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YIELD AND QUALITY OF MUSTARD SEEDS DEPENDING ON MINERAL NUTRITION AND FERTILIZERS UNDER CONDITIONS OF SOUTHERN BLACK SOIL

Abstract. The biological features of mustard allow it to be widely used as food, medicinal, fodder, green manure, oilseed and honey plant and in various industries. It is a valuable source of high-quality oil, rich in vitamins, has phyto-reclamation and phytosanitary properties, and is a good predecessor for other crops. However, despite the high value and the prospect of use in agriculture, it has been little studied. The requirements for mineral nutrition of the soil and mineral fertilizers have not been studied, which is very important for the production of stable and high-quality crops, which was the purpose of our research. The studies were conducted on humus of the southern steppe zone of Northern Kazakhstan. The experiments were carried out according to a 14 variant scheme, to create different levels of phosphorus and nitrogen in the soil in order to determine the quantitative relationship between the level of nutrient content in the soil and the productivity of mustard varieties. Studies have shown the responsiveness of mustard varieties to nitrogen-phosphorus fertilizers, depending on the content of nutrients in the soil. In the conditions of southern black soil, the effectiveness of applied fertilizers is determined by the level of nutrients content in the soil, the conditions of moisture supply, temperature conditions and the biological characteristics of mustard varieties.

Key words: mustard, nitrate nitrogen, mobile phosphorus, fertilizers, southern humus, yield.

Introduction. Oilseeds have taken an important place in human nutrition, as they remain the main sources of calories and protein for a large part of the world's population.They are in high demand in the global market and highly profitable. Given the great demand for oilseeds in recent years, sown areas in Kazakhstan have significantly increased. It should be noted that in 2019 the area under mustard increased by 3.5 times and amounted to 78.3 thous.ha [1].

Mustard is a valuable source of high-quality oil, has phyto-reclamation and phytosanitary properties, adapted to different growing conditions, even in unfavorable conditions of cultivation. Mustard is widely used in food, canning, confectionery, bakery, margarine, perfumery and other industries [2,3].

Mustard oil contains many vitamins as A, B_6, PP, D, E, K, and P. It has the lowest acid index and much longer than others retains its properties.Mustard powder, due to its content of essential (allyl) oil, has strong fungicidal and bactericidal properties [4,5].

Mustard is the third largest source of vegetable oils in the world after soybean and oil palm. The residue remaining after extraction of the oil (i.e. cake or flour), rich in protein, can be used as livestock feed [6]. Its oil refers to low-drying oils, so it is used to lubricate car engines and equipment operating at low temperatures [4].

Mustard seeds have a high energy content, 28–32% oil with a relatively high protein content (28–36%). Mustard oil has a special composition of fatty acids: 20–28% oleic, 10–12% linoleic acid, 9,0–9,5% linolenic, 30–40% erucic acids [7], contain relatively less carbohydrates [8].

In a balanced diet for human health, 20–25% of calories should come from oils and fats, which are the main sources of fats and fat-soluble vitamins, which play a significant role in the human diet [4].

Mustard seeds act as a laxative, stimulating effect on the gastric mucosa and increase the secretion of the intestine [9].

Mustard cake contains a significant amount of nitrogen, phosphorus, potassium, calcium, magnesium, iron, copper, sulfur, essential mustard oil [10]. Due to the presence of essential mustard oil in the cake, it has antimicrobial, antiseptic, bactericidal disinfectants, deodorizing, phytoncidal and fungicidal properties.

Mustard forms a large green mass and can be used as a green fertilizer. It prevents soil from being affected by erosion,and it is an excellent good precursor for crops,as a source of control against weed plants, diseases and pests and is not demanding on soil conditions,can grow in lightly saline soils [11]. A powerful root system of mustard, deeply penetrating into the lower layers of the soil, uses sparingly soluble nutrients and water,and how drought-resistant culture can grow inharsh arid climatic conditions of the steppe zone.

