საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემია

GEORGIAN ACADEMY OF AGRICULTURAL SCIENCES

International Scientific Conference

„AGRICULTURAL MECHANIZATION AND TECHNOLOGY IN EUROPE AND PERSPECTIVES“

MAY 27-28, 2022, TBILISI, GEORGIA

PROCEEDINGS

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International Scientific Conference "Agricultural Mechanization and Technology in Europe and Pespectives", was organized by Union of European Academies for Science Applied to Agriculture, Food and Nature - UEAA and the Georgian Academy of Agricultural Sciences – GAAS (Tbilisi, Georgia).

International Scientific Conference

AGRICULTURAL MECHANIZATION AND TECHNOLOGY IN EUROPE AND PESPECTIVES

Date of the Conference: May 27-28, 2022
Tbilisi, Georgia

Working languages of the Conference is English and Georgia

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Givi Japaridze (Georgia)	Academician, Vice-President of Georgian Academy of Agricultural Sciences, Co - Chairman
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Marine Barvenashvili (Georgia)	Doctor, Georgian Academy of Agricultural Sciences

CONFERENCE PROGRAM

May 26, 2022,

Arrival in Tbilisi;
Dinner at the Hotel.

May 27, 2022,

11:30 – 12:00 Registration of participants (Tbilisi Time)

10:00 – 11:00 Paris Time (P.t)

12:00 – 13:00 Tbilisi Time (T.t.) Opening of the International Conference; Greetings

11:00 – 11:30 Paris Time (P.t)

13:00 – 13:30 Tbilisi Time (T.t.) Coffee & tea break (GAAS)

11:30 – 15:30 Paris Time (P.t)

13:30 - 18:00 Tbilisi Time (T.t.) Plenary Session;

May 28, 2022 (Tbilisi Time)

10:00 – 11:55 Plenary Session;

12:00 - 12:30 Coffee & tea break

12:30 – 14:35 Plenary session

14.35 – 15.00 Coffee & tea break

15.00 – 16.35 Plenary session

16.35 – 17:25 Closing of the Conference, Declaration

May 29, 2022,

Departure of participants.

CONFERENCE OPENNING

Guram Aleksidze – President of UEAA, President of Georgian Academy of Agricultural, Sciences, Academician.

WELCOMING SPEECHES – ADDRESSES

- **George Kvesitadze – Academician, President of Georgian National Academy of Sciences;**
- **Michel Thibier (France) - Professor, French Academy of Agiculture;**
- **George Khanishvili – First Deputy Minister of Enviromental Protection and Agriculture of Georgia;**
- **Iveri Akhalbedashvili – Dr., Parliament of Georgia;**
- **Omar Kacharava – Dr., Ministry of Enviromental Protection and Agriculture of Georgia;**
- **Levan Ujmajuridze – Prof., Director of the Scientific-Research Center of Agriculture;**
- **Bakur Gulua - Patriarchate of Georgia.**

INTERNATIONAL SCIENTIFIC COMMITTEE

Name, Surname	Position
Guram Aleksidze (Georgia)	Academician, President of Georgian Academy of Agricultural Sciences, Chairman of Scientific Committee
Givi Japaridze (Georgia)	Academician, Vice-President of Georgian Academy of Agricultural Sciences, Co - Chairman
Michel Thibier (France)	Professor, French Academy of Agriculture; Co – Chairman of the Scientific Committee
Baiba Rivza (Latvia)	Professor, President of Latvian Academy of Agricultural and Forestry Science, Co - Chairman
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Simone Orlandinni (Italy)	Professor, University of Modena and Reggio Emilia, Member of the Academy of Georgofili
Ioan Jelev (Romania)	Professor, Vice - President of Romanian Academy of Agricultural and Forestry Sciences
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Vilem Podrajski (Czech Republic)	Professor, Vice-President of Czech Academy of Agricultural Sciences
Kerstin Niblaus (Sweden)	Professor, Royail Swedish Academy of Agriculture and Forestry Sciences
Elgudja Shapakidze (Georgia)	Academician, Head of the Academician Department of Georgian Academy of Agricultural Sciences
Revaz Makharoblidze (Georgia)	Academician, Academician-secretary of the Agroengineering scientific department of the Georgian Academy of Agricultural Sciences
Anatoli Giorgadze (Georgia)	Academician, Georgian Academy of Agricultural Sciences

Content

Introduction

Brief Information about History of Mechanization and Nowadays Situation in Georgia

Guram Aleksidze – Academician, President of Georgian Academy of Agriculture Sciences (GAAS), Tbilisi, Georgia;
President of Union of European Academies for Science Applied to Agriculture, Food and Nature (UEAA);
E-mail: guram_aleksidze@yahoo.com;

The importance of holding an international scientific conference in agriculture mechanization in the conditions of independent Georgia is especially great. Application of modern machine technologies will significantly contribute to raising the prestige of Georgian agricultural products in the international arena; it will promote entering and establishing its agricultural product in European markets, which is extremely important for the country's economy.

Georgia's agricultural mechanization system was, and is still mainly tied to the foreign machine system. We have direct use of imported tractors and agricultural machines, maintain their modernization and adjustment to zonal conditions, according to the technological features of crop maintenance.

At the same time, a set of original machines were created and produced for the care and cultivation of separate crops, such as tea. The share of agricultural machines created and produced in Georgia today in the system of complex mechanization system should be increased sharply as compared to the previous years.

In addition, it should be considered that due to the establishment of agricultural farms**,** the demand for agricultural machinery has increased, both in terms of quantity and in terms of assortment. At the same time, there is a greater demand for the machines of small and medium size power, including energy-technical means of small-scale mechanization.

Therefore, it is very important to determine the optimal ratio of energy resources and agricultural machinery in the system of complex mechanization of agricultural production in Georgia.

In this regard, the machine technologies for the care and cultivation of agricultural crops and the machine system should be developed as soon as possible in Georgia, taking into account the diversity of agriculture in both the state and regional contexts.

Considering currently existed economic difficulties, in the first place, the development and production of agricultural machinery that has no foreign counterparts should be financed.

This primarily applies to mechanization machines for tea care, as well as set of machines for the maintenance of vineyards and orchards. At the same time, when working on development of those machines, the modern world tendencies and, first of all, of Europe in development of agricultural machinery, should be taken into account.

In particular, the new generation of machines must have replaceable working bodies, should be quickly adjustable, based on the principles of block-model design, universalization and unification. In a word, adaptive energy means and agricultural machines should be created, which can be easily adapted to different agro and zonal conditions.

In addition, in order to reduce the number of imported tractors from abroad, various types of tractors need to be developed with more powerful medium-sized mobile units using block-model, bridge, tandem, catamaran and other schemes to create foundation for more powerful, mobile, energetic technical means.

An international conference on the use of agricultural machinery and modern technologies in Europe is one of the most necessary, effective events, and it could be a means to realize the economic potential of the field of agro-engineering. The Conference will be attended by scientists from the Union of European Academies of Agriculture, Food and Nature (UEAA), agro-engineering specialists from European countries, such as France, Italy, Spain, Germany, Sweden, Czech Republic, Slovakia, Ukraine, Lithuania, Latvia, etc, in which agricultural machinery is developed at a high level;

The agricultural machinery of these countries has been successfully operating and serving Georgian agriculture for many years after the restoration of Georgia's independence. Sharing the experience of UEAA member countries will be very useful for scientists and specialists working in the field of agro-engineering in Georgia, also for farmers, private agricultural companies and organizations, where the emphasis is mainly made on agricultural machinery produced abroad and on modern plant care technologies.

At the same time I would like to briefly present some important historical facts confirmed by archeological excavations on the territory of Georgia that from ancient times the first bronze and then iron tools for tillage were successfully made and used in the South Caucasus.

Bronze metallurgy reached a fairly high stage of development in the 2nd millennium. Agricultural tools, such as, hoe, ax, hammer are known to be widely used in Georgia.

In one of the ancient Georgian archaeological sites, Ergeti, 140 hoes, along with other iron items, were found. Harvesting agricultural tools are well represented; those are bronze, iron and flint sickles, pounders, grinders, pressures, and more.

The study of archeological material found on the territory of Georgia confirmed that the development of copper-bronze metallurgy in Georgia dates back to 4th millennium B.C. and different types of weapon and agricultural tools were made from copper and bronze.

During that period, land-cultivating tools and the world-famous Colchian axe appeared. On the territory of Colchis, many mining and metallurgical centers existed which in ancient times supplied metal products not only to the Kingdom of Colchis, but also to neighboring countries.

Iron metallurgy (Iron Age) was promoted from the middle of the 2nd millennium.

Ancient Jewish, Assyrian texts, as well as Greco-Roman sources indicate that Asia Minor - the world of the Caucasus people - was one of the first places where iron production was born and developed.

Professor of the University of Vienna D. F. Zippe, names the Chalyb kingdom as one of the countries famous for its iron production. Pseudo-Aristotle provides similar information. The ancestors of the Georgians - the Subaru tribes, who occupied the territory from northern Mesopotamia to the Caucasus, began to use iron in the middle of the second millennium; they were well known for production of metal. According to many foreign scholars' opinion, the Black Sea coast, in particular, the Pontus region was the center of processing of some non-ferrous and ferrous metals, and the Kartvelian (Georgian) tribes Khalibs, Mosiniks and Tabals were the first producers of these metals all over the world. From this period also begins the replacement of the bronze hoes used for soil tillage with the iron ones, which were much more solid than its predecessor was.

Later, in the Early Bronze Age, in the period -from the 4th millennium to the first half of the 1st millennium BC - development of metallurgy reached a high level and both - agricultural tools and weapon were produced from local raw materials.

In the Middle of Bronze Age, in the second half of the 3rd millennium, when production of metal tools was well- developed, a wide application of soil tillage tools started. During the same period, Georgian aboriginal wheat varieties, grape seeds, nuts and other crops present direct evidence.

During this period, some aboriginal vine varieties "Mtsvane", "Rkatsiteli" were known, and the seeds of those ancient vine varieties are found on the territory of Georgia. Some semi-circle (hooked) iron knives for punning vine are also found, dating back to the same period, which once again indicates to the development of viticulture and fruit growing in this region.

In conclusion, I would like to once again greet conference participants and wish success to each of you in your work; also I want to assure you that what you are doing in mechanization of agriculture in your country is one of the key factors in the further development of this field, and therefore in the provision of food to world population.

მოკლე ინფორმაცია მექანიზაციის ისტორიის და დღევანდელი მდგომარეობის შესახებ

გურამ ალექსიძე - აკადემიკოსი, საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემიის (GAAS) პრეზიდენტი, თბილისი, საქართველო;

ევროპის სოფლის მეურნეობის, სურსათისა და ბუნებათსარგებლობის აკადემიების კავშირის (UEAA) პრეზიდენტი.

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განსაკუთრებით დიდია საერთაშორისო სამეცნიერო კონფერენციის ჩატარების მნიშვნელობა დამოუკიდებელი საქართველოს პირობებში. იგი დიდად შეუწყობს ხელს საერთაშორისო არენაზე თანამედროვე სამანქანო ტექნოლოგიების გამოყენებით ქართული სასოფლო-სამეურნეო პროდუქციის ავტორიტეტის ამაღლებას, ევროპის ბაზრებზე შესვლას და დამკვიდრებას, რაც მნიშვნელოვანია ქვეყნის ეკონომიკისათვის.

საქართველოს სოფლის მეურნეობის კომპლექსური მექანიზაციის სისტემა ძირითადად მიბმული იყო და არის საზღვარგარეთის მანქანათა სისტემაზე. ჩვენთან ხდება შემოტანილი ტრაქტორებისა და სასოფლო სამეურნეო მანქანების უშუალო გამოყენება ან მათი მოდერნიზაცია და მორგება ზონალურ პირობებზე, გამომდინარე კულტურების მოვლა- მოყვანის ტექნოლოგიური თავისებურებებიდან.

პარალელურად ცალკეული კულტურების (ჩაი) მოვლა-მოყვანისთვის იქმნებოდა და მზადდებოდა ორიგინალური მანქანათა კომპლექსები. თანამედროვე პირობებში საქართველოში შექმნილი და დამზადებული ენერგეტიკული საშუალებების და სასოფლო-სამეურნეო მანქანების ხვედრითი წილი კომპლექსური მექანიზაციის მანქანათა სისტემაში, ადრინდელთან შედარებით, მკვეთრად უნდა გაიზარდოს.

ამასთან, მხედველობაშია მისაღები, რომ გლეხური (ფერმერული) მეურნეობების ჩამოყალიბების კვალობაზე კიდევ უფრო გადიდდა მოთხოვნა სასოფლო-სამეურნეო ტექნიკაზე, როგორც რაოდენობრივი, ისე ნომენკლატურული თვალსაზრისით. ამასთან, უფრო მეტი მოთხოვნაა საშუალო და მცირე სიმძლავრის, მათ შორის მცირე მექანიზაციის ენერგო-ტექნიკურ საშუალებებზე.

აქედან გამომდინარე მეტად აქტუალურია განისაზღვროს საქართველოს სოფლის მეურნეობის წარმოების კომპლექსური მექანიზაციის მანქანათა სისტემაში ადგილზე

დასამზადებელი და შემოსატანი ენერგეტიკული საშუალებებისა და სასოფლო-სამეურნეო მანქანების ოპტიმალური თანაფარდობა.

ამასთან დაკავშირებით რაც შეიძლება მოკლე ვადებში უნდა დამუშავდეს საქართველოში გავრცელებული სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანის მანქანური ტექნოლოგიები და მანქანათა სისტემა როგორც სახელმწიფო, ისე რეგიონალურ ჭრილში მეურნეობრიობის მრავალფორმიანობის გათვალისწინებით.

ამჟამინდელი ეკონომიკური სიძნელეების პირობებში უნდა დაფინანსდეს ისეთი სასოფლო-სამეურნეო ტექნიკის დამუშავება და დამზადება, რომელთაც საზღვარგარეთული ანალოგი არა აქვთ.

პირველ რიგში ეს ეხება ჩაის მოვლა-მოყვანის კომპლექსური მექანიზაციის მანქანებს, ასევე ვენახებისა და ხეხილის ბაღების მოვლა-მოყვანის მანქანების კომპლექსებს. ამასთან, მათი დამუშავების დროს გათვალისწინებული უნდა იქნეს მსოფლიო და პირველ რიგში ევროპის სასოფლო-სამეურნეო მანქანათმშენებლობის განვითარების ტენდენციები.

კერძოდ, ახალი თაობის მანქანები უნდა იყოს საცვლელ მუშაორგანოებიანი, სწრაფად გადაწყობადი, შექმნილი ბლოკ-მოდულური პროექტირების, უნივერსალიზაციის და უნიფიკაციის პრინციპების საფუძველზე. ერთი სიტყვით, უნდა შეიქმნას ადაპტური ენერგეტიკული საშუალებანი და სასოფლო-სამეურნეო მანქანები, რომლებიც ადვილად მოერგებიან სხვადასხვა აგროფონს და ზონალურ პირობებს.

ამის გარდა, ტრაქტორების ნომენკლატურისა საზღვარგარეთიდან შემოსატანი ტრაქტორების რაოდენობის შესამცირებლად დასამუშავებელია საშუალო და მცირე სიმძლავრის ტრაქტორებისა და მათი ენერგეტიკული ნაწილისაგან ბლოკ-მოდულური, „ხიდური“, “ტანდემი“, „კატამარანი“ და სხვა სქემებით უფრო მძლავრი მობილური ენერგეტიკული საშუალებების შექმნის საფუძვლები.

ევროპაში სასოფლო-სამეურნეო მექანიზაციის ტექნიკური საშუალებების და თანამედროვე ტექნოლოგიების გამოყენებისადმი მიძღვნილი საერთაშორისო ღონისძიების - საერთაშორისო კონფერენციის ჩატარება ერთ-ერთი მეტად საჭირო, ეფექტური ღონისძიება და საშუალებაა აგროინჟინერიის დარგის ეკონომიკური პოტენციალის რეალიზების თვალსაზრისითაც. მის მუშაობაში მონაწილეობას მიიღებენ ევროპის სოფლის მეურნეობის, სურსათისა და ბუნებათსარგებლობის აკადემიების კავშირის (UEAA) მეცნიერები, აგროსაინჟინრო დარგის სპეციალისტები ისეთი ქვეყნებიდან, როგორიცაა საფრანგეთი, იტალია, ესპანეთი, გერმანია, შვედეთი, ჩეხეთი, სლოვაკეთი, უკრაინა, ლიეტუვა, ლატვია და ა.შ., სადაც მაღალ და თანამედროვე დონეზეა სასოფლო-სამეურნეო მანქანათმშენელობა.

აღნიშნული ქვეყნების სასოფლო-სამეურნეო ტექნიკა საქართველოს დამოუკიდებლობის აღდგენის შემდეგ მრავალი წელია წარმატებით მუშაობს და ემსახურება საქართველოს სოფლის მეურნეობას. UEAA-ს წევრი ქვეყნების მეცნიერების გამოცდილების გაზიარება მეტად სასარგებლო იქნება საქათველოს აგროსაინჟინრო სფეროში დასაქმებული მეცნიერებისა და სპეციალისტებისათვის, ფერმერებისათვის, კერძო სასოფლო-სამეურნეო კომპანიებისა და ორგანიზაციებისათვის, სადაც ძირითადად საზღვარგარეთ დამზადებულ სასოფლო-სამეურნეო ტექნიკურ საშუალებებზე და მცენარეთა მოვლა-მოყვანის თანამედროვე ტექნოლოგიებზეა გადატანილი აქცენტები.

მინდა რამდენიმე სიტყვით შევეხო საქართველოს ტერიტორიაზე არქეოლოგიური გათხრებით დადასტურებულ ფაქტს, რომ უძველესი დროიდან სამხრეთ კავკასიაში

წარმატებით მზადდებოდა და გამოიყენებოდა ჯერ ბრინჯაოს, ხოლო შემდეგ ნიადაგის დასამუშავებელი რკინის ხელსაწყოები.

მე-2 ათასწლეულში განვითარების საკმაოდ მაღალ საფეხურს აღწევს ბრინჯაოს მეტალურგია.

საქართველოში სამეურნეო იარაღებიდან ცნობილია თოხი, ცული, ნამგალი. ამ პერიოდში ეკონომიკურად საგრძნობლად წინაურდება კოლხეთი. რკინის სახნისი ფართოდ გამოიყენება, რამაც მნიშვნელოვანი გარდატეხა მოახდინა მიწათმოქმედებაში. ამ დროს წარმოდგენილია მიწის დამუშავებასთან დაკავშირებული რკინის იარაღები-თოხი, სახნისი და სხვა. ერგეტის ერთ-ერთ კოლექტიურ სამარხში რკინის სხვა ნივთებთან ერთად 140 თოხი აღმოჩნდა. კარგადაა წარმოდგენილი მოსავლის აღებასთან დაკავშირებული იარაღები-ბრინჯაოს, რკინის და კაჟის ნამგლები, ხელსაფქვავები, სანაყები, სასრესები და სხვა.

არქეოლოგიური მასალის შესწავლამ დაადასტურა, რომ მეტალურგიას უძველეს დროში ჩაეყარა საფუძველი. ძვ.წ. IV ათასწლეულიდან საქართველოს ტერიტორიაზე იწყება სპილენძ-ბრინჯაოს მეტალურგიის განვითარება. მისგან ამზადებდნენ საომარ და სამეურნეო იარაღს. გაჩნდა მიწის დასამუშავებელი იარაღი და საქვეყნოდ ცნობილი კოლხური ცული. კოლხეთის ტერიტორიაზე გამოვლენილია მრავალი სამთო-მეტალურგიული კერა, რომელიც ანტიკურ ხანაში ლითონის პროდუქციით ამარაგებდა არა მარტო კოლხეთის სამეფოს, არამედ მეზობელ ქვეყნებსაც.

II ათასწლეულის შუა წლებიდან დაწინაურდა რკინის მეტალურგია (რკინის ხანა).

ებრაელთა ძველ მატიანის, ასურეთის ტექსტების, აგრეთვე ბერძნულ-რომაული წყაროებიდან ჩანს, რომ მცირე აზია - კავკასიის სამყარო - ერთ-ერთი პირველთაგანია, სადაც ჩაისახა და განვითარდა რკინის წარმოება. ვენის უნივერსიტეტის პროფესორი დ. ფ. ზიპე რკინის წარმოებით განთქმულ ქვეყნებს შორის ასახელებს ხალიბთა ქვეყანას. ასეთივე ცნობებს გვაწვდის ფსევდოარისტოტელეც. ქართველთა წინაპრებმა - სუბარულმა ტომებმა, რომლებსაც ჩრდილოეთ მესოპოტამიიდან კავკასიონამდე არსებული ტერიტორია ეჭირათ, რკინის გამოყენება II ათასწლეულეულის შუა ხანებში დაიწყეს; მათი მელითონეობა საქვეყნოდ იყო განთქმული. უცხოელ მეცნიერთა შორის დღესაც დამკვიდრებულია აზრი იმის შესახებ, რომ შავიზღვისპირეთი, კერძოდ კი პონტოს რაიონი, წარმოადგენდა ზოგიერთი ფერადი და შავი ლითონის დამუშავების ეპიცენტრს, ხოლო ქართველური მოდგმის ტომები ხალიბები, მოსინიკები და თაბალები ამ ლითონების პირველმწარმოებლები ყოფილან მთელ მსოფლიოში. ამ პერიოდიდან იწყება აგრეთვე მიწის დასამუშავებელი იარაღების ბრინჯაოს თოხების შეცვლა რკინის თოხებით, რაც გაცილებით მყარი იყო მის წინამორბედთან შედარებით.

საქართველოს ტერიტორიაზე აღმოჩენილი რკინის იარაღები მაღალი თვისებებით ხასიათდება. აქ ადრევე იყენებდნენ დაბალ, საშუალო და მაღალნახშირბადიან რკინას (ფოლადს).

ისტორიული წყაროების მიხედვით საქართველოს ტერიტორიაზე ძვ. წ. VIII ათასწლეულში, ქვის ხანის პერიოდში მიწათმოქმედების კულტურაში (ხორბლის, ქერის) დასამუშავებლად გამოიყენებოდა თოხები დამზადებული ძვლისა და ქვისგან.

უფრო მოგვიანებით, ადრეულ ბრინჯაოს ხანაში ძვ. წ. IV ათწლეულიდან ვიდრე ძვ. წ. I ათწლეულის პირველ ნახევრამდე მაღალ განვითარებას აღწევს მეტალურგია, რომელიც დაფუძნებული იყო ადგილობრივ ნედლეულზე, როგორც საბრძოლო ასევე

სამეურნეო იარაღები. ამავე პერიოდში, დასავლეთ საქართველოში უკვე ლითონის ნიადაგის დასამუშავებელი იარაღები იქნა ნანახი.

შუა ბრინჯაოს ხანაში, ძვ. წ. III ათწლეულის მეორე ნახევარში ძლიერად განვითარებულ მელითონეობასთან ერთად მიწის დასამუშავებლი ხელსაწყოების გამოყენება იწყება. ამ პერიოდში ნანახია ხორბლის ქართული აბორიგენული ჯიშები, ყურძნის წიპწები, თხილი და სხვა.

ძვ. წ. IX-VIII საუკუნეებიდან აღმოსავლეთ ამიერკავკასიაში რკინის ფართო ათვისების ხანა დგება, ბრინჯაოს ხელსაწყოები იცვლება და რკინის ნაკეთობებზე, მათ შორის სასოფლო-სამეურნეო იარაღებიც, რაც ადგილობრივი ნედლეულით იქმნებოდა. როგორც ჩანს ნიადაგის მოხვნისათვის უკვე ლითონის კავია გამოყენებული, ნიადაგი ამ შემთხვევაში უკეთესად (ღრმად) იხვნებოდა და ინტენსიურად მუშავდებოდა. ფართოდ იყო გამოყენებული ნიადაგის მორწყვა, ირიგაცია არხებით. მოსავალს კევრით ლეწავდნენ, იყენებდნენ ხელსაფქვავებს ხორბლისა და ქერის დასაფქვავად. ნამგლები მემცენარეობის გარდა გამოიყენებოდა ბალახის მოსათიბად. ამ პერიოდში ცნობილი იყო ვაზის ჯიშები „მწვანე“, „რქაწითელი“, ნანახია მათი წიპწები. ვაზის სასხლავად გამოყენებულია რკინის მოღუნული დანები, რაც მევენახეობის და მეხილეობის განვითარებაზე მიუთითებს.

ასეთი მოკლე ექსკურსის შემდეგ მინდა ერთხელ კიდევ მოგესალმოთ და გისურვოთ წარმატება კონფერენციის თითოეულ წევრს თქვენს საქმიანობაში და დაგარწმუნოთ, რომ ის რასაც თქვენ აკეთებთ მექანიზაციის ხაზით თქვენს ქვეყანაში, არის ერთ-ერთი ძირითადი ფაქტორი სოფლის მეურნეობის შემდგომი განვითარების და შესაბამისად მოსახლეობის სურსათით უზრუნველყოფის საქმეში.

Interaction between the French Academy of Agriculture and the Union of European Academies for Sciences applied to Agriculture, Food and Nature (UEAA)

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ABSTRACT

The **Union of European Academies for Sciences applied to Agriculture, Food and Nature** (UEAA) was created in October 2000 by 14 National Academies, both from European Union members and from countries external to it, all committed to the advancement of science in Europe.

The **French Academy of Agriculture** was with the Italian Academy of Georgofili a founder of UEAA 22 years ago.

The French Academy of Agriculture, established in 1761 by the King Louis XV, is committed to inform the French Government and the public opinion of progresses in all aspects of agricultural sciences. *"A passion for knowledge, a passion for transmission"*, words that are inscribed in the French Academy of Agriculture motto to translate the wealth of skills and knowledge of its members. A regular public session meeting is being held every Wednesday afternoon , in the premises of the Academy and which is also recorded and available to the public by internet on www.academie-agriculture.fr

Regarding the UEAA, the European Academies at creation have indicated among their main objectives *to foster* comparative studies on a European scale *regarding the development* and dissemination of knowledge *and the* innovation and sustainable development of *agriculture, land use and food supply.*. There are now 31 members from countries within the E U and also external to it which gives a comparative advantage to the UEAA. The President and the Vice President are elected. The current President is Professor Guram Aleksidze from Georgia and the Vice President from Slovakia is Professor Elena Horska.

Thanks to the commitment and the dynamism of the President Aleksidze and of the Steering Committee members, UEAA has recently been proactive to the E U Commission regarding the E U Forestry strategy and also on the issue of Gene Editing. By the same token, UEAA has set up a new "Best Abstract" scientific competition opened to all UEAA members and also now publishes a monthly Newsletter.

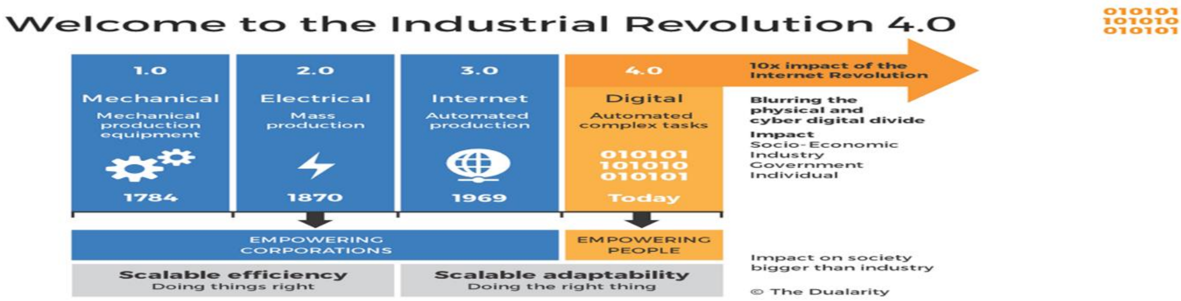
The UEAA has many comparative advantages having under the same hat more than 30 European Academies of Agriculture with hundreds of high-level scientists and Academicians ready to give wise recommendations to the politicians involved in management of Agriculture, particularly in the context of research and innovation which are critical for the future of the European Agriculture industry in such a global world as ours.

Smart Farming Industry in Agriculture: Latvian Case

Baiba Rivža – Dr.**,** Professor, **Peteris Rivza –** Dr., Professor,
Latvia University of Life Science and Technologies

New cycle of Industry 4.0

- **The new cycle of Industry 4.0 and digitalisation** affect the entire society – it means the **creation** of **new technologies**, software, and it also means the use of the technologies and the **development of a new type of labour force** and the training of it.
- This process has to be started **from the kindergarten** and, and it is very natural to continue integrating the knowledge of the new industrial cycle into education at **general and vocational schools and universities**.



A WISER AND MORE MODERN AND SUSTAIBALE CAP

- **Technological advancement and digitalisation** allows sharply increasing the efficiency of resource use, thereby contributing to smart agriculture in terms of environment and climate, which decreases environmental/climate impacts of agriculture, contributes to the resilience and health of soil and lowers costs for farmers.
- However, the introduction of new technologies in agriculture has still not reached the projected level and is **unevenly available throughout the EU.**

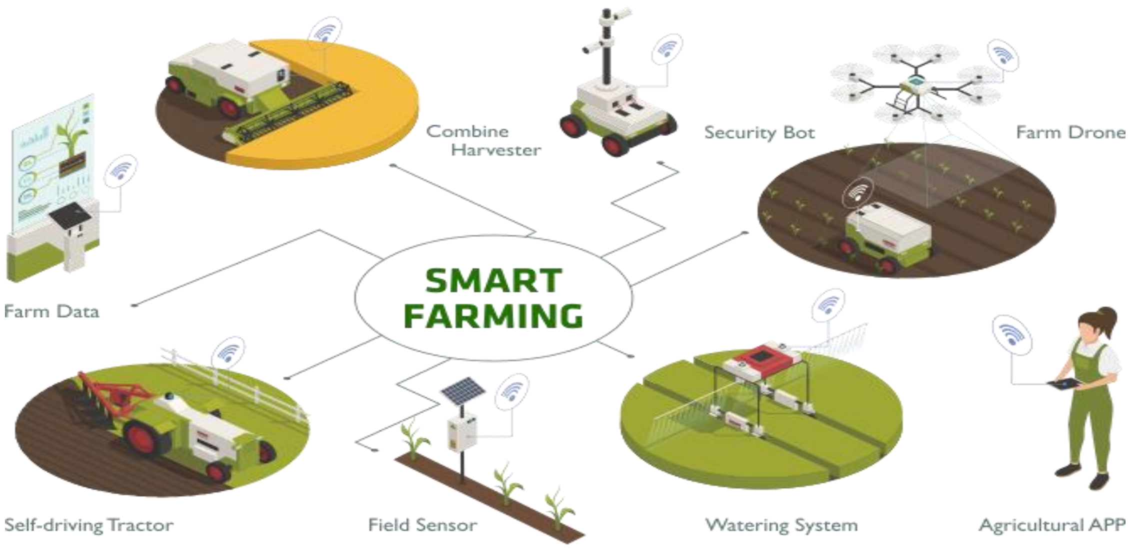
- Focus has to be placed also on ensuring the **accessibility** of **technologies** to small and medium farms.

The challenges of smart farming

- The challenge for all of us is to ensure climate and environmental sustainability. In agriculture, this can be done with precision farming and modern technology. Precise agriculture, including increasing business efficiency, goes hand in hand with caring for the environment. We need to be aware that the latest technologies and artificial intelligence are rapidly entering our daily lives and the agricultural sector is no exception. We can already see that the knowledge of Latvian farmers about precise agriculture and its application is growing.
- Farm and farm managers understand that precision farming is neither a fear nor a magic wand to make decisions for agronomists, but a means to realize agronomists' goals and increase efficiency and yields.

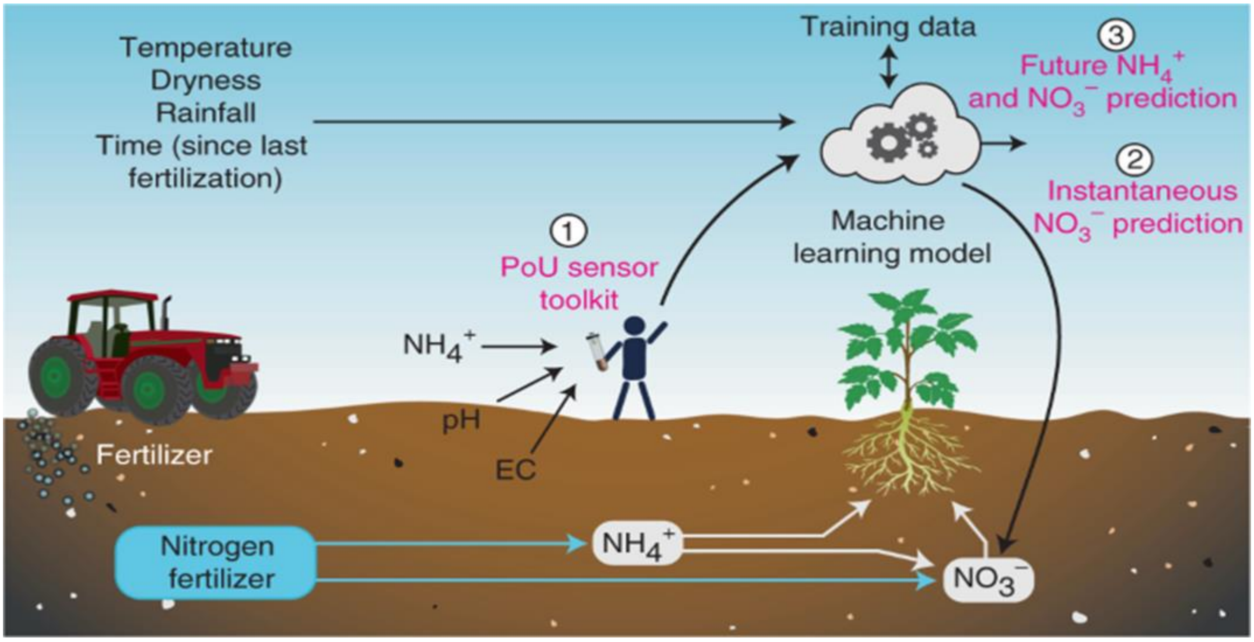
Smart agriculture in Latvia

- Latvia's large farms, which use smart technologies, manage efficiently, make investments wisely and are based on data, saving the invested funds and trying to obtain the maximum yield level.
- Smaller farms are also offered financially sound solutions in precision agriculture.



The nitrogen sensor

- The nitrogen sensor is the next level we recommend for farms with 300 ha and more. Proper use of this sensor can save nitrogen in areas with low field potential and maximize yields in areas with high field potential, as well as reduce veld and produce higher quality grain.
- The nitrogen sensor is easy to attach to the tractor, connects to any ISOBUS display and is very easy to use - scan, enter a dose, select a strategy and get started.



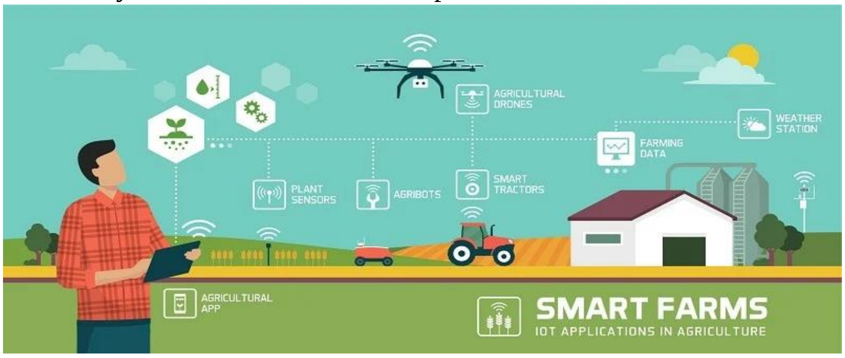
Smart farming for different farms

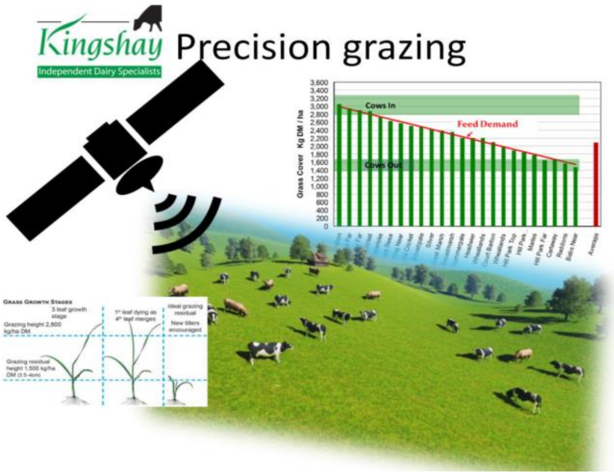
- Precision farming is a set of many solutions that can, of course, be used individually or as a complex solution, depending on the size of the farm.
- For farms starting at 500 ha, we estimate that all precision farming solutions are profitable, and the investment pays off in one or a few years.
- Small farms need to consider which investments to make and which not.
- It depends on the crops that are grown.
- It is less efficient to grow cereals on a small area, but it can be very efficient to grow vegetables using precise technologies.



Smart farming tools

- Accurate soil analysis with prepared variable application maps,
- long-term, specially prepared satellite imagery biomass maps,
- nitrogen sensor system for accurate nitrogen application according to plant needs,
- farm management software that can process all data and maps, from field history to all types maps, scheduling and the ability to create variable rate maps.



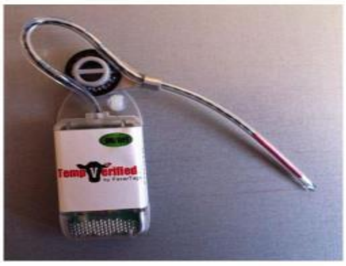


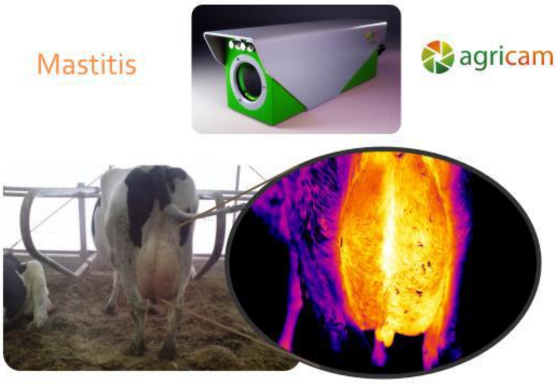
What are the benefits of precision farming solutions?

- The short answer is twice the profit!
- It may seem exaggerated to some, but the correct application of all AgriCon solutions on the farm gives an additional 240 EUR / ha and more.
- Because each kilogram of fertilizer or plant protection product does its job 1.5 to 4 times more efficiently, because it is used at the right time and in the right dose.
- I have not seen any investment in agriculture that recoups every euro invested as fast as precision farming.
- It is not always about saving resources, but about the efficiency we get from the raw materials we use.
- There are many cases when we use too little of a product, such as phosphorus, or we use too little plant protection products.

Wireless sensor networks

- Wireless sensor networks are used in agriculture, as well as wireless sensors for forestry machinery.
- This allows precision farming technologies to be used: field aerial photography, automated identification of fertiliser and plant protection chemical application rates, precision drainage and field levelling by using GPS data; precision livestock farming and poultry farming - microclimates in livestock buildings, animal marking, monitoring, automation of physiological processes and other advantages.
- An important prerequisite is the compatibility of agricultural machinery, sensors and equipment.
- One of the hindering factors is the cost of new technologies. A discussion within a working group resulted in an opinion that modern technologies could be appropriate for farms sized at least 100 ha.



Data Driven Dairy Decisions for Farmers (4D4F)

- The USA and western European countries are the leaders in the use of modern technologies, yet the first sensors in dairy farming were introduced on the LLU research and training farm Vecauce before more than ten years.
- *The goal of 4D4F* is to spread smart technologies, incl. Information and knowledge of best practices regarding the use of various technologies.
- More than ten handbooks have been produced within the project.



Case study from Latvia: *Latvian University of Agriculture study and research farm "Vecauce"*

- In Vecauce farm are located 632 dairy cows
- In the voluntary milking group are included 104 Holstein Black and White breed cows. In this group are used: **milking robots, automated feed stations, body condition scoring camera, step counters.**
- The technologies, installed in farm, not only helps to improve production, reproduction and welfare of dairy cows, **but also allows to introduce dairy sensors to students**
- With the introduction of sensor technologies **increased average milk productivity from 8105 kg up until 10 741 kg** and cases of metabolic diseases reduced by **43%.**

The importance of sensor technologies

- Sensor technologies are used in dairy farming to electronically monitor livestock, their environment, and to collect real-time data to make more informed decisions, to improve the quality of farmers life.
- Currently there are several sensors which are being used in a number of dairy farms across Europe and other countries.

International Partnership

SAMS – Smart Apiculture Management Services

SAMS in a nutshell

Challenge

- Current use of resources in European pig farming is inefficient and results in high emissions and losses
- Main causes: outdated building standards, control systems and barn management approaches
- High priority of animal welfare, competitiveness and public image of farmers must be maintained
- Many approaches improve individual aspects of the systems, but so far there are no solutions that consider the whole system

E-commerce in agriculture

- An approach that combines digital tools and social networks is practised in the SME agricultural segment in particular; person-to-person massages are spread, which is a more operational and cheaper way than maintaining a website.
- According to research data, 60% of new enterprises have a profile in social networks and no website.
- Not only the local but also the global market is available by means of IT. At present, individuals tend to use smartphones instead of stationary computers.
- Direct marketing – the enterprise itself delivers products to final consumers who establish a network and spread and distribute the products among themselves – has expanded and developed in Latvia.
- This process involves several advantages: fresh products, communication and market studies.

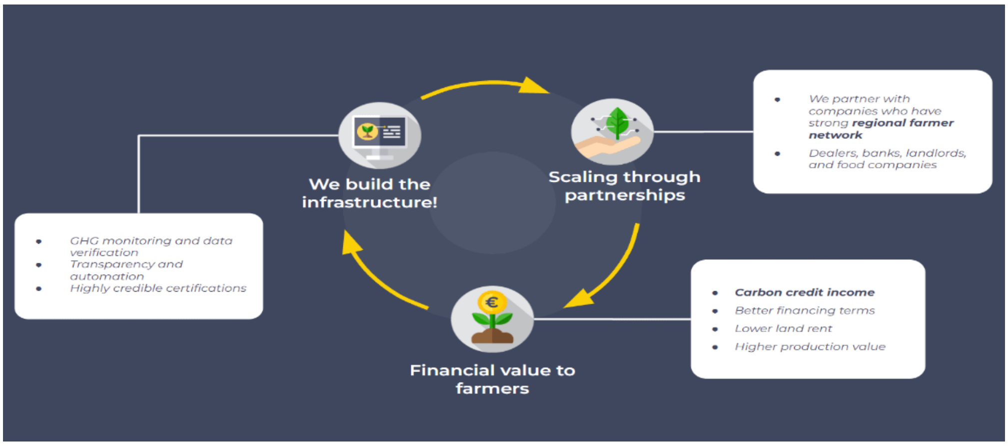
Resilient future CAP (2021-2027)

Priorities:

- **Farmers and the rural environment have to be completely integrated into the digital economy.**
- **To achieve the priorities, the agricultural industry and EU rural areas will need to be strongly linked with human capital development, as well as research and support for innovation will have to be enhanced.**
- **The future CAP will have to achieve greater synergy by means of research and innovation policy in the field of innovation promotion.**

E Agronom **https://eagronom.com/lv/**
Robin Salouks
We have a strong team of 35 people who are
Passionate wants to make the world a better place.

Empowering organizations that promote sustainable food production



E-agronom projects

Robotic garden platform

- Within the framework of the project “Autonomous robotic platform Latvian iDārzs - for sustainable development of the plant growing industry”, an innovative, remotely controlled platform capable of navigating the teams assigned by the operator has been created.
- The central part of the robotic platform houses its main operating elements, which are two optical cameras: an RGB camera and a multispectral camera.
- The main purpose of the platform will be to survey a specially designed garden and collect information on different crops.
- The information collected will be sent to a database for further analysis
- The future use of such and similar robotic platforms could be widely used and play an important role in various sectors of the economy.

Weed control robot

- LLU has developed a weed robot - a device that is able to move autonomously through the field, identify weeds and separate them from the crop, as well as using a high-energy laser or precisely positioned mechanical unit to destroy the weed or significantly interfere with its further growth.

Conclusions

- Smart agriculture, including increasing business efficiency, goes hand in hand with caring for the environment.
- We need to be aware that the latest technologies and artificial intelligence are rapidly entering our daily lives and the agricultural sector is no exception.
- We can already see that the knowledge of Latvian farmers about precise agriculture and its application is growing.
- Latvia's large farms, which use smart technologies, manage efficiently, make investments wisely and are based on data, saving the invested funds and trying to obtain the maximum yield level.
- Smaller farms are also offered financially sound solutions in precision agriculture.

Conclusions_2.

- **The most popular applications of smart agriculture in Latvia:**
  - **accurate soil analysis with prepared variable application maps,**
  - **long-term, specially prepared satellite imagery biomass maps,**
  - **nitrogen sensor system for accurate nitrogen application according to plant needs,**
  - **cow milking robots,**
  - **farm management software that can process all data and maps, from field history to all types maps, scheduling and the ability to create variable rate maps.**

Poster Session

Dessiminating Innovative Sollutions for Antibiotic Ressistance Management

B. Rivza, S. Zeverte - Rivza, Professors, Latvia University of Life Sciences and Technologies.

CURRENT STATE AND TRENDS OF MODERN AGRITECHNOLOGIES USING IN UKRAINE

Yuriy Lupenko - Vice President, Academician of NAAS, Doctor of Economic Sciences, Professor;
National Academy of Agrarian Sciences of Ukraine,
Andrei Gutorov - Academician-Secretary of Agrarian Economy Department of the Presidium of NAAS.

Agriculture of Ukraine: Main characteristics, 2021

Share in gross domestic product – 10,6 %;
Amount of man-power employed - 2,7 a million of men (17,1 % of total employed);
Crop and pulses production – 86,0 million tons;
Oilseeds production – 22,6 million tons;
Farmlands– 41,3 million ha;
Cultivated area– 28,6 million ha;
Among them crop and pulses– 56,0 Industrial crop – 32,3 %;
Number of tractors at the companies – 130,5 thous. pcs;
Harvester thresher – 26,5 thous. pcs ;
Corn harvesters – 1,5 thous. pcs ;

Agriculture of Ukraine: Main features, 2021
Constant production volumes; Increasing productivity; Widening using of current production technologies; Constant growth in exports; Improvement of product quality; Wide offer of modern machinery and equipment, seeds, plant and animal protection products, other products on the domestic agricultural market.

NATIONAL ACADEMY OF AGRARIAN SCIENCES OF UKRAINE:
ROLE IN NEW TECHNOLOGY DEVELOPMENT

Types of sci-tech products	Quantity of created scientific and technical products, units	
	2016–2020	2021
Plant protection agents	30	2
Crop plants lines	3783	257
New machinery (machines, equipment, full-scale model)	143	8
New materials	57	3
Breeds and types of animals, herds	25	5
Plant hybrids and varieties	856	82
Manufacturing technology of animal protection products	45	2
Technologies, technological methods	845	76

MAIN RECEIPT WAYS OF MODERN TECHNOLOGIES ON THE UKRAINIAN MARKET

- Strategic policy of agricultural structures;
- Government import support of high technology and innovative products;
- Widening offers of imported machinery, equipment, plant and animal protection products, seeds and other products;
- Compliance policy of foreign seeds importers of crop cultivation technology;
- Knowledge deepening of advanced development of native and foreign scientific institutions.

