. The frost-free period lasts approximately 110 – 120 days a year. Snow cover is present up to 5 months, with an average thickness of about 20-35 cm. Frosts begin in the second half of September. In some years, frosts may occur in late August. Snow cover appears first in the middle of October.

The soils are southern black vetrosols. Humus content in the upper layer is on an average of 3%, the absorption capacity is 41 mg/eq CO_2 - 1.8-3.0%. The soil effervescence comes from the surface. The presence of absorbed sodium proves weak alkalinity of the soils. The content of the absorbed sodium is about 2% in the 0-10 cm layer. According to the surface topography the southern carbonate black vertosols lie in the undulating plain under the feather-fescue plant grouping with small admixture of steppe grasses in yellow brown quaternary carbonate heavy loam and light clay with deep-lying ground water. The humus horizon (A + B1) is equal to an average of 40.5 cm and has dark gray color often with a slight brown tint, crumbly structure, with B2 horizon thickness of 65 cm. The visible border of gypsum horizon extends to the depth of 90-150 cm; the soil effervescence is at the bottom of B1 horizon or at the border of the humus layer. Soil samples were taken twice 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) cm. 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. was attached to each sample bag then registered in the 'field journal'. The major soil parameters of the experimental plot are shown on Table 1.

According to the soil classification by humus content by Tyurin method (in %)[10] and by the content of labile phosphorus and nitrate nitrogen in the soil by Chernenok gradation[11] (mg/kg), the soil has very low content of P and N in the layer of 0-20 cm and 0-40 cm. In regards to the rate of exchange potassium (determined by Machigin method (mg /kg))[12], the soil belongs to the groups with relatively high content of exchanged potassium. In regards to the degree of acidity, the soil pH ranges from neutral to slightly alkaline.

Moisture conditions

The snow cover height on the experimental plots by the end of February (average for 2014-2015) was an average of 22.6 cm, the weight was 10.1 grams, the density was 0.294 g/cm3 and the amount of water was 36.4 mm. The spring moisture reserves in the top one meter layer of soil before sowing averaged between 57.5 mm and 79.6 mm (depending on the two contrasting agro-technologies).

The reserves of available moisture for harvest in fields under the traditional technology were of about 33.7 mm, and in the fields under the zero-tillage technology of about 40.2 mm. The rainfall during the growing season was irregular except May when the amount of precipitation was lower in comparison with the long-term average annual index. The amount of precipitation in the winter months (January, February) was lower than the long-term average annual rates by 1.5-2.2 times. In March, the precipitation was equal to the long-time average annual index. In the following spring months, the amount of precipitation exceeded the long-time average annual index by 1.8 times. The rainfall in June was lower than the long-term average annual index by 19.3 mm, in July by 24.9 mm and in August by 2.3 mm.

The calculations of hydrothermal index made on the basis of the prevailing temperature and the amount of precipitation during the growing season (HTI -1.1) characterize the meteorological conditions of the year 2014-2015 as slightly dry.

Agro-technology used for experiments

The entire experiment area had a uniform slope (0.4-0.7 m by 100 m). A deep-ploughing was done according to the traditional technology using a plow PLN 5-35 to the depth of 25 cm followed by disk-cultivation with a field drag BDT -10 to the depth of 6 cm. In the spring (2nd decade of April when the soil moisture permits) a harrowing with ZBZTU-1 spike-tooth harrow that was hitch-mounted to C-11U was done in order to mulch moisture (leveling the soil surface) and to extirpate early spring weeds in "white thread" phase. Subsequently, pre-sowing cultivation with simultaneous harrowing with KPNA-3 mounted cultivators with ZBZS-1 average harrows hitched to SN-54A and rolling down with 3 KKSH-6A star-wheeled rollers and T-75 tractor was conducted prior to sowing (the 1st decade of May). Variants with zero-technology were not cultivated mechanically.

The sowing was carried out in the second decade of May with a seeding rate of 0.8 million of germinating seeds per 1 ha at the depth of 6 cm. Seeds were air-heated prior to sowing. The seeds were graded into uniform size by means of sieves separating an average fraction of seeds 3.5-5.0 mm in diameter. A set of sieves was used for grading.

