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ARMENIAN NATIONAL AGRARIAN UNIVERSITY

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АГРОНАУКА И ТЕХНОЛОГИЯ

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Adjustment of Irrigation Regime for the Agricultural Crops through CROPWAT Software Application

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ABSTRACT

The efficient management of the irrigation water is of utmost importance in conditions of the irrigated agriculture; hence, new methods are currently being developed and new devices are applied to achieve the maximum savings in water consumption.

The computation method introduced in the current article is the best option for the identification of efficient water consumption standards, which will entail to appropriate management and savings in irrigation water.

The abovementioned method has been applied in the other regions of Armenia as well, where the best indicators for irrigation water consumption have been also recorded.

Introduction

Identifying the opportunities of irrigated agriculture and enhancing their efficiency is crucial for poverty elimination, food safety increase and agricultural productivity in Armenia. Irrigated agriculture accounts for more than 80 % of gross crop production. In this process the irrigtion water is the only natural factor which regulates the effect of the other factors creating optimal conditions for the plants growth and development, which in its turn promotes the increase of soil fertility and yield capacity.

One of the main issues in the efficient utilization of the land and water resources in Armenia is the improvement of irrigation system and watering facilities as a result of which it becomes possible to get a high and sustainable yield from agricultural crops by preserving and improving the soil fertility. To solve the mentioned issue it is necessary to study and disclose the effect of irrigation on the soil fertility and crops yield capacity depending on the crops irrigation methods, water consumption and irrigation regime.

After the land-related reforms the available irrigation regimes not only failed to preserve the obtained economic indices, but even more, they exacerbated their decline (Terteryan, et. al, 2007).

Particularly in recent years the irrigated land area has been considerably reduced, the yield capacity of the agricultural crops has strongly decreased and the irrigated lands have been subjected to secondary salinization. According to the reserachers' evaluation one of the main reason of the abovementioned negative processes is the violation of irrigation regimes and their incomplience with the contemporary land use requirements (Yeghiazaryan, et. al, 2011).

Irrigation is watering process of the agricultural crops and the irrigation regime is the discrepancy between the provision of the humidity required by the the agricultural crops and the water regimes for the given territory. To determine the irrigation

regime it is necessary to identify the water consumption standard for the agricultural crops beforehand and afterwards the real irrigation regime as the discrepancy between the water consumption of the agricultural crops and the natural water regimes of the specific area. The supplied water amount which provides the plants regular and uninterrupted growth and development is considered to be the water consumption norm. Besides, the plants water consumption is factually only transpiration, anyhow the physical evaporation from the soil is practically supplementary for the latter. The natural soil humidity very often doesn't satisfy the water consumption requirement, thus, a necessity appears to add it in an artificial way, which is implemented through irrigation. Irrigation is considered to be the key method for land reclamation and is carried out for the soils' desalination, fertilization and other purposes (FAO 2008).

Materials and methods

The irrigation regime depends on the hydrometeorological conditions, crop species, its vegetation duration and on soil properties (Wright, 1982).

Depending on the soil and climatic conditions the issue of effective irrigation planning can be handled through the application of innovative irrigation technologies, reconstruction, expansion and improvement of irrigation systems, while the highest water-saving rate can be achieved in case of identification of the appropriate irrigation regime for the agricultural crops.

The mentioned track of the problem solution aims to increase the reclaimed land areas, as well as to create and preserve the needed and sufficient air, food, thermal, water and salt regimes. The change of lands water regimes is of particular significance by means of which the impact of other regimes on the soil fertility, crops yield capacity and on the environment is regulated. The elements providing the soil fertility in natural conditions are very often mutually exclusive, for example, in the soils with extra humidity the aeration terms, availability of various types of nutrients deteriorates, the heat access into the soils' lower layers decreases, some anaerobe procedures activate resulting in the accumulation of some organic substances in the soil, hence it becomes overmoistened and swampy (Verigo, Razumova, 1973).

In such land areas the access of humidity exceeds its outlet and the ground waters usually have relatively higher location aspects. When the evaporation of the humidity from the soil exceeds its access favorable conditions appear for the development of anaerobic activities, as well as for the decomposition of organic substances, the soils heat capacity decreases, the concentration of the soil solution increases as a result of which the soils become salinized, while due to their unsustainable structure the lands can undergo soil and water erosion (FAO 2008).

The academician A. Kostyakov has mentioned that the main issue of the amelioration consists in the management of the biological and hydrogeological cycle in water and chemical elements of the environment so that the hydrogeological cycle would strive to the minimum, while the biological one to the maximum.

To achieve the mentioned goal it is necessary to solve the irrigation problems not only from the perspective of crops' requirements satisfaction, but also to consider the complex impact of different factors existing in the "ground water-soil-plant-air" system.

The need for irrigation, its conditions and application are related to the plants water consumption rate, the amount of which depends on the temperature, relative air humidity, light, wind velocity, soil fertility, its hydro-physical, physical-mechanical and biological properties, crop species and agro-technical measures.

The highest water amount which the plants use for the transpiration is subjected to continuous changes depending on the environmental conditions. Related to the crop species their water consumption rate can change under the influence of both soil-and-climatic change and that of agro-technical conditions (Kostyakov, 1951).

To specify the water consumption standards the method of Penman-Monteith (Monteith, 1981) has been adopted. By means of the mentioned method it is possible to compute the evaporation rate (total evaporation) from the plants and soils.

The computations have been conducted through the CROPWAT software developed by the Food and Agriculture Organization of the United Nations (FAO). When implementing calculations the minimum and maximum air temperature peculiar to the given location, relative air humidity, wind velocity, sunshine duration, precipitation rates, altitude above the sea level, geographical data and a number of other information (FAO, 1988) has been taken into account.

Results and discussions

The average data of "Yerevan agro" meteorological center provided for 2012-2017 by the hydromet center of the RA Ministry of Emergency Situations have been served as a base to calculate and adjust the water consumption standards through the total evaporation in the Baghramyan province at the RA Armavir Marz (region).

Through the CROPWAT software the irrigation regimes of the grape and orchards cultivated in the given province have been computed; the data on average monthly total evaporation and efficient precipitation amounts have been retrieved.

The soil type has been selected according to its mechanical composition as well. Mid clay and sandy (loam) soil types are characteristic to the mentioned province on the background of which the further computations have been conducted.

Table 1. Meteorological indices in the Baghramyan province

Country - Armenia					Station - Yerevan-agro		
Altitude - 1080m		Latitude - 40.11^{0}N			Longitude - 43.5^{0}E		
Month	Min.Temp	Max. Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m^3/day	mm/day
January	-16.2	11	79	95	3.4	6.5	0.89
February	-11.4	14.8	71	121	5.5	10.4	1.48
March	-6.8	19.8	59	181	6.4	14.3	2.8
April	-1	28	53	181	7.9	19.1	4.45
May	6.8	30.8	55	181	8	21.1	5.12
June	11.1	37	45	242	10.8	25.7	7.51
July	14.2	38.5	43	302	11.5	26.2	8.55
August	15	38.1	39	302	10.8	23.6	8.24
September	8.1	34.4	46	207	9.7	19.2	5.7
October	1.9	28.6	63	138	6.7	12.4	3.14
November	-5.2	18.3	73	104	5.5	8.6	1.55
December	-13.8	10.7	81	86	2.8	5.5	0.86
Average	**0.2**	**25.8**	**59**	**179**	**7.4**	**16.1**	**4.19**

Table 2. The average monthly efficient precipitation rate in Baghramyan province

Station -	Yerevan-agro		Eff. Rain method -FAO/AGLW formula	
		Rain, mm	Eff. Rain, mm	
	January	29	7.4	
	February	25	5	
	March	34.2	10.5	
	April	29.8	7.9	
	May	48.9	19.3	
	June	33.1	9.9	
	July	20.4	2.2	
	August	10.6	0	
	September	10.3	0	
	October	34.3	10.6	
	November	26.3	5.8	
	December	28.5	7.1	
	Total	330.4	85.7	

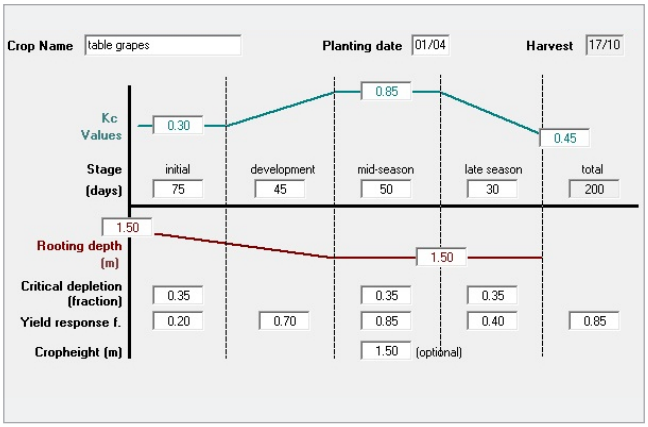

Figure. The plants coefficients considering the sprouting, bushing, blossoming and maturation phases.

Table 3. Soil type according to its mechanical composition

General soil data	Soil name -	Medium(loam)
Total available soil moisture (FC-WP)	290.0	mm/meter
Maximum rain infiltration rate	40	mm/day
Maximum rooting depth	900	centimeters
Initial soil moisture depletion (as % TAM)	0	%
Initial available soil moisture	290.0	mm/meter

Water requirements (the example refers to the grape vineyards) for each crop have been computed due to the plants coefficients considering the sprouting, bushing, blossoming and maturation phases.

According to the computations during the vegetation period 7627 m^3/ha water is required for the vineyards instead of previously planned 9600m^3/ha water.

Table 4. Irrigation requirement for table grapes per ten days and plant coefficients

Et_o station -	Yerevan-agro				Crop - table grapes		
Rain station -	Yerevan-agro				Planting date - 01/04		
Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Apr	1	Init	0.3	1.19	11.9	2.5	9.4
Apr	2	Init	0.3	1.36	13.6	2	11.7
Apr	3	Init	0.3	1.42	14.2	3.5	10.7
May	1	Init	0.3	1.43	14.3	5.8	8.5
May	2	Init	0.3	1.48	14.8	7.4	7.4
May	3	Init	0.3	1.74	19.1	6	13.1
Jun	1	Init	0.3	2.03	20.3	4.3	16
Jun	2	Deve	0.33	2.51	25.1	3.2	21.9
Jun	3	Deve	0.47	3.7	37	2.4	34.6
Jul	1	Deve	0.61	5.07	50.7	1.5	49.2
Jul	2	Deve	0.76	6.56	65.6	0.5	65.1
Jul	3	Mid	0.91	7.73	85	0.4	84.7
Aug	1	Mid	0.96	8.1	81	0.1	80.9
Aug	2	Mid	0.96	8.07	80.7	0	80.7
Aug	3	Mid	0.96	7.2	79.2	0	79.2
Sep	1	Mid	0.96	6.26	62.6	0	62.6
Sep	2	Late	0.95	5.4	54	0	54
Sep	3	Late	0.84	4.05	40.5	0.1	40.4
Oct	1	Late	0.7	2.73	27.3	2.8	24.5
Oct	2	Late	0.58	1.75	12.2	3	8
					809.5	45.5	762.7

Table 5. Computation of watering days and standards through the software program

Et_o station -	Yerevan-agro	Crop -	table grapes	Planting date - 01/04	Yield red.
Rain station -	Yerevan-agro	Soil -	medium(loam)	Harvest date - 17/10	0.0%

Table format	Timing	Irrigate at critical depletion
* Irrigation schedule	Application	Refill soil to field capacity
Daily soil moisture balance	Field eff.	70%

Date	Day	Stage	Rain	Ks	Eta	Depl	Net. Irr.	Deficit	Loss	Gr. Irr/	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
19 Jul	110	Dev	0	1	100	36	156.1	0	0	223.0	0.23
9 Aug	131	Mid	0	1	100	36	154.6	0	0	220.8	1.22
30 Aug	152	Mid	0	1	100	36	154.4	0	0	220.6	1.22
30 Sep	183	End	0	1	100	35	154.0	0	0	219.9	0.82
17 Oct	End	End	0	1	0	3					

Total						
Total gross irrigation	884.4	mm	Total rainfall	176.2	mm
Total net irrigation	619.1	mm	Effective rainfall	173.6	mm
Total irrigation losses	0.0	mm	Total rain loss	2.6	mm
Actual water use by crop	807.8	mm	Moist deficit at harvest	15.1	mm
Potential water use by crop	807.8	mm	Actual irrigation requirement	634.2	mm
Efficiency irrigation schedule	100.0	%	Efficient rain	98.5	%
Deficiency irrigation schedule	0.0	%			

The software program enables to identify the watering standards needed for the total evaporation and for the provision of the plants growth and development, as well as yield capacity enhancement. The analysis shows that the difference between the values of the total evaporation and water requirement is the rate of atmospheric precipitation, which has made 455 m^3/ha according to the data of hydromet station.

Based on the entered baseline data the software has developed the schedule of the crops irrigation, which is determined upon the term that the regular watering should be implemented during the period of the plants optimal pre-watering humidity, i.e in the state of humidity, the lower indices of which would cause stress to the crops due to which yield capacity decrease is recorded. It means that the scheduled watering should be implemented in time until the minimum humidity so as to save the yield. The computations are summed up in figure 4, where the scheduled irrigation days, their appropriate watering standards and surface flows are clearly demonstrated. The same calculations have been conducted for the orchards of the mentioned province and according to the computations conducted by the Penman-Monteith method the annual water requirement for the vineyards of the Baghramyan province at Armavir region makes 7627 m^3/ha, that of the orchards - 7380 m^3/ha which is less than the previously stated standards by about 18 %-20 %.

Conclusion

Thus, based on the abovementioned data provided by the meteorological station and upon the results of the computations it is possible to accurately identify the annual water requirement for the specific crop, which will entail to 18 %-20 % of water saving and its efficient utilization. Besides, through the contribution of an innovative irrigation technique, such as the drip irrigation system, the crops yield capacity will increase by 20 %-50 %.

The aforementioned computations are conducted by the example of crop rotation scheme as well, where the crops, their planting times, occupied areas are mentioned. When comparing the water amount required for the irrigation per 1 ha area with that of determined through the graph regulated by means of hydro module of the previous regimes, a considerable difference is observed, which testifies that in case of applying irrigation water amount planned and computed through the recommended method the irrigation water is consumed more efficiently with high water-saving outcomes.

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Receiving Irrigation and Drinking Water Together with Electricity in Remote and Arid Areas Using Membrane Desalination Device

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photovoltaic panel

ABSTRACT

The availability of irrigation and drinking water, as well as water supply for agricultural purposes are important requirements for living in remote areas. The hybrid desalination device has been designed and tested under field conditions. In the mentioned device the electricity is produced with the help of absorbing solar energy by PV panels and water desalination process is performed due to thermal amount released from its heating. The novelty of this system is the structure of the device, which combines a PV panel and a MD desalination unit. The pilot plant had a total yield of 9.6 kg/m^2 and 680 W h/m^{2}day. The suggested device is a self-supply one that produces water for aeroponic and hydroponic (of drip and flow style) irrigation systems. It is also a means for satisfying the needs of drinking water and electricity.

Introduction

Water and energy are the two most essential substances for life sustaining. Supplementing the deficiency of high-quality water resources has become an important priority, especially in remote, arid and semi-arid regions. As these regions are characterized by sunny and warm climate, as well as by enormous ground resources and sea water, the lack of clean water can be supplemented by thermal desalination and the electricity can be received through solar energy. Seawater and ground saline water are inexhaustible resources for getting pure water. The total dissolved solids (TDS), which averagely make 1–45 g/L, must be decreased to the required norms for drinking and irrigation purposes.

Multi-Effect Distillation and Multi-Stage Flash equipments (Hum, Tsang, Harding, Kantras, 2006, Danald, Kathlcen, Ferguson, 2004) are mainly used for desalination of seawater and ground water. In these equipments the latent heat of evaporation is used in turn at all stages and in case of low atmospheric pressure the secondary vapor energy can be used. Evaporation processes are used for large scale desalination cases and require high capital investments and also have high energy cost. Chemical method is used for supplying pure water to plants, electric power stations and boiler-houses. In case of high salt concentrations problems, connected with the amount of reagents and recovering, increase the exploitation expenses, thus, the process becomes

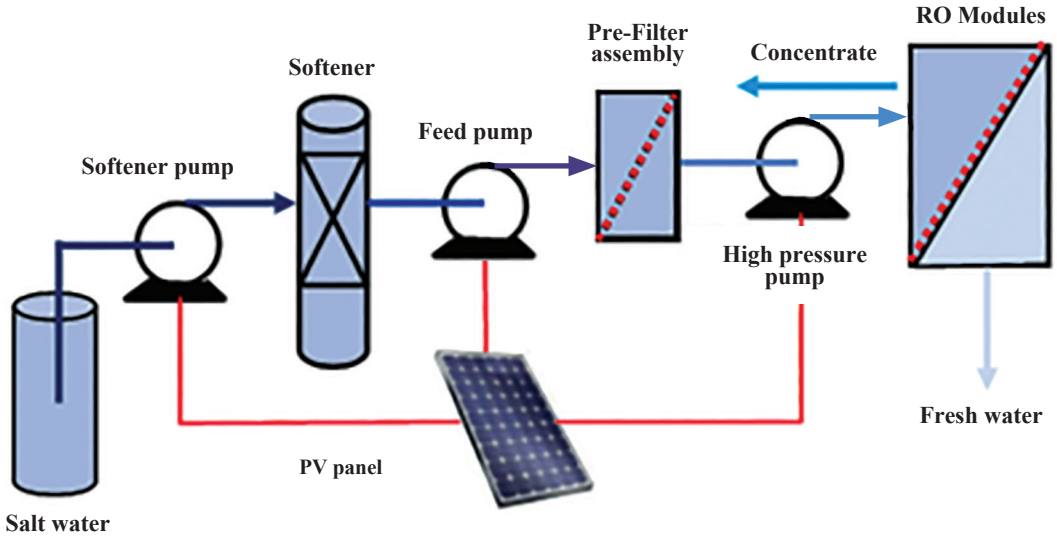

Figure 1. Simple reverse osmosis system with integrated PV panels.

economically unprofitable.There are also ecological problems related to environmental pollution. Solar still (SS), membrane distillation (MD), reverse osmosis (RO) processes are used for production of small amounts of drinking water and for not large irrigation systems (aeroponic and hydroponic) in remote and arid areas.

The solar still technology is a practical method to get fresh water from saline solutions by desalination (Pramod, 2018). The process, which is similar to the natural hydrological cycle, takes place in a "greenhouse" box and demands only solar energy. Solar still devices are simple and of easy maintenance. However, passive solar still devices have a low thermal efficiency coefficient (40 %) and the output is approximately 2-3 l/m^{2}day (Shailesh, Sorabh, 2015, Al-Karaghouli, Renne, and Kazmerski, 2010).

The membrane distillation (MD) process is a prospective method for concentrating and desalinating the aqueous solutions using solar energy (Alanezi, Mohammed, 2018, Rahman, 2013, Dytnersky, Hakobyan, 1990, Hakobyan, 2011). The principle of MD is the following: by means of low potential energy, on the both sides of the membrane, a temperature difference is established. The volatile molecules (in this case molecules of water), originating from the evaporation of heated solution, pass through the membrane and condense on the cold side, resulting in an overall transmembrane flux. The molecules of water vapor transfer through the pores of the membrane from the high pressure side to the low pressure side. The thermal energy consumption in this device is 175-350 kWh for getting 1m^3 pure drinking water and the productivity is within the range of 6.8-9.5 kg/m^2 h (Chafidz, Faisal, et al, 2001, Kiefer, Spinnler, Sattelmayer, 2018).

In recent years reverse osmosis (RO), one of the membrane processes, has been widely used for desalination (Ghermandi, Messalem, 2009). Reverse osmosis operates under high osmotic pressure on semipermeable membranes without phase changes and at environmental temperatures. Filtration process is accompanied by separation of salt ions from solution. RO operating pressure ranges from 17 to 27 bars for brackish water and from 55 to 82 bars for seawater. It has been calculated that in case of seawater desalination the expenses of preliminary water treatment can comprise up to 60 % of the whole process. Reverse osmosis systems can be coupled to PV panels to desalinate water (Hasson, Drak, Semiat, 2001, Biltona, Kelleyb, Dubowskyb, 2011).

Desalination processes by reverse osmosis require large capital investments and are not suitable for use in case of high concentration of dissolved salts. Besides, membranes used for RO are very sensitive towards environmental active chlorine and pH.

Thus technological schemes, which are somehow applicable, can be conditionally divided into the following blocks: 1.Desalination block, 2.Thermal energy providing block, 3.Electric power providing block, 4.Block providing process operation (heat exchangers, pumps, valves, regulators, measuring and recording devices).

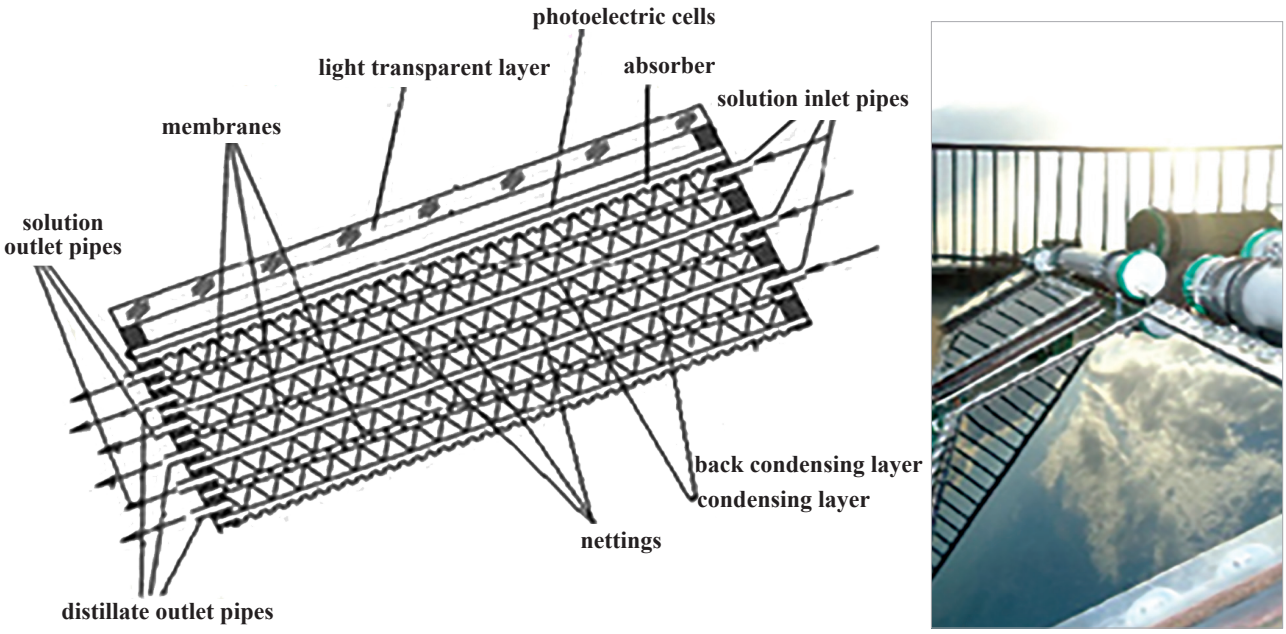

Figure 2. The construction of the desalination device with integrated PV panel and its photo.

Electric power providing block and also PV panels can be used for domestic demands in remote areas. The photoelectric processes are the most applied technologies for generating electrical energy. Photoelectric elements absorb electromagnetic rays of light, both from infrared and visible spectra. The main objective of PV panel is to absorb maximum solar radiation in order to ensure high efficiency. In this system efficiency coefficient of converters is 15 % (Kabir, Kumar, 2018). Only a part of the visible spectrum is converted into electrical energy. Most of the absorbed radiationis, which are not converted by solar cells, result in an increase of the temperature of the elements and in a decrease of the electric efficiency. The amount of absorbed energy of a solar cell depends on the location, season, day and hour.

In remote areas, in case of small productivity and not large agricultural farms, when we want a small, portabl device with easy maintenance to provide water amount about 100 to 500 liters a day, the use of presented schemes is quite problematic. Thus, a problem appears to design a hybrid solar distillation device with integrated photovoltaic panel, which can be used for drinking and irrigation (aeroponic and hydroponic of drip and flow style irrigation systems) water production in remote arid communities and in small sunny areas, using the positive characteristics of these technologies. The device can receive also electricity together with water production, besides, it occupies small ground areas and operates with high thermal efficiency.

Materials and methods

The designed device is a greenhouse box heat trap with a glass covering. The entire desalination process of seawater which means heating, evaporating, condensing and the multistage use of heat and electrical power generating is established in a single device. A photovoltaic transmission block is implemented in the form of a solar cell attached to the surface of the front thermal transmission layer, located in the device.

The constructions of the flat combined MD desalination device and pilot device are shown in figure 2.

The photovoltaic block consists of the absorber with photoelectric cells attached to the top and is installed in the front of the device. There is an air gap between the absorber and the light transparent glass cover. The distillation block is implemented with the multistage membrane and is made of layers of successive similar stages. Each stage includes a layer of micropore membranes, which are covered with the support netting layers on both sides. The stages are separated from each other by condensing layers. Each of the distillation block stages has a saline solution inlet pipe, a distillate outlet pipe and a concentrated saline solution outlet pipe. The front distillation layer, which is located towards incident solar rays, is bordered by the absorber, which has a grooved surface.

The pilot devices are 55 cm long, 30 cm wide and 3–7 cm thick. The desalination experiments were performed on a sample taken from the Black Sea. The TDS were 17.5 g/L.

The temperature of the seawater at the inlet of the device reached maximum to 50°C during the day. The water hadn't been treated before the desalination process. The experimental observations of MD solar desalination devices were made in Yerevan city (Republic of Armenia), which has a geographical latitude of 40°11′ N and a geographical longitude of 44°31′ E. The devices were set towards south with their absorbing surfaces and had a slope of 35°. The tests were held from 9:00 am to 7:00 pm and the distillate was taken once per an hour during the whole day. The main tests were performed during July. The recorded ambient temperature was in the range of 28°C–37°C. The values which were measured during the experiments were the following: the temperature of the solution, the ambient temperature, the solar radiation, the concentration of saline solution, the concentration of dissolved salts in the distillate, the electric current and voltage.The intensity of solar radiation striking a horizontal surface was measured by the pyrometer "Apogee PYR-pA5". The voltage and electric current were measured by the multimeter UNI-T (THERMOPROZESS Gruppe, Germany).The total amount of dissolved salts was measured by the Hanna Instruments HI 86301 set with an accuracy of 1 mg/L. The material of the membranes was PTFE, and the material of the support was PP. The thickness of support was175 μm, the pore size was 0.22 μm, and the porosity was 70 %.

The coefficient of performance is one of the most important parameters for evaluating the daily productivity of a multistage device, which is defined by the following equation:

$$\eta = \frac{\sum_{i=1}^{N} Ji}{J_1}, \quad (1)$$

where $\sum_{i=1}^{N} Ji$ is the total daily specific productivity of the desalination device per all stages expressed in units of kg/m²day, and J_1 is the daily specific productivity of the one stage desalination device expressed in units of kg/m²day. Process selectivity or retention rate was determined by:

$$K = C1 - C2, \quad (2)$$

where $C1$ - is salt concentration in solution, $C2$ - is salt concentration in permeate.

Results and discussions

Specific productivity and coefficient of the thermal efficiency are the main characteristics of the process. Specific productivity is the amount of clean water produced by the unit of surface during a day, kg/m²day. Electrical energy amount produced by the PV panel was also measured.

Experimental investigations were carried out on the desalination device with integrated PV panel (Figure 3) to investigate the power produced from PV panels and to evaluate the fluxes and the quality of drinking water.

Figure 3. Desalination device with integrated PV panel.

The data (the values of the specific productivity of received water and electricity depending on different hours of the day) obtained in testing of the portable four-stage device are shown in figure 4. During the experiments the device reached its operating regime when the seawater in the first stage was heated up. A noticeable amount of distillate appeared after 10:00 am. Later on, the hourly specific productivity achieved its maximal value during the period from 2:00 pm to 4:00 pm. The intensity of radiation varied during a day from 600 – 1000 W/m². The temperature and consequently the partial pressure had the main influence on the output. The daily cumulative yield productivity was 9.6 kg/m²day. When sun was in zenith and electric-magnetic rays fell on absorber surface perpendicularly, the power was the largest and equaled to 98 W/m². The variations of main hourly characteristics of photovoltaic hybrid desalination device had parabolic shape determined by square equation. The temperature of seawater in the device at 3:00 pm was 67°C, 64°C, 58°C, 51°C respectively at the first, second, third and fourth stages. The performance coefficient, which is defined by the equation (1) for four- stage MD device, was 2.8.

Cumulative values of productivity (J) and electrical energy (P) were also evaluated.

J is the total daily accumulative value of the productivity of the four-stage desalination device expressed in kg/m²day. P is the daily accumulative values of electrical energy produced by PV panels of the device.

P was determined by the sum of products, resulted from the data of multiplying voltmeter and ammeter.

Test results obtained from experiments held on field conditions are presented in figure 5.

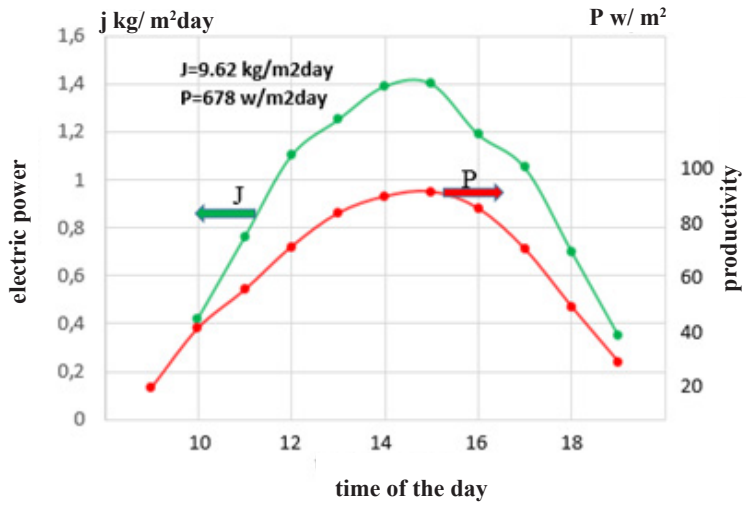

Figure 4. The specific productivity (J) and electric power (P) in four-stage desalination device with integrated PV panel, depending on different hours of the day; the solar radiation is 6.4 kWh/m² day.

