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ARMENIAN NATIONAL AGRARIAN UNIVERSITY

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АГРОНАУКА И ТЕХНОЛОГИЯ

НАЦИОНАЛЬНЫЙ АГРАРНЫЙ УНИВЕРСИТЕТ АРМЕНИИ

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Analysis of the Technical and Economic Indices for Reservoir Exploitation by the Example of Tolors Reservoir

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Tolors reservoir,
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rock fill,
water diversion tunnel

ABSTRACT

The comprehensive analysis of reservoir enables to disclose the operational terms of various constructive parts during the dam's exploitation, as well as the problems related to its filtration properties and efficient exploitation. In the current work, planning and cartographic documents of hydro-system on the example of Tolors reservoir have been studied and operational-technical indices of individual constructions have been enhanced and compared with the monitoring results recorded during the dam's exploitation. A number of events have been developed the application of which will promote the provision of the natural exploitative conditions for the reservoirs and their adjacent hydro-constructions.

Introduction

Tolors reservoir was put into operation in 1974. It is located 3.0 km south to the Sisian community, its area makes 4.7 square km, the length is 4.5 km, the maximum water depth - 56.5 m, the total volume - 96.0 million cubic meters, the active (effective) volume - 80.0 million cubic meters. Water is stored in the Tolors reservoir through the Vorotan river stream, as well as through the household water flows from the Sisian and Ayri rivers. The minimum water horizon in the reservoir makes 1625.5 m, since it is impossible to carry out the works of the Shamb Hydro Power Plant below this mark. The Hydro Power Plant of Shamb is located on the right bank of the Vorotan river and has 1716 MW capacity. Water diversion of the HPP has been realized through the round section pressure tunnel with 4.6 m diameter. The flotation ability in the tunnel makes 75.0 cubic meter water per second. The tunnel has 6871.44 m length. The equalizing reservoir installed at the end of water diversion tunnel consists of upper and lower chambers and vertical pipe string connecting the mentioned chambers, the diameter of which makes 6.0 m. The threshold mark of water intake unit is 1618.9 m (Report on hydro-technical structures of Shamb HPP, 2012-2015).

Tolors reservoir is a rock-fill dam with core, which is endowed with high stability rate. In the rock and rock-fill dams stones of different sizes are used, which entails to their tighter structure, as well as to the sedimentation of the stone remnants. The latter increases the filling mass and decreases the subsidence of the dam body as the vacuums

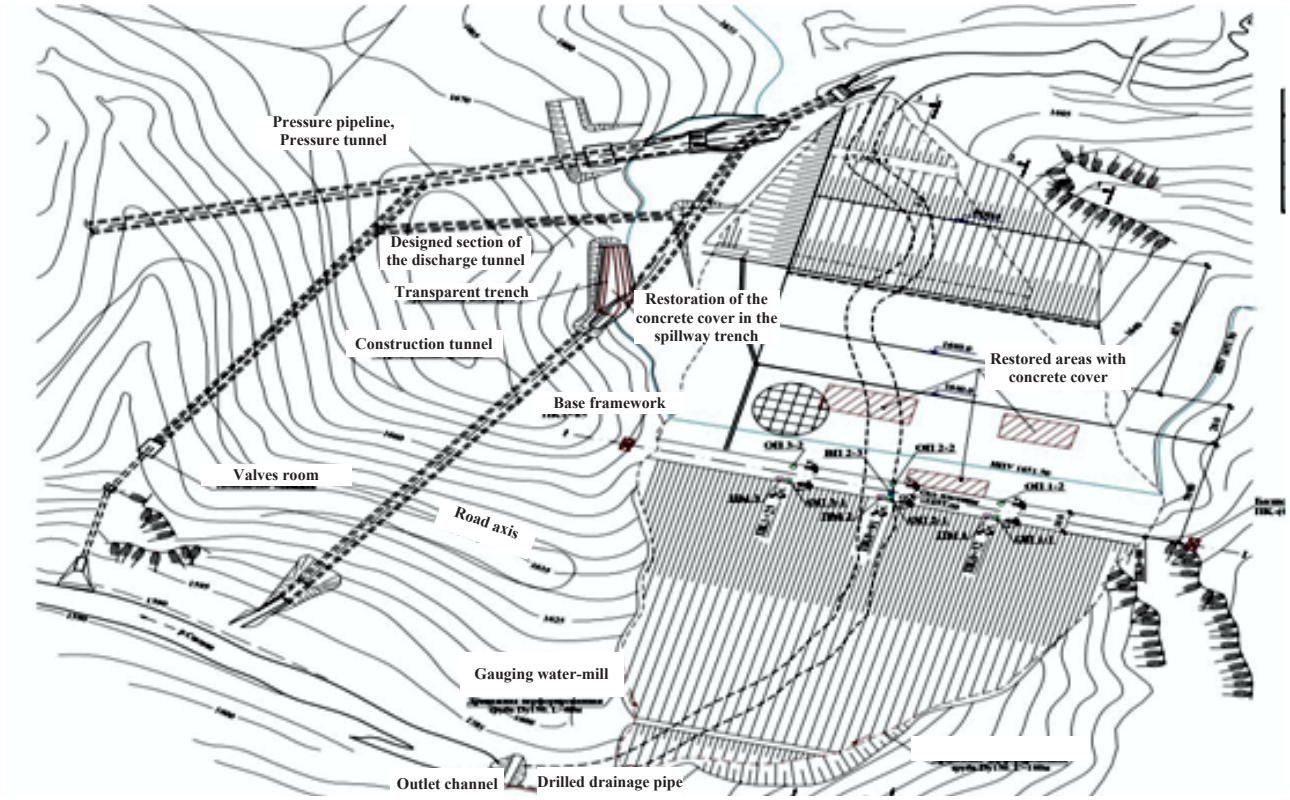

Figure 1. The main plan of the Tolors reservoir and hydro-technical structures (*composed by the author*)[1,2,3].
Source: [1.]Report on the Hydro-Technical Structures of the Shamb HPP, 2012-2015, [2.]Zamarin, E.A., Popov, K.V. (1946). Course on Hydro-Technical Structures, [3.]Baghdasaryan, A.B (1986). Hydro-Technical Structures.

can cause deformations in the dam body. Nevertheless, extremely large amount of rock remnants (more than 20 %-30 %) can bring about the case when the loading of the dam passes not onto the large rocks but on the small ones, which will lead to the subsidence of the dam and to the reduction of the stability in its sections. The minimum weight of individual rocks shouldn't exceed 80 kg, while for the high dams large rocks are preferable (Zhuravlyov, 1979). The body volume of the filling dams is greater than that of in the dams with dry structures (up to 40 %), anyhow the construction of rock-fill dams is considered to be more beneficial, since the dry structure is much more expensive than the structure with rock-fill. In the mixed dams part of the profile is designed through the rock filling regarding the dry race, while in case of the wet race it is implemented through the power-tamped earth (Zamarin, 1946). The core serves as an anti-filtration element in the Tolors reservoir. Anyhow, the core has got high water proofness rate, besides, some problems appear during the core restoration activities (Grimin, 1962). Among the advantages of rock-fill dams the application of local materials, seismic resistance, the construction simplicity, opportunity of the dam's construction throughout the entire year (due to the mechanization of the work), facilitation of the further uplifting of the dam height and the moderate requirements towards the dam base can be involved. The main disadvantages of the rock-fill dams are huge labor intensity and further subsidence of the dam as a result of which there is a great need for updating and re-fitting of the tools in the dam's body. To ease the process of rock-fill dams' construction it is necessary to possibly maximize the mechanized work related to the rocks processing and their transportation (Baghdasaryan, 1986).

Materials and methods

The researches have been conducted through the study of monitoring results on the plan and exploitative indices of the individual structures in the reservoir hydro-system, as well as through analysis and comparison methodology. The plan and cartographic documents of the Tolors reservoir

have been studied in natural conditions, the working terms of individual structures have been examined and then, being compared with the technical exploitative conditions stated upon the standards, the violations and deviations of the exploitative conditions of individual structures in hydro-system have been revealed based on which their upgrading measures have been developed.

The aim of the current research is to study the technical and economic state in the reservoir exploitation on the example of the Tolors reservoir. In the result of our investigations the main breakdowns occurred in the Tolors reservoir and the activities aimed at their elimination have been studied. One of the most common breakdowns is the clogging of the pressure pipeline. Due to the untimely performance of cleaning activities clogging in the sub-chamber cells of the pressure pipelines occurs (Semenkov, Lentyaev, 1973). Because of the clogging the water horizon rises up in the pressure chamber. Here are the activities and their sequence for the breakdown liquidation:

a) Continuous control over the discrepancies between the horizons of the pressure chamber and the sub-chamber of the pressure pipeline.

b) Operation of a refuse-collecting truck and continuous cleaning of the sub-chamber cells focusing the machine work on the most contaminated part in case when no disposal or pressure decline is observed.

c) When complete or partial disposal takes place with pressure decline the opening valve is closed and the working units are switched off (upon the permission of the shift manager).

d) To supply water into the pipeline the raising of the closed panel should be implemented gradually in compliance with the production instructions in the hydro plant.

To prevent the abrupt water filtration in the dam, concrete injection activities are implemented in the hydro-system every year. Anyhow, filtration growth is observed from time to time in the following sections of the dam:

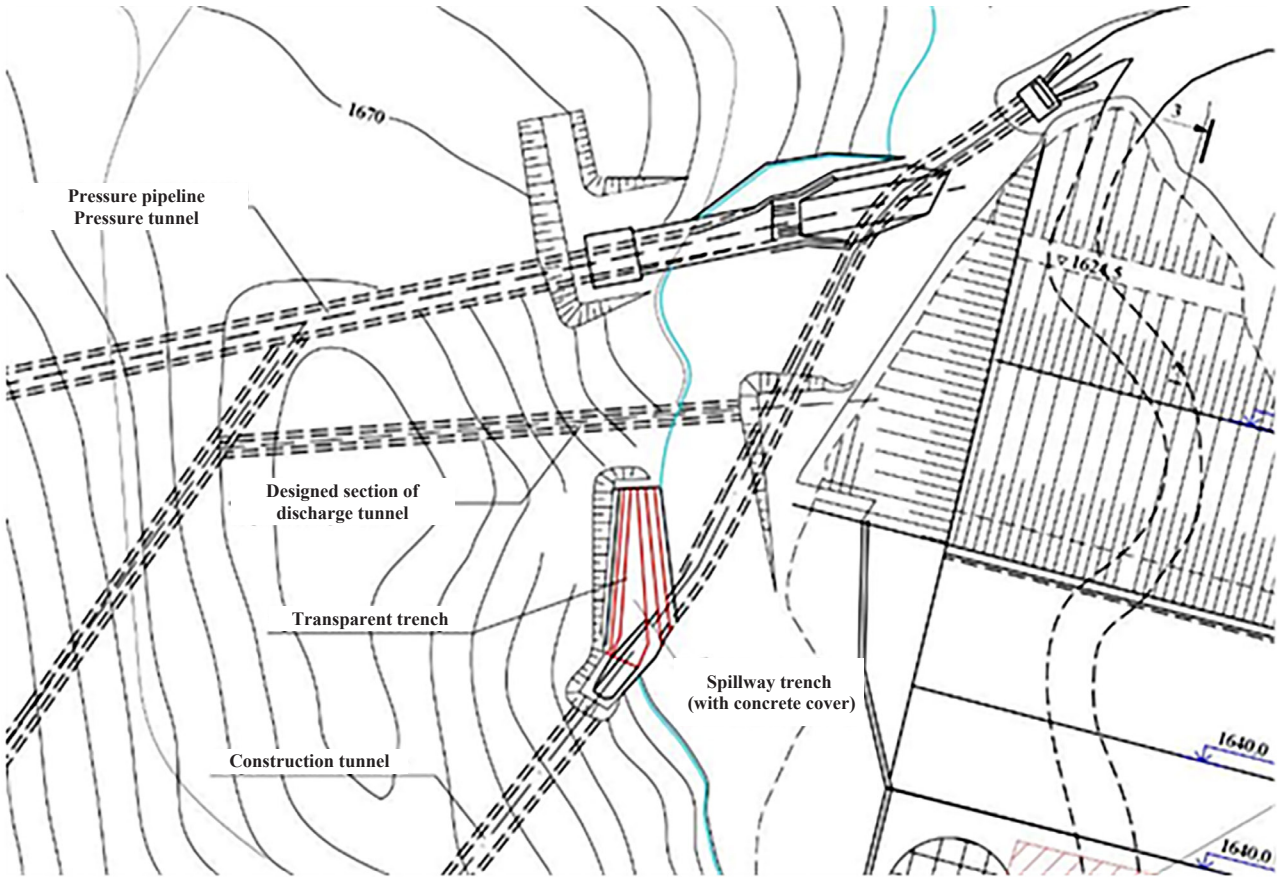

Figure 2. Pressure pipeline of the pressure sub-chamber (*composed by the author*)[1,2,3].

Source: [1.]Report on the Hydro-Technical Structures of the Shamb HPP, 2012-2015, [2.]Zamarin, E.A., Popov, K.V. (1946). Course on Hydro-Technical Structures, [3.]Baghdasaryan, A.B (1986). Hydro-Technical Structures.

- Between the dam's body and foundation footing
- In the dam's body-deeper than the mark of foundation's filler structure
- In the dam's coastal attachments
- Through the dam's body

The filtration growth can lead to the dam's destruction in the lower deck near the water leakage outlet zones (Chugaev, 1985). In case of detecting any leakage through the dam it is necessary to eliminate it in the following ways:

- In case of accident threat, when the leaking water can cause dam's destruction, it is necessary to lower the headwater level down to the threshold mark of water intake unit by means of water diversion.
- To provide the stability of the lower deck and to protect the soil from the tailwater swelling it is necessary to charge it with more water-permeable heavy inverse filter, such as macadam, gravel, etc.
- As a result of investigations, it has been also disclosed that the accidents often happen in case of closed water diversion, which causes destruction of water diversion tunnel. In the closed water diversion the accident happens when at the water diversion point the water horizon exceeds the estimated cost level.

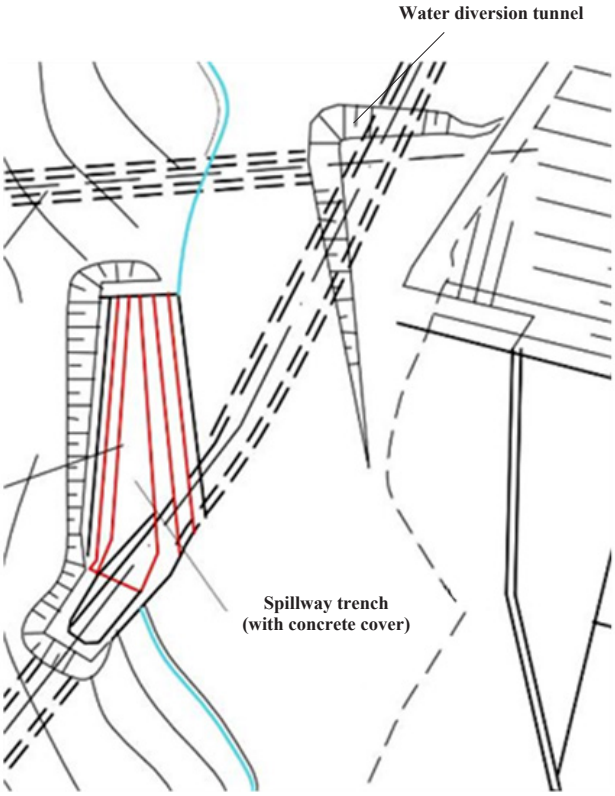

Figure 3. Water diversion tunnel (*composed by the author*).

In case of serious damages in the water diversion tunnel, flooding dangers for the tunnel coating soil appear. Besides, in case of significant tunnel damages, there may be restrictions or termination of the water access into the pressure chamber. In order to eliminate this accident it is necessary to follow the mentioned successive actions: when fixing the damage in the water diversion tunnel it is necessary to disclose the nature and sizes of the damage and in case of any threats, i.e. when the water can destruct the tunnel walls and floor, it is necessary to stop the water supply into the water diversion tunnel. When the destruction nature and sizes are found out restoration works should be implemented.

Results and discussions

In the study results it turns out that there is a need for the observation and regular care for the structural conditions in the hydro-system. Each construction of the hydro-technical structures has it specific exploitative standards, which should be ensured in the result of ongoing monitoring activities. In all main structures the following monitoring activities should be implemented:

- Monitoring over the deformations and cracks appeared in the concrete structures and coating sediments upon the strengthening the decks in the thermal compression dam.
- Monitoring over the filtration through the structures, over the activities in the water supply structures, as well as over the water marks in the piezometric measurements.
- Monitoring over the fluxes, landslides and the moss coverages in the reservoirs.

For the regular exploitation of the reservoirs and their adjacent hydro-structures the preparation activities for floods and the discharge of flood waters are considered to be among the priority tasks. All preparation events should be over 15 days before the start of possible flooding. Every year a plan on the flood waters discharge and the measures for protecting hydro-technical structures should be developed before the start of spring floods. At least a month before the expected floods the relevant committee inspects and evaluates the preparedness of hydro-technical structures for the floods, takes control over the flood

water discharging activities after which the staff starts examining the structures once more. Well before the start of the floods it is necessary to clean the waste storage cages in the ports of water intake units at the central units, so that in case of intensive water inflow no clogging or artificial advancement in water horizon is recorded. It is also necessary to check and test the water intake units and their lifting mechanisms.

In case of increasing household water flows from Sisian and Ayri rivers , as well as at the start of floods the water horizon level in the Tolors reservoir stays within the minimum range but not below the minimum allowable limit (1625 m).

The Tolors reservoir is located 1625 m high above the sea level and due to climatic conditions there can be some problems in winter. In severe frosts freezing of the water supply surface is sometimes inevitable, which is more dangerous for the water intake unit. Under the impact of winds and waves the ice can break down and float towards the water intake unit. In the mentioned period a particular attention should be paid to the cells not allowing their obstruction with ice. In case of air temperature decrease below -10 ^{0}C it is necessary to slightly move the ice in the valves every day to avoid freezing of the moving parts in the valve gasket. When detecting anomalous phenomena in the hydro-technical structures it is necessary to enhance the reasons and to initiate measures for their elimination.

Conclusion

In the result of researches we can come to the conclusion that monitoring on the technical and economic state of hydro-technical structures introduced in this article should be implemented by the end of each exploitative year for the improvement of their exploitation results and safety, so as to avoid the possible accidents. By the example of Tolors reservoir we can state that accidents often happen in the pipeline of the pressure chamber, dam's body and in the water diversion tunnel.

Thus, it is recommended to implement monitoring every year in order to provide uninterrupted work in the mentioned structures.

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Peculiarities of Heavy, Oversized and Hazardous Cargo Trasportation

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oversized cargo,
transport,
security

ABSTRACT

The article analyzes the peculiarities of different transport modes indicating the advantages of cargo transportation by motor vehicles. It is shown that the transportation of both dangerous and oversized heavy cargo, especially in mountainous areas, requires strict observance of safety rules, especially when about 20 % of the total cargo transportation includes hazardous cargo. It was also noted that there are tools and equipment (cargos) that requires professional rolling stock for transportation, while for some cases special means should be created for transporting the given cargo, including platform, trailer, trolley, etc.

Introduction

Cargo transportations have been implemented with ease since the times when a human being invented the wheel and was able to tame some wild animals using them as traction force. Currently, most of the cargo transportation is carried out by water, rail, air, motor vehicles and pipelines. Each of the listed means has its fixed place with its characteristic advantages and disadvantages. Depending on their geographical locations, many countries cannot use all of the abovementioned methods. In this view, the ovrwhelming majority of cargo transportation in the territory of the Republic of Armenia is carried out by motor vehicles and the small part - by the railway transport, as the railway network is not widespread. In this respect car transportation has a number of advantages among which the following are worth to be mentioned (Savin, 2002, Khmelnitski, 2017):

- fast transportation organization with the scheme of "up to the destination point",
- control over the cargo throughout the whole transportation process,
- ad-hoc route modification depending on the situation,
- economic feasibility due to lack of intermediary actions.

On the whole, cargo transportation by motor vehicles is more costly as compared to railway and water transport depending on the ton/dram ratio of transported cargo. However, it is a faster means of transportation, especially for oversized and dangerous cargos. The following types of cargo transportation have been distinguished: intracity, intercity and international. It is apparent that for the first two variants, there is no any alternative for motor vehicle transportation. Meanwhile, in case of international transportation the cargo quantity, its type, time factor and

transportation costs should be considered and then the preferable transportation mode for the specific case should be implemented.

Materials and methods

The hazardous cargo can be transported equally by all the abovementioned types of vehicles, and in all cases the safety rules applicable to the transportation for each type of dangerous cargo must be complied with. There are many cargoes under this category, including explosives, ammunition, fireworks, compressed gas, liquefied gas, frozen liquid gas, dissolved gas, other chemicals that cause suffocation, oxidation, easy combustion and poisoning. Nitrogen, argon, helium, xenon, neon and carbon dioxide are among the suffocating gases. Oxygen, air, nitrous oxide and fluoride are the gases that contribute to combustion (fire). Ethylene oxide and chlorine are quite dangerous. This series can be still continued; therefore, when transporting such materials, first, it is necessary to get acquainted with the international agreement - ADR, which coordinates and organizes the process of transporting dangerous cargo in Europe (Pakhno&Shok, 2018). It should be pointed out that the types of dangerous goods have their own logos, which must be posted on the car transporting the given cargo.

The danger of aforementioned cargo types is mainly due to the fact that vehicles loaded with such cargo can leak resulting in explosion or fire due to technical problems (valve opening, cracks, etc.) or, more likely, due to traffic accident, which can cause great damage to the population and the environment. To minimize all these, the cargo/ goods of dangerous class should be transported only by professional transport vehicles. In some cases, it is also preferable to use additional security measures, such as blocking roads for other vehicles, providing escort headed by a patrol with appropriate functions, organizing transportations only at certain times of the day and so on.

A clear example of the large-scale cargo transportation in mountainous conditions is the transportation of the sailing ship “Cilicia”, made by a group of enthusiasts, from the Republic of Armenia through the territory of Georgia to the Black Sea and its return. Special trailers used for transportation of hydro turbines for hydroelectric power plants were also used in this case taking into account the dimensions and weight of the ship’s body (length - 20 m, width and height - 5 meters each, weight - 25… 28 t before navigation and afterwards as a result of water absorption). If we take into account the dimensions of the towing car as well, the total length of the motorail makes about 30 meters, and such a giant had to pass through Dilijan, Pushkin mountain pass and the other roads with abrupt bends. It should be mentioned that according to the traffic rules, the maximum height of vehicles is 3.8 m and the length is 24 m. The difference is very significant, regarding the height, as there is a problem of passing under many bridges. In such cases, a specially designed trailer is definitely used. We have participated in the transportation of 2 oversized cargos, which are shown in figures 1 and 2.

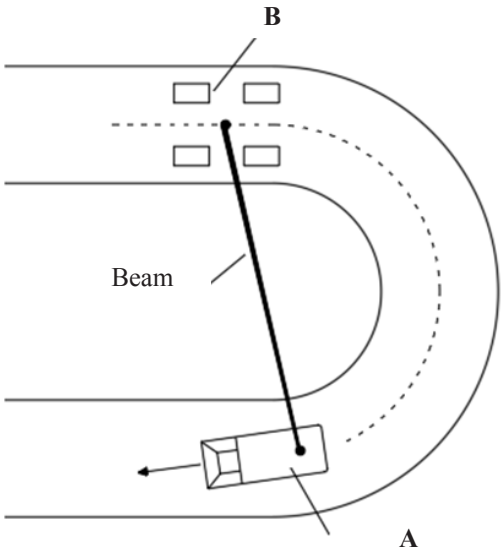

Figure 1. Diagram of semitrailer motion designed for transporting the shovel of the wind power plant (*composed by the author*).

Figure 1 clearly shows that two equivalent approaches can be used to move along such trajectory: a) - “B” trolley has its own engine and steering system driven by the second driver sitting there and b) - when the trolley is automatically controlled, during which the trolley moves in the direction of the traction motor. The transported oversized cargo can be a wind power plant shovel, elements of archs for field irrigation, bridge structures, etc. Surely, the structure of the beam must contain telescopic elements so that it is aligned with the length of the specific cargo. The turning radius of the motorail with a semitrailer of classic structure is formed according to the following scheme:

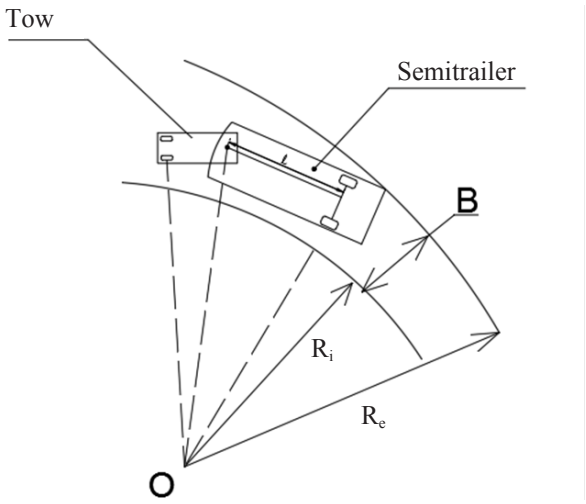

Figure 2. Diagram of motorail turning (*composed by the author*).

Depending on the "l" size and the needed turning radius, the "B" size of the passage occupied by the motorail undergoes significant changes causing a great difference between the motion trajectories of the wheels in the tow and semitrailers.

We also see the similar picture when transporting the sailing ship "Cilicia":

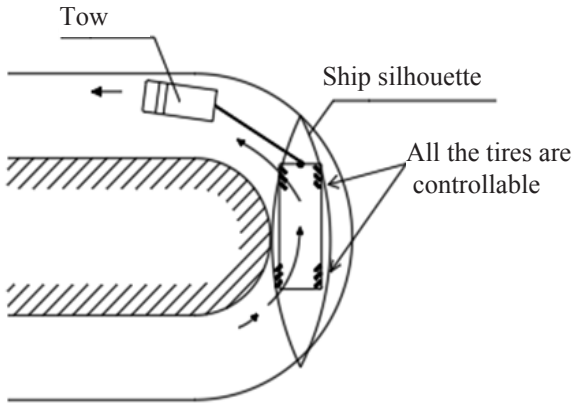

Figure 3. Passage of "Cilicia" ship through "Dilijan" bends (*composed by the author*).

Results and discussions

As it was previously mentioned, about 20% of all cargo transportations include different types of dangerous cargo (Pakhno&Shok, 2018). In order to correctly and safely organize transportation of dangerous and oversized cargo it is necessary to follow the changes taking place in the legal area of the sector, as well as to plan serious preparatory works aimed at the preparation and selection of the rolling stock, trainings of the driving staff, labeling the vehicles with special labels based on the type and peculiarities of the transported cargo. It is not ruled out that even without a traffic accident, fires, explosions and other incidents may happen to dangerous cargo by other reasons. It is noteworthy that the United Nations (UN) has compiled a list of hazardous substances (more than 3 000 names), each of which has its own four-digit code, according to which the transportation of the cargo type must be organized and implemented. According to these rules, each type of dangerous cargo is transported by a special professional vehicle and the drivers receive special instructions. In order to ensure the safety of cargo transportation, the corresponding vehicles must be equipped as proper, the drivers must take additional professional training courses and obtain a relevant certificate, based on which they are allowed to transport such types of dangerous cargo. In this case, the comprehensiveness of the documentations related to the cargo transportation is also quite essential. It is noteworthy that since 2013 all vehicles carrying dangerous goods must have a satellite control system via GLONASS (Information and Analyses Center for Positioning, Navigation and Timing). For safety purposes, drivers carrying such cargos must be completely informed about the hazardous properties and consequences of the transported cargo, be ready for rendering the needed assistance during accidents and be aware of the options for eliminating the consequences.

In mountainous conditions, the safety-related problems in the transportation of hazardous materials become even more complicated. The steep descents and ascents, winding roads, abrupt changes in external atmospheric conditions that adversely affect drivers, need to be adjusted. Taking into account the aforementioned, we find it expedient to have a second driver for such cases and to equip the car with the automatic facilities transmitting the appropriate warning signal (regarding the cargo type, its quantity and the place of accident) to the department responsible for the emergency management. There is apparently a great demand for the transportation of oversized cargo by motor vehicles. Oversized cargo is usually a structure of specific designation or equipment of the energy sector (nuclear power plant reactor, turbine, generator, transformer, wind power plant pillars and shovels, ships, etc.). Oversized cargoes include those which are super heavy, but the sizes of which are not very large or those relatively not heavy, but large in geometric sizes, as well as those in which both the sizes and weight are large. There is an individual

approach towards each abovementioned variants which consists of the selection of corresponding vehicle with tows (if necessary) and determination of the transport route. It is evident that apart from merely technical issues that arise during the transportation of both heavy oversized and hazardous cargo, which are solved by the cargo transportation company, many other problems come forth, the solutions of which are provided by other relevant departments. Among such issues we can single out the following ones: passing ability under the air power networks and bridges, passing ability under the tunnels, the cargo loads of the bridges, passing ability under the gas pipelines or other pipes, the traffic suspension of other vehicles in the route, etc.

When studying the auto transport means designed for transportation of oversized and heavy cargo, we see a great variety. However, depending on the specific road conditions, occasionally it is impossible to use them and in some cases platforms have to be designed for the transportation of the heavy or oversized equipment (Gromakovski, 2009). Here semitrailers transporting the wind turbine shovels can be involved. The length of such shovels in some cases amounts up to 80-100 m. The transportation of oversized cargo becomes rather complicated on the mountain roads due to abrupt ascents, descents and bends, in particular. The latter have fairly small curve radius, especially in mountain passes, and for the majority cases in such locations it is also impossible to build a temporary alternative road.

To avoid the problem, a controllable trolley is used. Uninterrupted motorail driving on a twisted road presumes combined trajectories for the motion of the tow and trolley wheels, which can be ensured by the second driver sitting in the trolley. Anyhow, it is more expedient to use an automatic steering system that will ensure identification of the trolley trajectory in accordance with the trajectory of the leader (tow). It is known that currently motor vehicles moving without any driver are being used according to the selected route, the automatic control system of which operates based on the data received on location, road network, traffic organization in the given sector and on many other online data. In this case, there is only one baseline datum, which is related to the trajectory of the leader's motion. Now let us see how to interrelate the trajectories of the leader and the trolley.

The motion is observed only on the x, y plane. The leader in position O_1 has the coordinate (x_0; y_0) and α_0 angle against the meridian. Each i position of its trajectory is definite (the data are obtained from an electronic gyroscope and a locating device) and is entered into an on-board computer, based on the signals of which the wheels of the trolley are operated so that the O_1^u point passes through the same O_i point. The towing power of the trolley wheels is provided by electric motors.

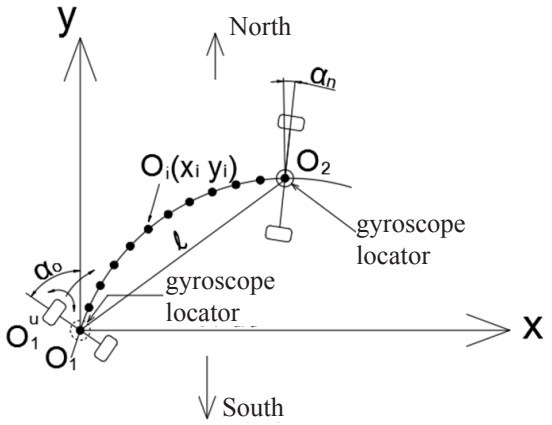

Figure 4. Trajectory marking diagram (*composed by the author*).

The scientific novelty of the current research

Simultaneous use of the virages in the curved sectors is the standard adopted in road construction. The structures viewed as oversized are very often transported through direct fields, which have transverse slopes with (φ) angle (figure 5).

