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SOME ASPECTS OF MINERAL AND ORGANIC NUTRITION FOR IMPROVED YIELD AND OIL CONTENTS OF MUSTARD (*BRASSICA JUNCEA*)

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Abstract

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The experiment was conducted during the 2008-2009(2009), 2009-2010(2010) and 2010-2011(2011) growing seasons on a meadow chestnut soil at the experimental station "Agrouniversity" of the Kazakh National Agrarian University of Almaty in Kazakhstan to evaluate the effect of mineral, organic fertilizers and their combination on yield and quality of mustard (*Brassica juncea*) in short crop rotations (three year rotations). It has been established that annual application of $N_{75}P_{70}K_{45}$ mineral fertilizers or of cow dung (30 $t.ha^{-1}$) three times a year is necessary to get the seed yield between 23.0 and 24.0 $q.ha^{-1}$. With fertilization, the product quality enhances, i.e. crude oil content, the maximum quantity of which was recorded in case of cow dung and vermicompost (3$t.ha^{-1}$) treatments in the natural and artificial phosphorus conditions.

Key words: irrigated mustard; NPK; cow dung; vermicompost; seed yield; oil content

Abbreviations: q - quintal, ha - hectare, t – tonne, m – meter, cm – centimeter, mm - millimeter, WHC - water holding capacity, CD – cow dung

Introduction

The key trends of stable agribusiness industry development in Kazakhstan involve working on new high-performance agricultural technologies in terms of cultivation of no conventional crops ensuring increase in their productivity with simultaneous soil conservation and reproduction. Under these circumstances, the oil crops such as castor-oil plant, brown mustard and flax, which have a high oil content and yielding capacity, along with wheat, sugar beet, corn, soya, safflower, etc. are expected to be very promising for the Southeast region of the republic. They are valuable because oil seeds can be used not only for production needs, but also for technical needs (Sariev, 1983). Fertilizers are one of the factors ensuring increase of seed yield and quality improvement with simultaneous soil preservation and fertility enhancement. Irrigation and fertilizer management are important agronomic practices for a higher yield. Irrigation facilitates mustard growth and yield in addition to water need. It also ensures availability of different nutrients in crop plants (Piri et al., 2011). The alternative fertilization system increases nitrate-N accretion (by 8.7-15.7 %) and labile phosphorus (by 5.6-14.5%) to a less extent than the conventional system, but results in organic matter growth by 0.02-0.05% versus its initial content. The chemical soil load decreases by 30% versus the conventional fertilization system, while its productivity decreases only by 2-10%. The organic fertilization system efficiency is low in the irrigated crop rotation. The yield decreases by 31%, and the entire crop rotation productivity decreases by

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21-27% in the compared cases versus the conventional fertilization system (Suleymenova, 2000).Treating with $N_{60}P_{60}K_{40}$ enabled to increase mustard plant conservation by 7.6% and increase the height by 1.2 – 8.6 cm at all development stages versus the control treatment (Ramasanov, 2008). Patel et al. (1998) specified that the seeds yield, and straw yield was enhanced largely in case of increased quantity of organic and nitrogen fertilizers, while the nitrogen content clearly correlated with the seeds yield. Sugave and Sheike (1997) established in their studies that the seeds yield for about 2 years achieved the values of 12.7; 17.2; 19.4; and 20,1 $q.ha^{-1}$ in case of nitrogen application in the quantity of 0, 40, 80 and 120 $kg.ha^{-1}$. In this context, the task was set to study the effect of different quantities of mineral and organic fertilizers on the nutrient absorption by mustard plants, their productivity and oil content in the mustard seeds.

Material and Methods

Details of field studies: The study was conducted at the "Agrouniversity" Experimental Station of the Kazakh National Agrarian University, located in the northwestern part of the Almaty region, Kazakhstan during the 2009 and 2011 growing seasons. The climate of the study area is characterized as strongly continental with an average annual rainfall of 350-420 mm. During the growing season, the precipitation ranges from 120-300 mm. The study area is located in a foothill desert-steppe region with elevation of 550-700 meters above sea level. Several mountain rivers and streams cross this region. Ground water is located at a depth of 1.2-1.6 m in many parts of this region and currently is an economic source of irrigation water. The four-year rotation was used in due course of time and space with the following crop rotation: 1-barley; 2-flax; 3-mustard; 4- castor-oil plant. Oil crop fertilizers in the crop rotation and mustard single-crop were studied using the following options: 1 - Control (without fertilizer); 2 – Recommended $N_{75}P_{70}K_{45}$ rate; 3 - ½ Recommended NPK rate; 4 – Cow dung, 30 $t.ha^{-1}$; 5 - ½ Cow dung + ½ NPK; 6 - Vermicompost, 3 $t.ha^{-1}$; 7 - Straw, 5 $t.ha^{-1}$. Nitrogen fertilizers were applied as ammonium nitrate (NH_4NO_3 – 32-34% N). Phosphorus fertilizer was also applied single superphosphate ($Ca(H_2PO_4)$, $CaSO_4 \cdot 2H_2O$) (18-19 % P_2O_5). The content of nitrogen, phosphorus and potassium in cow dung is defined: N – 0.52 %, P – 0.225 %, K – 0.635 % and in vermicompost - N – 288 $mg.kg^{-1}$, P – 748 $mg.kg^{-1}$, K – 8775 $mg.kg^{-1}$. A straw chemical compound: N – 0.33 %, P – 0.18 %, K – 0.8 %. The soils at the study site were a meadow chestnut soil with 4.38% organic matter content and pH of 7.8, total phosphorus, nitrogen and potassium contents of 0.211, 0.258 and 2.85 % respectively. Soil parent materials are loamy fewer deposits underlain by gravelly deposits. Soil moisture content was maintained at levels of 60-70 % WHC by 3-4 water applications at a rate of 600-750 m^3/ha during the growing season. The study was conducted on two soil areas with differing plant available soil phosphorus (P) levels at the beginning of the study to evaluate the effects of inherent soil P levels on mustard production. The first area was on soil that had no recent fertilizer P added with soil plant available P levels of 18-20 mg $P.kg^{-1}$ soil. The second area had 150 kg P_2O_5 added as single superphosphate (18-19 % P_2O_5) prior to the study resulting in initial soluble plant available P levels of 35-38 mg $P.kg^{-1}$ soil at the beginning of the study.

