БИОЛОГИЯ ПОЧВ

CSCSTI 68.05.45; 68.33.00

Y.A. Syrgabek[1], M. Alimzhanova[1], A. Amandykova[1], T.N. Akylbekova[2]

SOIL FAUNA OF VINEYARDS OF SOUTHEAST KAZAKHSTAN

[1]Kazakh National University named after al-Farabi, 050070, Almaty, al-Farabi ave, 71, Kazakhstan, e-mail: serkanat96@gmail.com

[1]Kazakh National University named after al-Farabi, 050070, Almaty, al-Farabi ave, 71, Kazakhstan, e-mail: mereke.84@mail.ru

[1]Kazakh National University named after al-Farabi, 050070, Almaty, al-Farabi ave, 71, Kazakhstan, e-mail:asem.amandikova1999@gmail.com

[2] Kazakh National Pedagogical University.Abai, Institute of Natural Sciences and Geography, Faculty of Chemistry, 050070, Almaty,Dostyk Ave., 13, Kazakhstan, e-mail: turar.83@mail.ru

*Abstract***.** The total humus content in the distribution along the profile was studied, which corresponds to each type and dark brown soil; the highest humus content is 3.68 %.It is established that there is a clear correlation between the content of humus in the soil and the number of soil invertebrates, which allows the use of data on the total composition of the mesofauna for the characteristics and this indicator. The influence of the humus content on the soil mesofauna content is considered on a dark brown soil with a humus content in the upper layers of 3.68 %, the number of soil mesofauna was 28 species/m^2. The main representative of the group of geobionts in dark brown soil are earthworms (Lumbricus). Their high soil content correlates with a high humus content and good soil structure. It is established that changes in the chemical composition of the environment, the physical properties of soils lead to changes in the number and species composition of organisms

*Key words:*mesofauna, soil, microaggregate, bioindicator.

INTRODUCTION

Modern viticulture of Kazakhstan is an economically independent and socially significant branch of agriculture with a long tradition of growing grapes, making high-quality wines, champagne, brandy, juices, and supplying fresh grapes to remote regions of the country.

Grapes are fruits with high biological activity. It is used in the food industry for several applications, including juices and jams. These compounds lead to a large number of by-products, which may contain biologically active compounds with interesting biological properties [1]. There are many useful antioxidants in grapes. In fact, more than 1,600 beneficial plant compounds have been identified in this fruit. Antioxidants in grapes remain present even after fermentation, so red wine also contains many of these compounds [2-4]. Numerous studies have been carried out about its benefits, showing that resveratrol protects against heart disease, lowers blood sugar levels and protects against cancer [5]. Containing a large amount of beneficial plant compounds, this fruit can help protect against certain types of cancer [3]. Compounds found in grapes can help protect against high cholesterol levels, reducing cholesterol absorption [6]. In one study, 69 people with high levels cholesterol has been shown that eating three cups (500 grams) of red grapes per day for eight weeks reduces total and cholesterol [7].

The traditionally recognized usefulness of grapes is confirmed by modern studies of anti-oxidant, anti-inflammatory, anti-neoplastic activities, a positive effect on the cardiovascular system of compounds present in certain ratios in all listed viticulture products.However, the vineyard areas in Kazakhstan, compared with the 1980s, have decreased more than half, and the gross harvest has decreased more than three times [8].

In the south-eastern zone of Kazakhstan, with an abundance of solar heat and the availability of irrigation water, the vineyards make it possible to get a good harvest and can be highly profitable. With a high potential opportunity, the productivity of a modern vineyard in Kazakhstan remains low. It is known that the main factor for increasing the productivity of grape plantations is the assortment, which is improved both by introducing varieties based on soil-climatic analogues, and by breeding and introducing genotypes created by methods of combinational selection on a genetic basis [9].

Today, in our country, the planting area of vineyards is about 15 thousand hectares, new territories are being developed, and serious research work is being done by scientific research institutes. According to experts, the potential of Kazakhstan's viticulture is great - in the south of the country there are still about 60 thousand hectares of land suitable for growing grapes, but they are not used for objective and subjective reasons [10].