BREEDING RESEARCHES ON AGRICULTURAL CROPS
IN THE SCIENTIFIC INSTITUTIONS OF THE NAAS
IN 2016–2021

Crop, a group of crops	Submitted to the state variety testing of varieties (hybrids), pcs.		New varieties and hybrids are included to the State Register of Plant Varieties Suitable for Distribution in Ukraine, pcs.	
	2016–2020	2021	2016–2020	2021
Winter grains	169	24	82	8
Spring grains	262	41	246	36
Cereal crops	11	2	13	3
Puls crops	30	6	28	2
Oilseeds	82	6	115	11
Forage crops	35	10	56	9
Fibre crops	9	3	7	3
Sugar beets	9	9	11	2
Potato	19	1	21	1
Vegetables	73	8	62	9
Cucurbits crops	6	2	7	0
Essential oil plants and medicinal herbs	13	6	23	7
Horticultural	47	9	50	5
Grape	7	0	5	2
Ornamental plants	35	0	16	0
Total	**807**	**127**	**742**	**98**

HIGH-IMPACT SYNERGY OF CROP GROWING TECHNOLOGIES DEVELOPED BY NATIONAL SCIENTIFIC CENTER «INSTITUTE OF AGRICULTURAL ENGINEERING AND ELECTRIFICATION»

Heavy disk harrow БДВП-6,3

Disk chisel harrow БДВП-3-01

Chisel ALCOR 7,5

Compactor AK-10

Chemical applicator МРД-5

Aggregate АСОГ-8 with chemical applicator

Disk chisel harrow БДВП-4,2-03 with chemical applicator

Applicator ПЖУ 5000-10

Tractor-mounted feeder ЄКО-600

HIGH-IMPACT SYNERGY OF CROP GROWING TECHNOLOGIES DEVELOPED BY NATIONAL SCIENTIFIC CENTER «INSTITUTE OF AGRICULTURAL ENGINEERING AND ELECTRIFICATION»

Sowing machine ALCOR 10

All-crop pneumatic precision seeder VEGA 8 PROFI

Sprayer ОСШ-2500

Trailer sprayer ШТОРМ-3000-18

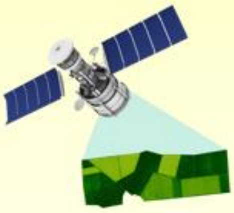
Self-propelled sprayer MAF-4200

INNOVATIVE TECHNOLOGIES AND TECHNICAL MEANS FOR DROP IRRIGATION DEVELOPED BY THE INSTITUTE OF WATER PROBLEMS AND MELIORATION OF NAAS

PRECISION FARMING SYSTEMS USED BY THE TOP UKRAINIAN FARMING COMPANIES

PRECISION FARMING is a management of crop productivity considering the variability of the field using accurate data such as farming equipment localization, dronie and satellite image, map data based on them

Precision farming elements:



Collection of soil samples

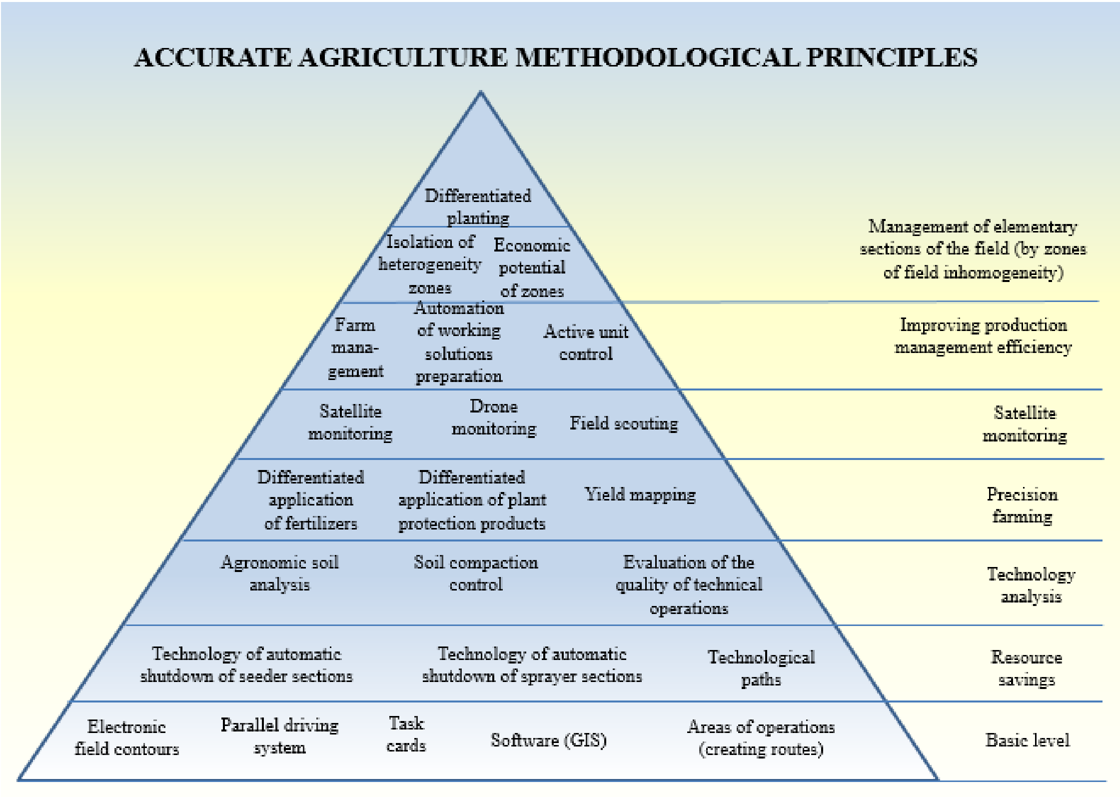
Satellite filled maps

Self-driving field machine;

Crop productivity monitoring

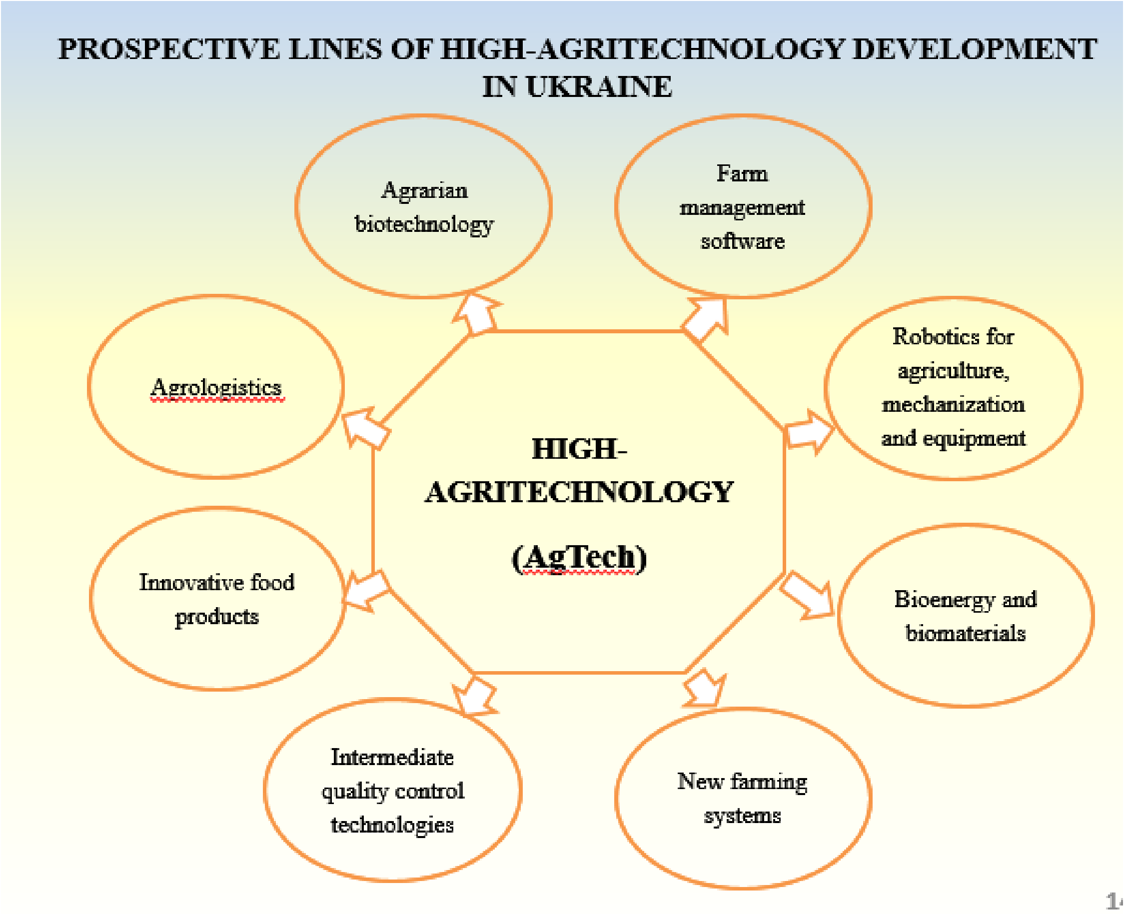
Parallel driving methods

11



INNOVATIVE SOLUTIONS FOR ORGANIC AND BALANCED AGRICULTURE WHICH ARE PRODUCED AND USED IN UKRAINE

Type of product	Product name	Appointment	Effect
Liquid organic fertilizers	Humic fertilizers from peatlands and lake sapropel	To increase the humus content in the soil, assimilation of atmospheric nitrogen, uptake of carbon dioxide by plants from the air, etc.	Increase of productivity by 20-30%, improvement of nutritional value and taste qualities and cheaper products
Ecological organic fertilizers for foliar fertilization of plants	Fertilizers with trace elements, phytohormones, amino acids and other additives	To yields and improve product quality products increasing	Obtaining organic agricultural products and increasing yields, for example, for wheat - by 15–25%
Environmentally friendly EM technologies	EM-drugs of foreign companies and domestic manufacturers	To soil fertility, improve nutrition and increase plant immunity restoring	Increase productivity, improve product quality, reduce costs
Biocomplexes for environmentally friendly plant protection	Natural nitrogen-fixing, fungicidal, phosphorus- and potassium-mobilizing and other bacteria and their active metabolites	To protect plants from pathogens	Increase in yield by 10-30% and reduce production costs by 15-30%
Biologicals stimulate plant growth and development	Concentrated mixture of viable and inactivated microorganisms and their active metabolites	For root and foliar feeding	Improving product quality and safety, reducing costs
Nanobiologicals for balanced and organic farming	A mixture of nanoparticles of essential micronutrients essential for plants with safe and high bioavailability in a form that is common in wildlife	For spraying and root feeding of plants	Yield increase: winter wheat - by 45%, barley - 53%, sunflower - 33%, corn - 32%, soybeans - 87%, peas - 14%, winter rape - by 27%



PROSPECTIVE LINES OF INNOVATIVE BIOECONOMICS DEVELOPMENT

(according to the data from the Institute for INNOVATIVE BIOECONOMICS of NAAS)

BIOECOPLATFORM

- Creation of an innovative bio-eco-system for ordering, development of agricultural technologies, production and sale of innovative products on a cluster basis of public-private partnership.
-

BIOTECHNOPOLIS

- Creation of a model of innovative development of agro-regions on the basis of smart specialization, efficient use of natural and industrial bioresources to create competitive bioproducts in demand by the market and society,
-

BIOECOPLATFORM

- Creation of an innovative bio-eco-system for ordering, development of agricultural technologies, production and sale of innovative products on a cluster basis of public-private partnership.
-

BIOTESTPLANT

- Creation of a market-oriented system of management of objects of rights and thorough quality control of bioprocesses and bioproducts based on textplant technologies.

MAIN RISKS OF APPLICATION MODERN AGROTECHNOLOGIES IN UKRAINE, 2022

- Lack of financial, material and labor resources during the war and in the postwar period.
- Investment shortfalls including foreign ones, due to the growing risks of martial law and blocking the export of Ukrainian products.
- Reduction opportunities of producers to acquire and compliance with the requirements of modern agrotechnologies.
- Structural changes of cultivated areas in favor of crops where modern technologies are less in demand.
- Reduction of cultivated areas where new technologies were used due to hostilities, ammunition availability, soft surface disbalance, structural changes of production.
- Reducing funding for research on advanced technology issues in the context of the priority of military needs and economic recovery.

CONCLUSIONS

- Ukraine has a significant potential for production of high quality agricultural products and its increase using modern agricultural technologies;
- Widening prospects of high-agritechnology usage depends on time period and implement of cessation of hostilities, possibility of sponsorship of postwar economy;
- In modern conditions, the role of promising research and development of innovations is growing, which allows to increase production on the basis of sustainable development;
- Successful development of modern agricultural technologies will be facilitated by the expansion of international scientific relations, the use of proven developments and experience.

ENERGY SELF-SUFFICIENCY OF FARMS

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Abstract. Taking the example of France, the author shows how public policies have placed all agricultural production in total dependence on an energy supply not only of fossil origin, but also from outside Europe.

Alternative solutions exist however, they have appeared, in an ephemeral way, according to the various oil crises. These same responses have been hailed by great innovation awards at specialized trade fairs, although without experiencing a commercial launch.

Following the awareness of the direct impact of carbon dioxide emissions of fossil origin on climate change, the decarbonization of practices is gradually turning self-evident through recent announcements from manufacturers.

Hydrogen, methane, vegetable oils, bio or synthetic fuels, green electricity could constitute an energy mix, compatible with the necessary transition. Coherent public policies could sustain these trends.

The energy self-sufficiency of French agriculture was perfectly assured until the middle of the last century. In fact, the number of draught animals recorded in 1950, after World War II, was the same as in 1914. A late phenomenon, agriculture had been fully mechanized since the end of the previous century. The proportion of arable land devoted to food for working animals is estimated at between 10 and 15%, depending on the farm structure.

It was not until 1954 that the motorization of agriculture was truly developed thanks to the Marshall Plan. In 1980, the first phase of equipment was practically completed throughout the territory. This situation masks a terrible and worrying reality: the totality of our agriculture is immersed in a total dependence on an energy not only fossil, but also of extra-European origin!

Yet alternative solutions exist, they will appear and reappear as the oil crises unfold. The 2020s saw the emergence of achievements in the various fields of diversification and energy transition. Their sustainability could be anchored in the collective awareness of the impact of fossil carbon on climate change.

Early Achievements: The "Manure Gas"

It is well known to our elders that the manure pile in the farmyard produces heat and combustible gases. The first to have developed a practical process to recover this gas was Marcel Isman, agronomic engineer and professor of Rural Engineering. In the late 1930s, together with his colleague Gilbert Ducellier, they filed the patent bearing their name and designed an operational digester at the Institut Agricole d'Algérie in Maison-Carrée. This school where they are teachers-researchers will be autonomous in energy during the Second World War.

As early as 1945, Isman and Ducellier developed the compression of the «manure gas», as well as its simple and economical purification by washing with water. This process eliminates all hydrogen sulphide and almost all carbon dioxide, thus eliminating the corrosive effect and the bad smell.

In 1946, Marcel Isman succeeded in equipping a first manure gas tractor. Thousands of installations were created. Unfortunately, the introduction of zero-rated farm fuel in 1956 will mark the choice of a total dependence on our energy supplies. A high-risk choice…

Following the first oil crisis of 1973, Marcel Isman was urgently recalled and took back his pilgrim stick. This is a difficult task, as the advocates of zero-rated agricultural fuel are mobilized. The many conferences and public interventions are often confrontational and turn into a pugilat. And yet in the face of the oil crisis, the message is getting through and hundreds of manure gas installations are set up all over France.

The Research Centres are no exception. For example, a station of three vats on the model promoted by Marcel Isman is born at the experimental center of the Technical Institute of Cereals and Fodder *(ITCF of Boigneville in the Essonne)*. Another is installed at the experimental farm of the Institut National Agronomique de Grignon in the Paris region. Agricultural diesel engines adapt to methane by simply blocking the injection pumps at the minimum flow rate to ensure ignition, the power being provided by the methane controlled by the throttle lever at the inlet.

Once again, the return to low-cost fossil fuels will defeat the efforts and work of our researchers and farmers…

Today, France's commitments to fight global warming are changing public policies. The Energy Transition Act of 2010 and the environmental issue encourage the production of "green" methane. The increase in the purchase price of purified gas favours investments for direct injection into the network. As a result, most of the projects are located in the immediate vicinity of the Gaz de France pipelines.

The conference organized by SITMAFGR at the Châlons-en-Champagne Fair on Monday, September 3, 2018, made us aware of the sudden development of methane projects in our national territory.

With more than 9,000 methanisers, the considerable advance taken by our German neighbours in the production of biogas of agricultural origin is nevertheless tainted by a most questionable drift: the use of agricultural land for energy purposes.

This is the reason why the French decree 2016-929 sets the maximum threshold for food and energy crops grown as a main crop and incorporated in digesters at 15%. The figure of 15% is not determined at random, it was the part devoted to the feeding of working animals at the beginning of the 20th century, at the time of animal traction.

Methanisers are mainly supplied with plant waste and intermediate crops, in particular rye. This hardy cereal does not require fertilizer or phytosanitary treatment and maintains a permanent plant cover, thus avoiding the use of glyphosate.

Intermediate crops protect the land in winter from soil leaching, and participate in so-called “conservation” agriculture. The digestate resulting from the methanisation process is a natural fertilizer, an alternative to synthetic chemical fertilizers.

Against this backdrop, New Holland presented at SIMA 2017 the latest tractor prototype, the "T6 Methane Power". It is the result of a joint project between New Holland and Itaipu Binacional, the world’s largest producer of clean and renewable energy, west of Paraná in Brazil.

The T6.180 Methane Power is equipped with a NEF6 low-pressure methane engine manufactured by FPT Industrial. Its configuration is very similar to that of diesel tractors currently marketed. Compressed methane is stored in 10 tanks built into the overall design, with a capacity of approximately half a day of range, plus three additional front tanks for a full day.

Several dozen methane tractors equip producers and local authorities, a market driven by 800 short-term installation projects, which will double the number of production sites on national territory.

Vegetable oils

The second oil shock of 1980 will see the development of a renewable alternative response based on vegetable oils.

At the time, Austria drew up an energy self-sufficiency plan for its agriculture based on oilseed production. The idea reached France and many farmers produced their fuel, and in the early 1980s there was a break in supply… in oil presses!

Agricultural tractors are very easily adapted to these alternative fuels, insofar as the engines are almost exclusively pre-combustion chamber diesels. This feature, which differentiates them from road diesels with direct injection, allows them to operate with all types of vegetable oil, provided that a certain proportion of diesel is retained to ensure the lubrication of the injection pumps and injectors.

The return of low prices for "easy energy" of fossil origin will accompany the transition to high-performance, direct-injection engines that can only run on perfectly standardized fuel.

Energy autonomy through innovation

In recent years, awards have been given to innovation in changing energy sources for greater sustainability and above all to free farms from random supply. More than the technological break, it is indeed this autonomy that constitutes a notable advance in the evolution of motorization.

The NH2 Tractor *(2009 SIMA Gold Medal):*

This application for innovation, submitted to the Technical Research Incentive Committee (CERT) in September 2008, is not, however, innovative. Indeed, all the components of this set are known for a long time:

- Photovoltaic collectors for power generation (about 900 m2 of roofs to supply a tractor all year round)
- Water electrolysis for hydrogen production
- Hydrogen compression and storage
- Using on-board hydrogen and air oxygen to generate electricity through a fuel cell
- Presentation of a tractor equipped with electric motors for propulsion, traction and power functions

It was the concept of energy autonomy of the farm that convinced the jury for the award of a remarkable Gold medal at the 2009 SIMA.

This project, the result of Fiat Group R&D, is part of the New Holland «Clean energy leader» programme.

The polymer electrolyte membrane cell (PEMFC), a proton conductor, works with hydrogen at the anode and air at the cathode and produces water steam.

The electron current is recovered and powers the electric motors.

Electrolysis of the water at the start and restitution of water vapor, it is the perfect solar cycle for an eternally renewable mobility.

How to explain the stagnation of such projects, still not commercialized to date? Cost of components, especially the electrodes of fuel cells? However, projects are underway in the automotive sector. More recently, Van Huizen in the Netherlands has had a production Fendt 313 Vario converted to electric by its dealer Holland Utrecht. The Fétis Group, based in Nantes, specializes in fuel cell retrokits to meet end-user requests. This company is starting a partnership with Manitou for the upcoming launch of hydrogen telehandlers. It's time!

And to stay on this same energy source, JCB announces the design of a hydrogen fuel combustion engine.

John Deere Flex Fuel Engine *(2013 SIMA Gold Medal)*:

Where we hear again about vegetable oils… Developed by the engineers of the John Deere European Centre for Technology and Innovation in Kaiserlautern, Germany, this engine concept accepts three types of fuel in a single tank:

• RNG;
• pure vegetable oils;
• RNG-oil mixtures.

Sensors identify the fuel by measuring viscosity, density, permittivity, temperature, etc. Then, the engine control unit adapts the injection and the different algorithms to meet the latest Stage IV anti-pollution standards.

Other sensors check the exhaust result, in particular the NOx level and interfere with the control unit.

The limit of this concept remains... the European regulations. Indeed, as explained by the manufacturer, "the legislator currently favours the obligation of means, by imposing RNG, rather than the obligation of result in terms of compliance with emission standards."

In the meantime, the John Deere flex-fuel tractor may have been very well received in the United States and South America with the rise in crude oil prices.

In 2013, placing this new flexible fuel engine at the top of the SIMA list, CERT members raised several inconsistencies: on the one hand, the concept of sustainable agriculture is incompatible with the use of non-renewable energy. On the other hand, this fossil energy cannot continue to be the only reference for obtaining the approval 97/68 of the engines, precious sesame of the road type approval of the automotors.

This engine recognises the type of fuel, or the mixture of fuels used, and its control unit adapts the various parameters accordingly to meet the requirements of phase 4 of the European anti-pollution directive, the famous «97/68».

This fine technical feat should encourage the legislator to impose the essential: the result, rather than requiring the means.

Many electrical vehicle realizations.

The vineyard was a pioneer in the field of electric tractors, in 2013, two silver medals were awarded at the SITEVI in Montpellier. One for the KREMER T4E electric straddle tractor, 110 hp, displaying a day of autonomy at work, for 8 hours and 10 €uros of recharge cost. The other for the TECNOMA Voltis 100 hp. electric straddle tractor.

Field crops are not left out. The JOHN DEERE "Sesame" tractor is one of the winners of the 2017 SIMA, the first very powerful electric tractor (300 kW). The Agritechnica of Hannover highlights this development with the top 5 electric tractors at the 2017 edition.

Since then, applications for innovation for agricultural electric vehicles have multiplied, telescopic loaders, dispensors, loaders. They are no longer on the awards list because the “technological leap” has now won several medals.

Electrical applications are also proposed to the jury of the «Sommets d'Or» of the Clermont-Ferrand Livestock Summit. In fact, farmers appreciate electric vehicles very much (feed-pushers, slurry planes, feed dispensers), because they do not make noise and do not spread exhaust gases in buildings. The animals are quieter and in better health conditions.

The electric farm valet tractors therefore have a certain future in breeding, because moreover the autonomy is not a constraint, the charging station is always nearby.

The Quads do not escape the electric trend, whether for the centrifugal spreader, the anti-slug treatments and the installation of mobile fences in rotating grazing.

Conclusion

Will these few missed meetings with the energy autonomy of farms finally lead our decision-makers to remove a notorious contradiction? Indeed, can we carry on promoting sustainable agriculture (as evidenced by the email addresses of our correspondents «prenom.nom@developpement-durable.gouv.fr»), while financing, through zero-rated farm fuel for nearly 70 years, an energy of fossil origin, by nature non-renewable?

AGTECH COMPETENCE:
URGENT NEEDS AND POSSIBLE PATHWAYS

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During the 19th century, it took approximately 4200 minutes to harvest and thresh one ton of grain thanks to the invention of the knife bar, the steam engine and the threshers. But today, with the biggest combine harvesters, such as the John Deere X9, the farmer can harvest and thresh one ton in just 2 minutes (fig. 1). It illustrates a fabulous productivity development in agriculture (Frankelius, 2019a). The technological milestones have been many over the years. While Google launched its self-driving car Waymo in 2009, agriculture has had self-driving tractors since at least 2002. Regarding robots, it can be mentioned that ABB and others relatively recently launched robots that can interact with biological agents (in that case humans). ABB launched one in 2019 (Svanström, 2019). But agriculture had robots that can interact with biological beings, namely cows, already 1992 thanks to the Lely's Astronaut. DeLaval had a patent before Lely but launched its robot later, in 1998.

Fig. 1. This X9 combine from John Deere can harvest 100 tonnes per hour. Photo: Per Frankelius.

But despite all the progress in agriculture, there is cause for concern. Some current observations: David Beasley, UN World Food Program, decared 6 May 2022: 276 million people worldwide are already facing acute hunger at the start of 2022 (World Food Programme, 2022). On 7 May we were reached by the news that Sri Lanka has declared a state of emergency due to lack of food, fuel and medicines (McLaren-Kennedy, 2022)

The world faces huge challenges regarding food needs in relation to food supply. According to estimates by the Food and Agriculture Organization (FAO), we need 60% more food in 2050 than today (United Nations, 2019). The expanding food needs are not only connected with population growth, but as much with changing food habits in Asia and elsewhere (Silva, 2018). Because agricultural production is vital for food production, many challenges must be handled through developing agricultural tools and methods.

At the same time food production needs to be boosted, there are many other kinds of challenges for agriculture, like threatened biodiversity (Secretariat of the Convention on Biological Diversity, 2020), sealing of arable land (Mission Board for Soil Health and Food, 2020), climate change (IPCC, 2019), soil compaction (Montanarella, 2015), lack of manpower (Rosenblatt, 2021) and spreading of animal diseases (FAO, 2017). On the shoulders of farmers are also changing regulations and expanding administrative complexity. To conclude, agriculture has many challenges to cope with at the same time, and these include contradicting goals.

In principle there are three pathways: evolution, imitation, and innovation (Frankelius & von Rosen, forthcoming). Evolution and imitation are much needed. But neither evolutionary changes nor imitation will be enough to cope with all challenges and the contracting goals. We need more revolutionary changes (Frankelius, 2019b). In other words, we need more innovation. But what kind of innovations do we need, and how can we secure innovation success? There are signs that agriculture is approaching a new technology era in agriculture (Frankelius & von Rosen, forthcoming). The new agtech era includes, among others, these tech areas:

(1) New crop and cultivation concepts that includes concepts such as

- High-speed phenotyping breeding
- Sensor and AI-aided precision
- Novel no-chem weed management
- Field vegetation combinations
- Compaction reducing concepts
- Subsurface drip irrigation

(2) Field robotics that includes concepts such as

- Small and big field robots
- Robot swarm concepts
- Robot mode functions
- Master and servant concepts
- Autonomous drone scouting.

(3) Climate-smart energy and products that includes concepts such as

- Carbon-free farm energy concepts
- Carbon-free necessities
- Crop-based biofuel production
- Fossil-free substitutes production

(4) Smart connected systems that include concepts such as

- Predictive maintenance
- Remote support
- Connected farm systems
- Traceability customer value

(5) Animal welfare technology systems that includes concepts such as

- AI-aided animal monitoring all around the clock
- Prevention of antibiotic usage
- Sex detection during incubation
- Sensor-aided breeding on new targets

One example of new technology in group (1) New crop and cultivation concepts is singulation for ordinary grain crops (by means of for example the Proceed machine from Väderstad). This means precision planting of seed along the moving direction. Another example is underground drip irrigation, also called surface drip irrigation (SDI) such as concepts proposed by the company Netafim. A key concept in this area is "fertigation" or “nutrigation” ie irrigation with nutrient-enriched water. One of Netafim's most important inventions is a small device made of plastic that allows the same amount of drops to come out even if the pressure in the hose varies between 0.4-4 bar. Still another example is precision machines with variable row spacing (like the Flexrow concept, fig. 2). That concept builds on new technology originally intended for airplanes. One big problem in modern agriculture is soil compaction. Concepts such as Compaction Prevention System (CPS) can help farmers to avoid this huge problem. The system gives farmers decision support regarding soil compaction risk. It helps deciding where and when to work on the fields and vehicle configuration. An algorithm creates an index out of information about wheels/tracks pressure on soil, soil type, soil moisture and field status. Maps of the compaction risk level are provided as well as real-time information on a meter as the vehicle moves. (The CPS concept won silver medal in Agritechnica innovation award 2022.)

Fig. 2. The Flexrow concept paving the way for pure flexible row distances. Photo: Per Frankelius

Regarding new technology in group (2) Field robotics there are probably more than 40 robot concept already out on the market. Still many are in concept state like the tank carrier robot Fieldgofer. The centerpiece of Fieldgofer is a U-shaped robot that can carry special tanks and is equipped with a three-point lift. Furthermore, at least 3 loose tanks and a road transport trolley are included. The robot is transported out to the field. There it can then, for example, spread mineral fertilizer or granulated biofertilizer itself. When the tank is empty, the robot itself switches to a refilled tank and continues until the job is done. The farmer can devote him- or herself to fetching more fertilizer for the field, but no one needs to drive a tractor for spreading. In addition, the equipment weighs less than a classic tractor with a fertilizer spreader, which reduces soil compaction.

One example of new technology in group (3) Climate-smart energy and products is biogas tractors with electric drivelines (like the one from the farm company AUGA Group). Another concept is Agrocolary including solar cell path in the fields (fig. 3). This area is in strong development mode right now (Frankelius and Lindahl, 2021). One shall have in mind that agricultural production is very much related to energy production, because fertilizers are produced by means of natural gas, grain drying needs lots of energy – and tractors or other farming machinery also need huge amounts of energy. Unlike road transport vehicles, it has been shown that battery operation is not sufficient for the heavy work in fields required in agriculture. At the same time, many actors in society want agriculture to switch to fossil-free energy. And even if it had been possible to switch to electric power, the problem remains that the electricity must be fossil-free produced for there to be any meaning to it all. Today, less than 30 percent of the world's electricity is fossil-free produced. Regarding fertilizers fossil natural gas is the main energy source today and many are struggling in finding alternatives.

Fig. 3. The Agrosolary conept. Image: Gustav Näslund/Kurt Hansson.

One example of new technology in group (4) Smart connected systems is the Expert Alert system by John Deere launched in 2018. Expert Alert is a remote service concept that shows how sensors, communication, AI and organizational arrangements can create interesting values for farmers as well as for the machine company. The machine, such as a tractor or combine, is, via telematics, in constant communication with a global command center at John Deere down in Germany. There, the system can warn that e.g. a layer in the combine is going hot. The key is that the command center collects lots of data from many machines and then, with the help of AI, can identify patterns and define combinations of conditions that are likely to lead to an injury or even downtime. The dealer then receives info and can inform the customer so that they put in service before an accident occurs.

One example of new technology in group (5) Animal welfare technology systems is animal data transmitting sensors such as SenseHub Feedlot from Allflex / Merck, or camera-based observation of animal breathing (like the concept from Saab/Agtech 2030).

All these areas and concepts increases the demand for new skills. That was the background to a multi year investigation project framed by The Royal Swedish Academy of Agriculture and Forestry. The work within KSLA's committee for technology in the green industries began in 2017. The assignment from KSLA was to "work to highlight challenges and opportunities in the introduction of new technology in agriculture and forestry". The Academy believed that it was important for the committee to be able to point out the problems and the need for knowledge that existed in the green industries and that could be solved, among other things, with new technology. It was also hoped that the committee's work would promote the introduction of new technologies in practical contexts. One way to implement this was to create increased communication between stakeholders and actors in the field. Finally, the academy expected the committee to provide concrete proposals and measures to support the introduction of new technologies in the industries. This gave the committee in the field of technology fairly free rein to shape its activities. It was interpreted as meaning that one should start by adjusting the situation with regard to both applied and new technology in agriculture, forestry and horticulture. Then you should create an overview of the need for and access to technology-related advice and experimental activities. Based on these insights, the committee would identify the most important challenges in the technical development of agriculture, forestry and horticulture in Sweden.

The results of the committee for technology in the green industries was presented in a report at the end of 2021 (Emgardsson, Frankelius & Martiin, 202). The committee worked at a time when the winds of change were blowing in agriculture. Among the proposals put forward were these three:

Proposal 1: Countries should invest in international cooperation and a national forum. All countries need to take action to improve the development of skills in agricultural technology. For small countries like Israel, Georgia or Sweden cooperation is extra important to maintain and strengthen competence. To enable cooperation, all countries must have competent actors with the ability to "give" something in exchange for what we want to "get" from other countries. Significant parts of the knowledge associated with new technology are advanced, so a key to success is that we strengthen academic educations focused on interdisciplinary competence in physical and digital agricultural technology.

Proposal 2: Independent technical advice needed. There is a need for commercially independent actors to whom agricultural professionals can turn for objective advice on technology issues. Today, both farmers and advisers are largely in the hands of actors who directly or indirectly represent manufacturers of the technical alternatives available. Therefore farmers need a function that captures and structures national and international experiences of applied physical and digital agricultural technology. One can observer such functions in some countries. This feature should include the ability to quickly evaluate whether and for which farms a particular new technology can become profitable. The need for a forum increases when the creation of knowledge is spread over many organizations in different places.

Proposal 3: New data platform. Data is becoming increasingly important in agriculture. But agriculture is lagging behind in terms of manufacturer-independent structures for managing and sharing data. The committee concluded that data management of the future in agriculture should be internationally compatible and based on sophisticated object models, ie. standards. Farmers should seek cooperation with farmers' organizations in other countries with the aim of influencing the machinery industry's systems and creating their own cross-border and farmer-controlled management systems for agricultural data.

How, then can we secure innovation success? Among the success factors are farm-based development centers – concepts beyond test farms because test is only one part of what can be done by farmers at farms. Another success factor is cooperation strategies alongside facilitators for collective innovation efforts. One example of innovation promotion is Volcani Center - Agricultural Research Organization in Rishon, Israel. Volcani Center is an impressive research and innovation environment hoste by the Israeli Ministry of Agriculture and founded as early as 1921. The focus is on developing agriculture in practice. Today they have about 200 researchers who must all draw their own research funds. The list of clients include Walmarks, Cargill, Pepsico, Unilever, Dow, Coca-Cola, Burger King, DuPont, Syngenta, General Mills, Monsanto, P&G and Bayer.

Another example of innovation promotion is the research and innovation program, Agtech 2030, hosted by Linköping University in Sweden. The purpose of Agtech 2030 is to stimulate sustainable growth through innovation processes supported by dynamic innovation environments. Focus is directed towards sensors, digital technology, AI and Internet of Things. About 90 partner companies and organizations have conducted ca 30 innovation projects during the last 3 years. Research by Agtech 2030 has been published in journals like Agronomy Journal, The Lancet, Journal of Cleaner Production, Journal of Agricultural and Environmental Ethics, Journal of Service Management and International Food and Agribusiness Management Review. Agtech 2030 has resulted in many patents and innovations. Some got international recognition.

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Potential of Smart Farming Technologies in the Czech Republic

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Abstract

Intensive agriculture is facing a number of serious environmental problems worldwide. Average weight, power or agricultural machinery performance increased several times, as well as the maximum tire load. Each year, at least than 86% of soil appears under the wheels of agricultural machinery using classic ploughing technology. In the headlands, soil degradation, mainly due to technogenic compaction, is already beginning to manifest. In CR, more than half of agricultural land is at risk of erosion (large fields, growing wide-ranging crops like maize, mostly for biogas plants). Possible solution: using state-of-the-art technique and technology – Smart Farming. The idea of smart (precision) farming was born in the US in the 1980s with yield mapping. A commonly used technology is the navigation of machines via GPS with RTK correction (accuracy to centimetres). Controlled Traffic Farming technologies also have great potential. The implementation of ISOBUS technology seems inevitable. Interesting data can be obtained by monitoring the work of agricultural machinery and remote sensing. The use of agricultural robots also seems inevitable.

Introduction

Intensive agriculture is facing a number of serious environmental problems worldwide. Undoubtedly, the most important of them are soil degradation, decline in the diversity of agricultural ecosystems, food quality, water or wind soil erosion, technogenic soil compaction, deterioration of the quality of water resources and last but not least also economy of agricultural production. Most of these problems are directly related to increasing the performance of agricultural machinery. Average weight, power or agricultural machinery performance increased several times, as well as the maximum tire load. This situation has been clearly described by Bernhardt et al. (2006) and then extended by Moitzi et al. (2016), see Fig. 1. Under Czech Republic conditions, each year, at least than 86% of soil appears under the wheels of agricultural machinery using classic ploughing technology. This situation is documented in Kroulík et al. (2009), while on headlands this situation is of course even worse (Kroulík et al., 2011). In the headlands of a lot of fields in the Czech Republic, soil degradation, mainly due to technogenic compaction, is already beginning to manifest resulting to lower yields (Kumhálová et al., 2013). Moreover, according to our Research Institute for Soil and Water Conservation (2021), in the Czech Republic, more than half of agricultural land is at risk of erosion (large fields, growing wide-ranging crops like maize, mostly for biogas plants). If it is to remain sustainable and ensure adequate quantities of healthy food, modern agriculture must respond to all these challenges. Nevertheless, this applies not only to the Czech Republic, but to the whole modern world.

Because one of the ways to solve these problems is the application of smart (formerly precision) farming methods, the main aim of this article is to outline the possibilities of smart farming, which are or can be usable for this purpose.

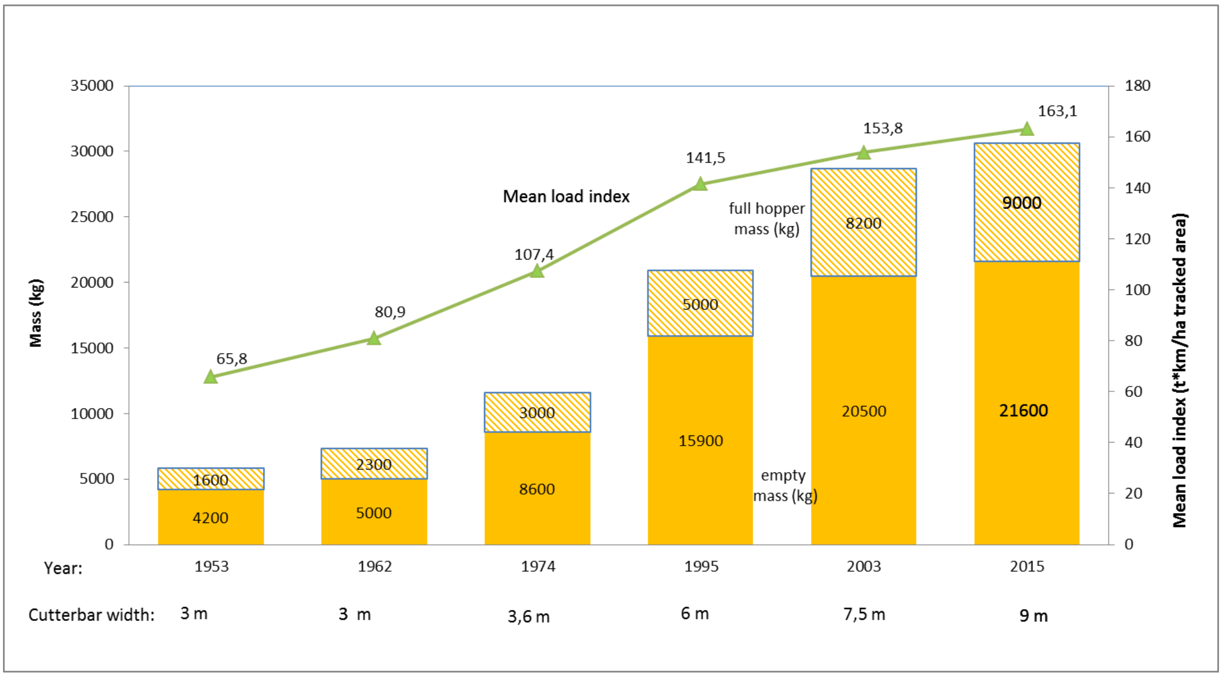

Fig. 1. Development of combine harvesters in empty mass, hopper capacity and mean load index. (Load index is the product of the half-loaded combine harvester mass multiply with driven distance in the field. This product is divided by the tracked area). According to Moitzi et al., 2016.

Materials and Methods

According to International Society of Precision Agriculture (ISPA), "Precision Agriculture is a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production" (ISPA, 2021). This definition alone suggests a significant potential of precision (smart) agriculture for solving the problems mentioned in the introduction. As the scope of smart farming is very wide, only some of the methods will be discussed, especially those that are already being used or are starting to be used in the Czech Republic.

Results and Discussion

Accurate navigation of the movement of agricultural machinery

In the conditions of the Czech Republic, precise navigation of the movement of agricultural machinery is the most widespread element of smart agriculture. The availability of RTK correction (RTK-GPS technology) allows navigation of agricultural machinery with an accuracy of centimetres. This is already used by most farms today. The accuracy of the navigation is also affected by the steering system used. Automatic steering delivers the best results (Kroulík et al., 2011), even with large working widths of around 30 m (Fig. 2). Evaluation of field operation errors with regard to pass-to-pass accuracy when using navigation proved that the error decreases with higher level of automation, human factor independence and with the type of receiving signal. The errors were mainly overlapping of passes.

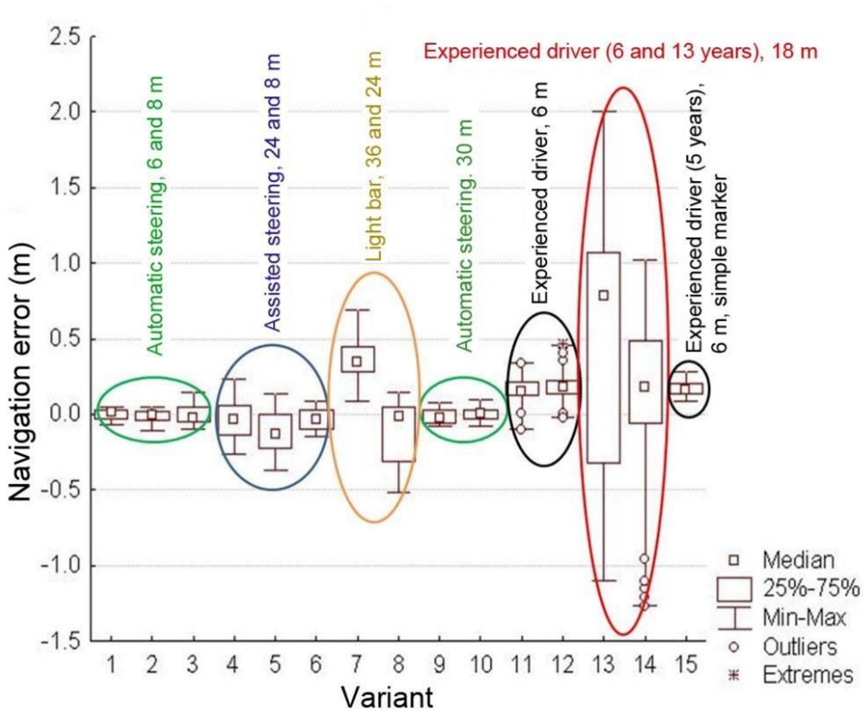

Fig. 2: Graphical overview of navigation errors when using different steering systems. According to Kroulík et al., 2011.

Controlled Trafficking Farming (CTF) technologies

According to Godwin et al. (2019), the effect of soil compaction, depending upon its severity, can significantly reduce crop yields by 10 to 15%, increase tillage energy requirements by 200 to 300% and drastically reduce infiltration rates, increasing the problems of run-off, diffuse pollution and flooding. Precise navigation of agricultural machinery also opens the way to CTF technologies. CTF technologies can reduce the area under the wheels of agricultural machinery from more than 85% to about 30% (Kroulík et al., 2011), mainly depending on the width of the module used. Different arrangements were tested under Czech Republic conditions (TwinTrac for smaller farmers, 4 m module; OutTrac for medium farms, 6 m module; AdTrac for agricultural holdings, 8 m module) with good results. These technologies can be used even when using the existing machinery without complicated modifications.

Field cultivation optimization

Computer programs, often integrated directly into machine navigation systems, can, for example, determine the optimal direction of routes when cultivating land. Even a simple change of driving direction by 10° compared to the direction determined on the basis of the operator's experience can save up to 2 km of travel on a field with an area of around 50 ha. This saving is certainly not negligible and costs practically nothing.

ISOBus technology implementation

It should always be borne in mind that the end user of smart farming technologies is the farmer himself. His profession is plant growing and / or animal husbandry, not the role of IT specialist. All smart farming technologies should have in common that they are user friendly. Unfortunately, this is far from the case at present. However, manufacturers of agricultural machinery are aware of this, so there is an effort for standardization. A good example of this is the use of ISOBus technology, which is especially important in tractor-implement communication. Therefore, almost all major manufacturers of agricultural machinery (from Czech Republic for example Bednar FMT, 2021, or Farmet a.s., 2021 and others) are already implementing this technology in their machines.

Soil physical properties characteristics

Soil physical properties are of great importance for the evaluation of soil compaction or for soil conditions characterization. The latter option is important for the purpose of soil tillage machines. Soil physical properties can be measured by different ways. Nevertheless, great attention must be paid to the informative value of individual methods (Chyba et al., 2016) as well as the interpretation of the results obtained. Physical properties of soil can be determined by specialized measurements (soil cone index measurement by horizontal penetrometer, undisturbed soil samples) or by indirect methods (measurement of operating parameters during machine operation, such as tensile force, wheel slip, fuel consumption). The physical properties of the soil also affect the soil conductivity or the results from the gamma spectrometer measurement.

Remote sensing

In terms of image acquisition, remote sensing can be divided into three groups: satellite imagery, aerial pictures, unmanned aerial vehicles (UAV) and ground sensors. All these groups can be used to manage interventions in agricultural production. All these groups can be used to manage interventions in agricultural production. Each of these groups has its advantages and disadvantages. Concerning to satellite imagery, Czech Republic is member state of European Space Agency (ESA) and ESA Remote Sensing satellites overflight over the CR is relatively frequent. Satellite Sentinel-1 (equipped with Synthetic Aperture Radar sensor) revisits the territory of the CR with a frequency of 6 days (Tůma et al., 2021) and Sentinel-2, (providing data in visible, near-infrared (NIR) and short-wavelength infrared (SWIR) spectra), with 5 days or better frequency (Jelínek et al., 2020). This fact is very interesting from using of satellite images for crop management point of view (Fig. 3). However, cloud problems need to be addressed (Tůma et al., 2021).

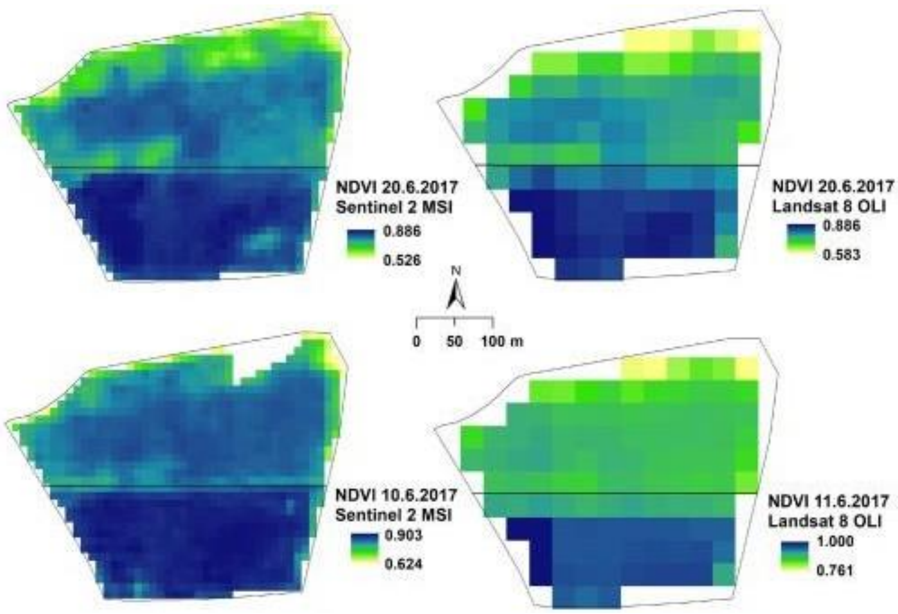

Fig. 3. Example of calculated normalized difference vegetation index (NDVI) from Sentinel 2, and Landsat 8 data. According to Jelínek et al., 2020.

With the technical progress of the past two decades, it has become possible to obtain images from unmanned aerial vehicles, which have a very high spatial resolution and can thus monitor the crop canopy with very high accuracy. Another advantage in comparison to satellite images is the flexibility of the acquisition time, ability to focus on selected phenological phases of the monitored stands, ability to acquire images with several sensors simultaneously, for example, thermal images are supplemented by multispectral images (Maes and Steppe, 2019). For example, colleagues monitored the growth of different varieties of wheat under different soil tillage technologies (Balážová et al., 2021), Fig. 4.