The treatment of plants with *phosphorus stimulator (Izagriy phosphorus)* was done in the phase of chickpea budding with knapsack sprayer 0.7 liters per hectare twice in July. 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 [13]. Izagry Phosphorus is a liquid fertilizer in concentrated solution of high phosphorous content (27.7%). It is intended for foliar treatment of plants. It enhances the growth and development of plants, prevents deficiency of phosphorus in plants and leads to yield increase from 300 to 1,000 kg/ha. It is effective in protection of plants against spring and autumn frosts, during drought periods and after heavy rains. 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 with 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 of plants to diseases, leads to increased plant growth (plant height), increases yield, accelerates seeds' ripening and improves product quality.

The mineral fertilizer *double superphosphate* ($CaSO_4 + 2N_2O_5$) was applied to the plant beds at the amount of 2.3 kg per ha before sowing with a planting drill SZS-2.1. The active substance is P_2O_5 46,6%.

The study used inoculation of legume seeds with bacteria of the genus *Rhizobium*. It was done by spraying with bacterial preparation Rizotorfin that is registered for seed treatment prior to sowing. Bacterial strains of Rizotorfin of chickpea were produced in JSC "Institute of Microbiology and Virology" in Almaty. Rizotorfin-preparation is a preparation of high-efficient legume bacteria, grown in peat substrate enriched with carbohydrates, vitamins and minor-nutrient elements. The content in 1 cm^3 of preparation (titer) is not less than 2.5 billion bacteria. The dose of Rizotorfin was 400-600 g. The innoculation was executed, because of the fact that new land planned for growing legume plants does not provide N-fixing bacteria. Seed inoculation with *Rhizobium* bacteria could lead to significant increase of plant productivity, i.e. yield [14]. Inoculation of chickpea seeds was made with a *Rizotorfin* 5 hours prior to sowing of chickpea. It was done in a trap with a size of 24 m^2 to avoid the sunlight.

Phenological observations were carried out in accordance with the method approved by State Commission for Variety Testing Crops in Kazakhstan[15]. 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:

$$Gv = \frac{D - 100}{Rv}:$$

where G_v is germination in %, D is actual plant density on shoots in plants/m^2, and R_v is seeding rate in seeds/m^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.

The following methodology for monitroing was used:

1. Sowing quality of seeds of crops (chickpea) was dete rmined in accordance with GOST 12038-84 "Seeds of crops" in the laboratory of seed studies of S.Seifullin KATU[16].
2. Registration and observation during the experiments were carried out in compliance with the methods of conducting experiments and State variety testing of crops[17] in the laboratory of S.Seifullin KATU.
3. The experimental data were processed by the software Statistica (StatSoft Inc.) in order to perform Analysis of Variance (ANOVA) for a large set of data and to perform multi-ranking test of Duncan (1953)[18].

RESULTS AND DISCUSSION

Morphological and productivity parameters of chickpea plants

During the study period, the chickpea plants exhibited relatively stable growth that was favoured by the weather conditions.

Biometric measurements in 2014 and 2015 showed that field germination of chickpea sown

Table 1. Major soil parameters of experimental plots at the layer of 0-20 cm, mean of 2014 and 2015