OBJECTS AND METHODS

In the conditions of the south-east, the population of the mesofauna of dark brown soils was studied at the experimental site of «Kazakh Scientific Research Institute of fruit growing and viticulture» of Talgar district of Almaty region. The objects of research were the grape varieties in the ampelographic collection: Almaly, Aisulu. Planting year of the vineyard is 2001. Scheme of placement of bushes - 3.0 x 1.5 m. The number of accounting bushes in the plot - 10. During this research, the generally accepted methods approved by long-term practice "Methodical guidelines on the selection of grapes", "Methods of agrotechnical research" and "Studying grapes varieties" were used [11-15].

1a

1b

Picture 1 - Grape varieties in ampelographic collection Almaly (1a), Aisulu (1b)

Soil richness depends on the type and variety of soil, on natural conditions and human activities. Their role in soil formation is exceptional. They are the active factor, the activity of which involves the processes of decomposition of organic substances and their transformation into soil humus. Soil invertebrates assimilate atmospheric nitrogen. They secrete biological substances necessary for the synthesis of enzymes and proteins, are the most active factor in the biological circulation of substances. The flow of plant nutrients into the soil solution, and, consequently, soil fertility depends on their activity.

It should be noted that in the ZailiAlatau soils a gradual increase in the activity of the mesofauna from sierozem to chernozem is observed.

RESULTS AND DISCUSSION

In the dark brown soils of the ZailiAlatau there is a slight decrease in the activity of the mesofauna compared to ordinary chernozems, which is because of a longer summer drying of the soil at high temperature and aeration. The greatest activity of mesofauna is observed in the upper layers, it decreases with depth. In the ordinary chernozems (black soils) the amount and group composition of the mesofauna is gradually decrease, while in dark brown soils, it is reduced sharply, this is due to the fact that dark brown soils are less rich in organic matter than chernozems, so the amount and group composition of mesofauna in them is reduced.

Here there are the same groups of soil invertebrates, as in the black earth, but in smaller quantities. Earthworms Lumbricus (80 species/m^2) as in the ordinary black soils occupy the dominant position. Subdominant positions are occupied by scarab *Scarabeidae*, *Elateridae* click beetles, *Tenebrionidae* darkling beetles.

Among the larvae of *Curculionidae* weevils *Sitona F.* have a large number of weevils (12 species/m^2).

The nature of soil invertebrates is influenced by the conditions of water, air and thermal regimes of soils, the reaction of the environment, the composition of decomposing organic residues, etc. Many groups of soil animals, as well as soil enzymes reflect the accumulation of humus in the soil. We have noted a clear correlation between the humus content and the quantitative composition of soil mesofauna (table 1).

Table 1 – Average humus content in the soil for 2018, the vineyards of Almaly, Aisulu

Soil	Samplingdepth, cm	Humus content
Dark brown	0-10	3,68
	10-20	3,45
	20-30	2,87
	30-40	2,15

Table 1 shown that the total humus content of the distribution by the profile corresponds to each type and subtype of soil.

In the studied dark brown soil, the highest humus content is 3.68 %. We have established that there is a clear correlation between the content of humus in the soil and the amount of soil invertebrates, which makes it possible to use data on the total composition of the mesofauna for the characteristics and this indicator.

Table 2 – Humus content and abundance of mesofauna of dark brown soils, the vineyards of Almaly, Aisulu (2018)

Soil type	Humus, %	The amount of soil invertebrates	
		Total	Amount of types to 1m^2
Dark brown	3,68-2,15	7	28

Table 2 shows the effect of the humus content on soil mesofauna abundance. For example, on dark brown soil with humus content in the upper layers 3.68 %, soil mesofauna abundance was 28 species/m^2. Certain types of soil invertebrates and soil enzymes can be used as indicators of particular physical, chemical or biological characteristics of the soil. Among the properties of the soil which have a significant impact on the distribution of soil invertebrates and enzymes, it is necessary to highlight their mechanical composition. Particle sizes determine the porosity of the soil, its water and air permeability (on which its hydrothermal regime depends) and particle connectivity, which determines the resistance to the laying of soil invertebrates.

The studied soils are medium loam by their mechanical composition (table 3).