As a rule, after loading the oversized structures, the "h_g" size of the gravity centre in the motorail considerably increases and there is a need to study and estimate the changes affecting the transverse stability of the motorail at that time from the prospect of the circumstance that the trolley rotates with α dimension against the semitrailer body, depending on the location. The "*C*" point of the tire rotates around the "*O*" point along the "*R*" radius:

$$R = \sqrt{\left(\frac{lu}{2}\right)^2 + \left(\frac{B}{2}\right)^2}.$$

As a result of the trolley rotation, the removal size of "*C*" point from the motorail axis will be:

$$\Delta B = R\cos\alpha - B,$$

which shows that "*D*" point moves inwards with equal sizes. Therefore, equivalent changes take place in the loads of "*C*" and "*D*" wheels. In other words, if $P_C = P_D$ interrealation occurs on the horizontal road, where Ps are the loads on the corresponding tires, then the following occurs on the curve:

$$PC + \Delta P > PC - \Delta P \text{ dependence.}$$

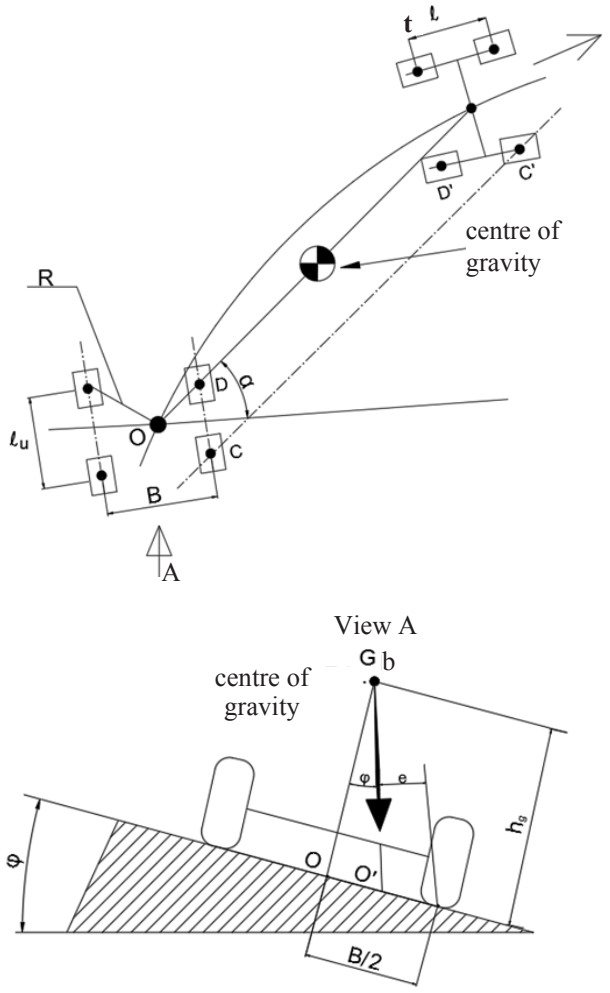

Figure 5. Redistribution of the load weight of the oversized cargo during the virage turning (*composed by the author*).

Due to such change in forces, the tires respond by modifying their initial characteristics, basically, in "*C*" wheel the support angle increases. Thus, to ensure a constant situation we find it necessary to apply an automated tire pressure adjustment system, where in each case "*O*" static load of the support point accepts the nominal pressure limit of the tires as a basis, which is subject to the dynamic changes based on the following relation for *C* and *D* tires respectively:

$$\Delta q = \pm f(\alpha).$$

The same regularity is true for the other tires as well.

Conclusion

The transportation of oversized cargo requires detailed planning for work organization, in particular:

- selection of appropriate vehicle,
- recruitment of the drivers with relevant qualification upon the instructions on cargo characteristics,
- optimal (safe) route development,
- marking the stops and fuel filling stations,
- additional cargo-related functions (labeling, illumination, etc.),
- legal functions (insurance, etc.),
- other organizational issues related to transportation.

In order to make the transportation of the cargo under the mentioned category safer and more efficient, we suggest installing video cameras and radio-communication in the driver's cabin so as to get in contact with the maintenance personnel. The analysis introduced in the current article can be also beneficial for agricultural sector, particularly for the transportation of special systems for orchard and field irrigation, the length of the details of which can reach up to 60 m.

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Evaluating Torque Moment Dependence of the Soil-Tiller Drum on Soil Loosening Depth and Drum Rotation Number

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ABSTRACT

In the result of field experiments on the soil-tiller with self-vibrating (mobile) and fixed blades, the regression equations $y=f(X_1,X_2)$ of the torque moment dependence (M_t, y) in the soil-tiller's drum on the drum's rotation numbers (n_d, X_1) and soil loosening depth h (X_2) have been derived and the set of curves describing the aforementioned dependences have been designed.

The results of research experiments have stated that the torque moment is reduced parallel to the increase of rotation numbers in the drums with self-vibrating (mobile) and fixed blades, while it grows up together with the increase of soil loosening depth.

Introduction

Selected methods of mechanical soil cultivation greatly affect the soil technological properties, its fertility improvement, as well as water and nutritional regimes of the plants. Among various soil cultivating machines used in the agricultural production the soil-tillers are of particular significance, the application of which enables to implement several technological activities simultaneously during a single stroke. The soil-tillers not only loosen the soil at the depth of 0.6-18 cm, but also flatten it; besides, when cultivating the fields covered with the remnants of forage and thick-stemmed plants, they crush and mix the soil (Panov, 1998). Thus, due to the aforementioned peculiarities the soil-tillers are widely used in the agricultural production and fully meet the main agro-technical requirements.

The efficiency of soil-tiller's application is apparent, nevertheless, the great values of power, traction resistance and dynamical load obstruct their efficient work throughout the soil cultivation. The upgrading of structural and technological parameters of the soil-tillers with vibratory axial hinge blades (Tarverdyan, Petrosyan, Hovhannisyan, 2018) will enable to reduce the traction resistance and the required power for the soil cultivation with tiller.

Materials and methods

The efficient work of the soil-tiller in different soil conditions is mainly related to the accurate selection of the structural parameters and working regimes for the working parts of the tillers, as well as to the evaluation of

the dependence of the torque moment in the tiller's drum on its rotation numbers and the soil loosening depth.

The theoretical research on the tiller's structure and the drum with self-vibrating blades is introduced by a number of authors (Petrosyan, Khazhakyan, 2019).

The scientific-research experiments have been conducted to evaluate the machine's energetical and agro-technical indices in the cultivation process and the effect of variations on the torque moment of the soil-tiller with the drums containing self-vibrating (mobile) and fixed blades. When describing the energy consumption rate and quality of the implemented activities during the soil cultivating activities by using soil-tillers, the torque moment of the working part, rotation numbers and moving velocity of the aggregate are considered to be the most relevant parameters.

The aim of the current research work is to determine the torque moment M_t (Nm) of the tiller's drum and the drum rotation number n_d (R/m). The imlemented research experiments enable to describe the technological process of the tiller with self-vibrating and fixed blades in different soil conditions and to select such working regimes, which will promote the reduction of traction resistance, specific fuel cost and the increase of the tiller's productivity.

The experiments were carried out through the soil-tiller with self-vibrating blades designed and developed by our research group in the arable lands owned by Anushavan Karapetyan at the village of Kotayk in Kotayk region.

The designed working part with the mobile blades is developed in a way, so as the latter are possible to attach fixedly as well, depriving them of moving capacity. The soil-tiller has been aggregated with China tractor series "JINMA-254", in a way that the torque moment is transferred from bevel gear speed reducer to the tiller's drum through chain-driven transmission, enabling to change the drum's rotation number. Due to the transmission of the chain wheels the rotation number of the drum is modulated within the range of 140-280 (R/m).

For recording the technical parameters of the field experiments the resistance strain gage of TRA-50K series, mercurial current collecting gear TRA-50K, algorithm converter Zet-210 and analog-to-digital signal booster Zet-410 have been applied.

TRA-50K resistance strain gage is designed for measuring the torque moment of the drum, which is installed between the tractor power take-off shaft and bevel gear speed reducer shaft of the tiller (Figure 1).

Figure 1. TRA-50K resistance strain gage installed between the tractor PTO shaft and bevel gear speed inducer shaft of the tiller.

The research experiments aimed at the determination of the drum torque moment (M_t) dependence on the drum rotation number (n_d) were conducted in two variants: through discs with fixed and self-vibrating (mobile) blades. Each experiment was carried out thrice $n=3$ upon different numbers of drum rotation – $n_d=140$ *r/m*, $n_d=210$ *r/m*, $n_d=280$ *r/m* and different soil loosening depths - $h=0.08$ *m*, *0.012 m* and *0.16 m*.

During the research trials the experimental site was divided into 15 m-length sectors. At the start of the experiment the values for M_t and n_d in the idle state of the tiller were recorded, then the drum was provided with appropriate rotation number and the blades were installed in the experimented depth. The trials were repeated according to the blades in their fixed and self-vibrating variants.

The results of the experiments were recorded through computer (Tables 1, 3, 4) and analyzed by the method of multi-factorial experiment planning theory.

Results and discussions

The dependence of the torque moment of the soil-tiller's drum with fixed blades (y_1) and that of with self-vibrating (mobile) blades (y_2) on the drums rotation numbers (X_1) r/m and soil loosening depth (X_2) cm was studied through the methods of experiment planning theory. For the description of the drum's torque moment a second order mathematical model was selected.

$$y = b_0 + b_1 X_1 + b_2 X_2 + b_{12} X_1 X_2 + b_{11} X_{12} + b_{22} X_{22}. \quad (1)$$

To derive such a regression equation in the research experiments the factors varied in three levels. Two-factor

central composite orthogonal design of second order was selected as a plan matrix for implementation of the experiments (Petrosyan, Grigoryan, 2001).

The research results on the dependence of tiller's torque moment (M_t) on the drum rotation number (n_d) and plowing depth (h) are presented in Table 1.

Table 1. Values of factors determination domain and variation ranges*

Matrix parameters	Encoded value	Drum's rotation numbers X_1 (r/m)	Loosening depth X_2 (cm)
Variation range	-	70.0	2.0
Lower level	-1	140	8.0
Main level	0	210.0	10.0
Upper level	+1	280.0	12.0

*Composed by the authors.

In the plan matrix the value of the α – chain wheel arm has been selected $\alpha=1$, hence, in that case the new variables have been determined: X_1 and X_2 have been identified:

$$X_1' = X_1^2 - \frac{2}{3}, \quad X_2' = X_2^2 - \frac{2}{3}, \tag{2}$$

For the two factors the second-order orthogonal design looks as described in Table 2.

Coefficients of regression equation based on the planning matrix orthogonality have been determined through the following formulae:

$$b_j = \frac{\sum_{j=1}^{N} X_{ij}\overline{y_j}}{\sum_{j=1}^{N} X_{ij}^2}, \quad b_0 = \frac{\sum_{j=1}^{N} X_{0j}\overline{y_j}}{\sum_{j=1}^{N} X_{ij}^2},$$

$$b_{ii} = \frac{\sum_{j=1}^{N} X_{ij}'\overline{y_j}}{\sum_{j=1}^{N} X_{ij}'^2}, \; b_{iu} = \frac{\sum_{j=1}^{N} X_{ij}X_{uj}\overline{y_j}}{\sum_{j=1}^{N} (X_{ij}X_{uj})^2}, \tag{3}$$

where i and u are the numbers of columns (factors) in the matrix, j is the number of experiment terms, X_{ij} and X_{uj} are the elements of the appropriate columns in the matrix, $\overline{y_j}$ is the average value of the torque moment for the experiment terms. The research experiments have been carried out upon repetitions $n=3$ and per experimental terms repetition $n=3$ the average torque value has been determined.

$$\overline{y_j} = \frac{1}{n}\sum_{i=1}^{n} y_{ij}. \tag{4}$$

The research results with three repetitions are introduced in Table 3.

Table 2. Second-order orthogonal design*

The number of experiment	n_d (r/m) X_1	h (cm) X_2	X_1X_2	$X_1^2 - \frac{2}{3}$	$X_2^2 - \frac{2}{3}$	M_t y
1	+1	+1	+	$+\frac{1}{3}$	$+\frac{1}{3}$	$\overline{y_1}$
2	-1	+1	-	$+\frac{1}{3}$	$+\frac{1}{3}$	$\overline{y_2}$
3	+1	-1	-	$+\frac{1}{3}$	$+\frac{1}{3}$	$\overline{y_3}$
4	-1	-1	+	$+\frac{1}{3}$	$+\frac{1}{3}$	$\overline{y_4}$
5	+1	0	0	$+\frac{1}{3}$	$-\frac{2}{3}$	$\overline{y_5}$
6	-1	0	0	$-\frac{2}{3}$	$-\frac{2}{3}$	$\overline{y_6}$
7	0	+1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	$\overline{y_7}$
8	0	-1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	$\overline{y_8}$
9	0	0	0	$-\frac{2}{3}$	$-\frac{2}{3}$	$\overline{y_9}$

*Composed by the authors.

Table 3. Plan of experimental results on the torque moment of the drum with fixed blades*

The number of experiment	Π_d (r/m) X_1	h (cm) X_2	X_1X_2	X_1'	X_2'	y_{1j}	y_{2i}	y_{3i}	$\overline{y_j}$	S_{j2}	S_j
1	+1	+1	+1	$+\frac{1}{3}$	$+\frac{1}{3}$	64.25	65.25	61.75	63.75	6.50	2.55
2	-1	+1	-1	$+\frac{1}{3}$	$+\frac{1}{3}$	129.3	125.6	129.1	128.0	8.66	2.943
3	+1	-1	-1	$+\frac{1}{3}$	$+\frac{1}{3}$	42.0	45.0	44.25	43.75	4.875	2.208
4	-1	-1	+1	$+\frac{1}{3}$	$+\frac{1}{3}$	90.5	89.0	83.0	87.5	31.5	5.612
5	+1	0	0	$+\frac{1}{3}$	$-\frac{2}{3}$	53.75	50.75	53.0	52.5	4.875	2.208
6	-1	0	0	$+\frac{1}{3}$	$-\frac{2}{3}$	106.75	101.25	102.5	103.5	16.625	4.077
7	0	+1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	82.37	78.87	81.25	81.25	81.25	2.9
8	0	-1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	52.25	55.75	57.0	55.0	12.125	3.482
9	0	0	0	$-\frac{2}{3}$	$-\frac{2}{3}$	62.5	67.0	69.25	66.25	23.625	4.86

*Composed by the authors.

Table 4. Plan of experimental results on the torque moment of the drum with mobile blades*

The number of experiment	X_1	X_2	X_1X_2	$X_1^2-\frac{2}{3}$	$X_2^2-\frac{2}{3}$	$\overline{y_j}$	$\hat{y}_j$
1	+1	+1	+1	$+\frac{1}{3}$	$+\frac{1}{3}$	47.5	44.1
2	-1	+1	-1	$+\frac{1}{3}$	$+\frac{1}{3}$	106.5	105.06
3	+1	-1	-1	$+\frac{1}{3}$	$+\frac{1}{3}$	26.25	26.22
4	-1	-1	+1	$+\frac{1}{3}$	$+\frac{1}{3}$	82.5	84.43
5	+1	0	0	$+\frac{1}{3}$	$-\frac{2}{3}$	30.0	33.84
6	-1	0	0	$+\frac{1}{3}$	$-\frac{2}{3}$	93.5	92.99
7	0	+1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	51.25	56.46
8	0	-1	0	$-\frac{2}{3}$	$+\frac{1}{3}$	38.75	37.205
9	0	0	0	$-\frac{2}{3}$	$-\frac{2}{3}$	48.75	45.09

*Composed by the authors.

Based on the results of the experiments the values of the regression equation coefficients have been determined:

$$b_0 = 75.72,\ b_1 = -26.5,\ b_1 = 14.46,$$
$$b_{11} = -5.13,\ b_{12} = 12.33,\ b_{22} = 2.46,$$

according to the obtained values for coefficients, the regression equation looks as follows:

$$y_1 = 75.72 - 26.5X_1 + 14.46X_2 - 5.13X_1X_2 + 12.33X_1^2 + 2.46X_2^2. \quad (5)$$

The regression equation for the dependence of torque moment (y_2) of the drum with mobile blades on the drum's rotation numbers (X_1) and soil loosening depth (X_2) looks as follows:

$$y_2 = 58.33 - 29.79X_1 + 9.625X_2 - 0.6875X_1X_2 + 18.12X_1^2 + 1.75X_2^2. \quad (6)$$

The homogeneity of the results of scientific trials, significance rate of the regression equation coefficients and compatibility degree of the investigated procedures with the regression equation have been tested by means of dispersion analysis. The fact of experimental results

deviations $\left(y_{ij}-\overline{y_j}\right)$ found in multiple other parallelly conducted experiments in the same terms testify on the variability of the results in the experiments. In this case the dispersion of the experimental results has been calculated through the following formula:

$$S_j^2=\frac{1}{n-1}\sum_{i=1}^{n}\left(y_j-\overline{y}\right)^2. \quad (7)$$

The reproductivity dispersion for the optimization parameters is estimated through the following formula:

$$S_2\{y\}=\frac{1}{N(n-1)}\sum_{i=1}^{n}\sum_{i=1}^{n}\left(y_{ij}-\overline{y_j}\right)^2, \quad (8)$$

where n is the number of parallel experiments and N is the number of experimental terms.

The homogeneity of dispersions for all terms (N) of research experiments has been tested by Fisher's criterion in case of $\alpha=0.05$ significance degree or $p=0.95$ probability in reliability:

$$F_z=\frac{S_{max}^{\ 2}}{S_{min}^{\ 2}}, \quad (9)$$

where $S_{max}^{\ 2}$ and $S_{min}^{\ 2}$ are respectively the maximum and minimum dispersions of the experimental terms.

All coefficients of the regression equation

$$b_0 = 75.72,\ b_1 = -26.5,\ b_2 = 14.46,$$

$$b_{12} = -5.13,\ b_{11} = 12.33,\ b_{22} = 2.46$$

describing the torque moment of the drum with fixed blades are significant, since $|b_i| > \Delta b_i$.

If we drop out the coefficient of regression equation $b_{12}=-0.6875$ ($\Delta_{12}<1.47$ in case of Student's t-test) describing the torque moment of the drum with fixed blades, the equation will look as follows:

$$y_2 = 58.33 - 29.79X_1 + 9.625X_2 + 18.12X_1^{\ 2} + 1.75X_2^{\ 2}. \quad (10)$$

The set of curves (Figures 2, 3) describing the results of the torque moments in the drums with fixed (y_1) and mobile (y_2) blades have been designed by means of the derived regression equations, which are actually curves of extremum.

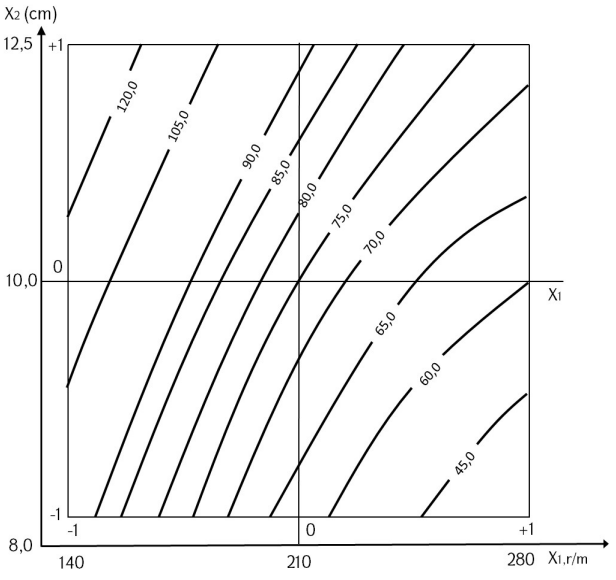

Figure 2. Set of curves describing the effect of the drum's rotation numbers (X_1) and soil loosening depth (X_2) on the torque moment (y_1) of the soil-tiller's drum with fixed blades (*composed by the authors*).

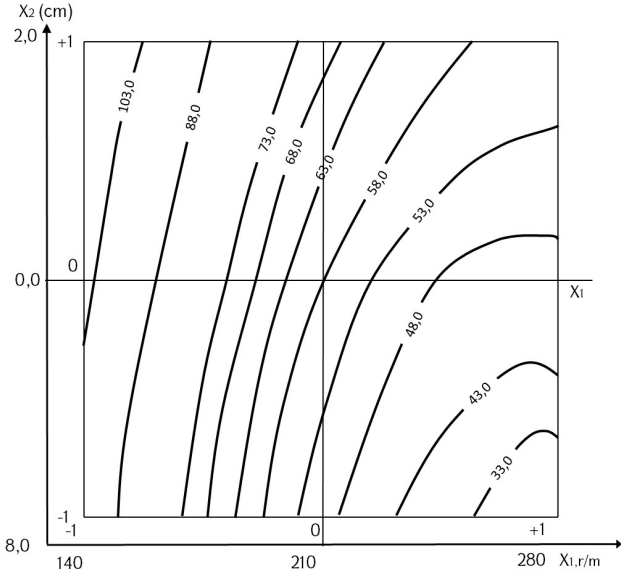

Figure 3. Set of curves describing the effect of the drum's rotation numbers (X_1) and soil loosening depth (X_2) on the torque moment (y_1) of the soil-tiller's drum with self-vibrating (mobile) blades (*composed by the authors*).

Conclusion

Based on the results of the conducted researches, the following conclusions have been drawn:

1. The torque moment of the soil-tiller's drum with both fixed and mobile blades is considerably influenced by all main effects of the regression equation: thus in case of y_1, b_1=*-26.5* (drum's rotation number), b_2=*14.46* (loosening depth), in case of y_2, b_1=*-29.79*, b_2=*9.625*, besides in both cases the torque moment decreases parallel to the increase of drum's rotation numbers, while it grows up together with loosening depth increase.
2. The drum's torque moment is greatly influenced by the interactive effects of the regression equation b_{12}=*-5.13* (y_1), while in case of the drum with self-vibrating (mobile) blades b_{12}=*-0.6875* (y_2), it is insignificant and has been excluded from the regression equation.
3. The drum's torque moment is considerably affected only by the second-order effects b_{11}=*12.33* (with fixed blades) and b_{11}=*18.12* (with mobile blades) related to drum rotation number in the regression equation; the torque moment grows up parallel to the increase of drum's rotation numbers in both variants, while the variations of the second-order effects (b_{22}) characterizing the soil loosening depth are insignificant.
4. The desired values of the drum's rotation numbers for the soil-tiller are chosen from the set of the introduced curves (Figures 2, 3) in line with the size of soil loosening depth.

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Theoretical Research on Vibratory Cutting of the Plants Stems in the Dense Environment: Vibrationless Cutting

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ABSTRACT

The first article of the series considers the results of theoretical research on the plants stems cutting in dense environment (water, soil). It has been proved that in case of necessary technological speeds in the blades of the rotary cutting apparatus the resistance forces of the environment are much more extensive than the force of the very stem cutting. The double increase in the rotation numbers of the rotor in the cutting apparatus brings about the increase in the resistance forces of the environment in about five times, which makes the use of the cutting apparatus of the mentioned series quite irrelevant from the technical and technological perspective.

Introduction

Cleaning the reservoirs and channels from the water plants, particularly from the canes and the plants of the same family is still an urgent issue worldwide.

The analysis of the work and structure of cutting apparatus used for the abovementioned purpose, provides a base to state that irrespective of the structural and operational characteristics, the current cutting machines are not applicable in the dense environment (water, soil) during the plant cutting process.

The trials on the application of the available cutting tools in water environment (for cleaning the reservoirs and channels from vegetation) and in the soil (for cutting and removal of the root crop tops, for single harvesting of tomato, as well as for that of different essential oil crops) haven't recorded any success, since in all cases a rapid deterioration in the technical and exploitative indices has been observed (Tarverdyan, 1996).

The aforementioned is mainly conditioned by the high values (30 ... 50 m/s) of the absolute speed in the blades of cutting machines.

In case of high speeds in blades the forces of motion resistance, therefore the rate of energy consumption rapidly grow up in the dense environment. The abrupt growth in the resistance forces leads to the decrease of the rotation frequency in the rotor of the apparatus, which in its turn entails to the deterioration of the cutting quality, particularly, the most part of the stalks remain uncut in the water environment, the plants harvesting technological process is disturbed; besides, the exploitative indices of the cutting apparatus sharply decrease.

All experiments aimed at the elimination of the mentioned shortcomings by means of structural improvements and changes of kinematic parameters in the existing apparatus have doomed to failure (International Scientific Research Institute of Economics and Technology (ISRITE), Moscow, 1978).

Consequently, a necessity has appeared to develop an apparatus with new structural and working principles in order to implement cutting of the plants in dense environment.

As a result of multiple experimental researches on cutting of thin and thick-stemmed stiff crops in laboratory conditions, in aquatic environment and in 10…20 cm soil stratum, it has been proved that the most rational cutting method with the least energy consumption is recorded when the blade carries out a complicated motion with vibration of high frequency and low amplitude and with a movement of relatively low velocity (Tarverdyan, 1996, Tarverdyan, 2014).

Upon the researches it has been found out that the cutting apparatus with plane rotors best meet the mentioned requirements.

Throughout the solution of the problem several variants of rotary vibrational cutting apparatus have been developed, prepared and put into practice under the production conditions (Tarverdyan, 1996, Tarverdyan, 2014).

The trials carried out in water and soil conditions have shown that the abovementioned tools provide full cutting of the stems with minimum energy consumption, at the same time providing high indices of exploitative reliability.

In the result of theoretical studies the apparent advantage of vibratory cutting has been stated and justified, as well as some expressions have been derived which enable to determine the optimal values of kinematic and dynamic parameters in the vibratory cutting equipment (Tarverdyan, 2014).

Materials and methods

It is worth mentioning that no theoretical investigations on vibratory cutting are carried out in dense environment and we have hardly ever found such research results while studying various volumable research works related to this sector. Thus, we have set a task to study the vibratory cutting processes in dense environment theoretically with the aim of disclosing the principle of vibratory cutting with low energy consumption in dense environment. It is clear that only after the identification of the characteristics and principle of the vibratory cutting it will be possible to develop and design a cutting apparatus with optimal parameters in order to work in dense environments. Despite the experiments which have indicated on the optimal features of the equipment, the holistic image of the discussed apparatus is possible to introduce only through the theoretical researches.

Based on the goals set the problem has been divided into two parts:

First, it is necessary to study the cutting process in dense environment (water) without the blade/knife/ vibration.

Second, it is necessary to study the process in the same conditions upon the blade vibration.

It is noteworthy that the vibration cutting of the plant stems in the aerial environment has been studied comprehensively and cutting theories have been developed, which enable to accurately describe and identify the vibro-cutting principle. Based on the obtained results and conclusions cutting apparatus have been designed. The results of the mentioned investigations are introduced thoroughly and explicitly in some research works (Tarverdyan, 1996, Tarverdyan, 2014). In the current study these results will serve as special basic control data.

Let's consider the vibro-blade/knife as an object at rest plunged in the boundless water environment, which receives motion. So, in the first considered case the blade/ knife receives only rotational shifting motion without any vibratory motion (Fgure 1).

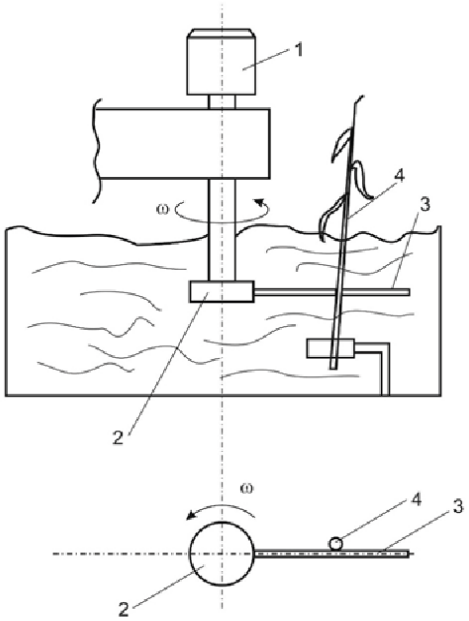

Figure 1. Diagram of the plant for the study of plants stem cutting in water environment (*composed by the authors*).

The motion from the electrical motor 1 is transferred to the rotor 2, which rotates in the water medium and its blade/ knife 3 cuts the plant 4 enrooted in the water. In order to transmit rotational motion to the blade a certain energy amount is needed, so as to cut the plant stems and to handle the resistance. The conclusion about the drag force exerted by the liquid towards the body moving just in its medium was drawn still by Newton stating that the drag/resistance force should be proportional to the projection surface of the body on the plane which is vertical to the movement, to the liquid density and to the squared velocity of the body movement (Milne-Thomson, 1964, Prandtl, 2000).

Anyhow, later on it was found out that it didn't address the real image of the body and liquid interactions and that the drag force of the liquid/fluid is resulted from the discrepancy of the pressure and tangential stresses caused throughout the fluid streamline. Besides, the component caused by the difference of pressures in the resistance is predominant.

This difference is proprtional to the dynamic pressure $\frac{\rho v^2}{2}$, therefore, the resistance is proportional to the product of the pressures difference and to the body surface area which is influenced by it (Milne-Thomson, 1964, Prandtl, 2000).

$$F = c \cdot A \cdot \frac{\rho v^2}{2},$$

where c is the resistance coefficient and it depends on the Reynolds number: $R = \frac{v \cdot b}{\upsilon}$, where v is the velocity of the body movement (cm/s), b is the body length towards the movement (in our case it is the blade width) expressed in cm, υ is the kinematic viscosity of the fluid expressed in cm²/s; for water under the conditions of 20 ^{0}C υ=*0.01* cm²/s ($\upsilon = \frac{\mu}{\rho}$, μ is the viscosity coefficient, for water μ=0.01 g/cm·s).

In our case the blade carries out rotational movement, moreover the blade plane overlaps with that of rotational movement. In the blade motion zone the speed of the fluid movement drifting apart from the blade surface through vertical directions gradually equals to 0, which is related to the friction forces. The distribution epure for the speeds is presented in figure 2.

If the boundary zone of the velocity changes comes forth as a value of δ type and the body size (the blade width) towards the movement is b, then the friction force per a volume unit will be (Prandtl, 2000):

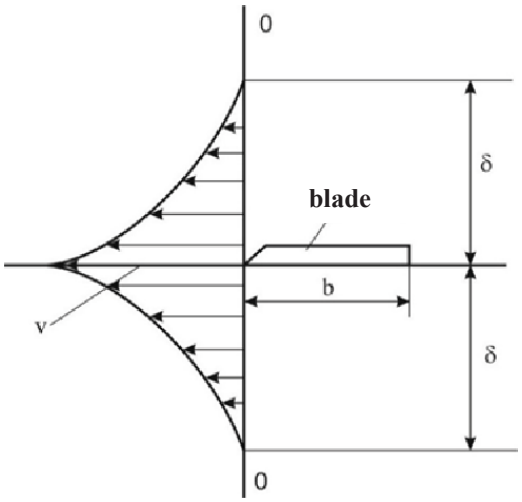

Figure 2. The epure of the fluid motion velocity in the vicinity of the blade moving in its medium (*composed by the authors*).

$$F_{fr} = \mu \frac{\partial^2 u}{\partial y^2},$$

which has the following value: $\frac{\mu \cdot v}{\delta^2}$, while the inertia force per a volume unit will be $\frac{\rho v^2}{b}$ and since in the boundary stratum these two forces are values of similar category, hence:

$\frac{\mu v}{\delta^2} = k \cdot \frac{\rho v^2}{b}$, from which $\delta = \sqrt{\frac{\mu b}{k \rho v}}$ or $\delta = \sqrt{\frac{\upsilon b}{kv}}$, from which $\frac{\delta}{b} = \sqrt{\frac{\upsilon}{kvb}} = \frac{1}{\sqrt{kR}}$, since k is a constant coefficient of relativity, therefore $\frac{\delta}{b}$ is a function only from the Reynolds number. This dependence is true for all boundary strata in case of constant movement (Prandtl, 2000).

The overall complexity and peculiarity of our task consists in the fact that the blade carries out rotational movement, consequently the points of the cutting margin along the whole cutting length have variable speeds, which change upon the rotation axis with the following regularity: $v = \omega \cdot r_x$, where ω is the rotational frequency in the rotor, r_x is the current distance of the marginal point in the cutting blade from the rotation axis.

When the speed becomes a variable value δ and R also become variable values which significantly alters the principle of the task.

In case of stabilized working regime in the cutting apparatus the expression of δ will look like this: $\delta = \sqrt{\frac{\upsilon b}{k\omega \cdot r_x}}$, from which it can be inferred that the Reynolds number becomes variable along the blade cutting margin:

$$R = \frac{(\omega \cdot r_x \cdot b)}{v}.$$

Thus, the regularities of the fluid movement and resistance undergo significant changes along the longitude of the cutting edge. The fluid movement is generated not only throughout the blade width, but also throughout the length of the cutting edge; besides, the movement is generated in two ways, namely upon centrifugal forces and upon the gradient of the pressures related to the ratio of circumferential speeds. The mentioned two movements, i.e., the vertical towards the blade cutting edge and the movement along the blade cause turbulent motion in the fluid, which in its turn sharply enhances the resistance force of the blade movement.

Due to the torque moment M applied in the rotor shaft the blade conducts rotational movement in the water environment as a result of which in addition to the resistance force of stem cutting (P_c) resistance forces in the friction of water environment occur as well in the longitudinal direction of the blade cutting edge - T_x, in the vertical direction of the cutting edge - T_z, the hydrodynamic resistance force - P_d of the water medium and inertial forces (Figure 3).

Under the concept of inertial forces those generated by the speed transmitted to the water mass are meant. In case of constant working regime of the apparatus (ω=*const*) the circumferential speed is equal to 0. As in our study the speed of the blade and consequently that of the fluid movement is much higher towards the direction of z than towards the other two directions and it changes greatly in the direction of x axis, only one equation out of those about stress state of fluids (Milne-Thomson, 1964, Prandtl, 2000) plays a great role in the resistance determination:

$$\frac{\partial z_x}{\partial x} = \mu \frac{\partial^2 u_z}{\partial x^2},$$

where z_x is the tangential stress, u_z is the deformation towards the z_s (it is worth mentioning that in case of liquids the stresses are directly proportional not with the deformations but with their speeds).