Mustard is demanding for mineral nutrition conditions in the soil. Phosphorus and potassium contribute to the accumulation of oil in the seeds, and nitrogen fertilizers enhance protein biosynthesis, but adversely affect the oil production process [12]. As P.Vavilov [13] notes, under white mustard, the roots of which are more assimilable, it is possible to introduce insoluble phosphorus fertilizers.

Mustard consumes much more nutrients to form a crop and responds well to the application of mineral fertilizers. Intensive consumption of nutrients by mustard is observed in moderately wet conditions. According to O.L.Tomashov [14], mustard is responsive to phosphorus fertilizer application. E.Y.Zotova [15] in her studies notes that the application of nitrogen-phosphorus fertilizers contributes to an increase in seed collection by 0,42-0,70 t/ha.

The world record of mustard yield is 5,7 t/ha thanks to GMO mustard in India, using SMI technology, in the Umariya District, Madhya Pradesh.As a result of the tests, some varieties of GMO mustard produced 3,0-4,0 t/ha, with an average oil content of 42% in seeds.

The rate of nutrient intake, as indicated by V.D.Pannikov (1964), depends on the formation of carbohydrates and other organic compounds in plants and the removal of nutrients per unit of yield varies depending on soil and climatic conditions, precursors, agrotechnics, fertilizers and varieties [15].

From the above it follows that the responsiveness of mustard to the content of the basic elements of soil nutrition and mineral fertilizersis important in the study of its mineral nutrition.

In the study of mustard in Kazakhstan, the main attention was paid to biology, breeding, and crop cultivation technologies [16-20], when the issues of mineral nutrition of the soil and the impact of mineral fertilizers on the productivity and quality of mustard varieties were practically not considered, which was the purpose of our research.

Materials and methods. The research was carried out on the humus of the southern carbonate steppe zone of Kazakhstan. The experiments were laid down according to the 14th variant scheme, where 7 levels of phosphorus, 3 nitrogen and paired combinations were studied. The scheme provided for the creation of various levels of phosphorus and nitrogen in the soil (from low to excessively high) in order to establish a quantitative relationship between the level of nutrient content in the soil and the productivity of mustard varieties. The soil is southern carbonate black soil. The thickness of the humus horizon is 45-47 cm. Humus content – 3,8%, total nitrogen 0,25-0,30%, mobile phosphorus - 15-20 mg/kg, potassium 35-50 mg/100g of soil. pH level – 8,0-8,1. Carbonates in the soil were found from a depth of 28-30 cm.

Fertilizers (ammonium nitrate and ammophos) were applied under the main tillage of the soil. The area of one plot is 54 m^2. The repetition in the experiments is threefold. The Bourgault 3710 sowing complex planted the mustard. The sowing rate of seeds is 10-15 kg/ha. Varieties - Rushen, Profi. The New Holland combine carried out mustard harvesting.

The selected samples were determined: soil moisture - by the weight method [GOST 28268-89], nitrate nitrogen - by reaction with disulfophenolic acid (according to the Grandval-Lyazhu method), mobile phosphorus and exchange potassium from one extract - according to Machigin (GOST 26205-91), absorbed by Ca^{2+}+$Mg^{2+}$by the trilonometric method (GOST 26428-85).

Mathematical processing of yield data was carried out by the method of dispersion analysis according to B.A.Dospekhov [21].

Results and discussion. Weather conditions of Akmola region were quite typical for the climate of Northern Kazakhstan. According to weather conditions, the agricultural year was difficult: only 273 mm

of precipitation fell, which is less than the average long-term norm by 92 mm and extremely unevenly distributed by months and periods.

In April, 44 mm fell at a rate of 25, which amounted to 176% of the norm. This created a high level of moisture in the pre-sowing period. But June and July were arid. Only 61 mm of precipitation fell versus 103 mm or 59%. August was at the average long-term level, but there was an uneven fall over decades.

In terms of temperature regime – May and June were cool, July and August – close to the average indicators.

Meteorological conditions have significantly affected both the soil processes and the characteristics of the growth and development of plants and the formation of the mustard crop.

The moisture content of mustard in the experiments depended not only on the conditions of the growing season, but also on the spring reserves of productive moisture accumulated due to autumn-winter precipitation.