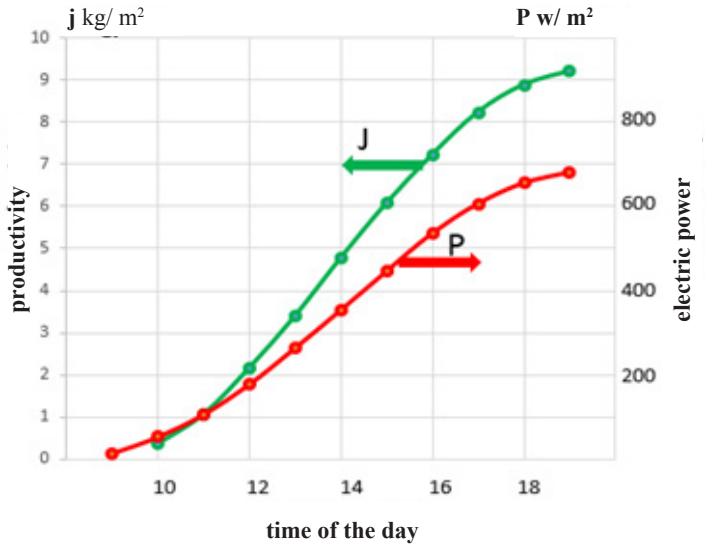

Figure 5. The accumulative values of productivity (J) and electrical energy (P) in four-stage desalination device with integrated PV panel; the solar radiation is 6.2 kWh/m² day.

The experiments were conducted during a typical sunny day, in September, when air maximum temperature raised up to 32°C at 3 pm. During the first three hours we got almost 50 % of the daily specific productivity, because the temperature of saline solution got its maximum value after noon. The daily cumulative yield productivity is 9.2 kg/m² and the accumulative values of electrical energy amounts to 680 W h/m².

Pure water is produced in all series of experiments using the combined MD devices. The TDS is equal to 10 mg/L on average, which indicates that the membrane does not become wet during the desalination process and membrane defects like large size pores do not exist. The retention rate was 99.99 % and nighttime breaks did not influence on the membrane. The electricity produced by photoelectric elements can be used for powering household devices, as well as for other personal needs.

Conclusion

A new device for receiving fresh water and electricity has been designed, which has satisfied the needs of smaller communities and families. Acquiring fresh water and generating electricity are combined into one compact and mobile device. The variation of fresh water productivity and electrical energy during a day was investigated. The water and electricity product deeply depends on the solar radiation. The field experiments show that the system productivity regarding water and electrical energy amounts to about 9.6 kg/m^2 and 680 W h/ m^2 during a day correspondingly. Process selectivity or retention rate was determined and equaled to 99.9 %. The device has a high efficiency since the solar energy absorbed by the absorber is used multiple times with minimal losses. The advantages of MD solar desalination devices consist in their simple robust constructions, small sizes, mobility and independence on fossil fuels and external electricity sources. Thus, the suggested system is a self-supply one that produces fresh water for crop irrigation and is considered to be a source for drinking water and electricity.

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Kinematic and Dynamic Study of the Rotary Crusher Transmission Gear in the Potato Digger

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ABSTRACT

Theoretical study of the geometric and kinematic as well as dynamic parameters of the gear drive wheel rotary soil crusher of the potato digger with planetary mechanism has been implemented and the optimal parameters have been selected.

In the result of field and laboratory experiments it has been revealed that the distance between the grouser bars of the drive gear wheel should be approximately 0.17 m, thus, the angle formed by the adjacent grouser bars makes 180, while their number should be 20.

Introduction

Different soil and clod crushers are used in order to increase the level of sifting potato and soil mass when harvesting with potato diggers. The main source of drive gear for the latter is the shutter shaft of the tractor capacity. The rotary crusher of the potato digger developed by us (Tarverdyan, Yesoyan and others, 2018) takes the movement from the gear wheel anchored in the soil. In the result effective horsepower of the tractor is saved and the productivity of the tractor and aggregate increases. The rotary crusher of the potato digger 1 (picture 1) is fixed to the front part of the digger through lever pivot-hinged system 2. In the transport state of the aggregate the crusher comes off from the ground with the help of the suspension system of the tractor together with the potato digger and in the working state it is settled on the soil bed border. The regulatory device regulates the sticking degree of working organs and soil grousers into the soil. The regulator device is a hydraulic cylinder 3 controlled by tractor distribution system which is connected with the potato digger through suspenders on the one side, and on the other side – with the horizontal bar connecting the levers (Picture 1). In order to give torque movement to the working rotors 5 from the gear wheel 4 of the crusher anchoring in the soil, four-bar planetary gear with parasitic tooth chisel was chosen in the result of studies and analysis.

The mechanism (Picture 2) consists of towing and steering arm 4, which gets the torque movement from the carrying wheel anchoring in the soil, parasitic wheels 2, central carrying wheel 3, the torque movement of which is given through half shafts to the rotors of the crusher and from the fixed internal annulus 1 which at the same time serves as mechanism casing. The numbers of the toothed gear are Z_1, Z_2 and Z_3 respectively.

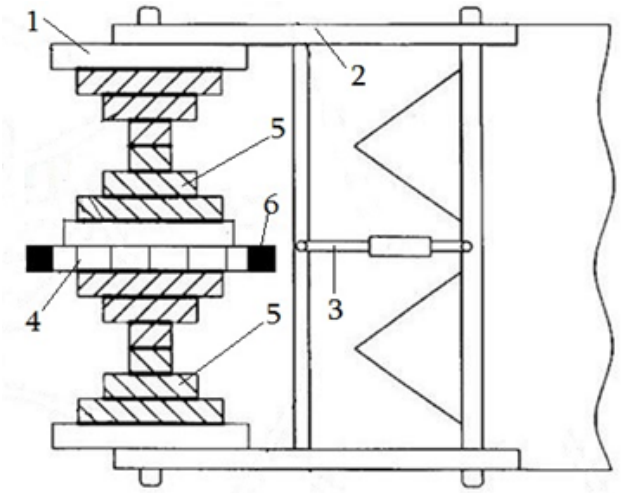

Figure 1. The scheme of the Rotary Crusher of the Potato Digger with Gear Drive Wheel *(composed by the authors).*

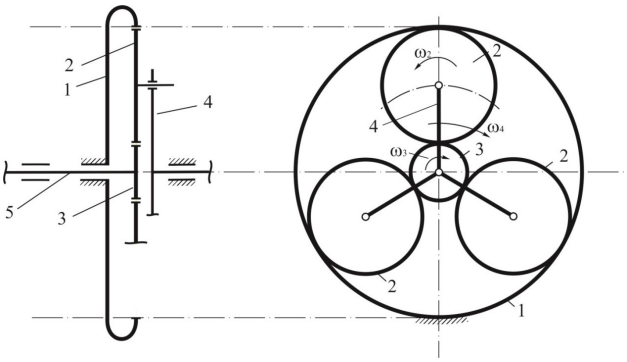

Figure 2. The Scheme of the Four-Bar Planetary Mechanism *(composed by the authors).*

During the forward movement of the potato digger the wheel 4 (Picture 1), due to the resistance of the soil grousers 6 penetrating into the soil, when turning around also turns the carrier 4 (Picture 2) together. The carrier turning with gearing number i (i>1) turns the annular ring 3 (Picture 2) in the direction of its rotation. In the result the annular ring with the help of half shafts 5 (picture 2) rotates the crusher with a bigger rotation numbers which turns into active rotary working organ (Tarverdyan, Yesoyan and others, 2018).

Materials and methods

The effective operation of the crusher is conditioned mainly by the right selection of planetary mechanism and calculation of optimal geometric and kinematic parameters. The important parameter of the mechanism is the transmission number.

The correlation of the transmission from the 4th carrying ring to the 3rd tooth gear is defined through the following expression (Artobolevskiy, 1988, Zinovyev, 1975):

$$i_{43}^{(1)} = 1 + \frac{z_1}{z_3} \quad \text{or}$$

$$\omega_3 = \omega_4 \left(1 + \frac{z_1}{z_3} \right). \qquad (1)$$

The rotation directions of the carrying wheel and crusher rotors coincide. And the selection of the abovementioned option of the driving mechanism with parasitic tooth gear is conditioned by this as the crushed soil clods should be thrown away in the direction opposite to the aggregate movement.

For the effective grinding of soil clods and throwing them away at about 9-10 m/s speed (the experiments showed that at this and higher speeds the soil clods grinding is significantly intensified in the result of striking) the transmission number of the planetary mechanism should be more than 8 (Tarverdyan, 2014, Sineokov, Panov, 1977).

In the result of the primary calculation it has been found out that it is expedient to choose 8.2 (this number is limited by the mechanism size and mass). The transmission number from the third ring to the first in case of immobility of the carrier will be:

$$i_{31}^{(4)} = 1 - 8.2 = -7.2 \quad \text{or}$$

$$i_{31}^{(4)} = -\frac{z_1}{z_3} = -7.2 \qquad z_1 = 7.2 z_3. \qquad (2)$$

From coaxiality condition

$$z_2 = \frac{z_1 - z_3}{2} = 3.1 \cdot z_3 , \qquad (3)$$

we will obtain from (2) and (3):

$$\frac{z_1}{z_2} = \frac{7.2 z_3}{3 z_3} = 2.4 . \qquad (4)$$

The tooth number Z_1 of the 1st immobile annular ring should be chosen in a way so that the phenomena of undercutting and interference of the teeth are excluded (Artobolevskiy, 1988, Anurev, 1973). The mentioned requirements are met if $Z_1 \geq 60$ (Artobolevskiy, 1988). Let's consider that $Z_1 \geq 62$, in that case $z_3 = \frac{z_1}{7.2} = 8.6$, but Z_3 cannot be less than 13 (Artobolevskiy, 1988, Anurev, 1973), hence considering Z_1=15, we will define Z_1 and Z_2 retrospectively taking into account the coaxiality condition. We will obtain Z_1=105, Z_2=45.

Together with meeting the necessary conditions of the required transmission number and module, the conditions of mechanism assembly, satellite vicinity and transmission

coaxiality should be met as well which has the following expression for the suggested mechanism:

$$z_1=2z_2+z_3,$$

which is also met $(105 = 2 \cdot 45 + 15)$.

The optimal number of satellites is defined through the following expression:

$$k = \frac{\pi}{\arcsin \frac{z_2 + 2}{z_3 + z_2}} = \frac{\pi}{\arcsin 0.75} = 3.71 .$$

As K<4 (Artobolevskiy, 1988, Zinovyev, 1975) we consider k=3satellite.

For the kinematic and dynamic analysis of the mechanism it is necessary to define the radii of the dividing circumferences of the tooth gear (let's consider the module of the tooth gear m=10), we will obtain:

$$r_1 = \frac{m z_1}{2} = \frac{10 \cdot 105}{2} = 525 \text{ mm}$$

$$r_2 = \frac{m z_2}{2} = \frac{10 \cdot 45}{2} = 225 \text{ mm}$$

$$r_3 = \frac{m z_3}{2} = \frac{10 \cdot 15}{2} = 75 \text{ mm}.$$

Checking the coaxiality condition is done: $r_1 = 2r_2 + r_3 = 2 \cdot 225 + 75 = 525$ mm.

The coefficient of the mechanism is defined through the following expression:

$$\eta = 1 - \left| \left(1 - \frac{1}{i_{43}^{(1)}} \right) \right| \psi ,$$

where ψ = 0.05 is the coefficient of the losses, placing $i_{43}^{(1)} = 8.2$ we will obtain η = 0.96.

In order to make a dynamic analysis of the mechanism, it is necessary to identify the speed of the characteristic points of the planetary mechanism (Bat, Djanilidze and others, 1975, Loytsanskiy, Loureh, 2006). The radii of the dividing circumferences of the tooth gear r_1, r_2, r_3 and rotational velocity of the carrier ω_4 are known in the problem under discussion, it is necessary to identify the rotational velocity ω_3 of annular ring 3, the momentary velocity of the satellite and the speed of points A, B, and C (picture 3).

For the suggested mechanism the 3- annular ring and 4-carrier are rotating around the immobile axis, and the satellites make smooth movement. The speed of the O_1 center of the satellite rotation as carrier point will be:

$$V_{O_1} = (r_3 + r_2) \cdot \omega_4 . \quad (5)$$

Taking into account the O_2 momentary center of the satellite velocity:

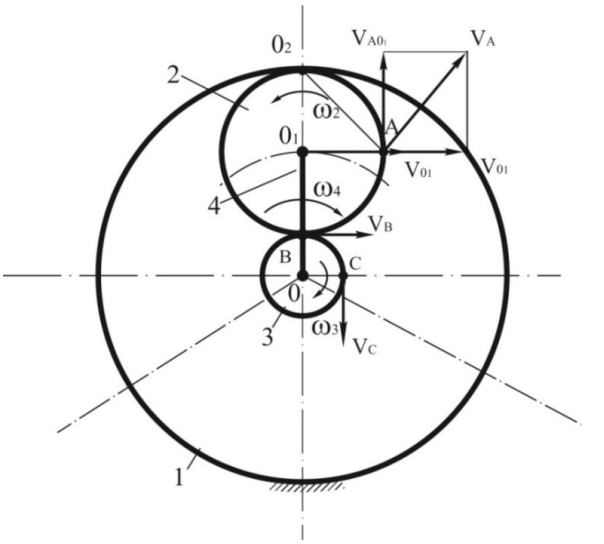

Figure 3. The Scheme of the Identification of the Speed of Characteristic Points of the Planetary Mechanism *(composed by the authors).*

$$V_{O_1} = (O_1 O_2) \cdot \omega_2 ,$$

or

$$\omega_2 = \frac{V_{O_1}}{O_1 O_2} = \frac{\omega_4 (r_2 + r_3)}{r_2} . \quad (6)$$

The velocity of Point B of 3- annular ring will be:

$$V_B = \omega_2 \cdot 2r_2 ,$$

and

$$\omega_3 = \frac{V_B}{r_3} = \frac{\omega_2 \cdot 2r_2}{r_3} . \quad (7)$$

The velocity of point A belonging to the sattelite will be:

$$V_A = \omega_2 \cdot O_2 A = \omega_2 \cdot r_2 \sqrt{2} .$$

The velocity of point C belonging to 3- annular ring will be:

$$V_C = \omega_3 \cdot r_3 = \frac{\omega_2 \cdot 2r_2 r_3}{r_3} = \omega_2 \cdot 2r_2 . \quad (8)$$

After the identification of the velocities it is necessary to calculate the momentum of inertia of the mechanism to the 3rd ring from where the momentum and rotary movement are transferred to the working rotors.

The expression of the kinetic energy of the suggested mechanism will be as follows (Bat, Djanilidze and others, 1975, Loytsanskiy, Loureh, 2006):

$$W = W_4 + 3W_2 + W_3 , \quad (9)$$

where W_4 is the kinetic energy of the carrier:

$$W_4 = \frac{I_4 \omega_4^2}{2} ,$$

W_2 is the kinetic energy of the satellite, as they make smooth parallel movement, hence:

$$W_2 = \frac{I_2\omega_2^2}{2} + \frac{m_2 V_{O_1}^2}{2}$$

W_3 is the kinetic energy of the annular rings:

$$W_3 = \frac{I_3\omega_3^2}{2}.$$

The kinetic energy brought to the ring is as follows:

$$W = \frac{I^*\omega_3^2}{2}, \quad (10)$$

where I^* is the momentum of inertia of the mechanism.

Inserting the values into (8) and equaling the right parts of (8) and (10) (the value of V_{O_1} is inserted from the (5)) we will obtain:

$$\frac{I_4\omega_4^2}{2} + 3\left[\frac{I_2\omega_2^2}{2} + \frac{m_2(r_2+r_3)^2\omega_4^2}{2}\right] + \frac{I_3\omega_3^2}{2} = \frac{I^*\cdot\omega_3^2}{2}. \quad (11)$$

After the modification we will get the following for the given momentum of inertia:

$$I^* = I_3 + 3I_2\left(\frac{\omega_2}{\omega_3}\right)^2 + 3m_2(r_2+r_3)^2\left(\frac{\omega_4}{\omega_3}\right)^2 + I_4\cdot\left(\frac{\omega_4}{\omega_3}\right)^2. \quad (12)$$

Results and discussions

M_3 is transferred to the mechanism through 2 half shafts of the 3- annular ring. Besides the centrifugal inertia moment of satellites P_{i2} as external moment factors affect the mechanism which is applied conditionally at O_2 point and the P_{i4} centrifugal inertia moment of carrier 4 which is applied at the center of gravity of the carrier along the longitudinal axis O_3. It is known that:

$$P_{i2} = m_2\omega_4^2\left(r_3 + r_2\right), \qquad P_{i4} = m_4\omega_4^2\left(OO_3\right). \quad (13)$$

The analysis of the problem brings to the carrier, hence to the identification of the M_4 momentum balancing M_3 applied upon the driving grouser wheel.

Let's consider the balance condition of the 3- annular ring (Picture 4):

$$\sum M = 0$$

or

$$M_3 - P_{32}\cdot r_3\cos\alpha = 0, \quad (14)$$

Where α is the angle formed by the normal n-n of the profiles

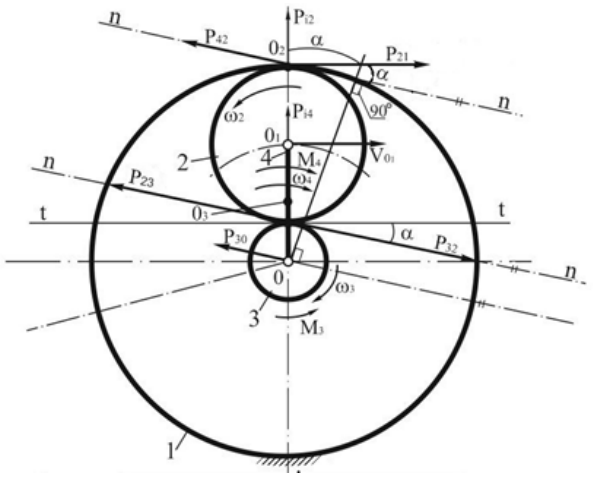

Figure 4. The Scheme of the Dynamic Analysis of the Planetary Mechanism *(composed by the authors).*

of satellite teeth and annular ring and the common tangent t-t of the initial circumferences of those tooth gear. From the (14):

$$P_{32} = \frac{M_3}{r_3\cos\alpha}. \quad (15)$$

From the balance condition of the forces influencing 3-annular ring we define the axial force of that wheel:

$$P_{30} = -P_{32}. \quad (16)$$

Considering the last expression and from the balancing conditions of the forces influencing the satellite we define the correlation force of the satellites and the carrier, P_{24}.

$$\overline{P}_{21} + \overline{P}_{23} + \overline{3P}_{i2} + \overline{P}_{24} = 0,$$

where $P_{21} = -P_{23}\cos\alpha$. Placing the values from the (13) and (15) we will obtain:

$$-P_{23}\cos\alpha - \frac{M_3}{r_3\cos\alpha} + 3m_2\omega_4^2\left(r_3 + r_2\right) + P_{24} = 0, \quad (17)$$

from this $P_{24} = -P_{42}$ is defined. The balancing condition of the carrier defines the balancing momentum M_4.

$$M_4 + P_{42}\cdot\left(r_3 + 2r_2\right)\cos\alpha = 0,$$

where α is the angle formed by P_{42} force direction and the perpendicular taken to that direction from the carrier axis:

$$M_4 = -P_{42}\cdot\left(r_3 + 2r_2\right)\cos\alpha,$$

or by inserting the value of P_{42} from the (17) we will obtain:

$$M_4 = \left[\frac{M_3}{r_3}\left(\frac{1}{\cos\alpha} + 1\right) - 3m_2\omega_4^2\left(r_3 + r_2\right)\right]\cdot\left(r_3 + 2r_2\right)\cos\alpha.$$

The momentum of M_4 from the carrying wheel is applied to

the carrier 4 which through rotation moves the satellites.

For the dynamic analysis of the mechanism as well as the grinding it is necessary to identify the angular acceleration of the carrier. The carrier weight is P_4, satellite – P_2, annular ring – P_3 (Picture 5). The position of any ring of the mechanism is defined by the generalized coordinate φ, for which the Lagrangian formula is the following (Bat, Djanilidze and others, 1975).

$$\frac{d}{dt}\frac{\partial W}{\partial \dot{\varphi}} - \frac{\partial W}{\partial \varphi} = P_{\varphi}. \quad (19)$$

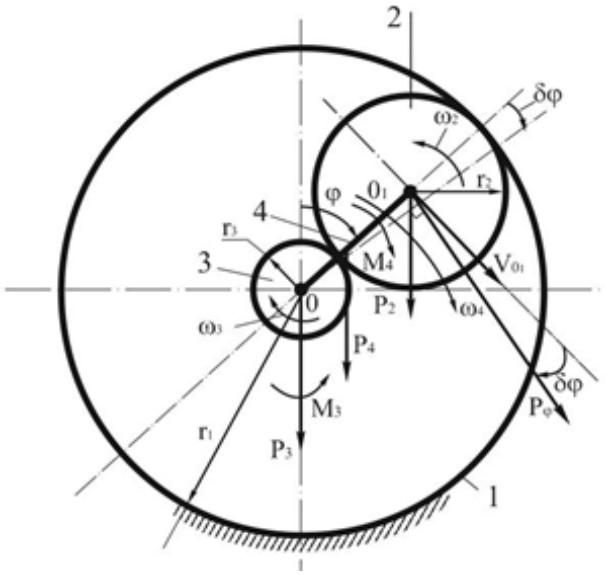

Figure 5. The Scheme of the Identification of the Angular Acceleration of the Carrier in the Planetary Mechanism *(composed by the authors).*

The active forces in the system are P_4, P_2, P_3, and momentum M_4.

Let us give the angle φ elemental growth of δ_φ (clockwise). In order to define the generalized force P_φ, we need to calculate the work done by the active forces influencing the elemental movement δ_φ.

$$\delta_A = M_4 \cdot \delta\varphi + P_4 \cdot \left(\frac{r_3 + r_2}{2}\right) \cdot \sin\varphi \cdot \delta_\varphi + P_2 \cdot (r_3 + r_2)\sin\varphi \cdot \delta_\varphi,$$

or

$$\delta_A = \frac{1}{2}\left[2M_4 + (P_4 + 2P_2)\cdot(r_3 + r_2)\sin\varphi\right]\cdot\delta_\varphi. \quad (20)$$

Taking into consideration that according to the definition $\delta_A = P_\varphi \cdot \delta_\varphi$ we can express (20) in the following way:

$$P_\varphi = \frac{1}{2}\left[2M_4 + (P_4 + 2P_2)\cdot(r_3 + r_2)\sin\varphi\right]. \quad (21)$$

The kinetic energy of the entire mechanism to the given rotation axis of the 4th rim is defined by the following expression ($\varphi = \varphi_4$):

$$W = \frac{I^* \cdot \omega_4^2}{2} = \frac{I^* \cdot \left(\dot{\varphi}\right)^2}{2}. \quad (22)$$

According to the expression (9) the kinetic energy of the entire mechanism will be:

$$W = \frac{I_4\omega_4^2}{2} + \frac{3I_2\omega_2^2}{2} + \frac{3m_2V_{O_1}^2}{2} + \frac{I_3\omega_3^2}{2}, \quad (23)$$

where $I_4 = \frac{1}{3}\cdot\frac{P_4}{g}(r_3 + r_2)^2$, $I_2 = \frac{P_2 r_2^2}{2g}$, $m_2 = \frac{P_2}{g}$,

$V_{O_1} = \omega_2 r_2$ $\quad I_3 = \frac{P_3 \cdot r_3^2}{2g}$.

Taking into account that $\omega_4 = \omega = \dot{\varphi}$, according to (6) and (7) we will have the following expressions for ω_3 and ω_2:

$$\omega_3 = \omega_4\left(1 + \frac{r_1}{r_3}\right) = \frac{(r_1 + r_3)}{r_3}\cdot\dot{\varphi},$$

and

$$\omega_2 = \frac{\omega_4(r_2 + r_3)}{r_2} = \frac{(r_2 + r_3)}{r_2}\cdot\dot{\varphi}.$$

Inserting the values into the (23) we will obtain the following for the kinetic energy:

$$W = \frac{P_4(r_3 + r_2)^2}{6g}\cdot\left(\dot{\varphi}\right)^2 + \frac{3P_2 r_2^2(r_2 + r_3)^2}{4g\cdot r_2^2}\cdot\left(\dot{\varphi}\right)^2 + \frac{3P_2 r_2^2(r_2 + r_3)^2}{2g\cdot r_2^2}\cdot\left(\dot{\varphi}\right)^2 + \frac{P_3 r_3^2(r_1 + r_3)^2}{4g\cdot r_3^2}\cdot\left(\dot{\varphi}\right)^2,$$

or

$$W = \frac{1}{12g}\left[(2P_4 + 27P_2)(r_2 + r_3)^2 + 3P_3(r_1 + r_3)^2\right]\cdot\left(\dot{\varphi}\right)^2. \quad (24)$$

The partial derivative of the kinetic energy according to the generalized velocity $\left(\dot{\varphi}\right)$ will be:

$$\frac{\partial W}{\partial \varphi} = \frac{1}{6g}\left[(2P_4 + 27P_2)(r_2 + r_3)^2 + 3P_3(r_1 + r_3)^2\right]\cdot\dot{\varphi}. \quad (25)$$

Let us derive the obtained result according to the time, we will have:

$$\frac{d}{dt}\frac{\partial W}{\partial \dot{\varphi}} = \frac{1}{6g}\left[\begin{array}{l}\left(2P_4 + 27P_2\right)\cdot \\ \cdot\left(r_2 + r_3\right)^2 + 3P_3\left(r_1 + r_3\right)^2\end{array}\right]\cdot\ddot{\varphi}. \quad (26)$$

Inserting (21) and (26) expressions into the Lagrangian equation and considering that $\frac{\partial W}{\partial \varphi} = 0$ (according to (24) kinetic energy does not depend on the generalized coordinate φ) we will obtain the differential equation of the mechanism movement for the generalized coordinate φ:

$$\frac{1}{6g}\left[\left(2P_4 + 27P_2\right)\left(r_2 + r_3\right)^2 + 3P_3\left(r_1 + r_3\right)^2\right]\cdot\ddot{\varphi} =$$

$$= \frac{1}{2}\left[2M_4 + \left(P_4 + 2P_2\right)\left(r_3 + r_2\right)\sin\varphi\right],$$

where we define the required angular acceleration $\ddot{\varphi}$ of the carrier from:

$$\ddot{\varphi} = 3g\frac{\left[2M_4 + \left(P_4 + 2P_2\right)\left(r_3 + r_2\right)\sin\varphi\right]}{\left[\left(2P_4 + 27P_2\right)\left(r_2 + r_3\right)^2 + 3P_3\left(r_1 + r_3\right)^2\right]}. \quad (27)$$

Based on the expression (27) it can be concluded that for the equal rotation of the grinding rotors of the potato digger, it is necessary that:

$$M_4 = -\frac{\left(P_4 + 2P_2\right)\left(r_3 + r_2\right)\sin\varphi}{2}.$$

This condition stipulates the number and size of the soil grousers on the driving gear wheel rim.

It is evident that the bigger the number of the soil grouser bars on the rim is, the more equal the rotational movement is. But it should be noted that the increase in the number of grouser bars assumes decrease in the inter-bar distance which will definitely bring to the abrupt decline in soil mass resistance and skidding of the carrying gear wheel (Tarverdyan, 2014, Sineokov, Panov, 1977, Golushkevich, 1948). Considering this condition and based on the field and laboratory experiment results it has been established that the circumferential distance between adjacent grouser bars should be bigger than 0.17m (the radius of carrying wheel rim is 0.525 m, grouser length – 0.1 m). In this case the number of the grouser bars is 20. So, that radii of the adjacent grouser bars will form central angle of 180, 20 grouser bars will be installed on the rim, 3 grouser bars will be in touch with the soil simultaneously and the area creating clinging resistance during the movement will actually stay stable.

It should be noted that in field and laboratory experiment we used carrying wheel, the radius of which is 0.25 m, the grouser length – 0.1 m. In that case the number of grouser bars is 10. It is evident that the optimum number (n) of the bars is conditioned by the radius of the carrying wheel R_W. In practical calculations, the approximate number of the grouser bars can be defined in the following correlation:

$$n = 40R_W,$$

where R_W is the wheel radius in meters. The number (n) defined in this way should be rounded up to the closest even number.

Conclusion

The best option of drive gear mechanism of rotary soil crusher in the soil digger is 4-ring planetary mechanism with parasitic satellites, the transmission number of which from the carrying wheel to the working rotors should ensure the throwing V velocity of soil clods at 9-10 m/s (in the discussed case the chosen i transmission number is 8.2).

In the result of kinematic and dynamic analysis of the mechanism theoretical expressions have been derived which give us the opportunity to define the resistance momentum of M_3 of the working rotors and the necessary momentum of M_4 transferred from the clinging tooth gear to its balancing carrier.

The conditions of the equability of the rotation for the working rotors have been identified according to which the angular acceleration of the carrier will be zero or a value very close to it. Based on that condition the necessary weights of the tooth gear and the carrier have been determined.

The necessary number of the grouser bars on the wheel rim was established to exclude the equal rotation and skidding of the clinging drive gear wheel.

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Theoretical Justification of Optimal Geometric and Kinematic Parameters in Moving Parts of Clod-Crusher in Potato Harvester

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ABSTRACT

The impact of geometric forms and sizes of the working parts in the automated clod crusher of the potato harvester on the soil-sticking and motion resistance force, as well as on the clods strike and their throwing velocity have been studied. Theoretic investigations have resulted in the derivation of expressions which enable to determine the resistance force and the clods throwing velocity for cylindrical flat-fronted, cylindrical hemispheric-fronted and conical headed clod crushers.