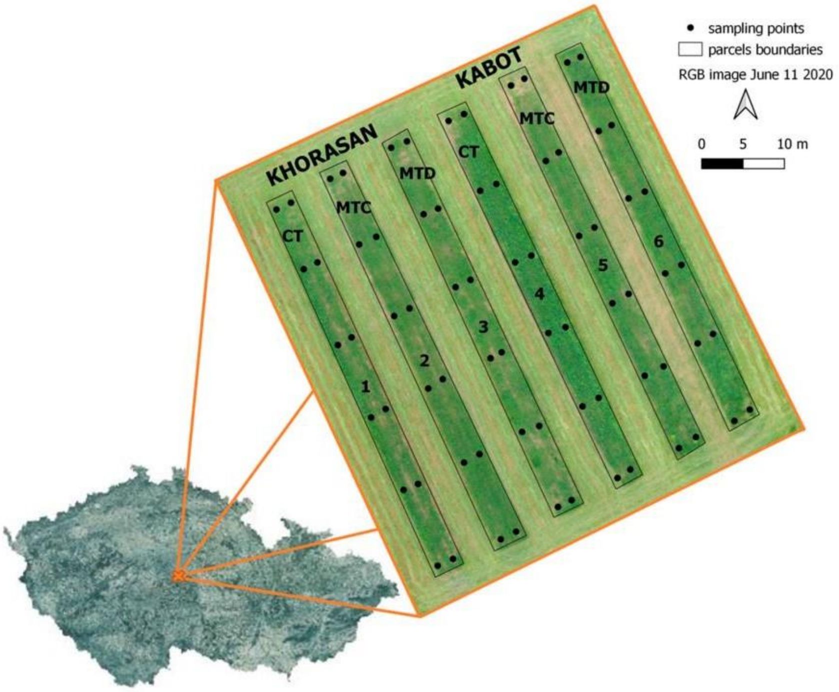

Fig. 4. The experimental area divided according to variety and soil tillage technologies: conventional tillage (CT), minimum tillage (MTC), and minimization tillage, monitored by UAV eBeeX.

Agricultural robots

Undoubtedly, robotics opens up other new possibilities for solving the problems of modern agriculture (Bechar and Vigneault, 2016). The emergence of self-governing system structures brings the possibility of developing a whole new range of agricultural equipment based on small intelligent machines that can do the right things in the right place at the right time and in the right way. This definition of agricultural robots itself is very close to the definition of smart agriculture. Robotics enables further replacement of tedious human work, which is important even in periods of global epidemics, when the mobility of workers is significantly reduced both between and within states. The current coronavirus epidemic of Covid 19 is a typical example. Robotic structures also allow large and heavy machines to be replaced by smaller ones. These cooperating robotic machines can achieve the same performance, but they will not be so heavy on the soil (Fig. 5). The operator will thus be able to supervise the work of several machines or correct it. The need for human labour will thus remain the same or may even decrease. On the other hand, it will generally bring greater demands on the operators. Operators will have to be more educated in the orientation to information technology in general.

Fig. 5. Field robot developed by the robotic team of the Department of Agricultural Machines, Faculty of Engineering, CULS in Prague, based on the Spider platform.

Conclusions

From the above overview, it is clear that smart farming technologies are undoubtedly a viable way to solve the problems associated with modern productive agriculture. In the conditions of the Czech Republic, some of them are already widely used (accurate navigation), some are used to be beginning (CTF) and some are in the research stage and the beginning of use (remote sensing, agricultural robots). Of course, the implementation of these technologies is not neglected even by major manufacturers of agricultural machinery (ISOBus). It is gratifying that there is currently considerable interest in all these technologies among farmers.

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DEVELOPMENT OF SMALL SMART DATA LOGGER ROBOTS EMBEDDED IN IOT SYSTEM FOR CROP PRODUCTION

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ABSTRACT

The original idea for the research project came from Wang et al.'s 2019 article. In the development of a small smart robot described herein, a 360-degree rotating camera collects the data and sends images and

videos to a telephone or computer terminal. In this paper the sensing possibilities have been significantly expanded upon. With the help of an RGB camera and a set of sensors mounted on a robot, it is possible to detect diseases, lesions, pathogenic syndromes, as well as soil-plant micro-climate, and by leaf sampling other characteristics of plants can be measured to enhance databases using a neural network.

Keywords: Small Smart Robot, Internet of Things (IoT), AI, Lidar, Plant and Soil monitoring, Big Data

INTRODUCTION

Recently, several studies have highlighted the need for a paradigm shift again. According to a study published by *Longchamps et al.* in 2018, the current adverse effects of agriculture on the biosphere cannot be mitigated by knowledge provided by research based on traditional experiments. A paradigm shift is also needed to reduce the time between the perception of a harmful phenomenon and the response. The methods of the scientific approach must also be changed. The authors also point out that the gap between our slowly expanding knowledge to address environmental impacts and challenges is widening, fissures are opening up, and we are unable to address the challenges in a timely manner. David Tilman's (1998) admonitions remain relevant: we need to green the green revolution, as the use of synthetic fertilizers and pesticides is gradually increasing globally.

Unfortunately, precision technology has not lived up to its promise from an agro-ecological point of view. Our experience in the development of precision technology over the past 25 years confirms the need for a larger database than before.

The next stage of development is the Internet of Things (IoT): things, objects, living things, and so on, transferring over the Internet. The guiding principle for the development of IoT is that anyone can communicate with anything, anything can be identified, and anything can interact with anything. They primarily analyze ideas about the technical conditions that need to be provided to create IoT technology. At the same time, IoT appears in agriculture, and especially in crop production, under special conditions and the "things" about which we collect information are –as mentioned above– living, intelligent systems that are not just programmed to adapt to the conditions. On the other hand, sensors must also provide continuous data in the long term under natural climatic conditions. This means that there needs to be special technical requirements. Among other things, this is the reason why only a small number of experimental applications of IoT technology have been implemented under operating conditions.

IoT systems have very large databases. At the same time, the information base can be expanded by orders of magnitude with on-the-go measurement options, in our case with small smart robots traveling between the installed measuring units. Since IoT is an enhanced version of Data Fusion, additional information can be collected from satellites or by integrating the images provided by drones.

INTERNET OF THINGS AND SENSORS IN AGRICULTURE

An important element of precision technology is the location-specific data collection with different sensors. IoT is a system of networked embedded devices with a unique identifier. In this way, different devices, systems and services can be connected without human intervention, using artificial intelligence (M2M: machine to machine). All this facilitates data collection and process automation in many application areas. In this way, much more data can be processed faster and in real time, which, in turn, induces a further increase in the amount of data, increasing the ecological efficiency and profitability of agricultural activities. Additionally, the importance of cloud computing should be emphasized (*Ambrus,* 2021).

WHAT IS A ROBOT?

A robot is defined as any functioning entity that perceives and interprets the characteristics of a dynamically changing environment, and intervenes in its environment in an adapted manner. Another important feature is communication and cooperation. The autonomous system needs information to make the right decisions before taking action. If the autonomous system has incorrect information, it will make wrong decisions and take an incorrect action. One of the most important criteria in the development of robotics is the issue of sustainable development; compliance with this places great responsibility on developers.

AGRICULTURAL ROBOTS

An agricultural robot, like any robot, must have essentially three important components: acquiring and processing information, making decisions, and performing a task (*Thompson et al.*, 1991).

In terms of types, the following exist for agricultural robots: data collector, weed control, plant protection, harvester, and respective combinations of these, as well as robots working in animal husbandry (milking robots, feeding robots, herd health monitoring robots).

The machine operation of agricultural robotic systems requires real-time correction, as spatial coordinates should be determined with high accuracy as immediately as possible point by point (*Gomes et al.*, 2018). So-called real-time differential correction (RTK) can greatly increase the accuracy of GPS data. Over the past decade, RTK technology has undergone a great development (+/-1 inch) (*Busics*, 2005).

APPLICATION OF ARTIFICIAL INTELLIGENCE, MACHINE LEARNING

There are a number of options available today that facilitate the processing of information from large databases. Today, the opportunities offered by machine learning are evolving greatly. Artificial neural networks have been incorporated into agriculture in many applications because of their advantages over traditional systems. The main advantage of neural networks is their ability to make predictions based on the interaction of information. Neural networks can be formed instead of actual programming. In the case of robots used in agriculture, it is not only the changing environment that is a major challenge, but also the fact that equipment often has to handle living, vulnerable materials. Applied artificial intelligence also integrates the opportunities provided by machine learning. In most agricultural robots, the use of machine learning contributes to performing complex tasks more efficiently.

Artificial vision is used to identify syndromes of plant diseases, pests, and pathogens, taking into account a number of visual characteristics that can be divided into three general categories: biological (morphology), spectral reflection characteristics, and visual structure.

MATERIALS AND METHODS

In the first part of our research work, our aim was to examine the available data collection technologies. The measuring system developed during the tender won by the Department of Biological Systems and Food Technology (Mosonmagyaróvár - Agro Internet of Things: M-AIoT) is located on two different fields under agricultural cultivation.

The structure of the IoT is based on three layers: the sensor layer, the data transmission layer, and the application layer. The M-AIoT system is designed to collect data on both arable land and surrounding natural areas. In this case, the relationship between natural ecology and agroecology can be thoroughly studied.

Samples of soil, atmospheric, plant and environmental data are taken approximately every 15 minutes (data collection and transport can cause slippage of a few minutes). On the plots under cultivation, each node is located in areas with different soil types (sandy loam, loamy, silty loam) (Figure 1).

Fig. 1. Location of measuring stations in the experimental fields

Installed devices are commercially available, such as Libelium and Boreas, but self-developed Arduino-based equipment also provides data (Figure 2).

Fig. 2. Libelium, Boreas and self-developed data acquisition systems

The monitoring parameters are: soil electrical conductivity, soil O_2 and CO_2 content, soil temperature and moisture content at different depths, leaf surface moisture of sown crops, air temperature, humidity, and atmospheric pressure. Continuous groundwater monitoring sensors (nitrite, nitrate, pH, etc.) need to be developed. This system also includes a complex meteorological station that collects and transmits the parameters of the plant's microclimate (e.g., global radiation, rainfall, wind speed, and direction). All metering units operate on efficient solar panels, providing energy in cloudy and short daytime (winter) conditions. Online data transmission is based on the LoRaWAN (Long Range Low-Power Wide-Area Network) communication protocol. Through Gateway the data is sent to a cloud server for storage. This information is available on any computer or smartphone, allowing one to make decisions faster and more efficiently. The web interface is designed to handle different measuring stations in the field uniformly. This web-based system can provide comparative and valuable analysis with experience and inferences of the different accuracy and field applicability of the sensors.

SELF-DEVELOPED DATA COLLECTION SYSTEMS

Coauthor Bálint Ambrus (PhD student: supervisors: Miklós Neményi and Gergely Teschner), was responsible for the development of a self-developed measuring system in addition to the commercially available measuring systems. The designed measuring system has a modular design. It can be broken down into three major components, such as the power supply unit, the data processing and storage unit, and the physical quantity measuring unit (sensors). During its design, it also strived to have a simple, compact design and low energy consumption, as these criteria are essential for a measuring device placed in a field. The instrument itself is based on an Arduino single-chip computer to which individual sensors are connected. The connectors are sensors that provide data on soil moisture, soil temperature, ambient temperature and humidity. An additional component is a built-in real-time clock module that measures the date and time from a preset time, and this value is retained by the module even after a power failure. In addition, the device also includes an SD card module for easy storage. For easy transmission, cloud-based storage, and processing of the measured data, the system uses a wireless LoRaWAN communication module. The acronym stands for Long Range, which is a new radio modulation scheme.

During the conversion of the measuring system, it was necessary to create a transmitter and a receiver unit. The transmitter section contains the sensors measuring the environmental information and the transmitter LoRaWAN module. The receiver component is responsible for transmitting the information received by the transmitter to the server where the data is stored and displayed. The operating program is written in the C programming language of Arduino's own development environment. It includes function libraries essential for the operation of sensors, the buses to which the sensors are connected, the retrieval of the quantities to be measured, any transformations, and the storage of data.

The data was stored and displayed using an online application called ThingSpeak developed by Matlab. The application is easily accessible through a browser after registration. Sensor data is available in tabular and graphical form, as well as simple statistical analysis, and alarm notifications are sent to the users.

DEVELOPMENT OF A MOBILE DATA COLLECTION DEVICE (ROBOT)

In addition to the previously mentioned measuring stations, according to literature of Wang et al. (2019), we are developing a mobile measuring unit, the data of which complements the existing data. The robot itself is a rubber-footed device mounted on a metal frame, driven by two DC motors. The original control (Raspberry Pi 3) has been replaced with a Raspberry Pi 4 microcomputer, which is protected by a specially designed cover panel that houses other additional electronic components and connectors. The robot has a three-axis servomotor-based arm, which at the end has a level sampling device that can be moved by a servomotor. It is also equipped with an RGB camera that can also be positioned along two axes with servomotors. The device has an ultrasonic distance sensor as well as a lidar sensor for orientation, so it is able to travel autonomically between the rows of the crop. It also collects information from the environment, such as global radiation, ambient temperature and humidity, soil surface temperature, and soil properties (temperature, moisture content, EC, pH, NPK). In the analysis of camera images, artificial intelligence based on a neural network is able to detect changes in plant parts and signal this to the robot operator. The robot's control software is written in the Python programming language. It allows the user to have complete control and optimization of the machine. It is possible to operate the device via both wired (LAN) and wireless (Wifi, Bluetooth) connections (Figure 3).

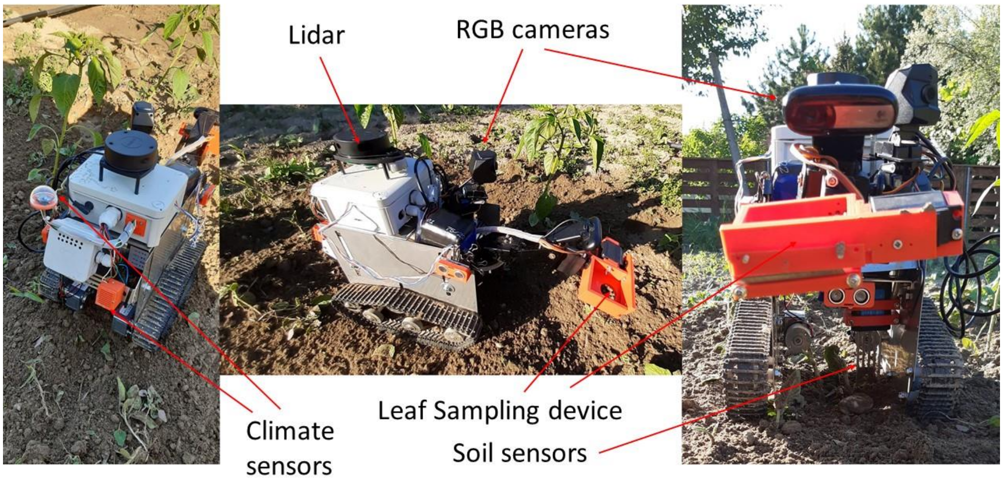

Fig. 3. Architecture of the developing smart small robot

CONCLUSIONS

Precision farming incorporates a range of modern technological tools integrated into farming in order to optimize the production process and reduce the impact of risk factors. Continuous monitoring of environmental conditions and plant conditions can be achieved through a networked system of different sensors. The availability of appropriate data is the basis for timely and targeted interventions.

These can be used to optimize irrigation water use, nutrient replenishment, and crop protection, thus reducing the amount of inputs and costs while increasing or stabilizing crop yields. All this points to a reduction in the environmental burden of agricultural origin and an improvement in the profitability of farming. This is a major step towards achieving sustainable agriculture, which is of immense importance due to the growing population of the world.

With the development of robots and robotics, there will be a major transformation in agriculture, as in all areas of life. The systems developed so far will be replaced by autonomous systems in the future that do not require human intervention, which will not only be usable for one target area, but can be equipped with more and more sensing systems in line with developments. The above-mentioned robot provides leaf sampling utilizing HRI (Human Robot Interaction). Additionally, the instrumentation could be expanded with new sensors (hyperspectral and acoustic sensors, electronic tongue, electronic nose). The robust, high-energy equipment in use today (e.g., combine harvester) will be replaced by small-scale equipment that will operate with a possible division of the given workflow. Taking into account spatial performance factors and sustainability considerations, robot swarms will work together in a “master-slave” relationship (URL[1]). The collected information will also be available chronologically retrospectively using “big data” data sets, which will be adapted to perform the task adaptively using the possibilities provided by Artificial Intelligence (AI), supplemented with data of stable and mobile measuring stations located in the field. These developments contribute to the development of unmanned tractors that are smaller than average but are adaptable to production conditions. At the same time, the authors are convinced that the current ecological efficiency and productivity of agricultural production can only be increased with cheap, small, smart, reliable data collection robots. Through IoT (Internet of Things) and the small smart robots that work with it, it is also possible to continuously collect data on the production unit and its near and far natural and near-natural environment. This will significantly increase the efficiency of the forecast.

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THE CURRENT STATE AND TRENDS OF AGRI-ENGINEERING STUDIES IN GEORGIA

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Abstract: The article analyzes the main results of agri-engineering studies in Georgia, taking into account the world trends; proceeding from the distinctness of the agriculture of the country the main directions of the fundamental and integrated applied studies in the branch of mechanization are defined. The attention is paid to the branches of the mechanics and mathematical sciences, which application significantly raises the scientific level of agri-engineering studies. The measures for stabilization of the engineering sphere of the agricultural sector and development of agriculture on the way of technological and technical innovation are defined.

Keywords: agri-engineering studies, priorities, innovation, resource-saving.

Introduction. The engineering sphere of the agro-industrial complex comprises such industries, which are in mutual connection and mutually determine each other: the machine technology of cultivation of crops, a system of machines, the technology of agricultural machine-building, and agri-engineering service. Machine technology plays the leading role in the mutual influence of the mentioned industries. On the modern stage, much higher requirements are laid down to the construction of agricultural machines and the level of machine-building in the aspect of precision of implementation of technological processes, increasing of performance, and especially resource-saving. Therefore substantiation of perspective resource-saving mechanized technologies, prognostication of rational parameters of machines and equipment, formation of optimal machine system, machine and tractor fleet is a necessary prerequisite of creation, production, and use of new technics. The solution of all mentioned problems jointly must be taken into consideration for the determination of priorities of agri-engineering studies.

The main results of agri-engineering studies. Based on the specificity of agriculture of Georgia, the research works were conducted in the direction of mountain agriculture and the mechanization of subtropical cultures. The scientific bases of working on the slopes of tractors and agricultural equipment, in their number, their dynamics of traction, theory of stability and cross-country capability, the methods of mathematical and physical simulation of working of equipment on the slopes, the basics of calculation and designing of the main parameters of hillside tractors have been developed. Several modifications of hillside tractors have been constructed and manufactured in limited editions. Significant studies have been conducted and the machine technologies, the respective working tools, and complexes of machines have been created for soil tillage on slopes and cultivation of crops (annual and perennial). “Cultivation and harvesting of crops on the slopes” has been defined in the “Machinery System” as an individual chapter.

The Georgian scientists and constructors occupy leading positions in the world in the creation and manufacturing of technical means for integrated mechanization of the technological processes of cultivation of tea culture. The scientific basics of calculation of optimal parameters of these machines, increasing reliability and longevity, exploitation, and repair have been developed. Some of these works were awarded union and republican prizes. The factory of special agricultural machines was engaged in the serial manufacture of these machines. In the nationwide “Machinery System” the section “Machinery complex for cultivation and harvesting of tea and subtropical cultures” was separated as an individual paragraph.

Significant works have been conducted in the direction of scientific support of the production of technical means of small-scale mechanization. Taking into consideration that by the mentioned machines the technological processes proceed in transient mode, they were classified according to the source of power, the motion of the working tool, the law of variation of the reduced moment of inertia, and the law of variability of resistance on the working tool. The method of calculation of optimal parameters of technical means of small-scale mechanization was based on such classification that also took into consideration the biomechanical properties of the human body. A special factory in Georgia was engaged in the serial manufacture of walking tractors and small-size tractors for small-scale mechanization.

“The system of machines and technologies for the production of products of plant-growing and cattle breeding”, developed in the Institute of mechanization and electrification may be considered as the significant achievement of the recent years. By the request of the Ministry of Agriculture, it has been published in four books, and it is a basis of the technical and technological re-equipping of the agriculture of Georgia in conditions of the market economy. The use of this “System” gives a commodity producer a possibility to choose from all variants of machine technologies the acceptable one, based on his economic possibilities, and gradually transit to modern, resource-saving technologies of production of crops. The “System” is developed on the modern level of agri-engineering sciences and it needs further permanent perfection following the development of the respective branches of science in our country and abroad.

The adaptive modification with self-propelled chassis has been invented for small farms. The balanced suspension of the rear leading tandem-wheels allows adapting its energetic possibility to various technological operations, for soil basic and inter-row tillage and cultivation and harvesting of cultures on all stages of growth and development of cultures. Moreover, the tandem wheels allow maximal use of the power parameters of the engine, for increased traction and cross-country capability of the tractor. The modification of chassis in such a form allows to reduce significantly the nomenclature and quantity of energy-technical means, and as well the self-cost of produce in farms.

The combined equipment for pre-sowing treatment and sowing deserves attention, which makes five technological operations in one passage. It allows to make coulisses and micro-terraces on slopes from 4 to 10^{o}, tillage of soil on the depth up to 22 cm and to prepare the sowing area on the depth 12-14 cm, to make a seedbed, to sow in two rows, and to ram the sown area. It is used both for clear and companion planting of annual crops, as well as for planting potatoes. It is aggregated on a tractor of 14 - 30 kN class of traction; the combined tractor will allow reducing the nomenclature of the soil-tillage and sowing machines 2-3 times.

In recent years due to a lack of funding, thousands of hectares of tea plantations and agricultural arable lands have been withdrawn from circulation. The machine technologies and complexes of machines are developed that are suitable for rehabilitation of tea plantations, and for conducting culture-technical works in degraded plantations and arable lands. For their rehabilitation, the resource-saving adaptive machine made on the block-module principle, with active working tools has been invented, that in one passage cuts tea bushes on necessary height, minces the cut mass, and disperses it in a form of mulch in the row spacings. In the first years, the mulch promotes the growth and development of tea sprouts and then is used as a high-quality organic fertilizer. The machines and equipment with passive or active working tools are specially invented for uprooting or local chopping of the root system of degraded tea plantations. For deep tillage of spacings of tea plantations to be rehabilitated a chisel-cultivator has been invented with special legs, which together with tillage of soil insert a dispersed mulch in lower layers of soil in spacings and mix it with soil. The same technology and complexity of machines can be used for carrying out cultural-technical works in arable lands abandoned for years.

In the sphere of mechanization of gardens and vineyards, the prospective direction is an invention of block-module equipment, which will have quickly detachable and rearrangeable modules of various names (for pruning, fruit harvesting, digging of pits, loading and unloading device, for spraying and sprinkling, ramming of pickets and so on). For mounting such modules, the universal frontal suspension system with a lifting device is invented as a basic for tractors of various classes. The tillers and chisel-cultivators with active and passive working tools for soil tillage are invented for replaceable working tools and variable width of gripping.

In cattle-breeding in the industry of forage-producing, the "packed haylage" is a prospective technology that comprises of the following mutually-connected operations: mowing of grass and squashing by special rollers; overturning and heaving of mowed herbage, formation of swaths, taking of swaths and pressing in high-density bales, packaging of haylage bales in special round bales, chopping of bales and distributing to animals. The special machines, destined for artificial sown lands and big areas make the mentioned operations abroad. In our country, the greater part (by traditional technology) of forage is produced in household plots, in small contour croplands, in plots near roads and forests.

The Institute of mechanization and electrification of agriculture has developed a technology, which allows the production of forage for animals from these plots by high technology. In particular, the above-mentioned forage producing operations are carried out by the technical means of small-scale mechanization, and pressing and packing of grass in small size bales - on a stationary device of worm-screw type. The electric engine and also tractor shaft for power extraction may be used as a drive shaft of worm-screw.

Priorities of agri-engineering studies. The modern trend of the development of machine technologies and complexes of machines is expressed in the minimization of some independent operations. In the ideal case, the number of operations must be equal to the number of cycles in common processes of production of crops or be maximally close to it. In such case sustainability of the production of agricultural produce in any weather conditions will be guaranteed, because the multi-operation equipment simultaneously implements the moisture-saving and resource-saving technology.

The mechanics of land farming as a science has been once formulated for the development of theoretical foundations of the creation of separate technological processes, working tools, and machines. On the modern stage the sub-theories, if they refer to known processes, serve to the perfection of existing traditional technologies and machines. However, the invention of science-intensive resource-saving machine technologies and technical means requires principally new generalized theories. In the nearest years in the branch of mechanization of agriculture, based on fundamental and complex applied studies scientific foundations for engineering calculations of such parameters of resource-saving adaptive technologies and technical means of new generation must be invented, which will provide a rational interaction of agricultural machines with biological objects: soil, plants, animals.

The general fundamental and applied studies for solving the mentioned problem must be conducted in the following directions:

- Studying the main regularities of deformation, breaking, and displacement of agricultural objects and materials; developing the main constants characterizing their rheological properties and standardization of these methods;
- Studying the agricultural materials (seed, fruit, new sprouts of tea, root tuber, etc.) on sustainability in respect of mechanical and other type damages, these criteria of damage must be substantiated, which will characterize the acceptable sum mechanical influence (static and dynamic, of various intensity and cycling) on their working tools.
- Substantiation of minimal theoretic specific power capacities of the technological processes; based on it, the technological efficiency of existing machines and working tools, quality of compatibility of means of mechanization and technologies, the level of their perfection, and ways of increase of efficiency will be determined;
- Developing and improving the methods of construction of physical and mathematical models of functioning of technical means and systems of mechanization of agriculture, using the achievements of the modern agri-engineering sciences;
- Developing and improving the methods of analysis and synthesis of combined machines destined for resource-saving technology;
- Developing and improving the methods of optimization of parameters of combined machines destined for resource-saving technology, according to technical and technological criteria;
- Developing in conditions of mountain land farming the resource-saving machine technologies for the production of ecologically pure agricultural products, the energy supply systems and complexes of machines of new generation, taking into account the various forms of farms;
- Developing the typical machine technologies of production of agricultural produce with customer appeal according to the zones of the republic, using the complex system of control of the quality of products;
- Developing the high machine technologies and technical means of cultivation of the main crops, using new physical effects (electrohydraulic, hydrodynamic, gasodynamic, oscillations of high-frequency range, and so on), highly productive seeds (mini seed pelleting, hydro thermic treatment, electric separation, selection of biologically perfect material and so on), focal batching application of full-component biologically active organo-mineral fertilizers, using the admissible influence of technical means on soil, optimal control of vegetative conditions;
- Developing machine technologies and complexes of machines for guaranteed production of annual and perennial crops for mountain conditions, using soil protective, erosion preventing, moisture saving, terracing, adaptation of walking parts and working tools to slope, automatic bridge land farming, small-scale mechanization, combined and replaceable working tools and other complex measures;
- Developing for peasant economies (farms) of complexes of agricultural machines with replaceable, rapidly re-arrangeable flexible working tools, based on technical means of small-scale mechanization, based on the block-module principle, unification, using progressive transmissions (hydro, electro);
- Developing highly intensive technologies and technical means for the processing of secondary products and agricultural wastes;

- Developing highly effective methods of use of transport in agro-industrial complex (state and peasant economies), taking into account the new forms of economic management, to create means for transportation and loading-unloading of agricultural products with multifunction working tools, which will provide guaranteed carrying out of the harvest in any weather conditions;
- The invention of mobile and stationary power means and complexes of machines of agricultural destination, which will work on gas, the solar, wind, and other alternative and renewable energy sources;
- Establishing in agriculture the methods and technical means of automated control and quality control of mechanized works for all stages of cultivation of crops, processing, storage, and reprocessing, including the use of GPS navigation systems;
- Developing the scientific foundations of optimization of technological complexes of machines, machine and tractor fleet, the infrastructure of technical service, taking into account the reduced nomenclature of machines, composed by block-module principle, universalization, and unification, as well as new forms of economy management;
- Developing the methods and automated technical means of rapid multifunction tests of technological processes and complexes of machines, using the mathematical and physical models;
- Developing and refinement of the methods of determination of reliability parameters of agricultural machines and tractors, taking into consideration the mountain conditions, operating conditions, and other peculiarities;
- Developing the technology and technical means of a fight with natural phenomena (freezing, hail, landslides, etc.).

Improvement of the scientific level of agri-engineering studies. On the modern stage, the scientific-technical progress in agricultural production is impossible without permanent perfection of scientific knowledge and its use in the solution of practical tasks. Therefore, the development of high, resource-saving technologies and technical means requires the scientific support of the respective level. In particular, the mechanics of land farming must more perfectly establish the scientific basics of sustainability of soil and other agricultural objects and materials. The complex structure of agricultural materials is responsible for a diversity of their physical-mechanical properties. Some of these properties are studied, but in the development of high technologies and working tools we face a huge resistance because the mechanical properties that characterize their resistance to deformation and breaking are studied weakly; these are the so-called rheological properties (modulus of elasticity, viscosity factor, strength limit, relaxation time, etc.); these parameters enter as coefficients in the differential equations, which describe their stressed deformed state during various loads. The rheological properties must be studied in functional dependence with the variable factors of time, temperature, moisture, density, etc.

The Academician V.P. Goryachkin has based the general theory of working tools on the wedge theory and theory of rupture. At the same time, he mentions that the quality of work of wedge may be perfectly solved by the use of elasticity theory. Development of high theory requires the use of elements of the theory that studies big deformations - rheology. By traditional technology plowing of soil and loosening of furrow slices are performed in a form of operations independent from each other. However, in resource-saving technology, both operations are performed simultaneously. At the same time, the additional loosening of furrow slices is performed by the rotary working tools. The cutting knife passing through the soil creates in its certain volume the stressed deformed state. The further displacements create and propagate the cracks tearing furrow slices. If we impact on furrow slice when it is in the pre-stressed deformed state, then the number of arising cracks will be maximal and energy losses on loosening - minimal. A furrow slice as an elastic viscous body is in a stressed deformed state during the relaxation time. So, using rheology science for the development of wedge theory helps us in substantiation of high technologies and rational arrangement of combined working tools fulfilling them, their kinematic and dynamic parameters.

The use of achievements of rheology is necessary for scientific support of such high technologies, as the production of corn and root tubers by ridge-strip technology, forage production by "packed haylage" technology, etc.

The majority of working tools of agricultural machines work on the shock principle, therefore by using the energetic theory of shock of classic mechanics the Acad. V.P. Goryachkin has developed some issues necessary for the mechanics of land farming. Then the Academicians M.E. Matsepuro and P.M. Vasilenko mentioned that the perfect satisfaction of the requirements of calculation of working tools of agricultural machines, one of the significant issues of the mechanics of land farming is a further development of shock theory. Using the modern achievements of vibration, contact theories of shock, and rheology methods we have developed the engineering theory of deformation and rupture of agricultural materials; based on it the parameters of working tool and working modes of agricultural machines, working on shock principle, have been substantiated. In the same monograph is given an attempt of further development of theories of rupture of plant materials, densification (compacting), and wheel rolling for more complete taking into account of rheological (elastic-viscous) properties and the operating conditions of working tools.

Creation of machine technologies and machines, fulfilling them, following the development of mechanical-mathematical methods, the following basic theories of mechanics of land farming must be perfected: wedge theory, theories of cutting, rupture, deformation, displacement, separation, densification, etc., of agricultural environment and materials.

The use of pneumodynamic effect is considered as the resource-saving technology of loosening of compacted soil, and retention of precipitation on a slope. The experiments in this direction have been conducted in Germany, Japan, Russia, and Georgia. The theory of the mentioned technology in mechanics of land farming was not developed, which naturally prevents the wide dissemination of this method because it is difficult to substantiate technological and technical parameters during the designing of respective machines. The authors for the first time in the mechanics of land farming have developed the theory of the technological process of deep loosening of soil by the pneumodynamic effect, using the achievements of the explosion theory. The theory is based on the assumption that when the pressurized air is supplied to the required depth of the soil, an explosion effect occurs. From the place of air supply, the compression waves propagate in all directions; their velocity is more than the rate of deformation in the soil environment. For arising of cracks in the soil and its knifing the waves reflected from the free surface are the most important. The compression waves put in motion all particles from the place of supply of pressurized air in radial directions, but this motion is braked due to the reaction of layers more distant from the delivery zone. Compressing the soil layers, the compressing waves cause accumulation of certain elastic energy in them. When the compressing waves reach the free surface of the soil, its compressed layers begin widening towards the free surface, because in this direction no resistance arises. The intensive motion of soil towards the free surface is transmitted to the layers more distant from the free surface. Within the soil, the tensile wave is transmitted from the free surface, which causes tensile deformations in the medium. This means that compression waves after reflection from the free surface transform into tensile waves. Since the ultimate tensile strength is much less than the ultimate compression strength, arising of cracks in soil needs less energy, than during its treatment by mechanic working tools (by subsoilers).

The development of high technological agricultural assemblies is made mainly by the block-module principle when the rigid connection of energetic and technological blocks creates the energy-technical block. This unites in one construction design the advantages of a tractor (increased annual load, universality and relatively low specific material consumption) and self-propelled combine (increased performance, power/weight ratio, and compactness). In most cases, the energetic block presents the disengageable one-axle block with front, rear, and lateral joint units and with energy taking system, and the technological block is an independent wheeled chassis with the device of response docking and with permanent or replaceable working tools. By this principle, it is possible to create complete energy-technological modules for the cultivation of separate crops. The disengageable energetic modules during the year will work with a full load, and the technological blocks will be universally unified with replaceable working tools, quickly rearrangeable and where it will be possible, will fulfill several technological operations.

The mechanics of land farming must develop the scientific basics for engineering calculation of technological, geometric, kinematic, and energetic parameters of flexible energy-technological complexes made by block-module principle. Optimization of parameters of the technical means of such type, by technological, as well technical and economic criteria is necessary. The technological criteria may be used firstly for optimization of parameters of working tools, the technical ones - for determination of transmission devices, as well for optimal ratio of masses and velocities of energy-block and technological blocks, the economic ones - for calculation of optimal composition of complexes of machines made by block-module principle during the whole period of exploitation.

V.P. Goryachkin assumed that the issue of normal values of masses and velocities is the main in the mechanics of land farming. It seems that the then-level of development of mechanical-mathematical methods did not allow a complete solution to this problem, so he thought that the issue is worth to be developed in more detail in the future.

The theory of masses and velocities in modern understanding is the theory of optimization of parameters of machines and their control systems (in their number, automatic control). In recent years several fundamental studies have been devoted to this problem. Fitting of the mentioned theories to equipment made by the block-module principle must be made in the direction, that will withdraw the following discrepancy. The fact of the matter is that an energetic block with the same mass and velocity must be rigidly connected with technological blocks with different masses and technological velocities, so the ratios mass/velocity optimized for one energetic module will not be optimal for the remaining ones. At the same time in the technological system, the masses and velocities participate in the formation of stresses (together with technological resistance), as well as the rigidities of elements of transmission mechanisms. Therefore, if we use as a criterium of optimization the minimization of loads or energy consumption, then the masses and velocities of various energy-technological modules will be selected from quality parameters of the fulfillment of technological process, and minimization of loads must be made by insertion in transmissions of elastic-viscous elements (dampers). At the same time attention must be paid to a finding of such ratio of machine parameters, during which the transient processes (in their number, transient processes in control systems of automatic systems) will damp in minimum time (optimization of criterium of operation).

At the creation of machines made by high technology, designed by block-module principle, the most important is the perfection of the methodology of calculation of their reliability. The reliability theory used now in machine building, which takes sources in the reliability theory of radio electronics, is far from perfection. The main defect of the probabilistic method of evaluation of reliability is that the reliability parameters are not directly related to physical characteristics (masses, moments of inertia, velocities, rigidity, etc.) of separate mechanisms and components and external loads (physical characteristics of the material to be processed) that impact the working tools. Due to the mentioned, use of methods developed in the theory of reliability is limited on the stage of designing of machines, especially when using of the method of reserving of increasing of reliability is difficult and high reliability of separate elements is the sole means of creation of machine with highly reliable characteristics. It turns out that the existing method of calculation of characteristics of reliability is not relevant to engineering calculation of its design and construction, engineering construction-technological methods of provision of reliability.

It proceeds from the above that the mechanics of land farming must develop such theory of reliability of agricultural machines, that by the way of synthesis of probabilistic and deterministic methods will relate characteristics of reliability, firstly with the physical-mechanical properties of the material of construction of the machine, also with the change of these properties in time and secondly, with the parameters of separate segments, components, and mechanisms of the machine, with forces impacting the working tool and the modes of exploitation of the machine.

The development of the topical issues of the mechanics of land farming will accelerate the conversion in agriculture of resource-saving machine technologies and technical means.

The scientific-organization difficulties of agri-engineering studies. There is not a systematic approach to innovation in the mechanization of agriculture. Therefore the technical re-equipping is mainly made based on traditional operational technology of cultivation of crops. As a result, despite the increase in the number of technics purchased abroad, the volume of agricultural production does not increase respectively. To permanently control the scientific-technical progress, to conduct substantiated innovation policy, it is necessary to establish a mechanism of necessary influence on purchasing of respective technics (in certain cases - it's manufacturing). Such a mechanism may be a permanently renewable system of resource-saving technology of cultivation of the main crops and a system of machines. Such “systems” are formed for a certain, sufficiently prolonged period – 5 - 10 years. Their development must be made in research institutions under the request of the government agencies and must be approved by the Ministry of Agriculture and the Academy of Agricultural Sciences in agreement with the Council of Ministers of the republic. The system of technologies and machines must be the main document for the creation of new machines, in necessary cases - of their modernization and financing of local production of some specific machines, for the formation of machine-tractor fleet and objects of engineering service, i.e. for management of innovation processes. On a national scale, the main difficulty for conducting innovation policy is a liquidation of research organizations working in the direction of mechanization. Earlier the research Institute of mechanization and electrification of agriculture, the institute of agricultural machine-building (Geoagromachine), the testing station of machines, the station of rationing offered scientific support. Due to such reform, the agricultural equipment is imported from abroad without preliminary testing and technical-economical substantiation; the works are not rationed (determination of fuel consumption and performance) according to technological operations and natural-climatic conditions of the regions of the country. The majority of imported equipment fails too early, often its quantity exceeds the purchased ones; therefore the area of cultivated lands does not increase. The lack of rationing of works results in excessive fuel consumption.

For stabilization of the engineering sphere of the agricultural sector of Georgia and its development on the way of technological and technical innovation it is necessary to establish a scientific-technical center, which will simultaneously implement scientific research, testing of machines and technologies, and the function of rationing of mechanized agricultural works, i.e. the functions of four earlier existed organizations; otherwise, the priority development of agriculture will be impossible. The factories for tractors and agricultural machine-building that existed earlier do not function. The mechanization of highland land farming and mechanization of subtropic cultures requires specific machines, in the creation and production of which the Georgian scientists and constructors had world priority. In the beginning, it would be possible to launch at full capacity the experimental-mechanical factory of the research Institute of mechanization and electrification, which manufactured in small series the complexes of machines for rehabilitation of tea, as well as for the fulfillment of cultural-technical works in degraded tea plantations and the lands withdrawn from circulation. Also, the plows imported from abroad would be equipped with blade cultivators for flat plowing on slopes and erosion preventing treatment.

Implementation of agri-engineering studies on a high level is hampered by weak equipping with modern devices and equipment, such are portable tensometric apparatus, mobile tensometric laboratory, calculation technics that is used as the pilot device in substantiation of constructions, parameters, and operating conditions of new agricultural machines on the stage of their designing; for automatic designing of experimental samples and prototypes of systems, etc.

Conclusion. In the nearest future, the scientific basics of engineering calculation of resource-saving adaptive technologies and technical means of new generation must be established in the branch of mechanization of agriculture, based on fundamental and complex applied studies; they will ensure a rational interaction of working tools of agricultural machines with biological objects: soil, plants, animals. Based on this, the main directions of required studies and as well the branches of mechanics and mathematics sciences, which use will significantly improve the level of agri-engineering studies are defined. The measures for the development of agriculture by the technological and technical innovation way.

საქართველოს აგროსაინჟინრო სექტორის სტაბილიზაციისა და განვითარების პრიორიტეტები

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რეზიუმე: სტატიაში გაანალიზებულია საქართველოში აგროსაინჟინრო კვლევების ძირითადი შედეგები მსოფლიო ტენდენციების გათვალისწინებით და საქართველოს სოფლის მეურნეობის თავისებურებებიდან გამომდინარე გამოყოფილია უახლოეს წლებში მექანიზაციისა დარგში ფუნდამენტური კომპლექსური გამოყენებით კვლევების ძირითადი მიმართულებანი, ყურადღება გამახვილებულია მექანიკა-მათემატიკური მეცნიერებების იმ დარგებზე, რომელთა გამოყენება მნიშვნელოვნად ამაღლებს აგროსაინჟინრო კვლევების მეცნიერულ დონეს და დასახულია ღონისძიებანი აგროსამრეწველო სექტორის საინჟინრო სფეროს სტაბილიზაციისა და სოფლის მეურნეობის ტექნოლოგიური და ტექნიკური ინოვაციის გზით განვითარებისათვის .

საკვანძო სიტყვები: აგროსაინჟინრო კვლევები, პრიორიტეტები, ინოვაცია, რესურსდაზოგვა .

შესავალი. აგროსამრეწველო კომპლექსისი საინჟინრო სფერო მოიცავს ისეთ ურთიერთ კავშირში მყოფ და ურთიერთ განსაზღვრულ დარგებს, როგორიცაა სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანის სამანქანო ტექნოლოგია, მანქანათა სისტემა, სასოფლო-სამეურნეო მანქანათმშენებლობის ტექნოლოგია და აგროსაინჟინრო სერვისი. აღნიშნული დარგების ურთიერთ გავლენაში წამყვანი როლი მიეკუთვნება სამანქანო ტექნოლოგიას. იგი თანამედროვე ეტაპზე გაცილებით მაღალ მოთხოვნებს უყენებს სასოფლო-სამეურნეო მანქანების კონსტრუქციას და მანქანათმშენებლობის დონეს ტექნოლოგიური პროცესების შესრულების სიზუსტეს, მწარმოებლობის გაზრდის და განსაკუთრებით, რესურდაზოგვის მხრივ. ამიტომ პერსპექტიული რესურსდამზოგავი მექანიზებული ტექნოლოგიების დასაბუთება, მანქანების და აგრეგატების რაციონალური პარამეტრების პროგნოზი, ოპტიმალური მანქანათა სისტემის და მანქანა-ტრაქტორთა პარკის (მტპ) ფორმირება წარმოადგენს ახალი ტექნიკის შექმნის, წარმოებისა და გამოყენების აუცილებელ წინაპირობას. ყველა აღნიშნული პრობლემების ერთობლიობაში გადაწყვეტა გათვალისწინებული უნდა იქნეს აგროსაინჟინრო კვლევების პრიორიტეტების განსაზღვრისათვის.

აგროსაინჟინრო კვლევების ძირითადი შედეგები. საქართველოს სოფლის მეურნეობის სპეციფიკიდან გამომდინარე, აგროსაიჟინრო დარგში კვლევითი მუშაობა ძირითადად წარიმართა სამთო მიწათმოქმედებისა და სუბტროპიკული კულტურების მექანიზაციის მიმართულებით. დამუშავდა ფერდობზე ტრაქტორებისა და სასოფლო-სამეურნეო აგრეგატების მუშაობის მეცნიერული საფუძვლები, მათ შორის, მათი წევითი დინამიკის, მდგრადობის და გამავლობის თეორია, ფერდობზე აგრეგატების მუშაობის ფიზიკური და მათემატიკური მოდელირების მეთოდიკა, ფერდობზმავლის ძირითადი პარამეტრების გაანგარიშებისა და დაპროექტების საფუძვლები. შეიქმნა ფერდობზმავლების რამდენიმე მოდიფიკაცია რომლებიც მცირე სერიებად იწარმოებოდა. ჩატარდა მნიშვნელოვანი კვლევები და შეიქმნა სამანქანო ტექნოლოგიები, შესაბამისი მუშა ორგანოები და მანქანათა კომპლექსები ფერდობზე ნიადაგის დამუშავებისა და საოფლო-სამეურნეო კულტურების (ერთწლიანი და მრავალწლიანი) მოვლა მოყვანისთვის . „მანქანათა სისიტემაში“ ცალკე თავად გამოიყოფოდა „ფერდობზე სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანა და აღება“ .

მსოფლიოში წამყვან პოზიციებზე იმყოფებიან ქართველი მეცნიერები და კონსტრუქტორები, ჩაის კულტურის მოვლა-მოყვანის ტექნოლოგიური პროცესების კომპლექსური მექანიზაციისათვის ტექნიკური საშუალებების შექმნისა და წარმოების საქმეში. დამუშავდა ამ მანქნების ოპტიმალური პარამეტრების გაანგარიშების, საიმედოობისა და ხანგამძეობის ამაღლების, ექსპლუატაციისა და რემონტის მეცნიერული საფუძვლები. ზოგიერთი ამ სამუშაოებისა აღინიშნა საკავშირო და რესპუბლიკური ლაურეატობის პრემიებით. სპეციალური სასოფლო სამეურნეო მანქანების ქარხანა დაკავებული იყო აღნიშნული მანქანების სერიული წარმოებით. საკავშირო „მანქანათა სისტემაში“ ცალკე პარაგრაფად გამოიყოფოდა განაკვეთი ჩაის და სუბტროპიკულიკულტურების მოვლა-მოყვანისა და აღების მანქანათა კომპლექსი“.

მნიშვნელოვანი სამუშაოები ჩატარდა ასევე მცირე მექანიზაციის ტექნიკური საშუალებების წარმოების მეცნიერული უზრუნველყოფის მიმართულებით. იმის გათვა-ლისწინებით, რომ აღნიშნული მანქანებით ტექნოლოგიური პროცესები სრულდება ძირითადად გარდამავალ რეჟიმში, მოხდა მათი კლასიფიკაცია ენერგეტიკულ წყაროს , მუშა ორგანოს მოძრაობის, დაყვანილი ინერციის მომენტის ცვალებადობის კანონის და მუშა ორგანოზე წინააღმდეგობის

ცვალებადობის კანონის მიხედვით. ასეთი კლასიფიკაცია დაედო მცირე მექანიზაციის ტქენიკური საშუალებების ოპტიმალური პარამეტრების გაანგარიშების მეთოდიკას, რომელიც ითვალისწინებს ასევე ადამიანის სხეულის ბიომექანიკურ თვისებებსაც. საქართველოში სპეციალური ქარხანა დაკავებული იყო მცირე მექანიზაციისათვის მოტობლოკებისა და მცირე გაბარიტიანი ტრაქტორების სერიული წარმოებით.

უკანასკნელი წლების მნიშვნელოვან მიღწევად უნდა ჩითვალოს სოფლის მეურნეობის მექანიზაციისა და ელექრიფიკაციის ინსტიტუტში დამუშავებული „მემცენარეობის და მეცხოველეობის პროდუქტების წარმოების ტექნოლოგიებისა და მანქანების სიტემა“, რომელიც სოფლის მეურნეობის სამინისტროს დაკვეთით გამოცემულია ოთხ წიგნად და წარმოადგენს საქართველოს სოფლის მეურნეობის ტექნოლოგიური და ტექნიკური გადაიარაღების საფუძველს საბაზრო ეკონომიკის პირობებში . აღნიშნული „სისტემის“ გამოყენებით საქონელმწარმოებელს საშუალება აქვს სამანქანო ტექნოლოგიების ყველა შესაძლო ვარიანტებიდან, თავისი ტექნიკურ-ეკონომიკური შესაძლებლობებიდან გამომდინარე, აირჩიოს მისაღები ვარიანტი და თანდათნაობით გადავიდეს სასოფლო-სამეურნეო კულტურების წარმოების თანამედროვე, რესურსდამზოგ ტექნოლოგიებზე. „სისტემა“ დამუშავებულია აგროსაინჟინრო მეცნიერებების თანამედროვე დონეზე და მოითხოვს შემდგომ მუდმივ სრულყოფას, შესაბამის მეცნიერებათა დარგების განვითრების კვალობაზე როგორც ჩვენში, ისე საზღვარგარეთ.

მცირე ფერმერული მეურნეობებისათვის შექმნილია ადაპტური თვითმავალი შასის მოდიფიკაცია. შასის უკანა წამყვანი ტანდემ-თვლების ბალანსური დაკიდება საშუალებას იძლევა მიუსადაგოთ ენერგეტიკული საშუალება სხვადასხვა ტექნოლოგიურ ოპერაციას როგორც ნიადაგის ძირითადი და რიგთაშორისებში დამუშავებისათვის , ისე სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანისა და აღების შესაბამის ოპერაციას სასოფლო-სამეურნეო კულტურის ზრდაგანვითარების ყველა სტადიაზე. ამას გარდა ტანდემ-თვლები საშუალებას იძლევა მაქსიმალურად გამოვიყენოთ ძრავას სიმძლავრითი მაჩვენებლები , ტრაქტორის წევითი და გამავლობითი თვისებების გაზრდისთვის. შასის ასეთი სახით მოდიფიცირება საშუალებას იძლევა მნიშვნელოვნად შევამციროთ ენერგო-ტექნიკური საშუალებების ნომენკლატურა და რაოდენობა , ასევე წარმოებული პროდუქციის თვითღირებულება ფერმერულ მეურნეობებში.