Table 3 – Percentage mechanical composition of the soil (2018)

Soil	Sampling depth, cm	Particlesizes, mm								Sum of particles less than 0.001 mm
		Physical sand					Physical clay			
		>3	3-1	1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	>0,001	
Dark brown	0-29	3,23	2,15	3,10	0,89	45,29	14,29	12,15	18,77	45,32
	29-46	1,85	3,01	3,11	1,08	45,43	15,26	11,98	18,36	45,49
	46-90	1,64	1,96	2,19	3,79	44,87	15,67	11,34	18,53	45,54
	90-140	0.38	1,44	1,00	3,70	45,52	17,78	9,24	20,78	47,86

As shown in table 3, the studied soil has favorable thermal and air regimes, richer in food elements, which affects the resettlement of soil mesofauna. The content of physical clay in dark brown soil in the profile ranges from 45.3-47.8 %.

In the studied soil the predominant fraction is the fraction of coarse dust (0.05-0.01 mm) ranging from 45.2-45.5 %. According to the degree of stony properties dark brown soils are weakly stony. Particles larger than 3 mm in diameter contain 0.38-3.23 %. Soil invertebrates are not random inhabitants of the soil. The soil can not exist without them, it was created by them, and that is why soil is their main habitat. Mesofauna activity is useful in that it leads to the improvement of physical properties, making them more loose, more easily permeable to water and air. All of these characteristics play an important role in soil formation, as a factor of the soil fertility creation. Physical properties are represented in table 4.

Table 4 – Physical properties of the soil of ZailiAlatau under the vineyards of Almaly, Aisulu (2018)

Soil type	Sampling depth, cm	Volume weight, g/cm^3	Specificweight, g/cm^3	Total porosity, %
Dark brown	0-10	1,23	2,47	52
	10-20	1,27	2,45	51
	20-30	1,32	2,56	49
	30-40	1,30	2,57	49

According to table4, the dark brown soil's average bulk density is 1.27 g/cm^3, specific gravity is 2.54 g/cm^3 and porosity is 55-49 %. Volume weight in 30 cm soil layer, the average specific gravity is 2.66 g/cm^3 and porosity is 47-45.

Kachynski N.A. [14] has established that the higher the dispersion factor, the less strong the microstructure. The dispersion factor does not exceed 10 %, in brown soils is 10-20 %, and columnar saline increases to 60-80 %. In full accordance with this we have studied the dispersion factor. So dark brown soil's dispersion factor is 14.1 %. Obtained data indicate a high water resistance of microaggregates. This is due to the fact that there is a clear dependence on the content of humus in the soil.

Sokolov A. [16] has established that the coprolites of earthworms are much more resistant to erosion than aggregates formed only under the influence of plant roots and microorganisms. The number of aggregates larger than 0.25 mm in the upper horizons of mountain soils inhabited by earthworms ranges from 75 % to 90 %.

The ability to resist the erosion action of water is inherent in both microaggregates and macroaggregates, and it depends on the mechanical composition of the soil and the amount of cementing agents.

Microaggregate composition of the soil affects the structure, its addition, and finally affects the settlement and distribution of mesofauna in the soil. Therefore, this study is extremely important, and in our opinion determines the quantitative composition of soil mesofauna. The results of the determination of the microaggregate composition of dark brown soil are summarized in table 5.

Table 5 – Soil microaggregate composition(2018)

Soil	Sampling depth, cm	Size fractions, mm Content in %							
		1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	>0,001	>0,001	Dispersionfactor
Dark brown	0-10	20,56	32,67	34,24	9,19	0,68	2,66	18,82	14,1
	10-20	17,37	31,79	38,14	7,83	2,23	2,64	18,36	14,4
	20-30	17,48	31,84	36,02	8,41	3,56	2,71	18,42	14,7
	30-40	16,98	31,35	35,97	7,87	3,45	2,84	18,12	14,5

From table 5 it is seen that the magnitude of the fractions smaller than 0.25 mm is the total amount of unstable aggregates. It mean that by the content of the fraction larger than 0.25 mm, it is possible to explain water resistance of microaggregates. Thus, in 30 cm layer of dark brown soil contains 18.1 % of water resistant microaggregates in average.