It has been disclosed that the form of the crusher's working part practically has zero impact on the soil clods throwing velocity; it is a constant value for all considered cases.

Introduction

The study of dynamics of interaction between soil and moving parts of tillage machines (ploughs, cultivators, trench digger) is hitherto an actual issue. Though there are numerous researches (Goryachkin, 1968, Sineokov, Panov, 1977, Tarverdyan, 2014) in this area their theoretical and empiric investigations on designing new soil cultivation machines are insufficient to accurately determine their optimal geometric, kinematic and dynamic parameters. The difficulty in solving the problem is also related to great diversity and variability of the physical-mechanical properties of the soil (ground) in one and the same field.

It is approved that the resistance force p of solid body's (tillage machine working part) sticking motion into the soil can be introduced as a sum of three forces (Goryachkin, 1968, Sineokov, Panov, 1977, Tsytovich, 1983, Tsvetkova, 2004).

$$P = P_1 + P_2 + P_3$$

Where P_1 is the dynamic force resulted from the inertia of the environmental particles. It is assumed that it is directly proportional to the motion velocity square of the moving part v^2. P_2 is the force of environmental viscosity that appears due to overcoming contact forces between the environmental particles and the moving machine part. It is directly proportional to its motion speed V. P_3 is the force of the environmental static resistance, the value of which does not depend on speed, but is determined by the soil strength index.

Thus, P force can be represented as follows:

$$P = Av^2 + Bv + C$$

Where A, B and C are positive constants and the values of which depend on the soil properties and the form and size of the working part.

From that standpoint the issue related to determining the optimal values of the geometrical and kinematic parameters of clod crusher in the potato harvester becomes very urgent.

Materials and methods

Three finger types have been designed for the recommended clod crusher: flat-fronted cylindrical, cylindrical hemispheric-fronted and conical (Tarverdyan, Yesoyan, et. al, 2019). (figure 1):

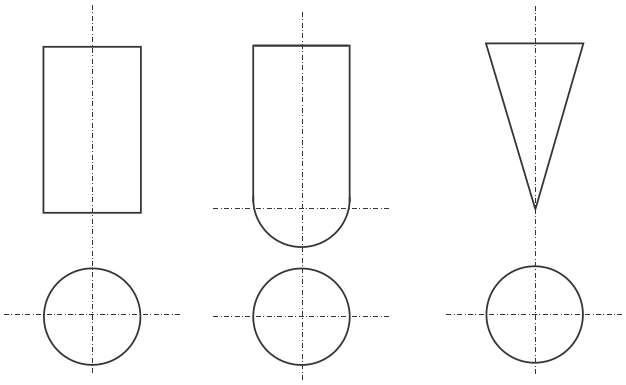

Figure 1. The diagram of experimental fingers of clod crusher in potato harvester.

Testing of different types of crushing fingers is conditioned by the need for the choice of the best option in case of which, the maximum possible clod grinding sizes will entail to the minimum value of traction resistance.

Let's discuss nominated options individually, and then compare the results per sticking force resistance in clod grinding. We will also estimate the perfection of the proposed theory and its application in the design and calculation of other soil tilling machines by comparing theoretical research and experimental results.

Results and discussions

1. Flat-fronted cylindrical crusher.

Obviously, in case of theoretical solution of the problem, first, it is necessary to make assumptions and form a design model. Let's admit that the crusher is an absolutely rigid cylinder with V_0 speed that is vertical to the cylinder axis and strikes into the plane of the soil semi-space. Let's determine the regularity of cylinder's sticking into the soil environment, the latter being a plastic compressible environment.

The experiments have shown that after striking the soil environment is subjected to the wave movement within the volume of semi-space at the striking surface of cylinder, the rest of soil volume practically remains unused (Tsytovich, 1983, Tsvetkova, 2004, Tarverdyan, Khanaghyan, 2016, Knaus, 1968). It is assumed that the striking speed is high and the tangent forces of cylindrical surface can be ignored especially when those forces do not play any particular role in the crushing process.

Upon these assumptions, a flat shock wave spreads from the striking point in soil due to which particles are always in smooth one-dimensional movement. The motion of the soil (clod) between the sticking cylindrical surface and the shock wave is described through the following equation (Tsytovich, 1983, Tsvetkova, 2004, Tarverdyan, Khanaghyan, 2016, Loitsanski, Lurie, 2006):

$$\rho\left(\frac{\partial v}{dt}+v\frac{dv}{dx}\right)=-\frac{\partial p}{dx}\ , \qquad (1)$$

where x is the coordinate that derives from the point of intersection of the axis of the cylinder surface and the plane of the ground (Figure 2);

ρ - the density of the clod

p - the pressure in the cylinder and soil interaction zone

v- the speed of the cylinder front section (or soil particles).

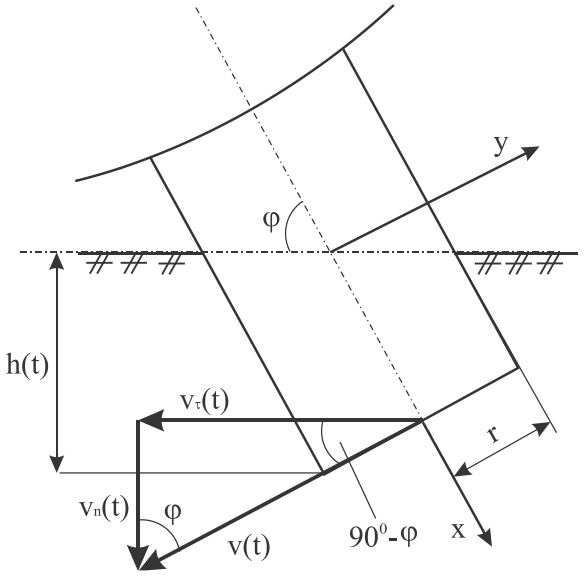

Figure. 2. The diagram of sticking cylindrical clod-crusher *(composed by the authors)*.

As we have noted, the soil is accepted as a plastic compressible environment the density of which changes only on the shock wave. The density beyond the wave is the same for all the particles.

It is confirmed that such an assumption enables to get possibly simple expressions without significant distortion of the final results (Tsitovich, 1983, Tsvetkova, 2004, Vinogradov, 1968).

Due to condition of incompressibility it follows that $\frac{dv}{dx}=0$, therefore the velocity of soil particles is only a time function t: If $h(t)$ is the sticking depth of crusher then:

$$v_n(t)=\dot{h} \qquad \frac{\partial v_n(t)}{\partial t}=\ddot{h}\,, \tag{2}$$

where $v_n(t)=v(t)\cos\varphi$ is the vertical component of speed, φ -the angle of the cylinder axis and the soil surface plane, which changes in $\varphi_0 \div \frac{\pi}{2}$ domain during the rotation of the crusher device and φ_0 is a constructive parameter.

In case of the proposed device: $\varphi_0 = 45°$.

Thus, expression (1) can be presented as follows:

$$\rho\ddot{h}=-\frac{dp}{\partial x}\,. \tag{3}$$

By integrating, we get the following according to X:

$$p=-\rho\ddot{h}\,x+c. \tag{4}$$

On the shock wave at the level of $x=h_1$ coordinate we will have the following for pressure:

$$p_i=-\rho\ddot{h}\,h_i+c\,. \tag{5}$$

On the other hand, the following expressions are derived from the basic laws of motion mechanics on the shock wave (Knaus, 1968, Loitsanski, Lurie, 2006):

$$p_i=\frac{\rho_0\left(\dot{h}\right)^2}{1-k}, \qquad h_i=\frac{h}{1-k} \qquad k=\frac{\rho_0}{\rho}, \tag{6}$$

ρ_0 is the preliminary soil density before the movement. For the section of frontal cylindrical crusher $x=h$, therefore the expression will look like the following :

$$p=-\rho\ddot{h}\,h+C\,. \tag{7}$$

Eliminating integration C constant from (5) and (7) we will have:

$$p=p_i+\rho\ddot{h}\left(h_i-h\right). \tag{8}$$

Using (6) expressions we will get following expression for (8):

$$p=\frac{\rho_0}{1-k}\left[\left(\dot{h}\right)^2+\ddot{h}\,h\right]. \tag{9}$$

The force acting by the soil environment on frontal surface of cylindrical crusher with absolute value will be:

$$P=\frac{A\rho_0}{1-k}\left[\left(\dot{h}\right)^2+\ddot{h}\,h\right]. \tag{10}$$

Where A is the front surface area of the clod crusher. In the considered case it is a circle, therefore:

$$P=\frac{\pi r^2\rho_0}{1-k}\left[\left(\dot{h}\right)^2+\ddot{h}\,h\right]. \tag{11}$$

Usually the second member of the bracket expression is smaller than the first one, so it can be ignored in practical calculations. To effectively break and loosen the clods it is necessary to determine the minimal speed limit in the strike. Let's assign the mass of the working part as M. In this case, we can introduce the equation of motion and crusher sticking into the soil environment as follows:

$$M\ddot{h}=-\frac{\pi r^2\rho_0}{1-k}\left(\dot{h}\right)^2. \tag{12}$$

This equation is brought into the first-degree equation that is easily integrated. As a result we will get:

$$\dot{h}=v_0e^{-\frac{\lambda h}{M}}\,, \quad h=\frac{M}{\lambda}l_n\left(1+\frac{\lambda v_0}{M}t\right), \tag{13}$$

where $\lambda=\frac{\rho_0\pi r^2}{1-k}$:

Since $\dot{h}=v_n(t)$, for the clods' throwing speed $v_\tau(t)$ we will have (Figure 2):

$$v_\tau(t)=v_0tg\phi e^{-\frac{\lambda h}{M}}.$$

The last obtained and (13) expressions allow determining both the striking force and the velocity of particles.

2. Consider the motion regularity and sticking of the working part (crusher) into soil when the corpus of the part is cylindrical and the front part is hemisphere (Figure 3). It should be noted that all the above mentioned hypotheses and assumptions concerning the environment are also used in this case.

Considering the plastic nature of the soil environment deformation, the shock wave in the soil will be very close to the hemisphere surface, consequently the pressure on the latter can be determined through the following expression with some approximation (Tsytovich, 1983, Tsvetkova, 2004, Vinogradov, Semenov, 1968):

$$p=\left(1-\frac{k}{2}\right)\rho_0v_n\cos^2\theta \tag{14}$$

where $v_n=v\cos\varphi$ - is the vertical component of velocity $k=\frac{\rho_0}{\rho}$, the compressibility level of clod, θ is the current

angle composed of the radius of current observed A point of hemisphere and sticking direction:

$$-\frac{\pi}{2} \le \theta \le \frac{\pi}{2}.$$

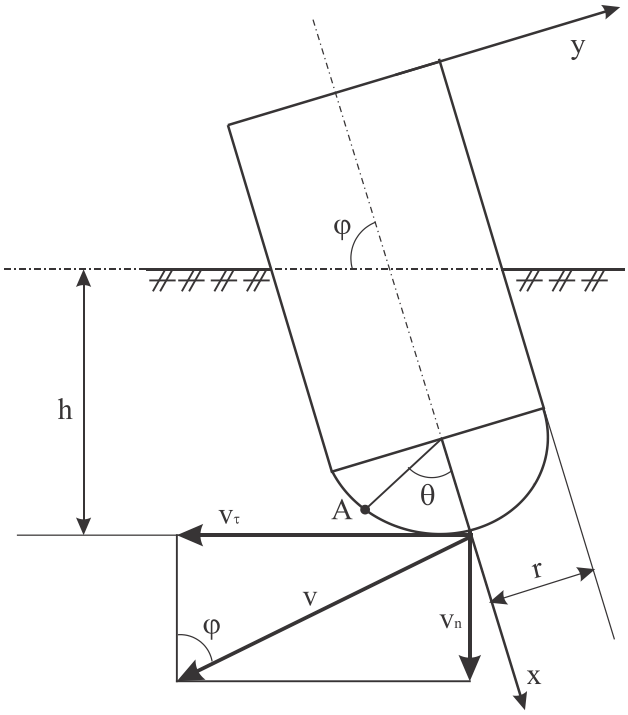

Figure 3. Diagram of clod crusher with hemisphere front *(composed by the authors).*

Consider the sticking case of the crusher when $h < r$. In this case, the current angle θ will be determined by the following expression:

$$\cos\theta = \frac{r-h}{r}. \quad (15)$$

The force of sticking resistance of hemisphere at that moment will be:

$$P = \int_0^{\theta} pds, \quad (16)$$

where $ds = 2r2\sin\theta d\theta$ is the area of the sticking part of the hemisphere surface. By placing the value of the pressure p from the expression (14) and then integrating it, we will have:

$$P = \frac{1}{2}\rho_0 v_n \pi r^2 \left(1-\frac{k}{2}\right)\left(1-\cos^4\theta\right). \quad (17)$$

Taking into account the (15) expression, the (17) one can be presented as follows:

$$P = \frac{1}{2}\rho_0 v_n^2 \pi r^2 \left(1-\frac{k}{2}\right)\left[1-\left(1-\frac{h}{r}\right)^4\right]. \quad (18)$$

During the crusher's further sticking process $h \ge r$ additional pressure affects the frontal hemisphere surface. We obtain the absolute value of the resistance force (18) from the expression assuming that $h = r$:

$$P = \frac{1}{2}\rho_0 v^2 \pi r^2 \left(1-\frac{k}{2}\right). \quad (19)$$

To determine the velocity of the particles of clod we use Newton's second law:

$$\frac{2M}{\pi r^2 \rho_0 \left(1-\frac{k}{2}\right) v}\frac{dv}{dh} = -1+\left(1-\frac{h}{r}\right)^4, \quad (20)$$

where *M* is the mass conveyed by the crusher.

By integrating this expression from initial values $v=v_0$, $h=0$ up to their current values during the sticking process we'll have:

$$\frac{2M}{\pi r^2 \rho_0 \left(1-\frac{k}{2}\right)}\ln\frac{v}{v_0} = h + \frac{r}{5}\left[1-\left(1-\frac{h}{r}\right)^5\right]. \quad (21)$$

In case of h=r, the velocity of particles (21) will be:

$$v = v_0 e^{-\frac{8M}{5\pi r^2 \rho_0\left(1-\frac{k}{2}\right)}}. \quad (22)$$

The throwing speed of clods (figure 3) will be:

$$v_\tau = v_0 tg\phi e^{-\frac{8M}{5\pi r^2 \rho_0\left(1-\frac{k}{2}\right)}}.$$

3. Let's consider the last of the three versions of the clod crushers, that is the sticking and moving regularities of the crusher with conical head in the clod mass.

Let us assume that the crusher with conical head and cylindrical corpus confronts the soil surface and is stuck into it with initial speed v. The cone generator with the soil surface forms β angle, hence the contact surface of conical crusher and clod gets wider with $v_A = v\,ctg\beta$ velocity.

In order to simplify the solution of the task let us make an extra assumption by moving the marginal terms from the surface of the cone body to the horizontal projection of the contact surface (through the comparison of further theoretical and empiric results it will be further shown that this assumption does not have any significant impact). After that, the conical body and

the soil contact area will come forth as a disk surface with *r(t)* radius. Moreover, the *r(t)* radius increases with $v\,ctg\beta$ speed and the disk points generate a smooth one-dimensional motion of the soil particles in the soil plastic compressing environment with *r(t)* velocity vertically down to the bottom.

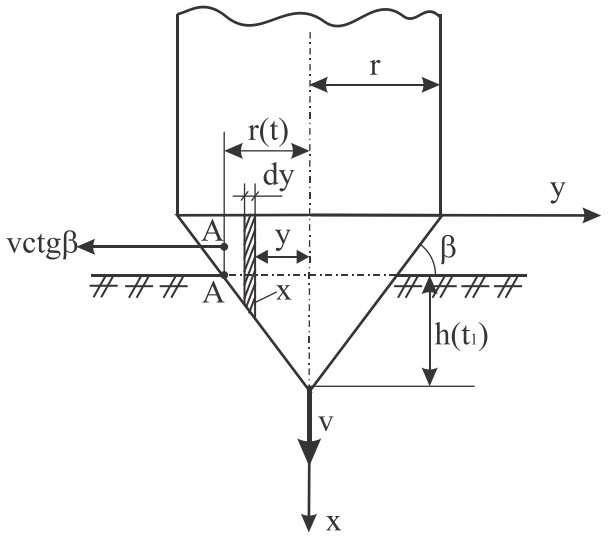

Figure 4. The diagram of the sticking clod crusher with conical head (*composed by the authors*).

In case of equable smooth motion of the soil particles, the environmental pressure affecting the conical surface as of expression will be:

$$p = \frac{\rho_0}{1-k}\left(v(t)^2 + \dot{v}(t)x\right), \qquad (23)$$

where $v(t)$ is the sticking velocity at the *t* moment, *x* is the sticking size of the mentioned disk point at that moment. Let's assume that the particle which is in y distance from disk axis starts the motion at the moment of t_1. In that case we'll have:

$$y = \int_0^{t_1} v\,ctg\beta\,dt_1 = h(t_1)\,ctg\beta, \qquad (24)$$

where $h(t_1)$ is the sticking depth of cone head at $t_1<t$ moment.

The depth of the sticking point $x(t; t_1)$ located in y distance from disk center will be determined through the following expression:

$$x(t; t_1) = \int_{t_1}^{t} v(t)\,dt = h(t) - h(t_1). \qquad (25)$$

The force of the soil environment impact on conical surface will be determined by the following expression:

$$P = \int_0^{h(t)ctg\beta} p\,2\pi y\,dy,$$

or taking into account the expressions (23), (24) and (25):

$$P = \frac{2\pi\rho_0 ctg^2\beta}{1-k}\cdot$$
$$\cdot\left\{v^2(t)\int_0^t h\dot{h}dt_1 - \dot{v}(t)\int_0^t\left[h(t)-h(t_1)\right]\dot{h}(t_1)h(t_1)dt_1\right\}. \qquad (26)$$

After calculating the integrals, the expression of *P* force will look as follows:

$$P = \frac{\pi\rho_0 ctg^2\beta}{1-k}\left\{v^2h^2 - \dot{v}(t)\frac{h^3}{3}\right\}. \qquad (27)$$

As in the previous two cases, we use Newton's second law to determine the sticking regularity:

$$M\frac{dv}{dt} = -\frac{\pi\rho_0 ctg^2\beta}{1-k}\left\{v^2h^2 - \frac{h^3}{3}\frac{dv}{dt}\right\}. \qquad (28)$$

The last expression will be presented in the following form:

$$\frac{M}{v}\frac{dv}{dt} = -\frac{ah^2}{1+\frac{ah^3}{3M}}, \qquad (29)$$

where the following was assigned: $\alpha = \frac{\pi\rho_0 ctg^2\beta}{1-k}$.

The second member of the denominator at the right part of the expression (29) is much smaller than the first one. Thus, ignoring it we can write:

$$\frac{M}{v}\frac{dv}{dt} = -ah^2,$$

whereupon, taking into account the marginal values of velocity we will get the following for the velocity of particles:

$$v = v_0 e^{-\frac{ah^3}{3M}}. \qquad (30)$$

It should be noted that, like in the previous two cases, the crusher fingers get stuck into the variable φ angle of axis slant. In this case, for the throwing velocity in the tangent direction of clods we will have:

$$v_\tau = v_0 tg\phi e^{-\frac{\pi\rho_0 h^3 ctg^2\beta}{3M(1-k)}}.$$

Thus, in the three discussed cases we obtained expressions for the crusher's working part sticking and motion resistance force in the soil, as well as the clods' throwing velocities.

Taking into account the main geometrical and kinematic parameters of the testing machine, theoretical values of throwing velocity in clods and sticking resistance force of the moving part is presented below.

Baseline data: technological speed of potato harvester- 1.2 m/s the radius of moving tire - 0.2 m, crusher's rotor rotation

frequency - $\omega_1 = 4.88\ s^{-1}$, the transfer number of planetary gear - 8.2, the average rotation radius of crusher's working part - R_2=*0.18 m*, rotation frequency- 39.04 s^{-1}, the circular velocity of the working part *7.027 m/s*, *k= 0.40-0.75*, *r*= 0.015 m, $\rho_0 = 1200\ kg/m^3$, *M=0.45 kg*, *φ=60⁰* (for intermediate position).

1. In case of a cylindrical flat- fronted crusher
   P=24.34 N, $v_\tau = 9.76\ m/s$.
2. In case of a cylindrical hemispheric- fronted crusher
   P=15.03 N, $v_\tau = 9.73\ m/s$.
3. In case of conical head crusher
   P=8.91 N, $v_\tau = 9.63\ m/s$.

Conclusion

The geometrical form of the clod crusher's working part of potato harvester does not affect the throwing velocity of clods and is constant in conditions of identifiable kinematic parameters. While the sticking and clod crushing resistance force of the working part changes considerably; the minimum value is achieved in case of conical head crusher.

Thus, the resistance force should be taken as a key indicator in the choice of optimal geometric forms and sizes for the clod crusher. As for more generalized conclusions the results of field experiments of the proposed options are needed.

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Peculiarities of Territorial Land Tenure in Conditions of Community Enlargement

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ABSTRACT

The article considers the peculiarities of territorial land tenure organization based on the example of enlarged communities in Lori marz. Upon the results of the surveys the issues of quantitative changes in the boundaries of the administrative territorial units and their impact on the efficiency increase of land tenure have been assessed. The changes in consolidation coefficient of the community plots and their impact on the economic indices of land utilization have been studied.

To improve the land tenure efficiency it is recommended to amend the RA SCREC decision No. 186-N 2010, which will promote the elimination of various planning and cartographic errors in the cadastral maps and plans.

Introduction

Territorial land tenure is a type of land tenure through which the land fund of administrative units is organized for their targeted and efficient utilization. It is a process and a system of measures to be taken so as to organize, own, use, possess and preserve land areas in various sectors of the economy by means of proper land use organization, regulation, conversion, alienation, land and legislation registration and other land cadastral functions (Yezekyan, Efendyan, 2008).

One of the main objectives of the territorial land tenure is to plan the system of land users or landowners in a way so as to meet the economic, legal and environmental land requirements as set by land legislation and other land-related legal acts (Land Code of the Republic of Armenia, 02.05.2001). Odzun enlarged community in Lori Marz was founded in 2017 as a results of the elections held by the local self-governing bodies. Due to the extension reforms Odzun enlarged community was formed comprising the following rural communities with their administrative and territorial units: Odzun, Arevatsag, Mghart, Hagvi, Aygehat, Tsater, Ardvi, Karmir, Aghek and Amoj. Prior to the extension individual communities within Odzun community, except for Odzun and Arevatsag communities, had a population of less than 500 people. One of the main issues which the newly- established community faces as a result of the extension process is the community land fund registration, which implies obtaining necessary and reliable information on the natural state of the land fund enabling to create the necessary conditions for solving the issues related to the efficient land use. Priority issues include the regulation of land relations and land use, enhancement of investment programs efficiency, development of new land use and preservation programs, assessment of the effectiveness of land users' economic activity, ensuring operative and sustainable land rotation, providing a fair resolution to land-related arguments, provision of necessary land cadastral information to landowners and land users, adjustment of cadastral assessment indices, etc.

Materials and methods

The registration of RA citizens› real estate or any other property rights and the legal and economic consequences thereof are stipulated by the Constitution (RA Law on " State Registration of Property Rights"). However, for the implementation of this process such conditions must be created, so that the constitutional right of state registration, as well as the rights and obligations arising therefrom could be realized.In the established enlarged communities, the solution of this problem is considered to be a top priority and needs urgent resolution.

To understand the complexity of the problem resolution, it is necessary to analize the dynamics of primary registration process in real estate.It is known, that for the first state registration it's necessary to submit the document certifying the right on ownership (excerpts from the decision of the Local Commission for Land Reforms and Privatization, Land Use Certificates, Community Leader decisions, Council of Elders Decisions and other statutory documents) to the State registration authority i.e. real estate plan is needed confirmed by the community leader, as well as the decision of the community leader on restoration of the land allocation bases. After compiling all the necessary documents, the citizen applies to the RA SCREC Customer Service Office adjunct to the government and within four working days receives the Certificate of Real Estate Ownership or a decision on the State Registration rejection. However, due to socio-economic conditions, this process is actually quite complex as the residents of rural communities have very limited social opportunities, and in many cases they avoid the process of state registration. Our research aims to identify the problems encountered during the first state registration of real estate and recommends some ways to overcome them.

The subject of the study was the content of decisions made by Odzun community on recognizing the ownership rights of the citizens related to the first state registration of residential lands and construction sites. Another important issue is the improvement of the land resource management mechanisms in the enlarged communities. One of the most important indicators of territorial land tenure in Odzun community is the community consolidation, which is characterized by consolidation coefficient. It is determined through the following formula:

$$K = \frac{P}{P_1}, \qquad (1)$$

where K is the consolidation coefficient, P_1 - is the squared perimeter of the same area, which is determined through the following formula:

$$P_1 = 2\sqrt{S}. \qquad (2)$$

Results and discussions

As a result of the study of the peculiarities in territorial land tenure at the Odzun enlarged community it has been revealed, that state and local government systems aimed at the effective land resource management operate in Armenia. The systems of the local government and their legally set functions have been formed ever since 1996(RA Act on Local Government, 1996). However, our investigations show, that the regulation of land relations in new conditions depends not only upon the laws, systems and availability of legislative framework, but also on the citizens' mentality and the way they conceive the land and real estate ownership legislation.

Anyway, in order to increase the efficiency of land resource management a number of mechanisms should be contributed to the economy aimed at land relations organization providing the land policy implementation in conditions of the market economy, protection of the land ownership, posession and utilization rights, conduction of a fair tax policy and preservation of land as a natural wealth. Surveys show that the cadastral maps contain a number of errors related to the overlapping of the citizen›s house or land property rights with those of another citizens again recognized by law. Therefore, amendments should be made both in the Cadastral maps and in the registers. The requirements of the Decree No. 186-N, 2010 of the Chairman of RA SCREC should be considered as the grounds for elimination of the revealed errors, according to which the written agreements on behalf of the stakeholders ought to be considered (Decree of the RA SCREC Chairman on Approval of the Decree of Correction of Errors in Cadastral Plans and Maps No. 186-N). If this is impossible the problem should be solved in court not to break the ownership right of the citizens.In conditions of the market economy we consider that economic mechanisms and their efficiency are of utmost importance. Some of the particular regulators among the economic mechanisms are: land tax, payment, pledge value, cadastral price, normative price, market price, various fines for land environment exacerbation and so on. By means of such mechanisms, a number of land relation problems are resolved.

Thus, efficient distribution of land resources among different land users are provided, equal conditions are created between the landowners and land users, the land economic value increases and the incomes of the farmers grow up, as well as favorable conditions are created for enhancing the efficiency of investment policy. Odzun heavily-populated community, formed on November 10, 2017, and comprising 9 settlements, is located on the left bank of the Debed River, at an altitude of 1125 m above the sea level, 8 km southwest from Alaverdi town. The distance from the territorial center is 47 km. The administrative area of the community is 16659.44 hectares, with a population of 7995 people as of January 1, 2019. The land balance is shown in the figures.

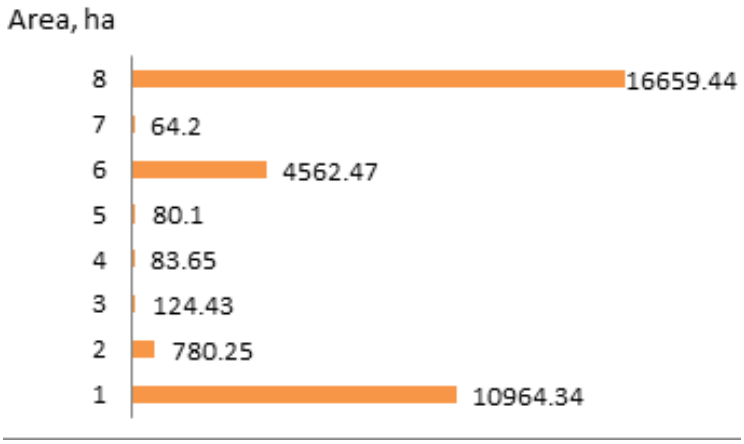

Figure 1. Odzun community land fund per its target use (*composed by the author*).
1 agricultural lands, 2-settlements, 3-industry, mining lands, 4-transport, communication 5-specially protected, 6-forest, 7-water, 8-total.

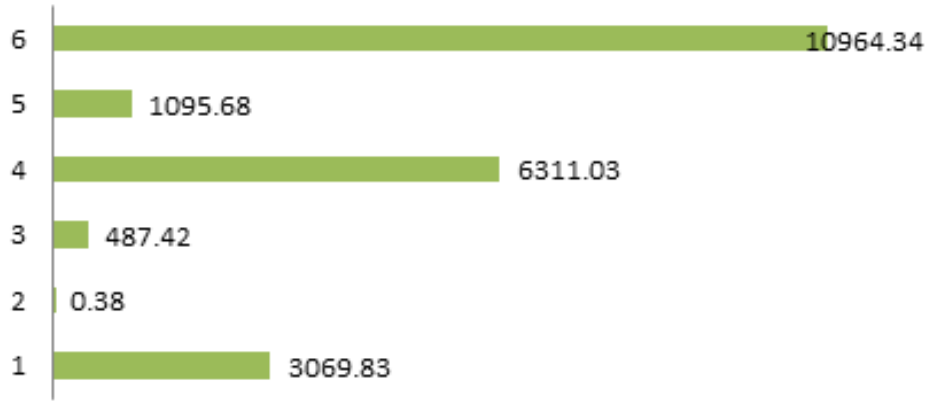

Figure 2. Structure of agricultural lands in Odzun community (*composed by the author*).
1-arable lands, 2-orchards, 3-grasslands, 4-pastures, 5-other land types, 6- total.