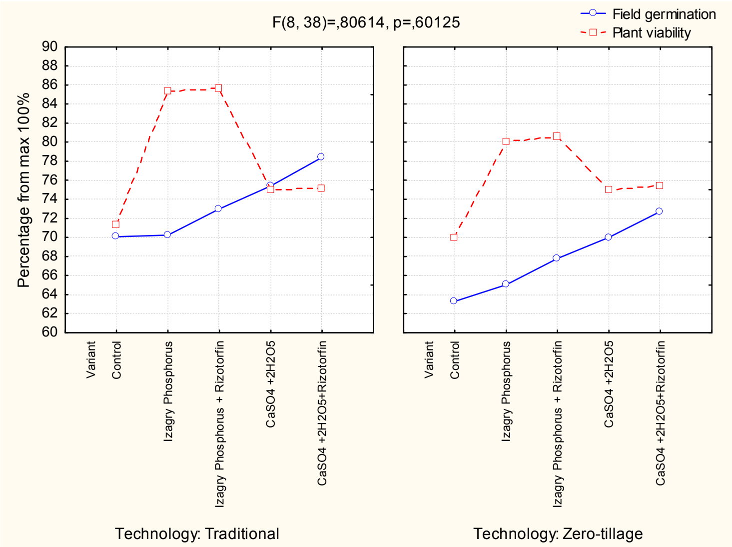
Technology	Soil layer, cm	humus, %	P_2O_5, mg/kg	K_2O, mg/kg	$N\text{-}NO_3$, mg/kg	pH
Traditional	0-20	2.89	3.61	521.3	3.11	7.22
	20-40		2.31		3.23	7.26
Zero tillage	0-20	2.51	2,51	452.1	2.28	7,00
	20-40		2.60		2.44	7.12

under the traditional technology ranged from 70.0% to 78.4%, and under the zero-tillage technology ranged from 63.0% to 73.4%. The chickpea plant viability under traditional technology ranged from 71.3% to 85.6% and under zero-tillage technology from 70.0% to 80.6% (Table 2).

The best field germination under the traditional technology was shown by the variant with application of $CaSO_4$ +2”$_2O_5$ + rizotorfin, i.e. 78.4%, compared to 70.0% shown by the control variant. The best viability was shown by plants after treatment with combination of Izagry

Table 2. Germination and viability of chickpea (in %) upon different treatments (variants) and under contrasting growing technologies, mean of 2014 and 2015

Variants	Field germination rate,%	Plant viability,%
Traditional technology		
Control	70.0	71.3
Izagry Phosphorus	70.2	85.4
Izagry Phosphorus + Rizotorfin	73.0	85.6
$CaSO_4$ +$2H_2O_5$	75.4	75.0
$CaSO_{4\ +}2H_2O_5$+Rizotorfin	78.4	75.2
Zero-tillage		
Control	63.3	70.0
Izagry Phosphorus	65.0	80.0
Izagry Phosphorus + Rizotorfin	67.8	80.6
$CaSO_4$ +$2H_2O_5$	70.0	75.1
$CaSO_{4\ +}2H_2O_5$+ Rizotorfin	73.4	75.4



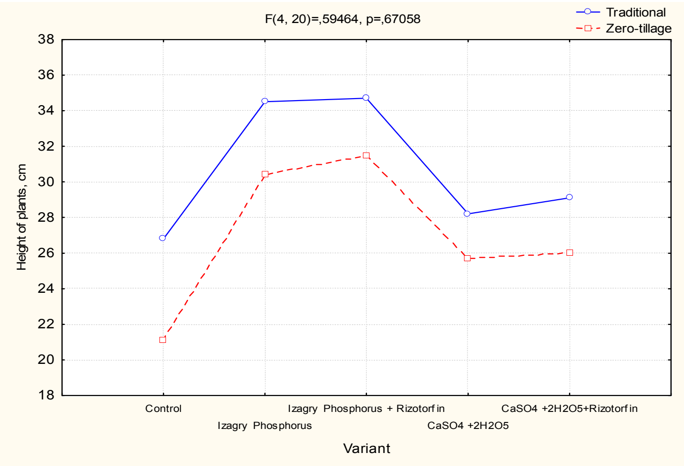
Factors:	SS	DF	MS	F	P
Technology	0,199	38,23	2	19	0,000*
Variant	0,028	23,60	8	38	0,000*
Technology*Variant	0,731	0,81	8	38	0,601

* indicates statistical significance at $p<0,05$.