Reserves of productive moisture in the meter layer before sowing mustard varieties were 169-170 mm, in the 0-20 cm layer – 25-27 mm. Due to the dry period in June-July, the productive moisture in the layer 0-20 cm decreased twice (9-12 mm) in the phase of the mustard budding.

Precipitation in August created a good background of humidity, it increased to 155 mm, which favorably influenced the phase of flowering mustard.High air temperatures without precipitation contributed to the rapid maturation of mustard seeds, which favorably influenced the formation of a productive crop.

A diagnostic indicator of the availability of soils with mobile phosphorus and exchange potassium is their content in the layer of 0-20 cm, and for nitrogen nitrates (due to its high mobility and ability to migrate) - in the layer of 0-40 cm [22-24].

The existing hydrothermal regime influenced the soil processes and the conditions of the mineral nutrition of mustard.The content of nitrate nitrogen in the soil according to the varieties of mustard was of average availability (10-11 mg/kg). In the development phases of mustard varieties, an increase in the nitrate nitrogen content to 15 mg/kg was noted due to the high air temperature and soil moisture, which favorably affected the nitrification process.

The initial content of mobile phosphorus in the soil for mustard varieties is average 20,5 mg/kg (Rushen variety), 21,5 mg/kg by the Profi variety.The main amount of phosphorus is concentrated in a layer of 0-20 cm. There is a slight increase in the content of mobile phosphorus in conditions of high soil moisture. Traces of phosphorus were found under the arable layer of the soil.

The availability of soil with exchange potassium is high (770-826 mg/kg). Most of it is located in the arable layer (0-20 cm) of soil.

Fertilizers had a great influence on the content and ratio of nutrients in the soil (table 1).

Table 1 –The effect of fertilizers on the content of nutrients in the soil before sowing mustard, mg/kg

Variants	Rushen variety			Profivariety		
	$N–NO_3$ in the 0-40 cm layer	P_2O_5 in the 0-20 cm layer	K_2O in the 0-20 cm layer	$N–NO_3$ in the 0-40 cm layer	P_2O_5 in the 0-20 cm layer	K_2O in the 0-20 cm layer
O	9,9	20,6	773	10,5	21,6	770
N30	12,1	19,9	771	11,1	19,7	770
N60	13,5	22,4	789	12,8	22,4	769
P60	11,3	26,7	790	11,6	26,7	773
P90	13,0	29,1	763	12,7	28,5	766
P120	13,4	36,6	819	13,0	37,3	772
P150	14,6	39,7	820	14,7	39,7	812
P180	14,0	42,6	771	14,0	43,7	773
P210	14,8	44,6	795	16,3	45,1	826

As can be seen from the table, the use of fertilizers contributed to a significant increase in the content of nitrate nitrogen in the soil by 2-5 mg/kg due to the active processes of the activity of microorganisms. Phosphorus fertilizers also increased the content of P_2O_5 from 26 to 45 mg/kg.

The content of the exchange potassium was practically unaffected by the application of nitrogen-phosphorus fertilizers.

An analysis of the effect of fertilizers on the productivity of mustard shows that it depends on indicators of soil fertility and hydrothermal conditions for its development.

According to the data of V.I.Radchenko [19], the interphase periods of growth and development of blue mustard strongly depend on soil moisture, and with its high content, the crop gives the maximum yield. Whereas under unfavorable conditions of humidification, phosphorus fertilizers played the main role, which was confirmed in our studies.

Backgrounds created by the application of nitrogen-phosphorus fertilizers affected the productivity of mustard varieties, table 2.