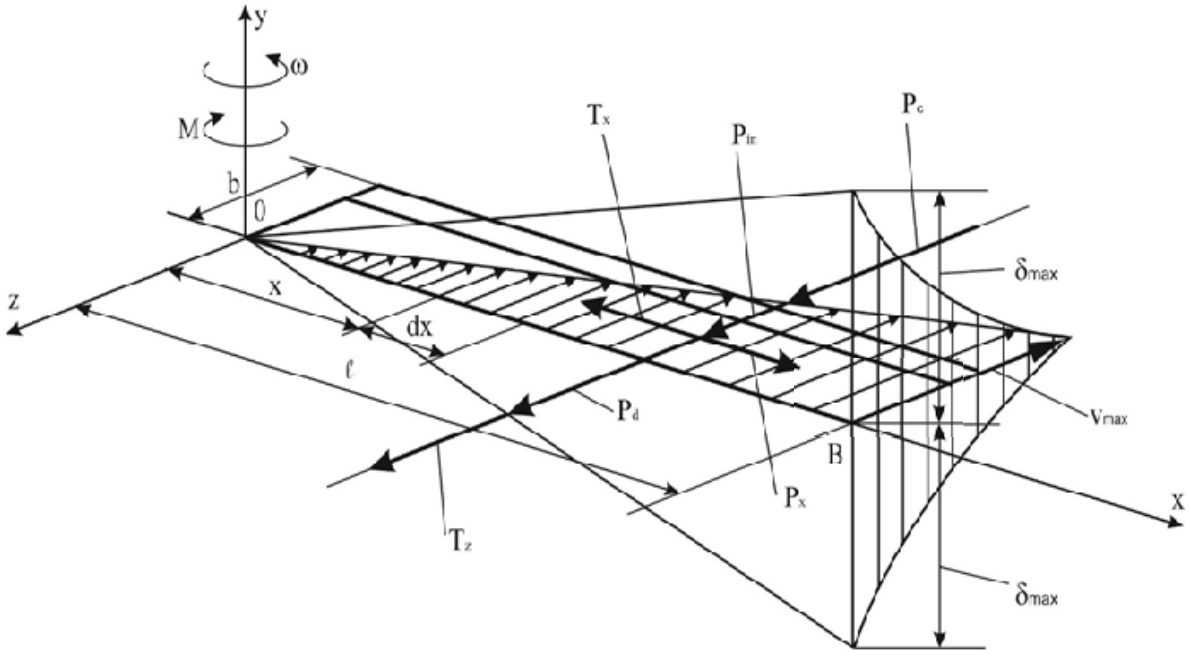

Figure 3. Diagram of resistance forces in the blade of rotational cutting apparatus in water environment (*composed by the authors*).

Results and discussions

Since in the considered case the impact of water medium on the dynamic indicators of the cutting apparatus is studied, the cutting force P_c can be ignored as a factor, because it has practically the same value both in aerial and aquatic environments. In other words we are interested only in such force factors which are generated upon the effect of water environment. In figure 3 the boundary zone of the moving fluid mass resulted from the blade rotational movement at the top point of the blade cutting edge is δ_{max} illustrated.

In order to determine the resistance forces let's cut *a* section from the blade starting point to the current *x* distance, then let's provide *x* with elementary progress, second section (Fgure 3) and consider the equilibrium terms of the movement in the isolated section (Figure 4).

In order to determine the friction, movement resistance and inertial forces, first, it is necessary to determine the fluid mass of the isolated section being in motion as a result of the blade movement.

It is worth mentioning that in such problems we don't deal with constant static mass but with so called mass flow (Milne-Thomson, 1964, Prandtl, 2000).

The water mass flow in the movement with elementary volume will be:

$$d_m = \rho \cdot d_Q, \quad (1)$$

where ρ is the water density, d_Q is the water volume flow involved in the elementary moving volume.

Considering the isolated part as a pyramid intersected with parabolic triangle bases we can have the following expression:

$$d_Q = \left[A_x + \left(A_x + dA_x \right) + \sqrt{A_x \cdot \left(A_x + dA_x \right)} \right] \cdot \frac{d_x}{3}, \quad (2)$$

where A_x and A_x+dA_x are the areas of the intersected pyramid bases (Fg. 4):

$$A_x = \frac{2}{3} \cdot \delta_x \cdot \mathbf{v}_x, \quad (3)$$

where δ_x is the height of boundary stratum in the speed changes of the water movement caused by the blade motion in one face of the blade plane,

$v_x=\omega \cdot x$ is the speed of the x coordinate point of the blade cutting edge, ω is the rotation frequency of the rotor (it is accepted as a constant value).

So by placing the values we'll have:

$$A_x = \frac{2}{3} \omega \cdot \delta_x \cdot x, \quad (4)$$

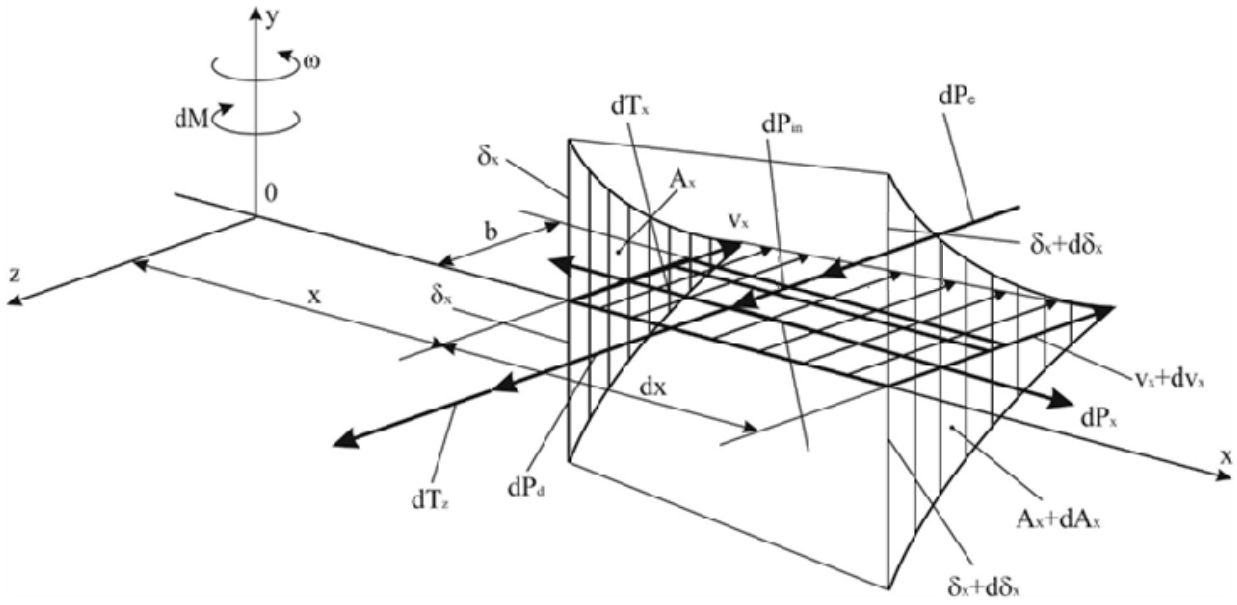

Figure 4. Diagram of the determination of the blade motion resistance forces in the rotational cutting apparatus in water environment (*composed by the authors*).

$$A_x + dA_x = \frac{2}{3}\left(\delta_x + d\delta_x\right)\left(\mathbf{v}_x + d\mathbf{v}_x\right). \quad (5)$$

The derived expression (5) is too extensive for the volume flow and consequently for the mass flow, which is not relevant for practical computations. Taking into account the abovementioned circumstance and the fact that the expression (5) in its open form contains nonfinite members of the second class, with some approximation (with deficiency) the isolated part can be considered as a prism with base. In that case we'll have:

$$dQ_s = A_x \cdot dx$$

or $$dQ_s = \frac{2}{3}\mathbf{v}_x\delta_x dx = \frac{2}{3}\omega\delta_x \cdot x \cdot dx. \quad (6)$$

For the elementary d_m mass we'll have:

$$d_m = \frac{2}{3}\omega\rho\delta_x \cdot dx,$$

considering that $\delta_x = \sqrt{\frac{\upsilon b}{\omega x}}$, for d_m we'll have:

$$d_m = \frac{2}{3}\omega\rho\sqrt{\frac{\upsilon b}{\omega x}}x \cdot dx. \quad (7)$$

The isolated elementary mass is influenced by the centrifugal force dP_x, the friction resistance force along the blade sheet length dT_x, hydrodynamic resistance force of the blade rotational movement dP_d, resistance force of the stem (s) cutting P_c, resistance force of the water movement in the transverse direction of the blade dT_z and by the relative inertial force of water and blade dP_{in}.

The equations of the movement equilibrium for the isolated section will be the following:

$\sum x=0, dP_x - dT_x = 0$ or $dT_x = dP_x$, where the centrifugal force dP_x is determined in the following way (Biderman, 1980):

$$dP_x = 2d_m \cdot \omega^2 \cdot x d_x. \quad (8)$$

The product 2 indicates that the friction forces appear along the blade sheet and in upper and lower surfaces; the next equation is $\sum M_y = 0$ or:

$$dM_y = (dP_d + dT_z + dP_{in}) \cdot x. \quad (9)$$

The hydrodynamic resistance force is determined through the following expression (Prandtl, 2000):

$$P_d = c \cdot A_1 \cdot \frac{\rho \mathrm{v}^2}{2}, \quad (10)$$

where A_1 is the area of the facial part of the blade cutting edge: $A_1 = l \cdot \lambda$,

λ is the thickness of the blade sheet.

For the isolated mass we'll have: $dP_d = c\lambda\rho\frac{\mathrm{v}_x^2}{2}dx$ or

$$dP_d = c\lambda\omega^2\rho\frac{x^2}{2}dx. \quad (11)$$

The friction resistance force is determined through the following formula:

$$T_z = 2kb\sqrt{\mu\rho\mathbf{v}^3},$$

k is the coefficient, which depends on the form and sizes of the object (blade) moving in water. In our case $k=3$ (Kochin, et al., 1942).

For the elementary isolated mass we'll have:

$$dT_z = 6b\sqrt{\mu\rho x\mathbf{v}_x^3} \text{ or } dT_z = 6b\sqrt{\mu\rho\omega^3}\,2xdx. \quad (12)$$

The inertial force of the relative water movement is determined through the following expression (Biderman, 1980):

$$P_{in} = -m\left(\frac{\partial^2 u_z}{dt^2}\right),$$

u_z is the shift in the direction of circular movement.

In the discussed problem the movement of the water particles on the b latitude of the blade spear point is of particular interest. The speed change of the fluid particles on the mentioned part will be $\frac{\mathrm{v}_x^2}{\mathrm{b}}$, since at the cutting edge of the blade $v_x=0$, while at the opposite edge (after crossing the b way) it acquires the maximum v_x value.

Based on these judgments for dP_{in} we'll have:

$$dP_{in} = -dm \cdot \frac{\mathrm{v}_x^2}{\mathrm{b}}. \quad (13)$$

Inserting the received values in (8), (9) and (13) expressions we'll have:

$$dT_x = \frac{4}{3}\rho\omega^3\sqrt{\frac{\upsilon b x^3}{\omega}}dx \quad (14)$$

$$dM_1 = \left(c\lambda\omega^2\rho\frac{x^3}{2} + 6b\sqrt{\mu\rho\omega^3}\cdot 2x^2\right)dx \quad (15)$$

$$dM_2 = \left(\frac{2\omega^3\rho x^3}{b}\sqrt{\frac{\upsilon b}{\omega \cdot x}}\cdot x\right)dx \quad (16)$$

$$dP_{in} = -\frac{2\omega^3 x^3\rho}{b}\sqrt{\frac{\upsilon b}{\omega \cdot x}}dx. \quad (17)$$

The equation of the equilibrium moments in the movement was introduced through one expression (9), while the last equations for the rotation or resistance moment are presented through two equations (15) and (16). It is conditioned by the fact that the moment towards the y axis has obtained [Nm] measurability from the powers of P_d and T_z, because the expressions don't contain force factors resulted from the mass flow *dm,* meanwhile P_{in} is just related to the *dm* mass and the component of moment obtains [Nm/s] measurability from that force (dM_2).

If we assume that the impact of resistance force factors per time unit (*1 s*) is discussed, their impacts on the total resistance moment will become equal. It is necessary to consider that in the dM_2 expression the sign of dP_{in} is positive because in the diagram (Figure 3, 4) its direction is already changed.

By integrating the derived (14), (15), (16) expressions we'll have:

$$T_x = \frac{4}{3}\rho\omega^3\int_0^{\ell}\sqrt{\frac{\upsilon b x^3}{\omega}}dx$$

$$\text{or}\quad T_x = \frac{4}{3}\rho\omega^3\sqrt{\frac{\upsilon b}{\omega}}\cdot\frac{2}{5}\ell^2\sqrt{\ell}, \qquad (18)$$

$$M_1 = \frac{c\lambda\omega^2\rho}{2}\int_0^{\ell}x^3dx + 12b\sqrt{\mu\rho\omega^3}\int_0^{\ell}x^2dx$$

$$\text{or}\quad M_1 = \frac{c\lambda\omega^2\rho\ell^4}{8} + 4b\sqrt{\mu\rho\omega^3}\cdot\ell^3, \qquad (19)$$

$$M_2 = 2\omega^3\rho\sqrt{\frac{\upsilon b}{\omega}}\int_0^{\ell}x^{7/2}dx$$

$$\text{or}\quad M_2 = \frac{4}{9}\omega^3\rho\sqrt{\frac{\upsilon b}{\omega}}\ell^4\sqrt{\ell}\ . \qquad (20)$$

In the laboratory plant developed and prepared by us the numerical values of the figures in (18), (19) and (20) expressions are as follows: ρ=1000 kg/m^3, υ=1·10^{-6} m^2/s, *c=1.45* (the value is related to the b/ℓ ratio; in our case it is 0.1, which corresponds to the value of 1.45 (Prandtl, 2000)), *μ=0.1 kg/m·s, b=0.03 m, l=0.3 m, λ=0.001 m, ω→0÷100 s^{-1}.*

By inserting the numerical values we'll have:

$T_x=4.5\cdot10^{-3}$ ω$^{5/2}$ N/s, assuming that *ω=50* s^{-1}, $T_x=79.55$ N/s, *ω=100 s^{-1}, T_x=450 N/s.*

$$M_1 = 1.47\cdot10^{-3}\omega^2 + 32.4\cdot10^{-3}\sqrt{\omega^3}\ \ Nm.$$

If *ω=50 s^{-1}, M_1=15.13 Nm, ω=100 s^{-1}, M_1=47.1 Nm.*

If we take into account that for implementing efficient cutting the blade plane with that of stem latitudinal cross section should make 22÷28^0 (Tarverdyan, 1996, Tarverdyan, 2014) in the expression of M_1 we should place $b\cdot sin\alpha$ instead of λ, since in that case hydrodynamic resistance comes forth by the area of $bl\cdot sin\alpha$ (projection of the blade sheet surface area on the vertical plane of the movement). Assuming that $\alpha=26^0$, for M_1 we'll get:

$$M_1 = 19.3\cdot10^{-3}\omega^2 + 32.4\cdot10^{-3}\sqrt{\omega^3}\ Nm,$$

if *ω=100 s^{-1}, M_1=225.4 Nm.*

So the effect of hydrodynamic resistance increases in about 5 times.

$M_2=0.34\cdot10^{-3}\ \omega^{5/2}$ *Nm/s* . If *ω=50 s^{-1}, M_2=6 Nm/s, ω=100 s^{-1}, M_2=34 Nm/s.*

The retrieved data with the deviation of 5÷10 % coincide with the results of the preliminary experimental researches (Tarverdyan, 1996, Tarverdyan, 2014, Altunyan, 2009).

Conclusion

The numerical numbers derived for T_x, M_1, and M_2 show that the double increase of the blade speed in water environment entails to the increase of the resistance force factors in the mentioned environment in 5 times, which apparently implies an equal increase in the amount of power needed to perform cutting.

Thus, the existing cutting apparatus are not relevant at all for cleaning the channels and reservoirs from the water plants from both technical-technological and energy saving perspectives.

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Analysis of the Research and Experimental Study Results in the Self-Driving Clod-Crusher of the Potato Digger

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ABSTRACT

Laboratory experiments on the self-driving rotary clod-crusher in the potato digger has been implemented which is aimed at the specification of kinematic and dynamic parameters resulted from the theoretical researches. During the experiments a torque measuring resistance strain gage of TRA-50K series, Zet-210 analog-to-digital converter, appropriate booster (Zet-410) and recording equipment have been used. Three finger types of the recommended clod-crusher have been experimented: cylindrical, cylindrical with hemispheric facade and conical. The experiments indicate that the theoretical research results accurately address the principle of the problem and they can serve as a background for the design and preparation of the clod-crusher.

Introduction

Different kinds of clod-grinders and clod-crushers are currently widely used in Armenia and CIS member countries to enhance the sifting rate of potato from the soil mass during the harvesting activities with the potato digger. Their main driving source is the tractor take-off power shaft. The application of such equipment leads to the tractor's extra energy consumption. The rotary clod-crusher of the potato digger developed by our research group (Tarverdyan, Yesoyan, et. al, 2020, Tarverdyan, Hayrapetyan, 2019) gets the drive due to the resistance forces of grouser wheel in the soil. As a result, the efficient tractor horsepower is saved, as well as the productivity of the aggregate and tractor on the whole becomes higher.

The rotary clod-crusher 1 (Figure 1) of the potato digger is attached to the front part of the potato digger through the lever-hinge 2 system. In the transport mode of the aggregate the crusher gets off the ground together with the potato digger by means of the tractor suspension system, while in the working state it is adjusted down on the bed dam. The sticking rate of the working parts and the grousers into the soil is regulated by the regulatory equipment. The regulatory equipment is a hydro cylinder 3 managed by the distributive system of the tractor oil pressure, which, with its one end is connected to the potato digger through the hinges and with another end to the lever-connecting horizontal bar. In the result of the studies and analyses quadri-circuit planetary mechanism with annular parasitic toothed-wheel has been selected to transmit rotational movement from the grouser wheel 4 of the recommended clod-crusher of the potato digger to the working rotors 5 (Tarverdyan, Hayrapetyan, 2019).

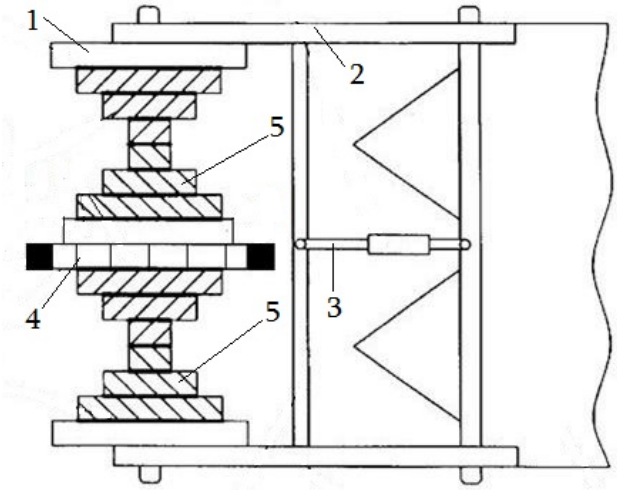

Figure 1. The diagram of the rotary clod-crusher of the potato digger *(composed by the authors)*.

Materials and methods

During the theoretical researches three finger types of the recommended clod-crusher (Tarverdyan, Yesoyan, et. al, 2020) have been studied: cylindrical with flat facade, cylindrical with hemispheric facade and conical (Figure 2).

Figure 2. The experimental fingers of the clod-crusher in the potato digger.

In the result of theoretical researches for the discussed three cases the following values of the sticking and moving resistance force for the clod-crusher's working part in the soil and the throwing speeds of the soil clods have been derived (Tarverdyan, Hayrapetyan, 2019):

1. In case of the clod-crusher with cylindrical flat facade we have P= 24.34 N, $V\tau$ =9.76 m/s.
2. In case of the clod-crusher with cylindrical hemispheric facade - P= 15.03 N, $V\tau$ =9.73 m/s.
3. In case of the clod-crusher wth conical top - P= 8.91 N, $V\tau$ =9.63 m/s.

As a result of theoretical researches we have obtained an important expression, which identifies the equal rotation term in the rotor of the clod-crusher (Tarverdyan, Hayrapetyan, 2019).

$$M_4 = -\frac{(P_4 + 2P_2)(r_3 + r_2)\sin\varphi}{2} . \qquad (1)$$

Laboratory and field experiments have been conducted to verify the mentioned term (1) and to accurately determine the quantity and sizes of the grousers worn on the rims of the driving wheels, as well as to select the optimal form of the clod-crushing fingers.

The laboratory experiments have been conducted in the earth trench of the laboratory at the chair of "Tractors and Agricultural Machines" at Armenian National Agrarian University in conditions of 0.6 m/s – 1.4 m/s forward movement of the wheelbarrow equipped with rotary clod-crusher. The laboratory experiments have been implemented with the methodology developed and established through multiple trials by our research group (Vysotskiy, 1968, Loginov, 1976, Matevosyan, 2018, Grigoryan, Tarverdyan, 2001). The research experiments are aimed at the study of the exploitative and operational regulations of the clod-crusher, particularly the functional relation between the rotor and the torque moment of the grouser wheel, as well as at the disclosure of the impact size of the clod-crusher's finger forms, geometric and kinematic parameters, as well as that of soil properties and conditions on the crushing process of soil crust in the external surface of the tuber chain.

Throughout the experiments analog-to-digital recording equipment, particularly torque moment determining resistance strain gage (Figure 3) of TRA-50K series has been applied, by means of which the received analog signals are recorded through the innovative multi-wave analog-to-digital converter Zet-210. The analog signals received from the resistance strain gage are intensified in 1000 times through Zet-410 booster, which is converted to the digital data through Zet-210 analog converter. The converted digital information is transferred to the computer by Zet-210 by means of USB interface.

Figure 3. The general view of TRA-50K resistance strain gage.

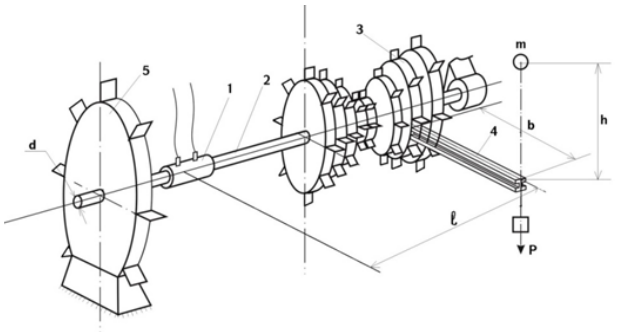

Figure 4. The diagram of static and dynamic calibration plant *(composed by the authors)*.

The digital information is recorded and stored through Zet Lab measuring-recording software, which enables to save and develop the digital outcomes recorded during the scientific experiments to determine the physical value chosen as an upgrading parameter for the research.

To determine the resistance force of the crushing fingers in the clod-crusher equipment, its kinematic parameters and sizes, as well as to identify the quantity of the soil grousers, calibration of TRA-50K must be implemented.

Calibration has been implemented through the methodology developed by our research group (Tarverdyan, Artemyan, 1992).

Based on the results of theoretical researches (Tarverdyan, Hayrapetyan, 2019), with some approximation we can state that the maximum theoretical moment M applied in one half shaft doesn't exceed 70 N-m (M=r·P·m·n, where r=0.18 m is the mid radius of the clod-crusher discs, P=24N is the maximum resistance force applied in one crushing finger, m is the number of crushing fingers of a disc completely stuck into the soil simultaneously, n is the number of the clod-crusher's discs).

According to the value of the torque moment we've selected the force value applied during the calibration (P) and the arm length of the force application.

After attaching the strain gage 1 to the half shaft 2, a hard bar with 0.82 m length 4 (Figure 4) was fastened to the disc 3 with mid radius (r = 0.18 m) through welding, providing 1 m length of arm force effect on the shaft axis. During the experiments the grouser wheel 5 was tightly fixed, so as to subject it to torque deformation.

During calibration not only the selection of the torque moment value but also the speed of the load with m mass at the moment of its striking to the hard bar is important. Upon the theoretical researches it has been stated that the maximum circular velocity of the clod-crushing finger is not related to the finger form and makes about 10 m/s (Tarverdyan, Hayrapetyan, 2019). To provide the average striking velocity (V_{av} =5.5 m/s) during the calibration it is necessary to allocate the load with m mass at the height of $h = \frac{V_{ave}^2}{2g}$ from the hard bar, which can show that h≈1.3 m.

Results and discussions

Taking into account that the kinetic energy K in the striking elastic element (in our case into a half shaft) is completely turned into potential deformation energy U, the solution of the problem results in the determination of the potential deformation energy and the dynamical coefficient k_d.

The calibration has been implemented in the following way: first of all the static Ps force was applied to the free edge of the hard bar 4 and the deviation rate of the oscillogram coordinate Δ_S received from the signal of resistance strain gage was recorded from the zero line, which corresponds to the unloaded state. Then from the h height the load with m mass (it should be noted that *PS=mg*) is released, which strikes the free edge of the hard bar; in this case the deviation rate of the oscillogram coordinate (light point) is also recorded in the monitor and measured from the zero position Δ_d.

It is known that in case of twisting of the bar with round cutting the potential energy of the twisting deformation is determined through the following expression (Belyaev, 1976):

$$U_S = \frac{M^2 \cdot \ell}{2GI_\rho} = \frac{\tau_{s\,max}^2 \cdot \ell \cdot W_\rho}{2GI_\rho},$$

where M is the torque moment of the bar, ℓ is its length, G is the sliding module of the bar material (for steel $G = 8 \cdot 10^5$ kgf/cm^2), I_ρ is the polar inertial moment of the bar cross-section and W_ρ is its polar resistance moment. The torque angle of the bar (half shaft) in case of static load application is determined in the following way:

$$\varphi_S = \frac{M\ell}{G \cdot I_\rho}.$$

The dynamic coefficient k_d is determined through the following expression (Belyaev, 1976):

$$k_d = 1 + \sqrt{1 + \frac{V^2}{g\delta_S}}, \text{ or} \qquad (2)$$

$$k_d = 1 + \sqrt{1 + \frac{K}{U_S}}, \qquad (3)$$

where V is the load velocity at the start of striking ($V = \sqrt{2gh}$),

$\delta_s = \varphi_s$ is the static deformation,

K is the kinetic energy of the striking load at the striking moment $\left(K = \frac{mV^2}{2}\right)$.

U_S is the potential energy of the deformation for force static application.

Using the expression (3) we can have the following for the dynamic torque angle of the bar (half shaft):

$\varphi_d = k_d \cdot \varphi_s$, placing the values of φ_s and K_d we'll have:

$$\varphi_d = \sqrt{\frac{2K \cdot \ell}{G \cdot I_\rho}}. \qquad (4)$$

The resistance strain gage, which is stuck at 45^0 angle against the bar axis, is subjected to the linear deformation due to the torque angular deformation and the final maximum tangential strain is recorded:

$$\tau_{d\,max} = k_d \cdot \tau_{S\,max} = \tau_{S\,max} \cdot \sqrt{\frac{K}{U_S}}, \qquad (5)$$

where $\tau_{s\,max} = \frac{M_s}{W_\rho}$, $M_S = P \cdot b$, $W_\rho = \frac{\pi d^3}{16}$.

By placing the value of $\tau_{S\,max}$ (5), we'll have:

$$\tau_{d\,max} = \sqrt{\frac{2KGI_\rho}{\ell W_\rho^2}} = 2\sqrt{\frac{KG}{F\ell}} \qquad (6)$$

$F = \pi r^2$ is the latitudinal cros-section area of the bar (half shaft).

Throwing the load with the following weights m = 1.0, 2.0, 3.0, 4.0 and 5.0 kg from different heights ($0 \le h \le 1.3$ *m*), we fix the corresponding deviations of the oscillogram coordinate, specify and identify the relations of kinetic energy and oscillogram ordinate at the striking moment of the load and then determine the scale.

In the laboratory experimental plant the numerical values of the abovementioned units are as follows: $m = 0.5 \div 10$ kg, b=1.0 m, l=1.2 (the length of the half shaft), d=2.5 cm (the diameter of the shaft at the sticking cross-section of the resistance strain gage), $G = 8 \cdot 10^4$ MPa, h=0.5 ÷1.3 m.

Based on the data received from the preliminary theoretical and calibration trials conducted for the enhancement of force factors in the recommended clod-crusher the baseline calibration data have been identified: P_s=98.1 N (it provides the needed torque moment: $M=P_s \cdot b$=98.1Nm), h=1.3 m, V=5.5 m/s, m=10 kg.

Repeating the experiment for several times the deviations of the oscillogram ordinate from the zero position Δ are recorded in the monitor of the measuring gadget.

In case of the abovementioned values the following values for the main calibration parameters have been received: at the start of the load strike at the hard bar the kinetic energy is K=130 Nm, the potential energy of the torque deformation in the half shaft in case of applying the static force P_s is U_s=2.21 Nm.

The dynamic coefficient is:

$$k_d = 1 + \sqrt{1 + \frac{K}{U_S}} = 8.73.$$

For the latitudinal cross-section of the strain gage shaft F=4.9·10-4 m^2, $W_\rho = 3.06 \cdot 10^{-6}$ m^3, $I_\rho = 3.8 \cdot 10^{-8}$ m^4.

In case of static load the maximum value of tangential strain will be:

$$\tau_{d\,max} = \frac{P_S \cdot b}{W_\rho} = 32.06 \text{ MPa}.$$

The dynamic tangential strain:

$$\tau_{d\max} = k_d \cdot \tau_{s\max} = 279.88 \text{ MPa.}$$

Since K >> U_s, in practical computations the dynamic tangential strain can be also determined through the (6) expression:

$$\tau_{d\max} = 2 \cdot \sqrt{\frac{KG}{F\ell}} = 266 \text{ MPa.}$$

The deviation of the tangential strains determined through two methods doesn't exceed 5 %.

The dynamic value of the torque moment will be:

$$M_d = \tau_{d\max} \cdot W_\rho = 813{,}9 \text{ Nm.}$$

M_d is determined also in the following way:

$$M_d = k_d \cdot M_S = 8.73 \cdot 98.1 = 856.4 \text{ Nm.}$$

In this case the deviation again doesn't exceed 5 %.

Repeating the experiments for several times the deviation of oscillogram ordinate from the zero line is recorded in the monitor of the measuring gadget.

In case of the abovementioned baseline data during the 5 experiments we have received the following values for Δ: 108 mm, 109 mm, 108 mm, 107 mm and 109 mm.The average value of Δ is: Δ_{av} = 108.2 mm.

The signal size of the dynamic torque moment recorded through TRA-50K resistance strain gage will be 7.7±0.2 Nm/mm in the recording gadget.

In the laboratory experiments the clod-crushing fingers were conventionally assigned: 1–cylindrical, 2–cylindrical with hemispheric facade/front, 3–conical.

In the laboratory plant such rotational numbers were provided to the input shaft of transmission gearbox of the pulley, which ensure the forward movement of the clod-crushing aggregate with 1.0 m/s, 1.3 m/s and 1.6 m/s velocity.

A number of modal outcomes of the laboratory experiments are introduced in the table. The data of the table testify that the increase in the velocity of the forward movement and consequently that of in the angular velocity of the driver by 30÷60 % leads to the increase of resistance moment, hence, to the force increase by 10÷15 %.

The table data show that the resistance forces derived from the theoretical calculations for three different fingers interrelate with each other nearly in the same way as the resistance moments received upon the experiments:

$$\frac{P_1}{P_2} = 1.6,\ \frac{P_2}{P_3} = 1.6,\ \frac{P_1}{P_3} = 2.28,\ \frac{M_1}{M_2} = 1.56,$$

$$\frac{M_2}{M_3} = 1.46,\quad \frac{M_1}{M_3} = 2.28.$$

Such overlapping interrelations (with slightest deviations) state on the acurate interpretation of the problem's real content through theory. Thus, the obtained results can be taken as a sound background for the design and computation of the clod-crushing machine.

Table. Data on the forward movement and angular velocity in different fingers of the clod-crusher*

Velocity of the clod-crusher's forward movement, m/s	Digging finger form	The maximum ordinate Δ_{max}, mm on the paper carrier of the recording equipment	The dynamic torque moment of the half shaft in one side M, Nm
1.0	1	13.6	105.6
	2	8.7	67.5
	3	6.0	46.3
1.3	1	14.5	112.0
	2	9.2	70.8
	3	6.4	49.4
1.6	1	15.4	118.5
	2	9.7	74.7
	3	7.0	53.2

*Composed by the authors.