Sample preparation and analytical methods: The plots were arranged in a randomized complete block design with three replications. Plant samples were collected using individual trials selected from five points of each trial plot using an envelope method. These mixed samples were selected out of all three-trial replications. Organic matter was determined by the Tyurin procedure (Mineev, 2001); total P and K were measured by flame photometry (Mineev, 2001); total N was determined by the Kjeldahl method (Mineev, 2001). The yield structure is determined prior to harvesting in all cases at two non-adjacent surfaces. We determine the total number of plants in sample areas, plant heights, number of their seeds and their mass, as well as seed biological yield. Yield accounting is performed using a continuous weight method, while biological yield accounting is made using a sheaf selection method, i.e. 2 m^2 from each trial field and from all three replications. Actual yield accounting was carried out when harvesting using Sampo combine, i.e. 130 m^2 from each trial field. Yield accounting was carried out on a manual and

field trial basis using fourfold number of replications in the trials. Oil content was determined by taking 100 g seeds from each treatments and oil was extracted by Soxlet method (Mineev, 2001). Statistical data processing was made using generally accepted methods (Dospehov, 1979).

Results and Discussion

Mustard yield is a quantification of integrated agrotechnical and agrochemical interaction with the environment. It is obvious that stable yields can be obtained by satisfying the plant needs in nutrient elements and water during their growth and development. In case of mustard cultivation in irrigated conditions, the food element ratio in applied fertilizers is very important for yield formation. The regularity of the effect of fertilizers is quite clear in our study. The yield varied to a wide extent depending on the nutrition. The analysis of triennial data shows that the yield level of t/ha without fertilizers was quite high in the meadow chestnut soil and applying the recommended $N_{75}P_{70}K_{45}$ rate for about three years definitely increased mustard productivity and was 23.2 $q.ha^{-1}$. Jadnav et al. (1998) proved in their studies that the greatest seed production (10.7 $kg.ha^{-1}$) had been obtained in case of band nitrogen fertilization in two stages versus treating with all fertilizer quantity whilst planting or partial fertilizing by spreading. Studying the test results, An (1999) arrived at the conclusion that the heaviest yield was in N case (which is 73% more than in case of control treatment without nitrogen fertilizers). In case of bigger quantities, there was excessive vegetative growth harmful for seed production. The positive effect of phosphoric fertilizers on mustard productivity was also studied by Mir (2010), Singh et al. (2008). The maximum additional yield versus the treatment without fertilizer was obtained at the expense of vermicompost application in 2009, and in 2010 and 2011 in case of recommended NPK rate. The weather conditions had a significant effect on yield, so the maximum yield values were obtained in the favorable year 2009 unlike 2010 and 2011. Both separate and joint application of mineral and organic fertilizers results in essential crop improvement versus the control in case of natural, and raised P_2O_5.

Improvement of product quality is one of the objectives of agricultural product intensification. The quality of the yield means chemical compound of obtained product, which this crop is planted for. This is protein content for one plant, and oil, starch etc. – for others. The determined quality of seeds under our investigation has shown that mineral fertilizers had influenced positively the qualitative indicators (oil content) and their derivative value along with crop improvement. Thus, applying the recommended (half and full) rate of fertilizers enabled to increase oil concentration in mustard seeds by 2.66-3.66% in contrast with control variant (38.67%). Admitting fertilizers importance in oil formation, Sugave et al. (1996) concluded that nitric fertilizers had not had a significant effect on oil content and had raised