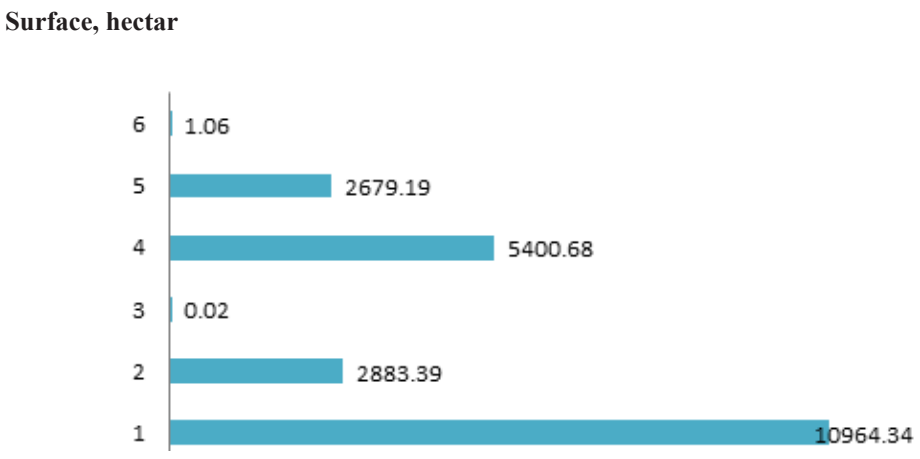

Figure 3. Structure of agricultural lands of Odzun community per equity entities (*composed by the author*).
1-total, 2-citizens, 3-legal entity, 4-community, 5-state, 6-special status.

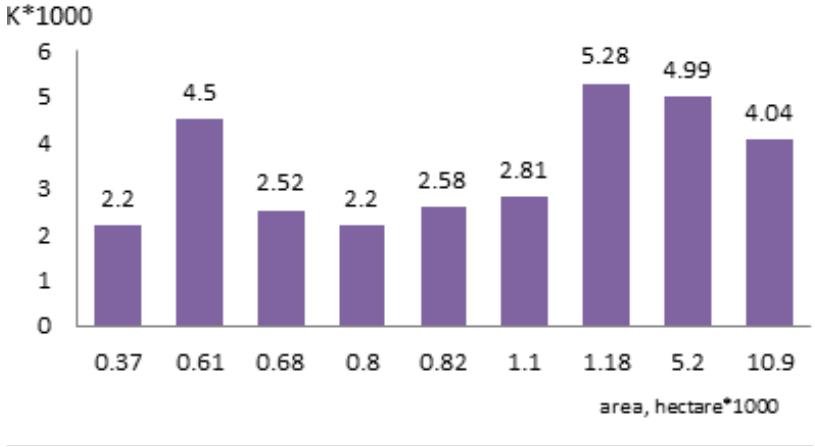

Figure 4. Dependence of the consolidation coefficient upon the area of the administrative sites in the individual communities within Odzun enlarged community (*composed by the author*).

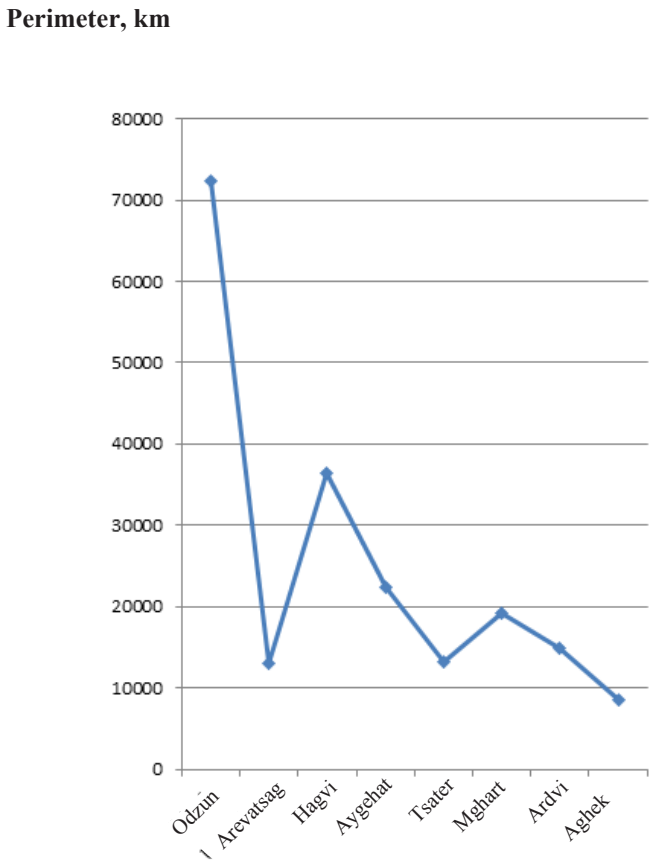

Figure 5. The extension of the individual administrative boundaries included in Odzun enlarged community (*composed by the author*).

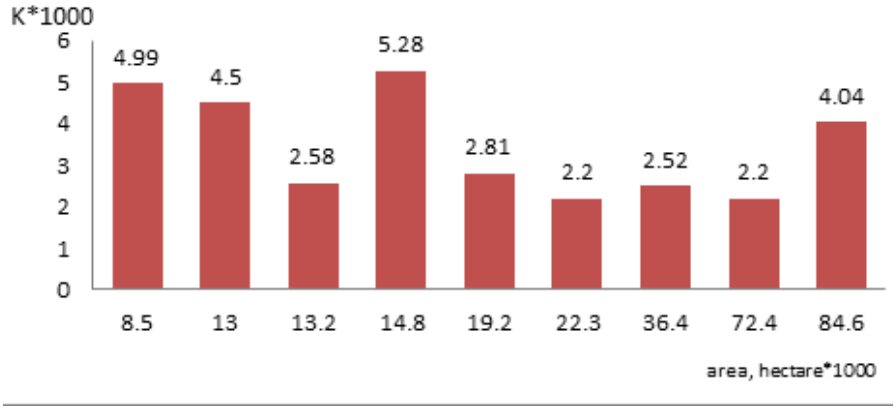

Figure 6. Dependence of the consolidation coefficient of the individual administrative regions included in Odzun enlarged community upon the perimeter of the individual administrative boundaries. (*composed by the author*).

From the analysis of the diagrams in the figures 4, 5 and 6 it becomes clear, that the alteration of consolidation factor of separate communities involved in the Odzun extended community, depending on the perimeter and surface of administrative boundaries undergoes respective changes from 2.2 up to 5.28, which means that the consolidation factor of the enlarged communities deviates by 3.7-times on the average. This circumstance can have an essential impact on the land utilization efficiency.

Conclusion

After the enlargement of the Odzun community the perimeter of its administrative boundary made 84646 m. Before the enlargement, the extension of the administrative boundaries of individual communities was 200011 m, which means that after the enlargement the administrative boundaries of the community were reduced in 2.4 times. Under the same circumstance the coefficient of consolidation ranges from 2.2 to 4.9. The average consolidation coefficient made 3.3. From the economic perspectives it turns out, that the expenses paid for the borders' description can be reduced at least in 2.4 times due to the community enlargement. To enhance the efficiency of real estate management and to regulate land relations in the enlarged communities, we recommend making amendments in the 2010 Decision 186-N of the State Committee on Real Estate which will enable to eliminate the flaws related to land ownership, land use and land registration as well as other types of planning and mapping errors in the cadastral maps and plans within the scope of the territorial land tenure.

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Issues of Effective Agricultural Land Utilization and Land Tenure Organization in Conditions of Lori Marz

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ABSTRACT

Based on the contemporary requirements for the development of effective ways for agricultural land utilization, a comprehensive analysis of land utilization planning and cadastral land evaluation was carried out by the example of Lori region. Results of the analysis of cadastral land evaluation and actual land use indices have disclosed the uncultivated land areas and their consecutive economic damage size caused to the community per agricultural land types. Based on the analysis, the coefficient values for identifying the conventional areas of the community land types have been derived which can make the evaluation process of land utilization measurable and comparable.

Introduction

One of the most important prerequisites for developing efficient methods of agricultural land use is the process of its proper planning and accurate cadastral evaluation (Yezekyan, 2002). Solving the problem from this standpoint leads first to the adjustment of cadastral evaluation indices and organization of their efficient use. Cadastral land evaluation implies obtaining objective and high-quality information on the land allocation, its qualitative properties, economic indices, and their further application in the current and future agricultural activities (Yezekyan, 2002, 2003). The cadastral evaluation indices serve as a background to organize land tax, land rent, as well as optimal land use systems, and to resolve problems related to relevant allocation of agricultural crops and many other issues (Yezekyan, 2003). In order to clarify and solve the abovementioned issues the Lori Marz Land Fund and Land Use System have been taken as the research objects upon the example of the land cadastral surveys on the evaluation indices of the farms involved in the administrative area of Odzun enlarged community (Official website of Lori regional administration, Cadastral evaluation of Armenian SSR lands, 1984).

Materials and methods

One of the strategic development goals of the Lori marz (region) is the development of intensive agriculture, a key component of which is the expansion of irrigated land areas and land tenure organization through their effective utilization. The irrigated land area in the administrative territory of Lori marz makes 9553.8 hectares, out of which 2000 hectares belong to residential and 7553.8 hectares to agricultural land types. 70 % of the irrigated land area is owned by citizens and 8.4 % is community-owned. The arable lands are dominant in

the structure of agricultural lands making 7193.6 hectares or 95.2 %, perennial plantations make 237.8 hectares or 3.1 %, and the grasslands occupy 122.4 hectares or 1.7 %. The arable lands in the whole region make up to 42037.4 hectares, out of which 9553.8 hectares or 22.7 % are considered irrigated, 67.4 % of the arable lands are considered to be the citizens' ownership, while 31.7 % are community-owned; the rest land areas are owned by state and foreign organizations. 42.2 % of the community-owned lands are rented out, the other 57.8 % are not put in use or rented out (Yezekyan,2003).

The structure of the region's land types which are currently out of agricultural use is introduced in figure.

The same situation is observed regarding the effective agricultural land use in Odzun community. About 50 % of 461.43 hectares of community land is not used; out of 198.73 hectares of the community-owned grasslands 178.02 hectares or 90 % are not put in use or rented out. 1898 hectares of pastures or 43 % of community-owned pastures have been left out of use.

The qualitative evaluation indices of the lands in Odzun community have served as bases for the study of land-cadastral indices, the total results of which are summed up in table 1 (Yezekyan, 2002,2003, Cadastral evaluation of Armenian SSR lands. 1984).

Based on the land cadastral evaluation indices and the research results on the actual land use, it has become clear, that there are multiple reasons for the agricultural lands to be left out of use, which have to be analyzed and synthesized for their further eradication. The lack of legislative bases and criteria for the classification of unused agricultural lands is an urgent problem to be solved.

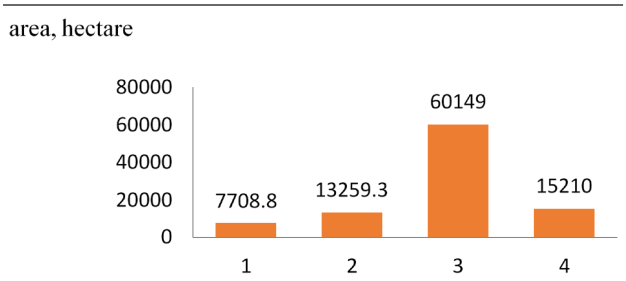

Figure. Structure of the land types out of agricultural use in Lori marz: *1-arable lands, 2-grasslands, 3-pastures, 4-other land types*.

Table 1. Summary results of the qualitative evaluation of the agricultural land types in Odzun community*

		Land evaluation group	Numbers of land contours					Area, ha	Average grade of bonitation
Arable land			Lower Debed-Aghstev						
		IV	22.19	44-47	12. 18	20	37-43	197.5	33
		III	1-2	5. 6	13. 21	16-17	31-36	298.1	48
		II	3-4	7-11	14-15			302.4	74
		I	23-30					297.4	81
		Total arable land						1095.4	61
		Upper Debed-Aghstev							
		V	90	81-89				42.6	20
		IV	78 51 74-76	67 62-63 69	56-61 72-73 48-50	70-71 53-55 66	64-65 52	288.5	29
		III	68	79-80	77			24.5	46
		Total arable land						355.6	31
Total arable land								1451.0	54
Evaluation zone			Forest-Meadow						
Natural Pasture	pasture	IV	99 98	100 91	96 101	95	93	460.0 1138.0	27 43
		Total pasture						1598.0	39
	Grassland	IV	94	92				177	37
		III	97					173	53
		Total grassland						350.0	45

**Land cadaster evaluation by "Haypethoghshin" Institute,1985.*

Table 2. The general evaluation indices of arable lands for the zones of Lower Debed-Aghstev, Upper Debed-Aghstev at Lori marz, Odzun community*

Number of contour according to the evaluation map	Area, ha	Code of the grading zone	Code of the land type and its sub-type	Score of the land type and its sub-type	Final score of the land type and its sub-type /5*20/	The main land properties					Average score according to the land properties (6+7+8+9+10+11)/6	Correction coefficient						Depth of the ground waters	Climate factor	Final grading score after the correction coefficients (12*13*14*16*17*18*19)
						Strength of the humus horizon	Humus content	Mechanical composition	Water-Proof aggregates	PH-in the water extract		Rockiness rate	Erosion rate	Sloping degree	Salinization and alkalization degree	Cementation degree	Humidity degree			
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
1-2	7.3	11	2	66	66	60	70	70	50	80	66	0.8	0.8	0.9	1	1	1	1	1	42
3-4	65.1	11	2	66	66	80	70	70	70	80	73	1	1	0.9	1	1	1	1	1	73
5	30.0	11	2	66	66	60	70	70	70	80	69	0.8	0.8	0.9	1	1	1	1	1	44
6	39.7	11	2	66	66	60	70	70	70	80	69	0.8	0.8	0.9	1	1	1	1	1	44
7-11	200.4	11	3	75	75	80	70	70	70	80	74	1	1	0.9	1	1	1	1	1	74
12	9.0	11	2	66	66	60	80	70	70	80	71	0.8	0.5	0.9	1	1	1	1	1	28
13	26.9	11	2	66	66	60	80	70	70	80	71	0.8	0.8	0.9	1	1	1	1	1	45
14-15	36.9	11	4	74	74	80	70	70	70	100	77	1	1	0.9	1	1	1	1	1	77
16-17	33.5	11	4	74	74	60	70	70	70	100	74	0.8	0.8	0.9	1	1	1	1	1	47
18	32.4	11	4	74	74	60	70	70	100	100	79	0.8	0.6	0.9	1	1	1	1	1	38
19	14.8	11	4	74	74	60	70	70	100	100	79	0.6	0.5	0.8	1	1	1	1	1	24

** Land cadaster evaluation by "Haypethoghshin" Institute, 1985.*

Results and discussions

The results of research carried out by the example of the enlarged Odzun community in Lori region show that the unused state of agricultural land types is very often related to the lack of material and technical resources, low profitability of agricultural activities, incompliance of agro-technical rules, insufficient capacity of the irrigation network and limited water resources (Yezekyan, 2002, 2003). Rural farms organize the land use not from the perspective of growing the most efficient crops in the given soils, but they do it randomly cultivating the least costly and low price crops. Hardly ever any pre-sowing activities such as soil loosening, fertilization, surface reclamation of natural rangelands or orchard treatment are implemented. The established sowing norms are roughly violated in the arable lands, as a result of which at least 40 % - 50 % of arable lands get deprived of the corresponding crops, perennial plantations are characterized by sparsity, grasslands are not timely mowed per plant development phases and the remote pastures appear in a totally abandoned state.

As a result of land use mismanagement, the soils are subjected to degradation causing soil erosion, fertility decline and desertification. There is no regional and community monitoring activities on land protection and control so as to disclose the uncultivated and unused land areas.

In order to estimate the economic damage of agricultural lands left unused due to various reasons in the rural communities, we estimated the value of cadastral net income in 3092.5 hectares of unused land areas in conditions of Odzun enlarged community according to land evaluation groups and land types. The results are summarized in tables 3,4,5 and 6.

Table 3. Loss of cadastral income from uncultivated irrigated lands*

Land type	Irrigated		Area, ha	Total, AMD
	Class	Cadastral net income, AMD		
Arable land	2	64291	176.3	11334503
	3	51425	36.8	1892440
	4	38579	5.8	219900,3
	5	19280	11.6	223648
Total	-	-	230.5	13670492

Table 4. Loss of cadastral income from uncultivated arid lands*

Land type	Arid		Area, ha	Total, AMD
	Class	Cadastral net income, AMD		
Arable land	2	-	-	-
	3	36001	64.6	2325665
	4	25713	74.9	1925904
	5	9009	84.5	761260.5
Total	-	22378	224	5012829

Table 5. Loss of cadastral income from the unused grasslands*

Land type	Arid		Area, ha	Total, AMD
	Class	Income, AMD		
Grassland	2	6429	160	1028640
	3	-	-	
	4	190	190	36100
	5	-	-	
Total	-		350	1064740

Table 6. Loss of cadastral income from the unused pastures*

Land type	Arid		Area, ha	Total, AMD
	Class	Cadastral net income, AMD		
Pasture	2	6429	110	707190
	3	4501	419	1885919
	4	3213	1759	5651667
Total	-	-	2288	8244776

** Composed by the authors*

Thus, due to failure of land cultivation, the annual economic damage to the community makes 27992837 AMD, which is 9051 AMD per 1 hectare. Based on the land qualitative evaluation indices, we can identify the concept of conventional area in the land tenure sector which reflects the ratio of efficient area and the physical surface of the land type. The estimations are summed up in tables 7,8 and 9.

Table 7. Estimation of the conventional area in the arable lands*

Physical surface, ha	Bonitation grade	Cadastral comparative area, ha	Conventional area per unit of physical surface, ha
197.5	33	65.175	
298.1	48	143.088	
302.4	74	223.776	
297.4	81	240.894	
1095.4		672.933	0.614326274

Table 8. Estimation of the conventional area in the grasslands*

Physical surface, ha	Bonitation grade	Grading surface	100 grade	Cadastral comparative area, ha	Conventional area, ha
177	37	6549	100	65.49	0.37
173	53	9169	101	90.78	0.52
350	90	15718	201	156.27	0.45

** Composed by the authors*

Table 9. Estimation of the conventional area in the pastures*

Physical surface, ha	Bonitation grade	Grading surface	100 grade	Cadastral comparative area, ha	Conventional area, ha
460	27	12420	100	124.2	0.27
1138	43	48934	100	489.34	0.43
1598					0.35

** Composed by the authors*

Conclusion

Based on the result analyses of the land use surveys conducted for the development of effective ways of agricultural lands utilization, the uncultivated land areas and their consecutive economic damage size caused to the community per agricultural land types has been revealed. It has been disclosed that it makes 13670492 AMD for irrigated arable lands, 5012829 AMD for arid arable lands, 1064740 AMD for grasslands, 8244776 AMD for pastures and the total economic damage makes 27992837 AMD with 9051 AMD per hectare. Based on the analysis, the coefficient values for identifying the conventional areas of the community land types have been derived which make 0.61 for the arable lands, 0.45 and 0.35 for the grasslands and pastures respectively.

Based on the aforementioned conclusions it is recommended to take the coefficients identified for the determination of conventional areas of the agricultural land types as a background when planning the agricultural development indicators in conditions of Lori region. The recommended methodology can be also applied for the increase of land use efficiency in the other regions of Armenia.

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Interrelations of Ethics and Management in Business

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ABSTRACT

Nowadays, the only key to survive in the competitive market is to understand all marketing rules and aspects. The most crucial concepts in this field are related to managerial, ethical and economic issues and the interrelations of these three indicators. Ethical issues are not only directly connected with businesses, but also compose corporations' activities in accordance with global marketing regulations. By means of ethical issues managers can make SWOT analysis to overcome the problems inside and beyond the corporations. In this study the author attempts to show the correlation of these three indicators by regression and Spearman's analysis as statistical approaches.

Introduction

Nowadays many managers may consider that ethical issues are not too much related to managers' decision making and are not too much effective in the management process. But the fact is that they are exactly correlated; the concept of managerial ethics shows this correlation rather obviously. It is an obvious fact that management is a core element for any corporation to reach its goals which are economic growth and benefits. On the other hand, upon the study of some well-known corporations which didn't pay sufficient attention to ethical issues in management field and thus doomed to failure we initiated to make a survey related to the significance and necessity of ethics and its impact on management process, consequently on the solution of economic issues.

Materials and methods

Qualitative, statistical and applied researches have been conducted. It implies that the results which have been derived from this research can be applied in reality. The aim of this research is to show the correlation of ethical issues and management in business. To show this correlation more clearly the methods related to data collection, modeling, mathematical fraction and Spearman's correlation analysis have been used. For in-depth analyses we have conducted surveys in Central Bank of Iran, Tehran branch. It was selected as the case study in this survey due to its importance among financial institutes worldwide. Customers and shareholders are considered as the main assets for the banks. Thus, in this survey, 36 loyal customers with more than 10 years' loyalty to this bank have been questioned about the reason of their loyalty according to the ethical indicators mentioned in the following sector. The questions were ranked from 5 points to 1 point; the calculations were done by means of SPSS and Minitab software according to the data derived from the questionnaires. The models which the author suggests are the following:

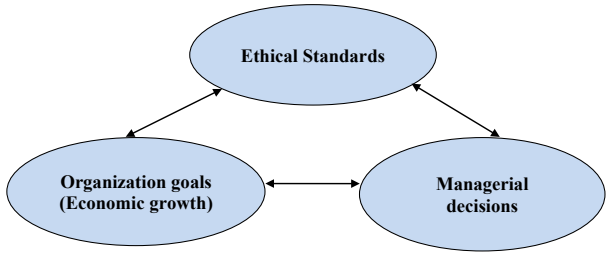

Figure 1. Ethics, management and economic correlations (*composed by the author*).

This model shows the close interrelations between ethical standards, managerial decisions and organization's goals. It emphasizes the crucial role of ethical issues within an organization. Individuals in an organization will not be able to cooperate properly to meet the organizational goals without considering ethical issues.

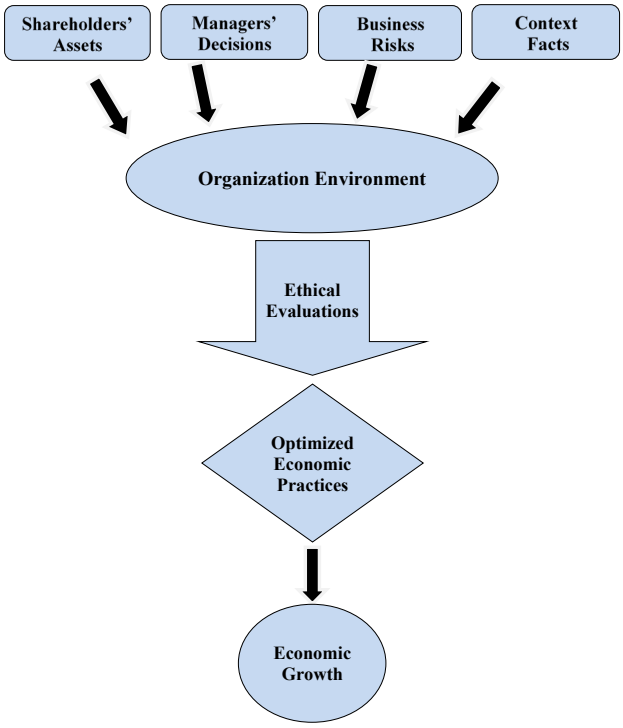

Figure 2. Ethical model to have optimized economic practices (*composed by the author*).

We can show the effectiveness and importance of ethics in small and huge enterprises as in the model of Figure 2. If we assume the organization activity as a mechanism, its inputs which are practiced in this procedure can be considered as the following: shareholders' assets, managers' decisions, business risks and context facts. After the needed procedure is accomplished, its results enter the next phase, namely ethical evaluation phase. This phase controls the results according to external and internal ethical issues in the management and economic field. If the results are ethical, we will have optimized ethical economic practices. At the final phase, these ethical economic practices will lead to economic growth which is the goal of any organization.

Results and discussions

Managerial ethics is a set of principles and rules stated by the upper management that define what is right and what is wrong in an organization (Terry, Cooper, 1994). In fact it is the guideline that helps direct a lower manager's decisions in the scope of his or her job when a conflict of values is presented. It is clear that without considering these values and standards, not only the individuals but also the groups in an organization will not be able to cooperate properly to reach the organization's goals, namely- economic growth.

Ethical issues are closely connected with economic issues. To understand the concept of this interrelation we should first understand the ethics indicators. Generally we can divide ethics indicators into two parts:

Internal ethics indicators, which are ethics enforcement inside the corporation and external ethics indicators, which are ethics enforcement outside the corporation (e.g. global marketing).

Some of the most important internal ethics indicators are explained below:

- Enforced pressure to compromise organizational standards: this kind of pressure is a leading indicator of the potential for future workplace conduct.
- Observed misconduct: it is the most fundamental indicator of whether employees follow the rules and regulations and live out a firm's core values.
- Reporting of observed misconduct: reporting allows leaders to address and fix ethical workplace issues since management cannot address problems it does not know about. Consequently, the availability of anonymous and/ or confidential reporting mechanisms is an important component for promoting an ethical workplace. Management should clearly convey the availability of such reporting methods, encourage their use and ensure tipsters that they will be protected if they make a report (Rezayi manesh, 2018).

External ethics indicators are those which influence the process of enterprise in the market. Ignoring these ethics can lead to serious harmful consequences for the whole corporation. Some of these indicators are:

➢ *Manipulating accounts*

Most companies are involved in the cooking of their books to hoodwink investors, lenders and end-consumers. They tweak

their financial reports to show inflated profits and lowered depreciation. This makes investors think that the company is faring well, and they end up buying more stocks from the share market (Terry, Cooper, 1994).

➢ *Misleading product information*

Many companies promote injurious products with misleading information that can be harmful to consumers or the environment, purely for the sake of improving the bottom-line (Terry, Cooper, 1994).

➢ *Unfair competition*

Defamation of a competitor, misappropriation of their trade secrets, and trade mark infringement – all these fall under unfair competition which gives a wrong impression to the consumers about the competitor and its products. It is not wrong to use a competitor's name in the marketing material, but it should not deplore the company or its products (Lowton, 2000).

Provision of models for different size enterprises concerning the ethical indicators can be considered as a helpful tool for managers. In any organization there are many important economic decisions which must be taken. These decisions must be taken for the benefit of the whole corporation and not only for individual(s). But the fact is that the economic domain is very broad - from small enterprises, like individual businesses and trades, to huge corporations - and consequently the ethical roles and their effectiveness in these different domains are different as well (Carrol, 1990).

Let's take an individual trade as an example. In such an enterprise, the shareholder and manager are usually the same and the rate of required workforce is usually lower than that of in a huge corporation. Thus, the role of internal and external ethics in such enterprises is less significant than in huge ones. While in the huge corporations, such as financial institutes (e.g. banks), there are a great number of employees and a great stress is put on the internal ethics to manage and lead the corporation. On the other hand the need of external ethics is also a must here, because these corporations have international enterprises and activities and must follow the international ethical standards to survive.

In fact if we consider these relations as a mathematical correlation we can suggest the following fraction: (fraction is composed by the author):

$$\text{Economic growth } \alpha \ \frac{\text{Management factors} * \text{Economic factors}}{\text{Unethical issues}}$$

Economic growth is directly proportional to economic and management indicators and is inversely proportional to unethical issues. While the unethical issues decrease, because it is located in denominator of the fraction, the numerator of the fraction increases and the economic growth will increase subsequently.

The Effects of Observance of Managers' Professional Ethics on Bank Customers' Loyalty

When developing business field and competitiveness the organizations sometimes face with the harmful risk of losing customers in recent decades. Therefore, considering the effects of different kinds of business ethics, such as behavior and interaction of employees with customers, has become more important than before. In this regard managerial ethics is of high significance. It controls all standards within and outside an organization to keep the customers satisfied with services and prevent the risk of losing them.

This study attempts to show that preserving old customers and establishing a strong relationship with a new customer ensures the survival of the mentioned bank among other competitors. It also confirms the claims of experts in this field, that the cost of keeping current customers is far lower than that of attracting new ones. It is necessary for banks to ensure their survival in a competitive market by providing a precise definition of the concept of loyalty and applying realistic methods to achieve their high goals. According to the results of some researches, observance of ethical considerations in managers and employees' behaviors has a major impact on customers' loyalty to the products and services of the institutions (Hill & Alexander, 2000).

To have a better understanding we have examined the interrelation of ethical issues and customers' loyalty in the target community.

The number of customers was due to statistical standards of random samples. We have examined this interrelation through Spearman's analysis in the target community.

Spearman's correlation analysis

After suggesting the ratio between two variables as in the model of figure 2, we have tried to measure the impact of managers' professional ethics on customers' loyalty. Eight hypotheses have been considered:

H0: There is no significant relationship between observing managers' ethics and customers' loyalty in banking system.

H1: Observing ethical principles and professional behavior of managers with customer's loyalty has a significant relationship.

H2: Enforced pressure to compromise organizational standards by managers has a significant relationship with the loyalty of the customers.

H3: Observed misconduct by managers has a significant relationship with customer's loyalty.

H4: Reporting the observed misconduct to mangers has a significant relationship with customer's loyalty.

H5: Manipulating accounts by the mangers has a significant relationship with customer's loyalty.

H6: Misleading product information by the mangers has a significant relationship with customer's loyalty.

H7: Unfair competition of the company mangers has a significant relationship with customer's loyalty.

The correlation test results are shown below:

Table 1: Results from Spearman's correlation coefficient (N=36)*

Ethical indicators	Correlation	Sig
Enforce pressure to observe standards	0.721	0.000
Observed misconducts	0.709	0.000
Reporting of misconducts	0.702	0.000
Manipulating accounts	0.690	0.000
Misleading information	0.678	0.000
Unfair competition	0.632	0.000

* *Composed by the author*.

From the results of correlation between managers' ethical issues and customers' loyalty, it can be concluded that, since the level of significance is less than 1% (p<1%), all managerial ethics indicators have a significant relationship with customers' loyalty and all assumptions are confirmed in this study.