The dependence of the biological activity of the soil on its moisture is primarily due to the fact that moisture affects the microbiological activity and the activity of the root system.

Table 6 – Humidity of the main types of soils of ZailiAlatau under the vineyards of Almaly, Aisulu (2018)

Soil	Sampling depth, cm	Soil humidity, %			pH of aqueous suspension
		spring	summer	autumn	
Dark brown	0-10	22,87	19,87	21,33	7,6
	10-20	24,45	20,18	21,70	7,6
	20-30	21,67	20,66	16,65	8,3
	30-40	23,20	21,14	14,56	8,5

Table 6 shows that soil moisture and pH depend on the type of soil and vary according to the seasons of the year. The maximum value of humidity in the upper soil layers was observed in the spring, it was 21.87 %, while in the summer humidity was 20.46 %.

The requirements of soil invertebrates to soil moisture conditions have not yet been sufficiently studied. It can be assumed that not all soil invertebrates have the same need for water. It might be possible that xerophiles are adapted to life in arid places, mesophiles are adapted to life in conditions of medium water supply and hydrophiles are more likely to be adapted to live on excessively moist soil. Conditions of moisture, aeration and pH of the medium are those parameters on which the depth to which the soil invertebrates go depends. Thus, the study of mechanical, microaggregate and chemical composition, water-physical properties of the studied soils of ZailiAlatau indicates more favorable conditions for the development and settlement of mesofauna in dark brown soils. The studied soils of the ZailiAlatau are classified mainly by humus content, gross stocks of nutrients, capacity and composition of the absorbed bases, which are indirect indicators of fertility. For the first time we have made an attempt to biodiagnostics of soil data by mesofauna, which is an integral part of the soil (live phase). We carried out biodiagnosis of the studied soils according to the classification based on trophic connection and habitat of soil invertebrates.

According to the degree of connection with the soil, there are three main groups of invertebrates found in it Gilyarov M.S. [17]:

1. Geobionts – organisms, the whole development cycle of which occurs in the soil.

2. Geophiles – organisms, part of the development cycle of which necessarily occurs in the soil.

3. Geoxenes – organisms, more or less accidentally leaving in the soil, using the soil as a temporary shelter (table 7).

Table 7 – Mesofaunicbiodiagnostics of the main types of soils of ZailiAlatau by the type of habitat (0-20cm), under the vineyards of Almaly, Aisulu (2018)

Soil type	Type of habitat		
	Geobionts	Geophiles	Geoxenes
Dark brown	Earthworms (Lumbricidae)	Ground beetle (Carabidae) Scarab (Scarabeidae) Click beetles (Elateridae Darkling beetles. (Tenebrionidae) Weevils (Curculionidae)	Ladybugs (Coccinellidae)

According to table 7, it can be seen that geophiles are the dominant group, for which the most important is the nature and degree of soil porosity, humidity, temperature regime, distribution of the remains of organisms and humus. The same indicator by type of habitat can also serve as a bioindicator of soils.

The main representative of the group of geobionts in dark brown soil are earthworms (*Lumbricus*). Their high abundance in the soil correlates with high humus content and good soil structure. The importance of soil invertebrates for soil formation varies, their activity plays the greatest role associated, firstly, with the processes of decomposition, mineralization and humification of organic matter and, secondly, with the mechanical impact on the soil cover.

When choosing organisms, the occurrence of which in the soil can be an indicator of soil conditions, there is an important question about food relations, since this factor can be decisive in the spread of the animal, but insignificant for the characteristics of the soil.

The processing of plant organic matter is carried out mainly by herbivorous animals that feed on both living parts of plants (phytophages) and dead (saprophages).

Trophic activity of animals leads to mechanical destruction and grinding of organic matter, to its biochemical transformations in the animal body, to the enrichment of organic residues by microorganisms [18].