Table 2 – The effect of fertilizers on the yield of varieties (c/ha) and the quality of mustard fat (%)

Variants	Rushen variety			Profi variety		
	Productivity at control and increase to it, c/ha	%	Fat content, %	Productivity at control and increase to it, c/ha	%	Fat content, %
O	14,1	–	28,1	15,6	–	32,9
N30	-0,1	–	32,7	-0,2	–	35,2
N60	-0,3	–	28,3	-0,4	–	35,8
P60	5,6	39,7	28,6	1,0	6,4	35,6
P90	6,3	44,7	29,6	3,4	21,8	36,9
P120	6,5	46,1	29,1	3,7	23,7	37,5
P150	6,6	46,8	30,4	4,7	30,1	35,6
P180	6,3	44,7	29,1	6,6	42,3	34,9
P210	3,0	21,3	29,0	2,8	17,9	34,3
m,%	0,32			1,40		
$НСР_{05}$	0,18			4,15		

The main purpose of the research was to create several levels of nitrogen and phosphorus – from very low to excessive levels, to determine the needs and requirements of mustard varieties for the conditions of mineral nutrition in the soil.

As can be seen from the table, the best result was achieved by different doses of the applied fertilizers. The yield on the control was 14,1 (Rushen variety) and 15,6 c/ha (Profi variety).

Due to the low productive moisture in the soil, nitrogen fertilizers did not give the desired effect. Crops in both varieties were low compared to the control option.

The best results were obtained with phosphorus backgrounds. With an increase in the content of mobile phosphorus in the soil, the productivity of the mustard crop by varieties also increased, the average increase was from 1,0 to 6,6 c/ha.

Stable increases were obtained from the Rushen variety, an increase of P_2O_5 in soil to 40 mg/kg gave an increase to 47%. Further saturation of soils with phosphorus reduced the yield by 3 centner or 20%.

This shows how important it is to determine the most accurately – to what level it is advisable to bring the phosphorus content in the soil.

The revealed regularity of the reaction of mustard of the Rushen variety is also characteristic of the Profi variety, with the only difference being that the variety itself exceeded the productivity of the Rushen variety by 1,5 c/ha, but it turned out to be significantly more sensitive to phosphorus deficiency in the soil and better reacted to the application of phosphorus fertilizers. An increase in P_2O_5 from 28 to 43 mg gave an increase from 3,4 to 6,6 kg/ha, almost twice. The best result was obtained according to the variant P180 kg when the content of mobile phosphorus was 43,7 mg/kg, the yield was 22,2 c/ha (6,6 c to the control or 42,3%).

This indicates the species differences in mustard on the requirement for the content of nutrients in the soil and fertilizers, which was the purpose of our research.

The positive effect of fertilizers is not limited only to productivity. An equally important role is played by the quality of fat in mustard seeds. As with yields, the best fat content is obtained from Profi, compared to Rushen, by 4,8-7,1%.

In general, nitrogen fertilizers did not contribute to the increase in the fat of mustard grain. Moreover, there has been a clear tendency to reduce it, regardless of the level of soil availability with nitrogen.

Phosphorus fertilizers have a positive effect on the accumulation of fat. The fat content ranged from 28,6 to 30,4% in the Rushen variety, 35,6-37,5% in the Profi variety. The best results were obtained, respectively, according to the variants P120-P150, which indicates the different requirements of mustard varieties for soil conditions.

From the above data on the productivity and quality of mustard grain, it is visible how important it is to take into account when applying fertilizers not only the content, but also the ratio of elements, both in soil and in fertilizers.

Calculations of economic efficiency showed that the use of fertilizers for mustard is highly profitable. According to the studies, it is clear that even with a yield increase of 1,0 c/ha (P60), a net income of 36960 tg was obtained with a profitability of 129%.

Thus, the studies showed the responsiveness of mustard varieties to nitrogen-phosphorus fertilizers, depending on the content of nutrients in the soil. The efficiency of applied fertilizers is determined by the level of the contents of nutrients in the soil, moisture conditions, temperature conditions and biological characteristics of mustard varieties.

Conclusion. Studies on southern humus of the steppe zone showed that mustard species, based on biological and genetic characteristics, present certain varietal requirements for the conditions of mineral nutrition in the soil. Therefore, it is important to find not only the optimal levels of nutrients in the soil, but also determine the ways to achieve them in order to realize the maximum potential of the crop.