Conclusion

The expression for identifying the optimal grouser numbers determined through the theoretical researches in equal working terms of the self-driving clod-crusher's rotors in the potato-digger has been derived and analyzed through the results of the scientific experiments.

The ratio of the resistance force factors theoretically received for the recommended three finger forms (cylindrical, cylindrical with hemispheric front and conical) in the clod-crusher has been proved upon the experiments.

The theoretical expressions derived as a result of kinematic and dynamic analyses of the clod-crusher can be completely used for the development and design of such machine series.

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Empirical Specification of Factors Affecting Per Capita Pork Consumption in Armenia

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ABSTRACT

The aim of this paper is to estimate the main factors affecting per capita pork consumption in Armenia. For this analysis, the log linear model of per capita pork consumption was estimated. In the analysis 17 observations were used for the period of 2001 through 2017. The data were mainly taken from websites of "Statistical Committee of the Republic of Armenia" and "Food and Agriculture Organization". The parameter estimate of each variable is calculated using STATA statistical software. Further analysis has shown that real price of beef, real price of mutton and real per capita disposable income had statistically significant impact on per capita pork consumption in Armenia.

Introduction

The pork industry plays a major role in the increasing meat production. This is due to the biological characteristics of pigs since they are the most productive among domestic animals (Davtyan, et al., 2004). Also, pork production is cost effective. Pigs are omnivorous, eat all the food used to feed farm animals, as well as food and food debris (Davtyan, et al., 2004). Pork is one of the main meat products in Armenian cuisine. It is very important to know which factors have significant influence on the demand of pork to be able to control them. Being aware of the factors which have influence on the pork demand, it will be easy to predict upcoming changes in the quantity demanded. Therefore, it will be possible to take actions for stabilizing economics in Armenia. In addition, it is interesting for farmers to see what factors influence pork consumption, for better planning and positioning their business.

The table drawn below contains information about pork production, import and export for 2011-2017.

The numbers show that pork consumption in Armenia had an increasing tendency within 2011-2017. Furthermore, local production of pork more than doubled during these years, whereas, import had the cyclical pattern. Below drawn figures will help to illustrate the data better.

Table 1. Pork production, import, export and prices during 2011-2017*

Year	Production (tons)	Import (tons)	Export (tons)	Total resources (tons)	Price (AMD)
2017	12732	7027.2	_	19759.2	3088.2
2016	12625	5659	_	18284	2645.1
2015	13971.5	6429.5	_	20401	3620.6
2014	12079	7295.8	_	19374.8	3341.3
2013	9399	8136.4	0	17535.4	3112.2
2012	6127	8261.5	0	14388.5	3456.8
2011	5482.6	5081.6	0.006	10564.2	2783.4

**Source: (Statistical Committee of the Republic of Armenia, 2011-2017).*

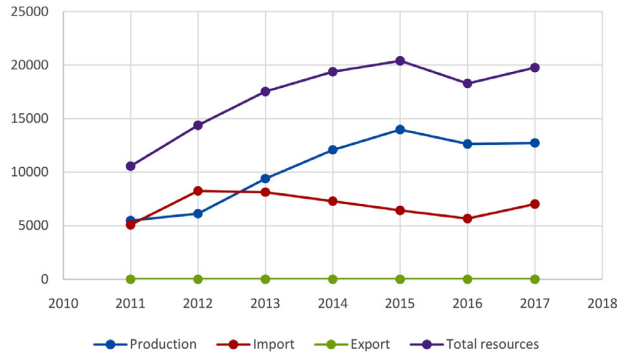

Figure 1. Pork production, import and export (*composed by the authors*).

Figure 2. Proportion of import, export and production (*composed by the authors*).

After 2012 production of pork exceeds import. Major countries, which export pork into Armenia, are Brazil, Canada, Spain and Germany. Approximately 50 % of imported pork comes from Brazil (Ghazaryan, 2016, https://hetq.am/hy/article/68775). Export quantities were negligible comparing with production and import. Prices also had the cyclical pattern varying from 2645.1 AMD to 3620.6 AMD during 2011-2017.

The key research question for this paper is: "What factors are influencing per capita pork consumption in Armenia?"

All the estimations, findings and conclusions were made based on the regression analysis, which estimates whether the effect of the chosen factors on per capita pork demand are statistically significant or not.

Literature review

Sona Telunts examined the factors influencing per capita beef consumption in Armenia in her paper of "Empirical Estimation of Per Capita Beef Demand in the Republic of Armenia". She included the natural logarithm of per capita real income, the price of the beef and some complement products. She also included trend in the model, assuming that there is an increasing trend in the capita consumption of beef. Ms. Telunts estimated double-log linear regression model by using quarterly time-series data. The estimation results of her paper showed that the average real price of beef was negatively associated with the average per capita consumption of beef, besides the demand for beef was inelastic. Beef was estimated as a normal good (Telunts, 2014).

The next paper which is considered to be reliable and relevant for this study is "Elasticity of consumer demand on pork meat in the Slovak Republic" written by P. Bielik, Z. Šajbidorová in 2009. The paper examined the factors affecting the elasticity of the pork meat demand for consumers. In their model authors included the price of pork, income and some substitute products. As authors mention, the results of the analysis of the demand elasticities on the consumer level show that Slovak consumers of pork react more responsively on the change in income than on the change of the pork price (Bielik, 2009).

The next source supporting the model used in this paper is the fourth edition of "Basic econometrics" written by D. N. Gujarati. In the mentioned work the classical theorems affecting the quantity demanded of any product are presented. It claims that there are several factors affecting the consumption of the product. These factors are: income or wealth of people, price of the product, complement products, substitute product, tastes, preferences, etc. (Gujarati, 2003).

Materials and methods

Empirical Model: In this analysis the dependent variable is per capita consumption of pork (Qt). Based on theory, literature review and common sense, the independent variables that suppose to influence it are real own price of pork (rl_ppork), real prices of substitute products (rl_pbeef, $rl\_pmutton$, $rl\_ppoultry$) per capita, real monetary income (rl_pcdpi) and trend/tastes and preferences/(rl_trend).

MWD (MacKinnon, White, and Davidson) test was used to choose between linear and log-linear models. Based on the results, log-linear model is used for the further analysis.

$$\ln\_Q_t = \beta_0 + \beta_1 \ln\_rl\_ppork_t + \beta_2 \ln\_rl\_pbeef_t + \\ + \beta_3 \ln\_rl\_pmutton_t + \beta_4 \ln\_rl\_ppoultry_t + \\ + \beta_5 \ln\_rl\_pcdpi_t + \beta_6 rl\_trend_t + e_t,$$

where:

- $\ln\_Q_t$ is the natural logarithm of per capita pork consumption;
- $\ln\_rl\_ppork_t$ is the natural logarithm of real price of pork in drams. Based on the literature review we expect to have the parameter estimate associated with the real own price variable to be negative, because of the law of demand;
- $\ln\_rl\_pbeef_t$, $\ln\_rl\_pmutton_t$, $\ln\_rl\_ppoultry_t$ respectively are the natural logarithms of real prices of beef, mutton and poultry in drams. The parameter estimate associated with the substitute products' prices (beef, mutton, poultry) are expected to be positive, as if the price of substitute products has lower prices people will start to consume more of that product and less of pork. In other words, if the price of pork substitutes increases, the quantity demanded for pork will increase;
- $\ln\_rl\_pcdpi_t$ is the natural logarithm of per capita real monetary personal income in drams. Parameter estimate associated with the real per capita monetary personal income is expected to be positive, since pork is considered to be a normal good. In case of a normal good, increase in income leads to higher consumption rate;
- $trend_t$ is trend for tastes and preferences. Parameter estimate associated with the trend is expected to be positive, since we assume that when tastes and preferences go up, per capita pork consumption would also increase;
- e_t is disturbance, or error term.

Based on the used time series data, different tests were done for checking and correcting violations of OLS assumptions (multicollinearity, autocorrelation, heteroscedasticity).

At first we check, if there are omitted variables in the model or not. Ramsey test has been conducted for checking misspecification of the model. The test shows that model has no omitted variables, which means that all the necessary variables are included in the model.

Multicollinearity: Originally, multicollinearity meant the existence of a "perfect," or exact, linear relationship among some or all explanatory variables of a regression model. But in this paper we check for multicollinearity is less than perfect. If multicollinearity is less than perfect, the regression coefficients cannot be estimated with great precision or accuracy (Gujarati, 2003).

We suspect that there is a multicollinearity in the data, because F is statistically significant, the R^2 is very high ($R^2=0.9527$), also, there are 3 independent variables from 7 which statistically are not significant (price of pork, price of poultry and trend).

Another way to suspect multicollinearity is the pair- wise (zero-order) correlation matrix (Table 2). Not all the variables are highly correlated, but some of them have high correlation. So, we can see multicollinearity in the data.

One way to find out whether there is multicollinearity in the data is examination through partial correlations. If the coefficient of multiple correlations is high, but partial correlation coefficients are low, we can suggest that the variables are highly intercorrelated and at least one of these variables is superfluous (Table 2) (Gujarati, 2003).

Table 2. Partial correlations*

	In_rlppork	*In_rlpbeef*	*In_rl_pmutton*	*In_rl_ppoultry*	*In_rl_income*	*trend*
In_rl_ppork	1.0000					
In_rl_pbeef	0.6030	1.0000				
In_rl_pmutton	0.6924	0.8910	1.0000			
In_rl_ppoultry	-0.6199	-0.6637	-0.7581	1.0000		
In_rl_income	0.6448	0.7088	0.7872	-0.9436	1.0000	
trend	0.6063	0.7283	0.7908	-0.9494	0.9818	1.0000

Table 3. Partial correlations*

Variable	Correlation	Significance
ln_rl_ppork	0.2655	0.404
ln_rl_pbeef	0.6401	0.025
ln_rl_pmutton	-0.7685	0.003
ln_rl_ppoultry	0.4753	0.118
ln_rl_income	0.6528	0.021
trend	0.3070	0.332

Table 4. Auxiliary regression*

	R^2
Original model	0.9527
ln_rl_ppork	0.5491
ln_rl_pbeef	0.8110
ln_rl_pmutton	0.8592
ln_rl_ppoultry	0.9108
ln_rl_income	0.9692
Trend	0.9738

*Composed by the authors.

Since the R^2 is very high (0.9527), we assume that correlations between consumption of pork and independent variables need to be high. But the numbers for the real price of pork (0.2655), price of poultry (0.4753) and trend (0.3070) are very small, consequently, we can suspect that there is a multicollinearity in the data.

Another way of finding whether there is a multicollinearity issue is the auxiliary regressions. Instead of formally testing all auxiliary R^2 values, Klien's rule of thumb was adopted, which suggests that multicollinearity may be a troublesome problem only if the R^2 obtained from an auxiliary regression is greater than the overall R^2. Table 4 depicts the auxiliary regression results.

Since in the auxiliary regressions R^2 of real per capita disposable income and trend are greater than R^2 of original model, based on Klien's rule of thumb, we suspect that there is a multicollinearity in the data.

Some authors use the VIF (variance inflation factor) as an indicator of multicollinearity. The larger the value of VIF, more "troublesome" or collinear the independent variables are. As to the rule of thumb, if the VIF of a variable exceeds 10, which will happen if R^2 exceeds 0.90, that variable is considered to be highly collinear. As we can see from the VIF table drawn below, trend, *ln_rl_income* and *ln_rl_ppoultry* are greater than 10, which means there is a multicollinearity problem in the data (Table 5).

For tolerance we compare values with 0.1 (which variables are less than 0.1). Again, as TOL (1/VIF) numbers show, *trend*, *ln_rl_income* and *ln_rl_ppoultry* are less than 0.1, which means there is multicollinearity in the data.

After testing several options, we saw that the multicollinearity problem disappears when we drop trend from the model.

$$\hat{Q}_t = -11.87 + 0.10 ln\_rl\_ppork_t + 1.34 ln\_rl\_pbeef_t - 0.87 ln\_rl\_pmutton_t + 0.93 ln\_rl\_pcdpi_t$$

Table 5. Variance inflation factor*

Variable	VIF	TOL (1/VIF)
Trend	38.14	0.02622
ln_rl_income	32.43	0.033083
ln_rl_ppoultry	11.21	0.08921
ln_rl_pmutton	7.1	0.140761
ln_rl_pbeef	5.29	0.189036
ln_rl_ppork	2.22	0.450942
Mean VIF	16.07	

*Composed by the authors.

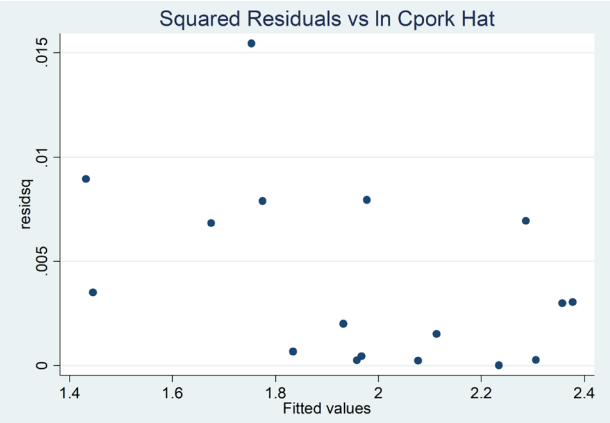

Figure 3. Residual squared against estimated per capita pork cons. *(composed by the authors).*

The new regression results show that the model hasn't multicollinearity. Although R^2 is still high, auxiliary regression shows that there is no any independent R^2 which is greater than R^2 of the model. The VIF and TOL analysis shows that all values for VIF are smaller than 10 and all values for TOL are higher than 0.1. The question arises: whether the new model is biased or not? In order to check whether regressors are biased or not, Ramsey test was conducted. The test has shown that prob (F) = 0.0296, which is less than 0.05 (5 % significance level), meaning that the model has omitted variables. So parameter estimates of the new model are biased. In this case, the decision is to reject the new model and continue the future analysis with the original model, as even in case of multicollinearity the parameter estimates were considered to be unbiased. It is better to have all the necessary variables included in the model rather than have biased estimates.

Heteroscedasticity problem: One of the important assumptions of the classical linear regression model is the assumption of homoscedasticity, or equal (homo) spread (scedasticity), that is, equal variance: $var(u_i|X_i)=\sigma^2$ (Gujarati, 2003).

Mainly heteroscedasticity is detected in cross sectional data. In 90 % cases error variance is heteroscedastic in cross sectional data. Also, heteroscedasticity is expected when heterogeneous units exist. For this paper time series data are used, and there aren't heterogeneous units, so we do not suspect heteroscedasticity in the model. To be sure whether there is heteroscedasticity in the model, we draw the scatterplot of the residual squared against estimated per capita pork consumption.

In the graph at least 1 outlier is noticed, consequently we can suspect that the error variance is heteroscedastic. To be sure Park test was applied. The test has shown that there is no heteroscedasticity in the model at 5 % significance level, since p-value for $\widehat{ln\_cpork}$ is equal to 0.083 which is greater than 0.05.

Glejser test also was conducted which proved that there is no heteroscedasticity in the model at 5 % significance level, since p-value for $\widehat{ln\_cpork}$ in this case is equal to 0.081 which is greater than 0.05.

Breusch-Pagan-Godfrey (BPG) test was applied to find out if the error variance is heteroscedastic at the 5 % significance level. Since the calculated θ is less than χ_6^2 (5.50<12.5916), there is no heteroscedasticity in the model at 5 % significance level. Finally, in order to be sure that the model is homoscedastic, White test was conducted. Since nR^2 is less than χ_{16}^2 (17.00<26.2962), we conclude that there is no heteroscedasticity in the model at 5 % significance level.

To sum up the foregoing analyses, we can state that the error variance is homoscedastic and there is no heteroscedasticity problem in the model.

Autocorrelation problem: One of the main assumptions of the classical linear regression model is the absence of autocorrelation between the disturbances (*cov [ui, uj| Xi, Xj]=0*) (Gujarati, 2003).

Autocorrelation in time series data can be defined as correlation between members of series of observations ordered in time, the CLRM assumes that: *E(ui uj)=0, when* $i \neq j$ (Gujarati, 2003).

There are various ways of examining the residuals. The plot residuals vs Years, standardized residuals vs years, also current residuals vs residuals lagged are presented below.

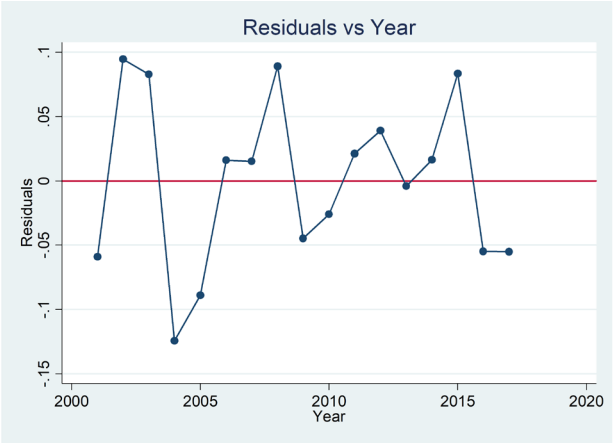

Figure 4. Residuals vs Years *(composed by the authors).*

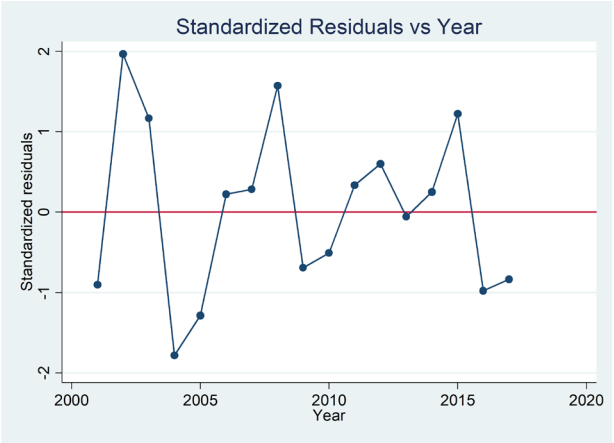

Figure 5. Standardized Residuals vs Year *(composed by the authors).*

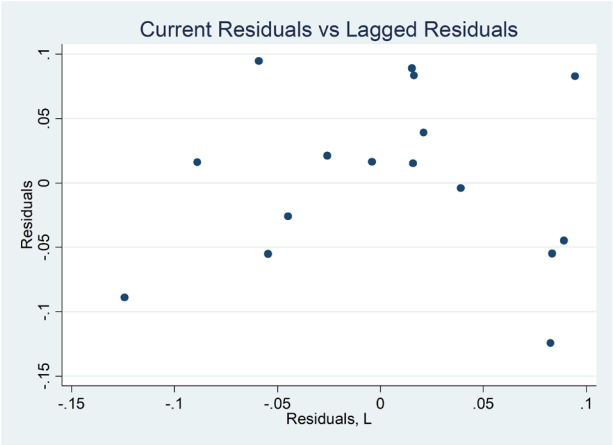

Figure 6. Current Residuals vs Lagged Resid.*(composed by the authors).*

Graphs do not show any correlation. Graph 3 shows that u's are not correlated, consequently, autocorrelation is not expected. In order to be sure, Durbin-Watson *d* test was conducted. Since d=1.899 which is greater than d_L=0.451 and less then d_u=2.537, it is unknown whether autocorrelation exists in the model or not as d is in indecision zone. That is why Run test was implemented. The 95 % confidence interval for *R* is [5.571; 13.371]. Since 95 % confidence interval contains number of runs which is equal to 8, the conclusion is that there is no autocorrelation at 95 % confidence level. Breusch-Godfrey (BG) test also proves that the model hasn't autocorrelation issue at the 5 % significance level.

Data Description

We have 17 observations for 2001-2017. The data were mainly taken from the websites of "Statistical Committee of the Republic of Armenia" and "Food and Agriculture Organization". The observations are taken annually, the mean value for the whole year. Log-linear model was used during the study. You can see the summary statistics of variables in Table 6:

Per capita consumption of pork (ln_Q): For the period 2001-2017, the mean value of per capita consumption of pork in Armenia was 7.48 kg, the standard deviation was 2.13. The minimum value for this variable is equal to 4.00 kg and the maximum value is 10.7 kg.

Real price of pork: For the period 2001-2017, the real price of pork in Armenia was 2421.55 AMD, the minimum value for real price of pork we get in 2002 (1765.63), and the maximum value in 2012 (3131.16).

Real price of beef: For the period 2001-2017, the mean value of real price of beef in Armenia was 1930.56AMD, the minimum value of the real price of beef was 1604.63 AMD and the maximum value of beef was 2304.35 AMD.

Real price of mutton: For the period 2001-2017, the mean value of real price of mutton in Armenia was 2182.46 AMD, the minimum value of the real price of mutton was 1474.19 AMD and the maximum value was 3105.80 AMD.

Table 6. Summary statistics*

Variables	Obs	Mean (kg)	Std. Dev.	Min (kg)	Max (kg)
Average per capita pork consumption	17	7.48	2.13	4.00	10.70
Average real price of pork	17	2421.55	386.20	1765.63	3131.16
Average real price of beef	17	1930.56	212.25	1604.63	2304.35
Average real price of mutton	17	2182.46	562.42	1474.19	3105.80
Average real price of poultry	17	1446.21	157.82	1193.80	1691.30
Average per capita real disposable income	17	30120.55	10270.58	14426.25	47080.52
Trend	17	9	5.04	1	17

*Composed by the authors.

Real price of poultry: For the period 2001-2017, the mean value of real price of poultry in Armenia was 1446.21AMD, the minimum value of the real price of poultry was 1193.80 AMD and the maximum value was 1691.30 AMD.

Real per capita monetary income: For the period 2001-2017, the mean value of real per capita monetary income in Armenia was 30120.55AMD, the minimum value was 14426.25 AMD and the maximum value was 47080.52 AMD.

For adjustment of prices, producer price index (PPI) was used and consumer price index (CPI)- for income.

Results and discussions

The estimation results are drawn in the table 7.

All the parameters have the expected signs, except real price of pork and real price of mutton.

Since the corresponding F statistic is equal to 33.55, which is greater than 4.06 (*F-statistic =33.55 >F8.41= 4.06*), all the parameter estimates are jointly statistically significant at the 5 % significance level. R^2=0.9527, which means that 95.27 % of the variation in the dependent variable are explained by the model. All the parameter estimates are statistically significant at 5 % significance level except price of pork, poultry and trend since their p-values are greater than 0.05. Since the log-linear model was used, the parameter estimates indicate the elasticities.

$\widehat{\beta}_3 = 1.15$: If real price of beef increases by 1 %, per capita pork consumption will increase by 1.15 %, everything else held constant.

$\widehat{\beta}_4 = -0.82$: If real price of mutton increases by 1 %, per capita pork consumption will decrease by 0.82 %, everything else held constant.

$\widehat{\beta}_6 = 0.88$: If per capita real disposable personal income increases by 1%, per capita pork consumption will increase by 0.88%, everything else held constant.

Table 7. Estimation results*

	Coeficient	Sd. Error	t	P>|t|
$lnQ_t = -18.87 + 0.16 \ln\_rl\_ppork_t + 1.15 \ln\_rl\_pbeef_t - 0.82 \ln\_rl\_pmutton_t + 1.08 \ln\_rl\_ppoultry_t + 0.88 \ln\_rl\_pcdpi_t + 0.02 trend_t$				
Constant	-18.87	6.16	-3.06	0.012
ln_rl_ppork	0.16	0.19	0.87	0.404
ln_rl_pbeef	1.15	0.44	2.63	0.025
ln_rl_pmutton	-0.82	0.22	-3.8	0.003
ln_rl_ppoultry	1.08	0.63	1.71	0.118
ln_rl_pcdpi	0.88	0.32	2.72	0.021
Trend	0.02	0.02	1.02	0.332
R^2=0.9527		R^2 adj = 0.9243		F=33.55

*Composed by the authors.

Since parameter estimate associated with real price of beef variable in absolute value is the greatest, it has the largest impact on pork consumption. Also, taking into account that own price elasticity is inelastic ($e_{op}=0.16<1$), the growth in own price will increase the revenue. But since own price of pork coefficient is not statistically significant, better not to take it into consideration. Income elasticity shows that ($e_{ip}=0.88>0$) pork is a normal good. Cross-price elasticity for beef and poultry ($e_{cp}>0$) shows that they are substitutes for pork.

Conclusion

The purpose of this paper was to estimate factors affecting per capita pork consumption in Armenia. The chosen independent variables were: real price of pork in AMD, real price of beef in AMD, real price of mutton in AMD, real price of poultry in AMD, real per capita disposable income in AMD and tastes and preferences (trend). Based on MWD test, log-linear regression model was estimated using annual data (2001-2017).

The estimation results show that the real prices of beef, mutton and per capita real monetary income had statistically significant impact on per capita pork consumption, at 95 % confidence level. The greatest effect has real price of beef. Hence, the pork producers need to pay attention to beef market. The elasticity of income shows that pork is a normal good. It is worth to note that cross price elasticities show that beef and poultry are substitute goods. So, producers need to pay attention also to these 2 products. The price of pork is inelastic.

For future researches, we recommend for more accurate conclusion taking into account quarterly data. It can help to solve the problem of multicollinearity and will allow doing estimations about seasonality of pork consumption. Considering the Armenian traditions, consumption for pork in summer and winter projected to be higher.

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Cigarette and Tobacco Manufacturing Sector in the Economic System of Armenia and its Development Peculiarities

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ABSTRACT

The industry of Armenia, particularly the production of tobacco varieties has been studied in current prices and the price weighted index has been estimated in the current article. Tobacco plantations, gross yield and average yield capacity for 2014-2018 have been introduced per regions of Armenia. The production of cigarette and tobacco, import and export rates, the tariffs for the raw materials, as well as their types and sources have been described in tangible assets. The aim of the article is to emphasize the importance of cigarette and tobacco production in the economy of Armenia.

Introduction

The changes observed in the economy of Armenia in conditions of market economy are almost the same as they were in the former Soviet Union Republics: transition from state ownership to the private or mixed ownership relation, transition from the planned model of economic management to the market relations, from administrative pricing method to the supply-demand model, decentralization and liberalization of the labor market, formation of an independent tax, fiscal and monetary policy, etc.

The tobacco and cigarette production sector is a traditional and rapidly developing sub-branch of Armenian economy, which is provided with both local and imported raw materials.The development rates of production sizes aren't so much related to the organization sizes. The production development is mainly related to such factors as the demand on the product, raw material provision, the position held in the market, quality of goods, etc.

Table 1. The share of tobacco production in the whole industry of Armenia*

According to the types of economic activities Year	RA industrial product in current prices, mln AMD	Tobacco production types in current prices, mln. AMD	The share of tobacco product in the total industry, %
2010	824430.0	16193.3	2.0
2011	998963.7	19888.6	2.0
2012	1121906.7	25420.3	2.3
2013	1242070.3	38306.7	3.1
2014	1291274.1	63112.2	4.9
2015	1342700.1	111544.3	8.3
2016	1432708.9	136288.6	9.5
2017	1664279.0	157747.2	9.5
2018	1737685.6	178367.8	10.3

*Annual yearbook of Armenia, 2019. Industry

Materials and methods

According to historical literature review tobacco growing hasn't been much developed in Armenia, while in the period of Soviet times the development of tobacco growing was only consumer-oriented. Nowadays, there are four large tobacco and cigarette producing companies in Armenia, namely "Grand Tobacco" LLC, "International Masis Tabak" LLC, "Masis Tobacco" LLC and "SPS Cigaronne" LLC, besides, the first mentioned three companies belong to Grand Holding, which is the largest corporation of Armenia.

To understant the significance of cigarette and tobacco production in the social and economic system of Armenia the data on the whole RA industry and tobacco production from 2010 to 2018 are presented in current prices (Statistical Yearbook of Armenia, 2019) in Table 1.

Here are the data on the RA industrial production per the types of economic activities expressed in percents for 2016-2018:

1. processing industry - 62 %,
2. electricity, gas, steam and air conditioning supply - 20 %,
3. mining industry and open pit mining - 16 %,
4. water supply, sewerage, waste management and recycling - 2 %.

Meanwhile, the share of tobacco products makes averagely 13 % in the individual structure of processing industry for 2016-2018.

The sector of cigarette and tobacco production (Decree of the RA Minister of Health Care, 2014) in the social and economic system of Armenia and its development peculiarities are depicted in Table 2, where the tax duties and revenues for the RA treasury and the share of each tobacco producing company in the state budget is introduced.

Table 2. The amount of taxes paid by the cigarette and tobacco manufacturing organizations in the RA and their share in the state budget, mln AMD (2016-2018)*

Name of organization	2016		2017		2018	
	mln. AMD	share	mln. AMD	share	mln. AMD	share
Masis Tobacco	486	0.04	487	0.04	282	0.02
International Masis Tabak	9435	0.9	11388	1.0	13133	1.0
Grand Tobacco	22571	2.1	34751	3.0	42222	3.2
SPS Cigaronne	813	0.1	1303	0.1	2199	0.2
Total	33305	3.14	47929	4.14	57836	4.42
RA state budget tax revenues and duties	1078294.1	100	1156425.0	100	1306231.0	100

*State Revenue Committe of the RA

Table 3. Tobacco plantations, gross yield and average yield capacity for 2014-2018*

RA regions/ marzes	Years	Plantations, ha	Harvested yield, centner	Average yield capacity per hectare, centner
Ararat	2014	124	4536	36.6
	2015	171	6761	39.5
	2016	95	2843	29.9
	2017	74	2968	40.1
	2018	129	3844	29.8
Armavir	2014	78	1814	23.3
	2015	43	1355	31.5
	2016	31	1067	34.4
	2017	39	678	17.4
	2018	35	750	21.4
Lori	2014	1	80	80.0
	2015	2	30	15.0
	2016	1	70	70.0
	2017	2	4	2
	2018	-	-	-
Vayots Dzor	2014	5	353	70.6
	2015	18	325	18.1
	2016	17	500	29.4
	2017	16	580	36.3
	2018	20	250	12.5
Tavush	2014	302	5745	19.0
	2015	332	6323	19.0
	2016	302	6509	21.6
	2017	282	5891	20.9
	2018	209	4296	20.6
Aragatsotn	2014	-	-	-
	2015	16	363	22.7
	2016	18	332	18.4
	2017	20	370	18.5
	2018	-	-	-
Kotayk	2014	-	-	-
	2015	-	-	-
	2016	-	-	-
	2017	27	376	13.9
	2018	-	-	-
RA, total	2014	510	12528	24.6
	2015	582	15157	26.0
	2016	464	11321	24.4
	2017	460	10867	23.6
	2018	393	9140	23.2

*Statistical bulletin, 2014-2018.

It is worth mentioning that all organizations engaged in the entrepreneurial activities of cigarette and tobacco production sector in the territory of Armenia are involved in the list of 1000 large taxpayers annually published by the State Revenue Committee of Armenia (petekamutner.am).

The cultivation of highly productive tobacco varieties adapted to the local conditions and producing high quality raw material is of utmost importance for the development of tobacco growing. In Armenia both common tobacco (Nicotiana rustica) and the Turkish yellow tobacco have been cultivated, which have been used mainly in local organizations as a raw material. The occupied territories for tobacco growing, their gross yield and average yield capacity both in the whole republic and in individual regions are of particular interest. In case of identifying these indicators we can have a clear picture about the role of cigarette and tobacco production in the social and economic system of Armenia.

The data of table 3 show that only several regions of Armenia are engaged in the tobacco growing. This is a serious problem in respect of raw material production.

The functionality of any industrial branch in the national economic system of each country, including Armenia, consists in the fact that, for example, the economic entities engaged in the entrepreneurship of cigarette and tobacco production in Armenia, purchase raw materials and supplementary accessories from the partner countries presented in table 4.

Table 4. Types and sources of raw materials needed for tobacco production*

Type of raw material	Source of raw material
Tobacco raw material	Armenia, Iran, Greece, Bulgaria, Brazil, Republic of South Africa, South America
Aromatic mixture for tobacco production	Germany
Tobacco paper	Austria, France, Italy, Indonesia
Acetate filter	Armenia (Grand Tobacco), England, Italy
Tobacco filter paper	Austria, France, Italy
Tear strip	Germany, Czech Republic
Folding box	Armenia, iran
Glue	Armenia, Iran
Aluminum foil	Greece, Armenia
Cardboard	RF, Turkey
Tobacco carton patterns	Turkey

*grandtabak.com

Results and discussions

It is clear from the data of table 1 that parallel to the growth of overall industrial production sizes in the RA, manufacturing of tobacco product types and its share in the whole industry also grows up. Every year the same growing rate is recorded also in individual processing industries. In 2010-2018 manufacturing rate of tobacco products increased in 11 times, while its weighted index in the whole industry of the RA amounted to 10.3 % instead of previously recorded 2 %.

According to the data published by the State Revenue Committee in 2016, 2017 and 2018 "Grand Tobacco" held the second position in the taxpayers' list, staying behind the company of "Gazprom Armenia" in 2016-2017 and the "Zangezur Copper Molybdenum Combine" in 2018. In the table 2 we can see the dominant share of tobacco producing organizations in the total weighted index of tax revenues and duties collected in the RA state budget. This circumstance is related not only to the production sizes of the given company and the income taxes paid from the salary of numerous employees but also to the current value-added tax and to high interest rates of excise tax (Parsyan, 2017).