Fig. 1. Effect of major factors treatment (variant) and technology (traditional and zero-tillage) on chickpea field germination and plant viability, after ANOVA, as a mean of 2014 and 2015

Table 3. Length of the interphase periods of chickpeas and the height of plants during the growing season in relation to the treatments (variants) of the experiment and the contrasting technologies, mean of 2014 and 2015

Variants	Phase of plant development												Length of the growing period, days
	shooting		branching		budding		blossoming		pod formation		ripening		
	date	height, cm	date	height cm	date	height cm	date	height cm	date	height, cm	date	height, cm	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Traditional technology													
Control	10.06	4.0	23.06	12.2	13.07	17.0	23.07	24.0	10.08	25.0	08.09	26.8	105
Izagry Phosphorus	10.06	4.6	23.06	13.0	13.07	19.2	22.07	31.3	06.08	32.0	05.09	34.5	101
Izagry Phosphorus + Rizotorfin	10.06	4.7	23.06	13.7	13.07	23.5	22.07	32.0	06.08	32.6	05.09	34.7	101
$CaSO_4$ +2H_2O_5	10.06	6.0	23.06	14.6	13.07	20.2	22.07	25.1	06.08	27.2	05.09	28.2	105
$CaSO_4$ 2 H_2O_5++ Rizotorfin	10.06	6.6	23.06	15.2	13.07	21.1	22.07	25.7	06.08	28.0	05.09	29.1	105
Zero tillage													
Control	10.06	3.6	23.06	8.3	13.07	14.6	24.07	18.9	10.08	19.9	08.09	21.1	105
Izagry Phosphorus	10.06	4.3	23.06	9.0	13.07	17.8	22.07	28.1	06.08	28.9	05.09	30.4	101
Izagry Phosphorus + Rizotorfin	10.06	5.1	23.06	10.0	13.07	22.4	22.07	28.5	06.08	29.0	05.09	31.5	101
$CaSO_4$ +2 H_2O_5	10.06	5.9	23.06	12.2	13.07	20.2	22.07	24.1	06.08	25.1	05.09	25.7	105
$CaSO_4$ 2 H_2O_5++ Rizotorfin	10.06	6.2	23.06	12.9	13.07	21.0	22.07	24.9	06.08	25.9	05.09	26.0	105



Factors:	SS	DF	MS	F	P
Technology	103,8	1	103,8	26,51	0,000*
Variant	361,9	4	90,5	23,11	0,000*
Technology*Variant	9,3	4	2,3	0,59	0,671

* indicates statistical significance at $p<0,05$.

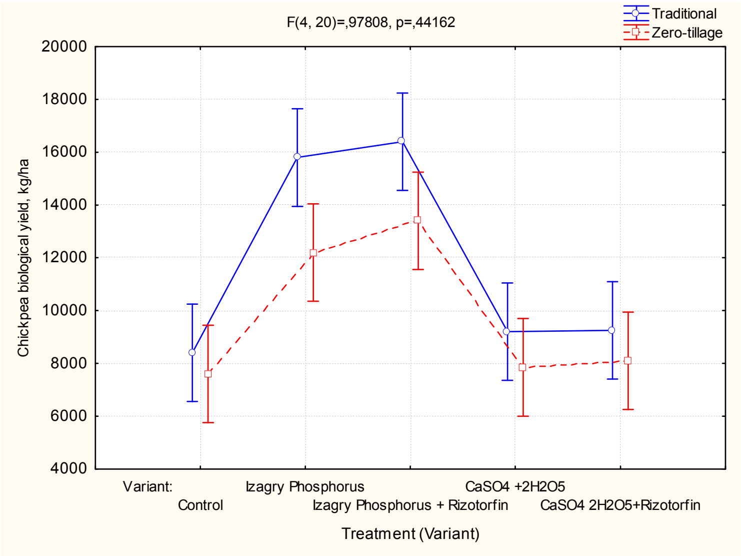
Fig. 2. Effect of major factors treatment (variant) and technology (traditional and zero-tillage) on chickpea height of plants, after ANOVA, as a mean of 2014 and 2015

Phosphorus and Rizotorfin, i.e. 85.6% compared to 71.3% shown by the control variant.