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ОҢТҮСТІК ҚАРА ТОПЫРАҚ ЖАҒДАЙЫНДА ҚЫШАНЫҢ ӨНІМДІЛІГІ МЕН САПАСЫНА ТОПЫРАҚ ЖАҒДАЙЫ МЕН ТЫҢАЙТҚЫШТАРДЫҢ ӘСЕРІ

Аннотация. Қышаның биологиялық ерекшеліктері оны азықтық, дәрілік, жем азықтық, сидератты, майлы, бал алу және өндірістің түрлі салаларында шикізат ретінде кеңінен қолдануға мүмкіндік береді. Оны жоғары сапалы май алуда, құрамы дәрумендерге бай, фитомелиоративті және фитосанитарлы бағытта өсіруге болады, басқа дақылдарға өте жақсы алғы құнды дақыл болып табылады. Алайда болашағы зор дақыл аталмыш құндылықтарына қарамастан жоғары өнім мен сапа көрсеткіштерін алуда маңызы жоғары топырақтың минералдануы мен тыңайтқыштарга деген қажеттілігі зерттелінбеген. Сондықтан біздің зерттеу жұмыстарымыз Солтүстік Қазақстанның оңтүстік қара топырағында жүргізіліп, осы бағытқа бағытталды.

Қыша сұрыптарының өнімділігіне топырақ құрамындағы негізгі қоректік заттардың әсерін зерттеуде топырақтағы азот пен фосфордың түрлі деңгейін жасау мақсатында олардың сандық арақатынасын анықтау үшін 14 нұсқалық танаптық тәжірибе салынды.

Зерттеу жүргізілген жылдағы метеорологиялық жағдайлар дақылдың өсіп-өнуіне гана емес, топырақ құрамындағы жүріп жатқан үдерістерге де әсер етті. Тәжірибедегі топырақ ылгалдылыгы дақылдың вегетациялық кезеңінде түскен жауын-шашындар мөлшерімен гана емес, күзгі-қысқы, көктемгі жиналган ылгал қорларына сәйкес жиналды.

Егін себер алдындағы топырақтың бір метр қабатындагы ылгалдылық 169-170, 0-20 см қабатта 25-27 мм-ді құрады. Қышаның бүршіктену кезіндегі маусым-шілде айларындағы құргақшылық кезең оның мөлшерін екі есеге төмендетті (9-12 мм). Алайда тамыз айында ауа температурасының жоғары болуы және мол түскен жауын-шашын мөлшері топырақ ылгалдылыгының жағдайын жақсартып (155 мм-ге дейін жоғарылады), қышаның гүлдену кезеңіне және дәннің толысып пісуіне, қышаның өнім құрауына әсер етті.

Топырақтағы нитратты азот мөлшері сұрыптар бойынша орташа қамтамасыз етілді (10-11 мг/кг). Дақылдардың жазгы вегетациялық кезеңінде ауа температурасы жогарылауынан және ылғалдылықтың мол болуынан нитрификация үдерісінің қарқынды жүруі олардың мөлшерін 15 мг/га-га дейін жогарылатты.

Топырақтағы жылжымалы фосфордың мөлшері сұрыптар бойынша да орташа (20,5-21 мг/кг). Ылғалдылыққа сәйкес олардың мөлшері сәл жоғарлады. Алмаспалы калий мөлшерінің қамтамасыз етілуі жоғары (770-826 мг/кг).

Бақылаудағы өнімділік Рушена сұрпында – 14,1 ц, Профи сұрпында – 15,6 ц/га құрады. Топырақтың ылғал мөлшерінің төмен болуына байланысты азотты тыңайтқыштардың тиімділігі бақылау нұсқасымен салыстырганда төмен болды.

Өнімділік бойынша жақсы нәтижелер фосфор аясынан алынды. Топырақтағы жылжымалы фосфордың мөлшері жоғарылаган сайын қыша сұрыптарының өнімділігі жоғарылап, екі сұрып бойынша қосымша өнім орташа 1,0-ден 6,6 ц/га-га дейін өсті.