Surely, tax receipt in the state budget is important but it is also a great problem for the organizations engaged in the mentioned sector. For example, in 2017 and 2018 the company of "SPS Cigaronne" LLC failed to make any investments for its production and economic activities due to high tax burden.

Besides, it is obvious that the greatest number of tobacco growing plantations is found in the Tavush region. On the average, 60 % of tobacco product is grown in Tavush. It should be mentioned that the yield capacity is not very high here. Thus, related to the peculiarities of climatic conditions, the region of Tavush provides continuously average yield capacity.

In 2017, 27 hectare tobacco was grown in Kotayk region for experiments but it was interrupted almost immediately after the start of the experiments because of high costs and low yield capacity. No other region is engaged in the tobacco growing except of those enlisted in the table. In 2018 tobacco growing activities were also interrupted in the regions of Aragatsotn and Lori. Throughout 2014-2018 the areas allocated for tobacco growing were reduced by 50 %. In Vayots Dzor the number of tobacco growing plantations and their productivity grew up to a certain extent in 2016-2017, but against the yield capacity recorded in 2014 it was only 51.4 %, while in 2018 it declined in about 3 times.

Summing up the data of table 3 and studying the tobacco growing plantations, gross yield and average yield capacity per regions for 2014-2018, we can state that in 2015 the tobacco growing plantations grew up by about 18 % comparing with the same index recorded in 2014, while starting from 2014-2016 they were reduced by 25 %. The yearly reduction of the plantations still goes on. In 2018, the tobacco growing plantations were reduced by 23 % against those recorded in 2014, nevertheless, the yield capacity stayed in the same level. The obtained indices serve as a warning alarm for the economic entities engaged in the mentioned sector, since only the skeletal (nuclear) raw material of cigarette is cultivated in the territory of Armenia.

It is possible that the monopsony market of the cigarette raw material has had its negative impact on the mentioned sector. For example, in 2000 the company of "Masis Tobacco" used to purchase 1 kg raw material with AMD equivalent to 1.2-2.5 US dollars. This raised interest among the raw material producers for increasing the production sizes. As a result, the market supply rate for cigarettes grew up and the buyer, taking advantage of his/her monopsonic position, reduced the prices down to 0.8-1.0 US dollar for one kg raw material.

Under such circumstances, there was no other way for the sellers than to comply with the situation. They had to sell own product with production prices, gradually reducing the plantation areas afterwards. Thus, the RA State Committee for the Protection of Economic Competition should take steps not allowing the processing organizations to set low monopsonic prices for raw material purchase (Khachikyan, 2010).

It is important to pay attention particularly to the land areas of Syunik region, RA and those of the Artsakh Republic, where tobacco growing was widely spread in the times of Soviet Union. In recent years certain measures have been taken in Artsakh to develop the tobacco growing branch, which was previously a rather leading sector of its industry. Anyhow, there aren't any precise statistic data for recent times. The number of tobacco growing plantations are continuously changing there. Besides, together with tobacco growing a number of serious and important issues related to its storage and preservation terms appear. A need for additional investments appears, which should be in the focus centre of government and private sectors.

Among the serious problems for cigarette and tobacco production, those related to the purchase of high-quality seeds, lack of special driers, irrigation problems and issues of plant protection from insects have been identified.

Conclusion

Almost all regions of the RA were engaged in tobacco growing in 1980. Both aromatic and skeletal tobacco varieties were cultivated then and about 17000 tons of raw material was produced, but today the situation is quite different: in 2014 its production amount made 12 528 c, in 2015 it made 15 157 c, while in 2018 it fell down to 9140 c.

In the national economic system of the RA, the organizations engaged in the entrepreneurial activities of the cigarette and tobacco production are carrying out intensive production and economic activities, they factually meet the internal market demand and have already great success abroad. Investigating the development dynamics of cigarette and tobacco production in Armenia the significance of the mentioned industrial branch becomes obvious. Cigarette is the most exported finished product in Armenia, which has a great share in the total range of exported products. The exportation size is also sustainably growing up. About 85 % of cigarette and tobacco products are manufactured for exportation.

The organizations engaged in this sector usually face the problem related to raw material and accessory material provision. Some accessories necessary for the cigarette production are produced by local organizations so as to be independent of foreign market. Anyhow, they purchase raw material and other necessary materials mainly from abroad irrespective of the fact that the tobacco varieties of "Virginia", "Burley" and "Samson", which are high quality raw materials for cigarette production, are cultivated also in Armenia.

The delay or interruption of raw material supply, fluctuations of raw material prices, run out of the raw material reserves after a while, seasonal road obstructions and geographical blockade very often cause temporary termination in tobacco production. This is a very actual and concerning problem in terms of further development of the cigarette and tobacco production sector.

The solution of the problem related to organizations' provision with local raw material can be found in attempts to stimulate the farmers and rural farm households to practice tobacco growing. Anyhow, the monopsonic price policy in the raw material market retards this process. In this circumstance the RA State Committee for the Protection of Economic Competition should take steps not to allow the processing organizations to set low monopsonic prices for raw material purchase.

The organizations of the given sector also have serious problems in terms of social awareness, which is related to the bans on cigarette and tobacco advertising (RA decree on "Advertising", 2014). The organizations are unable to introduce their own product to the consumer. Particularly, providing information on the new product varieties has become a great problem. The organizations in majority cases use indirect advertising methods, i.e. charity events, participation in national and international exhibitions, etc.

The cigarette and tobacco producing organizations in the RA also have problems related to state regulation events. It is necessary to propose systemized and ad hoc solutions for the state regulations of the entire economy and individual sectors of the enterprises. For instance, the taxing mechanisms effectively operating in one branch shouldn't be applied for the whole economy. Moreover, each country has weaknesses and strengths peculiar to its own economy, thus, Armenia has a rather rich land and labor resources for the cigarette and tobacco production and the role of the state is to regulate (support) the poorly developed sectors of the relevant enterprises through direct and indirect leverages and enable the developing and developed enterprises to efficiently operate in the local market and not only to satisfy the demands of internal consumers but also succeed in the foreign market.

The cigarette and tobacco producing organizations of the RA have a serious problem related to staff recruitment as well. Lack of skilled and professional specialists results in periodic vacancies and thus, in the need to recruit new staff, which implies extra costs for their education and trainings.

So, despite the fact that cigarette and tobacco are considered to be products posing public hazard, Armenia has the needed assets for the development of the mentioned production sector. The current organizations of Armenia work with profits and as of 2018 they provide 10.3 % of the whole industrial product and 4.4 % tax returns to the state budget. Thus, Armenia has land and labor resources, as well as real and potential reserves for the development of tobacco production.

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Veterinary Pharmaceutical Business in Armenia: Related Problems and Solutions

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ABSTRACT

Veterinary pharmaceutical business is an important and integral part of not only the pharmaceutical business in the Republic of Armenia, but also the intrinsic part of its agricultural sector. However, this area has not been studied properly and is not developed enough in our country. This scientific article highlights the problems and obstacles retarding the development of the veterinary pharmaceutical business in Armenia and suggests solutions that will ultimately boost the veterinary pharmaceutical business to a decent level.

Introduction

One of the leading directions in the economic development of the Republic of Armenia is agriculture. Meat and animal products produced in the country are highly valued not only in Armenia, but also in a number of countries having close trading with Armenia. Along with a large share of livestock, the culture of breeding pets is developing dynamically in the cities of Armenia. However, this cannot develop and stay sustainable without proper care for animals. Veterinary medicines play significant role in the welfare of animals and, therefore, in the well-being of the agricultural community as a whole. Along with the animal welfare, the veterinary industry and veterinary pharmaceuticals play a major role in the pricing processes of meat and animal products, as well as for the health and well-being of the final consumer of these products.

Currently, there are a number of problems in the veterinary pharmaceutical business in the Republic of Armenia, related to the legal branch, formation of prices and taxes on veterinary pharmaceuticals, quality control, as well as the illegal importation and distribution of drugs.

The goal of the current article is to identify and analyze the aforementioned problems and to recommend possible pathways for their solutions.

Literature review

Global economic health and social well-being depends a lot on both humans and animals. The animal health industry globally, especially in the developing world, is on the cusp of change. Given that 70 % of all diseases suffered by humans are caused by animals (zoonotic), this has resulted in the world paying much more attention to the veterinary pharmaceutical industry (https://www.animalhealthmedia.com).

The global animal healthcare industry showed dynamic growth in the period from 2006 to 2011 and registered a

compound annual growth rate (CAGR) of 6 % (Global Animal Health Care Market Outlook to 2016). The market growth trend continues to this day, and in 2018 the market amounted to $ 33.5 billion (https://www.statista.com).

Animal health products, including pharmaceuticals and vaccines, contribute significantly to the health and well-being of both food-producing and companion animals. The animal health industry is committed to contribute to the prevention and treatment of animal diseases and, hence, to the support of animal welfare, food safety and the protection of the environment (International Federation for Animal Health-Europe).

Growing awareness about safe and healthy animal proteins and milk is pushing drug manufacturers to comply with increasingly stringent quality standards. The world today has woken up to the fact that equal attention needs to be paid towards higher quality standards in the veterinary industry, similar to those that have been seen in the human pharmaceutical industry. This has led to regulatory changes both in the developed and emerging worlds (https://www.animalhealthmedia.com).

Unfortunately, there is lack of scientific research specialized in the field of veterinary pharmaceutical business.

Materials and methods

Study Design and Participants

A snapshot qualitative study was conducted using in-depth interviews to assess understanding and analysis of the current situation and existing problems in the veterinarian pharmaceutical business in the Republic of Armenia.

Participants were experts from the importing and wholesale field of the veterinary drugs, the Food Safety Inspection Body of the RA and from veterinary clinics.

Sampling and Participant Recruitment

The study participants were recruited using a purposive and convenience sampling technique. The sampling was purposive in terms of identifying the important characteristics of study participants corresponding to the research question in advance, such as age, gender, occupation, workplace, and clinical experience.

Data Collection

The data collection for the study was held in May, 2020. Six interviews were conducted. The interviews were carried out in a separate room and non-participants were not present during the interview process.

Data Analysis

The data were analyzed through qualitative analysis, using experts' opinions and thoughts. During data analysis, the codes were developed through an inductive approach using themes.

Due to time constraints and resource limitations, the research team was unable to assess the saturation (code and meaning) of the data. Hence, the results of the study are only thematic and descriptive.

Results and discussions

The Main Problems of Veterinarian Pharmacy Business in the Republic of Armenia

The main problem noted by our experts is the lack of licensing for the activities in the retail, wholesale and import sectors of veterinary medicines.

"Anyone can open a veterinary pharmacy, moreover, any person can import veterinary medicines and be engaged in wholesale activities without necessarily being a professional in this field or having specialized education."

Lack of licensing raises a lot of problems related to the professionalism of veterinary pharmacy workers, the proper working conditions of the employees and the proper conditions for storing medicines in a veterinarian pharmacy. The licensing requirements of community pharmacies are set up regarding personnel and premises, as well as numerous other requirements related to a specific type of a pharmacy activity (The RA Law on "Licensing").

"When anyone has the right to import medicines and is engaged in the import unprofessionally, this leads to a chaos in the market."

In the case of importing and the wholesale, the lack of licensing brings to the saturation of the market with low quality goods because of their affordability and low prices.

Another major problem in this field is that there are no mandatory quality standards for veterinary drugs, whereas in the case of medicines intended for human use, there are binding standards for quality. Moreover, any person who carries out pharmaceutical activities in the territory of the Republic of Armenia is obliged to fulfill every point of quality standard unlike those involved in veterinary activities. Also, regular inspections are carried out by state bodies for the quality control of pharmaceutical products, while there is no control over veterinary medicines.

"There are no obligatory quality standards responsible for the proper storage, transportation and distribution of medicines. Even cold chain drugs do not apply such standards."

This means that medicines can be stored under conditions in which they can deteriorate and lose their quality, which affects not only the health of an animal but also causes enormous financial burden to the breeder of the animal. Moreover, this product may have a negative impact on the health and well-being of the human who consumed it if the meat or other animal product was obtained from the animal that received this medicine.

Another significant problem in the veterinary pharmaceutical business in the Republic of Armenia noted by our experts is the complex and expensive registration process of medicines. According to the RA Law on "Drugs", registration of a new medicinal product requires payment for the expert evaluation, as well as tax payment and up to 150 calendar- day of waiting. Validity of registration is 5 years (The RA Law on "Drugs").

The cost for the first registration of the veterinary use medicines is 625 000 Armenian drams. For the next times the cost reduces to 500 000 AMD. Since Armenia is a member state of the Eurasian Economic Union (EAEU), it has certain obligations to the mentioned organization. And in order to register medicines in Armenia, medicines must be registered in the EAEU. If the medicine is not registered in the EAEU, then the first registration will cost 900 000 AMD (http://pharm.am).

High prices and long waiting times for registration lead to the fact that a small number of new veterinary drugs are registered in Armenia, which leads to a limited choice of medicine in the market and higher prices for new registered drugs. For a person or company engaged in the veterinary business, registration of a new medicine is not economically viable.

"Unfortunately, not all the positive aspects of the pharmaceutical business are applied in the veterinary sphere; however, the registration of drugs occurs on the same basis as drugs for human use. But the market and the demand of the veterinarian drugs is much less as compared to the human use drugs market and demand."

The next problem is directly related to the registration problem and pricing in the Republic of Armenia. Since in the neighboring countries of Armenia registration and taxation of veterinary medicines is much cheaper than in Armenia there is a problem of illegal importation and distribution of medicines in the territory of Armenia from neighboring countries.

"People transport medicines from neighboring countries and sell them in Armenia at low prices."

Such drug circulation as well as the quality of illegal drugs and ability to satisfy the given criteria of the drugs is difficult to control. It is necessary to note that we have the same problem in the pharmaceutical industry of human drugs.

The next problem is indirect but it is highly affecting the market and health of animal and the consumer of the meat and animal products. This problem is in a small number of specialized laboratories that work with animals.

"People often turn to human laboratories for animal tests. This leads to the fact that laboratories prescribe a drug with the active substance for a person, and such a medicine can be purchased in a common human pharmacy."

This phenomenon strikes the most important problem in the face of humanity in the medical field - Antibiotic Resistance.

The next major problem of the veterinarian pharmacy business in the Republic of Armenia is that there is no price regulation by the state. That causes the risks of monopoly and underbidding.

Possible Solutions

The proposed solutions were formulated by analyzing the information obtained during interviews with experts in the field of the veterinary pharmaceutical business, as well as by analyzing the current pharmaceutical business of the Republic of Armenia and several other countries.

The first step in optimizing and improving the veterinary pharmaceutical business in the Republic of Armenia should be the adoption of a law on compulsory licensing of companies engaged in veterinary pharmaceutical activities. Licensing requirements should be strict in order to limit the circle of people and companies involved in the veterinary pharmaceutical business, and leave only the most professional and trained ones to achieve the highest quality services in this area.

It is necessary to develop or adopt quality standards for veterinary pharmaceutical products and carry out state inspections according to these standards. It will ensure the safety and well-being of not only the animals but also the final consumers of the animal products.

It is recommended to make the registration process of the veterinary use drugs less complex and less expensive if the drug is registered in PIC/S (Pharmaceutical Inspection Co-operation Scheme - https://www.picscheme.org/) member countries or other international control bodies

such as FDA (US Food and Drug Administration - https://www.fda.gov/home). It will save a great amount of time and finance, moreover, it will motivate companies and individuals engaged in veterinary pharmaceutical business to import and register new medicines, which will lead to the increase in the choice of the drugs and obviously will decrease the prices.

Making registration process less expensive is the first step in the struggle against illegal import of the veterinary drugs from the neighboring countries. However it will not be enough to stop the stream of illegal drugs because the main stream comes from Georgia, where there is no VAT for medicines (GEPHA - GHG's pharmacy and distribution business https://taxsummaries.pwc.com/), so the drugs sold in Georgia will be 18 % cheaper compared to Armenia. To make the market of the Republic of Armenia competitive in the region it might be efficient to deduct the VAT for the medicines.

Conclusion

These are only a few but the most urgent possible solutions to the existing problems in the veterinary pharmaceutical business in the RA, which will strengthen and enlarge the whole business sphere:

- Adoption of a law on compulsory licensing of companies engaged in veterinary pharmaceutical activities.
- Implementation of the quality standards as well as conducting regular inspections by the state body.
- Making registration process easier and less expensive.
- Deduction of the VAT for the medicines.

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Distribution of Wood Mice Species (Muridae: Apodemus) in the Republic of Armenia

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ABSTRACT

West-Palaearctic wood mice species of the genus *Apodemus sensu lato* is widespread in Armenia. The current work considers the areal distribution of the wood mice species throughout all regions of the country. These rodents are actively involved in the circulation of zooanthroposes and can be pests for agricultural crops and forest plants. The results are validated upon the applied methods of genetic analyses.

Introduction

Wood mice of the genus *Apodemus* Kaup, 1829, have been the subject of many systematic and evolutionary studies in the last few decades (Mezhzherin, Zagorodnyuk, 1989, Filippucci, et al., 2002, Vorontsov, et al., 1992). Despite these numerous works, the taxonomic status, particularly, the biogeography of the genus *Apodemus sensu lato*, is not specified in Transcaucasia yet, especially, in the territory of the Republic of Armenia. The available information on the taxonomy and area of distribution of wood mice species in Armenia is rather fragmentary and scarce (Frynta, et al., 2001). So far, five existing species of the genus *Apodemus* have been reported from the territories adjacent to Armenia (Macholan, et al., 2001, Suzuki, et al., 2008, Bellinvia, et al., 2004, Vorontsov, et al., 1992): *A. uralensis* (*Pallas, 1811*), *A. witherbyi (Thomas, 1902)*, *A. flavicollis, A. hyrcanicus* (Vorontsov, et al., 1992) and *A. ponticus* (Mohammadi, et al., 2014). In this study, three species of wood mice inhabiting in the territory of the republic were clearly described and identified: *A. uralensis* (*Pallas, 1811*), *A. witherbyi* (*Thomas, 1902*) and *A. ponticus (Sviridenko, 1936)*, out of the previously declared 5 species, including: *A. sylvaticus (Linnaeus, 1758)* and *A. flavicollis (Melchior, 1834)* (Hayrapetyan, et al., 2014, Balasanyan, et al., 2018).

This article provides an overview of the distribution and species diversity of wood mice in all areas of the republic. The aim of the study is to collect and summarize the existing and newly collected data on the distribution of West Palaearctic wood mice species of the genus *Apodemus*.

Materials and methods

The subject of the study is to identify the distribution and frequency of occurrence of *Apodemus* species. Field

work was carried out during the expeditions conducted in the territory of selected monitoring stations including all regions of Armenia. During the field activities, data on the distribution and frequency of occurrence of animals were documented, the necessary information was obtained, and material was collected for further morphometric and genetic analyses. Data collection and analysis includes the relevant steps described in the standard fieldwork protocol (Heyer, et al., 2003).

To determine the species diversity and the number of wood mice, some trap models — live traps and crushers — were used. As bait, crusts of bread dipped in sunflower oil and cereal seeds were used. Traps were placed using the following method: *trap line method.* It is a fairly universal method widely used in various biotopes (Schnitnikov, 1929, Kalabukhov, Raevsky, 1933). Standard bait was used and traps were placed in lines. In our case, 20-40 traps were placed in a line. Each trap was filled with bait and placed in the area of the investigated biotope. The traps were placed in the evening at a distance of 5 meters from each other along the line. Trap sites were selected in accordance with the most probable places for animal trapping. Traps were checked several times during the night. Usually, this method was used for 2-3 days for each biotope under study.

The species of the captured samples was initially identified by the exterior indicators as the primary morphological analysis. Then, the identification of the species was carried out in laboratory using the method of sequencing the mtDNA gene.

The DNA was isolated from finger and tail tips preserved in absolute ethanol at -20 ^{0}C. The DNA was extracted using a DNeasy Blood and Tissue kit (Qiagen) following the manufacturer's protocol. PCR and direct sequencing of the cytochrome oxidase subunit 1 (COI) gene fragment was conducted using a BigDye Terminator Cycle Sequencing Kit v. 3.1 on an automated ABI 3500xL Genetic analyzer at the Laboratory of Molecular and Biometric Techniques, Museum and Institute of Zoology, PAS in Warsaw.

Results and discussions

As a result of research work throughout all regions of Armenia, the estimated data on the species diversity of representatives of the West Palaearctic wood mice belonging to genus *Apodemus* were obtained (Figure). Morphological and genetic studies have proved the occurrence of the mentioned species in certain regions of the republic.

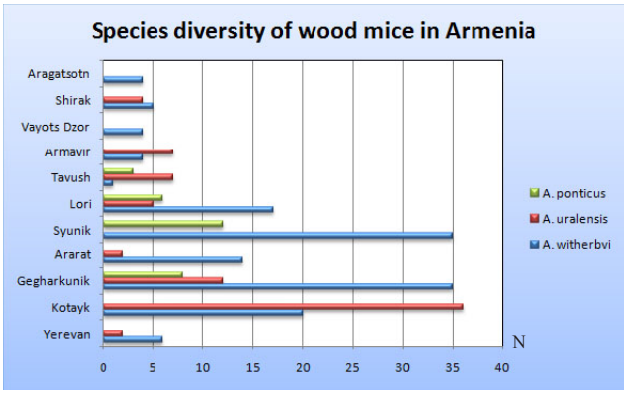


Figure. Species diversity of wood mice in Armenia (*composed by the author*).

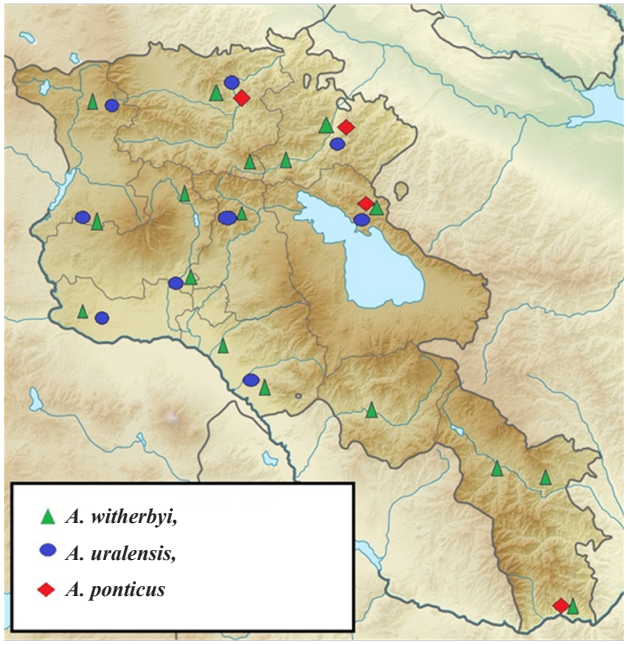
The Caucasian wood mouse *Apodemus ponticus (Sviridenko, 1936)* is the least widespread species in the fauna of Armenia. It is represented in four regions by relatively few populations. It is important to emphasize the "bipolar" distribution of representatives of this species in the territory of the Republic of Armenia, as in the course of our full-scale studies, samples were exclusively collected from the monitoring station of southern Meghri (Syunik) and from the northern regions (Lori, Tavush, Gegharkunik). This fragmented and maximally remote distribution area can be grounded by the history of penetration of this species into the territory of the Republic of Armenia. According to Bukhnikashvili and Kandaurov (2002), the Caucasian wood mouse is a fairly widespread species in Georgia with an exact distribution area to the south of the country bordering Armenia (Bukhnikashvili, Kandaurov, 2002). Mohammadi (2014) first mentioned in his work about the detection of *A. ponticus* in the territory of northwestern Iran (Mohammadi, et al., 2014).

The steppe wood mouse *Apodemus witherbyi (Thomas, 1902)* is ubiquitous in all regions of the Republic of Armenia - from south to north. The largest number of representatives of this species was caught from the territories having long-term monitoring stations in four regions of the republic. However, steppe mouse samplings and observations were conducted in other areas as well, where both periodic capture points and single capture points of animals were set up. Such a wide distribution of representatives of the mentioned species *A. witherbyi* can be explained by their preferences for various biotopes. They inhabit not only the steppes, but are also well adapted to the habitat in mature forest belts and in mountain steppes.

The Ural pygmy wood mouse *Apodemus uralensis (Pallas, 1811)* is found almost everywhere in Armenia - from the dry subtropical zones, semi-deserts and mountain steppes to the forest zones; it can penetrate even to the mountainous meadows and is found at the heights of 600-3200 m above the sea level. It lives in deciduous and mixed forests and has a preference for shrubbery. Their presence was also observed in treeless areas in conditions of steppe and mountain-steppe landscapes.

The results of our long-term observations showed that representatives of the species of Ural pygmy wood mouse inhabit mainly the central and northern regions of the Republic of Armenia (Kotayk, Gegharkunik, Lori, Tavush, Shirak), it is also found in Yerevan (strong evidence of syntropism). However, according to our study results it completely lacks in the southern regions of the republic (Vayots Dzor and Syunik).

Thus, it should be noted that the distribution of the wood mice genus *Apodemus* in the Republic of Armenia is almost ubiquitous (Picture). It is worth mentioning that unfortunately, many employees of sanitary-epidemiological services do not differentiate many rodents and cite them as super species.



Picture. Distribution of three *Apodemus* species in Armenia: *A. witherbyi, A. uralensis, A. ponticus*.

Conclusion

The data obtained enable to assess the quantitative distribution of representatives of the discussed genus in line with the biotopic allocation peculiar to each biotope species. So, Figure shows that almost half of the total number of the wood mice is concentrated in the central part of the republic, besides, they are almost equally spread in two regions of the republic: in the south part (Syunik) and in the north part (Lori). Most likely, such a quantitative prevalence of forest mouse species can be accounted for their main ecological indicators and biotope choice. The identification of the species in the abovementioned areas depends on the landscape and climatic conditions of the terrain. For example, it is well known that the pygmy wood mouse *Apodemus uralensis* prefers woodlands (Kotayk, Gegharkunik, Lori), forming an adjacent sympatric population with representatives of the steppe mouse *Apodemus witherbyi*, which are widespread not only in the woodlands but also in the territories with distinct steppe, mountain-steppe and mountain landscapes (Syunik, Vayots Dzor, Ararat).

Summarizing the results of our work, we can assume that *A. ponticus* is a sympatric species for the steppe field mouse *A.witherbyi* mainly spread in the steppe and rocky terrains, and *A.uralensis* lives in woodlands and can form an adjacent sympatric population with the steppe field mice. Also, the resulted distribution pattern of *Apodemus* species may testify on the existence of some parapatria in the populations.

Thus, apart from the relevance of monitoring and controlling the dynamics of number and distribution areas of the forest mice in the fauna of Armenia, these findings are also vital for identifying and preventing zoonotic diseases.

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The Effect of Organo-Mineral Fertilizers, Zeolite and Different Soil Tillage Methods on the Growth, Development and Yield Capacity of Winter Wheat in Conditions of Hrazdan Province

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ABSTRACT

Investigations carried out in 2017-2019 under dry agricultural conditions at the Hrazdan province of the Kotayk region have disclosed that out of the two tested soil cultivation variants (deep ploughing, single disk harrowing), soil loosening with the single disk harrowing is the most efficient variant for the winter wheat cultivated in the black soils, while out of the applied technologies (organo-mineral fertilizers and zeolite), that of the zeolite, manure and N_{30} applied on the background of $P_{90}K_{90}$ is the best variant. When applying this variant the soil agro-meliorative properties improve and 55.0 c/ha grain yield is harvested. Thus the mentioned variant is recommended for the introduction in the agricultural production.

Introduction

Winter wheat is rather sensitive towards the environmental conditions (humidity, air, nutritional elements, etc.). Unlike the other cereal crops, plants of the winter wheat usually have poorly developed root system in their early growing stage, meanwhile the intensive nutrition period of the plants is rather short (about 2 months). Thus, in order to get high and sustainable yield it is necessary to provide them with favorable air-water and nutritive environment from the very start of their growth and development.

The excess or shortage of any ecological phenomenon in the soil somehow retards the bio-chemical processes taking place in the plant parts, which has definitely an adverse effect on the plant growth, development, structural elements of yield, as well as on its quantity and quality (Galstyan, 2007, Galstyan, et al., 2018, Minyeev, 1980).

Multiple researchers both in our country and abroad (Galstyan, 2006, Gargus, et al., 1970) have proved that the mineral nutrients and environmental conditions have specific effects on the structural elements of the winter wheat yield. The authors mention, that by providing the plants with phosphorus and potassium from the very start of their growth the root formation intensity is improved, regular sprouting capacity and sugar content increase is promoted, which in its turn ensures high winter-resistance of the plants. Therefore, any study aimed at the creation of the medium needed for the development of the winter

wheat and at the provision of nutrients, is urgent and stems from the requirements of providing the population with safe agri-food system, which is stated by the agricultural development strategy of Armenia.

Materials and methods

The studies were carried out throughout 2016-2019, in conditions of Alapars community of the Hrazdan province in Kotayk region. In all mentioned research years the field experiments were carried out in common lime-free (delimed) black soils, which are characteristic to Hrazdan province. Winter cereal crops (mainly winter wheat) are cultivated in such soil types, where the humus content in the arable layers makes 5.8 %, the environmental reaction is close to neutral (PH 6.9-7.1), the content of easily hydrolyzed nitrogen makes 4.39 mg, that of the phosphorus-6.5 mg, while the exchangeable potassium makes 38 mg in 100 g soil. The soils of the experimental plot are averagely provided with humus, poorly provided with nitrogen, while they are rich in phosphorus and potassium (Melkonyan, et al., 2004).

The aim of the research is to study the effect of organo-mineral fertilizers, zeolite and different ways of soil cultivation on the growth, development and yield capacity of the cultivated winter wheat variety "Bezostaya-1" for the first time in the region and to identify the best variant for fertilization, soil tillage and the resulted yield in order to introduce it to the agricultural production.

The field experiments were set up with three repetitions; each experimental bed was 100 m^2. The following experimental variants were used for our investigations: 1. control (without fertilization), 2. $P_{90}K_{90}$-background, 3. background + manure 15 t/ha, 4. background + manure 15 t/ha + zeolite 2 t/ha, 5. background + manure 10 t/ha + N_{30} + zeolite 2 t/ha, 6. $P_{60}K_{60}$ + N_{90} + zeolite 2 t/ha.

The mentioned fertilization variants were applied upon different soil tillage methods, i.e. deep plowing (22 cm-26 cm) and single loosening (disk harrowing 10 cm-12 cm).

Winter wheat sowing, its further cultivation and harvesting activities were implemented in consistent with the agricultural rules accepted in the region.

Phosphoric and potash fertilizers, as well as the full doses of manure and zeolite were introduced in autumn during various ways of soil tillage, while in the 5th and 6th variant the nitrogenous fertilizer was introduced in spring through nutritive form. The soil agro-chemical and agro-physical indicators have been determined through universal methods introduced in the methodical manual on agri-chemistry analyses published under the editorship of B.A. Yagodin (Vadyunina&Korchagina, 1986, Yagodin, et al., 1989). The amount of winter wheat yield has been determined through the comprehensive yield calculation method during the harvesting period. The data on crop productivity have been subjected to mathematical analyses upon the identification of the experimental error (E_X, %) and the least significant difference ($LSD_{0.95}$ g) through the method of dispersion analysis (Dospekhov, 1973).

Results and discussions

The studies have disclosed that phosphoric and potash fertilizers and the doses of the manure with combination of zeolite and nitrogenous fertilizer applied on the background of the abovementioned fertilizers, as well as mineral fertilizers used in the region have demonstrated certain effect on the growth, development and structural elements of the winter wheat yield and its quantity.

According to the three-year average data (Table 1) when using manure with the dose of 15 t/ha on the background of phosphoric and potash fertilizers, the plants height amounts to 104.5 cm in case of common ploughing, while in case of disk harrowing it makes 109 cm; the number of spiciferous stems and ear length are 360 n and 5.7 cm; 390 n and 6.2 cm respectively in case of common plowing and disk harrowing (per one meter square). At the same time, the table data show that when adding zeolite with 2.0 t/ha dose and then N_{30} kg/ha to the 15 t/ha manure on the background of PK, the plants grow up more intensively than those in the former variant; they become of darker green color with higher plants (5-8 cm) both in case of common ploughing and disk harrowing, the number of spiciferous stems per a meter square grows up by 26 n-60 n and the length of an ear/spike increases by 0.9 cm-1.6 cm against the same indicators observed in the control variant.

This circumstance is accounted for the fact that soil zeolite creates more favorable air-water conditions for the regular growth and development of the plants, while the availability of the nitrogen in the soil apparently promotes the development of the plants vegetative mass.