Composition of the soil fauna can be divided into three main groups by type of nutrition:

1. Phytophages are organisms that feed on the underground parts of the living higher ones.

2. Zoophages are organisms that feed on other animals.

3. Saprophages are organisms that feed on dead and rotting remains of plants and organisms (table 8).

The data in table 8 indicate that among saprophages in dark brown soil under the vineyards of grape varieties of domestic breeding Almaly, Aisulu identified earthworms, scarab, millipedes, ladybugs. *Scarabeidae, Elateridae, Tenebrionidae, Curculionidae* are bright representatives of mesofauna on all studied soils from the group of phytophages.

Table 8 – Mesofaunic characteristics of the studied soils according to the type of nutrition (0-20 cm)

Soil type	Type of habitat		
	Saprophages	Phytophages	Zoophages
Dark brown	*Lumbricida* *Pyrrhococidae* *Oniscoidea* *Diplopoda* *Asilidae*	*Tenebrionidae, Scarabeidae, Elateridae, Curculionidae*	*Carabidae* *Coccinellidae* *Formicidae* *Muscidae*

Classification by type of nutrition has great practical importance, because it is possible to predict a decrease in the yield of cultivated crops.

Thus, the analysis of the amount and group composition of mesofauna in the studied soils shows that their classification by type of nutrition has positive, global, environmental, but also agronomic value. Mesofauna, along with other soil characteristics may be used as a bioindicator [19;20]. We carried out biodiagnosis of the studied soils according to the classification based on trophic connection and habitat of soil invertebrates.

From our observations it was found out that earthworms, the larvae of click beetles of the family Tenebrionidae are associated with soils with more humus and sufficient water supply(table 9).

Table 9 – Bioindication of the main types of soils of ZailiAlatau by the species composition of the mesofauna (0-20cm), under the vineyards of Almaty, Aisulu (2018)

Soil type	Type	Class	Group	Family
Bioindicators				
Dark brown	Arthropods (Arthropoda)	Insects (Insecta)	Beetles (Coleoptera)	Wireworms (Tenebrionidae)

From the data of table 9 it can be seen that the indicators in the dark brown soils are wireworms from the *Tenebrionidae* family. The result of our research has shown that common species are larvae of insects from the family *Carabidae, Formicidae*, as these species have plasticity (the ability to live in a variety of biotopes). The dominant species are insect larvae of *Formicidae*[21]. We have noted that the more common species of soil invertebrates found in the compared biogeocenoses, the more correct conclusions about the similarity of hydrothermal, chemical and biological regimes of the compared soils will be obtained. It was established that changes in the chemistry of the environment, physical properties of soils leads to changes in the amount and species composition of organisms. In this regard, soil invertebrates are one of the best bioindicators, as all actively moving species react to the slightest change in the environment by varying the number and violation of the ratios of trophic groups. It is revealed that the most convenient test objects are earthworms, larvae of click beetles, darkling beetles and some types of wood lice.

CONCLUSION

The ratio of groups in the complex of soil invertebrates varies throughout the season.With the growth of xerophytic habitats, the number of earthworms in the community is reduced.The complex of soil invertebrates is represented by three trophic groups: phytophages, zoophages and saprophages. Saprophages dominate everywhere. The prevalence of saprophages persists throughout the growing season.Indicators in dark brown soils are wireworms from the family *Tenebrionidae*.

Acknowledgements. *This work was conducted under the project AP08857501 «Improvement and development of highly sensitive methods for ensuring food safety in Kazakhstan» funded by the Ministry of Education and Science of Kazakhstan from 2020 to 2022.The authors express their special gratitude to Z.A. Tukenova from LLP "Kazakh Research Institute named after U. Uspanova Soil Science and Agrochemistry", Almaty, Kazakhstan for valuable advice in writing this article and KazybaevaS.Zh., from Kazakh National Research Institute of Harvesting and Grapes, Almaty, Kazakhstan for scientific advice.*

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ТҮЙІН

Е.А. Сырғабек[1], М. Алимжанова[1], А. Амандыкова[1], Т.Н. Акылбекова[2]

ОҢТҮСТІК - ШЫҒЫС ҚАЗАҚСТАН ЖҮЗІМДІКТЕРІНІҢ ТОПЫРАҚ ФАУНАСЫ

[1]әл-Фараби атындағы ҚазҰУ, 050070, Алматы қаласы, әл-Фараби даңғылы, 71, Қазақстан, e-mail: serkanat96@gmail.com