Тәжірибе бойынша тұрақты өнімділік Рушена сұрпынан алынды, топырақтағы P_2O_5 мөлшерінің 40 мг/кг-га дейін жоғарылауы 47%-га дейін қосымша өнім берді. Одан әрі фосформен қанықтыру өнімді 3 ц немесе 20%-га төмендетті.

Зерттеу жұмыстары көрсеткендей топырақтағы P_2O_5 мөлшерін 28 мг-нан 43 мг-га дейін жоғарылату Профи сұрпы бойынша 3,4-тен 6,6 ц/га-га дейін қосымша өнім алуга мүмкіндік берді. Ең жоғары нәтиже Р180 нұсқасы бойынша топырақтағы жылжымалы фосфордың мөлшерін 43,7 мг/кг шамасында өнімділік 22,2 ц/га (6,6 ц немесе 42,3%) алынды.

Азотты тыңайтқыштар қыша дәнінің құрамындағы майдың құрамына әсері болмады, тіпті кей нұсқада олардың мөлшерінің төмендегені байқалды.

Фосфорлы тыңайтқыштар керісінше дән құрамындағы майдың мөлшеріне оң әсер етіп, Рушена сұрпы бойынша ол мөлшері 28,6-дан 30,4%-га, Профи сұрпы – 35,6-37,5% дейін жоғарылады. Ең жоғары нәтижелер Р120-150 нұсқалары бойынша алынды, бұл сұрыптардың топырақ жагдайларына деген қажеттілігі түрлі екендігін көрсетті.

Келтірілген мәліметтер қышаның өнімі мен сапасын арттыруда тыңайтқыштарды енгізуге жоспарлаганда, олардың топырақтағы мөлшерлерін гана емес, элементтердің арақатынасын топырақ пен тыңайтқыш құрамынан ескеру қаншалықты маңызды екендігін көрсетеді.

Тыңайтқыштарды енгізудің экономикалық тиімділігін есептеу қышаға тыңайтқыштар қолданудың тиімділігі жоғары екендігін көрсетті, ягни 1 ц/га-га қосымша өнім алган жағдайда таза пайда 36 960 тг-ні, рентабельділік 129%-ды құрады.

Сонымен зерттеу жұмыстары қыша сұрыптарының топырақ құрамындағы қоректік заттардың мөлшеріне сәйкес азотты-фосфорлы тыңайтқыштарга деген қажеттілігі жоғары екенін көрсетті. Оңтүстік қара топырақ жағдайында қолданылған тыңайтқыштардың тиімділігі топырақ құрамындағы қоректік заттар мөлшеріне, оның ылғалмен қамтамасыз етілу деңгейіне, температура режиміне және сұрыптардың биологиялық ерекшеліктеріне сәйкес өзгергенін көрсетті.

Түйін сөздер: қыша, нитратты азот, жылжымалы фосфор, тыңайтқыштар, оңтүстік қара топырақ, өнімділік.

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УРОЖАЙНОСТЬ И КАЧЕСТВО СЕМЯН ГОРЧИЦЫ В ЗАВИСИМОСТИ ОТ МИНЕРАЛЬНОГО ПИТАНИЯ И УДОБРЕНИЙ В УСЛОВИЯХ ЮЖНОГО ЧЕРНОЗЕМА

Аннотация. Биологические особенности горчицы позволяют ее использовать как пищевое, лекарственное, кормовое, сидеральное, масличное и медоносное растение и широко использовать в разных отраслях промышленности. Она является ценным источником получения высококачественного масла, богата витаминами, обладает фитомелиоративными и фитосанитарными свойствами, является хорошим предшественником для других культур.

Однако, несмотря на высокую ценность и перспективу использования в сельском хозяйстве, она мало изучена. Не изучены требования ее к минеральному питанию почвы и минеральным удобрениям, что очень важно для получения стабильного и качественного урожая, что и являлось целью наших исследований.

Исследования проводились на черноземе южном степной зоны Северного Казахстана. Опыты закладывались по 14-вариантной схеме для создание различных уровней содержания в почве фосфора и азота с целью определения количественной взаимосвязи между уровнем содержания элементов питания в почве и продуктивностью сортов горчицы.