The mechanical analysis of the sample batches have revealed that the application of manure, manure and zeolite, as well as manure, zeolite and nitrogenous fertilizers on the background of phosphorous and potash fertilizers has had particular effect on the structural elements of the winter wheat yield. In all years of field experiments the application of the mentioned fertilizers, as well as individual and combined application of zeolite increased the grain weight in an ear of winter wheat and the weight of 1000 grains in general.

Table 1. The effect of organo-mineral fertilizers, zeolite and different soil tillage methods on the growth, development and structural elements of winter wheat yield (average for 2017-2019)*

n/n	Variants	Soil tillage methods	Spiciferous stems		Spike/Ear length, cm	Average weight of grains in an ear	Weight of 1000 grains, g	Average grain yield, c/ha	Average straw yield, c/ha
			number n/m²	height cm					
1.	Control (without fertilization)	common	340	93.5	4.9	0.40	38.0	20.1	36.2
		disking	346	96.5	5.2	0.45	38.8	22.4	39.0
2.	$P_{90}K_{90}$-background	common	351	98.0	5.3	0.50	39.8	26.0	39.3
		disking	359	99.5	5.6	0.53	41.0	28.5	46.4
3.	Background+ manure 15t/ha	common	360	104.5	5.7	0.58	45.0	47.2	65.8
		disking	390	109.0	6.2	0.63	46.0	49.4	70.5
4.	Background+manure 15t/ha+zeolite 2t/ha	common	386	109.5	6.5	0.68	47.2	48.9	71.0
		disking	423	112.0	7.0	0.69	47.6	51.6	79.6
5.	Background + manure 10t/ha+ N_{30}+ zeolite 2 t/ha	common	386	115.0	6.9	0.70	47.9	51.7	79.0
		disking	450	118.5	8.1	0.71	50.0	54.8	89.0
6.	Background + N_{90}	common	422	107.5	7.6	0.68	47.6	48.6	73.6
		disking	428	112.0	7.8	0.69	48.4	50.8	75.0

*Composed by the authors.

For example, if in the control variant (without fertilization) upon the common ploughing the weight of the grains per an ear has made 0.40 g, the weight of 1000 grains - 38.0 g and all in all 20.1 c grain yield, 36.2 c straw yield per hectare has been received, and in the background variant the mentioned indicators have made 0.50 g, 39.8 g, 26.0 c grain and 39.3 c straw yield respectively, then by applying 15 t/ha manure on the same background the weight of grains in an ear has exceeded that of the background by 0.8 g amounting to 0.58 g, the weight of 1000 grains to 45 g and as a result the grain yield has made 47.2 c and the straw yield - 65.8 c.

The increase in the mentioned indices is more obvious when the manure used on the background was supplemented in one case with 2.0 t/ha zeolite and in another case with nitrogenous fertilizer (per N_{30} active agent) combined with the same dose of zeolite. Against the variant of background + 15 t/ha manure, in the mentioned variants the grain weight in an ear has increased by 16.6 % and 21.1 % respectively, the mass of 1000 grains - by 4.85 % -6.4 %, the grain yield has increased by 34.9 %-54.0 % and the straw yield - by 16.7 %-51.2 %.

It is noteworthy, that though the application of organic fertilizer together with nitrogenous one on the background of phosphorous and potash fertilizers has had a positive effect in different soil tillage conditions (common ploughing and disk harrowing), it influences differently the winter wheat growth, development, its yield structural elements and yield capacity everywhere. The mentioned ameliorants have always provided higher results in case of disk harrowing than those provided in case of common ploughing. Thus, in the background variant, if in case of common ploughing the wheat yield has made 26.0 c/ha, in case of disk harrowing it has made 28.5 c/ha. Almost the same regularity for yield production discrepancy has been recorded in the other fertilization variants as well; everywhere disk harrowing soil tillage method with the same fertilization technology has provided higher yield than only the method of common ploughing. So, if by applying 15 t/ha manure on the PK background in conditions of common ploughing 47.2 c/ha grain yield and 65.8 c/ha straw yield has been harvested, then the same fertilization technology in conditions of single disk harrowing has provided 49.4 c wheat grain yield and 70.5 c straw yield

per hectare. Similar regularities in yield capacity increase have been observed also in the other fertilization variants, i.e. different technologies used with equal doses under the conditions of disk harrowing have provided higher grain yield for winter wheat by 2.5-3.1 centners and straw yield - by 71 %-100 % as compared to the same indices provided under the conditions of traditional (common) ploughing (Table 2).

Such a discrepancy caused by different soil tillage methods is accounted for the fact that the soil compaction resulted from the ongoing soil tillage process by means of heavy equipment causes decrease in the water permeability and in such soils the plant roots are unevenly settled into the soil profile or don't get extended deeper at all, therefore, in case of traditional/common ploughing unfavorable conditions are created for the plants root system and the plants of winter wheat demonstrate lower growth and development as compared to those recorded in case of disk harrowing tillage; as a result they provide lower grain and straw yield amount. According to the results of the researches conducted by different researchers the roots of winter wheat plants hardly penetrate through the monolithic black soil layers in case of compaction with 1.42 g/cm^3 bulk density, while in case of compaction with 1.50 g/cm^3 bulk density they fail to penetrate at all (Hayrapetyan&Shirinyan, 2003).

The authors have disclosed that when the soil compaction increases by 0.1 g/cm^3 the overall crop yield decreases by 6 %-8 %, the cereal crops yield - by 2 c/ha -10 c/ha, that of the potato - by 15 c/ha -25 c/ha, etc.

During our investigations (in the control variant) in case of common ploughing the soil compaction rate was 1.43 g/cm^3 and in case of only disk harrowing it was 1.39 g/cm^3 due to which, according to the three-year average data, in case of traditional ploughing the winter wheat plants (control variant) have provided 11.4 % lower grain yield than in case of disk harrowing tillage. The same regularity holds true for all variants of fertilization technologies: in case of applying single disk harrowing tillage method the yield surplus of winter wheat grain has made 2.5 c/ha-3.1 c/ha, and that of the straw yied - 7.1 c/ha-10.0 c/ha against the same indicators identified in case of traditional or common ploughing.

Table 2. The effect of organo-mineral fertilizers, zeolite and different soil tillage methods on the winter wheat yield per years*

n/n	Variants	Soil tillage method	Grain yield per years, c/ha			Average grain yield, c/ha	Surplus	
			2017	2018	2019		c/ha	%
1	Control (without fertilization)	common	19.6	21.4	19.3	20.1	-	-
		disking	23.2	22.4	21.6	22.4	2.3	11.4
2	$P_{90}K_{90}$-background	common	25.0	27.0	26.0	26.0	4.9	23.2
		disking	27.5	28.5	29.5	28.5	6.1	27.2
3	Background + manure 15 t/ha	common	47.4	46.9	47.3	47.2	123.7	65.8
		disking	48.9	49.9	49.2	49.4	120.5	70.5
4	Background + manure15t/ha + zeolite 2 t/ha	common	50.2	48.5	49.1	48.9	131.8	71.0
		disking	52.6	50.6	51.6	51.6	130.4	79.6
5	Background + manure 10 t/ha+ zeolite 2t/ha + N_{30}	common	52.0	51.3	51.8	51.7	145.0	79.0
		disking	54.2	54.6	55.6	54.8	143.3	89.0
6	Background + N_{90}	common	47.9	48.6	49.3	48.6	27.5	130.3
		disking	50.8	50.2	51.4	50.8	28.4	126.8
	E_X, %		0.7	1.1	0.9			
	$LSD_{0.95}$, g		1.2	1.5	1.4			

*Composed by the authors.

Conclusion

Being a natural and pure mineral raw material, zeolite absorbs the excessive moisture from the soil in dry agricultural conditions and retains it for a while due to its absorption capacity, and during the vegetation period it transfers the retained moisture to the soil environment, hence, creating favorable conditions for the plants regular growth and development and promoting considerable increase in the crops yield capacity.

In order to provide high and sustainable winter wheat yield cultivated in dry agricultural conditions on the black soils of the Hrazdan province at the Kotayk region it is recommended to reclaim the soil through the single loosening method (down to 10-12 cm depth), which in contrast to deep or common ploughing (22 cm-26 cm), creates more favorable conditions for the improvement of agro-meliorative properties in the soil and for the increase of soil fertility.

When organizing fertilization activities for the winter wheat, during the application of disk harrowing method it is necessary to introduce zeolite (2 t/ha) in the soil together with phosphoric and potash fertilizers in autumn ($P_{90}K_{90}$), while in spring it should be treated with nitrogenous fertilizer (N_{30}) in nutritional form. As a result 55.0 c/ha grain yield is produced. Thus, this methodology is recommended for the introduction in the agricultural production.

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The Effect of Seeding Rate on the Growth, Development and Yield Capacity of Lentil Cultivated in Vardenis Province of the Gegharkunik Region

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ABSTRACT

The current studies are related to the efficiency of the seeding rate variants determined for the fine seed lentil variety "Armyanskaya 88". The experiments were carried out in 2017-2018, in conditions of Tsovak community of the Gegharkunik region.

In the dry soils of Vardenis province in the Gegharkunik region, the lentil plant ripens in 88-92 days (the first ten days of August) and can be proper precursor for the winter wheat. Based on the mathematical processing data of the seed yield capacity and the received profit it is recommended to sow the small-seeded lentil with the rate of 2.7 mln viable-seed/ha in the land areas of Vardenis province in the Gegharkunik region and in other zones with similar climatic conditions.

Introduction

Lentil is an important food crop; its seeds are used in food products and food industry, particularly in the production of protein preparations, sausage and canned products, as well as in confectionary and pastry factories (Posypanov, 2006).

Lentil is second only to soybean in the content of protein (32 %) (Matevosyan, 2000). It is rich in indispensible/ essential amino acids, 10 of which sum to 147 g/kg in the dry matter of the seed.

The forage value of the straw and lentil threshing yield is also rather high, which contains 14 %-18 % proteins and its 1 kg is equal to 0.56 feed unit (Posypanov, 2006, Khachatryan, 1970).

Due to the great significance of the lentil in the food ration of the population, the extension of the crop cultivating areas is among the prior issues for the agriculture of Armenia, the implementation of which will enable to meet the population's demand for lentil.

The agro-technical value of the lentil is also extremely high. Lentil is a crop of Fabaceae family and the tuber bacteria, dwelling on the lentil roots and binding the atmospheric nitrogen to the soil, annually leave 40-100 kg/ha nitrogen in the soil on the average, thereby improving the soil quality. Considering the mentioned fact, it can be stated that lentil is also the best precursor for a number of crops.

Lentil is a relatively drought-hardy, less nutrient-demanding plant with short vegetation period and thus, it

is rather valued in the mountainous regions of the Republic of Armenia as a beneficial forecrop. It is cultivated in the Aragatsotn, Kotayk, Gegharkunik, Vayots Dzor and Syunik regions of the RA. As of 2017, their crop lands covered 81 ha and the average yield capacity was 13.8 c/ha (Statistical Bulletin of Armenia, 2015).

There are numerous investigations worldwide related to various lentil varieties and their seeding rates. Prior to our investigations we studied some research results (Ashiq Saleem, 2012).

The seed yield capacity of lentil is usually low, which is mainly due to agro-technical reasons and partially to the identification of the seeding rate as well. The latter needs to be regulated based on the soil and climatic conditions, which is exactly pursued in the current work.

Materials and methods

The studies were carried out in 2017-2018 in conditions of Tsovak community in the Gegharkunik marz/region. Black, dry (rainfed) and mountainous soils are characteristic to the mentioned community. The average annual precipitation rate is 450-500 mm and the average temperature amounts to 4.6-5.1 ^{0}C.

The experiments were set up in 4 repetitions with 10 m^2 experimental beds; the preceding plant was spring barley. The efficiency of different seeding rates with the variants of *2.1, 2.4, 2.7, 3.0* and *3.3 mln viable-seed/ha* for the fine seed lentil variety "Armyanskaya 88" was investigated.

Phenological observations, biometric measurements and calculation of the biological yield of straw and grain were conducted according to the accepted methods during the vegetation period. The mentioned observations were conducted within the period starting from the sowing up to harvesting times. i.e. during the plants growth and development period. The main objective of the mentioned activities is to register the plants developmental phase transitions.

The phenological observations were carried out through the visual methods during which the germination, budding and vegetation durations (by days) per individual variants were determined.

When speaking about the phenological phase, the manifestation of the external morphological properties of the given plant is meant. For each phase the data are recorded twice: at the start, when 10 % of the plants are involved in the mentioned phase and at the end, when 60 %-75 % of the total plant number (mass examination) is within the scope of observation (Khachatryan, 2002).

In the lentil experimental field the germination capacity and plants density were determined according to the methodology accepted for field experiment conduction per 1 m^2 field area; it was repeated twice - after the full germination and on the eve of harvest.

The plants height, the weight of the entire plant and its grains were calculated for 25 plants from each bed. Based on the data resulted from the grains and straw weight per 1 m^2 field area, the biological yield for 1 ha field area was estimated, which enabled to evaluate the lentil yield capacity in different variants of seeding rates.

Results and discussions

Lentil is cultivated on very small land areas in Gegharkunik region. Besides, the complex of agro-technical measures aimed at its cultivation is not completely examined yet. Determination of the best seeding rate is considered to be one of the vital technological measures for the plant cultivation, in case of which it becomes possible to get high yield with low cost price.

The plants number in the cultivated unit area is related to the seeding rate, while the field germination capacity of the seeds and the duration of the vegetation depends on the developmental transition phases of the plant. The results of the mentioned experiments are introduced in table 1.

The table data testify that the sowing was implemented in the best time period (26.04) for the given area. The germination of the lentil seeds was recorded 8-10 days after sowing (05.05-07.05) and the variants of the seeding rates were not significant for the duration of the germination phase. The effect of the seeding rate was noticeable in the further developmental and growing phases of the lentil plant. For example, budding, blossoming and maturation processes occurred earlier in the variant with low seeding rate (2.1 mln viable-seed/ha), where the mentioned phases were fixed on 21.06, 02.07 and 01.08 respectively.

Together with the increase of the seeding rate the budding phase was delayed gradually by 4 days, blossoming phase - by 5 days and ripening - by 6 days. The mentioned phases were recorded on 25.06, 07.07 and 07.08 respectively in case of high seeding rate.

The data on the vegetation duration (germination-ripening) were of particular interest. In case of low seeding rate (2.1 and 2.4 mln viable-seed/ha) the lentil ripened within 88-89 days, while at relatively higher rates (3.0 and 3.3 mln viable-seed/ha) it occurred in 92 days. In relatively favorable nutritional, humidity and light conditions, which is marked in the variant of low seeding rate, the lentil ripens up to 4 days faster.

Table 1. The growing and developmental phase transitions in lentil plant*

Variants mln. viable-seed, kg/ha		Recording date					Vegetation duration, day
		Seeding	Germination	Budding	Blossoming	Ripening	
1 2.1	73.2	26.04	05.05	21.06	02.07	01.08	88
2 2.4	84.4	26.04	05.05	21.06	03.07	02.08	89
3 2.7	94.8	26.04	06.05	23.06	04.07	04.08	90
4 3.0	105.3	26.04	07.05	23.06	06.07	07.08	92
5 3.3	115.9	26.04	07.05	25.06	07.07	07.08	92

Table 2. Field germination capacity of the lentil, the density and height of vegetation cover and the yield capacity*

Variants mln./viable seed	Field germination capacity, %	Number of plants at the harvest time, n/m²	Plants height, cm	Weight, g/m²		Biological yield, c/ha			Profit, thousand AMD
				entire plant	seeds	straw	seed	surplus %	
1. 2.1	84.7	169	32.4	278	136	14.2	13.6	100	534.9
2. 2.4	84.1	190	32.0	300	148	15.2	14.8	108.8	587.1
3. 2.7	83.0	210	31.9	340	167	17.3	16.7	122.8	674.8
4. 3.0	82.3	232	31.0	350	171	17.9	17.1	125.7	677.4
5. 3.3	79.7	246	30.5	362	172	19.0	17.2	126.4	675.0

E_x%=2.5 %, $LSD_{0.95}$=1.2 c/ha

*Composed by the authors.

The results of the experiments have disclosed that the seeding rate has somehow influenced lentil seeds germination capacity, plants preservation and their height, as well as the yield capacity and profitability of straw and seeds (Table 2).

In dry conditions the field germination capacity of the seeds is high (84.7 %) in the variant of low seeding rate, which, anyhow, swings down to 5 % in the other applied variants. Such regularity has been also fixed regarding the data on the plants height. Thus, the plants are high in the sparse sowings (169 n/m²) stretching up to 32.4 cm and they are relatively lower in the dense ones (246 n/m²) - 30.5 cm.

It has been also revealed that parallel to the increase of the seeding rate, the yield capacity of the lentil straw and seed grows up to 14.2-19.0 c/ha and 13.6-17.2 c/ha respectively, besides, the seed yield capacity sharply increases in the variant of 2.7 mln viable-seed, amounting to 16.7 c/ha, whereafter the increase of the seeding rate results in little growth of yield capacity amounting only to 0.4-0.5 c/ha. The surplus of the seed yield amount has fluctuated within the range of 8.8 %-26.4 %.

Any agricultural measure is evaluated from the perspective of reliable mathematical processing of the yield amount data and from that of indices of the resulted profits. The least significance difference (1.2 c/ha) in the estimated yield of our experiments is true (valid) for the first, second and third variants of the seeding rate, while for the next two variants it is not true (invalid), since their difference is lower than 1.2 c/ha and makes only 0.4-0.5 c/ha.

The profit, which was calculated upon the difference of the resulted seed yield and their expenses, has made 534.9-677.4 thousand AMD in the variants of the mentioned seeding rates. The gradual course of culmination has been observed up to the variant of 2.7 mln viable-seed (674.8 thousand AMD), whereafter the profit increase slowed down (0.2-0.6 thousand AMD).

Conclusion

By the experimental results it has been found out that the seeding rate has demonstrated certain effect on the field germination capacity of the lentil seeds, on the plants preservability and height, as well as on the yield capacity and profitability of straw and seeds.

In the rainfed/dry soils of Vardenis province in the Gegharkunik region the lentil ripens within 88-92 days (the first ten days of August) and it can be a promising precursor for the winter wheat. Based on the mathematical processing data on the seed yield amount ($E_x\%=2.5\ \%$, $LSD_{0.95}=1.2$ *c/ha*) and the recorded profit, it is recommended to sow the small-seeded lentil with the rate of 2.7 mln viable-seed/ha in Vardenis province of the Gegharkunik region or in other regional areas with similar climatic conditions.

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The Nutrition Effect on the Quantity and Quality of the Potato Yield in the Irrigated Conditions of Askeran Region in the Artsakh Republic

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ABSTRACT

The effect of nitrogen nutrition with different doses and application methods on the quantity and quality of potato yield in the irrigated conditions of the Askeran region of NKR was studied throughout 2018-2019. Four fertilization variants have been studied: manure 25 t/ha+P_{90} – background (control), background+ $N_{30+(35+35)}$ - pre-sowing and split nutrition, background+N_{100} - single nutrition, background+N_{120} - single nutrition.

As a result of conducted studies and estimations of economic efficiency, it has been disclosed that among the tested variants the highest gross and commercial yield was provided by the variant of background+ $N_{30+(35+35)}$, which amounted to 321.5 c/ha and 250.5 c/ha respectively. Meanwhile, 2.6 mln AMD profit has been resulted from the sale of marketable product.

Introduction

In the contemporary conditions the most urgent issue in the horticultural production is to meet the gradually rising requirements of the population towards the high-quality agricultural food supply. The solution of the food provision issue has an extremely important strategic significance for poverty elimination and for the improvement of human living standards. So, the key to its solution can be found in the enhancement of the cultivation efficiency for such agricultural crops as, for example, potato, which is factually considered to be “the second bread”. From this perspective the increase of the potato production sizes together with the development of cereal crop production sector can greatly promote the comprehensive solution of the problems in agri-food system.

Among the applied agro-technical events the establishment of scientifically justified fertilization system has an invaluable role in the increase of the potato yield capacity and its cultivation efficiency. Thus, the establishment of the abovementioned fertilization system is considered to be one of the extremely urgent tasks for the development of agriculture and increase of its production sizes in the Republic of Artsakh. Despite the fact that fertilization process is vital in the agro-technical measures of potato cultivation, the doses of the nurtured nitrogen shouldn’t be abused, which can cause a number of undesired consequences as it has been already proved by numerous research experiments of different scientists (Matevosyan,

Gyulkhasyan, 2000, Grigoryan, 1999, Vavilov, 1986).

A number of authors believe (Pfeffer, 1999) that in irrigated conditions high potato yield can be ensured only by applying 40 t/ha manure through the main fertilization method.

The trials conducted by B.V. Anisimov have testified that the highest efficiency of potato cultivation in the irrigated conditions of the Poltava region is provided upon the fertilization variant of $N_{120}P_{100}K_{90}$ (Anisimov, 2005).

Materials and methods

In the irrigated conditions of the Askeran region at the Artsakh republic we have studied the effect of various nutrition doses of nitrogen on the quantity and quality of the "Latino" potato variety. The studies were carried out within 2018-2019 and based on the agro-chemical indicators characteristic to the soils of the mentioned region the following fertilization variants have been tested:

1. Manure- 25 t/ha+P_{90}, which has been accepted as a background and taken as a control variant.
2. Background+$N_{30+(35+35)}$, out of which N_{30} had been introduced before the tubers planting, while the nutrition with 35 kg nitrogen was implemented twice during the vegetation period in two different time periods.
3. Background+N_{100} - with single nutrition.
4. Background+N_{120} - with single nutrition.

The experiments were set up with 4 repetitions in 4 variants upon the randomization principle and the estimated size of each experimental bed was 50 m^2, while the whole experimental plot was 800 m^2. During the vegetation period the treatment and harvesting activities in all experimental beds of each variant were carried out simultaneously and with the same principle, except for the nutritional doses of the nitrogen, which were provided according to the specifics of experimental variant selected by our research group.

Sturdy, undamaged 70 g-80 g potato tubers of "Latino" variety of the first reproduction have been selected as a planting material, which have been subjected to light germination for 28 days, the sprouts being amounted to 0.7-0.8 cm length (light germination was carried out under the 12 ^{0}C heating conditions and 70 % relative humidity). Planting was implemented in the third ten days of March (20.03 and 23.03 per study years) with the scheme of 70x30 and the study results are introduced in average indices.

Results and discussions

To study the efficiency of the recommended nutrition doses for the irrigated conditions of the Askeran region in the Artsakh republic and to identify the best variant, a number of phenological observations, measurements and weighing were conducted during the plants vegetation period. Based on the results of the aforementioned activities estimations on the economic efficiency were performed and the beneficial, as well as the most effective variant was identified. Particularly, the effect of nitrogen nutrition on the morphological indicators of the potato bush (plant height, the number of stems and leaves, leaf surface, etc.) was investigated, which alters significantly per variants (Table 1).

The table data testify that the bush height has increased together with the increase of nitrogen doses and exceeded the control variant by 9.7 cm-18.6 cm, besides the highest stem indicator has been recorded in N_{120} variant, which is quite an expected result, anyhow the similar growing

Table 1. The effect of nitrogen nutrition on a number of growing indicators in the surface parts of potato and its leaf surface (2018-2019)*

Variant	Bush height, cm	Ground-level stem diameter, mm	For one potato bush			Leaf surface in 1 ha, 1000 m^2
			Stems number, n	Leaves		
				Number, n	Leaf surface, cm^2	
Manure 25 t/ha+P_{90}-background	53.7	7.8	2.7	107.2	4150.5	197.5
Background +$N_{30+(35+35)}$	63.4	12.4	3.3	138.2	5880.7	279.8
Background +N_{100}	64.2	11.0	3.0	140.3	5907.4	281.2
Background +N_{120}	72.3	10.2	3.1	151.4	6875.4	327.3

*Composed by the author.

rate is absent in the stem diameter and its number. On the ground-level part the largest diameter and the greatest stem numbers per a plant have been recorded in the first experimented variant (Background+$N_{30+(35+35)}$), where the nutrition was carried out through split fertilization method by the end of sprouting phase and at the end of budding phase. In the second experimented variant (Background+N_{100}) the plant height is almost close to that of the previous variant exceeding only by 0.8 cm (64.2 cm), while regarding the stem diameter it lags behind the former variant by 1.4 cm. Despite the fact that in both variants N_{100} dose of fertilizer was totally introduced into the soil the significant differences in the mentioned indicators should be related only to the application times and methods of the fertilization in the soil.

The pre-sowing application of N_{30} promotes the intensive growth of the newly formed plant and the bush formation, while by the end of sprouting stage the nutrition with N demonstrates its beneficial effect on the stems growth and the increase of their number (3.3 stems). Regarding the other indicator (leaf number and leaf surface) the variant of N_{120} is unrivalled and such a high dose has promoted the plants stretching capacity and the increase in the leaf number and surface. The experimental doses of the nitrogen applied in the nutritional form have exerted their impact on the plants growth and on the duration of their developmental phase transitions, the results of which are introduced in Table 2.

According to the two-year average data of the experiments the planting of the tubers was implemented on March 21 and the germination in all variants was observed 19 days after planting, since the planting material had been subjected to the light germination beforehand, nevertheless starting from the budding phase, prolongation in the duration of the developmental phases together with the increase of nitrogen doses was observed. For example, if in the variant of the background+$N_{30+(35+35)}$ the transition phase between the tubers planting period up to the budding stage was prolonged by 11 days as compared to the same period observed in the control variant and up to the flowering phase-by 4 days against the control variant, then in the variant of background+N_{120} this difference was even more evident - by 14 and 13 days respectively, amounting to 92 and 99 days respectively. So, in accordance to these indicators the whole vegetation period of the plants was prolonged against that of the control variant by 6-15 days, totally amounting to 157-166 days.

The nutrition methods and doses of the nitrogen fertilizer have had a significant effect not only on the potato yield, but also on its quality and the quantity of the marketable tubers (Table 3).

Table 2. The effect of nitrogen nutrition on the potato growth, the duration times of developmental phase transition and on the vegetation period (2018-2019)*

Variant	Planting time	The duration of developmental phase transition (in days) from planting up to			
		Germination	Budding	Flowering	Natural death of haulms
Manure 25 t/ha+P_{90}-Background	21.03	19	78	86	151
Background +$N_{30+(35+35)}$	21.03	19	89	90	157
Background +N_{100}	21.03	19	88	91	158
Background +N_{120}	21.03	19	92	99	166

Table 3. The effect of nitrogen nutrition on the structural elements and yield capacity indicators in a potato bush (2018-2019)*

Variant	For a potato bush					
	Tubers number, n	Tubers weight, g				Tuber gross yield
		Total	Marketability			
			Large	Medium	Small	
Manure 25 t/ha+P_{90}-Background	5.7	505.7	131.3	198.7	175.7	240.2
Background +$N_{30+(35+35)}$	9.8	680.3	383.1	141.4	155.8	321.5
Background +N_{100}	8.2	631.2	311.7	139.2	180.3	298.8
Background +N_{120}	7.1	602.4	280.3	129.8	192.3	284.4

*Composed by the author.

Table 4. The economic efficiency of nitrogen nutrition in the potato sowings (2018-2019)*

Variants	Tubers' yield, c/ha		Commercial yield cost, thousand AMD	Sale price of 1c tuber, thousand AMD	Costs needed per 1 ha, thousand AMD	Profit per 1 ha, thousand AMD
	Gross	Commercial				
Manure 25 t/ha+P_{90}-Background	240.2	157.1	2043	13.0	574.0	1469
Background +$N_{30+(35+35)}$	321.5	250.5	3250	13.0	642.0	2608
Background +N_{100}	298.8	210.4	2730	13.0	634.0	2096
Background +N_{120}	284.4	190.7	2480	13.0	672.0	1808

*Composed by the author.

Regarding the number and weight of tubers formed per a potato bush the variant of background+$N_{30+(35+35)}$ is unrivalled, which has surpassed the control variant by 4.1 tubers and 174.6 g, while the other experimented variants stay behind the mentioned variant by 1.6-2.7 tubers and 49.1 g - 77.9 g respectively. Despite the fact that in the first and second experimental variants the doses of nitrogen are equal (N_{100}), they significantly differ by the resulted yield quantity and its marketability, the main reason of which is the time and method of fertilizer's application. In the variant of background+$N_{30+(35+35)}$, the fertilizer introduced with N_{35} dose in nutritional form at the end of germination phase, has had its positive impact on the intensive stem formation and further stolon formation processes. The remaining part of the nitrogen (N_{35}) introduced in the budding phase promotes the process of tuber formation and the emergence of the large tubers, which is clearly shown by the data of Table 3. Thus, in the best variant the lowest weight of small tubers formed per a bush is recorded which makes 155.8 g. In case of single nutrition with the dose of N_{100} not only a decrease in the resulted yield but also an increase in the weight of small tubers by 24.5 g (180.3 g) is recorded, meanwhile the weight of the large tubers have decreased by 71.4 g (311.7 g).

The further increase of the nitrogen dose (N_{120}) introduced into the soil in the single nutritional form leads not only to the decrease of the tuber yield, but also to the increase of the number and weight of the small tubers. Regarding the last indicator it has exceeded the best variant by 36.5 g and the control variant by 16.6 g.

To make sure that among all the tested variants background+$N_{30+(35+35)}$ is the most efficient and practical fertilization variant for agricultural production, an estimation for its economic efficiency has been also conducted and the size of the received profit has been determined, the results of which are summed up in Table 4.

The distinguished variant (background+$N_{30+(35+35)}$) exceeded all variants both in the gross yield and commercial yield quantity providing 321.5 c/ha and 250.5 c/ha yield respectively. Accepting that the sale price for one centner tuber is 13 thousand AMD, the cost of the marketable yield and the size of the received profit have been estimated as a result of which it has been revealed that the mentioned variant has provided 2.6 mln AMD profit. This number has surpassed that of the control variant by 1.2 mln AMD and the experimented variants - by 0.5-0.8 mln AMD.

Conclusion

Upon the results of the conducted research experiments it becomes clear that in the irrigated conditions of the Askeran region the variant of background+$N_{30+(35+35)}$ is considered to be the most efficient fertilization method for potato. It provides an unprecedentedly high profit per hectare and hence, is recommended to the farmers engaged in potato cultivation. So, as the potato yield grows up in case of applying the mentioned cultivation method the import sizes of potato from abroad can be significantly reduced as well.

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Application of Convolutional Neural Network in Agriculture on the Example of Plant Disease Detection

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ABSTRACT

Artificial Intelligence (AI) technologies are used in various sectors of the national economy, particularly in agriculture. These technologies are used in various fields of agriculture: detection of plant diseases, classification and identification of weeds, crops identification and computation, water and soil management, weather (climate) forecasting, determination of animal behavior, etc. This paper reviews advanced Artificial Neural Network (ANN) techniques available to hyperspectral data processing, with a special emphasis on plant disease detection. It is proposed to apply the developed ANN model to the agriculture of the Republic of Armenia to make it more modern and efficient.

Introduction

The technological revolution of the recent decades has opened new opportunities for the entities engaged in agriculture to find better ways to treat, grow and produce foodstuff. Anyhow, there is also a growth in the pollution rate and therefore, in the possible pathways for plants intoxication. The poisoning causes various plant diseases. These are dangerous threats for nearly every farm type and the expected damage can be high especially for small ones. Obviously, from this perspective no growth in mass production or its quality can be envisaged. Fortunately, algorithmic methods, in the face of image processing algorithms, come to fill the mentioned gap enabling to identify possible deviations and to get sustainable outcomes (Sharada, et al., 2016, Hanson, et al.,2017). Another well-positioned approach has become very popular in recent years, which is related to image processing based on Convolutional Neural Networks.

Convolutional Neural Network (CNN) (Srdjan Sladojevic, 2016) is one of the main methods for image recognition (Mercelin Francis, 2019) and classification (Ciresan, et al., 2011, Krizhevsky, et al., 2012). Object detection and recognition sector is one of the areas where CNNs are widely used. CNN image classification model takes an input image, processes it and then classifies it per identified categories (e.g., dog, cat, tiger, lion). Computers perceive

an input image as an array of pixels and the latter is related to the image sizes. Based on the image resolution, it will see (h = Height, w = Width, d = Dimension) matrix.

Materials and methods

It's very hard to take a large-scale control on diseases and their prevention. Thus, very often farmers take a number of struggling measures against the plant diseases. One of the widely used practices is the application of toxic sprays over cropping areas. This method, though effective, implies high costs and environmental risk exposure. In this article, we present the ML-based method, which aims to utilize Convolutional Neural Networks for disease detection in plants.

Convolutional Neural Networks are the most widely used types of Artificial Neural Networks for image classification. Structural peculiarities make CNNs well suited for their use in pattern recognition algorithms and for image analysis. The main difference between CNNs and multilayered perceptrons is the availability of hidden convolutional layers. Like in an ordinary artificial neural network, a layer in this network can be also viewed as a transformation of input data. In case of CNN this transformation is a convolution operation. To make convolution possible, filters with finite numbers should be matched with each convolution layer. Each filter is a matrix of nxm size. In each transformation phase realized by the convolution layer, the filter slides over the input matrix and in every convolution span the product of the filter and the appropriate submatrix of the input matrix is calculated. As a result, the output matrix is generated. These filters can be viewed as model determinants. The deeper the net is the more complex the filters can be.