ყურადღებას იმსახურებს თესვისწინა დამუშავებისა და თესვის კომბინირებული აგრეგატი, რომელიც ერთი გავლით ასრულებს ხუთ ტექნოლოგიურ ოპერციას. იგი საშუალებას იძლევა 4-დან 10°-მდე ფერდობებზე მოვაწყოთ კულისები და მიკროტერასები, გავაფხვიეროთ ნიადაგი 22 სმ სიმაღლეზე და მოვამზადოთ სათესი არე 12- 14 სმ სიმაღლეზე, მოვაწყოთ სათესი ბაზო , დავთესოთ ორ მწკრივად მოვტკეპნოთ ნათესი . იგი გამოიყენება როგორც ერთწლიანი კულტურების სუფთა და კომბინირებულ სათესად, ასე კარტოფილის სარგავად. აგრეგატირდება 14 -30 კნ წნევის კლასის ტრაქტორზე . კომბინირებული აგრეგატი საშუალებას მოგვცემს შევამციროდ ნიადაგ დადამამუშავებელი და სათესი მანქანების ნომენკლატურა 2-3- ჯერ.

უკანასკნელ წლებში , დაუფინანსებლობის გამო, ათასობით ჰექტარი ჩაის პლანტაციები და სასოფლო- სამეურნეო სავარგულები გამოვიდნენ მიმოქცევიდან. დამუშავებულია სამანქანო ტექნოლოგიები და მანაქანათა კომპლექსები ვარგისი ჩაის პლანტაციების რეაბილიტაციისათვის, ხოლო დეგრადირებულ პლანტაციებსა და სავარგულებში კულტურულ-ტექნიკური სამუშაოების ჩატარებითვის. რებილიტაციისათვის შეიქმნა რესურსდამზოგი, ადაპტური, ბლოკ-მოდულური პრინციპით აგებული მანქანა, აქტიური მუშა ორგანოებით, რომელიც ერთი გავლით ახდენს ჩაის ბუჩქების გადაჭრას საჭირო სიმაღლეზე, მოჭრილი მასის დაქუცმაცებას და

მის მობნევას მულჩის სახიტ რიგთაშორისებში. მულჩი პირველ წლებში ხელს უწყობს ამონაყარი ჩაის ყლორტების ზრდა-განვითარებას, ხოლო შემდეგ გამოიყენება, როგორც მაღალ ხარისხოვანი ორგანული სასუქი. დეგრადირებული ჩის პლანტაციების ფესვთა სისტემის ამოთხრისა და ადგილზე ჩაკეპვისათვის გამოიყენებიამ სპეციალურად შექმნილი მანქანა-იარღები პასიური ან აქტიური მუშა ორგანოებით. სარეაბილიტაციო ჩაის პლანტაციების რიგთაშორისების ღრმა გაფრხვიერებისათვის შექმნილია ჩიზელ-კულტივატორი სპეციალური თათებით, რომელიც ნიადაგის გაფხვირებასთან ერთად ახდენს რიგთაშორისებში მობნეული მულჩის ქვედა შრეებში ჩატანას და ნიადგთან არევას . იგივე ტექნოლოგია და მანქანათა კომპლექსი წარმატებით შეიძლება გამოყენებული იქნეს წლების განმავლობაში მიტოვებულ სავარგულებში კულტურულ-ტექნიკური სამუშაოების ჩატარებისათვის.

ბაღებისა და ვენახების მექნიზაციის დარგში პერსპექტიულ მიმართულებად ითვლება ბლოკ-მოდულური აგრეგატის შექმნა , რომელსაც ექნება სწრაფად მოსახსნელი და გადასაწყობი სხვადასხვა დასახელების მოდულები (სასხლავი, ნაყოფის საკრეფი, ორმოების ამოსათხრელი , დამტვირთავ- გადამტვირთავი მოწყობილობა, შემსხურებელ- შემფრქვევი, სარების დამსობი და ა.შ). ასეთი მოდულების დასამონტაჟებლად - როგორც საბაზო, შექმნილია უნივერსალური ფრონტალური საკიდი სისტემა ასაწევი მოწყობილობით სხვადასხვა კლასის ტრაქტორისათვის. შექნილია ასევე საცვლელი მუშა ორგანოებიანი და ცვალებადი მოდების განის მქონე ბაღებში და ვენახებში ნიადაგის დამამუშავებელი აქტიური და პასიური მუშა ორგანოების მქონე ფრეზები და ჩიზელ-კულტივატორები.

მეცხოველეობისათვის საკვებწარმოების დარგში პერსპექტიულ ტექნოლოგიას წარმოადგენს „ შეფუთული სენაჟი", რომელიც შეიცავს შემდეგ ურთიერთშეკავშირებულ ოპერაციებს: ბალახის მოთიბვა და დატყლეჟვა სპეციალური ვალცებით; მოთიბული ბალახის მასის გადაბრუნება და ამობურცვა; ღვარეულების წარმოქმნა; ღვარეულობის აღება და დაწნეხვა მაღალი სიმკვრივის რულონებად; სენაჟის რულონების შეფუთვა სპეციალურ აფსკურებში; რულონების დაქუცმაცება და ცხოველებისათვის დარიგება. აღნიშნული ოპერაციები საზღვარგარეთ სრულდება სპეციალური მანქანებით, რომლებიც განკუთვნილი არიან ხელოვნური ნათესებისა და დიდი ფართობებისთვის. ჩვენში საკვების უდიდესი ნაწილი (ტრადიციული ტექნოლოგიით) მზადდება საკარმიდამო ნაკვეთებში, მცირე კონტურიან სავარგულებში, გზისპირა და ტყისპირა ნაკვეთებში.

სოფლის მეურნეობის მექანიზაციისა და ელექტრიფიკაციის ინსტიტუტში დამუშავდა ტექნოლოგია, რომელიც საშუალებას გვაძლევს ასეთი ნაკვეთებიდან ვაწარმოოთ საქონლის საკვები მაღალი ტექნოლოგიით. კერძოდ, საკვებწარმოების ზემოთ ჩამოთვლილი ოპერაციები სრულდება მცირე გაბარიტებიან ბარდანებად შნეკური ტიპის სტაციონალურ დანადგარზე. შნეკის ამძრავად გამოიყენება როგორც ელექტროძრავა , ისე ტრაქტორის სიმძლავრის ამრთმევი ლილვი.

აგროსაინჟინრო კვლევების პრიორიტეტები. სამანქანო ტექნოლოგიებისა და მანქანათა კომპლექსების განვითარების თანამედროვე ტენდენცია ისეთია, რომ დამოუკიდებული ტექნოლოგიური ოპერაციების რაოდენობა იყოს მინიმალური. იდეალურ შემთხვევაში ოპერაციების რაოდენობა უნდა გაუტოლდეს საოსოფლო - სამეურნეო კულტურების წარმოების საერთო პროცესებში ციკლების რაოდენობას , ან/და მაქსიმალურად მიუახლოვდეს მას. ასეთ შემთხვევაში გარანტირებული იქმება სასოფლო-სამეურნეო პროდუქტების წარმოების მდგრადობა ნებისმიერი ამინდის პირობებში, რადგან მრავალოპერაციული კომბინირებული

აგრეგატებით ერთდროულად რეალიზდება როგორც ტენდამზოგი, ისე რესურსდამზოგი ტექნოლოგიები.

მიწათმოქმედების მექანიკა, როგორც მეცნიერება, თავის დროზე ჩამოყალიბდა ცალკეული ტექნოლოგიური პროცესების, მუშა ორგანოების და მანქანების შექმნისათვის თეორიული საფუძვლების დამუშავებისათვის. თანამედროვე ეტაპზე კერძო თეორიები, თუ ისინი ცნობილ პროცესებს ეხებიან, ემსახურებიან მხოლოდ არსებული, ტრადიციული ტექნოლოგიებისა და მანქანების სრულყოფას. მეცნიერებატევადი, რესურსდამზოგავი სამანქანო ტექნოლოგიებისა და ტექნიკური საშუალებების შექმნისათვის კი საჭიროა პრინციპულად ახალი, განზოგადოებული თეორიების შექმნა. **უახლოეს წლებში, სოფლის მეურნეობის მექანიზაციის დაგრში, ფუნდამენტური და კომპლექსური გამოყენებითი კვლევების საუძველზე, უნდა შეიქმნას რესურსდამზოგი ადაპტური ტექნოლოგიებისა და ახალი თაობის ტექნიკური საშუალებების ისეთი პარამეტრების საინჟინრო გაანგარიშებისათვის მეცნიერული საუძვლები, რომლებიც უზრუნველყოფენ სასოფლო-სამეურნეო მანქანების მუშა ორგანოების რაციონალურ ურთიერთქმედებას ბიოლოგიურ ობიექტთან : ნიადაგთან , მცენარეებთან, ცხოველებთან.**

აღნიშნული პრობლემის გადაწყევეტისათვის საერთო ფუნდამენტური და გამოყენებითი კვლევები უნდა შესრულდეს შემდეგი მიმართულებებით:

● შესწავლილი იქნეს სასოფლო-სამეორნეო ობიექტებისა და მასალების დეფორმაციის მსხვრევისა და გადაადგილების ძირითადი კანონზომიერებანი, დამუშავდეს მათი გეოლოგიური თვისებების დამახასიათებელი ძირითადი მუდმივების განსაზღვრის მეთოდები და მოხდეს ამ მეთოდების სტანდარტიზაცია;

●გამოკვლეული იქნეს სასოფლო-სამეურნეო მასალები (თესლი, ნაყოფი, ჩაის დუყი, ძირხვენები და ა.შ) მექანიკური და სხვა სახის დაზიანებების მიმართ მდგრადობაზე, დასაბუთდეს დაზიანების ის კრიტერიუმები , რომლებიც დაახასიათებენ მათზე მუშა ორგანოების დასაშვებ ჯამურ მექანიკურ ზემოქმედებას (სტატიკურ და დინამიკურ, სხვადასხვა ინტენსივობისა და ციკლურობის);

●დასაბუთდეს ტექნოლოგიური პროცესების მინიმალური თეორიული ხვედრითი ენერგოტევადობანი, რის საფუძველზე განისაზრვროს არსებული მანქანების და მუშა ორგანოების ტექნოლოგიური მარგიქმედების კოეფიციენტის გაზრდის გზები;

● დამუშავდეს და გაუმჯობესდეს სოფლის მეურნეობის მექანიზაციისა ტექნიკური საშუალებების და სისტემების ფუნქციონირების ფიზიკური და მათემატიკური მოდელების აგების მეთოდები თანამედროვე საინჟინრო მეცნიერებათა მიღწევების გამოყენებით;

●დამუშავდეს და გაუმჯობესდეს რესურსდამზოგავი ტექნოლოგიებისათვის განკუთვნილი კომბინირებული მანქანების პარამეტრების ანალიზისა და სინთეზის თეორიული მეთოდები ;

●დამუშავდეს და გაუმჯობესდეს რესურსდამზოგავი ტექნოლოგიისათვის განკუთვნილი კომბინირებული მანქანების პარამეტრების ოპტიმიზაციის მეთოდები ტექნიკური და ტექნოლოგიური კრიტერიუმების მიხედვით;

●დამუშავდეს სამთო მიწათმოქმედების პირობებში ეკოლოგიურად სუთა სასოფლო-სამეურნეო პროდუქტების წარმოებისათვის რესურსდამზოგი სამანქანო ტექნოლოგიები , ახალი თაობის ენერგომომარაგების სისტემები და მანქანათა კომპლექსები მეურნეობების მრავალფორმინობის გათვალისწინებით;

●დამუშავდეს ქვეყნის ზონების მიხედვით მოცემული სამომხმარებლო თვისებების მქონე სასოფლო-სამეურნეო პროდუქტების წარმოების ტიპური სამანქანო ტექნოლოგიები პროდუქტების ხარისხის მართვის კომპლექსური სისტემების გამოყენებით;

●დამუშავდეს ძირითადი სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანის მაღალი სამანქანო ტექნოოგიები და ტექნიკური საშუალებები ახალი ფიზიკური ეფექტების (ელექტროჰიდრავლიკური, ჰიდროდინამიკური, გაზოდინამიკური, მაღალი სიხშირის დიაპაზონის რხევები და ა.შ.), მაღალპროდუქციული თესლის (მინიდროჟირება, ჰიდროთერმული დამუშავება, ელექტრული სეპარირება, ბიოლოგიურად სრულყოფილი მასალის გამორჩევა და ა.შ.), სრულკომპონენტიანი ბიოლოგიურად აქტიური ორგანომინერალური სასუქების კეროზრივად დოზირებულად შეტანის, ტექნიკური საშუალებების ნიადაგზე დასაშვები ზემოქმედების, ვეგეტაციური პირობების ოპტიმალურად მართვის გამოყენებით;

●დამუშავდეს სამთო პირობებისათვის ერთწლიანი და მრავალწლიანი კულტურების გარანტირებული წარმოების სამანქანო ტექნოლოგიები და მანქანათა კომპლექსები ნიადაგის დამცავი, ეროზიის საწინააღმდეგო, ტენის შემნახავი, ტერასირების, სავალი ნაწილების და მუშა ორგანოების ფერდობზე ადაპტირების, ავტომატური ხიდური მიწათმოქმედების, მცირე მექანიზაციის , კომბინირებული და საცვლელი მუშა ორგანოების და სხვა კომპლექსური ღონისძიებების გამოყენებით;

●დამუშავდეს გლეხური (ფერმერული) მეურნეობებისათვის საცვლელი მუშა ორგანოებიანი, სწრაფგადაწყობადი, მოქნილი აგრომანქანების კომპლექსები მობილური და მცირე მექანიზაციის ტექნიკური საშუალებების ბაზაზე ბლოკმოდულური პრინციპის, უნიფიკაციის, პროგრესული ტრანსმისიების (ჰიდრო, ელექტრო) გამოყენების ბაზაზე;

●დამუშავდეს მეორეული პროდუქტების და სასოფლო- სამეურნეო ნარჩენების გადამუშავების მაღალ ინტენსიური ტექნოლოგიები და ტექნიკური საშუალებანი;

●დამუშავდეს აგროსამრეწველო კომპლექსში (სახელმწიფო და გლეხურ მეურნეობებში) ტრანსპორტის გამოყენების მაღალეფექტური მეთოდები მეურნეობრიობის ახალი ფორმების გათვალისწინებით, შეიქმნას საოფლო-სამეურნეო პროდუქტების ტრანსპორტირების და დატვირთვა-გადმოტვირთვის საშუალებანი მრავალფუნქციური მუშა ორგანოებით, რომლებიც უზრუნველყოფენ მოსავლის გარანტირებულ გამოზიდვას ნებისმიერ ამინდის პირობებში;

●შეიქმნას სასოფლო-სამეურნეო დანიშნულების მობილური და სტაციონალური ენერგეტიკული საშუალებანი და მანქანათა კომპლექსები, რომლებიც იმუშავებენ გაზის, მზის, ქარის და სხვა ალტერნატიული და აღდგენადი ენერგიის წყაროებზე;

●შეიქმნას სოფლის მეურნეობაში მექანიზებული სამუშაოების ავტომატიზებული მართვის და ხარისხის კონტროლის მეთოდები და ტექნიკური საშუალებანი კულტურების მოვლა-მოყვანის, დამუშავების, შენახვის და გადამუშავების ყველა სტადიისათვის, მათ შორის კოსმოსური GPS-ნავიგაციის სისტემების გამოყენები;

●დამუშავდეს მანქანათა ტექნოლოგიური კომპლექსების, მანქანა-ტრაქტორთა პარკის, ტექნიკური სერვისის ინფრასტრუქტურის ოპტიმიზაციის მეცნიერული საფუძვლები მანქანათა შემცირებული ნომეკლატურის, ბლოკმოდულური პრინციპით შედგენის,უნივერსალიზაციის და უნიფიკაციის, ასევე მეურნეობრიობის ახალი ფორმების გათვალისწინებით ;

●დამუშავდეს ტექნოლოგიური პროცესების და მანქანათა კომპლექსების დაჩქარებული მრავალფუნქციური გამოცდის მეთოდები და ავტომატიზებული ტექნიკური საშუალებები მათემათიკური და ფიზიკური მოდელების გამოყენებით;

●დამუშავდეს და დაზუსტდეს ტრაქტორების და სასოფლო-სამეურნეო მანქანების საიმედოობის მაჩვენებლების განსაზღვრის მეთოდები სამთო პირობების, მუშაობის რეჟიმის და სხვა თვისებურების გათვალისწინებით;

●დამუშავდეს სტიქიურ მოვლენებთან (წაყინვები, სეტყვა, მეწყერები და ა.შ) ბრძოლის ტექნოლოგია და ტექნიკური საშუალებანი.

აგროსაინჟინრო კვლევების, მეცნიერული დონის ამაღლება. სასოფლო-სამეურნეო წარმოებაში მეცნიერულ-ტექნიკური პროგრესი თანამედროვე ეტაპზე შეუძლებელია მეცნიერული ცოდნის ფონდის მუდმივი შევსებისა და მისი გამოყენების გარეშე პრაქტიკული ამოცანების გადაწყვეტის დროს. ამიტომ მაღალი, რესურსდამზოგი ტექნოლოგიებისა და ტექნიკური საშუალებების დამუშავება მოითხოვს შესაბამისი დონის მეცნიერულ უზრუნველყოფას. კერძოდ, მიწათმოქმედების მექნიკამ უფრო სრულყოფილად უნდა ჩამოაყალიბოს ნიადაგისა და სხვა სასოფლო-სამეურნეო ობიექტებისა და მასალების გამძლეობის მეცნიერული საფუძვლები. სასოფლო-სამეურნეო მასალების რთული აგებულება განაპირობებს მათ ფიზიკო-მექანიკურ თვისებების მრავალფეროვნებას. ზოგიერთი ამ თვისებებიდან შესწავლილია, მაგრამ მაღალი ტექნოლოგიებისა და შესაბამისი მუშა ორგანოების დამუშავების დროს დიდ წინააღმდეგობას ვაწყდებით, რადგან სუსტად არის შესწავლილი ის მექანიკური თვისებები, რომლებიც მათი დეფორმაციისა და მსხვერვის წინაღობას ახასიათებენ, ესენი არიან ე.წ. რეოლოგიური თვისებები (დრეკადობის მოდული, სიბლანტის კოეფიციენტი, სიმტკიცის ზღვარი, რელაქსაციის დრო და ა.შ), რომელთა მაჩვენებლები კოეფიციენტების სახით შედიან იმ დიფერენციალურ განტოლებებში , რომელებიც აღწერენ მათ დაძაბულ - დეფორმირებულ მდგომარეობას სხვადასხვა დატვირთვების დროს. ცხადია, რეოლოგიური თვისებები უნდა შეისწავლებოდეს დროის, ტეპერტურის, ტენიანობის, სიმკვრივის და ა.შ. ცვალებადი ფაქტორებისგან ფუნქციონალურ დამოკიდებულებაში.

მუშა ორგანოების ზოგად თეორიას აკად. ვ.პ. გორიაჩკინმა საფუძვლად დაუდო სოლის თეორია და მსხვრევის თეორია. ამასთან, შენიშნავს , რომ სოლის მუშაობის ხარისხი სრულყოფილად შეიძლება გადაწყდეს დრეკადობის თეორიის გამოყენებით. მაღალ ტექნოლოგიის დამუშავებისათის კი საჭიროა ასევე დიდი დეფორმაციების შემსწავლელი მეცნიერების - რეოლოგიის ელემენტების გამოყენებაც. ტრადიციული ტექნოლოგიით ნიადაგის მოხვნა და ბელტების გაფხვიერება სრულდება ერთმანეთისაგან დამოკიდებული ოპერაციების სახით. ხოლო რესურსდამზოგ ტექნოლოგიაში ორივე ოპერაცია ერთდროულად სრულდება. ამასთან, ბელტების დამატებითი გაფხვიერება ხდება როტაციული მუშა ორგანოებით . მჭრელი დანა, გაივლის რა ნიადაგში, ქმნის მის გარკვეულ მოცულობაში დაძაბულ-დეფორმირებულ მდგომარეობას. შემდგომი გადაადგილებით წარმოიქმნებიან და ვრცელდებიან ბელტის მომგლეჯი ბზარები. თუ ბელტზე ვიმოქმედებთ ფრეზის დანით იმ დროს, როდესაც იგი იმყოფება წინასწარ დაძაბულ-დეფორმირებ მდგომარეობაში, მაშინ წარმოქმნილი ბზარების რაოდენობა იქნება მაქსიმალური, ხოლო გაფხვიერებაზე ენერგიის დანახარჯები-მინიმალური. ბელტი, როგორც დრეკად-მავლობაში. ამრიგად, რეოლოგიის მეცნიერების გამოყენება სოლის თეორიის განვითარებისათვის გვეხმარება მაღალი ტექნოლიების და მათი შემსრულებელი მანქანების კომბინირებული მუშა ორგანოების ერთმანეთის მიმართ რაციონალური განლაგების, კინემატიკური და დინამიკირი პარამეტრების დასაბუთებაში.

რეოლოგიის მიღწევების გამოყენება საჭიროა ასევე ისეთი მაღალ ტექნოლოგიების მეცნიერული უზრუნველყოფისათვის, როგორიცაა სიმინდის და ძირხვენების წარმოება ბაზოზოლური ტექნოლოგიით , საკვებწარმოება „შეფუთული სენაჟის" ტექნოლოგიით და ა.შ.

სასოფლო-სამეურნეო მანქანების მუშა ორგანოების უმეტესი ნაწილი მუშაობენ დარტყმით პრინციპზე, ამიტომ კლასიკური მექანიკის დარტყმის ენერგეტიკული თეორიის მეთოდების გამოყენებით აკად. ვ.პ. გორიაჩკინმა დაამუშავა მიწათმოქმედების მექანიკისათვის საჭირო

მთელი რიგი აქტუალური საკითხები. შემდგომში აკადემიკოსები მ.ე. მაცეპურო და პ.მ ვასილენკო აღნიშნავდნენ რომ სასოფლო-სამეურნეო მანქანების მუშა ორგანოების გაანგარიშების მოთხოვნილების სრულყოფილად დასაკმაყოფილებლად მიწათმოქმედების მექანიკის ერთ-ერთ მნისვნელოვან ამოცანას წარმოადგენს დარტყმის თეორიის შემდგომი განვითარება. დარტყმის ვიბრაციული, კონტაქტური თეორიების და რეოლოგიის მეთოდების თანამედროვე მიღწევების გამოყენებით, ჩვენ მიერ დამუშავებულია საოსფლო-სამეურნეო მასალების დეფორმაციისა და მსხვრევის საინჟინრო თეორია, რომლის საფუძველზე დასაბუთებულია დარტმითი ჭრის პრინციპზე მომუშავე საოფლო-სამეურნეო მანქანების მუშა ორგანოების პარამეტრები და მუშაობის რეჟიმები. ამავე მონოგრაფიაში მოცემულია მცდელობა მცენარეული მასალების მსხვრევის, გამკვრივების (დაწნეხვის) და თვლა გორვის თეორიების შემდგომი განვითარებისა მასალების და ნიადაგების რეოლოგიური (დრეკად-ბლანტი) თვისებებისა და მუშა ორგანოების სამუშაო რეჟიმის უფრო სწორად გათვალიწინებისთვის.

რესურსდამზოგი სამანქანო ტექნოლოგიებისა და მათი შემსრულებელი მანქანების შექმნისათვის, მექანიკა-მათემატიკური მეთოდების განვითრების კვალობაზე მიწათმოქმედების მექანიკის ისეთი ფუძემდებლური თეორიების სრულყოფა, როგორიცაა: სოლის თეორია, სასოფლო-სამეურნეო გარემოსა და მასალების ჭრის, მსხვრევის, დეფორმაციის, გადაადგილების, სეპარაციის, გამკვრივებისა და ა.შ. თეორიები.

გამკვრივებული ნიადაგის გაფხვიერების, ასევე ფერდობზე ნალექების შეკავების რესურსდამზოგ ტექნოლოგიად მიჩნეულია პნევმოდინამიკური ეფექტის გამოყენება. ექსპერიმენტები აღნიშნული მიმართულებით ჩატარებულია გერმანიაში, იაპონიაში, რუსეთში და საქართველოშიც. მიწთმოქმედების მექანიკაში აღნიშნული ტექნოლოგიის თეორია დამუშავებული არ იყო, რაც ბუნებრივია აფერხებს ამ მეთოდის ფართო გავრცელებას იმის გამო, რომ ძნელდება ტექნოლოგიური და ტექნიკური პარამეტრების დასაბუთება შესაბამისი მანქანის დაპროექტების დროს. ჩვენს მიერ პირველად მიწათმოქმედების მექანიკაში დამუშავებულია პნევმოდინამიკური ეფექტით ნიადაგის ღრმა გაფხვიერების ტექნოლოგიური პროცესის თეორია აფეთქების თეორიის მიღწევების გამოყენებით . თეორია ემყარება იმ წინამძღვრებს , რომ ნიადაგში დაჭრიხნილი ჰაერის საჭირო სიღრმეზე მიწოდებისას წარმოიქმნება აფეთქების ეფექტი. ჰაერის მიწოდების ადგილიდან ყველა მიმართულებით ვრცელდება კუმშვის ტალღები, რომელთა სიჩქარე მეტია, ვიდრე ნიადაგის გარემოში დეფორმაციის სიჩქარე. ნიადაგის ბზარების წარმოშობისა და მისი გაფხვიერებისათვის ძირითადი მნიშვნელობა აქვს თავისუფალი ზედაპირიდან არეკლილ ტელღებს. კუმშვის ტალღებს მოძრაობაში მოჰყავთ ყველა ნაწილაკები დაჭირხნილი ჰაერის მიწოდების ადგილიდან რადიალური მიმართულებით, მაგრამ ეს მოძრაობა მუხრუჭდება მიწოდების ზონიდან უფრო დაცილებული ფენების რეაქციის გამო. კუმშავს რა ნიადაგის ფენებს, კუმშვის ტალღები იწვევენ მათში დრეკადი ენერგიის გარკვეული მარაგის დაგროვებას. როგორც კი კუმშვის ტალღები მიაღწევენ ნიადაგის თავისუფალ ზედაპირს, მისი შეკუმშული ფენები იწყებენ გაფართოებას თავისუფალი ზედაპირისკენ, რადგან ამ მიმართულებით რაიმე წინააღმდეგობა არ წარმოიქმნება. თავისუფალი ზედაპირის მიმართულებით ნიადაგის ინტენსიური მოძრაობა გადაეცემა ზედაპირიდან სულ უფრო დაცილებულ ფენებს . ნიადაგის შიგნით მისი თავისუფალი ზედაპირიდან გადაეცემა გაჭიმვის ტალღა, რომელიც იწვევს გარემოში გაჭიმვის დეფორმაციებს. ეს ნიშნავს, რომ კუმშვის ტალღები, თავისუფალი ზედაპირიდან არეკვლის შემდეგ, გარდაიქმნება გაჭიმვის ტალღებად. იმის გამო, რომ ნიადაგის ზღვრული წინააღმდეგობა გაჭიმვაზე გაცილებით მცირეა კუმშვის ზღვრულ

წინააღმდეგობაზე, ნიადაგში ბზარების გაჩენაზე იხარჯება გაცილებით ნაკლები ენერგია, ვიდრე მისი მექანიკური მუშა ორგანოებით (ღრმა გამაფხვიერებლებით) დამუშავების დროს.

მაღალი ტექნოლოგიის შემსრულებელი სასოფლო-სამეურნეო აგრეგატების დამუშავება ძირითადად ხდება ბლოკ-მოდულური პრინციპით, როცა ენერგეტიკული და ტექნოლოგიური ბლოკების ხისტად შეერთება ქმნის ენერგო-ტექნოლოგიურ მოდულს. ამით ერთ კონსტრუქციაში ერთიანდება ტრაქტორის (გადიდებული წლიური დატვირთვა, უნივერსალობა და შედარებით დაბალი ხვედრითი მასალტევადობა) და თვითმავალი კომბაინის (გადიდებული მწარმოებლობა, ენერგოგაჯერებულობა და კომპაქტურობა) უპირატესობანი. ენერგეტიკული ბლოკი უმეტეს შემთხვევაში წარმოადგენს გამოსანთავისუფლებელ ერთ ღერძიან ბლოკს წინა, უკანა და გვერდითი შეპირისპირების კვანძებით და სიმძლავრის ამრთმევი სისტემით, ხოლო ტექნოლოგიური ბლოკი არის დამოუკიდებული თვლიანი შასი საპასუხო შეპირისპირების მოწყობილობით და მუდმივი ან საცვლელი მუშა ორგანოებით. აღნიშნული პრინციპით შეიძლება შეიქმნას მთელი ენერგოტქნოლოგიური მოდულები ცალკეული კულტურების მოვლა მოყვანისათვის. გამოსანთვისუფლებელი ენერგეტიკული ბლოკები წლის განმავლობაში იმუშავებენ მთელ დატვირთვით, ხოლო ტექნოლოგიური ბლოკები იქნებიან უნივერსალური, უნიფიცირებული, საცვლელი მუშა ორგანოებით, სწრაფად გადაწყობადი და სადაც ამის საჭიროება იქნება, ერთდროულად შეასრულებენ რამდენიმე ტექნოლოგიურ ოპერაციას.

მიწათმოქმედების მექანიკამ უნდა დაამუშავოს ბლოკ-მოდულური პრინციპით მოქნილი ენერგოტექნოლოგიური კომპლექსების შექმნისათვის ტექნოლოგიური, გეომეტრიული, კინემატიკური და ენერგეტიკული პარამეტრების საინჟინრო გაანგარიშების საუძვლები. საჭიროა ასეთი ტიპის ტექნიკური საშუალებების პარამეტრების ოპტიმიზაცია, როგორც ტექნოლოგიური , ისე ტექნიკური და ეკონომიკური კრიტერიუმებით . ტექნოლოგიური კრიტერიუმები გამოსაყენებელია პირველ რიგში მუშა ორგანოების პარამეტრების ოპტიმიზაციისათვის, ტექნიკურ-გადამცემი მექანიზმების, ასევე ენერგობლოკების და ტექნოლოგიური ბლოკების მასებისა და სიჩქარეების ოპტიმალური თანაფარდობის მოსაძებნად, ეკონომიკური ბლოკ-მოდულური პრინციპით შექმნილი მანქანათა კომპლექსების ოპტიმალური შემადგენლობის გაანგარიშებისათვის მომსახურების მთელი პერიოდისთვის.

ვ.პ. გორიაჩკინს მიაჩნდა, რომ მასების და სიჩქარეების ნორმალური სიდიდეების საკითხი ძირითადია მიწათმოქმედების მექანიკაში. მექანიკა-მათემატიკური მეთოდების მაშინდელი განვითარების დონე, როგორც ჩანს, არ იძლეოდა საშუალებას ამ პრობლემის სრულად გადაწყვეტისათვის, ამიტომ იგი თვლიდა, რომ ეს საკითხი იმახურებს დაწვრილებით განვითარებას შემდგომში .

მასებისა და სიჩქარეების თეორია თანამედროვე გაგებთ ფაქტიურად არის მანქანების პარამეტრების და მისი მართვის სისტემების (მათ შორის ავტომატური მართვის) ოპტიმიზაციის თეორია. ამ პრობლემებს უკანასკნელ წლებში მიეძღვნა რამდენისმე ფუნდამენტური გამოკვლევა. ბლოკ-მოდულური პრინციპით შედგენილი აგრეგატებისათვის აღნიშნული თეორიების მორგება უნდა განხორციელდეს იმ მიმართულებით, რომ მოხსნას შემდეგი შეუსაბამობა . საქმე იმაშია, რომ ერთი და იგივე მასისა და სიჩქარის მქონე ენერგეტიკული ბლოკი ხისტად უნდა შეპირდაპირდეს სხვადასხვა მასისა და ტექნოლოგიური სიჩქარის მქონე ტექნოლოგიურ ბლოკებს, ამიტომ მასებისა და სიჩქარიეების თანაფარდობანი ოპტიმიზებული ერთი რომელიმე ენერგოტექნოლოგიური მოდულისათვის არ იქნება ოპტიმალური სხვა დანარჩენისათვის. ამასთან ტექნოლოგიურ სისტემაში დატვირთვების ფორმირებში მონაწილეობენ როგორც მასები და სიჩქარეები (ტექნოლოგიურ წინააღმდეგობასთან ერთად) , ისე გადამცემი მექანიზმების

ელემენტების სიხისტეები, ამიტომ, თუ ოპტიმიზაციის კრიტერიუმად გამოვიყენებთ დატვირთვების ან ენერგო დანახარჯების მინიმიზაციას, მაშინ სხვადასხვა ენერგო-ტექნოლოგიური მოდულების მასები და სიჩქარეები აირჩევიან ტექნოლოგიური პროცესების შესრულების ხარისხობრივი მაჩვენებლების მოთხოვნილებებიდან, ხოლო დატვირთვების მინიმიზაცია უნდა მოდხეს გადაცემებში დრეკადბლანტი ელემენტების (დემპფერების) ჩადგმით. ამასთან ყურადღბა უნდა მიექცეს მანქანის პარამეტრების ისეთი თანაფარდობის მოძებნას, რომლის დროსაც გარდამავალი პროცესები (მათ შორის ავტომატურ სისტემების მართვის სისტემებში გარდამავალი პროცესები) ჩაქრება მინიმალურ დროში (ოპტიმიზაცია სწრაფქმედების კრიტერიუმით).

მაღალი ტექნოლოგიის შემსრულებელი, ბლოკ-მოდულური პრიციპით დაპროექტებული, მანქანების შექმნისას განსაკუთრებით აქტიუალურია მათ საიმედოობაზე გაანგარიშების მეთოდიკის სრულყოფა. მანქანათმშენებლობაში ამჟამად გამოყენებული საიმედოობის თეორია, რომელიც სათავეს იღებს რადიოელექტრონული ტექნიკის საიმედოობის თეორიიდან, ჯერ კიდევ შორსაა სრულყოფისაგან. საიმედოობის შეფასების არსებული ალბათური მეთოდის ძირითადი ნაკლია ის, რომ საიმედოობის მაჩვენებლები უშუალოდ არ უკავშირდებიან მანქანის ცალკეულ მექანიზმების და კვანძების ფიზიკურ მახასიათებლებს (მასებს, ინერციის მომენტებს, სიჩქარეებს, სიხისტეებს და ა.შ.) და მუშა ორგანოზე მოქმედ გარე დატვირთვებს (დასამუშავებელი მასალის ფიზიკურ მახასიათებლებს). აღნიშულის გამო, საიმედოობის თეორიაში დამუშავებული მეთოდების გამოყენება შეზღუდულია მანქანების დაპროექტების ეტაპზე, განსაკუთრებით მაშინ, როცა საიმედოობის გაზრდის დარეზერვების მეთოდის გამოყენება გაძნელებულია და მაღალი საიმედოობის მაჩვენებლების მქონე მანქანის შექმნის ერთადერთ საშუალებას წარმოადგენს მისი ცალკეული ელემენტების მაღალი საიმედოობა. გამოდის, რომ მანქანის საიმედოობის მაჩვენებლების გაანგარიშების არსებული მეთოდი მოწყვეტილია მისი სქემისა და კონსტრუქციის საინჟინრო გაანგარიშებისაგან, საიმედოობის უზრუნველყოფის ინჟინრული კონსტრუქციულ-ტექნოლოგიური მეთოდებისგან.

ზემოთ თქმულიდან გამომდინარეობს, რომ მიწათმოქმედების მექანიკამ უნდა დაამუშაოს სასოფლო-სამეურნეო მანქანების ისეთი საიმედოობის თეორია, რომელიც ალბათური და დეტერმინირებული მეთოდების შერწყმა-სინთეზის გზით საიმედოობის მაჩვენებელს დააკავშირებს, ჯერ ერთი , მანქანის კონსტრუქციის მასალის ფიზიკო-მექანიკურ თვისებებთან, ასევე ამ თვისებების დროში ცვალებადობასთან და მეორეს მხრივ, მანქანის ცალკეული რგოლების, კვანძებისა და მექანიზმების პარამეტრებთან, ასევე მუშა ორგანოზე მოქმედ ძალებთან და მანქანის ექპულუატაციის რეჟიმებთან.

ზემოთ გამოყოფილი მიწათმოქმედების მექანიკის აქტუალური საკითხების დამუშავება დააჩქარებს რესურსდამზოგი სამანქანო ტექნოლოგიების და ტექნიკური საშუალებების ათვისებას სოფლის მეურნეობაში.

აგროსაინჟინრო კვლევების სამეცნიერო-ორგანიზაციული სიძნელეები. სოფლის მეურნეობის მექანიზაციაში ინოვაციისადმი არ ასებობს სიტემური მიდგომა. ამის გამო ტექნიკური გადაიარაღება ძირითადად ხდება სასოფლო-სამეურნეო კულტურების მოვლა მოყვანის ტრადიციული, ოპერაციული ტექნოლოგიის საფუძველზე. ამის შედეგია, რომ მიუხედავად საზღვარგარეთიდან შეძენილი ტექნიკის რაოდენობის ზრდისა, შესაბამისად არ იზრდება წარმოებული სასოფლო-სამეურნეო პროდუქციის მოცულობა. იმისათვის, რომ მეცნიერულ-ტექნიკურ პროგრესზე მოვახდინოთ მუდმივი კონტროლი, გავატაროთ დასაბუთებული საინოვაციო პოლიტიკა, საჭიროა შეიქმნას შესაბამისი ტექნიკის შეძენაზე

(ზოგიერთ შემთხვევაში წარმოებაზე) საჭირო ზემოქმედების მექანიზმი. ასეთი მექანიზმი შეიძლება იყოს ძირითადი კულტურების მოვლა-მოყვანის მუდმივად განახლებადი რესურსდამზოგი ტექნოლოგიების სისტემა და მანქანათა სისტემა. ასეთი „სისტემების" ფორმირება ხდება გარკვეული, საკმაოდ ხანგრძლივი 5 - 10 წლიანი პერიოდისათვის. მათი დამუშავება უნდა ხდებოდეს სამეცნიერო-კვლევით დაწესებულებებში სამთავრობო ორგანოების დაკვეთით და მტკიცდებოდეს სოფლის მეურნეობის სამინისტროსა და სოფლის-მეურნეობის მეცნიერებათა აკადემიის მიერ რესპუბლიკის მთავრობასთან შეთანხმებით. ტექნოლოგიებისა და მანქანების სისტემა უნდა იყოს ძირითადი დოკუმენტი ახალი მანქანების შექმნის, საჭიროების შემთხვევაში მათი მოდერნიზაციის და ზოგიერთი სპეციფიკური მანქანის ადგილზე წარმოების შესაბამისად დაფინანსებისათვის , მანქანა-ტრაქტორთა პარკების და საინჟინრო სერვისული ობიექტების ფორმირებისათვის , ე.ი საინოვაციო პროცესების მართვისათვის.

ქვეყნის მასშტაბით საინოვაციო პოლიტიკის გატარებისათვის ყველაზე დიდ გართულებებს იწვევს მექნიზაციის მიმართულებით მომუშავე სამეცნიერო-კვლევითი ორგანიზაციების გაუქმება. ადრე მექანიზაციის დარგში მეცნიერულ უზრუნველყოფას ემსახურებოდნენ: სოფლის მეურნეობის მექნიზაციისა და ელექტრიფიკაციის სამეცნიერო-კვლევითი ინსტიტუტი; სასოფლო-სამეურნეო მანქანათმშენებლობის ინსტიტუტი (საქაგრომანქანა); მანქანების საგამოცდო სადგური; ნორმირების სადგური. ამჟამინდელი რეფორმის შედეგად საქართველოში სასოფლო-სამეურნეო ტექნიკა საზღვარგარეთიდან შემოიზიდება ყოველგვარი წინასწარი გამოცდისა და ტექნიკურ-ეკონომიკური დასაბუთების გარეშე, არ ხდება სამუშაოების ნორმირება (საწვავის ხარჯისა და მწარმოებლობის განსაზღვრა) ტექნოლოგიური ოპერაციების და ქვეყნის რეგიონების ბუნებრივ-კლიმატური პირობების მიხედვით. შემოტანილი ტექნიკის უმეტესობა ნაადრევად გამოდის მწყობრიდან და ხშირად მისი რაოდენობა აჭარბებს შეძენილს, ამიტომ დამუშავებული ფართობის შესამჩნევი ზრდა არ შეინიშნება. სამუშაოების ნორმირების ჩაუტარებლობა კი ხელს უწყობს საწვავის დიდი რაოდენობის გადახარჯვას.

საქართველოს აგროსამერეწველო სექტორის საინჟინრო სფეროს სტაბილიზაციისა და სოფლის მეურნეობის ტექნოლოგიური და ტექნიკური ინოვაციის გზით განვითარებისათვის საჭიროა შეიქმნას სამეცნიერო პრაქტიკული ცენტრი, რომელიც ერთდროულად შეასრულებს დარგში სამეცნიერო-კვლევითი, მანქანების და ტექნოლოგიების გამოცდის და მექანიზებული სასოფლო-სამეურნეო სამუშაოების ნორმირების ფუნქციას, ე.ი. ადრე არსებული ოთხივე ორგანიზაციის ფუნქციას. წინააღმდეგ შემთხვევაში სოფლის მეურნეობის პრიორიტეტული განვითარება შეუძლებელი იქნება. საქართველოში არ ფუნქციონირებს ადრე არსებული ტრაქტორების და სასოფლო-სამეურნეო მანქნათმშენებლობის ქარხნები. სამთო მიწათმოქმედებისა და სუპტროპიკული კულტურების მექანიზაცია მოითხოვს სპეციფიკურ მანქანებს, რომელთა შექმნასა და წარმოებაში ქართველ მეცნიერებსა და კონსტრუქტორებს მსოფლიო პრიორიტეტები ეკუთვნოდა. დასაწყისში შესაძლებელი იქნებოდა სრული დატვირთვით ამუშავებულიყო მექნიზაციისა და ელექტრიფიკაციის სამეცნიერო კვლევითი ინსტიტუტის ექსპერიმენტულ- მექანიკური ქარხანა, სადაც მცირე სერიებად იწარმოებოდა ინსტიტუტში შექმნილი ჩაის რეაბილიტაციის, ასევე დეგრადირებულ ჩაის პლანტაციებისა და მიმოქცევიდან გამოსულ სავარგულებში კულტურულ-ტექნიკური სამუშაოების შემსრულებელი მაქანათა კომპლექსები. ასევე მოხდებოდა საზღვარგარეთიდან შემოზიდული გუთნების აღჭურვა ბრტყლადმჭრელებით ფერდობებზე გლუვი ხვნისა და ეროზიის საწინააღმდეგო დამუშავებისათვის.

აგროსაინჟინრო კვლებვების მაღალ დონეზე შესრულებას დიდ სიძნელეებს უქმნის თანამედროვე ხელსაწყოებითა და დანადგარებთ სუსტად აღჭურვა, როგორიცაა: პორტატული ტენზომეტრული აპარატურა; მობილური ტენზომეტრული ლაბორატორია; გამოთვლითი ტექნიკა, რომელიც გამოიყენება როგორც პილოტური დანადგარი ახალი სასოფლო-სამეურნეო მანქანების კონსტრუქციების, პარამეტრების და მუშაობის რეჟიმების დასაბუთებისათის მათი პროექტირების სტადიაზე; სისტემების ექსპერიმენტული და საცდელი ნიმუშების ავტომატური პროექტირებისათვის და ა.შ.

დასკვნა . უახლოეს წლებში, სოფლის მეურნეობის მექანიზაციის დარგში, ფუნდამენტური და კომპლექსური გამოყენებითი კვლევების საფუძველზე, უნდა შიქმნას რესურსდამზოგი ადაპტური ტექნოლოგიებისა და ახალი თაობის ტექნიკური საშუალებების ისეთი პარამეტრების საინჟინრო მანქანების მუშა ორგანოების რაციონალურ ურთიერთქმედებას ბიოლოგიურ ობიექტებთან: ნიადაგთან, მცენრეებთან, ცხოველებთან. აქედან გამომდინარე, გამოყოფილია ჩასატარებელი კვლევების ძირითად მიმართულებანი და ასევე მექანიკა-მათემატიკის მეცნიერებათა ის დარგები, როემლთა გამოყენება მნიშვნელოვნად აამაღლებს აგროსაინჟინრო კვლევების მეცნიერულ დონეს . დასახულია ასევე ღონისძიებანი სოფლი მეურნეობის ტექნოლოგიური და ტექნიკური ინოვაციის გზით განვითარებისათვის.

Selection of Rational Machinery Technologies for Small Farms in Adjara Region

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Abstracts. The article discusses the current condition in small farms in the mountaineous regions of Adjara and the ways of its further development. Nowadays, an important part of agricultural products in Adjara region is produced in small farms.

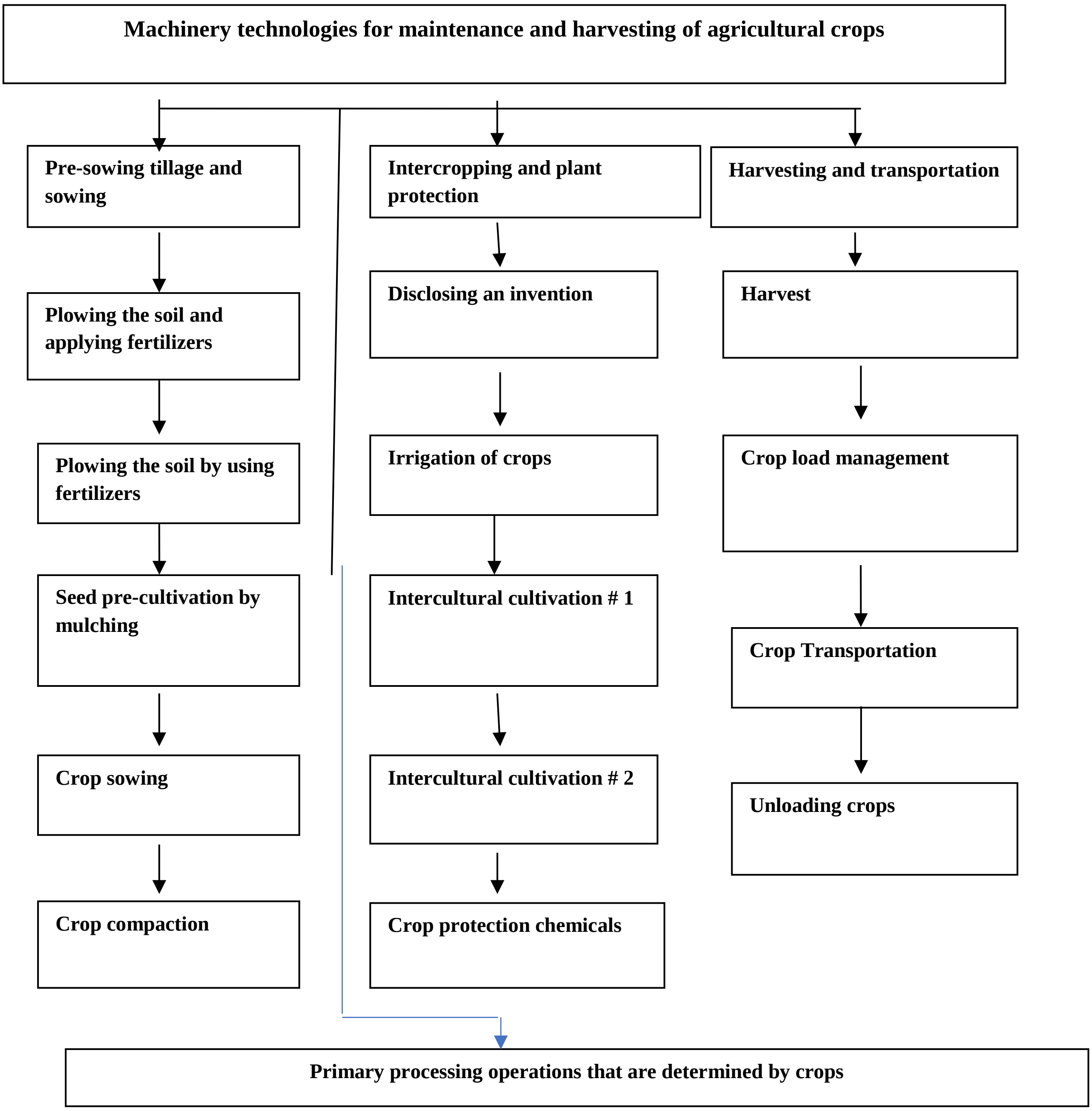
The necessary calculation methods are applied for the proper selection of rational energy means, based on the distribution of plots according to the needs of the family food, and the limits for the use of traction means required in small farms that are set based on the plot size.

Keywords: technologies, mechanization, profitability, soil cultivation.