Метеорологические условия в год исследования существенно отразились как на почвенных процессах, так и особенностях роста и развития растений и формировании урожая горчицы. Влагообеспеченность горчицы в опытах зависела не только от условий вегетационного периода, но и весенних запасов продуктивной влаги, накопившейся за счет осенне-зимних осадков.

Запасы продуктивной влаги в метровом слое перед посевом сортов горчицы составили 169-170 мм, в слое 0-20 см – 25-27 мм. Из-за засушливого периода в июне-июле в фазу бутонизации горчицы продуктивная влага в слое 0-20 см снизилась в два раза (9-12 мм).

Выпавшие осадки в августе месяце создали хороший фон влажности, она увеличилась до 155 мм, что благоприятно повлияло на фазу цветения горчицы. Высокие температуры воздуха без осадков способствовали быстрому созреванию зерен горчицы, что благоприятно сказалось на формировании продуктивного урожая.

Сложившийся гидротермический режим повлиял на почвенные процессы и условия минерального питания горчицы. Содержание нитратного азота в почве по сортам горчицы было средней обеспеченности (10-11 мг/кг). По фазам развития сортов горчицы отмечалось повышение содержания азота нитратов до 15 мг/кг за счет высокой температуры воздуха и влажности почвы, что благоприятно отразилось на процессе нитрификации.

Исходное содержание подвижного фосфора в почве по сортам горчицы среднее – 20,5 мг/кг (сорт Рушена), 21,5 мг/кг – по сорту Профи. Наблюдается незначительное увеличение содержания подвижного фосфора в условиях высокой влажности почвы. Обеспеченность почвы обменным калием высокая (770-826 мг/кг).

Урожай на контроле составил 14,1 (сорт Рушена) и 15,6 ц/га (сорт Профи). Из-за низкой продуктивной влаги в почве азотные удобрения не дали должного эффекта. Урожай по обоим сортам был низким по сравнению с контрольным вариантом.

Наилучшие результаты получены по фонам фосфора. С увеличением содержания подвижного фосфора в почве повысилась и продуктивность урожая горчицы по сортам, в среднем прибавка составила от 1,0 до 6,6 ц/га.

Стабильные прибавки были получены по сорту Рушена, увеличение P_2O_5 в почве до 40 мг/кг дало прибавку до 47%. Дальнейшее насыщение почв фосфором снизило урожай на 3 ц или 20%.

Как показали исследования, от увеличения P_2O_5 почвы от 28 до 43 мг по сорту Профи получена прибавка от 3,4 до 6,6 ц/га. Наилучший результат получен по Р180 кг д.в., при содержании подвижного фосфора – 43,7 мг/кг, урожайность составила 22,2 ц/га (6,6 ц к контролю или 42,3%).

Азотные удобрения не способствовали повышению жира зерна горчицы. Более того, наблюдалась явная тенденция к его снижению независимо от уровня обеспеченности почв азотом.

Фосфорные удобрения положительно влияли на накопление жира. Содержание жира варьировала от 28,6 до 30,4% по сорту Рушена, 35,6-37,5% – по сорту Профи. Наилучшие результаты получены по вариантам Р120-Р150, что говорит о разных требованиях сортов горчицы на почвенные условия.

Из приведенных выше данных по продуктивности и качеству зерна горчицы видно, насколько важно учитывать при внесении удобрений не только содержание, но и соотношение элементов как в почве, так и в удобрениях.

Расчеты экономической эффективности показали, что применение удобрений под горчицу высокоокупаемы, что даже при приросте урожая на 1,0 ц/га (Р60) получен чистый доход на 36 960 тг с рентабельностью 129%.

Таким образом, проведенные исследования показали отзывчивость сортов горчицы на азотно-фосфорные удобрения в зависимости от содержания элементов питания в почве. Эффективность применяемых удобрений определяется уровнем содержания элементов питания в почве, условиями влагообеспеченности, температурным режимом и биологическими особенностями сортов горчицы.

Ключевые слова: горчица, нитратный азот, подвижный фосфор, удобрения, чернозем южный, урожайность.

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