Plant Village Dataset (Saad Albawi, et al., 2017) has been chosen as a database for the study of the neural networks, which is available online for free. Pictures of this dataset were taken in the laboratory conditions and can provide up to 99.35 % accuracy. However, the image of the picture is quite different in case of taking it in real conditions. Moreover, in case of many problems, it is not possible to ensure high rate of accuracy.

Diagram 1 partially indicates the ratio of the number of plant diseases available in the database to the number of the corresponding pictures.

Not all diseases available in the mentioned database are found in the territory of the Republic of Armenia. However, taking into account the universality of the method, it is possible to use it in case of any visually observed disease: (Figure 1-6).

The raw dataset consists of colored, grayscale and segmented images. Colored images have been used as a data source for this experiment. Segmented images can be used as an alternative variant from the prospect of producing less noise. Each image has 256x256 pixel size. For in-depth study of neural networks, images should be represented as a three-dimensional array, even if the image is grayscale, additional dimension should be added for a single color channel. Also, cross-validation has been applied to data, where 80 % of the dataset was used for training and 20 % for testing purposes.

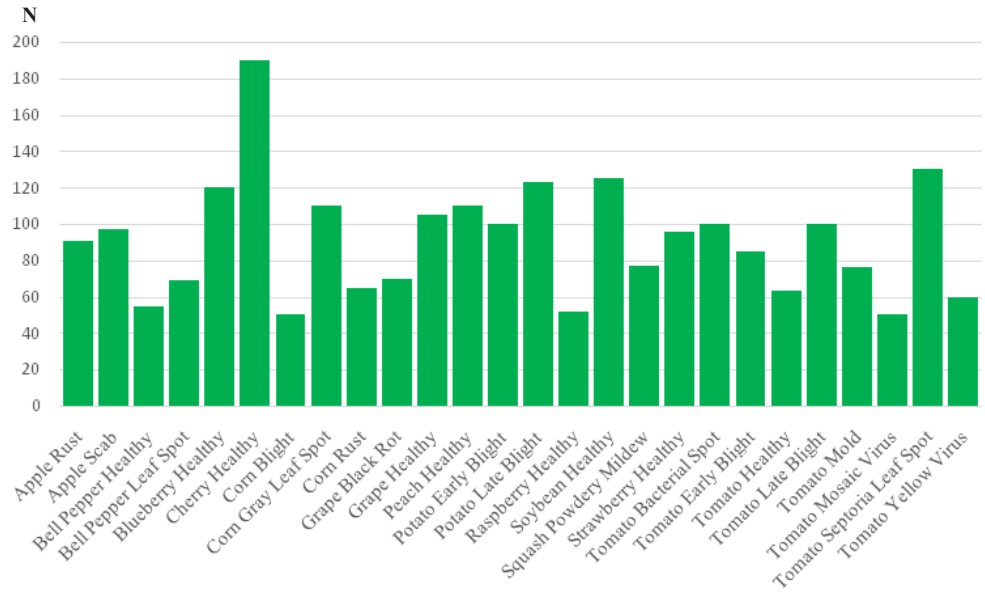

Diagram 1. Types of diseases and the number of the pictures (*Plant Village Dataset*).

Figure 1. Apple Black Rot, a picture in the dataset.

Figure 2. Apple Black Rot, a picture taken in real conditions.

Figure 3. Bell Pepper Bacterial Leaf Spot, a picture in the dataset.

Figure 4. Bell Pepper Bacterial Leaf Spot, a picture taken in real conditions.

Figure 5. Corn Gray Leaf Spot, a picture in the dataset.

Figure 6. Corn Gray Leaf Spot, a picture taken in real conditions.

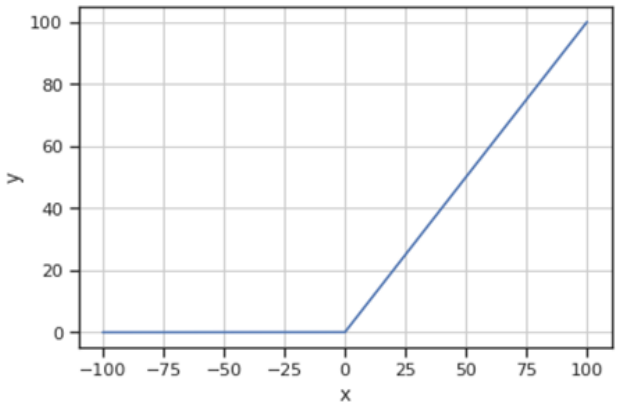

Diagram 2. ReLU Activation Function (*composed by the authors*).

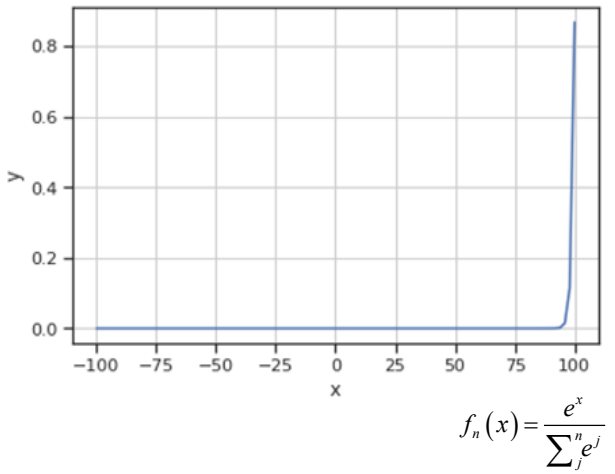

Diagram 3. Softmax Function (*composed by the authors*).

Results and discussions

The model of the developed CNN has the following structure (Diagram 4). The network starts with the convolution layer, which consists of 32 filters each with 3x3 kernel. The ReLU (Rectified Linear Unit) has been chosen as an activation function (Diagram 2). Without ReLU or another kind of activation function, the network can be viewed as a sequential multiplication of matrices. ReLU has several advantages as an activation function. The ease of computation and scale invariance are among the most important privileges. Besides, ReLU is very suitable for those nets the weights of which have been randomly pre-estimated and at the start of study only part of the neurons are activated. So, the addition of the ReLU layer helps to add some non-linearity to the network. The max-pooling layer follows the activation function. Its objective is to decrease the number of random variables under observation and obtain some set of variables principal to the current problem. During matrix pooling, we should choose some nxm matrix and slide this over input data with some strides. On each step, this matrix will cover some nxm sub-matrix of input data and pool out maximum value from that. It should be noted, that max-pooling comes right after convolution and activation layers. So, on the whole the max-pooling function consists in the choice of the most activated parts from the output. Another common problem is overfitting. Due to overfitting the network starts to behave very well to the training data. As a result, it is unstable to any new, unexplored data and consequently fails in the testing phase. To avoid overfitting dropout technique has been applied. Dropout weakens some connections between two layers, so that network becomes unable to learn some features from the new input data, but on the other hand accuracy for the test data use improves. In case of currently developing network nearly 25 % of connections have been dropped after the max-pooling layer. The next two sets of convolutional and ReLU layers follow the max-pooling layers.

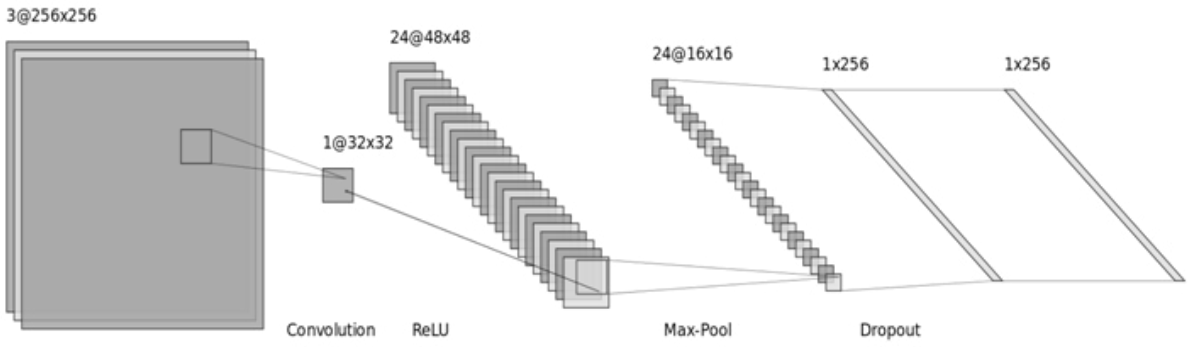

Diagram 4. Illustration of the first part of the network (*composed by the authors*).

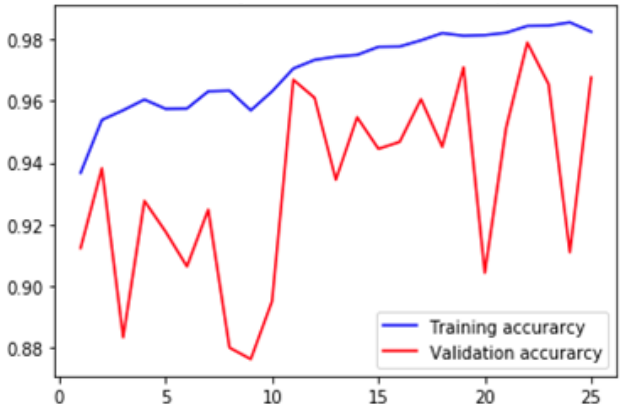

Diagram 5. Training and Validation accuracy (*composed by the authors*).

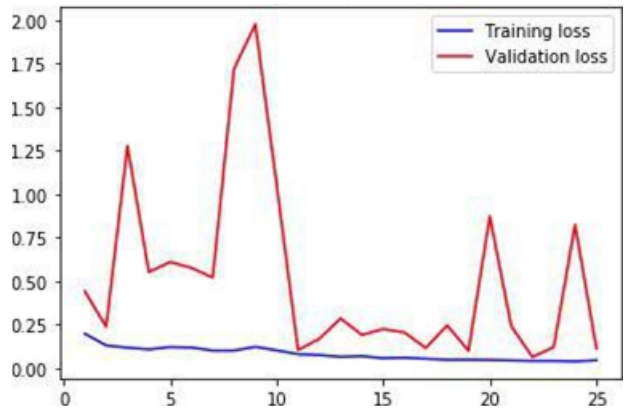

Diagram 6. Training and Validation loss (*composed by the authors*).

For the final part of the network, one more set of fully connected layer with respective activation layer was applied. Softmax function was used as the last layer (Diagram 3). Its main objective is to make probabilistic interpretations on the network outputs.

There is also a problem related to model optimization. Keras Adam (Diederik Kingma, 2015, Sashank, et al., 2018) optimizer was used as an optimization algorithm. Basically, it is another approach based on Stochastic Gradient Descent or SGD.

The results achieved throughout training and validation procedures are introduced in diagrams 5, 6. They also illustrate accuracies achieved during the training and validation phases. As it is known, the whole training and testing process consists of 25 phases. The best accuracy achieved in the training process was detected in the 23rd phase which is equal to about 97 %. It is clear that the introduction of such an outcome in the agricultural sector is practically rather beneficial. Diagram 6 shows loss function results during the training and validation phases.

Finally, it should be mentioned that 96.77 % accuracy was achieved during the testing phase, using the network described above.

Conclusion

Based on the aforementioned study results it can be concluded that Machine Learning models such as Artificial Neural Networks and their variations (CNNs) can have a great impact on the current state of agriculture. In this article a special attention was paid to the mechanisms for disease detection in the plants leaves. Upon the investigations it can be inferred that it is possible to detect the infected leaves of the plants with high accuracy even in fluctuating light conditions (Zeiler, 2014). In case of the availability of appropriate equipmet this method can be used to automate the solution of some agricultural problems.

However, it should be noted that the described method has limited applicability. One of the limitations consists in the fact that this method is not applicable to the plants infected at their initial development stage. In this case, it is impossible to solve the problems related to visual symptoms, as they are actually missing at this stage. Thus, whether the plant is infected or not is possible to find out only in laboratory conditions. Another restriction is related to the fact that the diseased plant may lack visual disease symptoms at all, or they may appear at the stage of the disease, when it can be only retarded, but not treated.

The practical application of the mentioned mechanisms can be considered as the further development of the current work. It is recommended to implement investigations and researches on the plants diseases in the territory of Armenia. Appropriate database should be reserved throughout the mentioned investigations. The described methods can be applied to these data to get accurately designed models. There are various tools which enable to serialize the designed Machine Learning/Deep Learning models for their further use. With such rich toolkits it's possible to develop either cloud-based or client-based mobile application to ease the process of plant protection and to find diseases in the early stage of plant development.

In the result of accomplished research and engineering works on the applications of the created models for artificial neural networks we recommend to use this

model in the agriculture of the Republic of Armenia. In this way, it will be possible to invest modern and robust technologies into agriculture. Under such circumstances it is possible to ensure high qualitative and quantitative indices for agricultural products.

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Peculiarities of Radish Seed Breeding in Conditions of Ararat Valley

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ABSTRACT

The aim of the current article is to study the impact of the measures taken via replanting of the radish seedlings and via leaving them in the sown areas (without replanting) on the morphological changes and seed productivity of the radish seed plants.

The research results have evidenced that the replanting of the plant seedlings is the best option for the radish seed production. In case of replanting 5.5 % more seedpods with large and uniform seeds have been developed on the floriferous shoots of the seedlings and the seed productivity per plant has exceeded the rivaling variant by 66 %; besides, the average weight of 1000 seeds exeeded the competing variant by 2.5 g.

Introduction

Enrichment of the vegetable crop varieties used by population has become an urget issue in the current market environment. Radish is namely among such vegetables, which is an annual root crop cultivated everywhere. This crop is used only fresh, and differs in its nutritional and palatability traits (Sazonova, 1982). Radish contains valuable enzymes, mineral salts, vitamines, essential oils that are important for the digestion of hardly digestible food and for metabolism regulation (Smirnov, 1981, Gusev, 1991). Apart from high nutritional value, radish is also endowed with vital medicinal qualities. It is worth mentioning that the annual per capita consumption of the vegetables amounts to about 125 kg, 1 kg of which is the share of radish crop (Dyachenko,1979).

Short vegetation period and high cold resistance rate are among other advantages of the discussed crop, due to which it is possible to get early yield. It is necessary to state that natural and climatic conditions of our republic are quite favorable for producing seeds of the above mentioned crop.

There is hardly any theoretically justified event accurately organized in the current agriculrural seed production sector in Armenia. It is well known that the seed qualitative indices are related to the growing conditions, applied agro-technical measures, as well as to varietal peculiarities. The aim of the current work is to study the effect of the measures taken via replanting the seed plants' seedlings

and those without their replanting on the biomorphological changes and seed productivity of the radish seed plants in the corresponding farms.

Materials and methods

The studies were conducted within 2017-2019, on the experimental farm of the Scientific Centre of Vegetable and Industrial Crops of the Ministry of Economy, RA.

The research works were implemented in line with the guidelines for primary seed breeding of vegetable and cucurbits crops (Ludilov, 1991).

Seeding was carried out on April 10.The seedlings were replanted in the field on May 12, with 70x35 cm planting plan. Approbation was conducted within the period of the root crops technical maturation during which root crops peculiar to the species were selected. After approbation, the plants were watered, whereafter the mature and healthy root crops were harvested. The tuber diameter in the root crops made 2.5-3.0 cm. On the seed plants of the root crops selected for planting, 3-5 cm-long central leaves (1-2 items) were left. The seedlings of the radish crops were planted in the soil with the depth of 1.5-2.0 cm and well tightened with soil, otherwise the rooting can slow down leading to their drooping. After planting the seedlings were watered. Since the weather conditions were dry and the air humidity was rather low throughout the cultivation period, the seedlings were watered twice. For the first time they were watered during the vegetation period, and then watering was conducted during the flowering stage. In addition to water supply the plants were also fertilized with mineral fertilizers. Weeding and loosening activities were also carried out.

To ensure purity of varieties, the seed field was cleaned from other varieties keeping 1000 m distance from each other. Pollination was performed by means of insects.

The radish seeding without replanting was conducted at the start of May. The disadvantage of the mentioned method for producing seed plants consists in the fact that it is difficult to make true choice among the plants, which leads to the deterioration in the varietal purity. The first discrimination care /weeding/ was implemented parallel to the plants sparsification in the mass tuber formation stage of the root crops. Only plants with varietal characteristic size and color in the upper parts of the root crops were selected. The second rogueing was implemented before the flowering stage. This time the plants with inflorescences of atypical colouring were removed. Harvesting was organized when the pods were light-yellow and seeds were light-brown. The seed stalks were harvested at once, since their pods are strong and do not open.

Phenological observations, biometric measurements and resulted seed estimation was implemented during the vegetation period. Field trials and numerical figures were processed by the method of variation dispersion analysis used for statistical processing of the data obtained (Dospekhov, 1985).

The experiments were performed with three replications on the radish variety “Diego”, which is widely cultivated in Armenia.

Results and discussions

The studies show that some changes have been observed in biomorphological characteristics of seed plants that were replanted and in those that were not (left in the sown areas).

According to the data presented in table 1, different conditions of seed plants cultivation have had certain impact both on the floriferous shoot emergence time and on the flowering and maturation times. Thus, floriferous shoots of replanted seedlings appeared on the 67th day after sowing, while in the seed plants which were not replanted floriferous shoots appeared on the 51st day after sowing. The same pattern was observed in the flowering and maturation phases.

Table 1. Duration of seed plants phenophases (average for 2017-2019)*

Phases	Replanted seedlings	Seedlings left in the sown areas (without replanting)
Sowing time	10.04	05.05
Planting time	12.05	-
Floriferous shoot emergence time	15.06	26.06/51
Flowering time	08.07	18.07/73
Maturation time	29.08	12.09/129
Duration of vegetation, days	142	129

*Composed by the authors.

Table 2. Changes in the main indictors of seed productivity depending on cultivation conditions (average for 2017-2019)*

Quantity	Replanted seedlings	Seedlings left in the sown areas (without replanting)
Number of seedpods per plant, n	285	270
Number of seeds per seedpod, n	5	4
Number of seeds per gram, n	100	120
Seed productivity per plant, g	15.0	9.0
Seed productivity c/ha	6.0	3.6

*Composed by the authors.

Table 3. Radish seed quality depending on conditions of seed plants cultivation (average for 2017-2019)*

Seedlings	Size and uniformity, %			Weight of 1000 seeds, g	Germination rate,%	Germination energy, %
	large	medium	small			
Replanted seedlings	50.5	42.0	7.5	10	93	86
Seedlings left in the sown areas (without replanting)	28.4	45.2	26.4	7.5	87	75

Different conditions of seed plants cultivation affected biomorphological properties and seed productivity of the seedlings as well.

The data presented in table 2 show that different ways of cultivation affected the number of floriferous shoots, seedpots and seeds per seedpot, as well as indices of seed quality. Thus, 285 seedpots were developed on the floriferous shoots of replanted seed plants, the number of seeds formed in seedpots was 5, as to the seed productivity, 15.0 g seed per plant and 6 c seed per hectare was produced. Meanwhile, for plants, that were left in the sown areas (without replanting) the mentioned indicators made 270 n, 4 n and 9.0 g, 3.6 c respectively.

Based on the seed quality indices, it should be noted that the average weight of 1000 seeds, the percentage rate of large and medium seeds, germination capacity and energy in the seedlings of replanted plants were rather high (Table 3).

Conclusion

The research work performed has testified that replanting of seedlings is the best option for radish seed production. The floriferous shoots of replanted seedlings produced 5.5 % more seedpods with large and uniform seeds, besides, the mentioned variant has been distinguished by its seed productivity which is 66 % higher than that of observed in the second variant (without replanting). Finally, the weight of 1000 seeds exceeds the similar indicator recorded in the seed plants left in the sown areas (without replanting) by 2.5 g.

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Improvement of Vegetable Crops Cultivation Technology by Applying Biostimulant in Protected Area

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ABSTRACT

In 2017-2019, during the winter-spring crop rotation period the effect of organic biostimulant Fulvit on the tomato variety "Lusarpi F_1", cucumber varieties "Nazrvan 45", "Nare" and on the sweet pepper varieties "Loshtak" and "Narinj" have been studied in greenhouse conditions.

The fertilizer was introduced through foliar application method in nutritional form with 1/100 dosage, 3 times with 10-15 days' intervals.

The research results have revealed that in comparison with the control variant in the rest investigated varieties Fulvit fertizer has promoted the plants growth and development; it has also improved the fruit and seed quality as well as yield capacity and profitability.

Introduction

The production of organic agricultural products is expanding both in Armenia and worldwide, becoming one of the most promising and perspective sectors of agriculture.

Synthetic growth stimulants, fertilizers and pesticides have been used in the crop cultivation for many years, the residuals of which are stored in soil, water and then transferred to vegetable crops (Djuvelikyan, 1999, Bezuglova, 2002).

Organic agriculture is a system aimed to improve and encourege the agricultural production in view of nature protection, as well as social and economic development. During the production of organic food no toxic or artificial materials, sustainable pesticides, chemical fertilizers or radiation is ever applied. This stimulates biodiversity, biological activities of soil and improves biological phases. Nevertheless, local organic seed varieties haven't been produced in Armenia yet, which is an obstacle for the local varieties to be invoved in the production of organic agriculture.

Organic fertilizers are recommended for producing organic, valuable and competitive seeds of local varieties for basic vegetable crops (tomatoes, sweet pepper, cucumber).

The liquid biostimulant Fulvit is an organic fertilizer manufactured by "EcoPlant" company, which contains

biologically active substances, humic and fulvic acids produced on biohumus base.

Our survey results have revealed that the use of Fulvit in Armenia and Nagorno-Karabakh Republic has had a positive impact on the growth, development, yield quality, disease and pest resistance, as well as on a number of other key indicators of vegetable crops. The aforementioned raised interest among the researchers and served as a background for the study and justification of the application effect of the mentioned fertilizer on the tomato variety "Lusarpi F_1", cucumber vaieties "Nazrvan 45" and "Nare", sweet pepper varieties "Loshtak" and "Narinj".

Materials and methods

In the glass greenhouse of the Scientific Center of Vegetable and Industrial Crops at the Ministry of Economy, RA, the effect of Fulvit fertilizer on the hybrid of tomato variety "Lusarpi F_1", cucumber varieties "Nazrvan-45" and "Nare", sweet pepper varieties "Loshtak" and "Narinj" was studied during the winter-spring crop rotation period, in 2017-2019. The plants transplanted in the greenhouse were treated with experimental fertilizer by foliar nutrition with the dose of 1/100. The foliar nutrition in the transplanted crops was implemented thrice, with 10-15-day interval during the vegetation period. Bio-liquid served as a control variant (standard), which was introduced with the same method (foliar nutrition) and doses.

The phenological and morphological observations of the plants were carried out throughout the whole vegetation period through the accepted method of State Variety Trial of Agricultural Crops (Fedin, 1985).

The fruits were sampled for chemical analyses at the start of fruiting stage, and just before the termination of the experiment. The dry matter content was identified by the refractometer "IGF-454B2M", sugar content - by Bertrand's method and vitamin C- by Moore's method (Peterburgskiy, 1968).

Seedlings were grown in trays and the plants of the experimental crop varieties were planted in the greenhouse according to 90+60x50 cm scheme. Significance of differences in treatments was tested using the least significant difference (LSD) method. The LSD values were calculated at $P<0.05$ probability level (Dospekhov, 1985).

Results and discussions

Upon our experiments the effect of Fulvit fertilizer on the growth, development and yield capacity of vegetable crops has been studied. It is worth mentioning that plants grown through Fulvit fertilizer had intense green color, which indicates on high chlorophyll content and intensive photosynthesis in the leaf chloroplasts.

The results of the study showed that depending on the application of the Fulvit fertilizer, the duration of phenological stages in the vegetable crops also changed (Table 1).

Table 1. Duration of phenological stages of vegetable crops depending on the application of Fulvit fertilizer (per days)*

Variants	Number of days from mass germination to				Duration of yielding period
	flowering	fruiting	first yield	last yield	
Tomato variety "Lusarpi F_1"					
Control	59	82	104	193	89
Fulvit	56	78	95	193	98
Cucumber variety "Nazrvan 45"					
Control	37	49	57	126	69
Fulvit	36	45	52	126	74
Cucumber variety "Nare"					
Control	50	50	63	104	41
Fulvit	48	47	53	110	51
Sweet pepper variety "Loshtak"					
Control	73	95	120	180	60
Fulvit	70	90	117	180	63
Sweet pepper variety "Narinj"					
Control	70	91	118	180	62
Fulvit	65	82	110	180	70

*Composed by the authors.

It should be noted that in the experimented crop varieties, where Fulvit fertilizer was applied the plant development stages accelerated depending on the crop and its variety. The number of days starting from germination to flowering stage was reduced by 1-5 days and to fruiting stage - by 3-5 days; as a result it affected the times of early yield formation as well. In the variant, where Fulvit fertilizer was applied the fruit ripening period was also accelerated by 3-10 days. The studied variants also differed by the duration of yielding period, which varied within 41–98 days depending on the crop and varieties. In the treated

variants, the cucumber variety "Nare" was distinguished by long yielding period (10 days longer than that of observed in the control variant). This pattern was observed in all experimented crops (Table 1).

The yielding period in the plants treated with Fulvit fertilizer started earlier than those in the control variant, which is a very important indicator, especially for greenhouse crops, since early yielding provides high price and consequently high profit level.

Analysis of the yield capacity indicators is significant for the evaluation of the new technology. Yield estimation has been conducted upon the research results; also the early and total yield amount has been determined. Analysis of yield data shows that the use of Fulvit fertilizer has promoted the increase of early and total yield amount. Depending on the crop species and its variety the use of Fulvit fertilizer provided 7.3 %-14.7 % growth in the total yield and 6.7 %-17.4 % growth in the early yield amount (Table 2).

According to the literature data the biochemical composition of the fruits of vegetable crops is conditioned by the morphobiological characteristics of the given species and varieties, as well as by different geographical origins, meteorological conditions and cultivation methods (Azaryan, Tadevosyan, 2014).

The data of table 2 indicate that in the variants, where the fruits were treated with Fulvit fertilizer the content of dry matters exceeds that of the control variant by 2.8 % in tomato fruit, by 4.6 % and 13.9 % in cucumber fruits, while in the varieties of sweet pepper the surplus made 4.1 % and 6.1 % respectively. The same regularity was marked in the data of total sugar content and vitamin C.

The research results evidence that in case of applying Fulvit fertilizer the net income was higher, which in its turn provided high profitability rate. Depending on the crop species and variety the latter fluctuated within the range of 91.2 %-173.7 % (Table 3).

Table 2. Vegetable crop yield capacity and qualitative indicators of fruit in case of Fulvit fertilizer application (2017-2019, kg /m^2)*

Variants	Early yield, kg/m^2	Early yield surplus, %	Total yield, kg/m^2	Yield surplus, %	Dry matter, %	Sugar content %	Vitamin C mg/%
Tomato variety "Lusarpi F_1"							
Control	1.2	-	9.5	-	5.28	2.41	17.02
Fulvit	1.3	8.3	10.9	14.7	5.43	2.75	18.05
			$LSD_{0.05}$ 1.1				
Cucumber variety "Nazrvan 45"							
Control	2.3	-	9.4	-	5.86	2.75	18.71
Fulvit	2.7	17.4	10.2	8.5	6.13	2.77	18.73
			$LSD_{0.05}$ 0.7				
Cucumber variety "Nare"							
Control	3.0	-	11.3	-	3.31	1.44	6.05
Fulvit	3.2	6.7	12.4	9.7	3.77	1.51	6.25
			$LSD_{0.05}$ 1.0				
Sweet pepper variety "Loshtak"							
Control	1.6	-	16.4	-	5.86	2.75	18.71
Fulvit	1.8	12.5	17.6	7.3	6.22	2.92	18.78
			$LSD_{0.05}$ 0.9				
Sweet pepper variety "Narinj"							
Control	2.1	-	14.5	-	5.97	2.90	18.75
Fulvit	2.5	19.0	15.6	7.6	6.22	2.92	18.78
			$LSD_{0.05}$ 0.5				

*Composed by the authors.

Table 3. The economic efficiency of vegetable crops due to application of Fulvit fertilizer (per 1000 m^2)*

Variants	Total yield, centner	Gross product cost, thousand AMD	Production expenses, AMD	Net income, AMD	Profitability rate, %
Tomato variety "Lusarpi F_1"					
Control	95.0	3325	1950	1375	70.5
Fulvit	109.0	3815	1995	1820	91.2
Cucumber variety "Nazrvan 45"					
Control	94.0	4230	1780	2450	137.6
Fulvit	102.0	4590	1830	2760	150.8
Cucumber variety "Nare"					
Control		1920	995	925	92.9
Fulvit	106.0	2120	1050	1070	101.9
Sweet pepper variety "Loshtak"					
Control	16.4	4920	1950	2970	152.3
Fulvit	17.6	5280	1995	3285	164.6
Sweet pepper variety "Narinj"					
Control	14.5	5075	1950	3125	160.2
Fulvit	15.6	5460	1995	3465	173.7

*Composed by the authors.

Conclusion

The research results have testified that foliar nutrition with Fulvit fertilizer has had a positive effect on the biomorphological, biochemical properties, as well as on the yield capacity of tomato, cucumber and pepper crops ensuring high level of profitability.

It is recommended to use Fulvit organic liquid fertilizer during the agro-technological activities in organic crop production and seed breeding for the main vegetable crops in greenhouse conditions which will significantly promote organic yield and seed production.

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The Nutrition Effect on the Quantity and Quality of the Potato Yield in the Irrigated Conditions of Askeran Region in the Artsakh Republic

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ABSTRACT

The effect of nitrogen nutrition with different doses and application methods on the quantity and quality of potato yield in the irrigated conditions of the Askeran region of NKR was studied throughout 2018-2019. Four fertilization variants have been studied: manure 25 t/ha+P_{90} – background (control), background+ $N_{30+(35+35)}$ - pre-sowing and split nutrition, background+N_{100} - single nutrition, background+N_{120} - single nutrition.

As a result of conducted studies and estimations of economic efficiency, it has been disclosed that among the tested variants the highest gross and commercial yield was provided by the variant of background+ $N_{30+(35+35)}$, which amounted to 321.5 c/ha and 250.5 c/ha respectively. Meanwhile, 2.6 mln AMD profit has been resulted from the sale of marketable product.

Introduction

In the contemporary conditions the most urgent issue in the horticultural production is to meet the gradually rising requirements of the population towards the high-quality agricultural food supply. The solution of the food provision issue has an extremely important strategic significance for poverty elimination and for the improvement of human living standards. So, the key to its solution can be found in the enhancement of the cultivation efficiency for such agricultural crops as, for example, potato, which is factually considered to be “the second bread”. From this perspective the increase of the potato production sizes together with the development of cereal crop production sector can greatly promote the comprehensive solution of the problems in agri-food system.

Among the applied agro-technical events the establishment of scientifically justified fertilization system has an invaluable role in the increase of the potato yield capacity and its cultivation efficiency. Thus, the establishment of the abovementioned fertilization system is considered to be one of the extremely urgent tasks for the development of agriculture and increase of its production sizes in the Republic of Artsakh. Despite the fact that fertilization process is vital in the agro-technical measures of potato cultivation, the doses of the nurtured nitrogen shouldn’t be abused, which can cause a number of undesired consequences as it has been already proved by numerous research experiments of different scientists (Matevosyan,

Gyulkhasyan, 2000, Grigoryan, 1999, Vavilov, 1986).

A number of authors believe (Pfeffer, 1999) that in irrigated conditions high potato yield can be ensured only by applying 40 t/ha manure through the main fertilization method.

The trials conducted by B.V. Anisimov have testified that the highest efficiency of potato cultivation in the irrigated conditions of the Poltava region is provided upon the fertilization variant of $N_{120}P_{100}K_{90}$ (Anisimov, 2005).

Materials and methods

In the irrigated conditions of the Askeran region at the Artsakh republic we have studied the effect of various nutrition doses of nitrogen on the quantity and quality of the "Latino" potato variety. The studies were carried out within 2018-2019 and based on the agro-chemical indicators characteristic to the soils of the mentioned region the following fertilization variants have been tested:

1. Manure- 25 t/ha+P_{90}, which has been accepted as a background and taken as a control variant.
2. Background+$N_{30+(35+35)}$, out of which N_{30} had been introduced before the tubers planting, while the nutrition with 35 kg nitrogen was implemented twice during the vegetation period in two different time periods.
3. Background+N_{100} - with single nutrition.
4. Background+N_{120} - with single nutrition.

The experiments were set up with 4 repetitions in 4 variants upon the randomization principle and the estimated size of each experimental bed was 50 m^2, while the whole experimental plot was 800 m^2. During the vegetation period the treatment and harvesting activities in all experimental beds of each variant were carried out simultaneously and with the same principle, except for the nutritional doses of the nitrogen, which were provided according to the specifics of experimental variant selected by our research group.