Privatized land acquired by rural residents establishes small farms. Nowadays, the main producers of agricultural products are small farms and peasants. The rational machinery technologies introduced in the country have been developed for energy-intensive plots using energy-intensive, large-scale equipment. The use of those tools in small-scale plots leads to a rise in the area of the soi structure and a decrease in yield and an increase in the cost of production. Therefore, the production of private farms is characterized by the same qualitative and quantitative indicators as public production. Therefore, the mixed use of machinery technologies and manual labor technologies in small plots will be profitable. As we have mentioned, in the small farms of Georgia, the possible complete satisfaction of the household with its own agricultural products is used. Such production leads to further fragmentation of an already small area.

Depending on the area of the land of the farmer and the number of industrial crops, the area occupied by individual crops does not actually exceed 0,3-0,4 hectares. Therefore, special care operations should be divided into two main parts: pre-emergence and post-emergence operations. The first step of those operations can be performed over the whole area and the plot after sowing that can be divided into separate crops.

Crop care and cultivation technologies may be presented as the following sctructural model:



According to the analysis of the structural scheme of crop maintenance technologies, they are designed for the use of energy-saturated tractors and the aggregates based on them which may not be written in small plots that leads to a further reduction of useful space of small areas and low efficiency of the unit, which makes these units unprofitable, so it is impossible to transfer high-quality technologies to small farms. As a result, the main problem of small farm production is the selection of rational traction means and complexing of aggregates.

The experience of highly industrialized countries represents that scientific and technical progress in agriculture does not negate the simultaneous existence of advanced forms of production and relatively backward forms. Therefore, alongside the traditional large mechanization machinery technologies and technical means, there are small machinery mechanization technologies and technical means.

According to the size of the plot, in order to choose rational energy means, it is necessary to determine the limits of use of traction means applied in Georgia.

To determine those limits, the literature uses a computational empirical formula for the production of unit shifts based on the application coefficients used in the workflows and technological advances. These coefficients in turn depend on the length of the plt to cultivate, i.e. the area of the plot:

$$W_{\text{ıG3}} = (48B(0{,}886 - \lambda_{ı}0)/(2{,}02 - \varphi) \qquad (1)$$

Where: B – Gauge of the unit;

λ_0 – Predictive coefficient of technological advancement;

φ –Coefficient of the use of workers' movements.

The formula (1) determines the required plot areas for optimal use of different classes of tractors:

For 30 kN class tractors above 10 hectares;

For 14 kN class tractors from 1,8 hectares to 28 hectares;

For 9-6 kN tractors from 0,75 hectares to 2 hecatres;

For 2 kN class mini tractors from 0,25 hectares to 0,75 hectares;

For motoblocks and motocultivators from 0,3 hectares below.

Constructive schemes of technological aggregates based on motoblock:

1. Soil picker;
2 Mineral fertilizer and crop transportation aggregate;
3. Soil mowing aggregate;
4. Two-layer tillage unit;
5. Groove cutters;
6. Sowing;
7. Land-compacting, compaction;
8 Milling machine;
11. Knapsack Sprayer;
12. Mowing potato pores;
13. Excavation of tubers.

The set of motoblocks required to assemble the aggregates given in the diagram includes:

1. Trailer cart;
2. Milling machine;
3. Tracer;
4. Passive cultivator;
5. Excavation of tubers;
6. Mowing.

The rest of the machinery tools are not only factory-made, but even the constructions are not processed.

The second cycle of technological operations should be performed based on the individual crops and their performance parameters that are determined by the characteristics of the crops. During the period, the size of the area occupied by individual crops is already evident.

The size of the areas allocated according to the normal amount of food under the crops represents that only the areas occupied by cereals, potatoes and sown grasses, the value of which ranges from 0,1 to 0,3 hectares, are the main subject for the machinery technologies.

The size of the areas occupied by the rest of the crops does not exceed 0,01-0,05 hectares, which leads to only episodic use of machinery technologies in these plots and a rise in manual labor.

აჭარის რეგიონში მცირე ფერმერული მეურნეობებისათვის რაციონალური სამანქანო ტექნოლოგიების შერჩევა

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ანოტაცია. წარმოდგენილ სტატიაში განხილულია აჭარის მაღალმთიან რეგიონების მცირე ფერმერულ მეურნეობებში არსებული მდგომარება და მისი შემდგომი განვითარების გზები. დღეისათვის აჭარაში სასოფლო სამეურნეო პროდუქციის მნიშვნელოვანი ნაწილის წარმოება ხდება მცირე ფერმერულ მეურნეობებში.

მცირე ფერმერულ მეურნეობებში რაციონალური ენერგეტიკული საშუალებების შერჩევისათვის წარმოდგენილია საჭირო საანგარიშო მეთოდიკა, რომელიც ეფუძნება ნაკვეთების გადანაწილებას ოჯახის საკვებ პროდუქციაზე მოთხოვნილების მიხედვით, და დადგენილია მცირე მეურნეობებში საჭირო წევის საშუალებების გამოყენების ზღვრები ნაკვეთის ზომების მიხედით.

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Drive of the Electrified Bridge Unit for Farms

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Abstract. The design of a motorized bridge unit moving along guide rails across a vineyard nursery is described. The unit's power supply is from a centralized 3-phase AC circuit through a cable running along the rails and wound on a drum. Maximal power consumption is 15 kW. Two working speeds are available for operations in the nursery including soil treatment, planting of seedlings, application of fertilizers, hilling, inter-row hoeing, spraying, sprinkling, pruning and extraction of seedlings. A procedure is proposed for calculating the drive motor operating conditions for longitudinal movement of the unit. Based on a semi graphical method, elements of the drive circuit are calculated for 5 selected cases. In each case the static and dynamic stability have to be verified. The results of a dynamic stability check are given for one case.

Most of traditional tilling technologies represent the consequences caused by the impact of agricultural aggregates on the soil, causing its degradation, made by overcompaction of the soil [1]. For reducing the pressure of aggregates on the soil in small farms, focused on the production of valuable products (flowers, vine seedlings, tea leaves, etc.), as well as in greenhouses, realistic is soil cultivation using a constant tramline with a span of 6, 12 and more meters. This technology is usually described as Controlled Traffic Farming (CTF) and involves separating the areas of movement of the machine from the areas of cultivation; The CTF systems provide the basis for the automation and robotization of most crop production processes, ensure efficient implementation of "precision" and "digital" farming and provide other significant benefits [2, 3, 4]. The most prominent example is bridge farming, which simultaneously provides precise positioning of active working organs of the unit towards the plant, is most promising for the cultivation of many energy-intensive crops. Bridge units will significantly intensify the farming processes, use industrial, energy- and labor-saving, soil-protective and environmentally friendly technologies. For example, in Australia, millions of hectares of land are cultivated using controlled field movement technology [5]. According to [6], the advantages of using agricultural bridge units are substantiated by the works of scientists from a number of countries, which show that their introduction, despite the high metal consumption, will provide energy savings and an increase in the efficiency and level of automation of crop production; The drive of specialized wide-track agricultural units can be fully electric or hybrid.

In our case to perform work in a vineyard nursery within a year, it is required to carry out up to 34 aisle passes using various agricultural machines, which causes excessive soil compaction, high energy costs for fuel and losses (up to 30%) due to damage to seedlings and, as a result increase in production costs. In addition, based on the requirements for the production of environmentally friendly products, in some crop production technologies, the agenda is to replace diesel-powered machine and tractor units with more advanced equipment. These tasks can be successfully solved by creating special agricultural far-reaching electrified bridge units. Moreover, one of the factors that determined the use of electricity in agriculture in the USSR was the low cost of fuel and subsidies for electricity supply - electricity was supplied to agriculture at a rate of 0.01 rubles/kWh. Of course, at the present time, with a sharp increase in tariffs, it is necessary to reassess the performance of work with various technologies and the importance of energy savings increases significantly.

Several agricultural electrified bridge units were designed at the Georgian Agrarian University, one of which was manufactured at the Rustavi Crane Building Plant and operated with positive results in the Kanda nursery (Mtskheta). This bridge unit (Fig. 1) is a load-bearing truss mounted on two running trolleys moving along rail guides, on which both active and passive working bodies are hung. The drive of the longitudinal movement of the unit was carried out by means of two asynchronous motors with a phase rotor, and the transverse movement from one line with an area of up to 0.1 hectares to another was carried out using asynchronous squirrel-cage motors; the drive is mounted on barrow trolleys. For the vertical movement of the wheels of transverse movement during the transition from one working strip to another, as well as for hanging agricultural implements, the unit was equipped with a hydraulic system [7].

The design of a motorized electrified gantry-type unit moving along guide rails across a vineyard nursery. Two working speeds (0.05 and 1 m/s) are available for operations in the nursery including preplant tillage, planting of seedlings, application of fertilizers, hilling, inter-row hoeing, spraying, sprinkling, pruning and extraction of seedlings.

The power supply of the bridge unit is carried out from a centralized 380 V alternating current network via a transformer substation through a 100 m long flexible cable running along the rails and wound on a drum mounted on one of the trolleys (Fig. 1). If the bridge unit operates at a speed of up to 0.33 m/s, its drive provides a maximum traction force of 7 kN with a units total mass of $\boldsymbol{m_{un}}$ = 3 MT; Maximal power consumption of the bridge unit is 15 kW; Overall dimensions of the unit (without a cab) 14.3 x 4.0 x 1.6 m, the horizontal grasp width is 11.5 m. These parameters are implemented by two identical motors of MTF-012-6 type with a power of 2.2 kW each; the rated speed of these motors is $\boldsymbol{n_n}$ = 890 rpm, that is, the nominal slip of the motor is $\boldsymbol{s_n} = (\boldsymbol{n_o} - \boldsymbol{n_n})/\boldsymbol{n_o}$ = 1000 - 890/1000 = 0.11, where the idle running speed of a six-pole motor is $\boldsymbol{n_o}$ = 1000 rpm. The operator controls the bridge and the working bodies from the control panel located in the modernized conventional cabin, and from there he can visually control the quality of technological operations.

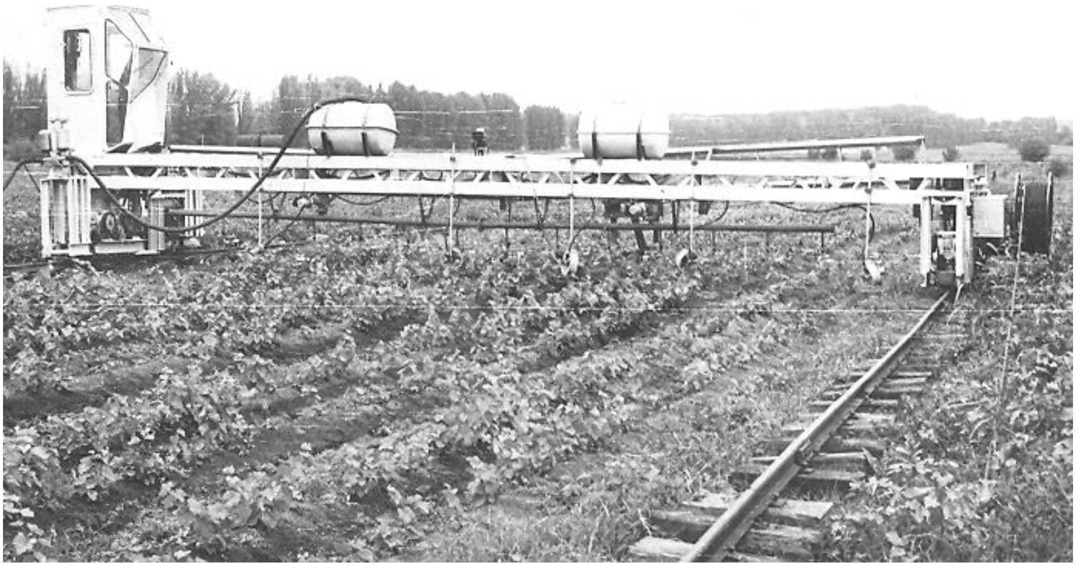

Fig. 1. Operation of the electrified bridge unit in the Kanda vineyard nursery.

The unit's trolleys move on used narrow-gauge P33 mine rails, which are usually used in mines and for the movement of tower and gantry cranes. The rails were laid directly on the soil layer on used wooden sleepers of limited length. Unlike industrial bridge cranes, in which both the traction force and the point of its application remain practically constant during the movement, the operation of the agricultural bridge unit is characterized by an asymmetric application of additional resistance to the movement of the unit caused by the presence of hinged working bodies, which, moreover, has a sharply variable character; the influence of the poor quality of the laying of the tracks is also increasing.

All this causes such undesirable phenomena as an increase in the friction of the wheel flanges on the rails, a discrepancy in the engine speed and, as a consequence, a skew of the unit, therefore, to balance the load torques of the $\boldsymbol{M_1}$ and $\boldsymbol{M_2}$ engines and harmonize their rotation, various schemes were tested, of which the most acceptable characteristics turned out to be in the case of the application of the so-called "working electric shaft system" with common resistance $\boldsymbol{r_{Rot}}$ in the rotor circuit, the value of which was regulated depending on the asymmetry of the loads (Fig. 2) [8]; a circuit in which the stator windings of the motors are connected to a three-phase current network, the rotor windings are connected to each other through slip rings, which ensure the rotation of two motors that are not mechanically connected to each other; in this case, a kind of elastic connection between the working machines is achieved. In addition to the stable operation of the unit and the high-quality performance of technological processes, the scheme allows for smooth start-up and braking without slipping and skidding.

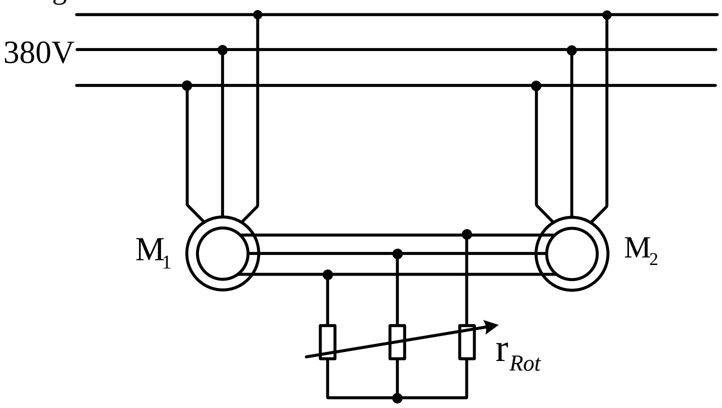

Fig. 2. Electric circuit of the working electric shaft.

In the event of load unbalance, to ensure synchronous operation of the motors located at a distance in the applied circuit, the active resistance of the common rotor circuit $\boldsymbol{r_{Rot}}$ should change depending on the load unbalance factor $\boldsymbol{K = M_2 - M_1/M_2 + M_1}$, and the dependence of the motor torques on the mismatch angle between the rotor axes are determined by the equations.

$$M_1 = M_{\text{K}}\left(\frac{1-\cos\theta-\frac{s}{s_{\text{K}}}\sin\theta}{\frac{s}{s_{\text{K}}}+\frac{s_{\text{K}}}{s}}+\frac{1+\cos\theta+\frac{s}{s_{\text{K}}}\sin\theta}{\frac{s}{s'_{\text{K}}}+\frac{s'_{\text{K}}}{s}}\right) \qquad (1)$$

$$M_2 = M_{\text{K}}\left(\frac{1-\cos\theta+\frac{s}{s_{\text{K}}}\sin\theta}{\frac{s}{s_{\text{K}}}+\frac{s_{\text{K}}}{s}}+\frac{1+\cos\theta-\frac{s}{s_{\text{K}}}\sin\theta}{\frac{s}{s'_{\text{K}}}+\frac{s'_{\text{K}}}{s}}\right) \qquad (2)$$

Where: M_K - is the value of the critical motor torque, s and s_K are the instantaneous and critical slip values of the motors, where $s'_{\text{K}} = s_{\text{K}}\frac{r_2+2r_{Rot}}{r_2}$ and r_2 is the motor rotor phase active resistance.

The choice of the total power of the drive motors was carried out according to the formula

$$P = (W_{un} + W_w)\, v / □_{tr}, \text{ kW}, \qquad (3)$$

Where: v - is the speed of the longitudinal movement of the unit, ms^{-1}; $□_{tr}$ - efficiency factor of the transmission. Unit movement resistance

$$W_{az} = g\,(m_{un} + m_l)\,(df + 2k)\,k_{reb}/D, \text{ NN}, \qquad (4)$$

Where: g = 9.81 m/s^2 - is acceleration of gravity; m_l is the maximum mass of the load, kg; d is the diameter of the running wheel, m;
f - coefficient of resistance to movement; k - coefficient of rolling friction of steel wheels on rails, m;
k_{reb} = 1.3 - coefficient of friction of wheel flanges on rails; D - axis diameter, m. Resistance to movement caused by wind

$$W_{вет} = qk_fHL, \text{ N}; \qquad (5)$$

Here q = 400 Nm^{-2} - is the value of the wind pressure; k_f = 0.3 - coefficient of integrity of the frontal surface of the unit;
H and L – bridge units height and width, m.

In [1] is outlined a method for determining the operating modes of a bridge unit moving on rails. The task was solved for a specific case, when two identical engines of MTF-012-6 type produced by the Tbilisi plant "Elektrodzrava" are installed on the trolleys; of course, this does not exclude the use of the same asynchronous motors of a different type. For five main values of unbalanced loads, the calculation of K and R_{SubRot} was performed, the results of which are summarized in Table 1.

The results of calculating the additional resistance of the rotor circuit

Table 1.

#	M_{C1}, Nm	M_{C2}, Nm	K	$R`_{tot}/r`_{Rot}$	R_{SubRot}, Om
1	17,7	23,6	0,143	0,9	0,6
2	11,7	23,6	0,333	2,2	1,5
3	5,9	23,6	0,6	4,6	3,1
4	23,6	23,6	0	0	0
5	0	0	0	-	-

Based on the experimental data and Table 1, a graph of R_{tot}/r_{Rot} versus K was plotted (Fig. 3). According to this graph, the value $R_{tot.}$ is determined, corresponding to the effective value of asymmetry K. The performed calculations and experimental studies have shown, that when $K \leq 0.2$, to compensate the asymmetry, it is necessary to include an additional total resistance $R_{SubRot} \leq\ _{rRot}$ in the rotor circuit. If $K > 0.2$, a significantly greater resistance is required, which causes an undesirable decrease in the speed of coordinated synchronous rotation of motors and a deterioration in the economic performance of the unit.

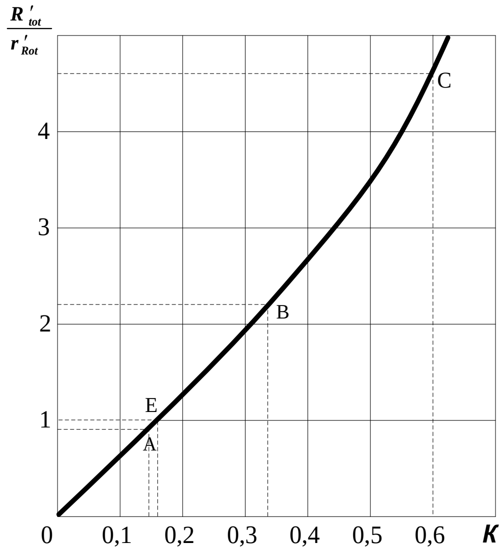

Fig. 3. *K* versus *R*

To comply with the condition $\boldsymbol{K} \leq 0.2$, it is necessary to use symmetric layouts of the unit's during design, to use a hinge of the working bodies on the bridge equidistant from the trolleys, and to rationally distribute the goods during transportation.

As a result of the studies performed, a scheme for automatic balancing of the unbalance of the loads on the drive motors of the bridge unit for nurseries was developed [9].

Fig. 4 shows an oscillogram of the balancing of the asymmetry of the loads of the motors of the working electric shaft, recorded during the treatment of the ground of the row-spacing's in the vineyard nursery with a cultivator. At point A, where the resistance torques $\boldsymbol{M_{c1}} = \boldsymbol{M_{c2}}$ of the two motors of the bridge unit are equal, the motors rotated synchronously at a speed of rotation $\boldsymbol{n}$ = 915 rpm. After the start of operation of the cultivator, located on the span of the bridge unit (Fig. 1) at a certain distance from the middle, closer to the first trolley of, at point B, the resistance torque of the first motor increases to $\boldsymbol{M_{c1}} = 1.3\boldsymbol{M_n}$, and the torque of the second motor $\boldsymbol{M_{c2}}$ remains equal to the nominal torque $\boldsymbol{M_{c2}} = \boldsymbol{M_n}$, $\boldsymbol{n_1}$ = 840 rpm and $\boldsymbol{n_2}$ = 910 rpm at the currents of the motors $\boldsymbol{i_1}$ = 7.5 A and $\boldsymbol{i_2}$ = 6.5 A and $\boldsymbol{K}$ = 0.1. The device made it possible to eliminate the asymmetry of the loads during the time $\boldsymbol{t}$ = 0.85 s while ensuring the values of the motor currents, respectively, $\boldsymbol{i_1}$ = 7.8 A and $\boldsymbol{i_2}$ = 7.9 A, that is, the asymmetry decreased to $\boldsymbol{K}$ = 0.02, that is, decreased by 80%. It should be noted that with the load asymmetry coefficient $\boldsymbol{K} > 0.6$, sustained oscillations of the motor currents of the working electric shaft appeared and, thus, the balancing device no longer fulfilled its function. In such cases, it is necessary to disconnect the bridge unit from the network and eliminate the load asymmetry in two ways.

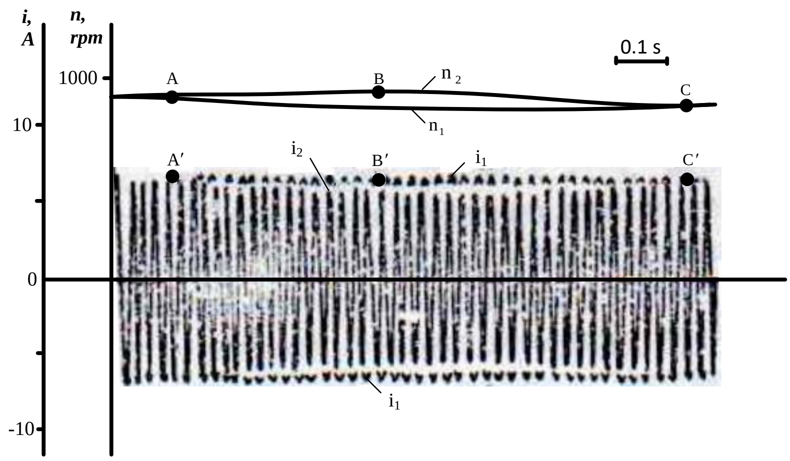

Fig. 4. Oscillograms of currents *i* and rotation speeds *n* for the motors of the working electric shaft when balancing the asymmetry of the drive loads of the longitudinal movement of the bridge unit using an automatic balancing device

Analysis of the technological process of growing vine seedlings in the nursery showed the feasibility of using an electrified bridge unit with a set of mounted agricultural implements. Tests and exploitation of the unit proved its capacity for work and economic efficiency and made it possible to establish that acceleration is limited to 0.4 ms^{-2} during start-up, and load asymmetry up to ***K*** = 0.2 can be eliminated in a time not exceeding 0.85 s, for large values up to ***K.***

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ანოტაცია. სასოფლო-სამეურნეო აგრეგატების მოძრაობისას ნიადაგზე ზემოქმედებით გამოწვეული უარყოფითი შედეგები დროთა განმავლობაში იწვევენ მის დეგრადაციას. მცირე ფერმერულ მეურნეობებში, რომლებიც ორიენტირებულნი არიან ძვირადღირებული პროდუქციის - ყვავილების, ვაზის ნერგების, ჩაის ფოთლის და ა.შ. წარმოებაზე, ამ ზემოქმედების შესამცირებლად არსებული მეთოდებიდან მიზანშეწონილია ნიადაგის დამუშავება 6, 12 მ და უფრო განიერი მალის მქონე მუდმივი ტექნოლოგიური ლიანდის გამოყენებით, რასაც სოფლის მეურნეობა მართვადი მოძრაობით (Controlled Traffic Farming, CTF) ეწოდება და რომელიც ითვალისწინებს აგრეგატის გადაადგილების ზონების გამოყოფას მცენარეთა კულტივირების ზონებისგან, ამავდროულად ის უზრუნველყოფს მცენარის მიმართ მუშა ორგანოს ზუსტ პოზიციონირებას. გარდა ამისა, ეკოლოგიურად სუფთა პროდუქციის წარმოების მოთხოვნებიდან გამომდინარე, მთელ რიგ ტექნოლოგიებში დღის წესრიგში დგას ორგანულ საწვავზე მომუშავე ტრაქტორების ჩანაცვლების ამოცანა, რომლის წარმატებული გადაჭრა შესაძლებელია სპეციალური სასოფლო-სამეურნეო ელექტრიფიცირებული ხიდური აგრეგატების გამოყენებით.

საქართველოს აგრარულ უნივერსიტეტში, აკადემიკოს ვალერიან მეტრეველის ინიციატივით, დამუშავდა ხიდური აგრეგატების კონსტრუქციები, რომელთაგან ერთ-ერთი დამზადდა რუსთავის ამწემშენებელ ქარხანაში და დადებითი შედეგებით მუშაობდა ქანდის სანერგეში (მცხეთა). ის წარმოადგენს რელსურ მიმმართველებზე მოძრავ ორ ურიკაზე დამონტაჟებულ მზიდ წამწეს, რომელზეც ხდება მუშა ორგანოების დაკიდება. გრძივი გადაადგილება ხორციელდება ორი ასინქრონული ფაზურროტორიანი ძრავის საშუალებით, ხოლო განივი მოძრაობა ნაკვეთის ერთი ზოლიდან მეორეზე - მოკლედშერთული ასინქრონული ძრავის მეშვეობით; ამ ცვლილებისთვის, აგრეთვე სასოფლო-სამეურნეო იარაღების დაკიდებისთვის, ხიდი აღიჭურვება ჰიდრავლიკური სისტემით.

სამრეწველო ამწეებისგან განსხვავებით, რომლებშიც წევის ძალაც და მისი მოდების წერტილიც გადაადგილებისას პრაქტიკულად მუდმივი რჩება, ხიდური აგრეგატის მუშაობა ხასიათდება გადაადგილების წინაღობის ძალის დამატებითი მდგენელებით, რომლებიც განპირობებულია საკიდი მუშა ორგანოებით, თანაც მას აქვს მკვეთრად გამოხატული ცვალებადი ხასიათი; ყოველივე ეს იწვევს არასასურველ მოვლენებს - ბორბლების რებორდების რელსებზე ხახუნის გაზრდას, ურიკების ძრავების სიჩქარეთა სხვაობას, შედეგად, აგრეგატის გადახრას. ამიტომ ძრავების დატვირთვის მომენტების დაბალანსებისა და მათი ბრუნვის სინქრონიზაციისათვის გამოვიყენეთ მუშა ელექტრული ლილვის სქემა ძრავების როტორების წრედში საერთო აქტიური წინაღობით, რომლის სიდიდე ავტომატურად რეგულირდება დატვირთვების ცვლილებისა და მოდების ასიმეტრიის მიხედვით. საველე გამოცდებით დადგინდა, რომ სქემა უზრუნველყოფს ორი ერთმანეთთან მექანიკურად დაუკავშირებელი ძრავის სინქრონულ ბრუნვას; აგრეგატის სტაბილური მუშაობისა და ტექნოლოგიური პროცესების მაღალხარისხიანი განხორციელების გარდა, სქემა უზრუნველყოფს მდოვრე ამუშავებასა და დამუხრუჭებას წაბუქსავებისა და იუზის გარეშე.

Tea Plantation Rehabilitation Vehicles

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In Georgia, at the end of 20th century, implemented reforms in the field of agriculture had a negative impact on tea-growing field. Practically, tea-growing field was liquidated, areas occupied by tea was reduced, existing plantations turned wild, the cultivation of new plantations was stopped, tea-growing field became unprofitable, Georgian tea quality and competitiveness worsened.

In the last years, with the effort of Georgian Government, the tea-growing field is gradually being revived and developed. Currently, in the regions of western Georgia, the interest of farmers and the population for the production of tea products is gradually increasing, but the efforts of one or two entrepreneurs are not enough for the full-scale revival and development of tea-growing field. Today for the tea-growing field development is necessary bigger and more rational projects. Except rehabilitation of the degraded plantations, it is also necessary to cultivate new fruitful plantations, to develop modern technologies and process technical means of tea maintenance-growing in production. Special attention should be given to mechanization of time-consuming processes of tea maintenance-growing. In this direction, scientific, design and technological works are being carried out in the Agro-Engineering Research Service of the LEPL Agricultural Research Center. In 2018-2020, a tea combining aggregate was developed and tested in the field, which performs four operations simultaneously in one pass in plantation: surface based trimming, trimmed mass fragmentation, mineral fertilizer application, soil cultivation between rows, trimmed mass and mineral fertilizer appliance in the depth. (View Fig. 1).

Fig.1. Tea combined aggregate

Fig. 2. Tea heavy trimming vehicle.

Besides, in the aggravated tea plantations is processed bush heavy trimming machine, disco-like, sharp segmented work piece, the advantage of which is the simultaneous pruning and cutting of large branches of shrubs, which ensures the cleanliness of the surface of the cut branches without any cracking and damage. (View Fig. 2).

Above mentioned vehicles are aggregated by Kharkov Tractor Factory, on the basis of chassis T-16 МГ produced in the previous century, which were modernized by Georgian Specialists for work in the Tea Plantations T-16 МГЧ, whose lights is elevated and is customized for work in the Tea Plantations.

In addition to the above mentioned vehicles, the agro-engineering research service has developed a engine block aggregate for cutting wild and afforested tea bushes with circular saws (View Fig. 3), the advantage of which is small size and energy saving. Its construction is being improved currently.

Fig. 3. Tea bush heavy trimming engine block aggregate.

Fig. 4. High-light Tractor БЛ-1020

Testing combined aggregate and other vehicles of tea showed us, that in Georgia there is still significant disadvantages of High-clearance self-propelled chassis T-16 МГЧ: In addition to its moral aging (the last series was released in 1991), its engine power (25-28 horsepower) is insufficient for the normal operation of modern multifunction aggregates. It is necessary to create a relatively powerful, more maneuverable and special high-light tractor. In this regard, the agro-engineering research service has developed a special, high-light tractor scheme, for the production of which, by the initiative of the Ministry of Environment Protection and Agriculture, a cooperation agreement has been signed between the LEPL Agricultural Scientific Research Center and the Belarusian agricultural machinery manufacturer "Blooming", by them in 2021 was produced High-clearance tractor БЛ-1000 (view picture 4), whose main features are: Tractor type – Universal, high-light, wheeled;

- Engine power -26 KW, (36 horsepower);
- Track -1600-2100 mm; Traffic light – 1200 mm.

Currently, separate devices for the tea combined aggregate are being developed together with Belarusian specialists, which will be assembled on the tractor БЛ-1020. In Georgia, its testing is scheduled for the 4th quarter of the year.

ჩაის პლანტაციების სარეაბილიტაციო მანქანები

ნუგზარ ებანოიძე - ტექ. მეცნიერებათა დოქტორი, პროფესორი; სსიპ სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრის აგროსაინჟინრო კვლევის სამსახური.

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ანოტაცია. სტატიაში განხილულია, საქართველოში მეჩაიეობის დარგის თანამედროვე მდგომარეობა და მისი განვითარებისათვის საჭირო ღონისძიებები, მათ შორის ძირითადია: დაკნინებული პლანტაციების რეაბილიტაცია, ახალი უხმოსავლიანი

პლანტაციების გაშენება, თანამედროვე ტექნოლოგიებისა და ტექნიკური საშუალებების დამუშავება და დანერგვა წარმოებაში.

სტატიაში მოცემულია, სსიპ სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრის, აგროსაინჟინრო კვლევის სამსახურის მიერ, 2018-2021 წლებში დამუშავებული, დაკნინებული ჩაის პლანტაციების სარეაბილიტაციო მანქანები: ჩაის კომპლექსური მანქანა, ჩაის მძიმედ სასხლავი მანქანები თვითმავალი შასის და მოტობლოკის ბაზაზე, ბელორუს სპეციალისტებთან ერთად შექმნილი, ჩაის პლანტაციებში სამუშაოდ განკუთვნილი, მაღალკლირენსიანი ტრაქტორი БЛ-1200, რომლის შემოტანა და გამოცდა საქართველოში გათვალისწინებულია მიმდინარე წლის მე-4 კვარტალში.

Technological Scheme of Tea Bushes Flatly Trimming Machine

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Productivity of tea bushes is depended on its biological condition, shape and size of the leaf-picking surface, which we may receive with using the types and forms of their trimming. There are distinguished different forms of trimming in agricultural machinery: semi-oval, oval, flat, cylindrical and others.

Tea culture is basically developed in the form of continuous wallpapers with a cylindrical surface in Georgia. Quality of picked leaf and final product is significantly depended on the formation of leaf picking surface. Under natural conditions tea plant has a sparce branching and mechanization of harvesting, in other words, mechanization of plucking of young leaves (new shoots) are practically complicated. In order to simplify the conditions of exploitation, tea bushes are given the form of tied up crown wallpaper. That's why they apply complete system of trimming, which is done by arc-shaped trimming machine with special purpose and having jointed hanging;

In second half of the previous century, arc-shaped tea trimming and tea picking apparatus determined for work in tea plantations were developed in Georgia, it happened firstly in the world. Active parts of these apparatus are located and moved on the cylindrical surface. Accordingly, after trimming these machines give tea bushes the cylindrical form surface; Giving such surface to the bushes is substantiated by scientists with an opinion that feeding elements are equally supplied from roots system of plant to central and peripheral regions of wallpaper working surface. Taking this opinion into consideration, in second half of the previous century, in Georgia there was implemented technology of trimming tea bushes with cylindrical form surface and accordingly, there was created a number of tea bushes trimming and leaf plucking apparatus having cylindrical form working details (see Fig.1);

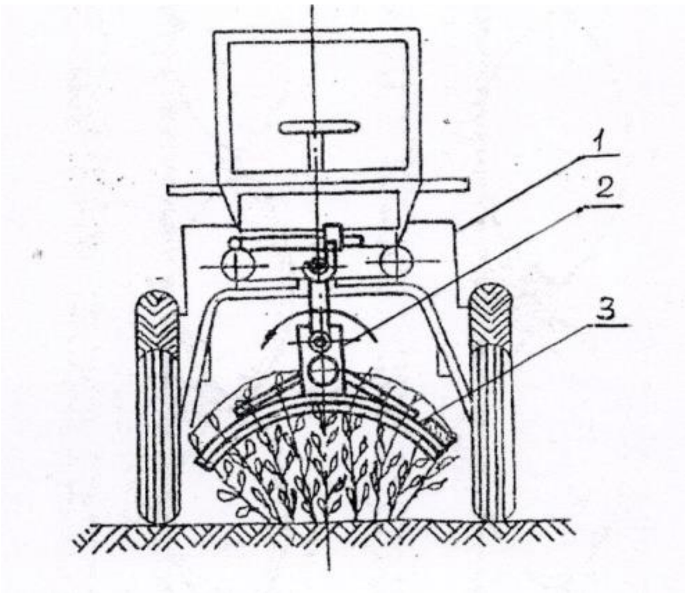

Fig. 1. Tea arc-shaped trimming apparatus with double pendulum hanging.
1 - Automotive chassis with high clearance; 2 - Double pendulum hanging mechanism; 3 - Tea trimming arc-shaped apparatus.

Practice showed us that under real exploitation conditions the work of arc-shaped trimming apparatus is complicated due to the numerous dynamic factors effect, such as forces of inertia, reactive moments, relatively increased magnitude of friction forces and so on. Totally, deviation of the working parts from the axis of symmetry of the wallpaper is occurred as a result of effect of these forces. Beside this, the quality of work of arc-shaped trimming apparatus are importantly affected by forced movement of automotive chassis (tractor) in vertical and horizontal direction that is caused by getting used of chassis to the soil relief in the tea rows. Aforementioned factors determined unevenness of the shape of the trimmed surface of the wallpaper and it complicated working of tea plucking machines, because adjusting of plucking machine on the working surface of tea bush is significantly complicated. Accordingly, the quantity of picked new shoots are reduced and their quality is worsened.

Hanging systems of apparatus partially balance forced vertical oscillations of arc-shaped trimming machines. As for the horizontal movements, they deteriorate the process of picking of leaves in peripheral parts of bush and worsening the quality of picked leaves. As a result of made examinations, the values of the deviation of the working surface parameters of the wallpaper obtained after trimming were concluded. As it is marked from the made examinations, the values of the deviation of the working surface parameters of the wallpaper obtained after trimming is finally reflected with change of radius of transverse section curvature of working surface and by the size of the displacement of its center in a horizontal direction; Under real exploitation conditions, in order to eliminate low-quality trimming obtained as a result of deviations of trimming apparatus, they applied to double passage of trimmings in opposite directions; As a result of doubling of labor and fuel expanses, it significantly increases the price of pruning process. Examinations made by us concluded that technology of arc-shaped trimming of tea bushes has important faults, which may be described as following:

- Constructive difficulty of trimming machines, expansive cost of making details and their knots;
- Low indication of life trimming apparatus that is caused by relatively high inertia forces, friction forces and reactive moments.
- High expanses of labor and fuel
- Frequency of current and capital repair.

In view of the above circumstances, we processes technological scheme of flat (it means parallel to the surface of soil) trimming of tea bushes; Suggested technological scheme considers increase of the width of the bush from l to L as a result of raise of its peripheral branches. (See. Fig. 2);

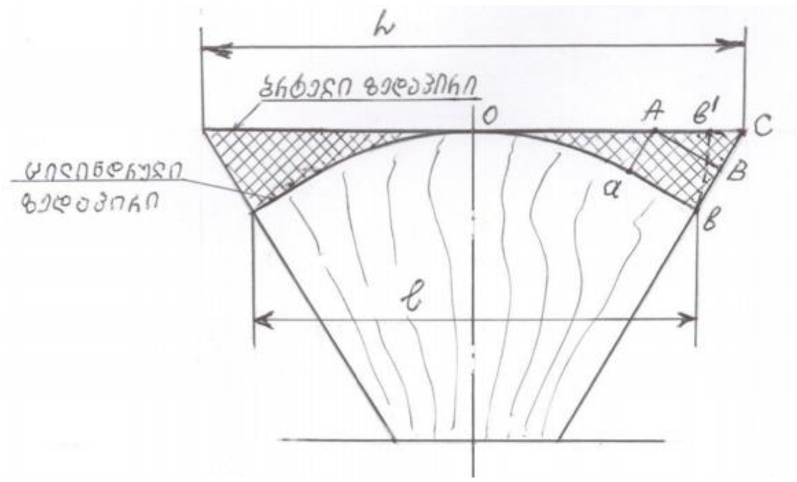

Fig. 2. Scheme for comparison of bush cylindrical working surface to flat surface.

As it is shown on the scheme, in case of flatly trimming of bushes, leaf picking surface is equal or in most cases is more in comparison with cylindrical leaf picking surface. It is practically done with increase of width of the bush. As it is seen from the scheme, the arc of the surface of a cylindrical bush is $Oab < OAc$; Since the hypotenuse of small right-angled triangles is greater than that of their largest cathetus; In case of our scheme $ab = AB$, and hypotenuse AC is more than the largest cathetus AB; Lately, in the countries abroad (Japan, Chine and others), formation of bushes in tea plantations are mainly occurred as a sluggish oval and horizontal (flat) surfaces. In such case, width of wallpaper working surface is increased, accordingly bush leaf picking surface is increased too and finally it increases the productivity of the bush in comparison with bushes having cylindrical shape. Beside this, the process of leaf picking is importantly simplified for both cases – picking of leaves by manual or automatic way.

Flatly to the tea bushes or in other words parallel to the soil surface, advantages of pruning process may be described as following:

- Construction of trimming apparatus is significantly simplified, complicated machine plants are not required at the time of preparation of its knots;
- Life of apparatus is increased because effect of inertia and friction forces are reduced on the mechanisms of apparatus.
- Area of bush working surface and qualitative values of picked leaves are increased. Since, at the time of forced movement of the apparatus in the transverse plane, rough new shoots are not met in the trimming area;
- Actuator energy charges of apparatus are reduced that is conditioned with movement of segment knives of working detail only on flat surface.
- Weight and Metal content of trimming apparatus are reduced.
- Finally, cost of technological operation fulfillment of tea bush trimming is importantly decreased. Basic agrotechnical requirement of tea bushes trimming apparatus is clean cut of branches, in other words, cutting of branches without any kind of damage. The cutting surface of the trimmed branch left on the bush should be without torn offs and crooked (like a comb surface) sides. Since the damaged surface of branches support spread of pests and fungi and finally it negatively effects on vegetation and productivity of bush.

At the time of superficial, wallpaper and semi heavy trimming, the diameter of cutting branches ranges within the frames of 2-10 mm. At the time of cutting of such branches, cutting knives having support are recommended to be used. In case of cutting without support, thin branches may be curved or damaged.

Taking these factors into consideration, we developed a kinematic scheme of tea bushes flat trimming machine and selected cutting apparatus with normal cut and $t = t_0$segment knives (See Fig. 3), which consists of rigid cogs and movable segment knives.

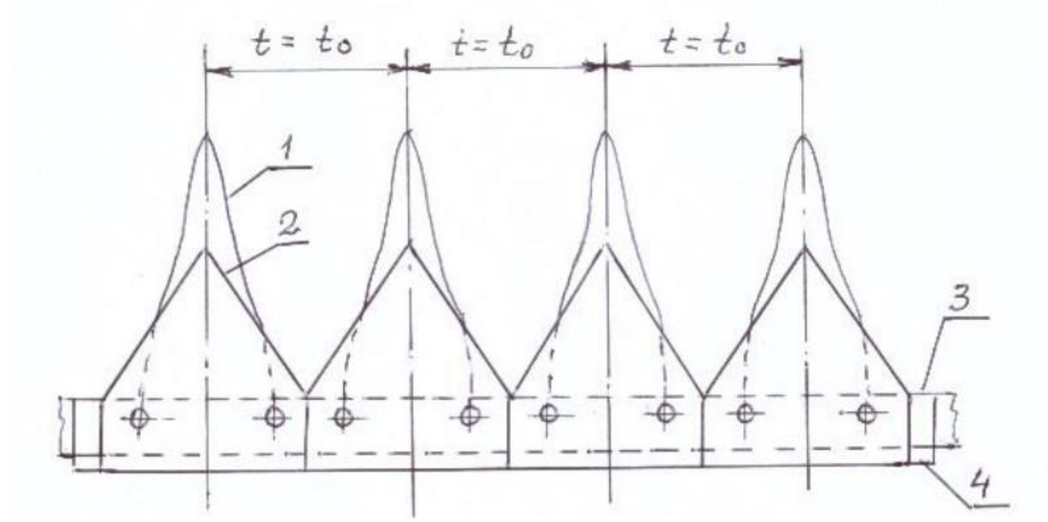

Fig. 3. Scheme of tea bushes trimming apparatus

1 - rigid cog; 2 - movable segment knife; 3 - rod of rigid cogs; 4 - rod of movable cogs.

Width of rigid cog is reduced in the area of cut that conditions easy penetration of rigid cogs into bushes and quality cutting of branches;

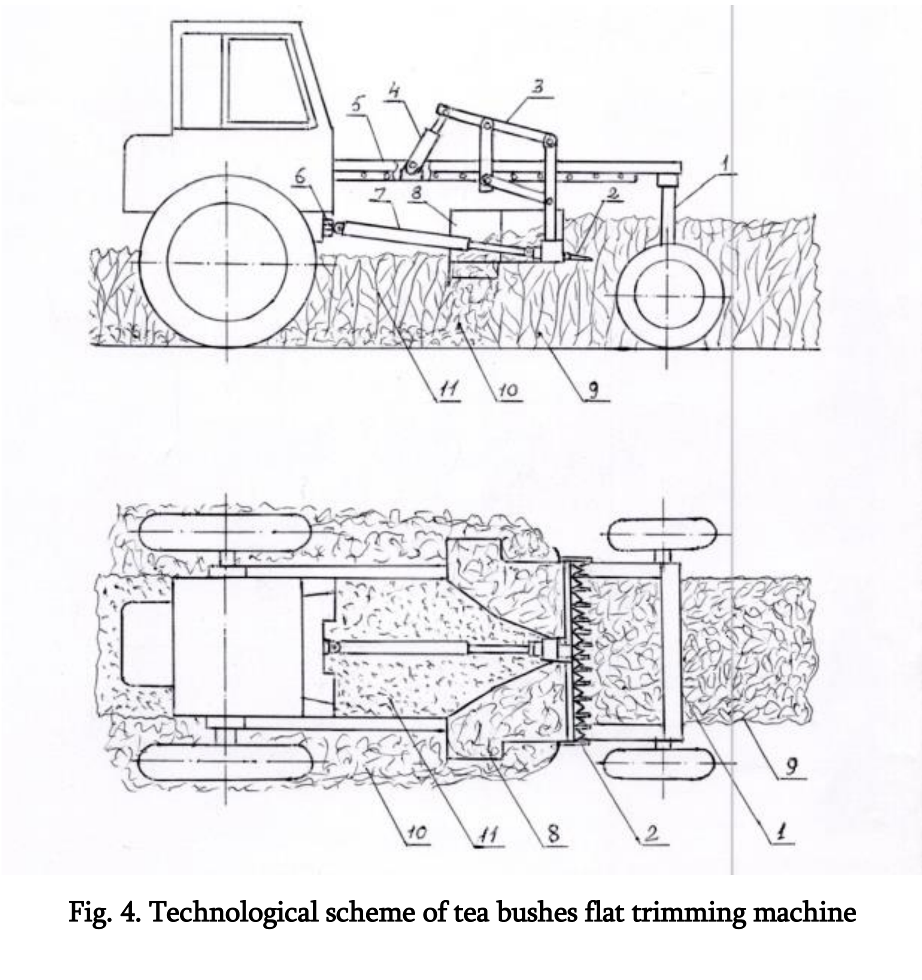

Fig. 4. Technological scheme of tea bushes flat trimming machine

Principal Scheme of Tea Plantation Flatly Trimming machine is developed by Specialist of Agricultural Engineering Examination Service of Agricultural Scientific Research Center and Trial sample. Technological scheme of working of machine is shown on Fig. 4. On Automotive chassis with high clearance 1 flatly trimming apparatus with segment knifes is aggregated 2, which by 3 parallelogram mechanism and 4 hydro cylinder is jointly depended on frame of automotive chassis (longeron) 5; Start of trimming machine is done from shaft of automotive chassis 6 via cardan gear 7. Taking of cut mass beside is done via sliding shield 8. Thus, one pass of automotive chassis provides superficial trimming and flatly formation of tea bush 9;

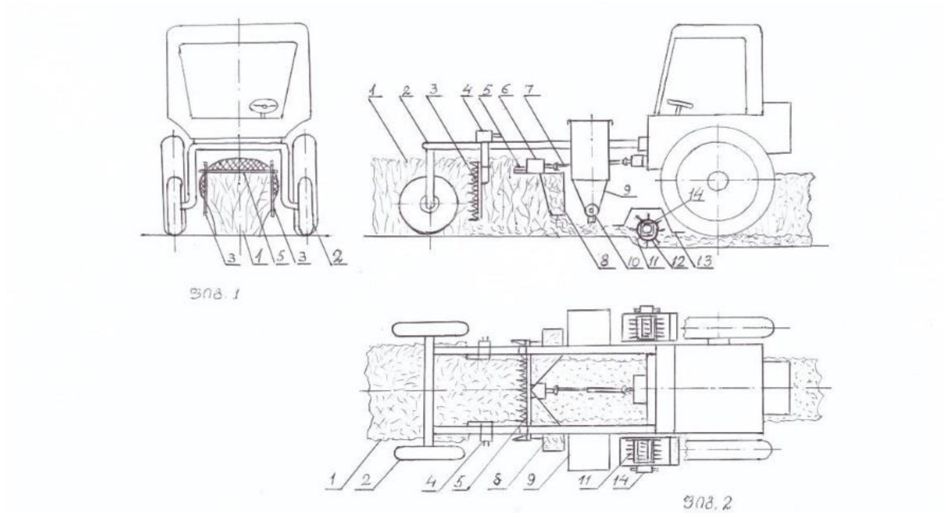

Fig. 5. Combined aggregate with tea bushes flatly trimming and shredding facilities.