Table 1
Effects of fertilizer treatment on the seed yield of mustard

Fertility Treatment	Low P Soil				High P soil			
	2009	2010	2011	Mean	2009	2010	2011	Mean
	----------q.ha^{-1}----------							
Control	17.8	15.1	17.5	16.8	20.9	17.0	19.3	19.1
Recommended $N_{75}P_{70}K_{25}$ Rate	23.6	21.2	24.9	23.2	24.6	22.5	25.5	24.2
½ Recommended $N_{75}P_{70}K_{25}$ Rate	20.9	17.8	19.3	19.3	21.5	19.5	21.8	20.9
Cow Dung	25.6	19.7	20.0	21.8	26.9	21.5	22.5	23.6
½ CD + ½ $N_{75}P_{70}K_{25}$ Rate	23.2	19.0	21.4	21.2	26.2	20.8	24.0	23.7
Vermicompost	25.7	19.8	19.0	21.5	26.4	20.8	21.1	22.8
Straw	18.3	17.1	19.5	18.3	21.4	18.1	21.2	20.2
LSD (0.05), $q.ha^{-1}$	3.1	2.46	4.72		3.61	3.98	2.52	
S_x, $g.kg^{-1}$	1.36	1.48	1.24		1.53	1.32	1.5	

protein content in the seeds. Treating with nitrogen of 0, 40, 80 and 120 kg.ha^{-1}, the oil content in seeds was 38.74; 38.87; 38.58 and 38.52%. However, Ahmad et al. (1999) studied the effect of 40 and 60 kg.ha^{-1} of sulfur and nitrogen (60, 100 and 150 kg.ha^{-1}) and their combinations on the oil content in mustard seeds and noted that joint treatment with sulfur and nitrogen fertilizers had increased oil content in mustard seeds. The maximum oil content was 51.2% when treating with 60 kg.ha^{-1} of sulfur + 100 kg.ha^{-1} of nitrogen. In case of cow dung (30 t.ha^{-1}) and vermicompost (3 t.ha^{-1}) treatment, the oil content was also higher than the reference one, i.e. 42.83% and 41.67% respectively. The oil content was higher in case of higher level of labile phosphorus content in the soil (P_{150}). It should be noted that the absolute indicators of seeds oil content in the wet year 2009 were higher, i.e. 43.12%, in case of natural agrochemical background they were 44.72-49.12%, which was higher than similar indicators in 2010-2011.

The mustard seed oil quality was assessed in accordance with GOST standards (Mineev, 2001) using physical and chemical indicators such as acid number, iodine number, and saponification number. As the iodine number specifies the content of unsaturated compounds in oil, using different fertilizers enables to increase the iodine number from 98 to 102 units towards the control, which has a positive impact on oil formation processes and quality both for technical and food needs. High-quality food and technical oils shall contain the minimum quantity of free fat acids. Thus, in case of NPK introduction, free fat acids decreased up to 1.61 %, while in other cases free fat acids increased (between 1.91 and 1.96). The saponification number varies between 171 and 182 units. It is minimal in case of cow dung treatment, and maximum – in case of vermicompost treatment.

Conclusion

Thus, scientific studies have shown that mineral and organic fertilizers make essential impact on nutrient content in plants of mustard, and, as a result, positively

Table 2
Effects of fertilizer treatment on oil content of mustard having two soil P regimes including effects of differences due to basal P levels

Fertility Treatment	Low P Soil				High P soil			
	2009	2010	2011	Mean	2009	2010	2011	Mean
	----------q.ha^{-1}----------							
Control	43.12	38.73	34.16	38.67	47.11	40.86	40.34	42.77
Recommended $N_{75}P_{70}K_{25}$Rate	44.72	40.54	38.73	41.33	48.0	39.51	40.29	42.6
½ Recommended $N_{75}P_{70}K_{25}$ Rate	48.08	40.21	38.7	42.33	48.42	39.46	39.62	42.5
Cow Dung	48.98	39.52	39.99	42.83	49.83	39.59	40.39	43.27
½ CD + ½ $N_{75}P_{70}K_{25}$ Rate	46.51	40.01	38.49	41.67	48.02	40.68	39.31	42.67
Vermicompost	49.12	39.45	34.94	41.17	50.44	39.58	41.29	43.77
Straw	47.34	40.03	39.62	42.33	47.11	40.12	39.76	42.33
LSD (0.05), q.ha^{-1}	2.1	1.7	1.39		1.84	2.76	2.68	
S_x, g.kg^{-1}	1.69	1.56	1.46		1.61	1.58	1.55	

Table 3
Effects of fertilizer treatment on a quality of oil of mustard (averages for 2009-2011)

Fertility Treatment	Iodic number, mg I г/100 g	Saponification number, mg	Acid number, mg KOH/g	Free fatty acids, %
Control	97.5	175	3.65	1.84
Recommended $N_{75}P_{70}K_{25}$ Rate	100.0	178	3.25	1.62
Cow Dung	99.5	175	3.75	1.88
Vermicompost	102.0	182	3.90	1.96

affect productivity and quality indicators of mustard seeds – oil. From the above discussion, it may be concluded that recommended NPK rate can be applied for maximum yield of mustard (sort Rushena) and oil content was highest in variant of cow dung.

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