Sturdy, undamaged 70 g-80 g potato tubers of "Latino" variety of the first reproduction have been selected as a planting material, which have been subjected to light germination for 28 days, the sprouts being amounted to 0.7-0.8 cm length (light germination was carried out under the 12 ^{0}C heating conditions and 70 % relative humidity). Planting was implemented in the third ten days of March (20.03 and 23.03 per study years) with the scheme of 70x30 and the study results are introduced in average indices.

Results and discussions

To study the efficiency of the recommended nutrition doses for the irrigated conditions of the Askeran region in the Artsakh republic and to identify the best variant, a number of phenological observations, measurements and weighing were conducted during the plants vegetation period. Based on the results of the aforementioned activities estimations on the economic efficiency were performed and the beneficial, as well as the most effective variant was identified. Particularly, the effect of nitrogen nutrition on the morphological indicators of the potato bush (plant height, the number of stems and leaves, leaf surface, etc.) was investigated, which alters significantly per variants (Table 1).

The table data testify that the bush height has increased together with the increase of nitrogen doses and exceeded the control variant by 9.7 cm-18.6 cm, besides the highest stem indicator has been recorded in N_{120} variant, which is quite an expected result, anyhow the similar growing

Table 1. The effect of nitrogen nutrition on a number of growing indicators in the surface parts of potato and its leaf surface (2018-2019)*

Variant	Bush height, cm	Ground-level stem diameter, mm	For one potato bush			Leaf surface in 1 ha, 1000 m^2
			Stems number, n	Leaves		
				Number, n	Leaf surface, cm^2	
Manure 25 t/ha+P_{90}-background	53.7	7.8	2.7	107.2	4150.5	197.5
Background +$N_{30+(35+35)}$	63.4	12.4	3.3	138.2	5880.7	279.8
Background +N_{100}	64.2	11.0	3.0	140.3	5907.4	281.2
Background +N_{120}	72.3	10.2	3.1	151.4	6875.4	327.3

*Composed by the author.

rate is absent in the stem diameter and its number. On the ground-level part the largest diameter and the greatest stem numbers per a plant have been recorded in the first experimented variant (Background+$N_{30+(35+35)}$), where the nutrition was carried out through split fertilization method by the end of sprouting phase and at the end of budding phase. In the second experimented variant (Background+N_{100}) the plant height is almost close to that of the previous variant exceeding only by 0.8 cm (64.2 cm), while regarding the stem diameter it lags behind the former variant by 1.4 cm. Despite the fact that in both variants N_{100} dose of fertilizer was totally introduced into the soil the significant differences in the mentioned indicators should be related only to the application times and methods of the fertilization in the soil.

The pre-sowing application of N_{30} promotes the intensive growth of the newly formed plant and the bush formation, while by the end of sprouting stage the nutrition with N demonstrates its beneficial effect on the stems growth and the increase of their number (3.3 stems). Regarding the other indicator (leaf number and leaf surface) the variant of N_{120} is unrivalled and such a high dose has promoted the plants stretching capacity and the increase in the leaf number and surface. The experimental doses of the nitrogen applied in the nutritional form have exerted their impact on the plants growth and on the duration of their developmental phase transitions, the results of which are introduced in Table 2.

According to the two-year average data of the experiments the planting of the tubers was implemented on March 21 and the germination in all variants was observed 19 days after planting, since the planting material had been subjected to the light germination beforehand, nevertheless starting from the budding phase, prolongation in the duration of the developmental phases together with the increase of nitrogen doses was observed. For example, if in the variant of the background+$N_{30+(35+35)}$ the transition phase between the tubers planting period up to the budding stage was prolonged by 11 days as compared to the same period observed in the control variant and up to the flowering phase-by 4 days against the control variant, then in the variant of background+N_{120} this difference was even more evident - by 14 and 13 days respectively, amounting to 92 and 99 days respectively. So, in accordance to these indicators the whole vegetation period of the plants was prolonged against that of the control variant by 6-15 days, totally amounting to 157-166 days.

The nutrition methods and doses of the nitrogen fertilizer have had a significant effect not only on the potato yield, but also on its quality and the quantity of the marketable tubers (Table 3).

Table 2. The effect of nitrogen nutrition on the potato growth, the duration times of developmental phase transition and on the vegetation period (2018-2019)*

Variant	Planting time	The duration of developmental phase transition (in days) from planting up to			
		Germination	Budding	Flowering	Natural death of haulms
Manure 25 t/ha+P_{90}-Background	21.03	19	78	86	151
Background +$N_{30+(35+35)}$	21.03	19	89	90	157
Background +N_{100}	21.03	19	88	91	158
Background +N_{120}	21.03	19	92	99	166

Table 3. The effect of nitrogen nutrition on the structural elements and yield capacity indicators in a potato bush (2018-2019)*

Variant	For a potato bush					
	Tubers number, n	Tubers weight, g				Tuber gross yield
		Total	Marketability			
			Large	Medium	Small	
Manure 25 t/ha+P_{90}-Background	5.7	505.7	131.3	198.7	175.7	240.2
Background +$N_{30+(35+35)}$	9.8	680.3	383.1	141.4	155.8	321.5
Background +N_{100}	8.2	631.2	311.7	139.2	180.3	298.8
Background +N_{120}	7.1	602.4	280.3	129.8	192.3	284.4

*Composed by the author.

Table 4. The economic efficiency of nitrogen nutrition in the potato sowings (2018-2019)*

Variants	Tubers' yield, c/ha		Commercial yield cost, thousand AMD	Sale price of 1c tuber, thousand AMD	Costs needed per 1 ha, thousand AMD	Profit per 1 ha, thousand AMD
	Gross	Commercial				
Manure 25 t/ha+P_{90}-Background	240.2	157.1	2043	13.0	574.0	1469
Background +$N_{30+(35+35)}$	321.5	250.5	3250	13.0	642.0	2608
Background +N_{100}	298.8	210.4	2730	13.0	634.0	2096
Background +N_{120}	284.4	190.7	2480	13.0	672.0	1808

*Composed by the author.

Regarding the number and weight of tubers formed per a potato bush the variant of background+$N_{30+(35+35)}$ is unrivalled, which has surpassed the control variant by 4.1 tubers and 174.6 g, while the other experimented variants stay behind the mentioned variant by 1.6-2.7 tubers and 49.1 g - 77.9 g respectively. Despite the fact that in the first and second experimental variants the doses of nitrogen are equal (N_{100}), they significantly differ by the resulted yield quantity and its marketability, the main reason of which is the time and method of fertilizer's application. In the variant of background+$N_{30+(35+35)}$, the fertilizer introduced with N_{35} dose in nutritional form at the end of germination phase, has had its positive impact on the intensive stem formation and further stolon formation processes. The remaining part of the nitrogen (N_{35}) introduced in the budding phase promotes the process of tuber formation and the emergence of the large tubers, which is clearly shown by the data of Table 3. Thus, in the best variant the lowest weight of small tubers formed per a bush is recorded which makes 155.8 g. In case of single nutrition with the dose of N_{100} not only a decrease in the resulted yield but also an increase in the weight of small tubers by 24.5 g (180.3 g) is recorded, meanwhile the weight of the large tubers have decreased by 71.4 g (311.7 g).

The further increase of the nitrogen dose (N_{120}) introduced into the soil in the single nutritional form leads not only to the decrease of the tuber yield, but also to the increase of the number and weight of the small tubers. Regarding the last indicator it has exceeded the best variant by 36.5 g and the control variant by 16.6 g.

To make sure that among all the tested variants background+$N_{30+(35+35)}$ is the most efficient and practical fertilization variant for agricultural production, an estimation for its economic efficiency has been also conducted and the size of the received profit has been determined, the results of which are summed up in Table 4.

The distinguished variant (background+$N_{30+(35+35)}$) exceeded all variants both in the gross yield and commercial yield quantity providing 321.5 c/ha and 250.5 c/ha yield respectively. Accepting that the sale price for one centner tuber is 13 thousand AMD, the cost of the marketable yield and the size of the received profit have been estimated as a result of which it has been revealed that the mentioned variant has provided 2.6 mln AMD profit. This number has surpassed that of the control variant by 1.2 mln AMD and the experimented variants - by 0.5-0.8 mln AMD.

Conclusion

Upon the results of the conducted research experiments it becomes clear that in the irrigated conditions of the Askeran region the variant of background+$N_{30+(35+35)}$ is considered to be the most efficient fertilization method for potato. It provides an unprecedentedly high profit per hectare and hence, is recommended to the farmers engaged in potato cultivation. So, as the potato yield grows up in case of applying the mentioned cultivation method the import sizes of potato from abroad can be significantly reduced as well.

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The Impact Study of Poline-Rich Polypeptide Galarmin D-15 Derivative on the Streptococci

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ABSTRACT

The antibody titer of the blood serum in the experimental animals treated with galarmin d-15 derivative of proline-rich polypeptide combined with inactivated streptococci has been evaluated according to the serological (precipitation) reaction. The investigated blood sera have been diluted in the physiological solution with the ratio of 1:5-1:20. It is worth mentioning that as a result of interaction with the antigen, blood sera, treated with galarmin derivative and inactivated streptococci, have generated precipitate in case of 1:5-1:20 dilution ratio, while in the control variant it has been marked in case of 1:5-1:10 dilution ratio. As a result of numerous experiments it has been found out that the galarmin derivatives are modulators for the activation of humoral and cellular immunities.

Introduction

Preventive measures taken against the contagious diseases of farm animals and socio- economic policy developed within the framework of combating such diseases have become urgent issues. The abovementioned is particularly true for streptococcal disease, since it is common for humans and animals.

Streptococci are widely spread in our environment, in the soil, as well as in the gastrointestinal tract of the sick and healthy animals. All mammals, birds and men are susceptible to the mentioned pathogenic bacterium (Grigoryan, 2002, Bessarabov, Vatutin, Voronin, 2007). Due to the stability and viability of the pathogens, they survive in the environment for 3-4 months, while in the purulence they maintain for 6 months.

Streptococci (chain of cocci) are found with great amounts in the internal organs of the animals stricken with streptostaphylococcosis, in the lungs of the animals sick with infectious and contagious pleuropneumonia, in the mammary glands of the mother animals infected with mastitis, in the lymphatic glands of the horses stricken with infectious lymphadenitis, in the muscular tissue, internal organs and blood of the animals infected with

foot rot (Paronychia contagiosa) and cause purulent foci.

The dairy and meat products, as well as internal organs and intestines of the animals afflicted with the aforementioned pathogens pose serious danger for humans.

The identification of the animals infected with streptococcus is implemented by means of serological (precipitation) reaction.

To promote the immunoreactivity in the organisms of the experimental animals there was a need to use the proline-rich polypeptide (PRP) galarmin secreted by the hypothalamus cells and its derivatives (Ala-Gly-ALg-Pro-Glu-Pro-Aala-Glu-Pro-Ala-Gln-Pro-Gly-Val-Tyt) (Galoyan, Aprikyan, 2003, Badalyan, Sargsyan, Galoyan, 2011).

It is noteworthy that PRP has been synthesized by the academician Galoyan and his co-workers in the Laboratory of Biochemistry, Neuroimmunology, Neurohormones and Analytical Chromatography after H. Buniatyan, NAS RA. It is a modulator for both humoral and cellular immunity, also for the differentiation of myelopoiesis and thymocytes as well as for the macrophage activation, as a result of which a great amount of protective antibodies are synthesized preventing the proliferation of the pathogenic bacteria penetrated into the organism (Galoyan, 1997, 2004, 2008, 2011, 2012). So, to increase the immunity in the animals' organism, the amount of immunoglobulins and cytokines, as well as the protective property of the blood serum, different stimulants have been used (Akiyama, Ishida, et. al, 1987, Huang, Nasr, et. al., 1992, Sargsyan, Galoyan, et. al, 2013, Sargsyan, Grigoryan, Galoyan, 2012, Sargsyan, Grigoryan, 2014, Sargsyan, 2015).

The aim of the current research is to study the immuno-stimulating effect of the derivative of PRP galarmin d-15 on the antibody titer of the blood serum in the experimental animals immunized with anti-streptococcal vaccine (Sargsyan, Grigoryan, 2015).

Materials and methods

The experimental works have been implemented at the ANAU research center of "Veterinary Medicine and Sanitary Expert Examination" and at the laboratory of "Biomedical Researches after H. Buniatyan".

For streptococci isolation the internal organs (spleen, liver, cordis, bone marrow), knee intra-articular fluid of two-month-old calves in four animal stocks died from streptococcosis and the milk of the cattle infected with mastitis have been sampled.

To determine the disease reproduction, virulence of the pathogen and the antibody titer of the serum, 36 stocks of 12-15-day-old mice with 15 g-18 g live weight and 18 guinea pigs at the age of 4-5 months with 400 g-500 g live weight have been selected.

To derive the microbial streptococcal (chain of cocci) isolates, glucose, blood, blood serum containing mediums (MPA and MPB) and the Barker mediums (Antonov, Borisova, Volkova, 1986, Nurazyan, 1988, Danielyan, 2002) have been used.

The morphological and antigenic characteristics of the streptococci have been determined in laboratory conditions based on the results of microscopic and micro-biological trials (Antonov, Borisova, Volkova, 1986, Nurazyan, 1988).

The amount of the antigen (streptococcus) has been determined through the bacteriological standard.The chain coccus of anti-streptococcosis vaccine has been inactivated with 0.3 % formaldehyde containing formalin solution. Inactivated glycerine anti-streptococcosis vaccine has been developed from the virulent endemic strains of the disease pathogen.

The vaccine safety has been tested on the experimental animals (mouse), while its purity – in an artificial nutritious medium.

The quantitative and qualitative changes of the formed blood elements have been examined through the generally acknowledged methods (Vasileva, 1982) and by means of immunoassay and hematological analyzers of the series *Star Fax 22400, Elecsys 2010 Roche (German) and Sysmex Xs-100i (Japan).

The lethal doses (LD50) of the streptococci have been identified on the 18 stocks of laboratory white mice with 15 g-18 g live weight, while the poison effect has been enhanced upon the decomposition of erythrocytes (Syurin, Belousova, Fomina, 1984).

The antigen (precipitogen) for the serological concentration determination has been produced from the tested streptococci, while the blood serum of the guinea pig (produced throughout the experimental activities) overimmunized with the appropriate antigen has been used as an antibody (precipitating serum) (Syurin, Belousova, Fomina, 1984, Nurazyan, 1988).

To promote the activity of anti-streptococcus serum the guinea pigs were intramuscularly injected with PRP galarmin d-15 derivative (25 μg per an animal) at the knee part (Figure 1).

Figure 1. Galarmin d-15 derivative.

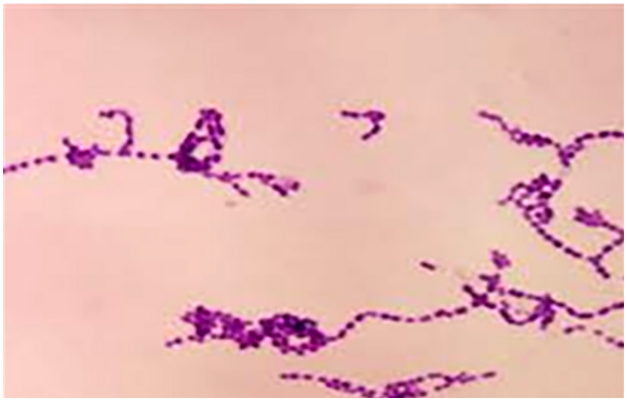

Figure 3. Streptococcus.

The antibody titer of anti-streptococcal serum was determined on the 7th -14th days of post infection period (Nurazyan, 1988). The investigated blood sera were diluted through physiological solution with the ratio of 1:5-1:40.

The effect of galarmin d-15 derivative and antibiotics on the streptococci was determined in vitro (Durgaryan, Matevosyan, Seferyan, Sargsyan, Grigoryan, Galoyan, 2011).

Results and discussions

As a result of microscopic investigations in the tissue smears received from the pathological materials and bacterial isolates, chain cocci with the size of 0.5-1.0 µm have been detected (Vorobyova, Bykova, 2003), while on the blood agar hemolytic zone round the bacterial colonies has been observed and in Barker's medium black colonies have been marked (Figures 2, 3).

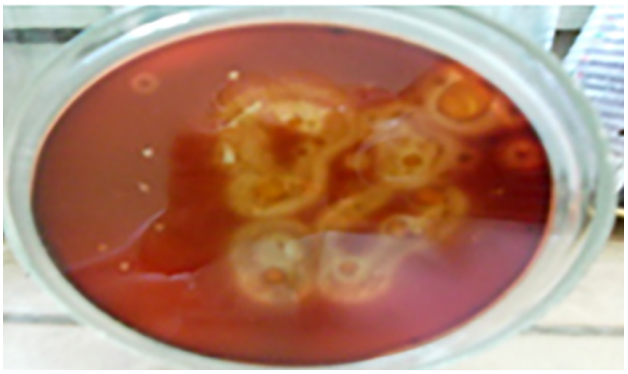

Figure 2. Blood agar (haemolysis).

Streptococci peculiar to the classical form have been detected in the smears produced from the mentioned colonies. The pathogenicity of the mentioned pathogen and the immune-stimulating activation of the galarmin d-15 derivative have been tested and determined in the white mice with 15 g-18 g live weight. The experimented mice were proportionally divided into three groups with 6 mice per a group.

The mice of the first group were injected with streptococcus (20-30 mln/mL), those of the second group were injected with galarmin d-15 derivative (10 µg /animal) combined with streptococcus (20-30 mln/mL) and the mice of the third group (control) were injected with physiological solution (1mL/animal) intramuscularly (Durgaryan, Matevosyan, Sferyan, Sargsyan, Grigoryan, Galoyan, 2011).

During the five-day post infectious period the mortality of the mice infected with 24 h. bacterial isolate made 83.3-91.6 %, while when treated with galarmin d-15 derivative combined with streptococci it made only 15-25 % (Figures 4, 5).

Taking into account the research results it should be mentioned that no morphological changes (size, concentration, colour) have been observed in the internal organs of the mice treated with the derivative of galarmin d-15 and streptococci. While the internal organs of the mice of the first and third groups have been subjected to modifications, and in the tissue smears produced from these organs, recruitments of the chain cocci have been recorded.

The results obtained during the research period testify that the galarmin d-15 derivative is endowed with immunoreactivity, which has inhibited the bacterial growth in the body of the mice infected with streptococci.

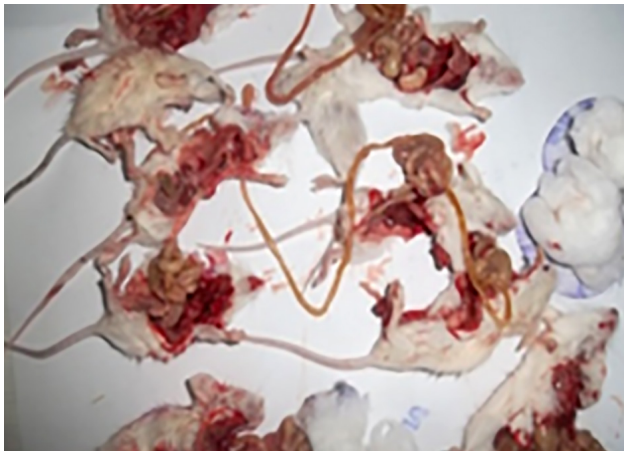

Figure 4. Mice infected with streptococcosis.

Figure 5. Galarmin d-15+inactivated streptococci.

Thus, the main objective of our research is to promote the activity of immunocompetent cells of the experimental animals treated with anti-streptococcal vaccine through the galarmin d-15 derivative which predetermines the amount of the synthesized antibodies and their immunogen activities.

So, 18 guinea pigs with 400 g-500 g live weight have been selected for our investigations. The guinea pigs have been similarly divided into three groups with 6 animals per a group. To enhance the vaccine activation the galarmin d-15 has been administered twice intramuscularly with 48 hours' interval.

The guinea pigs of the first group were injected with galarmin d-15 (25 µg /animal) combined with inactivated streptococci (2 bln/animal), the animals of the second group were treated with inactivated streptococci (2 bln/animal) and the pigs of the third group were injected with 0.9 % physiological solution (2 mL/animal) intramuscularly.

The immunity of the animals of the first and second groups was determined through the reinfection of the bacterial isolate with viable streptococci. Hence, the viability of the experimental animals treated with the vaccine and galarmin made 83.3 %, while that of the animals treated only with vaccine was 66.6 %.

The activity of the anti-bacterial serum, as well as the quantitative and qualitative changes of the formed blood elements have been evaluated on the 7th and 14th post-infection days (p. i.).

During the investigation considerable quantitative increase in IgG, lymphocytes, polymorphonuclear leukocytes and monocytes has been observed, which have exceeded the same index data in the animals of second (vaccinated with inactivated streptococci) and third (intact) groups in 2.2 times. From the diluted (1:5-1:40) blood serum of the animals treated with galarmin derivative and anti-streptococcal vaccine 0.3-0.5 ml mass was poured out into test-tubes and the same amount of hydrochloric acid antigen produced from the streptococci has been added in the tube.

As a result, the precipitate (grey-white cloud) of the blood serum in the animals of the first group was marked in case of 1:5, 1:10, 1:20 dilution, that of in the second group was fixed in case of 1:5 and 1:10 dilution, while in the third group it was excluded at all (Syurin, Belousova, et.al, 1984, Nurazyan, 1988, Sargsyan, 2015). It is noteworthy that the antibody titer of the blood serum in the animals treated with galarmin d-15 derivative was higher than the blood serum indices in the animals of other groups.

Conclusion

In the result of investigations it has been found out that galarmin d-15 derivative has increased the reactivity of the organisms in the experimental animals and a great amount of anti-streptococcal specific antibodies have been synthesized, which have been evaluated by means of serological reaction.

The timely detection of the disease pathogen and prevention of the streptococcosis propagation is a primary objective in the livestock and veterinary medicine sector.

The galarmin d-15 derivative has demonstrated bacteriostatic and the antibiotics have shown bactericidal characteristics In vitro.

Galarmin d-15 can be applied parallel to vaccination, which will increase the reactivity of the organism. The synthesized specific antibodies endowed with high antigenic properties will be used for diagnostic, therapeutic and preventive purposes.

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Dietary Exposure Assessment of Trans-Fatty Acids through Consumption of Ice-Cream in Yerevan, Armenia

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ABSTRACT

This study aims to assess the dietary exposure of trans-fatty (TFA) acids through the consumption of ice-cream in Yerevan. To this end, 24-hour dietary recall method is used to investigate the ice-cream consumption. TFA contents in ice-cream samples are determined using gas chromatography-mass spectrometry. On the average, people consume 0.018 g/day TFA through ice-cream for the whole year, while 0.111 g/day in summer. TFA intake through ice-cream consumption accounts for 0.007 % and 0.041 % of the total energy intake for a year and for summer season, respectively. Comparing with the WHO's threshold (less than 1 % of total energy), the daily intake of TFAs via ice-cream consumption during summer warrants some concerns.

Introduction

Trans-fatty acids (TFA) are unsaturated fatty acids with at least one double bond in the trans-configuration (Mozaffarian, et al., 2006; Pérez-Farinós, 2015). This configuration can come naturally from ruminant-based meat and dairy products, or artificially through partial hydrogenation of vegetable oils in the food industry and manufacturing processes (Mozaffarian, et al., 2006, Riobó, 2013). Several studies report that higher intakes of TFA increase the risk for heart disease, diabetes of type 2, infertility, obesity, Alzheimer's disease, allergy and certain cancers. Thus, it is recommended to reduce TFA in the diet (Delgado, et al., 2019, Takeuchi, 2017, Wang, et al., 2016, WHO, 2019).

World Health Organization (WHO) introduced the "Action Package to Eliminate Industrially Produced Trans-Fatty Acids" which recommends that the average intake of trans-fats should be less than 1 % of total energy (WHO, 2018). The first country regulating industrially produced TFA was Denmark, which in 2004 put into place a limit of 2 grams of TFA per 100 grams oils and fats in all foods (Stender, 2006). Meanwhile, in Canada, the average trans-fat intakes have been reduced to 1.42 % of overall energy (Ratnayake, 2009). In 2019, the EU also put into force regulations to limit industrially produced TFA to 2 grams per 100 grams of total fat in all foods (EC, 2019). Armenia is a member of the Eurasian Economic Union (EAEU) and in 2018 Technical Regulation that limits TFA to 2 %

in fats and oils came into force in member countries (CU TR 024/2011, 2013). However, studies shall be carried out to show if TFA needs to be regulated in other food products as well, that use fat and oil as their raw materials. From this perspective, TFA in ice-cream is a matter of concern since it is widely consumed among the local population, especially in the summer season. Previously no studies were conducted to evaluate the risks of TFA in ice-cream in Armenia. Hence, the present study aims to assess the dietary exposure of trans-fatty acids through the consumption of ice-cream.

Materials and methods

Sampling

Ice-cream was randomly sampled from the supermarkets of Yerevan. Then, 24-hour dietary recall survey was conducted that showed which are the most commonly consumed ice-cream products among the Yerevan population. Information regarding the most commonly consumed ice-creams among the sampled ones is presented in table 1.

Table 1. The most commonly consumed ice-cream products in Yerevan*

Ice-cream sample numbers	Producer/Brand name
I1	Ice-cream in a waffle cup "Grand Candy", Vanilla
I2	Ice-cream Vanilla "Tamara", cone
I3	Ice-cream "Ashtarak Kat", bourbon briquette
I4	Ice-cream Vanilla "Tamara", briquette
I5	Ice-cream Vanilla "Elite Shant" briquette
I6	Ice-cream "Ashtarak Kat" bourbon cone

*Composed by the authors.

Analysis of TFAs

Standard STB ISO 15304-2007 was used for the determination of trans-fatty acids in the selected food items (g/100 g of product) using gas chromatography-mass spectrometry (GC MS, Perkin Elmer) method (Pachytskaya, et al., 2015). This method is specially designed to evaluate the level of trans-isomers as formed during (high temperature) refining, or during hydrogenation of vegetable oils or fats. The analytical tests were performed by an independent accredited laboratory of "Standard Dialog" LLC. The determination of TFA content in samples was performed with three replications.

Data collection and statistical analysis

So, it has been already mentioned that 24-hour dietary recall method was used to investigate dietary consumption patterns of ice-cream among the Yerevan population. 1272 respondents aged from 18 to 65 took part in the survey. Data were analyzed by SPSS software (SPSS Ins., version 22.0). According to the survey results, only 90 respondents consumed ice-cream in the past 24 hours of the survey day. On the average, the daily intake of ice-cream throughout a year was 16.6 g, meanwhile, in the summer season it was 99.7 g. This number is the average for those who consumed ice-cream during the last 24 hours; therefore, it excludes those who haven't consumed it in the past 24 hours since the survey date.

Daily Intake of TFA

Daily intake (DI) of TFA (g/day) is calculated through the following equation:

$$DI = C \cdot IR, \quad (1)$$

where C is the mean content of TFA in all the studied ice-cream products (g in 100 g), IR is the daily consumption of ice-cream (g/day). In this study, DI was calculated in two ways - for all year round and for the summer season only. Correspondingly, daily consumption of 16.6 g is used to calculate the DI for a year, while 99.7 g is used to calculate it for the summer season.

The individual TFA intake as the percentage of total energy is calculated using the following equation (Liu, et al., 2015):

$$E\% = \frac{DI \cdot 9}{DE} \times 100, \quad (2)$$

where $E\%$ is the individual TFA intake as the percentage of total energy. DI is the individual TFA intake per day (g/day). The energy transfer index of TFA is 9 kcal/g. DE is the individual total dietary energy intake (kcal). Based on the ILCS-2016, the average Armenian consumes approximately 2420 kcal/capita/day (NSSRA/WB, 2016).

Results and discussions

Content of TFAs in Ice-Cream

The detected TFA contents are shown in table 2 as a percentage of the ice-cream. Since, according to the Customs Union Technical Regulation, fat content in ice-cream products cannot be above 12 % (CU TR 033/2013, 2013), 12 % was used as the TFA content in percentages in order to calculate TFA content in 100 grams of ice-cream.

Table 2. The contents of TFA in ice-cream*

Ice-cream sample numbers	Content of fat in ice-cream (%)	TFA content detected in ice-cream (%)	TFA content in ice-cream (g in 100g)
I1	12	1.2	0.144
I2		0.527	0.063
I3		1.4	0.168
I4		1.34	0.161
I5		0.08	0.009
I6		1.01	0.121
Average content of TFA in ice-cream products (g in 100 g)			0.111

*Composed by the authors.

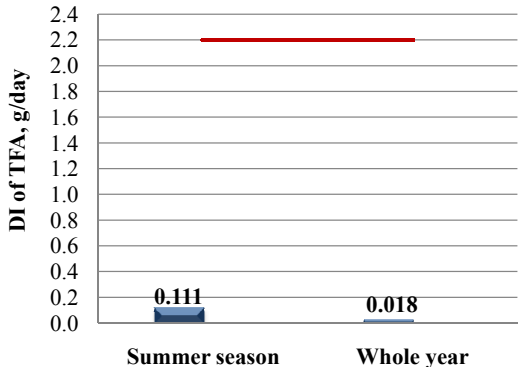

Figure 1. Daily intake of TFA via ice-cream consumption during the summer season and the whole year *(composed by the authors)*.

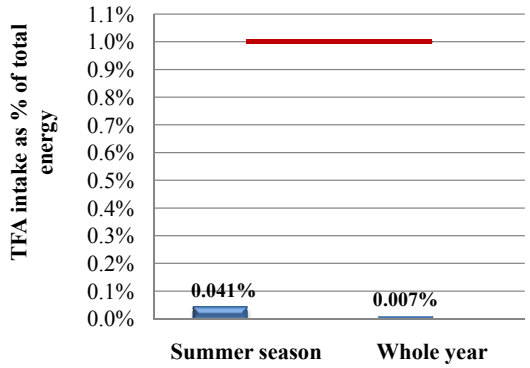

Figure 2. TFA intake through ice-cream consumption as the percentage of total energy *(composed by the authors)*.

The study results indicate that the TFA content in ice-cream samples range from 0.009 to 0.168 grams. Unfortunately, there is no regulation regarding TFA content in ice-cream in Armenia. Nevertheless, Armenia follows Customs Union Technical Regulation on Fat and Oil Products, according to which, starting from 2018, TFA content in margarine and milk fat replacers cannot be above 2 % (CU TR 024/2011, 2013).

To make a comparison with the study results of other countries, it can be highlighted that TFA content in Japanese ice-creams was on average 0.24 g, and was about two times higher than the average in the current study results (0.11 g). Similarly, according to the study carried out in Spain in 2015, the average TFA content in ice-cream was 0.271 g, that is, about two times higher than the presented results (Pérez-Farinós, et al., 2015). Moreover, a study carried out in Argentina indicated that TFA content in ice-cream ranged from 0.9 to 3.8 g (Kakisu, et al., 2018). Meanwhile, the content of TFA ranged from 1.1 to 1.9 g in Australian ice-creams (HY Wu, et al., 2017), which is again significantly higher than the current study results.

DI of TFA in Ice-Cream

In order to carry out a dietary exposure assessment, daily intake was calculated and compared with WHO's recommended level of less than 2.2 g/day for total TFA intake, which is equal to less than 1% of total energy intake (WHO, 2018). The results of this research indicate, that throughout the whole year the average TFA intake among the Yerevan population is estimated 0.018 g/day (Figure 1) and does not exceed the WHO limit of 2.2 g/day. Moreover, the obtained results reveal that on the average, during the summer season the Yerevan population has

approximately 0.111 g/day TFA intake through ice-cream consumption which is almost 6 times higher than the yearly average and does not exceed the WHO limit of 2.2 g/day. However, this number does not include people who reported that they did not consume ice-cream during the previous 24h according to the survey.

As the results indicate, TFA intake through ice-cream consumption accounts for 0.041 % and 0.007 % of the total energy intake for the summer season and for the whole year, respectively (Figure 2). The TFA intake obtained for the whole year didn't show a major health concern regarding the threshold (less than 1 % of total energy) recommended by WHO. Moreover, the TFA intake as a percentage of energy estimated for the summer season does not exceed the WHO's recommended threshold (WHO, 2018). This can be due to the relatively high level of ice-cream consumption in summer. Since there are other foods in Armenian's diet that can contain TFAs, the fact that ice-cream consumption alone exceeds the limit warrants some concerns.

Conclusion

The results of this study highlight the importance of investigations related to the daily intake of TFA through ice-cream consumption. This study indicates that the consumption of one product already contributes to the TFAs daily intake among the Yerevan adult population, however, does not exceed the WHO's recommended limit of less than 1 % of total energy. Moreover, the main outcomes of this study provided scientific evidence for the establishment of legislative requirements for the content of TFAs in ice-cream products. Besides, continuous monitoring on TFA contents should be performed that will also consider other food products of the population's diet. Meantime, efforts for reducing trans-fat intake must be implemented.

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