The most vivid correlation is related to "enforce pressure to observe standards" and the least correlation is related to "unfair competition".

Regression calculation

Now we'll try to find regression for "enforce pressure to observe standards" as an independent variable and loyalty as dependent variable. Basic formulae for calculating regression line parameters are presented below (Rawlings, Pantula, Dickey, 1998):

$$y = \alpha x + \beta,$$

$$\beta = \frac{n\sum XY - \sum X \sum Y}{n\sum X^2 - \left(\sum X\right)^2} \quad \text{or}$$

$$\beta = \frac{\sum\left(X - \overline{X}\right)\left(Y - \overline{Y}\right)}{n\sum (X - \overline{X})^2},$$

$$\alpha = \overline{y} - \beta \overline{X}.$$

As we have large database we use Minitab to calculate α, β. So we obtain α =3.5 and β = 2.8. Regression line can be utilized to assess the strength of the relationship between variables and for modeling the future relationship between them.

Table 2. Statistical description of ethical indicators in the target community*

Indicator	Max. Degree	Min. Degree	Standard Deviation	Average
Enforce pressure to observe standards	5	3	0.04810	3.921
Observed misconducts	5	2.8	0.04467	3.703
Reporting of misconducts	5	2.6	0.04883	3.623
Manipulating accounts	5	1.98	0.04557	3.477
Misleading information	5	1.80	0.04432	3.345
Unfair competition	5	1.58	0.04138	3.178

* *Composed by the author*.

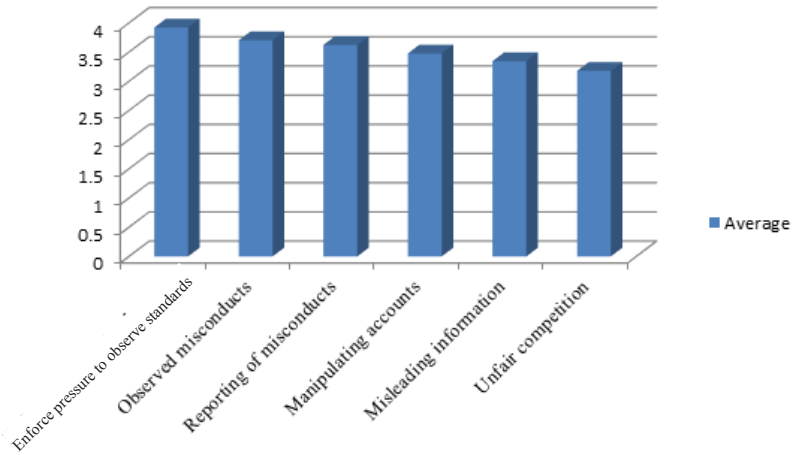

Figure 3. The average degrees of managers' ethical issues in accordance to customers' loyalty (*composed by the author*).

The results of the distribution of the questionnaires in the target community indicating the ranking of the components of professional ethics in the company are shown in table 2 and figure 3.

Conclusion

- There are crucial correlations between ethical issues and management within corporations. Corporations will not be able to see their goals without considering the ethical issues.
- Managers should clarify ethics and classify them elaborately to make SWOT analyses to overcome the problems where it is necessary.
- Both internal and external issues are crucial in corporations' activities and the supervision of these ethical implementations is within the scope of managers' responsibilities.
- Managers should have enough managerial competences to evaluate the implementation of ethical issues with different methodologies (e.g. questionnaires distribution) in the specific fixed periods (e.g. monthly or annually) to become aware of the implementation weaknesses in details as soon as possible.

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Changes and Reclamation Ways of Agricultural Lands at the Artik City and its Neighboring Rural Communities

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ABSTRACT

The impact of floods and wastes of closed stone ore at the Artik city on its urban agricultural land areas and on those of neighboring rural communities has been studied in the current article. The study has revealed, that in conditions of global climate changes the soil of the mentioned communities have undergone serious degradation due to the adverse effect of the closed stone ore wastes and floods. Recommendations presented per communities have been already contributed by the EPIU, at the RA Ministry of Environment, while the surface reclamation activities for the meadows will start from May, 2020. The implementation of the mentioned activities will lead to the prevention of the soil degradation in the mentioned communities and to the increase of soil fertility by 30.0 %-45.0 %.

Introduction

Human economic activity, particularly mismanagement of natural resources, causes many negative phenomena in the natural environment, e.g. destroyed natural balance, poor sustainability in global ecosystem, deteriorated biodiversity and human living environment, unpredictable current and future processes in biosocial systems (due to global climate changes- tornadoes, floods, mudflows and desertification).

In Armenia only 7.0-7.5 thousand hectares of land area is operating under the conditions of stone residual materials. These wastes are constantly polluting the air, water and land areas of the mentioned settlements through the winds, hurricanes and flooding causing considerable damage to the vegetation and fauna of these regions.

The most commonly used stone material is Artik's tuff. Since 1928 the mechanized tuff mining has been implemented at the Artik mine site and more than 51 million cubic meters of tuff materials have been mined up to date, out of which only 30 %-40 % were used as a construction material and the other part was discharged into the environment as a waste (Gabrielyan, et. al, 2017, Galstyan& Mkrtchyan, 2013).

About 30.0-35.0 mln m^3 dumps discharged into environment throughout more than 90 years of continuous mechanized mining have become the reason of not only industrial "desert" formation with scarce weed vegetation but also resulted in stone dust and flood sediments due to improper exploitation of the mentioned stone mining sites. As a result the productivity of natural and agro-ecological systems considerably decreases: the intensity of photosynthesis conducted by plants is getting lower, air and water transparency of arable lands is becoming poorer, the content of humus is decreasing,

productivity of lands and livestock is depleting. (Galstyan, 2018, Galstyan, 2016).

Taking into account the aforementioned circumstances and the decision of climate change adaptation foundation board on the development of a complete document package for the program of "Artik city closed stone ore dumps and floods management" it was decided to carry out the following activities considering the phenomenon of global climate change and adaptation capacities of natural and agricultural landscapes: studying the status of arable lands, degraded pastures and hay lands of the Artik city, as well as Vardaqar, Harich and Nahapetavan rural communities affected by the dust and floods of stone ores; demonstrating these areas schematically and proposing a package of interventions that would improve the productivity of arable lands, pastures and hay lands, as well as livestock of the mentioned communities (Sayadyan, 1999).

Materials and methods

To explore the state of arable lands, pastures and hay lands of the Artik city, as well as that of Vardakar, Harich and Nahapetavan rural communities, to compare the degradation rate for the two periods, i.e. before and after mass land privatization in the RA (1991), as well as to determine the degree of stone ore dust influence on degradation we have performed visual, cartographic, field and laboratory researches on soil genetics and fertility. When determining the degree of degradation of natural grasslands we were guided by the requirements of the "Guidelines for the Preparation and Implementation of Sustainable Management Plans for Pastures and Hay Lands". Quantitative and qualitative composition of plant varieties per unit area of pastures and grasslands have been estimated, whereby the degradation rate of meadows in % on the background of non-degraded ones has been identified and calculated (Tovmasyan, 2015).

Soil samples were taken from community arable lands, pastures and hay lands to determine the content of humus, environmental reaction (PH) and available nutrients (NPK), then these indices were compared with the agrochemical indices of non-degraded or exemplary agricultural plots and the degradation rate (degree) of these lands were determined.

Laboratory analyses of soils were carried out by universal methods, which are based on the methods of agrochemical analyses described by B.A.Yagodin (Yagodin, et. al, 1989).

Humus content was determined upon I.V. Tyurin`s method with the help of phenylanthranilic acid through titration method, CO_2 (carbonates) - through gaz measurement method (calcimeters) with 10 % hydrochloric acid application. The soil solution reaction (PH) was determined through electro-potentiometric method, the total nitrogen was determined through Kjeldahl method, and the easyly hydrolysed nitrogen – with the methods of I.V. Tyurin and M.M.Kononov. The content of the mobile phosphorus was determined according to the methods of Arrhenius and Machigin, and that of the exchangeable potassium - by means of Maslova's methods.

Results and discussions

Upon the results of the complex survey it has been found out that mountainous-meadow (9.3 thous. ha), meadow-steppe (3.5 thous. ha) and black-soil (31.5 thous.ha) types are involved in 44.3 thousand hectares of the overall land areas at Artik region, that are mainly formed on the background of weathered substances of andesite-dacites and tuffs (soil-formation maternal substances), where according to the studies of R.A. Edilyan and others (1990) 4 % -6 % humus is accumulated in the black soils and the moisture capacity is relatively lower. In arable lands, especially on the slopes, the humus content is lower than in virgin lands; depending on the degree of erosion, the aspect of the slope and their usage character the humus content varies from 3.0 %-3.5 %, in individual places up to 5.0 %-6.0 % (Hayrapetyan, 2000, Melkonyan, et. al, 2004. Atlas of soils of Armenia, 1990).

According to the referenced researchers, in the black soil areas the soil reaction is mainly neutral and the PH fluctuates within 7 value. The arable lands have been deprived of good structure as a result of non-regular cultivation and are generally characterized by weakly viscous or powder-forming strains. Before the last decade of the 20th century these lands were rich in total nitrogen (0.15 %-0.35 %), phosphorus (0.15 %-0.26 %) and potassium (1 %-2 %), but now they are poorly and moderately provided with available nitrogen and phosphorus, and well provided with potassium.

As a result of the laboratory analysis of soil samples taken from the administrative areas of the Artik city, Vardaqar, Harich and Nahapetavan rural communities, it was found out that the environmental response (PH) in the Artik urban community and Vardaqar rural community is 7.5-7.6 (low alkaline), and in the arable lands of Harich and Nahapetavan communities PH equals to 7.1-7.3 i.e. the environment response (PH) fluctuates from neutral to low alkaline domains (Table 1). In the mentioned arable lands, the content of humus per communities varies between 2.6 %-3.3 %, and the content of easily hydrolyzed nitrogen and available phosphorus is negligible, respectively, between 2.0 mg-2.9 mg and 1.9 mg-3,6 mg in 100 g soil i.e. they are poorly provided with the mentioned elements and averagely provided with potassium, i.e. the content of potassium in 100 g soil is 23.0 mg-29.0 mg.

Comparing the current agronomic and agrochemical indices of the mentioned arable land areas with the similar indices fixed in the 1990s of the 20th century and with those of the non-degraded arable lands in these communites, it should be noted that those areas of arable lands that were closer to Artik's tuff stone ore, have been subjected to deep degradation as a result of the negative impacts caused by wastes, heavy rainfalls, flood sediments and global climate change. Thus these areas have been singled out per communities and marked out on the large-scale maps with the recommendations of the needed reclamation works.

Table 1. Average agrochemical indicators of arable land areas in communities*

Community	Soil sampling depth, cm	Humus, %	Connected CO_2, %	General nitrogen, %	PH Water extract	The amount of available nutrients (mg) in 100 g soil		
						N	P_2O_5	K_2O
Artik	0-25	2,9	0,75	0,14	7,5	2,7	2,9	28,0
Vardaqar	0-25	2,7	0,81	0,15	7,6	2,9	1,9	27,0
Harich	0-25	2,6	0,27	0,13	7,1	2,0	3,1	29,0
Nahapetavan	0-25	3,3	0,62	0,16	7,3	2,8	3,6	23,0
Non-degraded arable lands	0-25	4,2	0,83	0,26	7,1	5,52	4,81	32,0

Table 2. Average agrochemical indicators and number of plant stems per 1 m^2 in pastures and hay lands of the communities*

Community	In pastures							In hay lands						
	Humus	Connected CO_2, %	PH in Water extract	Available nutrients in mg/ 100g soil			The number of stems on $1m^2$	Humus	Connected CO_2,	PH in Water extract	Available nutrients in mg / 100g soil			The number of stems on $1m^2$
				N	P_2O_5	K_2O					N	P_2O_5	K_2O	
Artik	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vardaqar	2,9	0,82	7,6	3,1	2,7	27,0	290	3,1	0,99	7,0	5,9	6,4	33,0	784
Harich	3,1	0,79	7,5	3,0	2,9	30,0	270	3,3	0,82	7,6	2,9	3,1	29,0	300
Nahapetavan	3,2	0,76	7,5	2,9	3,2	29,0	284	5,4	0,98	7,2	6,2	6,1	32,0	765
Non-degraded	4,9	1,04	7,1	5,4	5,0	34,0	800	5,3	1,02	7,0	6,1	6,3	33,0	892

**Composed by the authors*

By conducting similar studies in the pastures and hay lands of the mentioned communities, it has been found out that the content of nutrients and humus available in the pastures of Vardaqar, Harich and Nahapetavan and also those of the Harich haylands has decreased as compared to non-degraded areas (Table 2). Thus, if the humus content in the non-degraded pastures was 4.9 %, in the hay lands - 5.3 %, then in the degraded pastures this index was 2.9 % in Vardaqar, 3.2 % in Nahapetavan and in the Harich pasturelands it was 3.1 %, while in individual grasslands it made 3.3 %. The content of nitrogen, phosphorus and potassium in degraded pastures, as compared to non-degraded ones, has dropped respectively by 2.6 %, 46.0 % and 20.6 % in Vardaqar; 44.4 %, 47.8 % and 11.8 %, in Nahapetavan. The decrease of NPK in Harich pastures was 46.3 %, 42.0 % and 13.0 % and in the hay lands - 52.5 %, 50.8 % and 12.1 % respectively.

The study of pasture and vegetation cover in the mentioned communities has shown that if in case of non-degraded pastures there are 800 stems on 1 m^2 and 892 ones - in hay lands, then in degraded and strongly degraded pastures of Vardaqar community there are 290 plant stems on 1 m^2 and in Nahapetavan its number makes 284, while in Harich degraded pastures the number of plant stems on $1m^2$ is 270 and in hay lands - 300. At the same time, studies have revealed that almost no degradation has been observed in the hay lands of the communities of Vardaqar and Nahapetavan, where the number of plants is 784 n / m^2 respectively.

Conclusion

Thus, as a result of studies, it has been revealed that 300 hectares of arable land areas, 190 hectares of pastures and 15 hectares of hay lands in Artik city and the neighboring Vardaqar, Harich and Nahapetavan rural communities have been subjected to deep degradation due to the impacts of floods and closed stone ore at Artik city, as well as other anthropogenic activities (Table 3).

Table 3. The degraded agricultural lands to be reclaimed*

N.	Community	Degraded land area, ha		
		Arable land	Pasture	Hay land
1	Artik	132	-	-
2	Vardaqar	28	55	-
3	Harich	60	70	15
4	Nahapetavan	80	65	-
Total		300	190	15

**Composed by the authors*

So, it is recommended to implement the following activities to reclaim the abovementioned land areas:

1. Implementation of an effective fertilization system (Organomix 1 t / ha + $N_{100}P_{90}K_{90}$) for the fertility increase of the community arable lands and organization of deep ploughing for the loosening of compacted middle soil stratum.

2. Application of fertilization system (organomix 1 t/ha + $N_{50}P_{50}K_{30}$) in the degraded pastures and hay lands.

3. Sowing perennial plants (fescue, clover, sainfoin) with 16 kg/ha dose.

4. Prohibiting pasture use for 1-2 years in the reclaimed pasturelands.

Recommendations made on the degraded arable lands per communities have been already contributed by the Environmental Projects Implementation Unit, at the RA Ministry of Environment, while the surface reclamation activities for the meadows will start from May, 2020. The implementation of the mentioned activities will lead to the prevention of the soil degradation in the mentioned communities and to the increase of soil productivity by 30.0 %-45.0 %.

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Opportunities of Getting Ecologically Safe Yield in the Technogenic Soils Contaminated with Heavy Metals under the Influence of the Complex Fertilizer Produced from Alumo-Silicates

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ABSTRACT

The article considers the study results on getting ecologically clean potato yield in the technogenic-contaminated soils through the application of the processed dacite tuff (PDT).

The experiments were carried out in the technogenic-contaminated soils at the Noyemberyan province, where the amounts of mobile heavy metals were considerably high.

The obtained results have disclosed that in case of using PDT (variants-$N_{120}P_{90}K_{90\text{-}150}$ (PDT)) in the fertilization system the content of heavy metals in the tubers was in the permissible limit. While in the control and $N_{120}P_{90}K_{90}$ (KCl) variants their amounts were much higher than the identified allowable threshold limits.

Introduction

Food safety is an extremely important issue of strategic significance for each country and for its solution various innovative and advanced technologies are contributed to the agricultural production to increase the crops yield capacity; new land areas are used for cultivation through irrigation and reclamation activities and many other similar measures are taken (Galstyan, 2007, Avagyan, 1970, Mirzakhanyan, et. al, 2005, Mineev, et. al, 2006). When solving the mentioned problem it is of utmost importance that the resulted yield should be ecologically safe or have an ecologically permissible purity. Nevertheless, some intensively used agricultural land areas are located in the neighborhood of mining enterprises and have been contaminated with extremely harmful heavy metals and other harmful substances (Galstyan, 2007, Grigoryan, 1989) through irrigation water and dust. The consumption of yield resulted from such areas causes heavy and very often incurable diseases. Therefore, the development of the technologies for getting ecologically secure yield from

the contaminated land areas is very actual and stems from the population's strategic requirements for the food safety assurance and improvement.

Materials and methods

The studies were carried out in conditions of Haghtanak community of Noyemberyan province at Tavush region in 2016-2018. The field experiments were implemented through the following scheme:

Without fertilization (control),

$N_{120}P_{90}$ (background),

Background $+K_{90}$ (KCl)

Background $+K_{90}$ (PDT)

Background $+K_{120}$ (PDT)

Background $+K_{150}$ (PDT)

The experiments were organized in three repetitions; the size of each experimental bed made 50 m^2. The plants necessary phenological observations, surveys and calculations were conducted during the vegetation. The yield was calculated through the method of real/actual harvest weighing, the data were subjected to the mathematical analyses with the identification of the trial error (Ex %) and the least significant difference ($LSD_{0.95}$ g) through the method of dispersion analysis (Khachatryan, 2002).

The evaluation of the tubers' quality was carried out through the accepted method (Yagodin, et. al, 1989). The content of heavy metals in the soil samples and tubers was determined through the atomic adsorption analyzer.

The content of soil humus, carbonates and mobile nutrients was also determined through the method common in our country (Yagodin, et. al, 1989).

The contamination rate of the experimental plots with heavy metals was identified according to the scale established by K.V. Grigoryan (Grigoryan, 1989).

Results and discussions

The mechanical composition of the soils for field experiments was light and clayey, the humus content in the genetic horizon "A" made 3.00 %, in "B" horizon – 0.82 %, carbonate content was 2.5 %-4.6 %, the environmental reaction (pH) was almost neutral -7.2-7.5. They were poorly provided with easily hydrolyzed nitrogen and phosphorus /4.5 mg-4.9 mg N and 2.2 mg-2.8 mg P_2O_5/, while the provision with the exchangeable potassium was average making 31.0 mg - 34.0 mg K_2O in 100 g soil.

The experimental plots in Haghtanak and Derdzavan communities of Noyemberyan province are contaminated with heavy metals; particularly they are strongly contaminated with most dangerous pollutants Cu, Pb, Zn and Mn, while averagely contaminated with Mo (Table 1). Such situation is conditioned by the contamination with the heavy metals resulted from the nearby mining industries and river waters which are used for irrigation.

Table 1. Contamination rate of experimental plots with heavy metals (mg/kg in soil) according to the scale recommended by K.V. Grigoryan*

Genetic horizons, cm	Cu	Pb	Zn	Mn	Mo
A O-25	221.6 39.7	50.3 5.9	71.3 21.7	832.0 249.0	13.8 2.13
B_1 25-46	113.6 24.7	84.1 10.0	65.6 16.1	1259.6 268.0	11.4 2.0

Note - The total quantity of an element is indicated in numerator, while the content of mobile forms is indicated in denominator.

** Composed by the authors*

Thus, the reclamation of so much contaminated soils in irrigation conditions is of utmost agro-technical and economic significance for the country with scarce land resources. The reclamation activities will enable to use the mentioned land areas for cultivation and to get ecologically clean yield. Our earlier studies have shown that it is possible to implement these activities upon the application of fertilizers which are endowed with high absorption capacity and are able to absorb the mobile forms of heavy metals from the environment. So, the quantity of heavy metals decrease in favor of plants, therefore ecologically permissible clean yield can be harvested from the mentioned land areas.

The processed dacite tuff (PDT) is considered to be such fertilizer, which is fabricated from the potassium-rich alumo-silicates through thermo-chemical method (Yeritsyan, et. al, 1993, Avagyan, 1970). This fertilizer contains potassium, calcium, magnesium, phosphorus and amorphous silicon dioxide and it is also endowed with such indirect positive features which are not characteristic to the mineral fertilizers. For instance its water absorption capacity makes about 500 %, absorption capacity- 45 mg/eq -50 mg/eq in 100 g soil. Moreover, it imbibes heavy metals in non-exchangeable way, while the light metals and NH_4^+ and NO_3^- ions in an exchangeable way. The studies on the mentioned PDT properties have been conducted during the experiments of potato fertilization. The obtained data have shown that the application of the fertilizers has considerably influenced both the tuber's yield capacity (Table 2) and the tuber's qualitative indicators, as well as the content of its heavy metals (Table 3).

Table 2. The effect of the dosages of complex fertilizer (PDT) fabricated from alumo-silicates on the potato yield quantity and yield structure (average for 2016-2018)*

N/N	Variants	Yield of potato tubers per years, c/ha			Average yield for three years, c/ha	Yield surplus		Tubers' marketability, %	Average weight of the commercial tubers, g
		2016	2017	2018		c/ha	%		
1.	Control (without fertilization)	152.0	164.0	159.0	158.3	-	-	66.8	69.8
2.	$N_{120}P_{90}$ -background	275.0	262.0	270.0	269.0	110.7	69.9	81.2	87.2
3.	background + K_{90} (KCl)	294.0	286.0	293.0	291.0	132.7	83.8	82.4	89.0
4.	background + K_{90} (PDT)	300.0	308.0	310.0	306.0	147.7	93.3	89.2	93.0
5.	background + K_{120} (PDT)	329.0	323.0	339.0	330.0	172.0	108.7	93.6	95.6
6.	background + K_{150} (PDT)	332.0	336.0	341.0	336.3	178.0	112,4	93.8	96.0
	Sx, %	3.9	2.9	3.7					
	LSD $_{0.95}$, g	8.8	7.3	8.4					

Table 3. Effect of the application dosages of the complex fertilizer (PDT) fabricated from the alumo-silicates on the qualitative indices of the potato tubers and on the content of heavy metals*

№	Variants	The average for the three years								
		Dry substance, %	Starch, %	Vitamin C mg %	Nitrates, mg/kg	mg/kg in dry substance				
						Cu	Pb	Zn	Mn	Mo
1	Control (without fertilization)	25.4	20.2	7.4	130.0	15.8	3.8	12.2	21.4	1.2
2	$N_{120}P_{-90}$ - background	26.6	24.4	8.0	165.0	13.9	3.2	12.3	20.9	1.3
3	background +K_{90} (KCL)	27.2	24.6	8.2	170.0	14.0	3.2	12.0	21.5	1.2
4	background +K_{90} (PDT)	27.6	25.0	8.2	170.0	10.0	2.2	8.9	6.4	0.7
5	background +K_{120} (PDT)	28.9	25.6	8.3	175.0	8.5	1.7	6.0	5.2	0.5
6	background +K_{150} (PDT)	29.0	25.6	8.2	175.0	8.0	1.5	6.1	4.9	0.4

** Composed by the authors*

So, according to the 3-year average data the yield surplus in the fertilized variant has made 110.7 c/ha-178.0 c/ha against the control one. Besides, less surplus is observed in the background variant with the amount of 110.7 c/ha and then in the variant (132.7 c/ha) where potassium chloride together with the background (background + K_{90}KCl) has been used.

Meanwhile, when PDT was introduced together with the background, the tuber's yield surplus has made 147.7 c/ha-178.0 c/ha. Thus, when using PDT with same amount as the potassium the former has provided 15.0 c/ha (5.2 %) more yield as compared to that of the potassium chloride. In case of increasing the amount of PDT the yield capacity has increased even more amounting to 330.0 c/ha-336.3 c/ha, anyhow, the yield in the variant of background + K120 (PDT) is the most reliable. We believe that the high effect of PDT on the yield capacity is conditioned by the latter's positive side effects, i.e. it reclaims the soil properties and plants' nutrition (Yeritsyan, et. al, 1993, Yeritsyan &Farsiyan, 2016).

Application of PDT has also exerted a positive impact on the dry substance and starch content of the tuber's commercial yield (Table 3).

So, it is very important to harvest such yield from the soils contaminated with heavy metals in which the content of heavy metals is in the permissible threshold. In this regard some investigations have been carried out, which testify that the application of PDT on the background of nitrogenous and phosphoric fertilizers has significantly promoted the reduction of the content of heavy metals in the tubers. Besides, the reduction reached to the point, where the content of heavy metals is in the allowable threshold. It should be supplemented that this phenomenon is more obvious in the variants where PDT has been used with high dosages.

Thus, according to the average data for the three years, if in the variants of without fertilization, background, background + K_{90}(KCl) the content of heavy metals(Cu, Pb, Zn, Mn, Mo) exceeds the allowable threshold stated for those metals in 1.8-3.5 times (due to the Koltsov's scale, 1995, Agriecology, textbook-2000), then in case of applying PDT on the background of $N_{120}P_{90}$ with $K_{90,120}$ and $_{150}$ kg/ha dosages the content of heavy metals has decreased in 2.0 times for copper and zinc and for plumbum, molybdenum and manganese in 2.5, 4.3 and 3.0 times respectively. That is, in case of PDT application the content of the mentioned heavy metals in the yield is within the range of allowable threshold, therefore such yield is considered to be ecologically safe (Table 3).

Conclusion

Summing up the three-year results of the field and laboratory trials on potato we can draw the following conclusions:

1. The complex fertilizer PDT fabricated from the potassium-rich alumo-silicates is endowed with high absorption capacity; hence, it prevents the loss of nitrogen from the soil and imbibes the heavy metals, significantly decreasing their access into the yield fruits.

2. On the nitrogenous and phosphoric background the doses of K90 (PDT) and K150 (PDT) have provided a yield surplus with the amount of 15,0-45,3 c/ha as compared to that of recorded in KCl; at the same time a yield meeting the requirements of the eco-toxicological standards is produced.

3. It is recommended to use the processed dacite tuff for getting potato yield in compliance with the requirements of food safety standards in the strongly technogenically contaminated land areas.

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The Distribution and Ecology of Liriomyza Sativae (Blanchard 1938) in the Entomofauna of Artsakh Republic

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ABSTRACT

In 2018, for the first time in Artsakh, we've conducted research studies on leaf miners in the village Ivanyan at Askeran region. The objective of the work is to study the composition of leaf miner species, their distribution and eco-biological features. The results of the study have revealed the polyphagous species Liriomyza sativae. In this work we introduce the external structure of the species, its development peculiarities, as well as the length and location of miners (larvae feeding results) on the leaves of different vegetable crops.

Introduction

The distribution of entomofauna at the Artsakh Republic, which is promoted by the moderate climate conditions and geographical location of the Republic is rich and varied. However in our country we need serious entomological investigation. Agromyzidae is a large family of dipterans including more than 3.000 species belonging to 30 genera, widely distributed throughout the world (Spencer, 1989). Leaf miner flies are important agricultural pests worldwide, and cause both direct and indirect damage to plants. Nowadays, we don't have information about the leaf miner flies (Diptera: Agromyzidae), and especially about the ecology, biology, distribution, reproduction, growth and development of the species L. sativae, which belongs to the genus Liriomyza. So, in the current article, we have made attempts to introduce some results of observation related to L. sativae.

Artsakh Republic is an agricultural country where vegetable growing is the leading branch. The reason of various studies of this species is urgent and actual, because it's considered one of the most important pests in agriculture.

Materials and methods

The collected data and implemented observations have served as a material for our study launched from 2018 up to 2019. As the study area we've chosen the Ivanyan village which is located in the Askeran region of the Artsakh Republic. Leave samples infested with leaf miners were collected in spring, summer and autumn of the experimental years. Investigations of the given species have been carried out on various cultivated crops. For the sample collection and their future study we have used classical zoological methods (Martin Hering, E. 1951, Spencer, et al., 1986). To determine the presence of larvae under leaf epidermis, as well as for the study of formed mines on the leaves we used magnifying

glass. And we used digital microscopes of XSZ-0800 and ADSM302 types to study the external structure of the flies.

To find out the distribution of the L. sativae, we conducted ecological observations in the chosen areas in different seasons and months of the year. To identify the species we used different identification guidelines (Bey-Bienko, G. 1970, Spencer, et al., 1986).

Results and discussions

The fauna of invertebrate animals in Artsakh has not been studied at all. In this work, for the first time we introduce our own observations on L.sativae-one of the species of the Agromyzidae family. Today the cultivation of vegetable crops in Artsakh is growing rapidly, which naturally creates favorable conditions for the widespread distribution of discussed species in almost all zones of the republic. However, the observations were made in the Ivanyan village, which is located at an altitude of 580-600 m above the sea level (Figure 1).