[1]әл-Фараби атындағы ҚазҰУ, 050070, Алматы қаласы, әл-Фараби даңғылы, 71, Қазақстан, e-mail: mereke.84@mail.ru

[1] әл-Фараби атындағы ҚазҰУ, 050070, Алматы қаласы, әл-Фараби даңғылы, 71, Қазақстан, e-mail:asem.amandikova1999@gmail.com

[2] Қазақ ұлттық педагогикалық университеті. Абай атындағы ҚазҰПУ, жаратылыстану ғылымдары және география институты, химия факультеті, 050070, Алматы, Достық 13, Қазақстан, e-mail: turar.83@mail.ru

Әр типке және қара-қоңыр топыраққа сәйкес келетін қарашіріктің жалпы мөлшерінің кескін бойынша таралуы зерттелді; қарашіріктің максималды мөлшері - 3,68%. Топырақтағы қарашіріктің мөлшері мен топырақ омыртқасыздарының саны арасында нақты байланыс бар екендігі анықталды. Бұл мезофаунаның жалпы құрамы туралы мәліметтерді сипаттау үшін пайдалануға мүмкіндік беретін көрсеткіш. Қарашірік мөлшері 3,68% құрайтын, қара-қоңыр топырақтардың жоғарғы қабаттарындағы қарашірік мөлшерінің топырақ мезофаунасының мөлшеріне әсері қарастырылды, топырақ мезофаунасының саны 28 түр/м^2 құрады. Қара-қоңыр топырақтағы геобионттар тобының негізгі өкіл - жауын құрты (Lumbricus) болып табылады. Олардың топырақтағы жоғары мөлшері, топырақтағы қарашірік мөлшерінің жоғары және құрылымының жақсы болуымен өзара байланысты. Қоршаған ортаның химиялық құрамының, топырақтың физикалық қасиеттерінің өзгеруі организмдердің саны мен түрлік құрамының өзгеруіне әкелетіні анықталды.

Түйінді сөздер: мезофауна, топырақ, микроагрегаттар, биокөрсеткіш.

РЕЗЮМЕ

Е.А. Сыргабек[1], М. Алимжанова[1], А. Амандыкова[1], Т.Н. Акылбекова[2]

ПОЧВЕННАЯ ФАУНА ВИНОГРАДНИКОВ ЮГО-ВОСТОЧНОГО КАЗАХСТАНА

[1]Казахский национальный университет имени аль-Фараби, 050070, г.Алматы, пр. аль-Фараби 71, Казахстан, e-mail: serkanat96@gmail.com

[1]Казахский национальный университет имени аль-Фараби, 050070, г.Алматы, пр. аль-Фараби 71, Казахстан, e-mail: mereke.84@mail.ru

[1]Казахский национальный университет имени аль-Фараби, 050070, г.Алматы, пр. аль-Фараби 71, Казахстан, e-mail: asem.amandikova1999@gmail.com

[2]Казахский национальный педагогический университет им. Абая, Институт естественных наук и географии, химический факультет,050070, Алматы, Достык 13, Казахстан, e-mail: turar.83@mail.ru

Изучено общее содержание гумуса в распределении по профилю, соответствующее каждому типу и темно-коричневой почве; максимальное содержание гумуса - 3,68 %. Установлено, что существует четкая корреляция между содержанием гумуса в почве и численностью почвенных беспозвоночных, что позволяет использовать данные об общем составе мезофауны для характеристики и этого показатель. Рассмотрено влияние содержания гумуса на содержание почвенной мезофауны на темно-коричневой почве с содержанием гумуса в верхних слоях 3,68 %, численность почвенной мезофауны составила 28 видов/м^2. Основным представителем группы геобионтов в темно-коричневой почве являются дождевые черви (Lumbricus). Их высокое содержание в почве коррелирует с высоким содержанием гумуса и хорошей структурой почвы. Установлено, что изменение химического состава окружающей среды, физических свойств почв приводит к изменению численности и видового состава организмов.

Ключевые слова: мезофауна, почва, микроагрегаты, биоиндикатор.