Cut muss 10 is thrown in the raw of tea and then it is processed with soil cultivator shredder. Usage of mentioned apparatus is possible in tea combined machine (See Fig. 5), that simultaneously fulfills four operation (trimming of tea bushes, shredding of trimmed material, bringing of mineral fertilizers in rows, soil cultivation and covering of trimmed material and mineral fertilizer with soil);

Combined aggregate with tea bushed 1 flatly trimming and shredding facilities contains horizontal and vertical trimming apparatus connected to automotive chassis 2 with hanging and actuator systems, device for bringing of mineral fertilizer; Rotor type, articulated, shredding and soil cultivator shredder. Trimming apparatus is represented: as vertically located trimming device with segment knives 3, which starts moving from hydro motor 4, as horizontally located trimming device with segment knives 5, which starts moving from shaft of automotive chassis via redactor 6 and cardan gear 7, as device for taking cut branches beside and shields supplying between rows 8, facility bringing mineral fertilizer between rows, which is represented with pyramidal shaped bin 9 and sowing apparatus 10; trimmed material shredding and soil cultivator rotor facility, which is represented with articulated knives 11, cylindrical revolver 12 and shield 13 that starts moving via hydro motor 14;

Trial sample of tea combined machine is developed by specialists of Agricultural Engineering Examination Service of Agricultural Scientific Research Center, is tested under production conditions and work on preparation of its construction with small series and factory rule is in progress.

ჩაის ბუჩქების ბრტყლად სასხლავი მანქანის ტექნოლოგიური სქემა

ნუგზარ ებანოიძე - ტექ. მეცნიერებათა დოქტორი, პროფესორი; სსიპ სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრის აგროსაინჟინრო კვლევის სამსახური.

მარიტა მაჭარაშვილი, თენგიზ ცარციძე

სსიპ სამეცნიერო-კვლევითი ცენტრი, თბილისი, საქართველო.

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ანოტაცია. სტატიაში განხილულია ჩაის ბუჩქების გასხვლისა და ფორმირების სხვადასხვა სახეები. საქართველოში ძრითადად გამოყენებულია ჩაის ბუჩქების რკალური (ცილინდრული) სასხლავი აპარატები.

პრაქტიკამ გვიჩვენა, რომ რეალურ საექსპლოატაციო პირობებში რკალური სასხლავი აპარატების მუშაობა გართულებულია, ვინაიდან მათ გააჩნიათ მთელი რიგი ნაკლოვანებანი:

- სასხლავი აპარატების კონსტრუქციული სირთულე, დეტალებისა და კვანძების დამზადების სიძვირე;
- დაბალი ხანგამძლეობა, რაც გამოწვეულია შედარებით მაღალი ინერციის ძალების, ხახუნის ძალების და რეაქტიული მომენტების ზემოქმედების შედეგად;
- საწვავისა და შრომითი რესურსების მაღალი დანახარჯები;
- მიმდინარე და კაპიტალური რემონტების ჩატარების სიხშირე.

სტატიაში დასაბუთებულია ჩაის ბუჩქების ბრტყლად, ნიადაგის ზედაპირის პარალელურად, გასხვლის უპირატესობა. შესაბამისად დამუშავებულია ბრტყლად სასხლავი აპარატის კინემატიკური და ტექნოლოგიური სქემა. აღწერილია მანქანის ცალკეული კვანძების მუშაობის პრინციპი და მათი უპირატესობა რკალურ სასხლავ აპარატებთან შედარებით.

სტატიაში მოცემულია ბრტყლად სასხლავი აპარატის, ჩაის მოვლა-მოყვანის კომპლექსურ მანქანაში გამოყენების სქემა, რომელიც ერთდროულად ასრულებს ოთხ ოპერაციას: ჩაის ბუჩქების ზედაპირულ გასხვლას, ნასხლავი მასის დაქუცმაცებას, რიგთაშორისებში ნიადაგის დამუშავებას და მინერალური სასუქის შეტანას. აღნიშნული მანქანის საცდელი ნიმუში რკალური სასხლავი აპარატით დამზადებულია, გამოცდილია და მიღებულია რეკომენდაცია კომპლექსურ მანქანაში ბრტყლად სასხლავი აპარატის გამოყენების შესახებ.

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DIAGNOSTICS OF RESIDUAL STRESSES IN SPUTED AND FLUSHED COATINGS

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Abstract. One of the most urgent problems of ensuring the quality and reliability of remanufactured and hardened machine parts is the diagnosis of residual stresses. First of all, this is due to the use of technical measuring instruments that allow you to quickly obtain the required amount of information. This work is devoted to the solution of this problem, in which surface residual stresses in metal coatings deposited by plasma methods during the restoration and hardening of machine parts are experimentally diagnosed. It was found that the stress diagram is non-equilibrium and shifted towards compression. Small stresses σ_M = 15–20 MPa were recorded on the run-out of the stress diagram

Keywords: residual stresses, reliability, hardening, recovery, plasma methods, metal coatings

Introduction.

At present, the diagnosis of residual stresses in the development of resource-saving technologies for the restoration and hardening of machine parts by plasma methods can be performed mainly indirectly using the accumulated data on the patterns of their formation, distribution, influence, and the possibilities of their regulation. The practice of restoring and hardening machine parts shows that this factor is usually not taken into account when developing and improving technologies. The main reason for this is the lack of technical means for diagnosing residual stresses due to the high cost.

Therefore, one of the most urgent problems of ensuring the quality and reliability of remanufactured and hardened machine parts is the diagnosis of residual stresses. First of all, this is due to the use of technical measuring instruments that allow you to quickly obtain the required amount of information.

Purpose of the study.

Solving the problems of diagnosing residual stresses, in which surface residual stresses in metal coatings applied by plasma methods during the restoration and hardening of machine parts will be experimentally diagnosed.

In order to determine the effect of residual stresses arising in sprayed and melted coatings and in the fusion zone on the properties of coatings, experimental studies were carried out.

Materials and methods.

The studies were carried out at the research and production enterprise "Sigma-Test" on the equipment for non-destructive testing of residual stresses "SITON-ARM". The equipment allows measuring technological residual stresses by testing the amplitude-phase frequency characteristics of the metal of the surface layer of the product. This testing method is implemented by passing an electric current through the surface area under test. [1,2]. Technological residual stresses in the applied coatings were determined by testing the amplitude-phase frequency characteristics of the metal of the surface layer of the product, which was realized by passing an electric current through the surface area under study on the SITON-ARM non-destructive testing equipment.

The SITON-ARM equipment (Fig. 1) includes: a portable module, a special electrical contact sensor, a personal computer. Technical characteristics of the device are presented in table. one.

The portable module automatically controls the frequency of the measuring signal. A special algorithm makes it possible to determine the value of the average stresses in the h-layer from the measured electrical quantities, followed by recalculation into the integral of stresses and real voltages. [3,4,5].

Fig. 1. Equipment "Sitom-ARM"

For the study, a knife of the working body of a mobile drilling rig PBU-50M was made for the construction of mine wells. The knife was made from a sheet of steel St. 3 with geometric dimensions 267×77×9 mm. The entire length of the knife was covered with a coating 500 µm thick and 16–18 mm wide from the composite powder PR-N70Kh17S4R4 (27%) + PG-FBYu1-4 (73%) by air-plasma spraying followed by flashing [6, 7]. To ensure reliable electrical contact of the electrode with the surface, as well as to obtain reliable results, the controlled surface was cleaned and degreased using the Ezh paste-gel surface preparation solution (TU 2382-357-0206847-96).

The determination of residual stresses in the tested sample was carried out in the following sequence. The DU-26/13 electrocontact sensor was fixed on the verified sample with the help of a clamp (Fig. 2). After connecting the sensor to the sample, the display of the portable module (Fig. 3) displayed the indicated current. [8,9].

Technical characteristics of the "SITON-ARM" device

Table 1.

Indicators	Options
Sensitivity threshold for determining residual stresses, MPa	20
Number of scan steps	16
Maximum depth of determination of residual stresses, microns	500
Depth of determination of residual stresses, microns	8, 10,12, 16, 20, 25, 32, 40, 50, 63, 80, 100, 125, 160, 200, 250, 320, 400, 500
Material of objects of study	any conductive materials
Parameter measurement time	up to 8 min
Submission Form	graphs of the distribution of residual stresses in depth (diagrams)

The current value was measured periodically over a short time interval in order to reduce the power consumed by the device. The indicated current did not correspond to the current in the steady state and served only to control the presence of a contact. The device was started in standalone mode by pressing the "Enter" button, when the right button "↑" of the portable module was pressed, the measurement process was started using the "SITON-APM Interface" program from the internal memory of the device.

Fig. 2. Electrocontact sensor DU-26/13 fixed on the checked sample.

Fig. 3. Display of the personal module of the SITON-ARM equipment

Residual stresses were determined by the following method:

1. The current, voltage, and reduced power dissipation of the signal in the test sample were determined at a given frequency.

2. The given frequency of the measuring current corresponded to a certain depth of current penetration and the thickness of the measured layer.

3. Scanning the frequency of the measuring current from the minimum to the maximum was carried out in accordance with the specified frequency scale, as a result of which the current, conduction voltage and power in the material layers at different depths were determined.

4. The calibration coefficient was determined using the calibration samples selected by a special method, in which the conductivity of the material layers at different depths was determined and the residual stresses at the corresponding depths were determined by an alternative (destructive) method. In this system, the classical method of N.N. Davidenkova - I.A. Birger [10], implemented on a standardized installation "PION".

5. Residual stresses in the tested sample were determined by the method of calculating residual stresses from the electrical characteristics of the sample and calibration coefficients. [11].

For practical purposes, the stress diagram was parametrized by introducing a number of parameters and is presented in fig. 4:

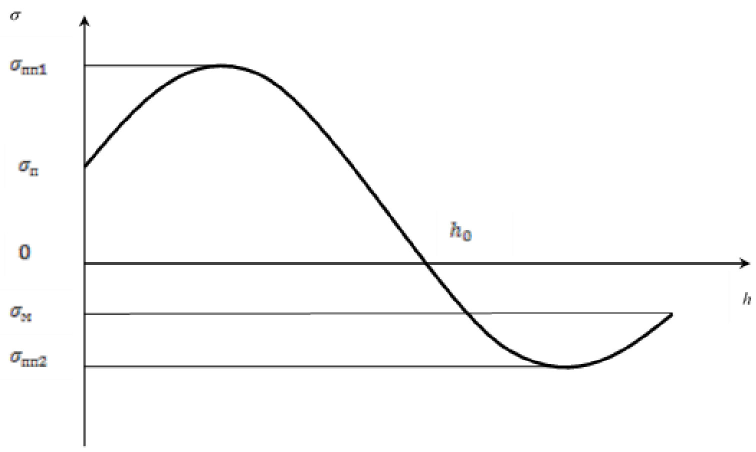

Fig. 4. Diagram of residual stresses.

$\sigma_{П}$ – surface stresses, MPa; $\sigma_{ПП1}$ – maximum subsurface stresses 1 up to the zero transition point, MPa;

$\sigma_{ПП2}$ – maximum subsurface stresses 2 after the zero transition point, MPa;

σ_{M} – stresses on the run-out of the diagram, MPa;

h_0 – zero transition point of the stress diagram, μm.

These parameters quite fully reflect the nature of the stress state of the metal of the surface layer of the part. The finished part must have residual stresses of the following form:

- stresses on the surface and the first subsurface compressive stresses, $\sigma_{П} < 0$, $\sigma_{ПП1} < 0$;
- the presence of a zero transition point, h_0 = 50–80 micron;
- second subsurface tensile stresses, $\sigma_{ПП2} > 0$;
- the value of the run-out voltage of the diagram tends to zero, $\sigma_M \to 0$.
-

Results and discussions.

Based on the results of the research, the following conclusion was formulated:

1. The nature of the distribution of residual stresses in the surface layer has the following features: stresses on the surface $\sigma_{П}$ = -100 MPa; the first subsurface maximum $\sigma_{ПП1}$ = MPa; the second subsurface maximum $\sigma_{ПП2}$ = +20 MPa. The stress diagram is non-equilibrium and is shifted towards compression.

2. After the coating is melted, the nature of the distribution of residual stresses in the surface layer has the following features: stresses on the surface $\sigma_{П}$ = -140 MPa; the first subsurface maximum $\sigma_{ПП1}$ = -220 MPa; the second subsurface maximum with the run-out of the diagram $\sigma_{ПП2}$ = +5 MPa. The stress diagram is non-equilibrium and is shifted towards compression.

3. On the run-out of the stress diagram, rather small stresses σ_M = 15–20 MPa are observed. It can be assumed that after the final processing, internal stresses are released.

Conclusion.

As a result of the work carried out, it was determined that residual stresses in coatings applied by plasma methods affect the strength of its adhesion to the base in two ways. On the one hand, they contribute to the reduction of stresses in the substrate, and on the other hand, they contribute to an increase in stresses in the substrate higher than they would be in the absence of a coating. In this case, the magnitude and sign of stresses depend on the physical properties of the materials being joined, and on the geometric dimensions of the part to be restored, as well as on the conditions of coating application.

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დალითონებითა და დაფრქვევით აღდგენილი ზედაპირების ნარჩენი დაძაბულობის დიაგნოსტირება

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ანოტაცია. აღდგენილი და განმტკიცებული მანქანათა დეტალების ხარისხისა და საიმედოობის უზრუნველყოფის ერთ-ერთ აქტუალურ პრობლემას წარმოადგენს ნარჩენი დაძაბულობის დიაგნოსტირება. პირველ რიგში ეს დაკავშირებულია გაზომვათა ტექნიკურ საშუალებებზე, რომელიც იძლევა მოთხოვნილი მოცულობის ინფორმაციის მიღების საშუალებას. ამ პრობლემის გადაწყვეტას ეძღვნება წინამდებარე ნაშრომი,

რომელშიც ექსპერიმენტულად დიაგნოსტირებულია პლაზმური მეთოდით აღდგენილი და განმტკიცებული მანქანათა დეტალების ლითონური საფარის ნარჩენი ძაბვები.

დადგენილია, რომ ძაბვების ეპიურა არათანაბარია და გადახრილია კუმშვის მიმართულებით. ეპიურაზე ძაბვათა გადახრაზე აღინიშნება მცირე ძაბვები σМ = 15...20 МПа.

Irrigation infrastructure planning and management

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Abstract. The viability and yield of the plant depends on the correct use of these factors. Most of the listed activities: relative improvement of soil and air moisture by irrigation or drainage, flushing of saline soils, control of mechanical impact on water-soil, leveling the soil surface (shrinkage), uprooting, etc. are related to the issues of water resources regulation, and their implementation necessarily requires maintenance of rather complex technical systems (irrigation and drainage network with its structures, etc.) and knowledge of management systems for their operation.

Key words: Agriculture; Agriculture crop; Management. water resources, optimization, irrigation; Irrigation water

Introduction

Agricultural production in Georgia is only at the initial stage of a competitive advantage. Its competitive advantages, as already mentioned, mainly depend on natural, climatic and environmental factors. Therefore, it is necessary to create a competitive environment, the introduction of modern agricultural technologies, the integrated efficient use of natural resources, the use of qualified human resources, the economically efficient use of natural resources and compliance with standards in accordance with modern requirements.

The variety of climatic, soil and relief conditions in Georgia also contributes to the heterogeneity of water use for the development of agriculture. In particular, the arid continental climate of eastern Georgia requires extensive use of irrigation, while in western Georgia is necessary to remove excess water and carry out activities relating to drainage.

Nowadays, the first task is to fully finance the land reclamation sector and effectively use the funds, gradual cessation of the downward trend, implementation of development-oriented measures, which also requires coordination of the functions and responsibility of irrigation management and drainage systems and harmonize its institutional structure.

Irrigation water supply scheme

As international experience shows, the management of irrigation systems should be carried out in such types and methods that are economically acceptable for water users.

When choosing a management model, the engineering and technical complexity of the irrigation system management, its operating costs, income and optimal consumption of water resources are of great importance. Consider a four-element analytical management model, as can be seen from the analysis of the existing model, basically the form of irrigation water management is distributed between the state and private companies, there are also mixed and single forms of management associated with the complexity of system services .

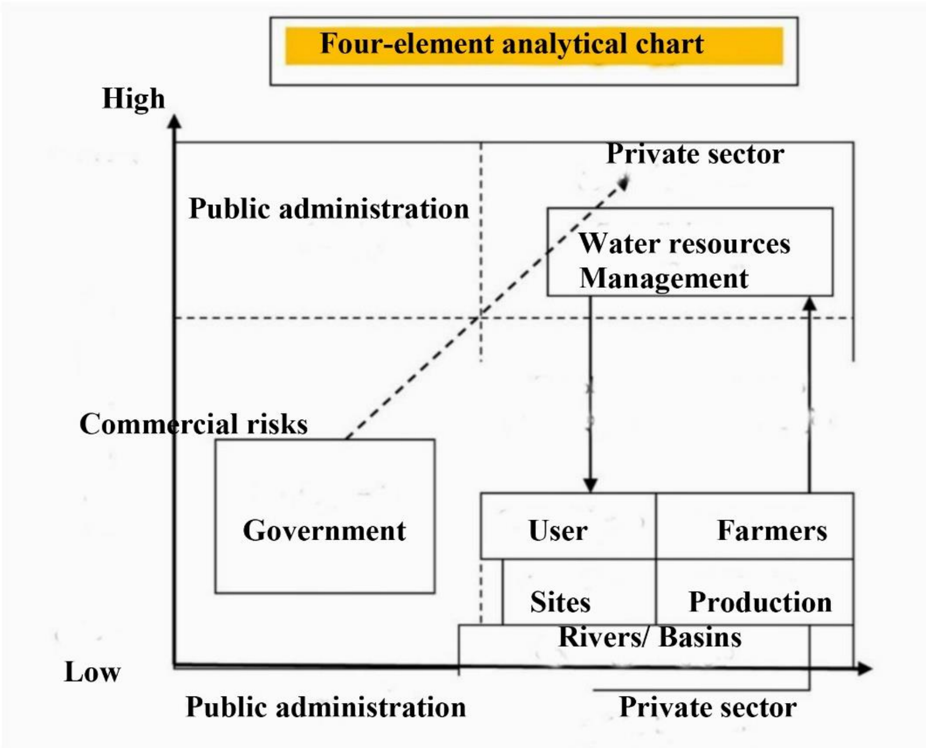

Fig. 1.Management of irrigation systems

The management of irrigation systems should be monitored and require subsidies from the state if complex irrigation systems are rehabilitated, in order to avoid technically unforeseen accidents, annual erosion processes caused by improper operation, natural disasters and disruption of agricultural activities..

According to the rule of water supply, irrigation systems can be divided into self-flow (gravity) and confined flow system. Currently, the land in Georgia is irrigated by gravity systems. This is how 90% of the total irrigated area is irrigated, although pumping stations remain in some regions. As part of the rehabilitation of the irrigation system, several new pumping stations have been built in recent years.

There are different attitudes towards the organization of irrigation services. The preferred option is a demand-based system that allows the farmer to request and receive water based on plant needs and climatic conditions. In this case, the customer submits an application to the water supply organization before the agreed term, receives the service within the agreed deadline and, accordingly, he/she determines the terms and conditions of the service. In terms of supply-based service, which is used in the presence of insufficient water resources or a low-tech system, the starting point is the existence of a water resource, according to which the water distribution rule is developed (rotation, pre-agreed supply, central planning, etc.).

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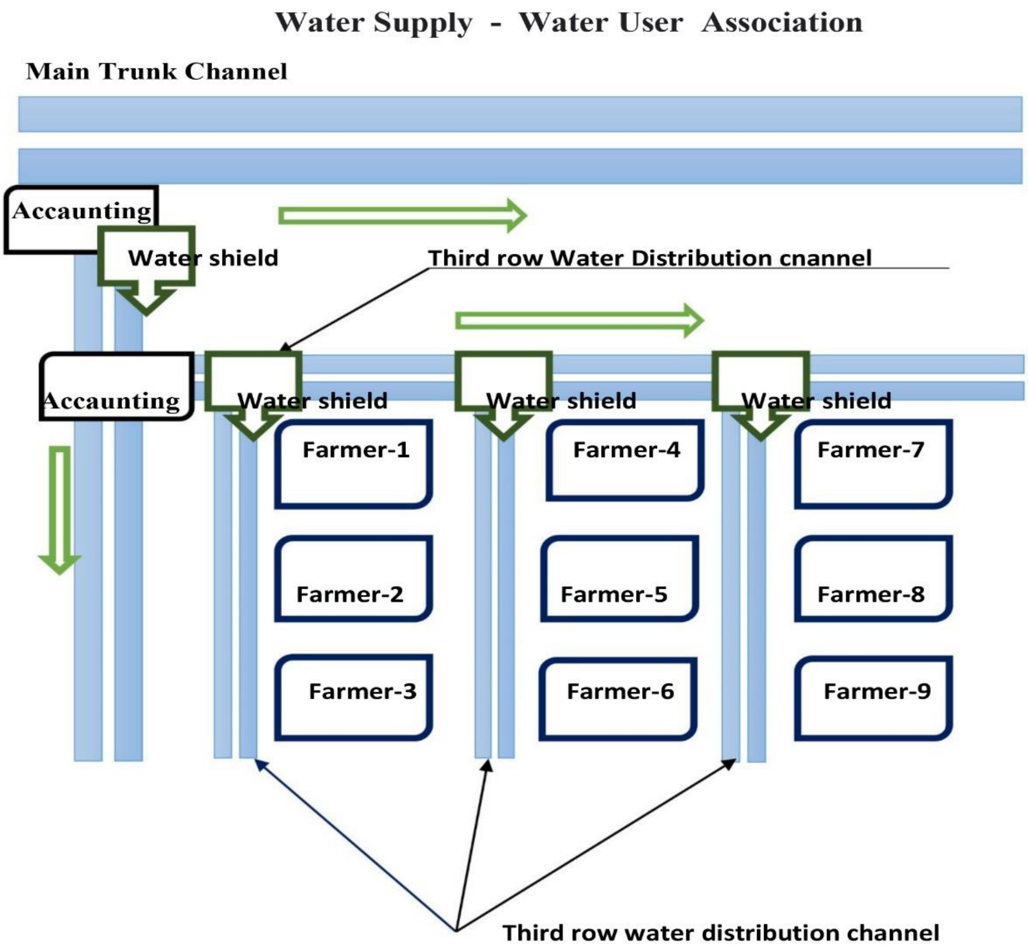

Fig. 2 Water User Association

Irrigation water service is determined by good management and proper operation of the irrigation infrastructure. Reliable, timely and necessary supply of irrigation water with products necessary for agricultural production, in particular seeds, fertilizers, etc. of agricultural crops, contributes to high yields and increases the income of farmers. The products grown as a result of the consumption of irrigation water and the income generated from it allow the farmer to pay the service fee. A high level of service increases the ability of the water user and his willingness to pay for it.

On the other hand, the solvency of the water user and the desire to introduce efficient water consumption determine the proper performance of service and the timely water supply.

The service provider's organization must have effective controls, especially in the areas of finance, operations and maintenance. The effectiveness of such management systems improves the quality of service [1,2].

Irrigation systems should be managed in forms and methods that are economically acceptable for the water user. Water supply services should be provided on the basis that the water user has an interest in agricultural activities, the sale of which will allow him to obtain economic profit. Due to the complexity of the systems, water charges vary by region. Leaving a fixed tax, as it is now, requires government subsidies, so it is necessary to expand the business, to find and offer alternative options.

Forms of management of irrigation systems: The classification is based on who determines - the state; Who supplies - service organization; Who pays - User:

Services are an integral part of the structural management of irrigation production, and the service of supplying irrigation water during maintenance is determined by good management and proper operation of the irrigation infrastructure. Reliable, timely and necessary supply of irrigation water with products necessary for agricultural production, in particular seeds, fertilizers, etc. of agricultural crops, contributes to high yields and increases the income of farmers. The products grown as a result of the consumption of irrigation water and the income generated from it allow the farmer to pay the service fee. A high level of service increases the ability of the water user and his willingness to pay for it.

The service provider's organization must have effective controls, especially in the areas of finance, operations and maintenance. The effectiveness of such management systems improves the quality of service.

Service fees for supplying or removing excess water depend on the quality of the service. This method of payment for services is widely accepted in countries with market economy experience. In Georgia, this method is still not widely used - as in the irrigation and drainage sector, similar problems with the collection of funds are found in other areas of service.

It is important to share the experience of other countries in order to determine the sources and area of financing for the sector in the future. Especially in countries that are somewhat similar to Georgia in terms of natural conditions: climate, relief, soil cover, water resources, crops, etc. and are at the same level.

Studies have shown that when choosing a management model, one should take into account all the circumstances that may accompany water supply activities. You should also take into account the culture of the local population and its main source of income. It is also necessary to take into account natural resources: soil, agro-climatic factors of water, ecological balance of the environment, etc., which affect water services, the cost of irrigation water .

Along with general economic development, the irrigation water service in Georgia is gradually strengthening, it is expected that collection of payments by water users will be improved, and state funding will be reduced. However, this depends on whether the involved structure receives the assistance needed to provide adequate services in the future. The current legal framework for maintaining the sustainability of the sector should regulate the legal relationship: between individuals - water users and government bodies in the field of natural resources. You should also pay attention to surface and ground waters, as well as protection zones when using them [3,4].

Conclusion

In agriculture, the key to managing natural resource efficiency is the integrated use and protection of water resources. We'll have to change priorities, the focus should be shifted from labor economics to efficient use of natural resources.

From a perspective, in order to effectively manage agriculture economically, in terms of optimal use of natural resources, it is recommended to move from linear economic models to circular economy, which leads to the optimization of the use of water resources in agriculture and the introduction of waste-free technological production.

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სარწყავი ინფრასტრუქტურის დაგეგმარება და მართვა

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ანოტაცია. მცენარის სიცოცხლისუნარიანობა და მოსავლიანობა დამოკიდებულია მელიორაციულ ღონისძიებათა გამოყენების სწორ ფაქტორებზე.

ნიადაგის ტენიანობისა და ჰაერში არსებული ტენის ფარდობითი გაუმჯობესება რწყვის ან დაშრობის საშუალებით, მლაშე ნიადაგების გამორეცხვა, წყლის ნიადაგზე მექანიკურ ზემოქმედებასთან ბრძოლა, ნიადაგის ზედაპირის მოსწორება (მოშანდაკება), ამოძირკვა და სხვა.

ჩამოთვლილ ღონისძიებათა უმეტესი ნაწილი წყლის რეგულაციის საკითხს გულისხმობს და მათი განხორციელება აუცილებლად საჭიროებს საკმაოდ რთულ ტექნიკური სისტემების გამართვას (სარწყავ და დამშრობ ქსელს თავისი ნაგებობებით და სხვ.) და მათი ექსპლუატაციისათვის მართვის სისტემების ცოდნას.

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Hazelnut calibrator based on electromagnetic vibration drive of reciprocating motion

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Abstract. The paper discusses the development of hazelnut production and export opportunities of Georgia; Innovative hazelnut calibration method, our own constant current magnetic reversible-forward motion electromagnetic hazelnut calibrating machine with the ability to change the number of fractions and adjust the productivity; The trajectory of the hazel movement on the surface of the screen and the scheme of forces acting on it; Analysis of the optimal technological parameters obtained as a result of the study of the working modes of the hazelnut calibrator.

Hazel tree *(Corylus)* is one of the oldest crops in Georgia, which is the most widespread compared to other hazelnut crops. The fruit of the hazel tree - hazelnut has a fairly wide and versatile use. Its processing makes it possible to obtain a wide range of products such as hazelnut oil, flour, milk, which are actively used in the confectionery industry, medicine and perfumery. Hazelnuts are used in baking and desserts, confectionery to make praline, and also in combination with chocolate for chocolate truffles and products such as chocolate bars, hazelnut cocoa spread such as Nutella of the company Ferrero (Italy). Fig. 1 shows a diagram of world hazelnut production from 2010/11 to 2020/21 [1].

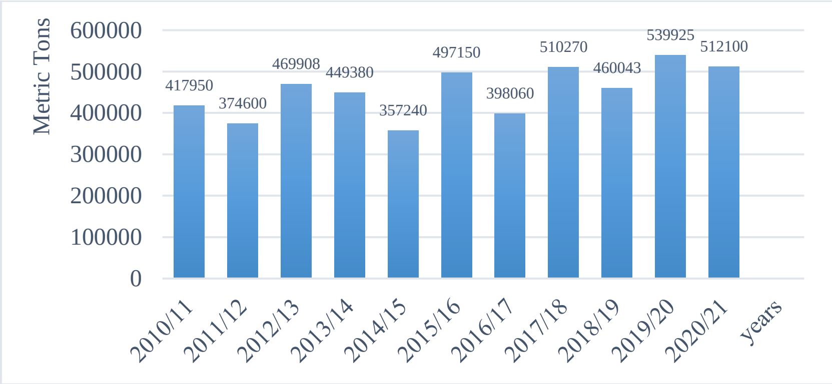

Fig. 1. World hazelnut (Kernel Basis) production worldwide from 2010/11 to 2019/2020 in metric tons.

From the diagram shown in Fig. 2 it can be seen, that the global hazelnut crop totaled over 512,000 metric tons (kernel basis) in 2020/21, the second largest production in the last 10 years. Turkey's crop accounted for 62% of the world total, and was estimated at 320,000 MT. After overcoming an unusually – weather related– low crop the prior season, Italy's 2020/21 was a bumper crop that surpassed the 75,000 MT threshold and was increased by 57% over the previous 10-year average. Both the crop in the United States and Chile have risen noticeably from the previous season and from the past 10-year average, reaching record highs this season.

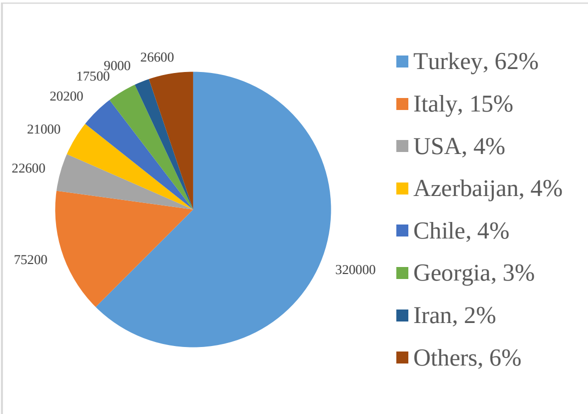

Fig. 2. World hazelnut production 2020/21 (Kernel Basis) in metric tons

Figure 3 shows a diagram of world hazelnut exports in 2009-2019 years [1].

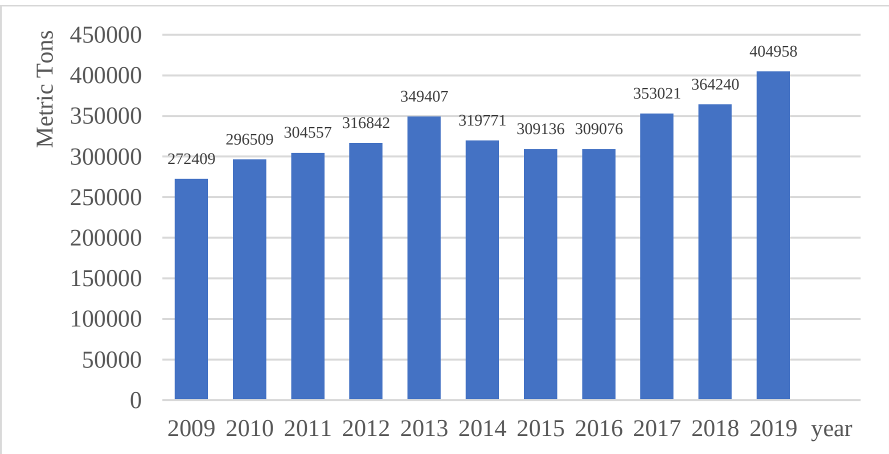

Fig. 3. World hazelnut (Shelled) exports from 2009 to 2019 (Metric Tons).

From consideration of figures 3 and 4 it follows that the world hazelnut exports reached around 405,000 metric tons. Turkey remained the world's largest exporter, accounting for over 77% of total export. The European Union and the United Kingdom were the largest destinations for Turkish exports (78%), with Germany and Italy accounting for 50% of the country share. The bulk of Italy's exports (93%) were destined for EU countries, especially Germany (52%) and France (17%). The United States accounted for 59% of the 36,302 MT of inshell hazelnuts traded in 2019. China (Mainland 33% + Hong Kong 6%) and Canada (12%) were the top destination

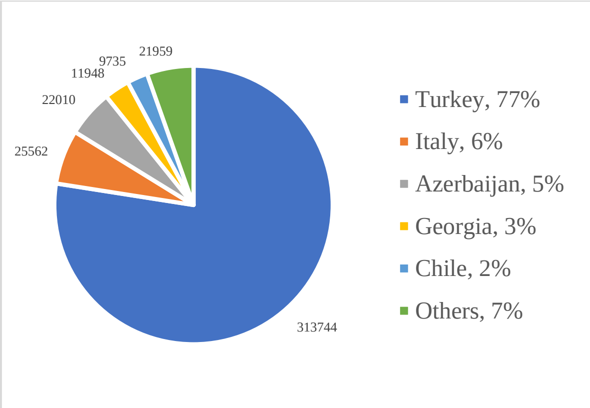

Fig. 4. World hazelnut (Shelled) exports in 2019 (Metric Tons)

As can be seen from the above data, Georgia ranks one of the leading places in the world, both in hazelnut production and export (Fig. 2, Fig. 4).

Among the agricultural commodities produced in Georgia, hazelnuts are one of the most promising crops and already have a significant competitive advantage in the international market. At present, hazelnuts are the only nut crop that is stable for export and has long been a product of economic importance for the country, as it has a leading place in the export of agricultural products. Hazelnut export markets are quite diversified, in 2015-2020 in total 57 different countries exported this crop, the largest volume of exports was to Italy and Germany, followed by Russia and other Central and Western European countries, Spain, Czech Republic, Lithuania, France, Ukraine etc.

In 2016-2018, the hazelnut yeald in Georgia significantly decreased, which is related to the spread of Brown marmorated stink bug (*Halyomorpha halys*) since 2015. As a result of the measures taken against the Brown marmorated stink bug, the damage caused by it was reduced, which was reflected even in the 2019 and 2020 yealds (Fig. 5).

The hazelnut production diagram in Georgia in 2010-2020 is presented in Figure 5 [2]. Recently, 677 ha of hazelnut orchards have been planted in Georgia within the framework of the state project of the Ministry of Environment Protection and Agriculture "Plant the Future" (including March 2020) and this process continues. Based on these data, we must assume that in a few years hazelnut production will increase by about 32% and as result, Hazelnut export opportunities will also increase. It is therefore important to develop hazelnut processing plants.

Prices are also getting better. Comparing to the same period of 2019 (we refrain from comparing to unusual pandemic 2020 year), price of the hazelnuts, in-shell, is 12% higher. Prices went up from $2.2/kg to $2.46/kg and for shelled – by +2% – from $5.78 to $5.88 in 2021 [https://east-fruit.com/en/news/georgia-to-increase-hazelnut-production-and-improve-quality-amidst-rising-global-competition/].

The first step in the hazelnut processing process is to calibrate the hazelnuts so that the hazelnut crushing machines are adjusted to the size of the hazelnuts, and the more thorough such calibration (more fractions), the better the hazels will be cracked and the higher the yield, which in turn affects the hazelnut price. Thus, vibrating calibrator is a major player in the processing of hazelnuts and other products and has continuously been improved over the past years [3, 4].

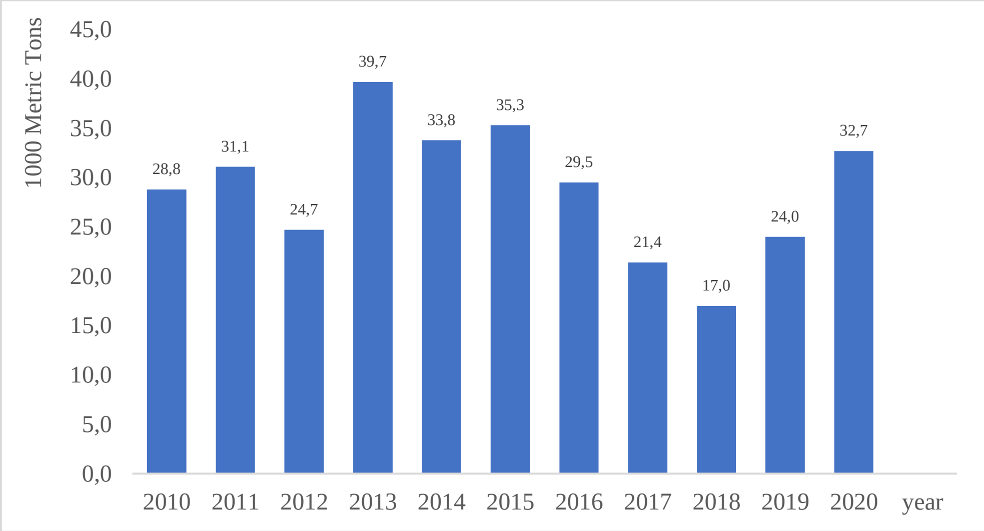

Fig. 5. Hazelnut production in Georgia in 2010-2020. (Thousand metric tons, Source: Geostat)

Existing machines for hazelnuts calibration are mainly rotary. In such machines, the rotational speed of the sorting drum is regulated by a frequency converter, the presence of which increases the cost of the machine and complicates the working process [3].

The aim of the work is to study a hazelnut calibrator equipped with a reciprocating electromagnetic vibration motor, analyze the vibrocalibration process of hazelnuts and determine the optimal technological parameters of the process.

Analysis of the calibration process and study of the modern constructions showed that the best calibration of the hazelnuts can be achieved by using of reciprocal motion. Therefore, we have developed a hazelnut calibration vibrating plant (Fig. 6), which is used as a drive, as well as our patented reciprocal motion electromagnetic vibrating motors (Fig. 6, # 1) with direct current magnetic biasing [6, 7, 8], where the oscillation amplitude of the operating elements can be adjusted by changing of the bias direct current.

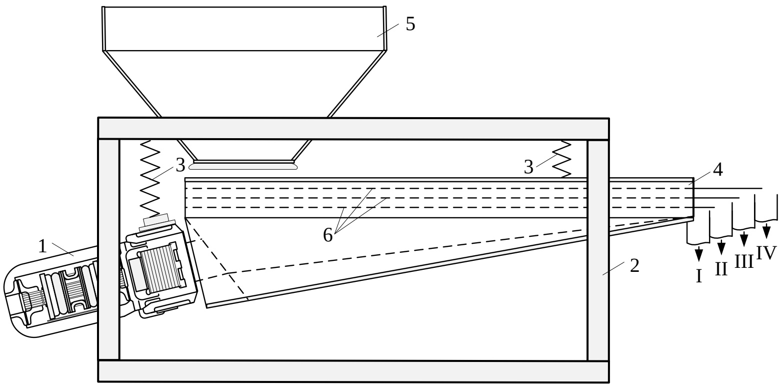

Fig. 6. Hazelnut calibrator with reciprocal electromagnetic vibrating motor.
1 - vibration motor; 2 - frame; 3 – hanging elastic system; 4 - vibrating tray; 5 - hopper; 6 - screens with openings of different sizes.

The hazelnuts from the hopper (Fig. 6, # 5) are supplied to the vibrating tray (Fig. 6, # 4), in which several screens (Fig. 6, # 6) are placed one above the other, with openings of different sizes (the number of screens depends on how many fractions we want to calibrate the hazelnuts). The hazelnuts will be divided into several fractions, of which I will be small-sized hazelnuts and impurities, which are necessarily found in raw materials for the first time, large II fractions, and so on. The number of fractions can be changed if necessary.

Under the influence of vibration there are: transportation, self-sorting and crushing of the hazelnuts. During the calibration process, the hazelnuts move on the screen in the direction of the exit and are divided into two fractions: a) which move in the screen openings, b) which can not pass and move on the screen surface towards the exit.

Consider the process of moving a hazelnut with a mass *m*, kg along surface *ABCD* of one of the screens of the calibrator, forming an angle α with the horizon (Fig. 7).

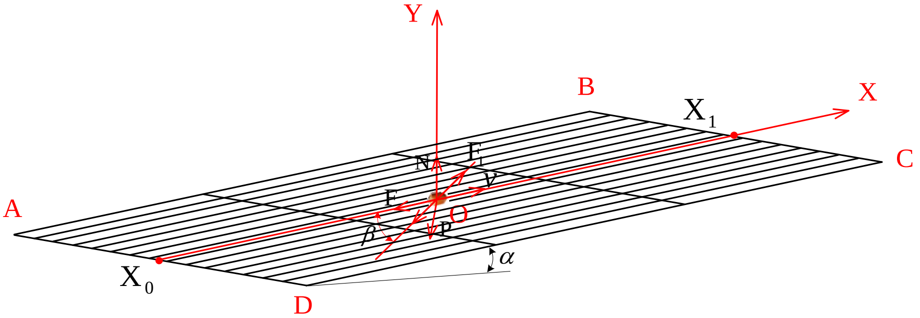

Fig. 7. Scheme of the action of forces on a hazelnut moving on the surface of a vibroscreen pronated at an angle α to the horizon.

In the *XOY* coordinate system, a hazelnut that fails to pass through the screen opening will have the following equilibrium condition [9]

$$\begin{cases} m\ddot{x} = F_f - mg\sin\alpha + F_i\cos\beta = 0 \\ m\ddot{y} = N - mg\cos\alpha + F_i\sin\beta = 0 \end{cases} . \quad (1)$$

It is affected by the gravity force $P = mg$, N; g – acceleration due to gravity, m/s^2; N - normal reaction, N; $F_f = Nf_s$ - friction force, N; f_s - coefficient of sliding friction and $F_i = mx_m\,\omega^2 sin\omega t$, N - force of inertia; x_m is amplitude of oscillation of the vibroscreen, m, ω - angular frequency of oscillation, s^{-1}. t - time, s; and β - angle of direction of oscillations towards the surface of *ABCD* screen, arcdegree.

In order for the hazelnut to move from x_0 to point x_1 on the screen surface (Fig. 7), the condition mx $m\ddot{x} > 0$ or $F_i\ cos\beta > mg\ sin\alpha - F_f$, from which

$$x_m\omega^2 \sin\omega t \cos\beta > g\sin\alpha - \frac{N}{m} f_s . \quad (2)$$

Depending on the operating modes, the hazelnuts can move:

a) Disconnected from the screen surface when $N < 0$. Accordingly, the reset parameter depends on the amplitude of the transverse force of the inertial force, the amplitude of the transverse force of the force of gravity.

$$w_0^* = \frac{x_m\omega^2 \sin\beta}{g\cos\alpha} > 1$$

b) Without breaking-off the hazelnut from the surface, $N > 0$, that is when $w_0^* < 1$.

Our studies have shown that, taking into account the physical and mechanical properties of hazelnuts, calibration using a reciprocating vibration motor is more effective when hazelnuts moving without break away from the sieve surface, for which it is necessary to justify the following parameters and operating modes of the vibration calibrator: frequency ω and direction angle β of oscillations; vibration amplitude x_m; shape and dimensions of the sieve openings. In this case, Y = 0 and the friction force

$$F_f = \begin{cases} -f_s N, & \dot{x} < 0 \\ f_s N, & \dot{x} > 0 \end{cases} , \quad (3)$$

but when the hazelnut that cannot pass through the screen to the surface is in a stationary position ($X = 0$, $Y = 0$), then the dry friction force can be calculated from (1) $F_{df} = -mgsin\alpha + F_icos\beta$, however, this state is maintained until the inequality - $f_{fs}N < F_{df} < f_{fs}N$ is completed, where f_{fs} is the coefficient of static friction; usually $f_{fs} \geq f_s$.

For effective calibration of the hazelnuts, taking into account the shape of the vibroscreen openings selected by us, it is advisable to use the mode when the hazelnut slides in one direction from point x_0 to point x_1 (Fig. 7).

In the *XOY* coordinate system, the hazelnut that moves through the opening (Fig. 8) will have the following equation of motion:

$$\begin{cases} m\ddot{x} = -F_i \cos\beta \\ m\ddot{y} = -mg + F_i \sin\beta \end{cases} , \quad (4)$$

from which, after the corresponding transformations, we obtain the speed of movement of the hazelnut

$$v_w = \sqrt{(x_m \cos\omega t \cos\beta)^2 + (-gt - x_m\omega \cos\omega t \sin\beta)^2} , \quad (5)$$

which depends on the amplitude, the frequency and the angle of direction of the oscillations. These values, as well as the distance to the next screen surface on which the hazelnuts to be driven into the upper screen should fall, should be selected so that jumps are minimized.

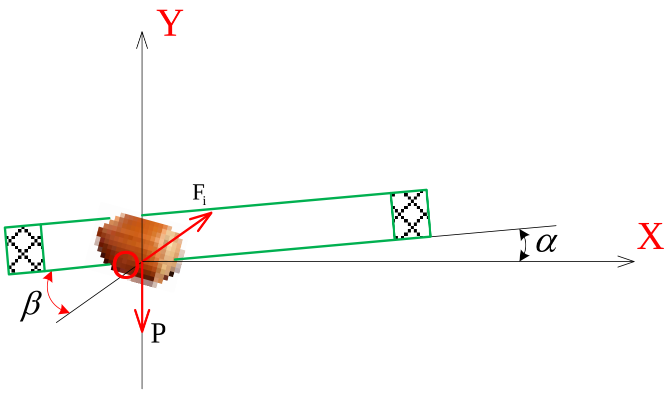

Fig. 8. Scheme of action of forces on a hazelnut moving in the opening of the vibroscreen pronated at an angle α to the horizon

Improvement in technology in the agricultural machinery sector plays a vital role in responding to population's needs. The evolution trend of vibrating calibrator production has emerged due to a number of development needs such as cost, quality, size, competition, productivity rates etc. The research has shown, that the productivity and quality of the vibrating calibrator depends on the speed of movement of the hazelnut on the screen surface, which in turn depends on the coefficient of friction, the angle of inclination of the vibroscreen towards the horizon, the frequency, amplitude and direction of oscillation.

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უაკ 631.362.322

თხილის დამკალიბრებელი უკუქცევით-წინსვლითი მოძრაობის ელექტრომაგნიტური ვიბროამძირავის ბაზაზე

გელა ჯავახიშვილი[1] - ტექნ. მეცნ. დოქტორი, პროფესორი,
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ანოტაცია. საქართველო მსოფლიოში ერთ-ერთ წამყვან ადგილს იკავებს, როგორც თხილის წარმოებაში, ასევე ექსპორტში. საქართველოში წარმოებულ აგროპროდუქტებს შორის თხილი ერთერთი ყველაზე პერსპექტიული კულტურაა და უკვე აქვს მნიშვნელოვანი კონკურენტული უპირატესობა საერთაშორისო ბაზარზე. დღეის მდგომარეობით, თხილი არის ერთადერთი კაკლოვანი კულტურა, რომელიც სტაბილურად გადის ექსპორტზე და ქვეყნისათვის უკვე დიდი ხანია ეკონომიკური მნიშვნელობის პროდუქტია, ვინაიდან აგრარული პროდუქტების ექსპორტში მოწინავე ადგილი უკავია.

თხილის გადამუშავების ტექნოლოგიურ პროცესში პირველი ეტაპია თხილის დაკალიბრება. დაკალიბრების პროცესის და ცნობილი კონსტრუქციების ანალიზმა აჩვენა, რომ თხილის დაკალიბრება შეიძლება მიღწეული იქნეს უკუქცევით-წინსვლითი მოძრაობის ელექტრომაგნიტური ვიბროამძრავის გამოყენებით. აქედან გამომდინარე, ჩვენს მიერ დამუშავდა თხილის დასაკალიბრებელი ვიბრაციული დანადგარი, მწარმოებლურობის და ფრაქციების რაოდენობის ცვლილების შესაძლებლობით, რომლის ამძრავად შეიძლება გამოიყენებული იქნეს, ასევე ჩვენს მიერ დაპატენტებული უკუქცევით-წინსვლითი მოძრაობის ელექტრომაგნიტური ვიბროძრავები მუდმივი დენის შემაგნიტებით, სადაც მუშა ორგანოს რხევის ამპლიტუდის რეგულირება შესაძლებელია შემაგნიტების მუდმივი დენის ცვლილებით.

თხილი ბუნკერიდან მიეწოდება ღარს, რომელშიც, ერთმანეთის ქვეშ მოთავსებულია რამოდენიმე ცხაურა, სხვადასხვა ზომის ღიობებით (ცხაურების რაოდენობა დამოკიდებულია თხილის ფრაქციების რაოდენობის მოთხოვნოლებაზე).

ვიბრაციის ზემოქმედებით ადგილი აქვს: თხილის ტრანსპორტირებას, თვითდახარისხებას და გაცხრილვას.

კვლევებით დადგინდა. რომ თხილის უკუქცევით-წინსვლითი მოძრაობის ელექტრომაგნიტური ვიბრაციული დამკალიბრებელის მწარმოებლურობა და დაკალიბრების ხარისხი დამოკიდებულია ცხაურას ზედაპირზე თხილის გადაადგილების სიჩქარეზე, რაც თავის მხრივ დამოკიდებულია ხახუნის კოეფიციენტზე, ცხაურას დახრის კუთხეზე ჰორიზონტის მიმართ, რხევის სიხშირეზე, ამპლიტუდაზე და მიმართულებაზე.