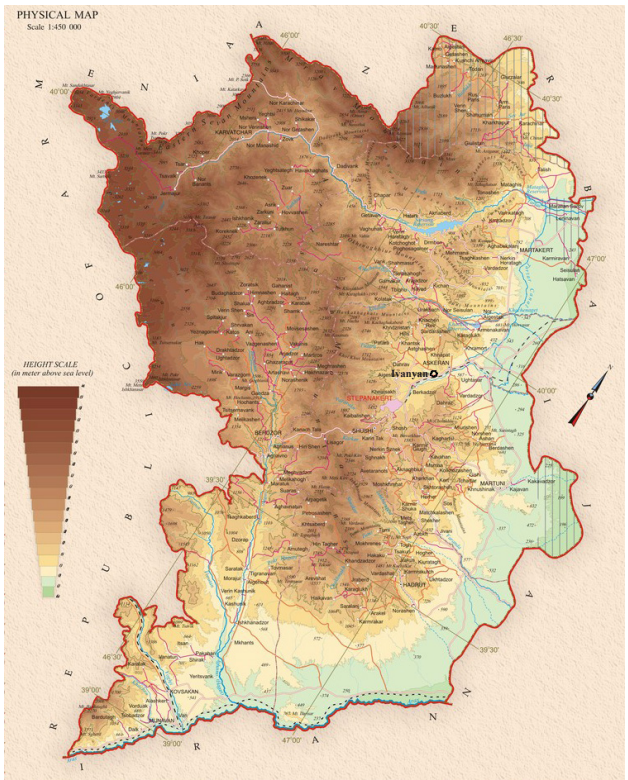

Figure 1. Ivanyan village on the map of the Artsakh Republic

The selected area has moderate climatic conditions, and we chose different vegetable crops as a target study object. Thus, L. sativae has different length of mines and larval development stages at the different plant species, and depending on particular plant the mines (the result of larvae feeding) are developed either on the front or the back side of the leaf blade. For example, the mines' length on the pepper (Capsicum L, 1753) leaves varies between 6.4 cm-10.5cm, the pupa develops within 9-10 days, and the mines are frequently formed on the back side (dorsal) of the leaves. The mines' length on the cucumber (Cucumis sativus L., 1753) leaves is 6.8 cm -12.8 cm, pupa development lasts 8-11 days, and mines are only formed on the front side (ventral) of the leaves. The mines' length on the tomato (Solanum lycopersicum L., 1753) leaves is 8.2 cm-10 cm, pupa develops in 8-10 days; mines appear only on the front side of the leaves. The length of the mines on the bean (Phaseolus vulgaris L., 1753) leaves varies from 6 cm-9.5 cm, pupal stage lasts 8-11 days, mines are found only on the front side of the leaves. On the pumpkin (Cucurbita L., 1753) leaves the length of the mine is 9.3 cm-10 cm, pupa development lasts 9-10 days, and mines are only formed on the front side of the leaves. The larvae-bearing leaves of the discussed crops were kept in separate jars each, under constant environmental conditions with 23˚C -24˚C temperature and 79 ± 2 % relative humidity. On the leaves of all plants the larval stage lasts 4-5 days, they form irregular serpentine mines and frass in threads on the right or left side of the mine.

The pupa development observations show that there are no significant differences in its development stages among the above mentioned plant species. In our opinion, it is conditioned by the necessary air temperature (26 ˚C -27˚C) and relative air humidity (70 %-75 %) (Table).

Larvae are often easily visible within the mine where they remove the mesophyll between upper surfaces of leaf. Larva is a colorless and headless maggot up to 2 mm in length when fully grown. Black mouthparts are apparent in all instars. The irregular mine increases in width from about 0.25 mm to about 1.5 mm as the larva matures (Figure 2).

Figure 2. Mines of L. sativae on the cucumber (Cucumis sativus L.) leaf

Table. Summary of the development features of L. Sativae and mine characteristics*

Scientific names of plants	Larval stage, days 23 ˚C -24˚C 79 ± 2% RH	Pupal stage, days 26 ˚C -27˚C 70%-75% RH	Type of mine	Mine length, cm	Mines' location on the leaves	Type of frass
Capsicum L., 1753	4-5	9-10	irregular serpentine	6.4-10.5	ventral side and dorsal side	threadlike
Cucumis sativus L., 1753	4-5	8-11	irregular serpentine	6.8-12.8	only ventral side	threadlike
Solanum lycopersicum L., 1753	4-5	8-10	irregular serpentine	8.2-10	only ventral side	threadlike
Phaseolus vulgaris L., 1753	4-5	8-11	irregular serpentine	6-9.5	only ventral side	threadlike
Cucurbita L., 1753	4-5	9-10	irregular serpentine	9.3-10	only ventral side	threadlike

* *Composed by the author.*

The mature larva cuts a semicircular slit (in the upper surface of the leaf) in the mined leaf just before formation of the pupa. The larva usually emerges from the mine, drops from the leaf, and burrows into the soil to a depth of only a few centimeters to form a puparium (Capinera, 2001).

The pupa is oval with variable colors, pale yellow-orange often darkening to golden brown. Pupation takes place externally. The adult emerges from the puparium, mainly in the early morning hours. The most favorable temperature for rearing adults is the 26˚C-27˚C, which is proven through our results obtained in laboratory conditions. Thus, the pupal stage lasts 8-11 days.

In the natural environment the favourable temperature conditions for the imago species development range between 25˚C-30°C. Therefore, under appropriate temperature conditions, mature individuals can give several generations per year. Adults are very small (1.3–2.2 mm in body length), females are slightly larger than males (Figure 3).

Mesonotum is black to the edge of a bright-yellow scutellum (Walker, K. 2005). The sides of scutellum are also black. Head is with broad, yellow frons and red eyes; palps are yellow; the hind margin of eye is mostly black, third antennal segment round and yellow. Wing costa extending to apex of vein M1+2; vein M1+2 nearest wing tip; outer vertical bristle (vte) on black ground and inner vertical bristle (vti) on yellow. Second (outer) cross vein (dm-cu) well developed; last section of CuA1 2.5-3 times length of penultimate section, wing length 1.3-1.7 mm; discal cell (1-M2) small (Figure 4).

Mesopleuron yellow, with black patches along front and lower margins; halteres yellow. Abdominal tergites black, sternites yellow; ovipositor is black. Legs with femora bright yellow, tibiae and tarsi brownish (Spencer, 1989).

Figure 3. The overall appearance of L. sativae.

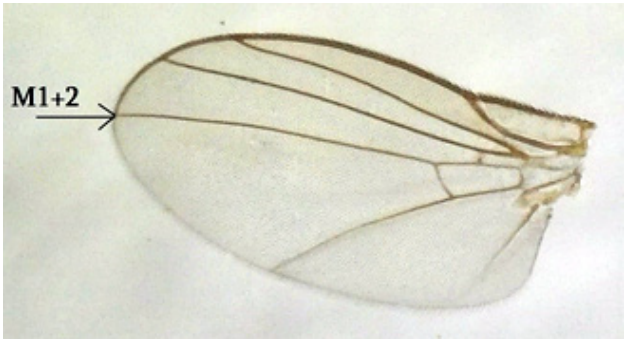

Figure 4. The wing of L. sativae.

Conclusion

So, Liriomyza sativae is extremely polyphagous and has been considered as a serious pest of several cultivated plants. The species has many host plants in the families: Cucurbitaceae, Leguminosae, Solanaceae (Spencer, 1990). The primary damage is the mines caused by the feeding of larvae. Immature leaf fall can be caused by extensive mining which leads to lack of shading and sun scalding of fruit. Studies have shown that the optimum temperature for pupa development is 26˚C -27˚C.

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Forest Amelioration Practice in the Steppe Zone of Aragats Mountain Range Located in the Central Region of Armenia

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ABSTRACT

The current article is devoted to the study of establishing anti-erosion forest crops in various soil-climatic and growing conditions. As a result of the research more prospective varieties of tree and bush species have been revealed, which are to be investigated in conditions of the Armenian highlands. The planting materials with open and closed root systems have been tested, where the best outcome was fixed in those of the closed root system. Agrotechnical system has also been developed, the survival capacity and preservation rate of various forest species have been determined. The best planting terms have been revealed and biometrical indexes of different varieties have been described.

Introduction

The forest ecosystem is one of the key components of structural and functional aspects in the natural and spatial agricultural complexes. Therefore, forest plantations performing different functional roles are established to fill the gap. It means that regardless of the outcome, implementation of landscape changes is associated with different ecological consequences.

Anyway, those anthropogenic processes are different from natural processes in view of consequences and spatial-temporal development. The man-made natural economic complexes may show very high productivity. Moreover, in addition to their main function those complexes can perform another structural role, i.e. ecological co-function which is characteristic to forest plantations. Although those complexes may obtain descriptive indices and natural ecosystem quality only thousands of years later, yet after decades of their establishment anti-erosion, climate regulation and other functions can be already implemented.

For this purpose we made an attempt to establish a forest plantation in the central region of Armenia, on the slopes of Aragats mountain range where the soil records very high sensitivity to erosion. Accordingly, this area was selected to prevent future erosion of the land and enhance its agro-climatic conditions.

The area is located between meadow-steppe landscape zones, in the administrative areas of 6 rural communities.Besides, in a range of plots of Ara, Hnaberd, Poqr Mantash, Saralandj and Kuchak land sites one of the landscapes is characterized by direct transition from a steppe to a meadow zone with no forest in its spectrum. In another plot of Kuchak and Lusagyugh the sites that have been selected for plantation activities were previously forest zones later converted into steppe areas (Mulkidjanyan, 1972).

The tree planting was planned in areas with various degrees of erosion or where soils were prone to erosion. When selecting areas according to the abovementioned criteria we have adopted a long-term perspective through estimating possible formation of a new landscape spectrum with the scope of future projects and tree planting potential.

Plantation areas have been selected based on three main criteria, namely:

- degree of soil erosion or sensitivity to erosion,
- storm control and climate regulation in agro-landscape,
- site conditions for forest growth.

Regarding the last criteria information was obtained and analysis was done on soil characteristics of the site including soil humus content and levels of mineral nutrients, mechanical composition and structural condition of the soil, also climatic aspects, such as temperature and moisture content, wind direction, slope angle and snow cover, seasonal range of temperature with latitude, as well as irrigation potential.

For the selected areas moderately warm and dry, moderately cool, humid climate zones are typical, where the annual sum of temperatures above 100 C is from 2000^0 C to 2500^0 C, and the number of days with similar temperatures is 75 -130 days, frost-free period ranges from 120 to 160 days. The lowest possible air temperature is - 32^0 C – 38^0 C and the highest possible temperature is + 30^0 C – +34 ^{0}C.

The annual sunshine duration is about 2400 hrs. The annual atmospheric precipitation ranges from 600 to 700 mm, air humidity coefficient is 0.4 – 0.6, i.e. the area is sufficiently humid or is humid from light to episodic drought frequencies (likelihood of extreme drought years reaches 59 %).

Materials and methods

The selection of tree and shrub species for planting was mostly based on forest growth conditions.

Large-scale forest amelioration activities have been implemented in this region since the mid half of the last century. However, plantations established during those years were mostly comprised of monodominant species: dominant species were Caucasian pine (Pinus hamata), pine ordinary (Pinus silvestris) and several other pine species (Khurshudyan, 1968).

In view of several disadvantages of monodominant plantations, we have developed draft schemes of mixed plantations which have not been applied in this area before. Tree species have been selected from the prospective list of tree and shrub species specially designed for this region (Ghazaryan, et.al, 1976)- Caucasian oak (Quercus macranthera), Caucasian pine (Pinus hamata), birch (Betula Liwinowii) and common ash (Fraxinus excelsior) in a very limited quantity.

As requested by the community population we have also used berry shrubs which will provide an extra source of income for the community.

Results and discussions

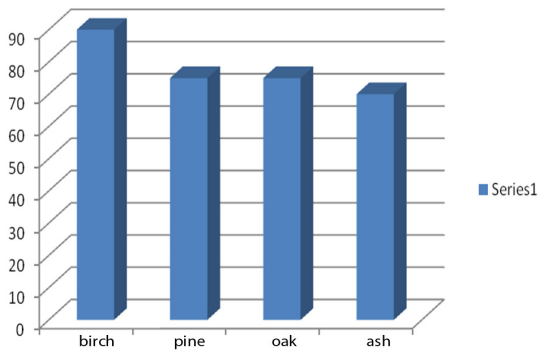
Planting material

For the establishment of plantations container-grown and bare root seedlings were used. Since this was test planting our objective was also to compare seedling production via different root systems and test their effectiveness.

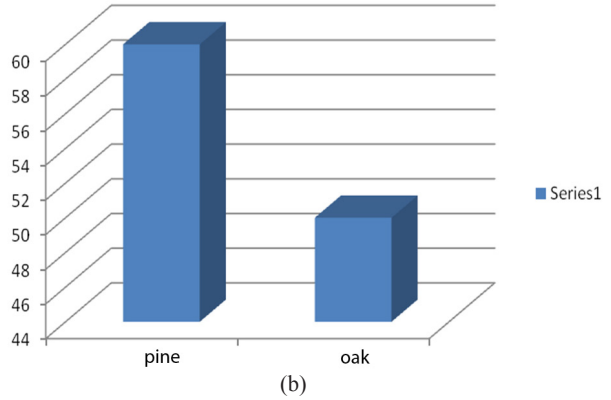
Among the tested tree species containerized production of birch seedlings has shown the highest survival rate in all planting plots. Survival rates of container-grown birch, pine, oak and ash seedlings are depicted in the diagram 1(a).

Accordingly, birch shows the highest survival rate (90 %), while in case of pine and oak the survival rate is only 75 % and in case of ash it makes 70 %.

We have tested only two species with bare root system which are pine and oak seedlings. The results of their survival rates are presented in the diagram 1(b).



(a)



(b)

Figure 1. Seedling survival rates (a) containerized production and bare root production (b) *(composed by the authors)*.

Survival rate of bare root seedlings was quite low: oak's survival rate was 50 % and pine's survival rate was 60 %. The decline in the growth of pine seedling was recorded mainly in the Saralandj community site where seedlings were affected also by fungal diseases.

Age of the seedlings

For measuring the optimum age of the seedlings, we have used a limited number of 4-5-year old seedlings only in Kuchak community site, while seedlings growing in all the other sites were 2 years old. The findings validated the results of the earlier conducted tests (Ghazaryan, Harutyunyan, Khurshudyan, Grigoryan, 1974) which testify that at the given age pine has shown very low survival rate. Thus, the further use of seedlings of this age is not suitable for afforestation of eroded slopes.

Type of land preparation

In our studies we have put a special emphasis on the land preparation method. The planting activities have been done by digging holes or trenches. Considering the age of seedlings, we have used 0.3 x 0.3 x 0.3 m sized holes, and trenches with 0.4 m width, 0.3m depth and 10 m length and 2 m interrow spacing.

The choice of land preparation method did not affect the seedling growth, though the advantage of using trenches was that seedlings were in a more favorable condition during the second half of vegetation cycle when humidity decreased.

The monitoring was done in Lusagyugh and Ara communities where over 80 % of dried out plants were planted in holes. Even by visual observation it was evident that the plant's root humidity in trenches retained longer, assimilation was not interrupted, and plants overcame the dry period. Thus, the plant has maintained its balance.

Planting period

Containerized nursery production of seedlings was not commonly used in Armenia. Since this was a new practice to be applied in the dry climate of Armenia's central region, we did observations on the planting period with a focus on summer planting potential.

In Lusagyugh community 6000 saplings of birch, oak and pine were planted in containers during the last ten days of June (after the solstice). The seedlings were irrigated three times and a single-dose nitrogen fertilizer was applied. In the autumn of the same year the monitoring results based on simple cross-calculations have shown 90 % plant survival.

Annual growth

In summer, 2016, measurements were done in all plantations established during 2014 – 2015 to determine the annual growth for seedlings of all involved tree species.

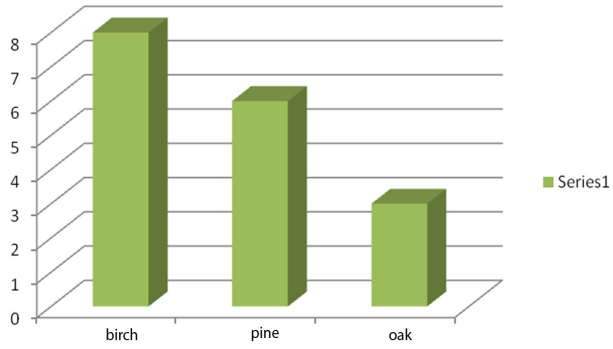


Figure 2. Annual growing indices of seedlings *(composed by the authors)*

The measurement results indicated that birch and pine have shown the best growing rate with mean annual growth of 8 cm and 6 cm, and maximum growth of 22 cm and 35 cm. The oak has shown a low growing rate with mean annual growth of 2–3 cm which is accounted for biological characteristics of this tree species.

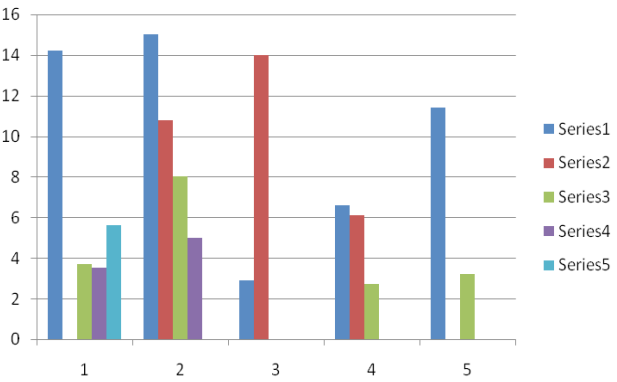


Figure 3. Annual growing indices of tree species in different communities for 2017 *(composed by the authors).*

The annual growing dynamics of tree seedlings was also observed during the summer 2017.

The maximum pine growing rate in Lusagyugh has made 19 cm and in Ara it is 22 cm. The highest growing index for oak has been registered in Ara community with the average growth of 8cm and maximum growth of 13 cm. In general, birch has demonstrated good results everywhere; maximum growing index has been observed in Ara community which makes 19 cm and in Saralandj it makes 17 cm. Ash and map, used (mainly for testing purposes) in very limited quantities, have shown average growing capacity.

Conclusion

Below we offer some recommendations based on the results of our study on forest amelioration and soil protection in the steppe zone of Aragats mountain range located in the central region of Armenia and on comparison of our findings with the previously conducted forest planting practices.

1. In Aragatsotn and Shirak marzes (regions), despite insufficient local growing conditions for tree species (low temperatures in winter, lack of humidity during the 2nd half of vegetation cycle, eroded and degraded soil) there is a great potential for creating forest vegetation along the eastern, north-eastern and northern slopes of mount Aragats as well.

2. Instead of using the old practice of monodominant plantations it is recommended to form sustainable mixed plantations in the site, mainly comprised of pine-birch, oak-pine and oak-birch-pine stands and include wild fruit-bearing species. It is also recommended to use berry species which give fruits in the second growing year.

3. Tree planting potential increases to a great extent when using container-grown seedlings, by producing good results even if planting is organized during early summer.

4. On the sunward slopes it is recommended to use the method of planting in trenches and carry out maintenance activities for effective and promising results.

5. Irrigation is crucial in tree planting requiring special treatment in windy sites during late summer periods and dry years.

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The Effect of Mykonet on the Quality of Pepper and Tomato Fruits, their Bio-Morphological Properties and Yield Indicators

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ABSTRACT

The effect of Indian mycorrhizal preparation Mykonet (Mn) on the growth, development, productivity and yield quality of the pepper varieties Zmrukht, Nush-55 and tomato varieties Anahit-351 and Noy was studied. Seeds of each variety were soaked in 0.01 % Mn solution for 1 and 2 hours. It was shown that Mn increased fruit quality and yield capacity of the pepper and tomato, depending on the treatment duration and crop variety. Two-hour-treatment was the most effective method for the mentioned plants. High productivity was recorded in the pepper variety Zmrukht and tomato variety Anahit-351. They exceeded the control variant by 16.5 % and 11.1 % respectively.

Introduction

Healthy soil is a fundamental necessity for increased food production. Soil fungi and their relationships with host plants (Fernanda, Hernan and others, 2012) significantly contribute to the soil fertility.

When the researchers apply natural fertilizers, they notice that certain extracts of the living organisms can often function as the natural stimulators for plant growth and protection.

In natural conditions the plants and mycorrhizal fungus are connected by mutually beneficial symbiosis. The fungal filaments can penetrate into the smallest pores of the soil minerals up to their thinnest root hairs, then, by gradually destroying them, fungi extract elements that are unavailable for plants nutrition, including such essential elements as phosphorus or the trace elements of zinc and cobalt. By marking the minerals with radioactive isotopes, it has been proved that there is a whole underground system of the thinnest yarns, where plants communicate by transferring and sharing the organic and mineral compounds. Thus, the total length of mycorrhizal filaments in the soil around the plant roots is 20-40 m/cm^3, due to which these fungi manage to get about 30 % of the synthesized carbohydrates (Chagnon, Bradley and others, 2013).

Mycorrhizal fungus Mykonet can enhance efficiency of plant roots to absorb water and macro and microelements from the soil or container media. This helps to reduce fertility and irrigation requirements, increases drought resistance and plant resistance to pathogens (Davies, et. al, 2000). The researched mycorrhizal fungus Mykonet was provided by the Indian producer “Elegant India”.

Materials and methods

For the experiment the sweet pepper (Zmrukht and Nush-55) and tomato (Anahit and Noy) varieties were chosen which are produced in Armenia and are very popular.

Zmrukht is a determinant variety of medium-early maturity. Fruits are conical, smooth, thick-walled with 70.0 g – 80.0 g weight. In technical ripening phase the color is green, in biological ripening phase it is red. It is also resistant to fusarium. Fruits are marketable, suitable for fresh use, marinades and drying.

Nush-55 is a determinant variety with medium maturity. Fruits are elongated and conical, smooth, thick-walled with 80 g - 90 g weight. In the technical ripening phase it has light green color, while in biological ripening phase it is red. This variety is resistant to fusarium and early withering. Fruits are marketable, suitable for fresh use, marinades and drying.

Anahit-351 is again a determinant variety of medium-early maturity. Its fruit is flat-roundish, with intensive red color; it weighs 150 g-170 g and is transportable.

Noy is still a determinant variety of medium maturity. Fruits are roundish with intensive red color; the weight is 200 g-220 g.

Seeds of experimental varieties were soaked in 0.01 % Mn solution for 1 or 2 hours, while the control seeds were placed in distilled water with the same duration, after which the seeds were sown. Forty five-fifty days after germinating seedlings were planted in the open field.

The experiments were performed on the experimental field of the Scientific Center of Vegetable-Melon and Industrial Crops, Armenia during 2018-2019. Soils of experimental plot had heavy mechanical composition of light clay content (carbonates 0.95 %). Its organic matter content was 1.96 %, total nitrogen - 0.09 %, pH - 6.8 %. The average temperature during the development season was around 30°C.

The phenological and morphological observations of the plants were carried out throughout growing season through the method of State Variety Trial of agricultural crops (Fedin, 1985).

The fruit samples for chemical analyses were collected twice: first - at the beginning of fruiting stage, and then - just before the end of the experiment. The dry material content was identified by the refractometer "IGF-454B2M", the sugar content - by Bertran method and vitamin C- by Moory method (Peterburgski, 1968).

The data on harvest efficiency of Mn has been also identified.

The experiment was set up according to block randomization method with 4 repetitions each with 90 plants per investigated variant, the nutritional surface for each pepper plant was 0.21 m^2 (70+70x30 cm) and that of each tomato plant - 0.28 m^2, (90+70x35 cm).

Significant differences between the treatments were tested using the method of the Least Significant Difference (LSD). The saved LSD values were calculated at $P<0.05$ probability levels (Dospekhov, 1985).

Results and discussions

It was found out that all pepper and tomato seeds treated with Mn germinated 2-3 days earlier than those in the control ones. They grew simultaneously and formed extensive over ground parts with larger (13-15 %) leaf blades than those of control ones and had well-developed root systems. The duration of their development stages was shorter in case of 2-hour-treatment than that of observed in case of an hour treatment. The phenological data varied depending on the variety and duration of Mn treatment. In the first case the flowering stage of pepper plants was 3-8 days earlier and in tomato plants it was 4-8 days earlier, the fruiting stage in pepper was 5-10 days earlier, and in tomato it was 5-6 days earlier as compared to the same indicators in the control variants (Table 1).

In case of 1 h Mn treatment the vegetation period for pepper and tomato was shorter than that of control ones by 8-13 days and 3-4 days, while the period of crop formation was longer by 3-8 days and 2-5 days (Table 1). Similarly, in case of 2 h treatment, the vegetation period was shorter by 13-22 days and 7-8 days and crop formation period was longer by 2-5 days.

The most significant effect was observed for the plant growing rate in the transitional period from budding to flowering and intensive fruit formation phases, when the general growth of stem slowed down. At the end of vegetation period the stems of sweet pepper varieties were higher by 10.5 %-15.5 % and those of tomato plants by 4.0 %-7.5 % than the similar indicators of the control variant.

The biochemical analysis also revealed differences in the fruit quality. In biological ripening phase fruit dry matter content of the control and Mn treated plants varied between 7.5 % - 8.1 % in pepper and 6.0 %-6.8 % in tomato fruits. DM in pepper and tomato fruits significantly exceeded that of the control variant only when the treatment duration was 2h.

Based on the sugar content data (Table 2), it could be concluded that the tomato varieties were more sensitive to Mn than those of the pepper ones. In pepper fruits the influence of Mn was not significant on the sugar content, while in tomato fruits sugar content grew up even when the duration of the treatment was 1 hour.

Table 1. The effect of Mn on the phenophase duration of pepper and tomato (days)*

Crop	Variety	Variants	From germination to flowering	From germination to fruiting	From fruiting to technical ripening	From technical to biological ripening	Vegetation period	Harvesting period
Sweet pepper	Nush -55	Control	78±1.2	85±1.1	40±1.4	26±1.0	151±2.1	65±1.1
		Mn 1h	72±1.1	78±1.4	36±1.2	24±1.2	138±1.2	73±1.2
		Mn 2h	70±1.5	75±1.3	32±1.0	22±0.8	129±1.5	87±0.8
	Zmrukht	Control	74±1.2	82±1.2	39±1.3	26±0.3	147±1.5	68±0.9
		Mn 1h	73±1.4	78±1.3	37±1.0	24±0.3	139±0.3	71±1.2
		Mn 2h	71±1.0	77±1.5	35±1.4	22±0.3	134±1.2	72±1.3
Tomato	Anahit-351	Control	61±0.5	72±0.5	-	30±1.0	102±1.0	43±1.1
		Mn 1h	55±1.3	68±1.1	-	30±1.3	98 ±0.3	45±0.8
		Mn 2h	53±1.0	66±1.5	-	28±1.0	94±0.2	47±0.5
	Noy	Control	65±1.1	75±0.6	-	36±1.4	111±1.1	48±1.2
		Mn 1h	62±1.1	74±1.2	-	35±1.0	109±0.9	53±1.1
		Mn 2h	61±0.8	70±1.4	-	34±0.3	104±0.2	57±0.5

Table 2. Mn effect on the content of dry matter, sugar, and ascorbic acid in pepper and tomato fruits*

Crop	Variety	Variants	Dry matter, %	Sugars, %	Ascorbic acid, mg%
Sweet pepper	Nush -55	Control	7.5	5.4	211.2
		Mn 1h	7.5	5.5	211.3
		Mn 2h	7.9	5.5	217.8
		$LSD_{0.05}$	0.2	0.2	0.3
	Zmrukht	Control	7.5	5.5	231.3
		Mn 1h	7.6	5.5	233.1
		Mn 2h	8.1	5.6	236.2
		$LSD_{0.05}$	0.4	0.2	0.8
Tomato	Anahit-351	Control	6.1	3.0	18.4
		Mn 1h	6.2	3.2	18.5
		Mn 2h	6.8	3.2	18.8
		$LSD_{0.05}$	0.2	0.1	0.2
	Noy	Control	6.0	3.1	19.0
		Mn 1h	6.0	3.3	19.2
		Mn 2h	6.2	3.4	19.5
		$LSD_{0.05}$	0.1	0.2	0.3

**Composed by the authors*

This was due to the fact that Mn induces extra root system development, branching and flower number, all of which together increase plants' productivity.

In the experimental varieties the marketable yield of Zmrukht pepper increased by 0.5-7.5 tons as compared to that of the control variant, the yield of Nush-55 variety increased by

5.2-7.2 tons, in the tomato variety of Anahit-351 it grew up by 1.5-8.4 tons and in Noy variety -by 0.9-8.4 tons. All the experimental varieties demonstrate the best results when treated with Mn for 2 hours. In the treated varieties the fruit mass also grew up.

Table 3. The effect of Mn on the yield capacity of pepper and tomato*

Crop	Variety	Variants	Yeild t/ha		Marketable crop surplus to the control, %	Fruit mass, g
			Total	Marketable		
Sweet pepper	Nush -55	Control	45.0	43.8	-	70
		Mn 1h	50.0	49.0	11.9	78
		Mn 2h	53.1	51.0	16.4	78
		$LSD_{0.05}$		2.1		
	Zmrukht	Control	47.0	45.5	-	75
		Mn 1h	48.0	46.0	1.1	78
		Mn 2h	54.3	53.0	16.5	80
		$LSD_{0.05}$		2.4		
Tomato	Anahit-351	Control	80.0	75.5	-	150
		Mn 1h	81.0	77.0	2.0	160
		Mn 2h	85.5	83.9	11.1	160
		$LSD_{0.05}$		1.7		
	Noy	Control	110.5	108.1	-	210
		Mn 1h	111.2	109.0	0.8	215
		Mn 2h	118.0	116.5	7.8	225
		$LSD_{0.05}$		0.8		

**Composed by the authors*

Thus, Mn stimulated all development phases improving plants properties. Most probably, these changes occur due to the phytohormones from auxins group, since they intensify the processes mainly controlled by these hormones (Azaryan, et.al, 2014).

Conclusion

The results obtained give a ground to conclude that Mn improves the pepper and tomato morpho biological and biochemical indicators in various degrees, depending on the treatment duration and on the crop variety. Effectiveness is high when seeds are soaked in 0.01 % Mn solution for 2 hours.

Thus, it is recommended to apply pre-sowing seed treatment with Mycorrhizal Mykonet preparation.

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Agronomic and Yield Potentials of Bambara Groundnut *(Vigna Subterranea (L.) Verdc.)* in Northeastern Nigeria

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ABSTRACT

Field trials were conducted in 2015 rainy season on the Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola and Department of Crop Science, Taraba State College of Agriculture, Jalingo to investigate the effect of inter-row spacing and nitrogen rates on the growth and yield of Bambara groundnut (*Vigna subterranean L.*). The experiments were laid out in a split-plot design with three nitrogen rates, 20 $kgNha^{-1}$, 25 $kgNha^{-1}$ and 30 $kgNha^{-1}$ as main plot treatments and four inter-row spacing of 20 cm, 25 cm, 30 cm and 35 cm as the sub plot treatment. Data were collected on the growth and yield parameters and were subjected to Analysis of Variance (ANOVA) and Least Significant Difference (LSD) procedure. Due to the findings it is suggested that nitrogen rate of 20$kgNha^{-1}$ and inter-row spacing of 35 cm should be adopted.