The treatment with combination of CaSO4 +2”2O5 + rizotorfin under the zero-tillage technology produced the best field germination of 73.4% compared to 63.3% by the control variant (Table 2). The best viability though was shown by plants treated with combination of Izagry

Table 4. Structural elements of chickpea yield in relation to variants of the experiment and the technology of cultivation, mean of 2014-2015

Variants	Number of plants for harvest, pcs/m^2	Number of seedpods per plant, pcs	Number of seeds per seedpod, pcs/plant	Weight of 1000 seeds, g	Biological yield, kg/ha	Increase to control, %
Traditional technology						
Control	30.0	24.0	48.0	241.0	8 400	100
Izagry Phosphorus	36.0	33.0	66.0	280.3	15 800	188
Izagry Phosphorus+ Rizotorfin	42.0	36.0	72.0	290.4	16 400	195
$CaSO_4$+$2H_2O_5$	33.0	27.0	54.0	260.1	9 200	109
$CaSO_4$+$2H_2O_5$+ Rizotorfin	36.0	30.0	60.0	271.9	9 250	110
Zero-tillage technology						
Control	27.0	15.0	30.0	180.0	7 600	100
Izagry Phosphorus	36.0	24.0	48.0	242.3	12 200	160
Izagry Phosphorus+ Rizotorfin	42.0	27.0	54.0	260.7	13 400	176
$CaSO_4$+$2H_2O_5$	30.0	18.0	36.0	196.7	7 850	103
$CaSO_4$+$2H_2O_5$+ Rizotorfin	33.0	21.0	42.0	224.0	8 100	106



Factors:	SS	DF	MS	F	P
Technology	294E5	1	294E5	12.48	0.002*
Variant	267E6	4	669E5	28.39	0.000*
Technology*Variant	921E4	4	230E4	0.98	0.442

/interaction/ * indicates statistical significance at p<0,05.

Fig. 3. Effect of major factors treatment (variant) and technology (traditional and zero-tillage) on chickpea biological yield, mean of 2014 and 2015

Phosphorus and Rizotorfin, i.e. 80.6% compared to 70.0% shown by the control variant.

Two-way Analysis of variance (ANOVA) shows that interaction of major factors technology and variants (treatments) did not have a significant effect on both parameters (at $p>0,01$) (Fig.1 above). However, the single effect of the traditional technology produced significantly better germination and viability of chickpea compared to the zero-tillage technology (at $p<0,01$). The same significant effect was found for the differences between variants (treatments).

Growing development of chickpea

The treatment with Izagry Phosphorus had a significant impact on the length of the main phenophases of chickpea plants, acceleration of their growth and overall development (Table 3 above). Variants with application of mineral fertilizer $CaSO_4$ +2"2O_5 +Rizotorfin and the control variant have shown a sum of 105 days of interphase periods (shoots to ripening) for the chickpea growth. However, upon treatment with bio-stimulator Izagry Phosphorus and combination of Izagry Phosphorus + Rizotorfin the length of the growing period was 101 days.

The better daily increase was shown by the chickpea treated with Izagry Phosphorus, i.e. 0.4 cm. The inoculation of chickpea seeds had no significant effect on plant height parameters. However, at ripening phase, the variant of Izagry Phosphorus + Rizotorfin has shown almost similar height, i.e. 34.7 cm as the one after treatment with single Izagry Phosphorus. Both variants were superior towards control variants and those with mineral fertilizers under both technologies (traditional and zero-tillage).

Two-way Analysis of variance (ANOVA) shows that interaction of major factors technology and variants (treatments) did not have a significant effect on chickpea height at the ripening phase (at $p>0,01$) (Fig.2 above). However, the single effect of the traditional technology yielded significantly higher chickpea plants compared to the zero-tillage technology (at $p<0,01$). The same significant effect was found for the differences between variants (treatments).

The structural elements of the chickpea yield (Table 4 below) showed similar trends as these shown by morphological parameters, i.e. treatments with bio-stimulator Izagry Phosphorus and combination of Izagry Phosphorus + Rizotorfin produces bigger number of plants for harvest, number of seedpods per plant and number of seeds per seedpod compared to control variant.