Features of the development of theoretical concepts for calculating the reliability of agricultural machinery

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Abstract. As you know, traditional methods of calculating machines for reliability are used for those objects that operate under stationary conditions. Such methods are not acceptable for agricultural machines, because of that their parts work in difficult conditions - they are constantly exposed to alternating dynamic loads, abrasive particles in the processed environment, high humidity and inclination of the relief. All these factors negatively affect reliability and cause failures of agricultural machinery.

The theoretical foundations for calculating the reliability of agricultural machines have been developed, which differ from the traditional classical methods used in radio electronics, aviation and mechanical engineering in that they take into account their work in special soil-climatic and dynamic conditions, the corresponding structural and logical schemes have been drawn up, as well as differential transition equations into various states according to Markov processes, as well as an original technique for studying single and complex indicators of operational reliability, their calculation for wear resistance to obtain the corresponding probabilistic and statistical models.

Keywords: Agricultural machinery, tractors, reliability, probabilistic-statistical model, failure

Increasing the reliability of vehicles is a problem of global importance, which has a great economic effect. Its solution is equivalent to increasing the number of vehicles without significant capital investment. It should be noted that the reliability of agricultural machinery is still low and cannot meet the modern requirements of science and technology.

A general theory of reliability has been developed recently. But such studies are insufficient for agricultural machinery. The general theory of reliability developed in aviation, radio electronics, automation, and machine building needs to take into account the structural features of agricultural machinery, the specific working conditions, and the modes — in them, the stationary failure flow begins relatively lately or does not begin at all; the objects are so sent to repairing.

As we have mentioned above, the calculation of the reliability of agricultural machinery differs in principle from the general theory of reliability developed in aviation, radio electronics, automation, and machine building.

All theoretical, constructive, and experimental research will be carried out by purposeful methodology and methods, using modern mathematical methods such as probabilistic-statistical modeling, mass service theory, design and optimization of extreme experiments, the theories of similarity and dimensionality.The object of study - unit of reliability and complex indicators, operating life of machines and details, hardness of metal coating restored on worn details by the proposed innovative technology, wear resistance, and other parameters, in general, can be presented in the form of the following set:

$$Y = \{y_1, y_2, y_3 \dots y_n\}$$

The set may be conditionally divided into two subsets: y_m and y_n, the so-called “black” and “light” boxes (Fig.1)

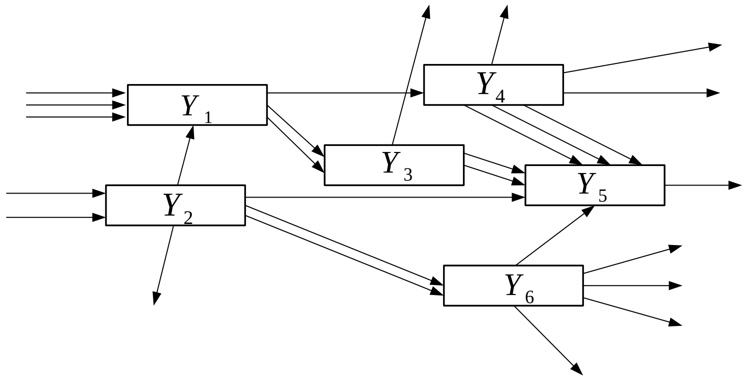

Fig. 1. The model of interrelated parameters

According to the figure, the research subject with the subset of experimental tasks $Y_n = \{y_1, y_2, y_3 \dots y_n\}$ and $Y_m = \{y_3, y_6,\}$ is separated by a closed line. The connection between the components of the test subject and the factors acting on is shown by arrows.

After that, the initial model of the parameter under study can be compiled - "black box" (Fig. 2).

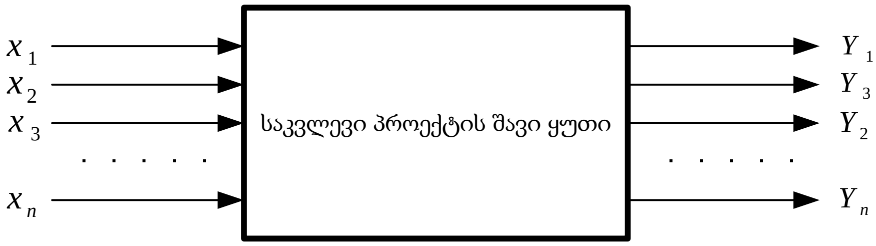

Fig.2. “Black box” of the parameter under study

The traditional experimental tasks and the subset Y_n belong to the "light box", i.e. problems that can be solved with well-known physical or mathematical models and simple experiments. "Black box" refers to a cybernetic model of a subject that is less or difficultly to investigate, in which the independent variables $x_1, x_2, x_3 \dots x_n$ (factors) act $y_1, y_2, y_3 \dots y_n$ on the output variables (optimization parameters). Mathematical and physical models of such objects are usually unknown and are the object of research. The theory of similarity and dimensionality will be used to obtain the mathematical model, which allows obtaining of models that take into account the simultaneous influence of different factors on the optimization parameters $y_1, y_2, y_3 \dots y_n$. To do this, according to the methodology developed by us, the characteristic dimensionless complexes will be obtained - similarity criteria π_i and criterion equations:

$$y_1 = f_1(\pi_1, \pi_2, \pi_3 \dots \pi_n)$$
$$y_2 = f_2(\pi_1, \pi_2, \pi_3 \dots \pi_n)$$
$$y_3 = f_3(\pi_1, \pi_2, \pi_3 \dots \pi_n)$$
$$- - - - - - - - - - -$$
$$y_n = f_n(\pi_1, \pi_2, \pi_3 \dots \pi_n)$$

The experimental part of the characteristic similarity criteria will be planned, conducted, and processed using the theory of design of extreme experiments. For this, multifactorial experiments will be performed and appropriate regression equations will be obtained.

In the case of three-factor experiments, the following regression equation is obtained:

$$Y = b_o + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{12}x_1x_3 + b_{23}x_2x_3 + b_{123}x_1x_2x_3$$

Where: Y - optimization parameter;
$x_1x_2x_3$ - factors influencing it;
b_o and b_i - coefficients of regression equation:

$$b_0 = \frac{\sum_{i=1}^{3} Y_i}{N}; \quad b_i = \frac{\sum_{i=1}^{n} Y_i x_{ij}}{N}$$

N – number of experiments;

The values of coefficients of the obtained regression equation, uniformity of dispersion, and the adequacy of the mathematical model will be checked according to the Student, Cochrane, and Fisher criteria, respectively. The obtained criterion equations will be optimized using the steepest ascent method and the Box-Behnken method, for which the gradient of the function is determined by the formula:

$$\overrightarrow{\Delta\varphi} = \frac{\partial\varphi}{\partial x_1}\vec{i} + \frac{\partial\varphi}{\partial x_2}\vec{j} + \frac{\partial\varphi}{\partial x_3}\overrightarrow{K}$$

Where $\vec{i}, \vec{j}, \overrightarrow{K}$ are the unit vectors of the coordinate axes, and:

$$b_1 = \frac{\partial\varphi}{\partial x_1}; \quad b_2 = \frac{\partial\varphi}{\partial x_2}; \quad b_3 = \frac{\partial\varphi}{\partial x_3}.$$

The general characteristics of the distribution of the parameter are determined by the formula:

- average arithmetical: $\overline{X} = X_0 + \nu_1 h$
- root mean square deviation: $\sigma = h\sqrt{\mu_2}$
- variation coefficient: $V = \frac{\sigma}{\overline{X}}$

where X_0 is that value of the parameter that corresponds to the maximal empirical frequency;
ν_1 -initial moment of the first series;
μ_2 -central moment of the second series.

The probabilistic-statistical model of the distribution of the parameter under study is expressed as follows:
a) for normal distribution:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\overline{x})^2}{2\sigma^2}}$$

b) for exponential distribution:

$$f(x) = \lambda e^{-\lambda x}$$

c) for Weibull distribution:

$$f(x) = \frac{b}{a}\left(\frac{x}{a}\right)^{b-1} e^{-\left(\frac{x}{a}\right)^b}$$

where $f(x)$ is the probability density of distribution or a differential function; X -value of the parameter;

λ - parameter intensity,
a and b are the parameters of Weibull distribution.

The integral function of the distribution is equal:
a) for normal distribution:

$$F(x) = \frac{1}{2} + \frac{1}{2}\phi(t)$$

b) for exponential distribution:

$$F(x) = 1 - e^{-\lambda x}$$

c) for Weibull distribution:

$$F(x) = 1 - e^{-(\frac{x}{a})^{e}}$$

where $\phi(t)$ is the Laplace integral function and is equal:

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-\frac{t^2}{2}} dt$$

$$t = \frac{X_i - \overline{X}}{\sigma}$$

The scheme of functioning of agricultural machinery is presented in Fig.3.

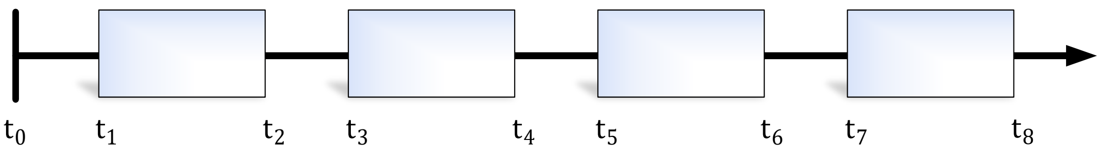

Fig.3. The scheme of functioning of agricultural machinery.

The following stages of functioning of agricultural machinery according to the scheme are possible:

$(t_0...t_1),(t_2...t_3),(t_4...t_5),(t_6...t_7)$ - machinery is working.

$(t_1...t_2),(t_3...t_4)$ - the adjustment of machinery is being made.

$(t_5...t_6)$ - the service of machinery is being made.

$(t_5...t_6)$ - the repair is being made.

This graph shows one repair cycle and can be used to assess the reliability of agricultural machinery.

When calculating the reliability of agricultural machinery, there is often a situation when the transition from one state to another proceeds step-wise, at a random moment, which is almost impossible to predict. The future development of Poisson's failure flows of recovery time for a recoverable system depends only on its current state and not on what was happening in the past. Such processes are called Markovian processes and are used to account for mass service theory-system graphs. Figure 4 shows the graphs of the possible condition of agricultural machinery.

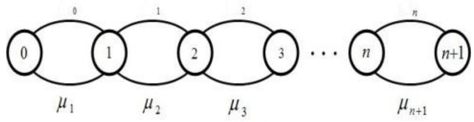

Fig.4. - Graphs of transition of agricultural machinery in various states

$0,1,2,3,\dots,n$ - various states of agricultural machinery - $\lambda_0,\lambda_1,\lambda_2,\lambda_3 ... \lambda_n$ and $\mu_1,\mu_2,\mu_3,...\mu_n$ (intensities of failures and recovery).

The vertices of the graphs correspond to the states of the machines, and the arcs correspond to the possible transitions from one state to another.

To calculate the probability of transition to different states, Kolmogorov differential equations are determined according to the graphs. Such probabilities are called interval-transient, and their calculation is the more difficult the more the system states are. Therefore, the Laplace transform is used to solve such equations:

$$F(S) = \int_0^\infty e^{-st} f(t)dt$$

F(s) – is the function transform.

f(t) – original.

Kolmogorov differential equations are as follows:

$$\frac{dP_0}{dt} = -(\lambda_{03} - \lambda_{01})P_0$$

$$\frac{dP_3}{dt} = \lambda_{13}P_1 + \lambda_{03}P_0$$

$$\frac{dP_1}{dt} = \lambda_{01}P_0 - (\lambda_{12} + \lambda_{13})P_1$$

$$\frac{dP_2}{dt} = \lambda_{12}P_1$$

Solving a system of differential equations using the Laplace transform with condition $P_0(t=0)$ = 1 gives the following:

$$\lambda(t) = \frac{(\lambda_{03} + \lambda_{01})(\lambda_{03} - \lambda_{13} - \lambda_{12})e^{-(\lambda_{03}+\lambda_{01})t} + \lambda_{01}(\lambda_{13} + \lambda_{12})e^{-(\lambda_{03}+\lambda_{01})t}}{(\lambda_{03} - \lambda_{13} - \lambda_{12})e^{-(\lambda_{03}+\lambda_{01})} + \lambda_{01}e^{-(\lambda_{13}+\lambda_{01})t}}$$

According to the obtained formula, the so-called approximation of the "bath curve" is made, which adequately reflects the intensity of failures of agricultural machinery during their running in, normal operation, and emergency condition.

Outcomes

1. The feature of calculating the reliability for agricultural machinery has been substantiated.
2. Developed a methodology and theoretical foundations for calculating single and complex indicators this technique
3. Differential equations of Kolmogorov are obtained taking into account Markov processes for calculating the intensity and restoration of the failure flows of agricultural machines.

4 Examples are given for obtaining and checking the adequacy of probabilistic-statistical models of failure rates.

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ანოტაცია. როგორც ცნობილია ,საიმედოობაზე გაანგარიშების ტრადიციული მეთოდები გამოიყენება ისეთი ობიექტებისათვის , რომლებიც მუშაობენ სტაციონარულ პირობებში. ასეთი მეთოდები არ გამოდგება სასოფლო სამეუნეო მანქანებისათვის იმის გამო , რომ მათი დეტალები მუშაობენ რთულ პირობებში -მათზე მუდმივად მოქმედებენ ნიშანცვლადი დინამიკური ძალები , დასამუშავებელ გარემოში მყოფი აბრაზიული ნაწილაკები , მაღალი ნესტიანობა და რელიეფის დახრილობა . ყველა ეს ფაქტორი უარყოფითად აისახება საიმედოობაზე და იწვევს სასოფლო სამეურნეო მანქანების მტყუნებებს.

დამუშავებულია სასოფლო სამეურნეო მანქანების გაანგარიშების თეორიული საფუძვლები, რომლებიც იმით განსხვავდებიან რადიოელექტრონიკასა და მანქანათმშენებლობაში გამოყენებული ტრადიციული კლასიკური მეთოდებისაგან , რომ ითვალისწინებენ მათ თავისებურ ნიადაგობრივ-კლიმატურ და დინამიკურ პირობებში მუშაობას. შედგენილია შესაბამისი სტრუქტურულ-ლოგიკური სქემები , სხვადასხვა მდგომარეობაში გადასვლის დიფერენციალური განტოლებები მარკოვის პროცესების გათვალისწინებით , ასევე ორიგინალური მეთოდიკა საექსპლუატაციო საიმედოობის ერთეული და კომპლექსური მაჩვენებლების გაანგრიშებისათვის ალბათურ-სტატისტიკური მოდელების მისაღებად.

საკვანძო სიტყვები : სასოფლო სამეურნეო ტექნიკა , ტრაქტორები, საიმედოობა, ალბათურ-სტატისტიკური მოდელი, , მტყუნება.

Innovative combined unit for mulching soil on the basis of a Motoblock

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SCIENTIFIC-RESEARCH CHENTR OF AGRICULTURE OF GEORGIA, TBILISI, GEORGIA.

Abstract: The article deals with the designs of technical means of small mechanization that are used in Georgia, namely agricultural machinery installed on motoblocks, the scale and advantages of their use in comparison with powerful equipment, and on the basis of a patent **(No AP 2020 15395)** a completely new combined machine for motoblock is proposed, which is currently in demand in the conditions of development of modern technologies for growing crops on the market. In particular, on small plots and greenhouse farms. The article offers a constructive description of the mentioned combined unit and the principles of its operation.

Key words: agriculture, mechanization, walk-behind tractor, unit, new technologies

Both mobile and small mechanization technical means, motoblocks and devices assembled on them are used to perform the operations necessary for the complex mechanization of maintenance and cultivation of agricultural crops.[1] Their use is particularly effective for regions where agricultural areas are small in contour and located in mountainous conditions (Adjara, Racha, Lechkhumi, Svaneti, Imereti, Kakheti, Samtskhe-Javakheti). For these regions, proposes a combined resource-saving agricultural aggregate based on a motoblocks for furrow forming on soil and mulching.

The combined aggregate allows loosening of soil with powered tillage tools, forming furrow, laying a drip water system, laying plastic mulch, covering it with soil, and drilling laid plastic mulch with one pass through small energy consumption. The proposed aggregate is a significant innovation in terms of both scientific and practical use, it will complement the untapped market segment in terms of the use of equipment in the agricultural sector, where mobile equipment cannot be used and will be in high demand in small and closed ground (greenhouses), among the producers of agricultural crops, growing vegetables, cucurbits and small-fruit crops, which are considered by the Georgian state a priority in the agricultural sector

The highland regions of Georgia are distinguished by such features as the location of agricultural lands on the slopes, fragmented narrow contour plots, mountainous conditions, sloping terrain, high air humidity, solar radiation, duplex soils, and more.

Due to the mentioned circumstances, it is not possible to use mobile and heavy equipment in most of the arable lands, there is no mountainous equipment and therefore, the main works are done by hand and use of technical means of small mechanization.

The concept of agricultural policy of Georgia states that Georgia occupies 69.7 sq.km, or about 7.0 million hectares, of which 0.8 mln. ha is arable land.

According to the conducted research, the total volume of plots up to 1 hectare is 12.7% of the total arable land, and the volume of plots from 1 to 5 hectares is 19.3%. Just in these areas the smallholder farmers and peasants produce vegetables, cucurbits, and small-fruit crops, and the above-mentioned smallholder farmers and peasants are the main users of small-scale mechanization equipment.

The machine for laying on the soil of plastic tape for mulching contains a frame, connected with the power tool, on which there are installed in sequence the tools for tillage and profiling of surface of furrows, a roll of plastic mulching tape, and soil fillers. The machine is additionally equipped with a drum with a drip irrigation pipe and a mulch tape perforator. Also, the drum with a drip irrigation pipe reeled on it is installed on the frame after the tool for profiling of furrow surface, which is a bow-shaped shield, and the soil-cultivating tool is made in the form of a rotary tiller with a horizontal shaft mounted on the front of the frame. Also, the power supply is a motoblocks, while the frame has supporting wheels, with the mulch tape perforator placed on the axle of support wheels and positioned between the mulch tape roll and the soil fillers. (**Figures 1-2**) shows the principle diagram of the proposed aggregate.

We proposed a completely new innovative, combined device for the motoblock, which is protected by the patent of Georgia (**No AP 2020 15395, Authors of the patent: 1. Giorgi Kutelija; 2. Jemal katsitadze; 3. Vladimir Miruashvili; 4. Otar karchava.**). [2].

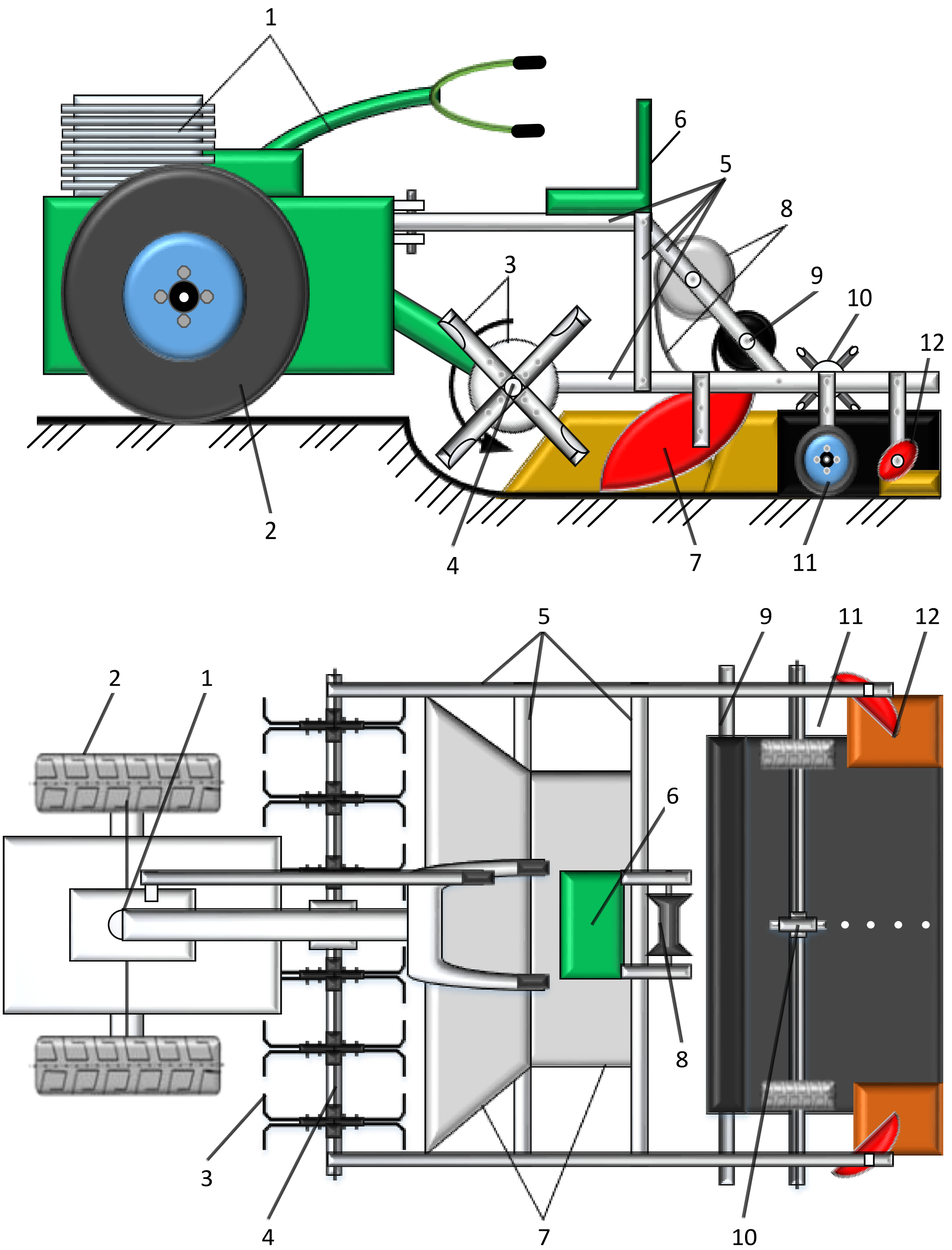

Fig. 1., Fig. 2. Innovative combined unit for mulching soil on the basis of a motoblocks (fig-1) side view (fig-2) top view.

The aggregate laying of plastic tape on soil for mulching contains the power tool - motoblocks 1 with drive wheels 2 to which frame 3 is connected. On the front part of frame 3, a soil cultivating tool is mounted, which is made in the form of rotary tiller 5 with horizontal shaft 4. The operator's seat 6 is attached to the upper side of frame 3. On the lower side of frame 3, after the rotary tiller 5, a tool for profiling the furrow surface is attached, which is a bow-shaped shield 7.After the mentioned tool 7 for profiling of furrow surface, a drum 8 with drip watering pipe reeled on it, the roll 9 of the mulching tape, the perforator of the mulching tape 10, and soil fillers 11 are mounted on the frame 3 in sequence. Frame 3 is equipped with support wheels 12. The perforator 10 of the mulching tape 9 is placed on the axle of the support wheels 12 and is located between the roll of mulch tape 9 and soil fillers 11.

The aggregate works as follows: after starting the engine of the motoblocks 1, the coupling (not shown in the drawings) of the drive wheels 2 and the rotary tiller 5 is turned on, as a result of which the two-wheel tractor 1 moves forward and the rotary tiller 5 starts working - cutting and loosening the soil layer. The layer of soil cut by the knives of the rotary tiller 5 is thrown back and meets the tool for profiling of furrow surface, which is a bow-shaped shield 7; its shape gives the soil layer cut by the rotary tiller 5 a certain direction and forms a furrow with a smooth surface. At the center of the profiles made by the rotary tiller 5 and the bow-shaped shield 7, a flexible drip irrigation pipe reeled on the drum is unreeled, then the pipe is covered with plastic mulch tape 9 from the roll 9 for mulching. The support wheels 12 move on the edges of the mulch tape 9, and the perforator 10, rotating under the action of the axle of support wheels, in the same zone makes holes for planting of saplings, and the edges of the mulch tape 9 are covered by loose soil using soil fillers 11.

The proposed aggregate for laying on the soil of mulching plastic tape is of simple construction, is characterized by low energy consumption, and allows to loosen a soil through a single pass of the motoblocks, to make furrows, unreel flexible drip irrigation pipe, to lay plastic mulch tape on furrows, to make pits for planting of saplings and cover the edges of the mulch tape with soil.[3-4].

Conclusions: The proposed combined unit, allowing from one pass: loosen the soil, form a furrow, lay a drip water supply system, cover the furrow plastic mulch, cover the edges of the plastic mulch with earth and create holes for planting plants. In essence, the proposed unit is a unit of minimal tillage. With the help of the grant, an experimental innovative, combined device will be manufactured, which will undergo laboratory and field experiments. This device to get a lot of consumption from peasants and small farmers. Based on the patent, a grant application for young scientists has been submitted.

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სსიპ სოფლის მეურნეობის სამეცნიერო კვლევითი ცენტრი თბილისი, საქართველო.

ანოტაცია. სასოფლო-სამეურნეო კულტურების მოვლა-მოყვანის კანომპლექსური მექანიზაციისათვის საჭირო ოპერაციების შესასრულებლად იხმარება როგორც მობილური, ასევე მცირე მექანიზაციის ტექნიკური საშუალებები, მოტობლოკები და მათზე დააგრეგატებელი მოწყობილობები. მათი გამოყენება განსაკუთებით ეფექტიანია ისეთი რეგიონებისათვის, სადაც სასოფლო სამეურნეო ფართობები მცირე კონტურულია და მთიან პირობებშია განლაგებული (აჭარა, რაჭა, ლეჩხუმი, სვანეთი, იმერეთი, კახეთი, სამცხე-ჯავახეთი). აღნიშნული პრობლემის გადაჭრის მიზნით პატენტის საფუძველზე **(No AP 2020 15395)** შემოთავაზებულია სრულიად ახალი კომბინირებული მანქანა მოტობლოკისთვის,

კომბინირებული აგრეგატი საშუალებას იძლევა მცირე ენერგეტიკული დანახარჯებით ერთი გავლით შესრულდეს ნიადაგის გაფხვიერება აქტიური სამუშაო ორგანოებით, ბაზოს წარმოქმნა, წვეთოვანი წყლის სისტემის გაყვანა, პლასტიკური მულჩის დაგება, მისი გადაფარვა მიწით და დაგებული პლასტიკური მულჩის დახვრეტა. შემოთავაზებული აგრეგატი წარმოადგენს მნიშვნელოვან სიახლეს როგორც მეცნიერული, ასევე პრაქტიკული გამოყენების თვალსაზრისით, ის შეავსებს ბაზრის იმ აუთვისებელ სეგმენტს აგრარულ სფეროში ტექნიკური საშუალებების გამოყენების თვალსაზრისით, სადაც მობილური ტექნიკის გამოყენება შეუძლებელია, ასევე აუცილებლად მაღალი მოთხოვნადი იქნება მცირემიწიან და დახურულ გრუნტში (სათბურებში), სასოფლო-სამეურნეო კულტურების მწარმოებლებში, რომელთაც მოყავთ ბოსტნეული, ბაღჩეული, და კენკროვანი კულტურები, რაც ქართული სახელმწიფოს მიერ აგრარულ სექტორში პრიორიტეტადაა მიჩნეული.

საკვანძო სიტყვები: სოფლის მეურნეობა, მექანიზაცია, ტრაქტორი, აგრეგატი, ახალი ტექნოლოგიები.

UDC 631.3

Machinery and equipment for the rehabilitation of abandoned agricultural land

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Abstract: The article presents machine technology and a system of machines for the rehabilitation of abandoned agricultural land. An ecological soil protection technology has been developed that involves cutting, grinding plant mass and introducing it into the soil in the form of mulch for further use as a bio-fertilizer. For deep tillage, a working body of a rotary type was developed, the dynamic parameters of which were determined from the allowable limits of soil deformation. The kinematic scheme and the principle of operation of the machine for the ridge formation have been developed. For land rehabilitation, a vegetation shredder, a plant root system shredder in the soil and a ridge forming machine have been developed.

Thousands of hectares of agricultural land in Georgia have been taken out of circulation, most of them covered with shrubs. In such areas, it is necessary to carry out land reclamation work, clear the areas of vegetation and prepare the soil for the production of crops.

Land reclamation works are cultural and technical works and are characterized by high energy consumption compared to agricultural work. Rehabilitation of forested and shrub lands requires clearing vegetation, shredding, uprooting or shredding the root system of plants, deep tillage and preparation for planting. All technological operations to be performed are cultural and technical works. The technical means of mechanization used to perform the above work are operating machines. Despite technical progress, a number of issues of design and manufacture of mechanization tools for some agricultural work have not been fully resolved yet. The fact is that the working bodies of the machine are designed without taking into account the rheological characteristics of the working medium.

A soil-protective machine technology for land rehabilitation, consisting of three operations and corresponding technological machines have been developed in the Department of Mobile Machines of the Institute of Machine Mechanics. R. Dvali:

1. Cutting and chopping vegetation;
2. Shredding the root system of plants in the soil;
3. Ridge formation.

Three machines have been designed and built in the Mobile Machine Department.

Main part:

1. Machine technology and technical means for cutting and chopping vegetation.

Machine technology for cutting and chopping vegetation allows cutting, chopping and mulching plants on the ground in one pass of the machine. The technology is implemented using a grinder. Which is attached to the tractor with a three-point suspension system. The technological scheme of felling and shredding vegetation is shown in fig. 1.

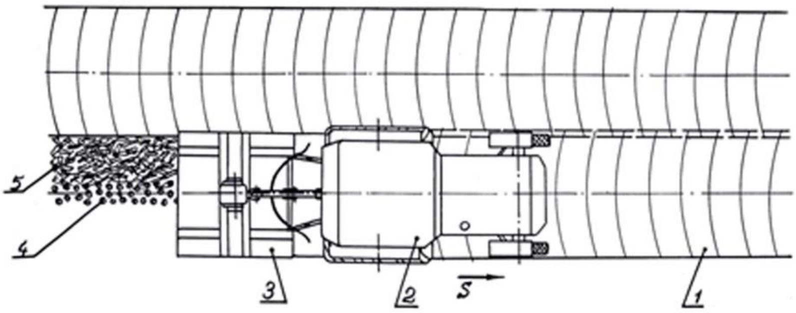

Fig. 1. Technological scheme of cutting-chopping
1. Vegetation; 2. Tractor; 3. Chopper; 4. Cut stems; 5. Shredded plant mass.

The tractor unit moves through the bushes, the stems of plants are introduced into the receiving chamber of the cutting unit using special guides. Repeated impacts of sharp cutting knives rotating in a horizontal plane cut and crush the plant. Figure 2 shows a machine for cutting and chopping bushes.

Fig. . 2. Machine for cutting and chopping bushes

Specifications

Capture width, (m)	B	1.5
Movement speed, (m/s)	Va	0,11…0,83
Cutting speed, (m/s)	V	157

Cutting height, (m)	H	0….0,4
Productivity, (ha/hour)	W	0,06.....0,44

2**. Technology and technical means for crushing the root system of plants in the soil.**

In soils that are not characterized by excessive moisture, promoters with active working bodies should be used to uproot the root system of plants, providing crushing of the root system directly into the soil. A machine technology for grinding the root system of plants has been developed. The technological process is carried out using a combined working milling cultivator (Fig. 3), which is connected to the tractor by a three-point suspension system.

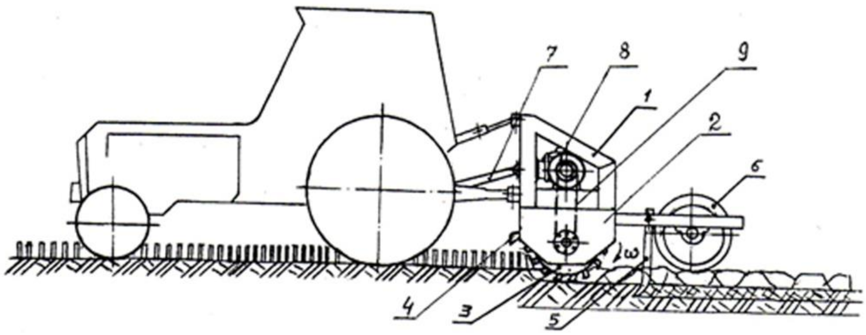

Fig.3. Unit for uprooting the root system of plants

The root system chopper consists of: - a rotary-type working body with sharp knives 3, which is mounted on the body 1 and closed by a casing 2, on which anti-cutting knives 4 are attached in front; chisel baking powder 5 attached to the housing 1 with the function of adjusting the height of the roller 6; - the drive of the working body with a cardan shaft 7, a conical gearbox 8 and a chain transmission 9.

The tractor unit moves at the minimum technological speed. With the help of an active working body - a cutter, the root system of the plant is crushed and mixed with the ground, while the lower cut soil layers are crushed by the passive working bodies of the cultivator. Fig.4. shows a cutter-cultivator for uprooting the root system of plants.

Fig.4. Mill-cultivator for uprooting the root system of plants.

Specifications

Capture width, (m)	B	0,8
Movement speed, (m/s)	Va	0,11

Cutting speed, (m/s)	V	9,4
Depth of processing, (m)	H	0,3
Productivity, (ha/hour)	W	0,03

3. **Technology of ridge formation and technical means.**

Machine technology and technical means for landing on ridges have been developed.

The machine technology for planting orchards on ridges provides for soil cultivation with chisel working bodies (50-70) cm, soil plowing to a depth of (30-40) cm, soil cultivation, ridge formation, rut opening in the ridge and planting of seedlings. Currently, seedlings are planted manually, but a planting machine is in the process of development, a structure that is mounted on the frame of a ridge-forming machine.

The ridge-forming machine (fig. 5, fig. 6) contains a frame 1, with a three-point suspension system with the possibility of rotation and fixation in a horizontal plane, articulated brackets 2 and 3. Longitudinal bars 5 and 6 are bolted to the brackets, with the function of rotation and fixation in the vertical plane. Sections with discs 6 and 7 are fixed at the ends of the rods, also with the possibility of rotation and fixation. The longitudinal rods are fixed relative to the frame with screws 8 and 9. The frame has a bracket 10, on which the ridge forming apparatus is mounted. The formation apparatus contains a bracket 11 with adjustment holes 12. A horizontal board 14 is mounted on the bracket with hinges 13, the slope of which is regulated by a screw 15. Side wings 16 and 17 are similarly attached to the board. In Fig.6. the ridge former is shown.

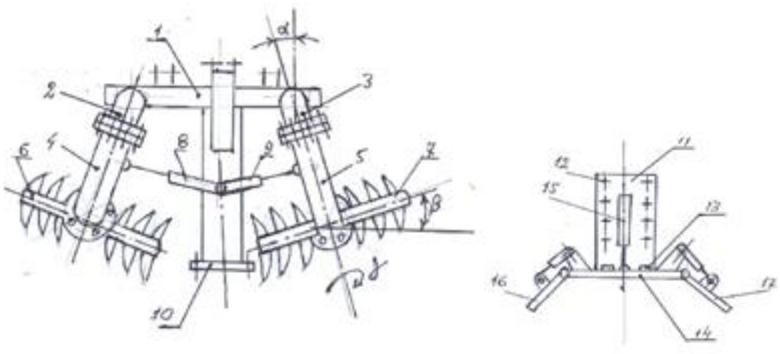

Fig.5. Kinematic scheme of the ridge former

Fig.6. Ridge former.

Specifications

Capture width, (m)	B	0,5.....6
Travel speed, (m/s)	Va	1,38......3,3

Number of discs	n	10
Ridge height (m)	H	0,2....0,9
Productivity, (ha/hour)	W	0,2

Conclusion: In order to restore abandoned agricultural land in Georgia, it is necessary to carry out cultural and technical work. The technical means of mechanization used to perform these works are expensive machines and are mainly imported from Europe. Institute of Machine Mechanics. R. Dvali developed machine technology for land rehabilitation and created rehabilitation machines.

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მიტოვებული სასოფლო-სამეურნეო მიწების რეაბილიტაციის სამანქანო ტექნოლოგია და მანქანები

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ანოტაცია. ნაშრომში მოცემულია მიტოვებული სასოფლო-სამეურნეო მიწების რეაბილი-ტაციის სამანქანო ტექნოლოგია და მანქანათა სისტემა. დამუშავებულია ეკოლოგიური, ნიადაგდამცავი ტექნოლოგია რომელიც ითვალისწინებს მცენარეული მასის მოჭრა-დაქუცმაცებას და ნიადაგში ჩაკეთებას მულჩის სახით, შემდგომში ბიოსასუქად გამოყენების მიზნით. ნიადაგის ღრმად დამუშავებისათვის შექმნილია როტორული ტიპის მუშა ორგანო, რომლის დინამიკური პარამეტრები განისაზღვრა ნიადაგის დეფორმაციის დასაშვები ზღვრების პირობიდან. დამუშავებულია ბაზოწარმომქმნელი მანქანის კინემატიკური სქემა და მანქანის მუშაობის პრინციპი. მიწის რეაბილიტაციის სამანქანო ტექნოლოგიისათვის დამუშავებულია მცენარეული საფარის საჭრელ-დამქუცმაცებელი მანქანა, მცენარის ფესვთა სისტემის ნიადაგში დამქუცმაცებელი მანქანა და ბაზოწარმომქმნელი მანქანა.

Machine technologies and economic evaluation of cultivation of blueberry

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Abstract. The paper presents the national economic importance of blueberry, one of the representatives of berries, the process of its formation as an agricultural sector, biology, machinery technologies of production, cultivation peculiarities, and comparative economic indicators of cultivation on traditional and plastic mulch, also machine technologies for the cultivation and production of blueberry.

The state of cultivation of small fruit crops in Georgia

In Georgia, berries are known to be profitable, their value is higher than many other fruits and they can be grown in a small plot. If we do not count strawberries, a few years ago berry orchards in Georgia did not exist at all. Its cultivation began with the donation of berry saplings by donor organizations to farmers. Later, several state programs were launched and now the cultivation of berry orchards in all regions of Western Georgia has become active.

The Ministry of Agriculture forecasts that by 2022 the area of blueberry in Georgia will reach 505 hectares, raspberry will be cultivated on 250 hectares, and the area of blackberry orchards will exceed 225 hectares. According to the preliminary calculations of the Ministry of Agriculture, the yield of these small fruit crops should reach 7 thousand tons by 2022.

According to statistics, Georgia has a sharply negative trade balance in small fruit crops (except blueberry), as well as in many areas of agriculture. The import almost 5 times exceeds export.

In the case of frozen small fruit crops, the trade balance is even more negative. In 2017-18, strawberry in frozen form was not exported at all. Last year the total export value of frozen blackberry and raspberry was no more than $ 600. Instead in 2018, frozen strawberry and musk strawberry worth 142.2 thousand dollars were imported into the country, while the import of frozen blackberry and raspberry amounted to 251.8 thousand dollars. Significantly, the volume of imported frozen berries has increased dramatically in recent years and since 2014 has increased almost 6 times. These statistics show that local producers have the potential to tap into this market segment and replace imports.

Biology of blueberry

Blueberry is an evergreen or deciduous, semi-bush or bush small fruit crop. The fruit contains sugars (glucose, fructose), catechins, pectins, tannins, malic, citric, lactic acids, flavonoids, ascorbic acid, vitamins B, C, D, and other useful compounds. Blueberry fruit is sour-sweet, used in raw condition; preserves are made from it. It has a medicinal purpose, in particular, live fruit regulates the action of the gastrointestinal tract, improves eyesight, cures rheumatism, and various inflammatory processes. Fruit and leaf tinctures are used for the treatment and prevention of diabetes, urinary tract pathology, and inflammatory processes in the eyes.

Blueberry crop (wild form) is less demanding of environmental conditions. It grows on all types of soils but gives maximum yields on acidic soils. In the wild, it grows on sparse, stony and sandy soils. It is less demanding to light and moisture. It is distinguished by the superficial root system and frost resistance; withstands the frost 20-25 °C. The blueberry species is the most widespread of the cultivated species in the world today. Seedlings are propagated by cell culture (in a test tube) under laboratory conditions. The blueberry variety obtained by this method is quite demanding to environmental conditions. For normal growth and development of plants and obtaining of a high yield, the soil pH should be 4.0-5.0, the plot should be well-drained, loosened, lighted and provided with moisture. Therefore, it can be cultivated quite successfully in the Black Sea regions of Western Georgia, on soils where tea grew earlier.

Blueberry is a frost-resistant, shrubby, small fruit crop that produces round blue fruits. It cannot withstand drought. It is characterized by high resistance to diseases. Due to its high nutritional and dietary properties, it is widely distributed in the world and deserves the great attention of consumers. The original, sour-sweet taste of the berry further increases the demand for it. It is harvested from late May to August. It is characterized by more dense fruit than any other berry crop. Blueberry can be planted in both fall and spring. The plant flowers in April-June, the fruit ripens in June-August. Contains vitamin C, and tannins; is used in cooking, and folk medicine, and has antioxidant properties. Its leaves' tea is good for diabetics. Is used to treat nonhealing wounds. Is a unique remedy for eyesight.

There are several types of blueberries: northern highbush, southern highbush, semi-high bush, etc. The blueberry attains up to 2 meters in height. Up to 150 varieties are known in terms of promising activities in the field of business, such as Legacy, Olein, Misty, and others. Blueberries require specific, moist, light, and well-drained soil for cultivation. It grows well only on acidic soils, i.e. those soils that are recommended for growing tea. Blueberry saplings were first imported from the United States in 2006 and planted for trial purposes in Imereti and Guria; the first crop was obtained in 2009. Blueberries are a new agricultural crop for Georgia, the introduction of which plays a positive role in increasing the production and income of local farmers.

Blueberry varieties. The following varieties of blueberry are cultivated and widespread in the world today: Bluecrop, Legacy, Berkeley, Patriot, Brigida, Duke, Sunrise, Spartan, Toro, Elizabeth, Early Blue, Blue gold, Misty, Chandler, Chantecler, O'Neal, Reka. The main agrobiological indicators of these varieties with literary data are presented in Table 1.

The main agrobiological indicators of blueberry

Table 1.

Variety	Height of plant (m)	Diameter of fruit (mm)	Yield per bush (kg)	Ripening of fruit (month)
Berkeley	1.8 – 2.1	18 -20	4.0 – 8.0	VIII
Bluecrop	1.6 – 2.0	18 -20	6.0 – 9.0	VIII
Patriot	1.2 – 1.8	19	5.0 – 7.0	VII
Brigitta	1.8 – 2.0	15	4.0 – 6.0	VIII
Duke	1.2 – 1.8	17 -20	6.0 – 8.0	VII
Sunrise	1.2 – 1.8	17 - 20	6.0 -8.0	VII
Spartan	1.5 – 2.0	16 - 20	4.5 – 6.0	VIII
Toro	1.8 – 2.0	18 -20	6.0 – 8.0	VIII
Legacy	1.6 – 1.8	15 - 18	6.0 – 9.0	VII
O'Neal	1.7 – 2.0	14 - 17	5.0 – 7.0	VI

Planting of blueberry garden

It is very important to select the right plot and prepare it before planting the plantation. 1-2 years before planting, the soil should be plowed to a depth of 40-50 cm, then harrowed and planned. Cultivation of blueberries is usually done by a seedbed-furrow (spherical) system. The distance between the plants in the inter-row spacing should be 3.0-3.2 m, and the distance between the plants in the rows should be 0.9-1.2 m. Taking into account such a nutrition area, 2800-3300 saplings per hectare are needed. As mentioned above, the optimal soil acidity for blueberry culture is pH 4.0 - 5.0, but if the pH is in the range of 5.0 - 5.5, then the soil acidity can be reduced by the use of physiologically acidic mineral fertilizers (ammonium sulfate, superphosphate, double superphosphate, potassium sulfate). If the acidity of the soil is equal to pH 5.5 - 6.5, then the sulfur powder is added to the soil: 10 - 15 g per square meter. In the spring and autumn before planting, the soil is irrigated with water with a solution of sulfuric acid (30 ml of accumulator acid in 10 liters of water), as well as a solution of table vinegar (100 ml in 10 liters of water). To improve the soil structure before planting the saplings, it is necessary to apply to the top layer of soil a pre-prepared organic fertilizer: a mixture of burnt manure and peat compost. When planting saplings, the root system of the plant should be completely placed in the soil, compacted, and watered. Mulching and arranging a drip irrigation system are also desirable. Mulching takes place along the plant side-by-side 60 cm. Mulching significantly promotes plant growth, protects it from weeds and overheating, retains moisture, and enriches the soil with organic matter. Mulch materials of inorganic origin (mulch films, etc.) are also used for mulching.

The technology of growing blueberry crops on plastic mulch

Before plantation, it is necessary to carry out an agrochemical analysis of the soil to determine the measures to improve the soil structure and the appropriate mineral nutrition regime.

First of all the plots should be free from previous year's plant waste and weeds. Total herbicides should be applied against weeds, after which the soil should be plowed to a depth of 25-30 cm and harrowed with rotary cultivators.

Before cultivation, composted organic fertilizers should be applied by applying 25 tons per hectare of arable land.

The most common blueberry plantations in modern plantations are the elevated seedbed furrows, the essential components of this technology are: mulching with polyethylene mulch material, a drip irrigation system, and fertigation apparatus that provides the plant with water and nutrients. This approach provides better protection against weeds and diseases. At this time the plants are planted in a row on an elevated furrow. The distance between the rows should be 3-3.2 m, and the distance between the plants in the rows is 0.9-1.2 m. When cultivating on a small area, when large-scale mechanization is not used, then the distance between the rows can be 1.20 meters, between the saplings 0.90 meters.

For the cultivation of blueberries, the topsoil is cultivated with a vertical rotary cultivator. (Fig.1)

Fig.1. Vertical rotary tool

After cultivation, it is necessary to use a combined unit for soil loosening and seedbed-forming, which allows the final loosening of the soil and the formation of seedbed furrows. (Fig. 2).

Fig. 2. Combined aggregate for soil loosening and arrangement of seedbeds

To lay down the drip system and lay the plastic mulch, it is recommended to use a combined machine, which simultaneously lays down the drip system and the plastic mulch. (Fig. 3)

Fig. 3. The combined machine for laying of a drip system and plastic mulch

FINANCIAL MODEL OF CULTIVATION OF PLANTATIONS OF BLUEBERRY

Cultivation of blueberry plantations becomes more popular in Georgia from year to year. According to 2017 data, in Georgia blueberry plantations are cultivated on about 205 hectares. The total yield was about 249 tons.

The cost of cultivating and caring for one hectare of a blueberry looks like this, item by item:

In the first year, the cost of cultivating the plantation is about 35,100 GEL; The annual maintenance cost is 13,600 GEL; The total cost of the first year:

35,100 (cultivation cost) + 7000 (part of the annual maintenance cost, until the saplings give us the first harvest) = ***42,100.***

The types of main expenses for the cultivation of plantation:

Processing of soil: expense, in sum 1300 GEL

Purchase and planting of saplings, total average cost - 24,500 GEL. To discuss in more detail, the distance between the blueberry saplings should be about 1 meter, and between the rows of saplings should be 3 meters and 30 centimeters. That is, about 3,000 saplings are planted per hectare. The average price of one sapling is 6.5 GEL. Accordingly, the cost of purchasing saplings per hectare is about 19,500 GEL.

The cost of planting saplings should also be taken into consideration: preparation of pits for saplings, watering, purchase of mulch (sawdust), etc. For these works, taking into account the remuneration of the staff, the cost reaches about 5000 GEL.
The cost of caring for saplings, which includes inter-row pruning, applying fertilizers and pesticides, etc., amounts to a total of 2100 GEL per year.

Arrangement of drip irrigation system: cost, on average 5500 GEL. This cost includes the materials needed to arrange a drip irrigation system and labor costs.

Unforeseen costs at the cultivation of 1 hectare of blueberry plantation amount to about 1700 GEL;

Annual expenses (excluding plantation cultivation) is 13,600 GEL. This expenditure includes harvesting, pruning, payment for irrigation water, plantation protection, agronomist consultation, purchase of boxes, and other annual expenditures totaling 13,000 GEL on average. Added to this are unforeseen expenses, about 600 GEL.