Introduction

Bambara groundnut is an indigenous African crop cultivated by small-scale subsistence farmers in semiarid, sub-Saharan Africa and tropical South West Asia. It is the fourth most important grain after cowpea (*Vigna unguiculata L.*) and groundnut (*Arachis hypogea L.*) and is named after the Bambara tribe of Mali that mastered the act of cultivating the crop (Hillocks et al., 2012, Jakusko, 2015). The pulse has an immense potential in enhancing food security especially in drought prone agricultural system. Its drought tolerance makes it ideal for production by resource poor farmers especially in communal and resettlement areas. As a result, it can grow well in communal areas where the pest and disease control is not seriously observed. The crop is intercropped with grain cereals to reduce risk of crop failure due to drought since it is more tolerant than other companion crops and can be produced under high temperature where other pulses fail to survive. (Vusamuzi, 1992, Akpalu, et. al., 2012).

In Nigeria, Bambara groundnut features predominantly in the traditional farming system as an inter-crop with grain cereals (maize, sorghum, and millet) and tuber crop (yam) without any definite pattern of precision (planting spacing, fertilizer application) even if it is cultivated as a sole crop. This inconsistency in the adoption of planting spacing and fertilizer application as factors for optimum yield is a gap that must be explored. It is on this premise that the study was conducted to

determine the effect of inter- row spacing and fertilizer rates on the growth and yield of Bambara groundnuts.

Materials and methods

The field trials were conducted in two locations during the 2015 cropping seasons. The first location was on the Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola, with the latitude of 90 19″N and longitude 120 28″E, at an altitude of 185.9 m above the sea level. The annual rainfall of Yola ranges from 900 to 1100 mm from May to October. (Adebayo and Tukur, 1999). The second location was on the Teaching and Research Farm of Department of Crop Science, Taraba State College of Agriculture, Jalingo with the latitude of 80 56″N and longitude-110 50″E at an altitude of 1600 m above the sea level, mean annual rainfall is 750 to 1000 mm (TADP, 2012) in the experimental rainy season from May to October.

The two experimental sites were slashed and the land was prepared by conventional tillage with disc plough and later harrowed and leveled with a hand hoe. A local Bambara groundnut cultivar *yarshelleng* was obtained and used. The experiment was 3x4 factorial in a split plot design, three (3) nitrogen fertilizer rates (20,25 $kgha^{-1}$ and 30 $kgha^{-1}$) as main plot and four (4) inter row spacing (20, 25, 30 and 35 cm) as sub plot treatment with three replications. Bambara groundnut was planted on 28 and 30 July, 2015 at Yola and Jalingo locations at the peak of rainy season.

Sampled plants were taken from the sub plot of 3 m x 2 m for the experiment on germination percentage, plant height, number of leaves, number of branches in the 3rd, 6th and 9th weeks after sowing, as well as on the days of their 50 % flowering, on that of 95 % maturity, number of pods per plant, number of seeds per plant, weight of 100 seeds (g) and grain yield ha^{-1} at harvest. Data collected were subjected to Analysis of Variance (ANOVA) appropriate to split plot design and means separation was done using the least significant difference (LSD) at 5 % level of significance as described by Gomez and Gomez (1984) and GENSTAT, 4th edition.

Results and discussions

The data results on the effect of inter-row spacing and Nitrogen rates on percentage of seedlings emergence, and number of leaves at 3rd, 6th and 9th WAS are presented in Table 1. The result shows that there was no significant difference ($p \leq 0.05$) between seedlings emergence rate related to Nitrogen rates at both locations. For the number of leaves in the 3rd, 6th and 9th weeks after sowing /WAS/ Nitrogen rate shows no significant difference ($p \leq 0.05$).

Table 1. Effects of Inter-Row Spacing and Nitrogen Rate on Percentage of Seedlings Emergence and Number of Leaves per Plant of Bambara Groundnut in Jalingo and Yola in 2015 Cropping Season*

Treatment	% Seedlings Emergence		Number of Leaves 3WAS		Number of Leaves 6WAS		Number of Leaves 9WAS	
	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola
Nitrogen Rates ($kgha^{-1}$)								
20	99.54	99.44	6.22	6.60	50.13	30.02	120.30	62.20
25	99.28	98.84	5.90	6.07	45.28	32.30	117.60	63.80
30	99.09	98.40	6.20	6.22	43.07	28.87	108.90	69.70
LSD	0.48	1.80	0.29	1.30	9.29	16.45	17.25	14.30
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Spacing (cm)								
20	99.43	99.24	6.20	6.80	41.96	30.73	111.20	63.00
25	99.30	99.53	6.02	6.09	43.31	29.73	109.30	70.50
30	99.17	98.89	5.96	5.78	47.13	30.87	119.10	70.10
35	99.31	97.92	6.22	6.51	48.24	30.24	122.90	57.30
LSD	1.13	1.77	6.43	0.89	2.84	3.05	14.78	14.56
Significance	NS	NS	NS	NS	**	NS	NS	NS
Interaction (NxS)	NS	NS	*	NS	**	*	NS	NS

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Table 2. Interaction between Inter-Row Spacing and Nitrogen Rates and its Effect on Number of Leaves per Plant in the 3rd Week after Sowing at Jalingo location in 2015 Cropping Season*

Nitrogen Rates	Spacing (cm)				
(kgha^{-1})	20	25	30	35	LSD
20	6.40	6.40	6.13	5.87	0.757
25	5.60	6.13	5.73	6.13	
30	6.60	5.53	6.00	6.67	
LSD (P≤0.05)	0.66 0.03				

Table 3. Interaction between Inter-Row Spacing and Nitrogen Rates and its effect on the Number of Leaves in the 6th Week after Sowing at Jalingo and Yola Locations in 2015 Cropping Season*

Nitrogen Rates (kgha^{-1})	Spacing (cm)									
	Jalingo					Yola				
	20	25	30	35	LSD	20	25	30	35	LSD
20	50.33	48.27	52.07	49.87	4.924	33.20	27.87	30.07	28.93	5.295
25	49.73	45.27	44.33	49.80		28.93	36.13	31.07	33.07	
30	45.80	36.40	45.00	45.05		30.07	25.20	31.47	28.73	
LSD (P≤0.05)	9.194 0.01					16.110 0.02				

**Composed by the authors*

However, significant difference was recorded in the 6 WAS at Jalingo location in inter-row spacing of 35 cm with a mean value of 48.24.

The data results on the effect of interaction between inter-row spacing and Nitrogen on number of leaves per plants in 3WAS for Jalingo is presented in Table 2. The result showed that at 3WAS 30 kg nitrogen rates and 35 cm inter-row spacing had the best interaction effect with the value of 6.67 and the least interaction was in case of 30 kg nitrogen rate and 25 cm inter-row spacing with a mean value of 5.53.

Table 3 presents the interaction between inter-row spacing and nitrogen rates on the number of leaves in 6 WAS at Jalingo and Yola locations. The results show that at Jalingo station, the best interaction was recorded in case of 20 kg nitrogen and 30cm inter-row spacing with a mean value of 50.02, the least interaction was recorded in case of 30 kg nitrogen and 25 cm inter-row spacing with a mean value of 36.40. Similarly at Yola station, 25 kg nitrogen had the best interaction with the mean value of 36.13 and the least interaction was recorded in case of 30 kg nitrogen and 25 cm inter-row spacing with a mean value of 25.20.

The effect of inter-row spacing and nitrogen rates on number of branches per plant and plant height in the 3rd, 6th and 9th WAS is presented in Table 4. The results showed that there was no significant difference ($p \leq 0.05$) between the number of branches and plant height at both weeks for the two locations concerning nitrogen rates. Regarding inter-row spacing, significant difference was recorded in the 6 WAS in Jalingo location for number of branches per plant, While Yola location had no significant difference. Similarly plant height in terms of inter-row spacing shows no significant difference ($p \leq 0.05$) for both locations.

The data results on the days of their 50 % flowering, those of 95 % maturity, number of pod per plants and seed per plants are recorded in Table 5, which indicates that nitrogen rates showed no significant difference ($p \leq 0.05$) in both locations. Regarding the inter-row spacing, days of 50 % flowering was significant at Jalingo location with 25cm inter-row spacing resulting in the highest mean value of 43.00. While Yola location showed no difference ($p \leq 0.05$). Days of 95 % maturity, number of pods per plants and number of seeds per plant show no significant difference ($p \leq 0.05$) in both locations.

Table 6 shows the effect of inter-row spacing and nitrogen rates on weight of 100 seeds (g) and grain yield per hectare. The result shows that both nitrogen rate and inter-row spacing showed no significant difference ($p \leq 0.05$) for both locations.

Table 4. Effects of Inter-Row Spacing and Nitrogen Rates on the Number of Branches per Plant and Plant height of Bambara groundnut at Jalingo and Yola in 2015 Cropping Season*

Treatment	Number of Branches/Plant						Plant height(cm)					
	3 WAS		6 WAS		9 WAS		3 WAS		6 WAS		9 WAS	
	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola
Nitrogen Rates ($kgha^{-1}$)												
20	3.77	3.70	15.87	11.62	22.90	13.88	22.87	19.37	23.71	20.01	24.10	20.59
25	3.68	5.30	16.38	12.28	21.00	15.99	22.29	19.82	23.62	20.64	23.65	22.04
30	3.78	2.23	15.62	12.08	20.57	14.03	22.50	19.77	23.43	20.97	23.50	21.98
LSD	0.51	3.17	3.18	4.89	2.72	4.498	0.86	1.65	3.41	1.71	1.88	2.90
(P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spacing (cm)												
20	3.69	2.40	14.93	11.02	20.69	13.33	22.79	19.63	23.64	20.67	23.74	22.58
25	3.73	4.60	15.51	12.80	21.33	14.38	22.33	19.17	23.10	20.48	23.53	22.70
30	3.76	4.27	16.58	11.96	22.09	14.97	22.36	19.52	23.90	20.63	23.95	22.38
35	3.81	2.38	16.80	12.20	21.84	15.87	22.69	18.94	23.70	20.38	23.78	22.71
LSD	0.36	4.68	1.51	1.41	2.54	2.423	0.94	1.28	1.33	1.15	1.17	1.07
(P≤0.05)	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (NxS)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Mean Effects of Inter-Row Spacing and Nitrogen Rates on Days of 50 % Flowering, Days of 95 % Maturity, and Number of Pods per Plant and Number of Seeds per Plant of Bambara Groundnut at Jalingo and Yola Locations in 2015 Cropping Season*

Treatment	Days of 50% Flowering		Days of 95% Maturity		Number of Pods per plant		Number of Seeds per plant	
	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola	Jalingo	Yola
Nitrogen Rates (kgNha-1)								
20	42.50	42.17	110.25	105.75	27.13	11.37	27.38	11.78
25	42.00	43.00	109.67	106.00	22.45	12.85	22.65	13.10
30	42.50	42.67	106.08	107.00	17.10	13.33	17.25	13.58
LSD	1.30	1.94	7.87	4.34	10.16	2.57	9.97	2.82
(P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Spacings (cm)								
20	42.78	43.00	108.33	105.00	23.24	12.40	23.49	12.64
25	43.00	42.11	108.78	106.89	23.09	12.02	23.47	12.16
30	41.89	42.78	109.44	106.56	22.27	12.80	22.44	13.33
35	41.47	42.56	108.11	106.56	20.31	12.84	20.51	13.16
LSD	0.95	1.07	0.69	1.38	3.27	2.49	3.24	2.72
(P≤0.05)	**	NS	NS	NS	NS	NS	NS	NS
Interaction(NxS)	NS	NS	NS	NS	NS	NS	NS	NS

NS= Not significant. **= Significant (P≤0.05)

**Composed by the authors*

Table 6. Effects of Inter-Row Spacing and Nitrogen Rate on the Weight of 100 Seeds (g), Grain Yield ha^{-1} (kg) of Bambara Groundnut at Jalingo and Yola in 2015 Cropping Season.

Treatment	Weight of 100 Seeds (g)		Grain Yield ha^{-1} (kg)	
	Jalingo	Yola	Jalingo	Yola
Nitrogen Rates (kgha^{-1})				
20	83.19	80.69	1033	418
25	82.54	75.79	868	368
30	86.01	79.69	607	357
LSD	9.64	4.60	485	54.8
(P≤0.05)	NS	NS	NS	NS
Spacing (cm)				
20	83.57	79.48	959	391
25	84.20	74.70	826	367
30	83.71	80.24	798	407
35	84.18	80.48	761	359
LSD	4.93	6.58	192	86
(P≤0.05)	NS	NS	NS	NS
Interaction (NxS)	NS	NS	NS	NS

**Composed by the authors*

Conclusion

The results of the study showed that growth parameters were affected by application of nitrogen and inter-row spacing at the two trial locations. However, nitrogen fertilizer and inter-row spacing had no significant effect on plant emergence in Jalingo and Yola trial locations. This suggests that when conditions for germination are favourable, seeds would germinate and emerge even if the nutrient status of the soil is poor. This is in line with the report of Madukwe et al., (2010) which states that nitrogen fertilizer had no significant effect on germinability of bambara groundnut seeds. No significant difference was observed in terms of nitrogen rates effect on number of leaves per plant, number of branches per plant in the two locations. This is in line with the findings of Madukwe et al., (2010), Iliya (2010) and Kamithi et al., (2009) who suggest that influence of environment must have played out a role which could have counted for the few leaves and branches in crops.

Inter-row spacing with 35 cm had significant effect on the number of leaves per plant and number of branches per plant (48.24 and 16.80) in the 6 WAS at Jalingo location having the highest number of leaves and branches per plant. This agrees with Akpalu et al., (2012) and Akpalu (2010) who reported that the higher leaf number produced by the higher spacing could be attributed to reduced interplant competition. Non-significant effect of Spacing on number of leaves per plant and branches per plant in Yola location agrees with Jalal (2008) who attributed such phenomenon to weather conditions. Interaction between nitrogen rates and inter-row spacing had significant influence on the number of leaves and branches per plant in Jalingo and Yola locations. Plant height was not significantly influenced by spacing and nitrogen rates in both locations, this finding corroborated Ibudialo et al., (2013) and Jalal (2008) who observed no significant difference in the plant height in their research due to weather conditions.

Days of 50 % flowering were significantly influenced by 25 cm spacing in Jalingo location with the highest mean value (43.00), while nitrogen rates had no influence at both locations. This result may be due to environmental influence on the crop.

Number of pods per plant and number of seeds per plant showed no significant difference at both locations regarding both nitrogen rates and inter-row spacing as a result of lack of optimum amount of water in the plant critical period; this result coincides with the findings of Vurayai et al., (2011) who stated that Bambara groundnut is more sensitive to water stress during reproductive growth stage.

100-seed weight was not significantly influenced by nitrogen rates and inter- row spacing in the two locations. This agrees with the findings of Olukayode and Kolapo (2014) who reported that yield of legume is affected in favour of vegetative growth. The results on grain yield per kgha^{-1} followed the same trend as no significant difference was recorded by the treatments. This result agrees with those of Tanimu et al., (1991) and Chiezey et al., (2005) whose research conducted in Samaru, Zaria on Bambara groundnut showed no significant difference regarding the effect of nitrogen starter dose on the grain yield.

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Results of Raising Repair Young Animals with the Latest Technologies at the Age of 0-6 Months

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ABSTRACT

The research was carried out in 2019 at the "Balahovit" teaching-experimental farm of the Armenian National Agrarian University on the three-breed heifers with the ratio of 1/4 Caucasian brown, 1/4 Jersey and 1/2 Holstein genotypes.

The growing and development indices of the experimental heifers have been much higher than those of the control group. Feeding profitability for 1 kg weight growth has made 10.8 MJ and 394 g digestible protein, while the same indicators in the control group are 29.4 MJ and 623.6 g.

So, it is recommended to apply the feed ration developed, tested and currently used at the "Balahovit" teaching-experimental farm in the livestock farms of Armenia for raising neonatal heifers.

Introduction

High level of milk productivity is currently ensured by raising animals with proportional exterior and solid constitution. Breeding animals with the best genotypes through customized mating and their targeted growing is of high importance in the selection activities.

The breeder not only creates a new genotype, but also develops such technologies which promote breeding of animals with high productivity and those of well adapted to the specific keeping conditions, which also differ from other animals both in the exterior uniformity and the development of their properties and characteristics.

Thus, since 1963 we have managed to implement complicated and reproductive cross-breeding and to get hereditary animals with the the combined blood content of 25 % Caucasian brown, 25 % Jersey and 50 % Holstein breed. In the recent 30 years the latter have been bred "within themselves" (without crossbreeding) and have demonstrated 4500 kg - 5000 kg milk productivity with 4.2 % fat content and 3.4 % protein content (Giloyan, 1986).

However, after the collapse of the Soviet Union, the entire livestock was transferred to the rural collective farms, where the animal breeding and caring terms were violated as a consequence of applying traditional cattle-breeding technologies; the live weight of cows dropped to 400 kg on average, and this is mainly because of repair youngs' malnutrition.

Materials and methods

Scientific-research experiment was conducted in 2019 on the cattle-breeding farm of Balahovit at the Armenian National Agrarian University.

Three-breed neonatal heifers with the ratio of 1/4 Caucasian brown, 1/4 Jersey and 1/2 Holstein (1/4 CB + 1/4 J + 1/2 H) genotypes were selected for the study. Experimental group involved 7 stocks of animals and 5 stocks were in the control group. The groups were formed on the principle of uniformity.

At the age of 0-6 months each heifer stock of the experimental group was fed with 200 kg whole milk, 355 liters of whole milk substitute (WMS) or 35.5 kg dry milk, 260 kg hay, 100 kg silage made from mountainous meadow greenery, 90 kg condensed forage prepared according to our recipe the nutritional value of which per 1 kg was as follows: 9.9 MJ exchangeable energy, 16.6 % raw protein, 2.8 % raw fat, 8.1 % cellulose, 0.8 % calcium, 0.7 % phosphorus, 1 % edible salt, 15 kg wheat and 22 kg barley. The nutritional value of the forage fed per each stock from the age of 0 to 6 months in the experimental group made up to 1288.3 MJ exchangeable energy and 46.79 kg digestible protein. The calves of the control group were fed in accordance of standardized diet and at the age of 0 - 6 months each stock head was fed with 280 kg whole milk, 60 kg wheat, 120 kg barley, 261 kg hay, 100 kg silage, 2500 kg salt. The total nutritional value of the feedstuff made up to1269.7 MJ exchangeable energy and 45.77 kg of digestible protein.

Weight and linear growth of the heifers in experimental and control groups was studied through livestock methods; weighing and body measurements were performed at the neonatal (starting from the 3rd day) and 6-month age; data were processed through biometric methods. (Merkuryeva, 1970).

Absolute weight growth has been determined through the following formula:

$$A = \frac{W_1 - W_0}{t_1 - t_0}$$

Relative weight growth has been determined through Brody's formula

$$B = \frac{(W_1 - W_0)}{(W_1 + W_0) \cdot 0.5} \times 100 .$$

The specific growing rate - through the following formula:

$$C = \frac{(\log W_1 - \log W_0)}{t \log e},$$

where $t=t_1-t_0$ $\log e=0.4343$

Results and discussions

The biometric data on the live weight of the heifers at neonatal and 6-month age for both the experimental and control groups are introduced. From the data analysis it becomes evident that the selected heifers of the mentioned groups are homogenous and uniform regarding the live weight and biometric values.

Table 1. Live weight of the heifers of experimental and control groups, kg*

Groups	Indicators				
	n	Lim	M ±m	σ	Cv
At neonatal age					
Experimental	7	28…31	29.71±0.42	1.11	3.7
Control	5	28…31	29.60±0.51	1.14	3.9
At the age of 6 months					
Experimental	7	146…151	148.3±0.61	1.60	1.1
Control	5	102…104	103.0±0.45	1.00	1.0

**Composed by the authors*

From the analysis of the table data, it becomes clear that the growth and development indices of the experimental heifers at the age of 0-6 months were as follows: absolute weight growth - 118.6 kg, average daily weight growth - 659 g, relative weight growth- 72.7 %, specific growing rate-0.3 and the growing coefficient-4.99; the same indices for the control group were 73.4 kg, 408 g, 62.3 %, 0.2, 3.48 respectively. The feeding profitability (return from cattle breeding) for 1 kg weight growth was the following: exchangeable energy - 10.8 MJ and digestible protein - 394 g, for the control group they were 29.4 MJ and 623.6 g, respectively. The provided data show that the weight growth advantages in case of raising animals with the recommended technology are obvious, thus, hereinafter the farms should feed the new-born calves according to the feeding diet recommended by us. As it is mentioned in the teaching manual (Giloyan, et. al, 2016), external conditions, in particular feeding level and balanced feed ration greatly influence animal growth and development causing various qualitative changes during physiological processes, which are confirmed upon the investigation of the linear growth of the heifers in the experimental and control groups (Giloyan, et. al, 2016).

The measuring values and coefficient of variation (CV) for each body part of the experimental heifers introduced in table 2 testify on the homogeneous and uniform development of the animals.

Table 2. Measurements of the body parts in the experimental and control heifers at the age of 6 months*

Groups	Experimental			Control		
Body parts measurements	Indicators					
	n	M ±m	Cv	n	M ±m	Cv
Wither height	7	104.0±1.15	3.0	5	89.4±0.93	2.5
Anus height	7	107.0±0.97	2.4	5	89.2±0.80	2.1
Ischium height	7	102.0±1.05	2.7	5	83.6±1.50	4.3
Chest depth	7	44.3±0.42	2.5	5	36.8±0.66	4.0
Chest width	7	32.7±0.56	4.6	5	27.6±0.51	4.1
Body oblique length	7	113.6±0.37	0.9	5	95.4±0.93	2.2
Shin circumference	7	15.4±0.57	9.8	5	15.0±0.71	10.5
Heart-girth	7	113.9±0.26	0.6	5	98.8±0.86	2.0
Head length	7	29.9±0.26	2.3	5	27.8±0.37	3.0
Forehead length	7	15.6±0.20	3.4	5	13.0±0.32	5.5
Head depth	7	22.1±0.46	5.5	5	21.0±0.37	4.9
Large width of the forehead	7	16.6±0.20	3.2	5	15.2±0.20	3.0
Small width of the forehead	7	13.4±0.30	5.9	5	11.6±0.51	9.8
Thurl width	7	25.7±0.28	3.0	5	22.2±0.37	3.8
Hip oblique length	7	30.4±0.30	2.6	5	26.2±0.37	3.2

* *Composed by the authors*

Table 3. Comparison of the body part measurements in the heifers of experimental and control groups at the age of 6 months*

Body parts measurements	Experimental	Control	Difference of measurements	
			Absolute	In percentages
Wither height	104.0	89.4	-14.6	-14.0
Anus height	107.0	89.2	-17.8	-16.6
Ischium height	102.0	83.5	-18.5	-18.1
Chest depth	44.3	36.8	-7.5	-16.9
Chest width	32.7	27.6	-5.1	-15.6
Body oblique length	113.6	95.4	-18.2	-16.0
Shin circumference	15.4	15.0	-0.4	-2.6
Heart-girth	113.9	98.8	-15.1	-13.3
Head length	29.9	27.8	-2.1	-7.0
Forehead length	15.6	13.0	-2.6	-16.7
Head depth	22.1	21.0	-1.1	-5.0
Large width of the forehead	16.6	15.2	-1.4	-8.4
Small width of the forehead	13.4	11.6	-1.8	-13.4
Thurl width	25.7	22.2	-3.5	-13.6
Hip oblique length	30.4	26.2	-4.2	-13.8

The heifers of the control group are characterized by the underdevelopment and uniformity disorders in the body parts at post-uterine part. The low index of variation coefficient (CV) is the result of growing disorders in the body parts and the fast growing body parts have lower values than the slower growing ones.

The measurements of the body parts of the control and experimental heifers at the age of 6 months are introduced in table 3.

By the comparative analysis of the data, it becomes evident that in the first 6 months of ontogeny the height measurements have grown more intensively as of the fast growing body parts in the calves (heifers) of the experimental group, while in the heifers of the control group the growth of the wither height, anus height, ischium height, the body oblique length and heart-girth has been retarded by 14.6 cm-18.4 cm or by 13.3 %- 18,0 %. The privilege of the body parts of experimental heifers over those of the control heifers is clearly illustrated in the diagram of the heifer's exterior (Figure).

Proportional development of the body parts in experimental group is also approved by its individual indices. Thus, at the age of 6 months, the index of leg's height (latitude) was 61.8 %, the longitudinal index, which reflects the ratio of the body oblique length and wither's height was 109.2 %, the hip and chest index was up to 127.2 % and the chest index- 73.8 %.

The best indicator of body mass development is its fatness, which is the ratio of heart-girth and oblique body length (100.3 %). These indicators are in line with the same indices of intensively grown Caucasian brown x Holstein heifers at the age of 6 months (Poghosyan, 2012).

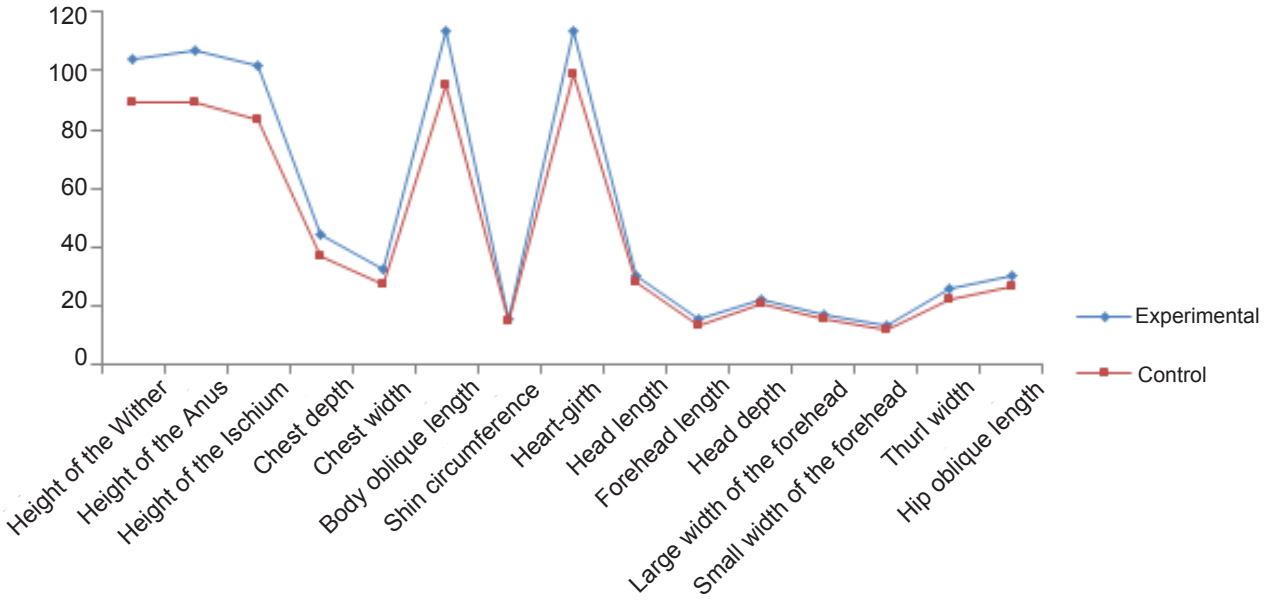

Figure. Diagram of animal's exterior (*composed by the authors).*

The overgrowing index is the ratio of anus and wither's height which makes 102.9%, the index of boniness is 14.8%, the index of mass density is the ratio of heart-girth and wither's height which makes 109.5%. These indicators state on the availability of the genotype with uniformly developed body parts in the heifers of the experimental group.

The heifers of the control group are characterized by the slow growing and development rate, non-uniform body parts, underdevelopment in some body zones and proportional disorders in body structure.

Thus, it is recommended to apply the feed ration developed, tested and currently used at the "Balahovit" teaching-experimental farm in the livestock farms of Armenia.

Conclusion

The reliable data of study results indicate on the high indices in the uniformity of body parts, derivative growing indices, absolute weight growth, growing rate, average daily and relative weight growth, as well as on the specific growing rate in the experimental heifers at the age of 6 months. Thus, the absolute weight growth has made 118.6 kg, the average daily weight growth - 659 g, the relative one- 72.7 % and the specific growing rate-0.3, the growing coefficient is 4.99, while in the control group these indicators are 73.4 kg, 408 g, 62.3 %, 0.2, 3.48 respectively.

As a result, 6-month-old heifers with proportional consistency are grown and this paves a way for raising high milk yield producing cows.

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Parasitic Fauna of Rainbow Trout Infected with Glugeosis in the Fish Farms of the Ararat Valley

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ABSTRACT

Upon the researches of the contemporary pisciculture it has been found out that fish species especially those of trout family, are susceptible to the widespread invasive - parasitic diseases. The high concentration of fish in ponds, violation of sanitary stanards in the pond farms, lack of treatment of some invasions contribute to the widespread occurrence of these diseases and the mass fish mortality.

For the period of 2017 - 2019 mass infection of rainbow trout with glugeosis was detected in the five pond farms of the Ararat valley, while ichthyophthirius, chilodonella, and trichodinosis were fixed as secondary invasions. Therefore, for the prevention of individual and mixed invasive diseases it is recommended to take timely fish-breeding, reclamative and veterinary - sanitary measures in the mentioned pond farms.

Introduction

Fish farming is one of the promising agricultural sectors in Armenia and fish is mainly bred in artificial pond farms of the Ararat valley. In the contemporary fish farming some species of trout family in particular, can get infected with widespread invasive - parasitic diseases, which is a consequence of the high rate of fish concentration in ponds, as well as violations of sanitary standards.