Two-way Analysis of variance (ANOVA) shows that interaction of major factors technology and variants (treatments) did not have a significant effect on the chickpea biological yield (at $p>0,01$) (Fig.3 above). However, the single effect of the traditional technology produced significantly higher amount of grain (kg/ha) of chickpea compared to the zero-tillage technology (at $p<0,01$). The same significant effect was found for the differences between variants (treatments), i.e. Izagry Phosphorus and combination of Izagry Phosphorus + Rizotorfin produced the highest biological yields under both technologies (Fig.3).

CONCLUSIONS

The overall agroecological and growing conditions for producing economically-important legume crop (i.e. chickpea) were analyzed and described.

The bioclimatic parameters monitored at the Agricultural complex "Novorybinskoe and Co" Ltd. in Akkol district located in the central part of Akmola region showed that for 2014-2015, the average climate conditions were similar to the long-time average annual parameters. Thus, the selected varieties of legume were successfully cultivated in this region, despite the temperature fluctuations and negative impact of irregular precipitation during the growing season, which resulted in soil moisture shortage in the phase of maximum water consumption by plants in the second half of summer (mid-July and beginning of August of 2014 and 2015). The reserve of available moisture for harvest in variants under traditional technology was 33.7 mm whereas in variants under zero-tillage technology was 40.2 mm.

The soil is classified as having very low content of nitrogen and phosphorus in the layer of 0-20 cm and 0-40 cm. During the growing season, the targeted chickpea plants developed better under the traditional technology compared to these under the zero-tillage technology. The germination and seed viability of chickpea under the traditional technology was better under all treatments compared to the zero-tillage technology. This may be attributed to better utilization of soil air after improved soil porosity of the soil layer of 0-20 cm when applying the traditional technology, as plant nutrients required for growth and development become readily available.

Combinations of mineral fertilizer $CaSO_4$ + $2H_2O_5$ + the innoculation promoter Rizotorfin, and Izagry Phosphorus + Rizotorfin may be recommended to farmers. In the beginning of growth of chickpea (i.e. shoots - branching), treatment (variant) with double superphosphate and Rizotorfin produced the tallest plants. Later (budding to ripening), the plant height was highest after treatment with the combination of Izagry phosphorus and Rizotorfin. This effect may be attributed to two factors, i) when mineral fertilizer double superphosphate was applied before sowing, it had a positive effect during the plant germination, but at later growing stages this effect decreased because the root system went down to a depth of approximately 50 cm, while the fertilizer was active at the layer of 0-20 cm, and ii) plant treatment in later phenophases (i.e. budding) with Izagry Phosphorus (done on the 25 of June). The application of plant inoculation product Rizotorfin was more effective when combined with promoter Izagry Phosphorus. This combination reduced the time of passing the main phenophases of chickpea, and the overall length of vegetation (in days), i.e. vegetation period was significantly lower ($p<0,05$) compared to control variant. The result provides farmers with an opportunity to apply late sowing, e.g. in the beginning of June and use the higher temperatures during main vegetation period.

Use of a biological preparation in combination with Izagry Phosphorus and Izagry Phosphorus + Rizotorfin had a positive effect on the biological performance of chickpea, i.e. at ripening phase under the traditional technology, the variant of Izagry Phosphorus + Rizotorfin has shown almost similar height, i.e. 34.7 cm as the one after treatment with single Izagry Phosphorus (34,5 cm). Both variants were superior towards control variants and those with mineral fertilizers under both technologies (traditional and tillage).

The results confirmed the research hypothesis that inoculation of chickpea seeds with Rizotorfin (based on Rhizobium bacteria) and addition of phosphate fertilizers would lead to a significant increase in plant productivity, i.e. yield, as suggested by e.g. Serekpaev (1998) [19]. As a result of stimulated growth, the overall biological yield of the chickpea (in kg/ha) was significantly higher under the traditional technology than under the zero tillage (at $p <0.05$). A remarkable increase of grain yield by 88% to 95% compared to the control variant, upon treatment with Izagry Phosphorus and Izagry Phosphorus + Rizotorfin, respectively, was observed. It provides new economic incentives for farmers that practice environmentally-friendly farming in Kazakhstan.

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