Invasive diseases often occur in fish in an associated form, which leads to the decrease in the profitability of pond farms and complicates the differential diagnosis and treatment of diseases manifested by similar clinical symptoms.

The invasive disease of glugeosis, discovered by the employees of the Department of Epidemiology and Parasitology of the National Agrarian University of Armenia in 2008, is of particular concern.

For the period of 2017- 2018, 781 fish belonging to different age groups were studied. Glugeosis infection in the pond fish belonging to three different age groups made 33 % - 35 % without any further decreasing tendencies. The same fish were simultaneously infected with ichthyophthirius, chilodonella and trichodinosis, due to which the rate of fish disease reached up to 15 % - 27 %.

In order to prevent fish infection it is necessary to organize and take some fish-breeding, land reclamation and veterinary-sanitary measures.

Mixed fish invasions were also observed in the pond farms of several countries, for example, in the Russian Federation (Akisheva, 2003, Garkavi, et. al, 1988, Lysenko, 1994, Lysenko, 2001, Lysenko, Yarovaya, 2003, Naghashyan, et. al, 2015, Csaba, 1984, Hristovski, 2001, Lom & Dykova, 1992, Molnar, 1971).

Thus, the aim of our work is to study the associated invasive diseases developed against the background of glugeosis in the rainbow trout bred in the pond farms of the Ararat valley.

Materials and methods

The studies were conducted during 2017 - 2019 in the parasitological laboratory of the Department of Epidemiology and Parasitology of the National Agrarian University of Armenia. Samples of fish were taken from the pond farms of "Emifish", "Rapeseed", "Fishka", "Bigamafruit" and "Ecofish" located in the Ararat valley. The fish were examined through the method of complete ichthyo-parasitological autopsy developed by V.A. Dogel (1933), modified by I.E. Bihovskoy (Naghashyan, 2005, Bykhovskaya, 1989). Fish up to one, two and three years old were investigated.

Parasites were collected and processed by parasitological methods used in ichthyo-pathology (Dogel, 1933).

In 2017, 781 trout from different age groups were studied, among them 74 trout were under one year, 102 - two years, and 97 - three years old. In 2018 the studies were conducted on 75 trout below one year old, 102 - two years old and 76 - three years old. In 2019, 98 investigated trout were under one year old, 105 - two years and 52 - three years old.

In the five experimental pond farms feeding and breeding conditions were identical, and the ponds were filled with running artesian water.

Results and discussions

As a result of parasitological autopsy and studies of different fish age groups, the following data were obtained for different years.

In the fish under one year old brought from the above mentioned five pond farms investigated in 2017, specimens with 26% glugeosis, 39% ichthyophthirius, 15 % chilodonella and 20% trichodinosis infections were found. In the indicated age group, mixed invasion, with the simultaneous detection of glugeosis, chilodonella and ichthyophthirius, made 15 %.

In two-year-old fish, 34 % glugeosis, 27 % ichthyophthirius, 20 % chilodonella and 18 % trichodinosis infections were detected. Among the fish of this age, mixed invasion with the simultaneous course of glugeosis, chilodonella and trichodinosis was 23 %.

In the fish up to the age of three, the following picture was observed: out of investigated samples 32 % were infected with glugeosis, 25 % with ichthyophthirius, 23 % with chilodonella and 21 % with trichodinosis. Mixed invasion rate made up to 18 % (Table 1).

In the investigations for 2018 the following data were obtained: among fish under the age of one year 32 % of glugeosis, 19 % of ichthyophthirius, 28 % of chilodonella, and 21% of trichodinosis infections were found. Mixed invasion in the indicated fish group with the simultaneous course of glugeosis, chilodonella, ichthyophthirius and trichodinosis amounted to 12 %. Among fish under the age of two 36 % of glugeosis, 19 % of ichthyophthirius, 27 % of chilodonella and 17 % of trichodinosis were recorded. Mixed invasion in the indicated group of fish, with the simultaneous course of glugeosis, chilodonella, ichthyophthirius and trichodinosis amounted to 24 %.

The following situation was observed in the samples of three-year-old fish: 35 % were infected with glugeosis, 26 % with ichthyophthirius, 22 % with chilodonella and 18 % with trichodinosis. Mixed invasion rate amounted to 22% (Table 2).

In 2019, the one-year-old fish brought from the pond farms of the Ararat valley "Emifish", "Raps", "Fishka", "Bigamafrut" and "Ecofish" demonstrated the following invasions: 33% glugeosis, 23% ichthyophthirius, 21% chilodonella and 22% trichodinosis. In the indicated fish age group the mixed invasion with the simultaneous course of glugeosis, chilodonella, ichthyophthirius and trichodinosis made 11% .

Table 1. The degree of infection with protozoa in different age groups of fish for 2017, expressed in absolute numbers*

Age groups	Total number of fish examined	The number of fish infected with glugeosis	The number of fish infected with ichthyophthirius	The number of fish infected with chilodonella	The number of fish infected with trichodinosis	The number of fish infected with mixed invasion
Under one year old	74	19	29	11	15	11
Two years old	102	35	28	21	18	23
Three years old	97	31	24	22	20	18

**Composed by the authors.*

Table 2. The degree of infection with protozoa in different age groups of fish for 2018, expressed in absolute numbers*

Age groups	Total number of fish examined	The number of fish infected with glugeosis	The number of fish infected with ichthyophthirius	The number of fish infected with chilodonella	The number of fish infected with trichodinosis	The number of fish infected with mixed invasion
Under one year old	75	24	14	21	16	9
Two years old	92	33	18	25	16	22
Three years old	78	27	20	17	14	17

Table 3. The degree of infection with protozoa in different age groups of fish for 2019, expressed in absolute numbers*

Age groups	Total number of fish examined	The number of fish infected with glugeosis	The number of fish infected with ichthyophthirius	The number of fish infected with chilodonella	The number of fish infected with trichodinosis	The number of fish infected with mixed invasion
Under one year old	98	32	23	21	22	11
Two years old	105	33	27	29	16	24
Three years old	52	14	11	18	9	7

**Composed by the authors.*

In two-year-old fish, 31 % glugeosis, 26 % ichthyophthirius, 28% chilodonella and 15 % trichodinosis infections were recorded. Mixed invasion rate detected in the indicated fish age group with combined glugeosis, chilodonella, ichthyophthirius and trichodinosis infections was 23 %.

In the three-year-old fish, the state of infection was as follows: out of investigated fish, 27 % were infected with glugeosis, 21 % with ichthyophthirius, 35 % with chilodonella and 17 % with trichodinosis. Mixed invasion rate made 13% (Table 3).

Thus, in the pond farms examined over three years the average infection rate with glugeosis in the three age groups was 33 % - 35 % without any further decreasing tendency. Almost the same infection rate was fixed related to mixed invasion. The causative agents of glugeosis are known to have a pronounced tropism for certain organs and tissues of the host. The most pathogenic are parasite species that infect the intestines and gills of fish. We have found cysts of the causative agent of glugeosis in all tissues of infected fish; anyhow they were dominant in the abdominal cavity, muscles and in the eyes (Figure 1).

Ichthyophthirius fish infection demonstrated the following dynamics: in 2017 the infection in all examined age groups ranged from 19%-39%, while the highest infection rate was observed in the fish under one year old, which was expressed upon the lesion caused to the subcutaneous tissue, fins and gills (Figure 2).

Figure 1. Clinical signs and microscopic pattern of fish Glugea infection.

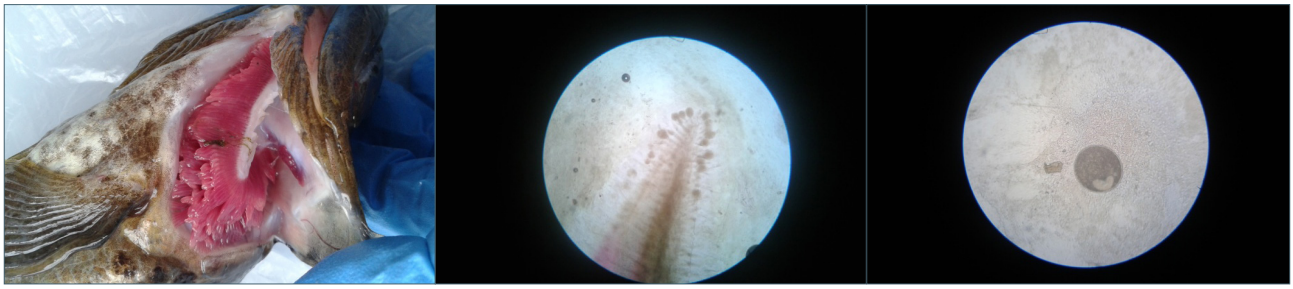

Figure 2. Gills infected with Ichthyophthirius and its microscopic pattern.

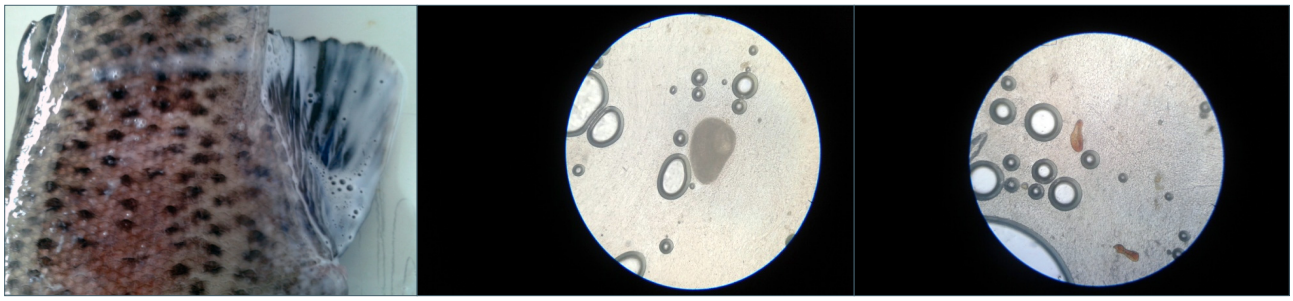

Figure 3. Clinical signs and microscopic pattern of fish Chilodonella infection.

Figure 4. Trichodina infection and its microscopic pattern

According to the studies in the pond farms of the Ararat valley the chilodonella infection rate ranged within 11 %-29 %. The disease was recorded from early spring. Pathoanatomical changes in chilodonella were expressed in the skin and gills of fish at the age of two and even older (Figure 3).

Trichodinosis has been clinically manifested by lesion of gills and skin in various parts of the fish body. In the fish of different age groups trichodinosis infection varied within the range of 9 %-22 % and held constant throughout the three years of investigation (Figure 4).

Conclusion

Summing up we can say that due to the use of artesian waters there are favorable conditions for the emergence and survival of parasitic systems in the pond farms of the Ararat valley which is greatly promoted by the infection of fish glugeosis. It should be noted that during the three years of investigation, fluctuations in dynamics of individual invasions were not observed. Therefore, for the prevention of individual and mixed invasive diseases it is recommended to take timely fish-breeding, reclamative and veterinary - sanitary measures in the mentioned pond farms.

The quarantine of the newly imported fish species is of paramount significance in the system of veterinary- sanitary preventive measures, since very often both infection and invasion diseases penetrate into the farms together with the imported new stocks.

The sufficient sanitary conditions of the reservoirs, water temperature, its saturation with oxygen are among the primary preventive measures against the fish diseases.

The drainage and disinfection of the reservoirs with chlorinated lime, quick lime, copper sulphate and with other disinfectants are also involved in the preventive measures.

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Risk Assessment of Malachite Green in Fish Produced in Armenia

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ABSTRACT

This study aimed to investigate malachite green residues in farmed fish and to assess its dietary exposure in Armenia. Quantitative measurement of malachite green in fish samples was done by the enzyme-linked immunosorbent assay method. The results were approved by the LC-MS/MS method. The malachite green residues were found only in 20 % of the investigated fish samples and exceeded the minimum required performance limit (MRPL) of 0.002 mg/kg set by the EU legislation. The obtained results highlighted the issues concerning the illegal use of malachite green in some fish farms in Armenia.

Introduction

Aquaculture has a great development potential in Armenia. Since 2010 the strategy for export-oriented production has been established by the government of Armenia. Besides, since 2011 the Russian market has opened for Armenia, but taking into consideration the high demand for fish in EU countries, efforts are being also made to enter the European markets. As a mandatory requirement, the EU regulations for monitoring food residue of animal origin must be implemented by the third countries (FAO 2005). In the scope of the residue monitoring program, not only the allowed but also the banned substances must be included. Among the banned substances, the malachite green is one of the illegally used chemicals.

Malachite green (MG) is a triphenylmethane dye that has been used worldwide as an effective and inexpensive therapeutic technique for ectoparasitic and fungal infections in fish farming since the 1930s. Due to several toxic effects of MG and its major metabolite leucomalachite green (LMG) on mammalian cells, MG has never been authorized as veterinary medicine in the EU. The US Food and Drug Administration does not approve the use of this dye either (Ali, et al., 2016, Bajc, et al., 2011, Bilandžić, et al., 2012).

Despite the ban, residues of malachite green and leucomalachite green have systematically been found in fish and fish products in the past decade, causing great concern for consumers in many countries, including European Union, Australia, Canada, the United States, Indonesia, and Vietnam (Chi, et al., 2017, Conti, et al., 2015, Renwick, et al., 2010). Moreover, several adverse toxic effects have been reported including carcinogenesis, mutagenesis, chromosomal fractures, teratogenicity and respiratory toxicity (EFSA 2016).

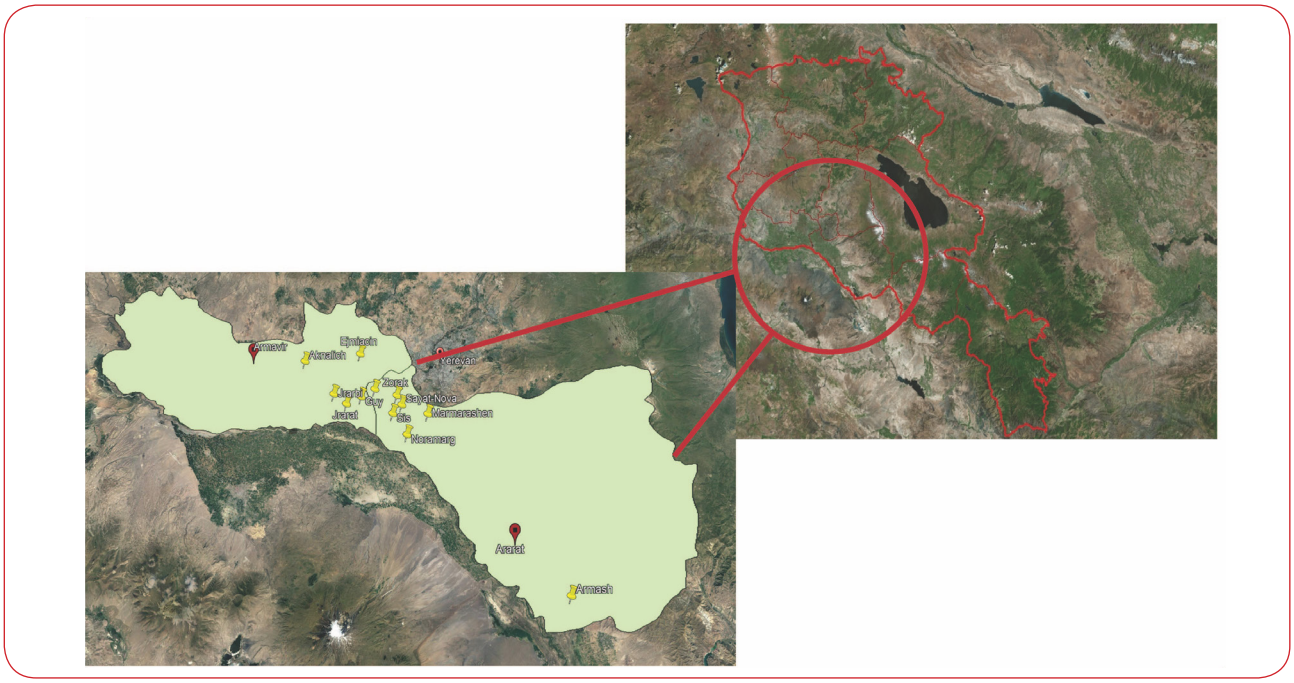

Figure 1. Fish sampling points (fish farms) in Armenia

The collection of detailed information on the use of malachite green in aquaculture is crucial for the evaluation of its toxic effects and potential health risks (Benford, et al. 2010). Therefore, this study aimed to investigate malachite green residues in farmed fish and assess its dietary exposure in Armenia.

Materials and methods

The sampling of fish produced in Armenia was done in the frame of the state residue monitoring program (2016-2017), according to the government decree on food sampling (RA Government 2012). The sampling points (fish farms) in Armenia are presented in Figure 1. In total, 15 samples (containing at least 3 sub-samples) of farmed fish (FM-1 - FM-15) were sent to the international accredited laboratory ‘‘RVSPCLS” SNCO SSFS MA RA for malachite green residue determination.

Quantitative measurement of malachite green in fish samples was done by the enzyme-linked immunosorbent assay (ELISA) method. The results were approved by the LC-MS/MS method (Ding, et al., 2007, Liang, et al., 2006). This method is intended to rapidly and precisely determine residue levels of malachite green and leucomalachite green in fish. Using positive mode electrospray ionization (ESI+) and multiple reaction monitoring (MRM) technique, the LC/MS/MS method shows the detection limit of 10 ppt. The analytical method was validated by analyzing fortified roast eel samples at 1, 2 and 5 µg/kg levels, corresponding to 0.5×, 1×, and 2.5× MRPL (Minimum Required Performance Limit) respectively. Seven replicates were performed at each level. Excellent recovery values of 90 %-106 % were obtained with RSD % ranging from 3.7 % to 11 %.

All chemicals were of reagent grade. MG oxalate salt and LMG were from Sigma-Aldrich (St Louis, MO, USA), and d6-LMG from WITEGA (Berlin, Germany).

Additionally, dietary exposure of malachite green through daily fish intake was estimated by the following equation.

$$EDI = C \times IR / Bw,$$

where EDI - estimated daily intake, mg/kg bw/day, C - malachite residue green content, IR - daily fish consumption (kg/day), according to Statistical Committee of Armenia (Armstat 2017), Bw - body weight (70 kg).

Results and discussions

The table data indicate the malachite green residues in farmed fish produced in Armenia.

According to data presented in the table it can be noted that for the majority (80 %) of investigated fish samples malachite green residues were not detected. Malachite green residues detected in 3 fish samples (FM-2, FM-5, FM-10) were in the range of 0.47 mg/kg -1.7 mg/kg.

Table. Malachite green residues in fish samples*

№	Sample Code	Malachite green residues, mg/kg
1	FM -1	N/D
2	FM-2	0.47
3	FM-3	N/D
4	FM-4	N/D
5	FM-5	0.87
6	FM-6	N/D
7	FM-7	N/D
8	FM-8	N/D
9	FM-9	N/D
10	FM-10	1.7
11	FM-11	N/D
12	FM-12	N/D
13	FM-13	N/D
14	FM-14	N/D
15	FM-15	N/D

Note: N/D – not detected.

**Composed by the authors.*

fish health management, and farm environment management (Kamaruddin & Baharuddin, 2015).

Since malachite green is a toxic substance, the consumption of contaminated fish may, therefore, pose adverse health effects on consumers. So, dietary exposure was estimated by combining malachite green contents' data and fish intake data. The estimated daily intakes for malachite green are presented in Figure 2.

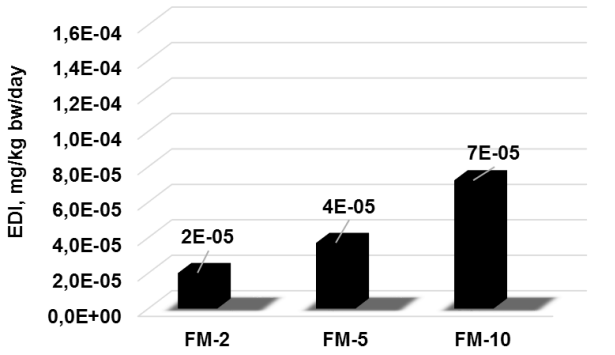

Figure 2. Estimated daily intake (EDI) of malachite green via consumption of fish

The Joint FAO/WHO Export Committee on Food Additives (JECFA) did not recommend MRLs for malachite green, as it did not support the use of malachite green for food-producing animals. Nevertheless, it can be emphasized that detected contents of malachite green were much higher than the established MRPL level (0.002 mg/kg) set by the EU (EC 2004).

Malachite green concentrations in fish muscle in Croatia were lower than the established MRPL (0.002 mg/kg). The concentration of malachite green ranged from 0.0003 mg/kg to 0.4872 mg/kg, measured in eel originating from the Netherlands in 2006 (Bilandžić, et al., 2012).

Sudova et al. stated that malachite green is widely used due to the lack of a proper alternative. Pyceze, however, is a pharmaceutical alternative to malachite green, with bronopol as its active ingredient (Srivastav & Roy, 2015).

It should be noted that success in fish farming is related to the possibility of providing an adequate supply of good-quality water with minimum contamination by organic substances and on the use of good-quality feeds. This will keep fish in the best health condition and increase their resistance to infections (Sudova, et al., 2007). From this point of view, the Good Aquaculture Practices (GAP) should be implemented in fish farming. GAP helps fish farms improve in key areas such as farm infrastructure management, farm husbandry,

The obtained EDI values are in the range of 2E-05 to 7E-05 mg/kg bw/day. These values were much lower than the WHO's best estimate: 1.5E-04 - 6.9E-04 (sum vet. Drug + contaminant) mg/kg bw/day (WHO 2008). In comparison to this, mean dietary exposure across different European dietary surveys and age groups ranged from 0.1E-6 to 5E-6 mg/kg bw/day. For high and frequent fish consumers, the exposure ranged from 1.3E-6 to 11.8E-6 mg/kg bw/day (EFSA 2016).

Conclusion

Taking into consideration the obtained results, it may be concluded that the concentrations of malachite green were identified only in 20 % of investigated fish samples. Overall, the measured malachite green residues exceeded the minimum required performance limit (MRPL) of 0.002 mg/kg set by the EU legislation. According to the EFSA CONTAM Panel, it is unlikely that exposure to food contaminated with malachite green at or below the reference point for action (RPA) of 0.002 mg/kg represents a health concern (EFSA 2016). Nevertheless, the obtained results of this investigation highlighted the issues concerning the illegal use of malachite green in some fish farms in Armenia. Hence, the national surveillance programs are required for the prevention of the illegal use of malachite green. Moreover, further investigations with a large number of fish samples

need to be carried out to perform more comprehensive risk assessment not only for malachite green residues but also for its metabolite- leucomalachite green.

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Exposure Assessment of Cadmium via Consumption of Fish Sold in the City of Yerevan

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ABSTRACT

The purpose of this research was to study residual cadmium in trout and to assess effects of daily and weekly exposure of this heavy metal on consumers' organism. The results obtained have indicated that residual cadmium in the studied fish samples vary between 6,00E-05 and 3,00E-03 mg/kg, whereas the estimated daily and weekly intake of this element does not exceed international standards.

Introduction

Fish and fish products are known to be healthy food which, as a source of proteins, fats and fat soluble vitamins having high biological value, is essential for improving the diet quality (FAO, 2014). Fish quality indices are negatively influenced by heavy metals, a constituent of water in natural water reservoirs, the levels of which largely vary depending on geochemical conditions (Yi, et.al., 2017). Heavy metals have a harmful impact on the environment (Ekpo, 2008) as well as living organisms and human health triggering allergic reactions, disorders in digestive and central nervous systems and so on (Renieri, et.al., 2014). Of all heavy metals, one of the primary water contaminants is cadmium (Cd), a rare but dispersed element (Burke, 2016). This element enters a fish body via feed and water and builds up mainly in gills (respiratory ways), stomach (gastro-intestinal tract), skin and mussles (Miri, et.al., 2017). It is well documented that after penetrating into a human organism, cadmium accumulates during a relatively long period (20-30 years), and that high Cd levels provoke respiratory disorders and bone diseases (Renieri, et.al., 2014); so the long-term effect brings to teratogenicity, gene mutations and cancirogenesis (Yuan, et al., 2016). In recent years, residual cadmium in fish has increased becoming a priority health issue (Storelli, et. al., 2005).

Cadmium belongs to the elements of the 1st class toxicity, so it is important to monitor residual Cd in Salmo Ischchan – a basic fish species in the diet of local consumers.

The purpose of this research was to study cadmium contents in fish meat sold in Yerevan and to estimate the daily intake of cadmium through fish consumption.

Materials and methods

Fish sampling was done in 2016 in the frame of a state monitoring program (Decision N 1142-N) from large food markets and supermarkets in Yerevan. A total of 5 composite samples of trout (Salmo Ischchan) within 3 subsamples were

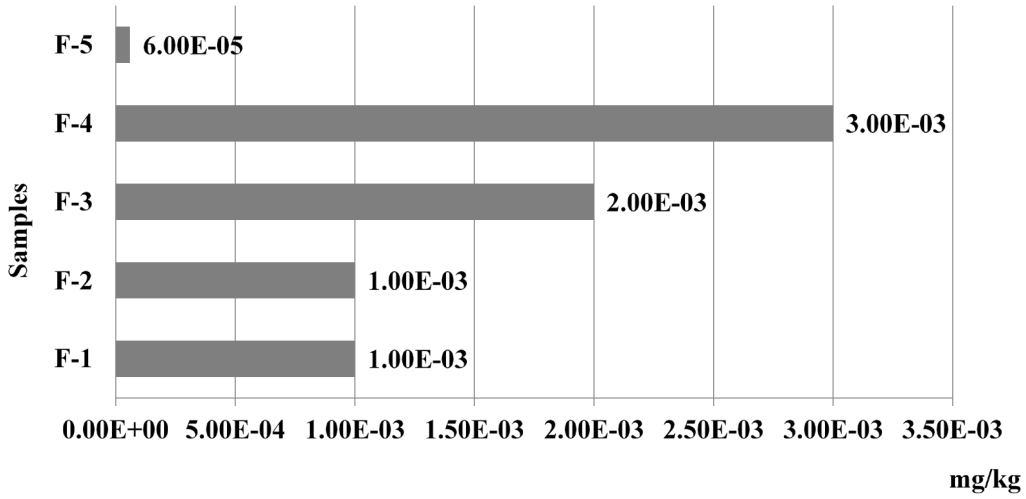

Figure. Concentration of Cd in Salmo ischchan samples (mg/kg) sold in Yerevan markets (*composed by the authors*).

collected from the 5 supermarkets and fisheries, which are the main source for fish retail. The samples were placed into appropriately tagged plastic bags and transported at 4°C to the Republican Veterinary-Sanitary and Phytosanitary Laboratory Services Center SNCO (RVSPCLS SNCO). The analysis was done through the atomic adsorption spectrophotometry method in compliance with EN 14083-2003 (EN 14083-2003 Foodstuffs) and using the Thermo ISE 3000 (Thermo Fisher Scientific Inc., USA) atomic adsorption spectrophotometer. The detected "Cd" residues were then compared with maximum residue limits (MRLs) of "Cd" in fish set by the Eurasian Economic Commission (EEC) and Commission of the European Communities (EC) 2.00E-01 mg/kg and 5.00E-02 mg/kg, respectively (Technical Regulations of Eurasian Economic Commission, 2011; Commission Regulation (EC) No 1881/2006, Renieri, et.al., 2014).

Estimated daily intake (EDI)

Estimation of daily intake of cadmium was done based on metal concentration in fish meat, the quantity of consumed fish and human body weight. Data on the quantity of trout consumed by Armenia's population were obtained from the database of Statistical Committee (SC) of the Republic of Armenia (ARMSTAT, 2016), which were then recalculated for daily intake since SC provides data on monthly intake of fish. The estimated daily intake was calculated by the following equation (Yi, et.al., 2017):

$$EDI = C \times Ccons / BW, \quad (1)$$

where C is the concentration of "Cd" in fish (mg/kg wet weight), Ccons (kg/day) is the average daily consumption of fish by population of Armenia (ARMSTAT, 2016) and BW is the average body weight for adults (65 kg).

Besides EDI (mg/kg BW per day), we also calculated estimated weekly intake (EWI) of "Cd" and the percentage of provisional tolerable weekly intake PTWI (in percent). The PTWI is the reference dose set by Food and Agriculture Organization (FAO) and World Health Organization (WHO) (Joint, 2011, Renieri, et.al., 2014) which represents a safe weekly intake of heavy metals (Miri, et.al., 2017).

$$PTWI_{\%} = EWI/PTWI \ *100, \quad (2)$$

where EWI (mg/kg BW per week) is the estimated weekly intake of "Cd" and PTWI is provisional tolerable weekly intake of Cd (7.00E-03 mg/kg of BW per week (Joint, 2011)).

Results and discussions

Data obtained from the analysis have indicated that "Cd" was present in all the five fish samples within the range of 6.00E-05 to 3.00E-03 mg/kg (Fig.). However, they did not exceed Maximum Residue Limits (MRLs) set by EEC (2.00E-01 mg/kg) and EC (5.00E-02 mg/kg). The calculated daily intake of Cd via consumption of fish was 7.32E-08 mg/kg of BW per day, whereas EWI (5.49E-07 mg/kg of BW per week) did not exceed the permissible level of PTWI (Joint, 2011) set by FAO/WHO for Cd.

One should stress that despite the absence of normative excesses, the ability of cadmium to cause chronic intoxication in humans even at minimal concentrations should not be disregarded (Ekpo, et. al., 2008). It should also be stressed that this metal can build up to toxic levels in fish and then enter food chains (Sarkar, et.al., 2016).

Conclusion

The main conclusion derived from this fish research was that residual cadmium detected in Salmo Ischchan samples does not exceed MRL set by EEC and EU and that EDI and EWI of this heavy metal meet the international standards set by joint FAO/WHO and EU.

Due to its toxicity cadmium belongs to the elements of the 1st class hazard, so a recommendation is made to continue monitoring on residual cadmium in Salmo Ischchan which is among the basic fish species in the diet of local consumers.

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