Machine technology and expenses for the cultivation of blueberry

#	Name of measure	Unit	Models of machines	Quantity	Price (GEL)	Amount (GEL)
1	Cleaning of surface of the area from plants and brushwood	ha	Tractor John Deere 6930, mulcher SEPPI M MINIIRST 175	1	1700.00	1700.00
2	Ploughing by subsoil plough	ha	Tractor John Deere 6930, subsoil plough Efrm fs. 1/94	1	1500.00	1500.00
3	Cleaning from roots with root extractor	ha		1	400.00	400.00
4	Removing of roots with tractors	ha		1	101.65	101.65
5	Cross-ploughing	ha	Tractor Zetor FORTERRA 140, peat applicator GASP&MASC.BV 140	1	500.00	500.00
6	Removing of roots and wastes	ha		1	70.00	70.00
7	Purchasing of peat	m^3		250	50.00	12500.00
8	Applying of peat to the soil	ha	Tractor Zetor FORTERRA 140, peat applicator GASP&MASC.BV 140	1	100	100.00
9	Purchasing of fertilizers NPK	kg		350	150	525
10	Applying of mineral fertilizers	ha	Tractor Zetor FORTERRA 140, fertilizer applicator NARDI SPQ 1000	1	0.3	0.3
11	Harrowing of soil	ha	Tractor Zetor FORTERRA 140, cultivator for overall tillage GASP&MASC-GRATOR 450 DELTA SPRING	1	350.00	350.00
12	Disking of soil	ha	Tractor Zetor FORTERRA 140, disk harrow GASP&MASC-	1	350.00	350.00

			RAMBO XP36/-XP44/-PRESTO-300			
13	Rototilling of soil	ha	Tractor John Deere 6930 vertical rotary tool TORTEELLA E6-300 GASP&MASC-DOMINATOR 3000	1	500.00	500.00
14	Cultivation with vertical rotary tool	ha		1	400	400.00
15	Soil analysis	pc.		1	200	200.00
16	Arrangement of seedbed-furrow	ha	Tractor Zetor FORTERRA 140, furrow cultivator HORTECH-AL 140 MAXI	1	1700.00	1700.00
17	Manual correction of seedbeds	ha		1	30.00	30.00
18	Purchasing of drip system	meter		3600	1.00	3600.00
19	Purchasing of mulch film	meter		3600	2.40	8640.00
20	Laying down of drip system and mulch	ha	Tractor Zetor FORTERRA 140, furrow cultivator HORTECH-AL 140 MAXI	1	1300	1300
21	Manual correction of mulch films	ha		1	300	300.00
22	Purchasing of peat (for pits)	m^3		0.005	300	21,00
23	Purchasing and planting of saplings			11.00 GEL	4200	46200.00
						80987.95

Local demand and export

There is a high demand for blueberry in local and export markets. Blueberry is exported to the countries of the European Union, Great Britain, Russia, and the United Arabian Emirates. DCFTA allows Georgian farmers to import blueberry into the EU without any trade barriers. There is a growing demand for blueberry in the EU and the UK, this product is in short supply in the EU and at the same time has a high market price. For example, in the EU market, the market price of 1 kg of frozen blueberry is 15-20 euros, in case the product is organic, then its price ranges from 22 to 24 euros.

Local demand and export

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ლურჯი მოცვის წარმოების სამანქანო ტექნოლოგიები და ეკონომიკური შეფასება

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ანოტაცია. ნაშრომში მოცემულია კენკროვანების ერთ-ერთი წარმომადგენლის ლურჯი მოცვის სახალხო მეურნეობრივი მნიშვნელობა, მისი როგორც სასოფლო სამეურნეო დარგად ჩამოყალიბების პროცესი, ბიოლოგია, წარმოების სამანქანო ტექნოლოგიები, გაშენების თავისებურები, გაშენების ტრადიციულ და პლასტიკურ მულჩზე მოყვანის შედარებითი ეკონომიკური მაჩვენებლები. აგრეთვე ლურჯი მოცვის გაშენების და წარმოების სამანქანო ტექნოლოგიები.

Innovative Technical Device for Pruning Tea Bush

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Abstract. The article presents results of development of an innovative technical means of small-scale mechanization and the technological process of pruning a tea bush. The technical device consists of a pruning seissors connected to the walk-behind tractor system. When using technical means labor productivity is increased significantly, the quality of tea is improved.

Key words: Tea, pruning, small mechanization, productivity.

Introduction.

The purpose of growing a tea plant (Camellia sinensis (L), O. Kuntze) is to obtain a large number of shoots from it and to produce various kinds of finished products using special technological processes.

The regulation of tea bush plucking depends on agrotechnical measures, soil fertilization, timeg and types of pruning, leaf plucking rules and much more. According to agricultural rules, it is necessary to carry out spring pruning and repeated plucking of young fleshes in the established order in leaf- plucking plantations.

This rational system enhances processes of photosynthesis, respiration and transpiration in tea leaves, which leads to increasing the yield and an improvement in quality of tea. With the help of these special methods, the natural physiological processes of the tea plant are activated and, as a consequence, the intensity of tea production [1]. In this way, yields and quality can be managed using special care methods and innovative technical means for the treatment of tea plantations.

The aim of the research is developing of innovative small mechanization technical means and technological process for pruning tea bush, theirs research and testing in field conditions.

Research objects and method.

Field experiments were carried out in 2021 in an experimental tea plantation (Ozurgeti, Likhauri); the distance between the rows of tea bushes is 2.05 m. The experiments were carried out according to the following method:

1. Pruning tea bushes with scissors and plucking according to agricultural rules –removing two-leaf tender soft fleshes from the shoots (control);
2. Pruning tea bushes and removing branches using the proposed technical means of small-scale mechanization. Plucking according to agricultural rules - removing two or three-leaf tender flushes from the shoots (experience).

Experiments in production conditions were carried out during the growing season of tea bush; repetition of experiments - 3-times. Along with the yield of a quality leaf, the total number of fleshes per unit area, as well as the proportion of normal and coars fleshes and their ratio were studied.

Experiments were carried out using standard research methods.

Results and discussion.

Figure 1 shows a small-sized mechanized innovative technical tool for pruning tea bushes [2]. A serial production walk-behind tractor is used in the design of the machine.

It is equipped with a corresponding support for attaching pruning mechanism, which consists of two parallel metal rods connected to each other, so that at the same time it is used as a base for the installation of the rear eyelet. which can rotate around axes. The main working body is scissors, which come into action and are held by kinematically connected mechanisms. The scissors can move vertically. The mechanism is activated by rotating the axis of the walk-behind tractor.

Technical characteristics of the innovative device for pruning tea bush:

- motoblock power - 7 horsepower;
- required power - 3 horsepower;
- weight - 150 kg;
- width of the trimming mechanism - 1200 mm;
- radius of curvature - 900 mm;
- overall dimensions, mm:
  - length - 1400
  - height - 1400
  - width - 2 400
- productivity - 0.08 - 0.09 ha/h

Carrying out a process of pruning bushes using the small mechanization method by leveling the surface of bushes and removal of side branches, affects the growth and development of normal fleshes.As a result of their increase in the total mass of the experimental raw material, its quality increases significantly (Table 1).

Fig. 1. Small-sized mechanized innovative technical tool for pruning tea bushes

Influence of tea bush pruning methods on the formation of normal and coarses fleshes (May-August, 2021)

Table 1.

№	Experiment variant	Number of fleshes				% fleshes		Normal / fleehes / fleshes coarse
		g/m²	%	g/m²		Normal	Coarse	
				Normal	Coarse			
1	Control	122	100	98	24	75	25	3
2	Experimental	126	103	104	22	77	23	3,35

The experimental results show that the pruning process with innovative technical means and the plucking of tea leaves according to agricultural rules contributes to an increase yield by 1,30 % (65 kg / ha (table 2).

Influence of pruning methods of tea bushes on on productivity plantation (May - August, 2021)

Table 2.

№	Experiment variant	Productivity		(+-) Compared to control	
		kg/ha	%	kg/ha	%
1	Control	4 992	100	-	-
2	Experimental	5 057	101,30	+ 65	+1,30

During harvesting operations, labor productivity increases 5 times compared to removal with a scissors. One technician servicing the machine replaces three skilled workers with scissors.

Conclusion:

1. In the application innovative technical means of small-scale mechanization during pruning, leveling the surface of bushes and removing side branches, labor productivity is 5 times higher than when pruning with scissors manually.
2. It has been shown that as a result of pruning tea bushes using innovative technical means and Experimental according to agrotechnical rules, it is possible to increase the yield by 1,30 % (65 kg / ha) and the quality of tea in comparison with the control version.

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MODERN TECHNOLOGIES OF MECHANIZED FEEDING OF SILKWORM CATERPILLARS

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Abstract. For the restoration and development of sericulture in Georgia, it is necessary to introduce modern resource-saving technologies of tudo-intensive technological processes of sericulture and especially in the process of feeding silkworm caterpillars. In Georgia, the Research Institute of Sericulture developed three versions of mechanized installations for feeding silkworm caterpillars **UVSH-1, UVSH-2** and **UVSH-3.** The most interesting is the installation of **UVSH-3,** which automatically performs the following operations: distribution of feed, change of litter and aeration of caterpillars when moving feeding areas. To date, farms can be recommended a new technology for feeding silkworm caterpillars using mechanized installations **UVSH-3.**

Keywords. Sericulture, technology, mechanization, installation, feeding of caterpillars.

Sericulture is one of the oldest branches of agriculture in Georgia. It has always stood at a high level of development, but since the second half of the XX century, its gross volume began to gradually decrease, and in 1964 the spread of the microplasmic disease "curly small-leaved" completely destroyed the food base in Western Georgia, as a result of which this industry fell into complete decline. This is confirmed by figures: until 1964, Georgia harvested annually 4.0 - 4.5 thousand tons of silk cocoons, which fully satisfied the demand of the country's light industry, and produced 450 tons of silk threads per year. To date, the picture has changed. In 1996-2005, 450 tons of silk cocoons (100 times less), 21 tons of silk threads (20 times less) and 0.126 ml of linear meters of fabric (30 times less) were harvested in Georgia [1], and after 2005 only a meager number of silk cocoons were harvested in the country.

Analysis of the state of sericulture in recent years shows that for its restoration and development it is necessary to carry out radical measures, otherwise the complete elimination of the industry is possible. To bring it out of a critical state, it is necessary to improve the quality and quantity of the feed base, the creation and introduction into production of means of mechanization and automation of labor-intensive technological processes of sericulture.

Of the technological operations, the most time-consuming is the process of feeding silkworm caterpillars, i.e. cocoon production. To obtain 100 kg of silk cocoons, 600 - 640 people / hour are spent, 56% of the labor costs of which fall on feeding silkworm caterpillars [2J. Therefore, to increase labor productivity in farms and increase the profitability of the industry, special attention should be paid to the mechanization of labor-intensive processes of feeding silkworm caterpillars.

Work on the problematic issues of mechanization of feeding silkworm caterpillars was started in the country in the 30s of the XX century [3], but on a large scale they began to be carried out in the 80s at the Educational and Research Institute of Sericulture of the Georgian State Agrarian University, where, under the guidance of the author of the article, three designs of installations for mechanized feeding of silkworm caterpillars were developed - **UVSH-1, UVSH-2** and **UVSH-3** [4,5,6,7].

The greatest interest is caused by the automatic installation for feeding caterpillars of older ages - UVSH-3 (Fig. 1,2), which can carry out the following operations: mechanization of feed distribution and change of litter, automatic movement of feeding areas for complete aeration of caterpillars and creation of a microclimate in worms [6,7,8,9].

A.

B.

Fig. 1. Mechanized installation UVSH-3 for feeding silkworm caterpillars.

A- Layout of the installation UVSH-3; **B –** Working version of the installation of UVSH-3.

The plant consists of 12 tiers, where 97 feed boxes (2) are located. The movement of boxes through the tiers is carried out by the right and left elevators (1), where box-pushing and exciting devices are located. Distribution of feed occurs on the 12th tier of the installation by a special feed dispenser (7) [8] and a conveyor (8), and the change of litter - on the first tier and its removal outside the worm water, is made by the conveyor (6) [9].

The technological process of the installation is as follows: in the initial position, the elevators (1) (left and right) are on the same level with the upper floor of the feed boxes. One of the boxes of the upper floor is loaded with food from the feeding unit (7.8) during its movement. An additional box and the entire row of boxes of the upper floor receive movement from pushers (4) located on the elevators. With the help of a pusher, the entire row is shifted to the left and the last box of the row goes to the left elevator. Thus, the right elevator is freed from the additional box, and on the left elevator the far left box is pushed out. Then, both elevators move synchronously down to the next floor of the frame (on the 11th tier). The pusher of the left elevator moves the entire row to the right At the same time, the left elevator is freed from the box, and the extreme is pushed to the right on the right elevator. After that, both elevators synchronously rise to the upper floor of the frame, and there the process is repeated. The movement of elevators from the 12th to the 11th floor of the frame occurs until the entire row of the 11th floor is filled. After it is filled, the elevators move from the 12th to the 10th floor of the frame and the 10th row of boxes is filled.

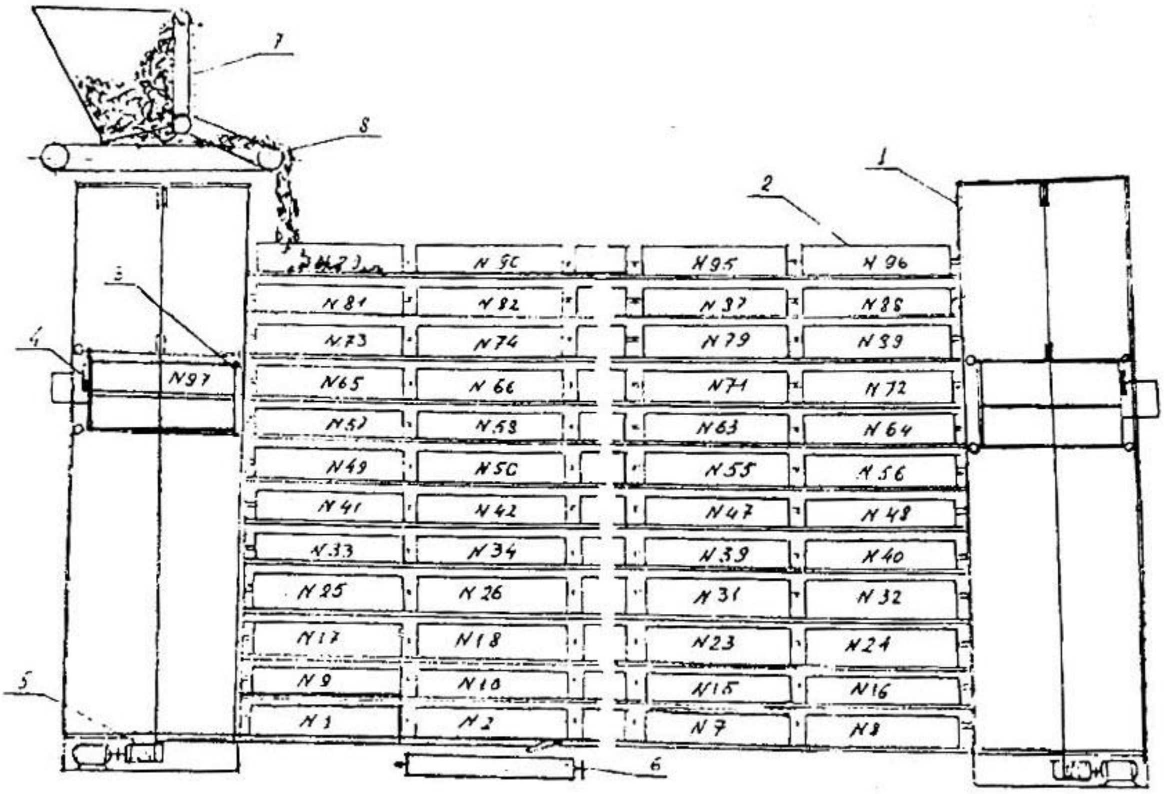

Fig. 2. Scheme of mechanized installation UVSH-3 for feeding silkworm caterpillars.

Thus, when distributing feed, the order of filling the rows of boxes is the following 12-11-12; 12-10-12; 12-9-12; 12-8-12; 12-7-12; 12-6-12 12-5-12,12-4-12,12-3-12; 12-2-12; 12-1-12.

According to agrotechnical requirements [6], it is expedient that the permissible value of time between feed distribution cycles T is minimal, which is not satisfied with the existing trajectory of the boxes in the UVSH-3 installation. Therefore, our goal was to optimize the trajectory of the feed boxes to ensure that each between two consecutive feed distributions from the minimum feed time T, which is ±15 minutes.

Many permissible routes of movement of boxes are associated with the design features of the installation.

The trajectory of any box is moving boxes from any tier to the 12th floor, where they receive food, and then moving them to any tier, where they stop in anticipation of a new cycle of movement.

For the installation of UVSH-3, containing 12 tiers of 8 feed boxes in each tier, as a result of one feeding cycle, 97 such elementary movements occur, each of which can be considered as an element of the permutation group Of Cri, and the totality of all movements - as the product of 97 operators of the permutation group:

$$P = \sum_{i=1}^{97} P_i \qquad (1)$$

In the case of installation of UVSH-3, the algorithm for replacing boxes during feeding is as follows: the boxes of the lower tier rise to the upper tier and displace the boxes of the upper tier in the lower, with the exception of the last box on the upper tier. A_{12-1}, which begins to displace the boxes of the second tier, etc.

The time between successive loadings of feed into the feed box, located in the i-th position during the M-th feeding, is determined by the formula:

$$t_i = T + \Delta t_i - \Delta t(P_i^{-1}) \qquad (2)$$

Where: T- is the time interval between the start of two consecutive feedings, s;

Δt_i - the time interval between the start of feeding and the loading of feed into the box located in the i-th cell of the installation, s;

P_i^{-1} - the cell from which the box as a result of permutations during feeding passes into the i-th cell;

To determine the average time T between feedings, we sum up both parts according to the formula (2) no i:

$$\sum_{i=1}^{M} t_i = MT + \sum_{i=1}^{M} t_i - \sum_{i=1}^{M} \Delta t(P_i^{-1}) \qquad (3)$$

The second and third terms on the right side of formula (3) coincide, because summation covers all terms of the same set. As a result, of (3) we get:

$$\bar{t} - \frac{1}{M}\sum_{i=1}^{M} t_i = T \qquad (4)$$

After that, consider the deviation of the time interval Δt between successive loadings of feed into the box from the feeding time T:

$$\Delta T = \Delta t_i - \Delta t(P_i^{-1}) \qquad (5)$$

Thus, the boxes located in the cells under the numbers 73-80, as well as 89, after the end of the cycle are in places that ensure rapid receipt of feed at the next feeding (a small value of the first member in formula (5). Whereas with the previous feeding, the feed is loaded into these boxes at the end of the cycle (large absolute value of the second member in formula (5)). Therefore, for a group of cells, the deviation from T will be maximum.

On the basis of a theoretical calculation, an appropriate computer program was compiled and on the basis of its analysis carried out for installations with 12, 10 and 8 rows, the optimal trajectory of the feed boxes was found.

Findings. For the installation of UVSH-3, the optimal trajectory differs from the standard one in that:

- ✓ boxes with numbers 81-88, located on the upper 12th level, are displaced not on the 11th, but on the 6th level;
- ✓ The 88th box at the end of the cycle is lowered not to the lower level, but to the 7th, displacing the 41st box, which descends to the lower level and occupies the starting position on the elevator.

As a result of such modernization, the maximum deviation of time between feed loads from the average time is reduced by almost half and thus the list of possible configurations of installations that provide a technologically permissible level of time error between feeds is expanded.

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დღეისათვის ფერმერულ მეურნეობებს, რომლებიც დაკავებული არიან ან იქნებიან მეაბრეშუმეობით, კერძოდ თუთის აბრეშუმხვევიას გამოკვებით და აბრეშუმის ნედლი პარკის მიღებით, შესაძლებელია შევთავაზოთ მექანიზებული დანადგარი „უვშ-3“, რომელზედაც შესაძლებელია 1,5-2,0 კოლოფი თუთის აბრეშუმხვევიას გამოკვება. ვინაიდან აღნიშნულ დანადგარზე თუთის აბრეშუმხვევიას გამოკვებისათვის, ე.ი. საკვების დარიგებისა და ნაძირის გამოცვლისათვის შემოთავაზებული გამოსაკვები ზედაპირების (გამოსაკვები ყუთი და შესაბამისი კასეტა) გადაადგილება გარკვეული ტრაექტორიით, მაშინ აღნიშნული დანადგარის გამოყენება, თუთის აბრეშუმხვევიას გამოკვებისაგან თავისუფალ დროს (შესაბამისი სადეზინფექციო სამუშაოების ჩატარების შემდეგ), შესაძლებელია სასაწყობო მეურნეობებში ხილის გამოსახმობად ან სხვა ოპერაციების შესასრულებლად.

საძიებო სიტყვები: მეაბრეშუმეობა, ტექნოლოგია, მექანიზაცია, დანადგარი, გამოკვება.

Minimal soil processing machine technology for small farms

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Annotation. The article discusses the resource-saving modern machinery of soil processing, discusses a constructive scheme of a combined resource-saving soil processing machine that allows deep loosening of the soil and performing a machine operation for the decomposition of the belt, as a result of which the soil is prepared to sow agricultural crops.

Keywords: soil, processing, resource saving, technology, deeply loosened.

Georgia is traditionally an agrarian country and occupies an important place in the agricultural sector to produce agricultural products. But over the past 30 years, the number of crops obtained per 1 ha has decreased significantly. One of the main reasons for the decline in kinship areas is the use of traditional, increased resource-protective technologies for soil processing, and the decrease in the yield of agricultural crops, including cereal crops, is caused by an increase in energy resources, a sharp increase in market prices for fuel-bakeries, fertilizers and plant protection facilities.

Intensive processing of the soil leads to negative consequences of an economic and ecological nature. It is estimated that, including increasing transport cargo on the field, 50-80% of the field during the year is covered with the footprints of the hardware suspension system. The depth of soil compaction reaches one meter. Therefore, the search for technologies and technical means of soil protection is underway that ensure not only a decrease in windy and water-induced erosion, but also for the effective use of the soil and the restoration of impaired ecological equilibrium.

The most energy-efficient process in the entire technological cycle of maintenance of agricultural crops is the processing of soil on which 50-60% of the fuel is spent, the first processing of the soil should create favorable conditions for plant growth and development, i.e. it should ensure the most favorable heat in the soil, water, air, biological and nutritional regimes for plant development. From this it is clear that for all regions of the country there cannot be the same soil processing system, and its production requires a differentiated zonal approach. Natural-climatic conditions, terrain, soil type and mechanical composition, precipitation amount and fermentation of its distribution, the duration of the vegetation period of the plant, the temperature and windmill regime, as well as the type and alternation of crops in the seed rotation are taken into account.

In recent years, the following soil processing technologies have been used in world practice: traditional, intense, soil-protecting, minimal, zero, mulching, alternate, basins and precision farming. The optimal soil processing technology according to the zones in Georgia should be visited in these technologies or in their rational compatibility.

In the middle of the 20th century, the following operations were used for soil processing: plowing, several cultivations, covering, pre-sowing of the soil, sowing, compaction of the soil after sowing. The power of the tractors, the depth of processing and the definition of mods were continuously increasing. As a result, the largest energy resources, primarily oil, were spent, catastrophically increased labor costs. As a result, the upper layers of the soil are highly loosened, and at the bottom of the arable layer the soil is very hardened as a result of the movement of the carriageway of the tractor. The loosened and correct surface of the upper layers of the soil became barren as a result of wind erosion, as a result of millions of hectares of erosion in the arable areas of the world, and the content of humus decreased significantly.

The arable layer of soil consists of several layers, where bacteria are present in the upper layers that breathe carbon, they are called aerobic bacteria; In the depths - in the lower layers, bacteria that instantly die in contact with air, they are called anaerobics. Bacteria in the upper layers during the turning of the belt, treated with what lower, die. Bacteria rising from below also die. As a result, we accept that the fertility of humus decreases sharply.

The second problem with plowing the soil is the formation of the root of the arable layer, i.e. creating an excessive density layer to a depth of 20-25 cm, which prevents the movement of water in the capillaries and stops the natural circulation of moisture altogether (fig. 1.) Due to this problem, the technological process is underway without turning the belt over.

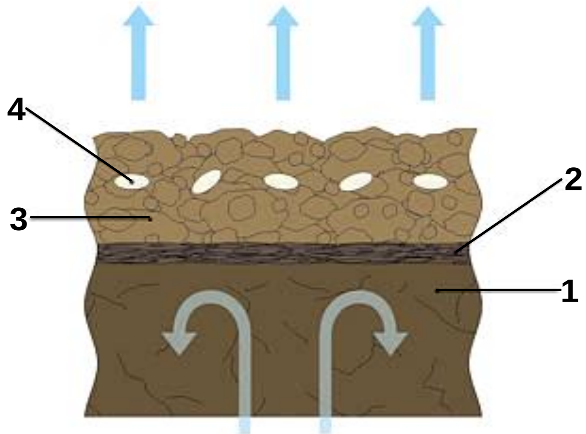

Fig. 1. Scheme of decomposition of the soil structure under the influence of a plow: 1-humus layer; 2-arable layer sole; 3-arable layer; 4-seeded.

One of the real ways to increase grain yields in the world's highly developed countries is considered to be the processing of new machine technologies.

From modern technologies for the production of agricultural products, taking into account the elements of the world economic crisis, the most promising resource-saving technologies are. Resource-saving technology means performing several operations through one passage by one car, thereby improving the qualitative indicators of the technological process itself and savings, among other factors, fuel, which is the most valuable product when performing agricultural technology.

Modern agriculture around the world is moving to a new economic model called energy-saving technologies. To solve this problem, it is necessary to process proven and implemented technologies in developed countries around the world that provide a guaranteed high yield. It is necessary to process such machine technologies that ensure the use of combined machines of replacement workers, during which it is possible to perform several technological processes through one passage of aggregates, where agrotechnical requirements allow this to be observed.

One of the main constituent elements of energy-saving technologies is the minimum soil processing technology, during which the depth of soil processing is equal to the depth of sowing seeds, i.e. much less than when plowing with winged plows. Using minimal soil processing technology, it is possible to achieve full preparation for sowing a cultural plant, which can be achieved through one passage of aggregate, the use of this technology is effective as well as when carrying out care for agricultural crops.

The modern technology of soil processing is attributed to zero processing technology, which ensures the creation of complex conditions for the creation of an optimal structure of the soil, i.e. a situation is created when there is no soil processing, but its function is completed. During zero processing, there is no mechanical impact on the soil, but nevertheless the soil is in the state required for the growth and development of the plant. To date, "zero" technology - this is the soil without mechanical processing (here it is not meant to affect the sowing machine on the soil).

There are various schemes for the cohesion of the working organs of the combined machines of soil processing, the purpose of which is to fully process the soil through one passage of the aggregate to sow the seeds of a cultural plant. It is important to create such favorable conditions for the growth and development of the plant at this time when it will be possible to obtain the maximum number of crops in conditions of minimal costs.

As a result of the field experiment, we identified the rationality of the working organs on the framework of the soil-processing combined car Layout (Fig.2.).

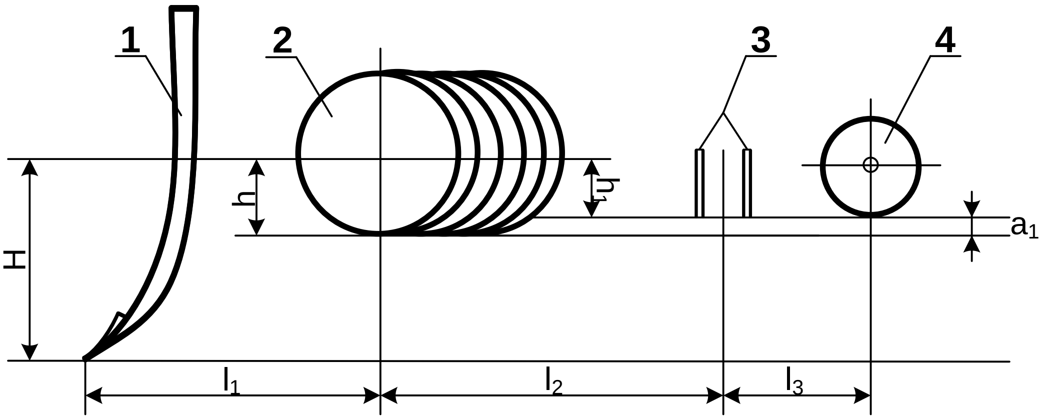

Fig. 2. Scheme for laying the working bodies of a combined car on the soil: 1 deeply baking powdered paws; 2-disc shield battery; 3-toothed shear section; 4-Mitchell Pierce.

With this in mind, we have developed an experimental type of soil processing combined car scheme (Fig. 2.), which through one passage of the aggregate provides deep loosening of the soil, top processing, adjustment and preparation for sowing.

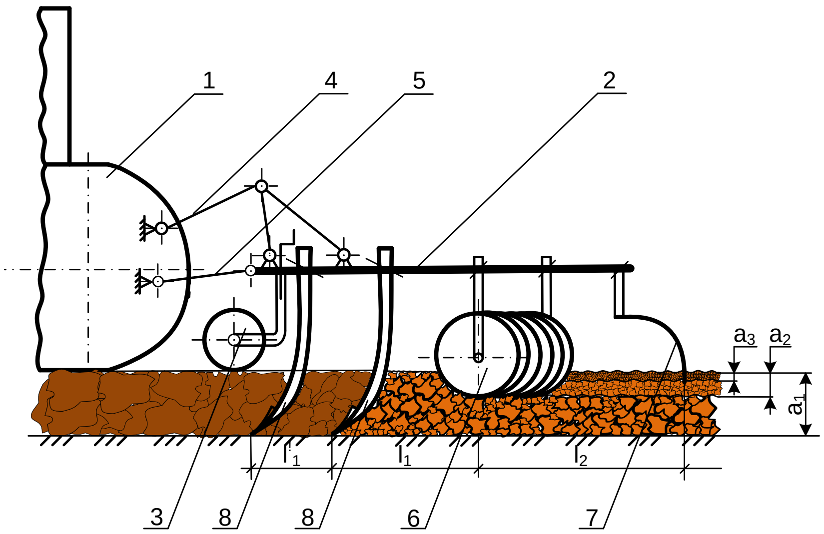

Fig. 3. Principled scheme of a combined car for soil processing:
1-tractor; 2-car frame; 3-support eye; 4-central traction; 5-side traction; 6-Discs section; 7-gallon finger; 8-deeply loose paws.

Soil processing machine (Fig.3.) The hanger is type and aggregates 9 kn. power tractor (1); The depth of soil processing is regulated by the universal hanger system of the tractor (4, 5) and the support wheels of the car (3); Soil with deeply loosening paws (8) can be processed at a depth of

0.35-0.45 m, after which large belts are dispersed and loosened using the disco shield section (6) at a depth of 0.1-0.15 m; The final adjustment of the soil, molting and preparation for sowing are produced by means of diluted toothed shears (7).

The working organs of deeply baking powder are loosened into the soil in a cut created by baking powdered paws, which grows to the cooled part of the loose soil. The angle is characterized by the degree of soil deformation in the transverse cut of the soil on both sides of the loosening powder (Fig. 4.).

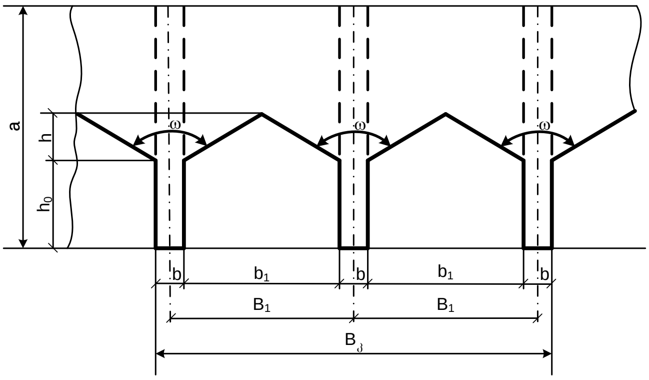

Fig. 4. Scheme for determining the parameters of the working organs of the combined car baking machine baking machine.

One of the main working bodies of the combined cars of soil processing is baking powder paws, which are divided according to the purpose and construction: rotation, breaking and spear paws. In combined cars, all three types of paws are mainly used, but preference is given to the bracket and then rotary paws due to the simplicity of the construction. They are used in soils of light and medium density, for basic (deep loosening) and pre-sowing processing. This type of paws for intensive loosening of the soil have a variable angle of loosening a, but in crushed soils they are easily clogged with plant residues, due to which the impedance of traction of the car increases.

Characteristic features of deep-processing machines in the direction of the soil in the direction of the modular ghana are the formation of unsold snags from the bottom, the top layers of which are loosened. The magnitude of the snags depends on the aside of the modesting of the working organs and the distance between the baking paws in the transverse direction.

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Findings.

For agricultural crops, the technology of combined soil processing of the soil has been developed, when through one passage of the aggregate it is possible to fully prepare the soil for sowing a cultural plant;

Based on the analysis of various schemes for the cohesion of the working bodies of the combined machines of soil processing combined machines, a combined car scheme was developed, where using several working bodies through one passage of aggregate it will be possible to achieve full-fledged loosening of the soil and prepare the soil for sowing agricultural crops;

An experimental model of a combined car of soil processing was produced; The machine through one passage provides deep loosening of the soil, decomposition of the belt and preparing the soil surface for sowing a cultural plant.

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ნიადაგის მინიმალური დამუშავების სამანქანო ტექნოლოგია მცირე ფერმერული მეურნეობებისათვის

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ანოტაცია. სტატიაში განხილულია ნიადაგის დამუშავების რესურსდამზოგი თანამედროვე სამანქანო ტექნოლოგიები, განხილულია კომბინირებული რესურსდამზოგი ნიადაგდამამუშავებელი მანქანის კონსტრუქციული სქემა, რომლის საშუალებითაც შესაძლებელია ნიადაგის ღრმად გაფხვიერების და ბელტის დაშლის სამანქანო ოპერაციის შესრულება, რის შედეგადაც ნიადაგი მზადდება სასოფლო-სამეურნეო კულტურების დასათესად.

სასოფლო-სამეურნეო დანიშნულების კულტურებისათვის დამუშავდა ნიადაგის კომბინირებულად დამუშავების სამანქანო ტექნოლოგია, როდესაც აგრეგატის ერთი გავლით შესაძლებელია ნიადაგის სრულფასოვნად მომზადება კულტურული მცენარის დასათესად;

· ნიადაგდამამუშავებელი კომბინირებული მანქანების სამუშაო ორგანოების შეთანაწყობის სხვადასხვა სქემების ანალიზის საფუძველზე დამუშავდა კომბინირებული მანქანის სქემა, სადაც რამოდენიმე სამუშაო ორგანოს გამოყენებით

აგრეგატის ერთი გავლით შესაძლებელი იქნება ნიადაგის სრულფასოვანი გაფხვიერების მიღწევა და ნიადაგის მომზადება სასოფლო-სამეურნეო კულტურების დასათესად;

· დამზადდა ნიადაგდამამუშავებელი კომბინირებული მანქანის ექსპერიმენტული მოდელი; მანქანა ერთი გავლით უზრუნველყოფს ნიადაგის ღრმად გაფხვიერებას, ბელტის დაშლას და ნიადაგის ზედაპირის მომზადებას კულტურული მცენარის თესვისათვის.

საკვანძო სიტყვები: ნიადაგი, დამუშავება, რესურსდამზოგი, ტექნოლოგია, ღრმად გაფხვიერება.

УДК 631.358

EVALUATION OF FACTORS AFFECTING CHARACTERISTICS OF HIGH-TEMPERATURE SPRAYING AND STRENGTH OF COATING AND BASE ADHERENCE

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Annotation. At present, the method of plasma spraying of refractory metals and chemical compounds is widely used in various branches of technology. This is explained by the fact that plasma coatings make it possible to create surfaces of parts with desired physical and mechanical properties: improved erosion and corrosion resistance, increased wear resistance, and high resistance to thermal and dynamic influences.

However, these advantages may lose their exclusive significance if plasma coatings have low adhesion and, as a result, change (or lose) the specified physical and mechanical properties during operation. To eliminate this disadvantage, the protected surface, before coating, is prepared by shot blasting with abrasive chips with a particle size of 0.9-1.2 mm or a sublayer is applied to it. This improves the adhesion of the coating to the substrate through mechanical and chemical interaction.

Key words: resistance, sputtering, hardening, adhesion, plasma methods, ionization, metals.

Introduction. Since the characteristics of the coating (adhesion, cohesion and other properties) are inextricably linked with the formation of the process of movement and heating of the source material, the purpose of this review is: 1) to consider the main characteristics of the plasma jet that affect the spraying of a wire or powder, and 2) to analyze the existing theoretical concepts about the physical processes in the formation of plasma coatings, bearing in mind to establish the factors that contribute to better adhesion of the coating to the surface of a composite material.

When spraying solid materials using a compressed arc, the source material can be fed into the plasma jet in the form of a powder (Fig. 1 a) or in the form of a wire (Fig. 1 b). In both cases, the energy of the plasma jet is used to spray and apply the coating material.

Materials and methods

The thermal and gas-dynamic characteristics of the metallization jet are determined by the temperature and velocity of the plasma jet, which in turn depend on the geometry of the anode nozzle, the thermophysical properties of the working gas, the location of the anode spot, and other factors.

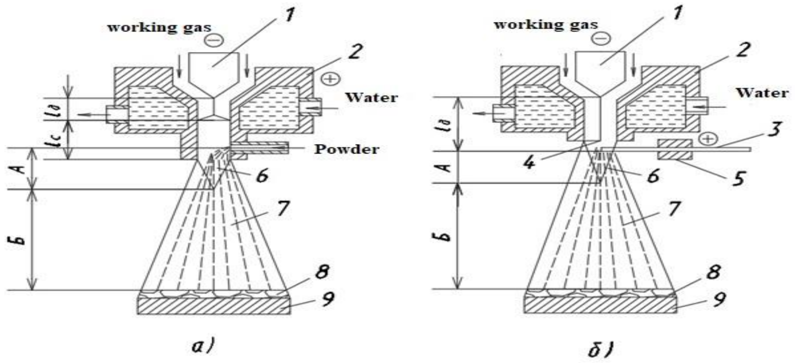

Fig.1.Scheme of the process of high-temperature sputtering of powder (a) and wire(b)using a plasma jet:
1 - tungsten cathode; 2 – copper water-cooled anode; 3 - sprayed wire; 4 - arc column; 5 – conductor; 6 - plasma jet; 7 – jet of sprayed particles; 8 – emerging coating material; 9 - technological mandrel.

The process of formation of a plasma jet in burners intended for metallization is as follows.

Plasma-forming gas (argon, nitrogen, helium, hydrogen or their mixtures) is supplied into the space between the thoriated tungsten cathode 1 (Fig. 1) and the copper water-cooled anode nozzle 2 and the arc is ignited. Due to thermal dissociation and ionization, the working gas absorbs a large amount of electric arc energy and flows out of the nozzle at high speed. Its temperature can reach 5000-20000°K.

Outside the anode spot, ionized particles are neutralized and atoms recombine into molecules. As a result, the energy absorbed in the arc is released and transferred to the environment [1].

The temperature and velocity of the plasma jet are determined by many factors. However, the main one is the location of the anode spot of the arc or the length of the arc - L_∂ (Fig. 1 a, b). As can be seen from Fig.1, the binding of the anode spot can vary significantly for burners designed to spray powder material and wire.

When the wire is sputtered according to the “open anode” scheme, the working arc burns between the tungsten cathode 1 (Fig. 1 b) and the conductive wire 3. The formation of the particle flow in this case is determined by the arc power, the location of the melting end of the wire in the plasma jet, the dynamic effect of the plasma flow and wire insertion speed. The latter is especially important when spraying a “neutral” wire [1, 2].

The plasma-forming gas, when moving in the nozzle part, is heated to a high temperature and flows out of the nozzle at high speed. The flow rate has a significant effect on the mechanism of the nucleation of sprayed particles during wire spraying (granulometric composition, speed, and other parameters). For example, at a low wire feed rate into the plasma jet, the end face is heated and melted at the jet periphery, where the flow velocity is low. As a result, large drops (particles) are formed, since the forces of the dynamic pressure of the flow are less than the forces of surface tension that hold the drop on the lower edge of the end.

In the case of spraying powder materials, the position of the anode spot of the arc is determined by the design parameters of the burner (the angle of the working gas inlet into the spray chamber, the diameter of the nozzle, etc.), the arc power and the flow rate of the plasma gas, as shown in Fig. 2 [3].

In addition, the anode spot can change its location along the channel length under the action of a high-speed working gas flow, causing low-frequency oscillations of the plasma torch, as is the case when nitrogen is used as a plasma-forming gas [4]. In section L_∂ (Fig. 1 a), due to the high gas velocity and the large intrinsic electromagnetic field, the arc column is strongly laced and occupies a relatively small part of the channel section. Behind the active arc spot (section L_∂ in Fig. 1a) in the nozzle channel, the temperature equalizes over the channel section due to the absence of electromagnetic compression forces of the plasma column. As the channel leaves the nozzle, the plasma jet expands and gradually loses its energy. The temperature field of the gas flow behind the nozzle exit will be determined by the thermophysical properties of the plasma-forming gases and the conditions of heat exchange between the jet and the environment.

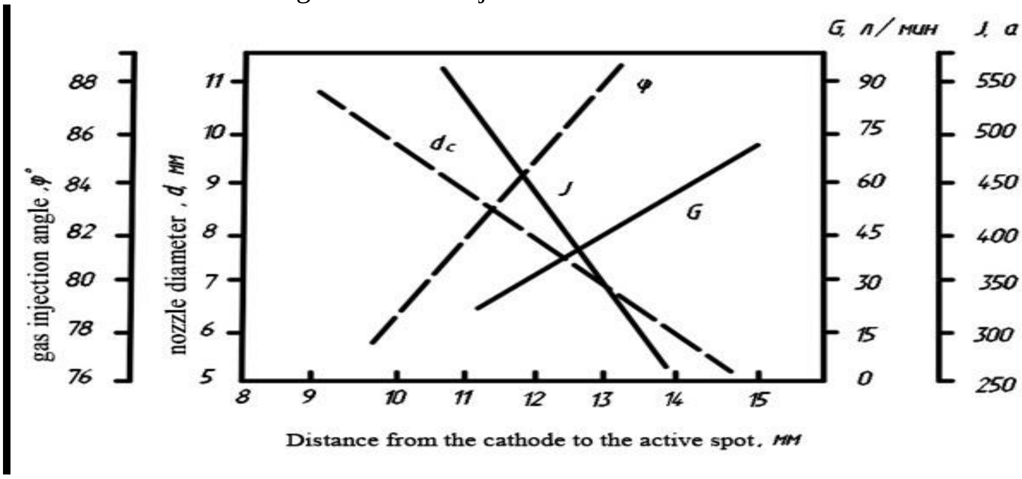

Fig. 2. Dependence of the position of the anode arc spot in the nozzle channel on the angle of plasma gas injection into the chamber (φ), nozzle diameter (d_c), arc discharge current (I) and plasma gas flow rate (G)

The temperature and velocity of the plasma jet and sprayed particles have been studied in many works. Moreover, some researchers focused on studying the parameters of the metallization jet up to the nozzle exit [3],
others - behind the nozzle exit [1,2,5]. As a result of these works, the process of heating powder materials and the temperature of the particles sprayed from the wire, when they move from the metallizer to the substrate, became clear and made it possible to quantify the temperature and speed of the sprayed particles.

To calculate the heating of particles during the spraying of the initial material from the powder, one can use the analytical dependence indicated in [2]:

$$X = \left(\frac{C\gamma Rm}{6\alpha}\ln\frac{T_c - T_o}{T_c - T_m}\right)^2 * \left[\frac{C_n\gamma Rm}{6\alpha(T_c - T_m)}\right]^2, (1)$$

where: X – distance required for complete melting of the particles;
T_c, T_0, T_m – jet, particle surface and melting temperatures, respectively;
C, C_n – heat capacity of particles in solid and molten states;
γ – particle density;
R – particle radius;
m – coefficient determined from the dependence $\vartheta_2 = F(x)$;
α – heat transfer coefficient.

The temperature and velocity of particles during spraying of a neutral wire can be determined by the method [11], according to which the mass average temperature of particles in the considered section of the metallization jet is estimated from the increment in the enthalpy of particles of the sprayed metal. The enthalpy increment of the metallized particles is determined by separate calorimetry of the metallized jet and the plasma jet without metal particles;

$$H_T - H_{298} = \frac{I * U * \eta_{me}}{G * 3,6} \quad (2)$$

where H_T – enthalpy of the metal at the considered temperature in j/kg;
H_{298} – enthalpy of metal at room temperature (298°K) in j/kg;
$I * U$ – metalizer arc power in watts;
G – the amount of metal received by the metallizer per unit of time in m3/h.

The mass-average temperature and enthalpy increment of tungsten and molybdenum particles decrease as they move away from the plasma metallizer [11].

The velocity of the sputtered particles in the plasma jet can be determined from the following expression[1]:

$$\upsilon\frac{\partial\upsilon}{\partial x} = \frac{3\Upsilon_2 * C_x}{4\Upsilon d} * (\upsilon_c - \upsilon) \quad (3)$$

where:

- υ – particle speed;
- υ_c – gas jet velocity;
- Υ_2 – specific gravity of gas;
- Υ – specific gravity of the material;
- C_x – drag coefficient;
- d – particle diameter

It can be seen from expression (3) that with the same size of sprayed particles, those with a lower specific gravity move faster. The latter is confirmed by the measurement data of particle velocities of sputtered wire made of titanium (Y=10200 kg/m^3) and tungsten (Y=19300 kg/m^3) shown in Fig. 3 [1].

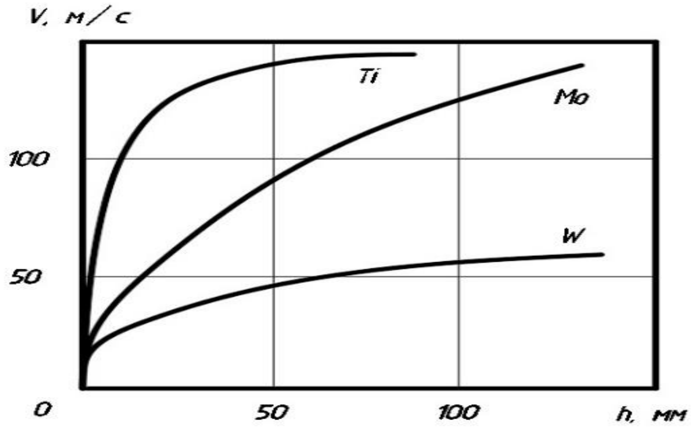

Fig. 3. Dependence of the particle velocity on the distance to the plasma torch nozzle exit for various metals

The analytical dependences of the thermal characteristics of the plasma metallization jet considered above show that the energy conditions in the coating formation zone can be controlled by arc power, plasma gas flow rate, and spraying distance. This makes it possible to obtain the required cohesive and adhesive strength of the sprayed material.

A feature of the plasma spraying process is the formation of a coating from molten and accelerated by a plasma jet metal particle that collide with the substrate and spread over its surface with a simultaneous volume of thermal and kinetic energy.

Table 1[11] shows the data obtained as a result of estimating the energy conditions and the kinetics of the chemical interaction of deposited metal particles (Ti, Ni, Mo) with a graphite substrate according to the procedure proposed in [3], i.e., using equation (4).

Table 1.

Coating	$T_n^{'}$, °C	$T_к^{'}$, °C	T_p, °C	t_a, сек	E_a, эв	$E_{c/2}$, эв
Mo	1100	2160	2600	$3,3*10^{-6}$	3,64	3,73
Nb	1150	2130	2500	$2,8*10^{-6}$	3,60	
Ti	1500	1642	1725	$3,5*10^{-5}$	3,30	

Note: T_n^′ - substrate heating temperature, at which Ni/Mo ≈σ/σ_0≈0.7; T_k^′ - temperature in the particle-substrate contact; T_p is the temperature of the sprayed particles, approximately equal to the melting point; t_a is the duration of the reaction; E_a is the sublimation energy of the substrate material (MG-1 graphite).

To eliminate this shortcoming, B.M. Zakharov proposes to estimate the relative adhesion strength of the coating to the substrate (σ/σ_a^·) depending on the coating thickness from the following empirical equation:

$$\frac{\sigma}{\sigma_a^{\cdot}} = \frac{0,8}{l^{3.2\delta}} + 0.2, \qquad (9)$$

where: σ – adhesive strength, kg/sm^2;

$\sigma_a^{\cdot}$ - minimum adhesive bonding strength of the coating, kg/sm^2;

δ – coating thickness, mm;

e = 2,718281828…

To solve the problem of the magnitude and nature of the distribution of residual stresses in the deposited layer, the study of temperature fields in the deposited layer and substrate was carried out. To reveal the mechanism of formation of residual stresses and to establish the nature of the influence of individual parameters of the deposition process on the formation of residual stresses in the deposited layer, tungsten wire was deposited on a narrow Kh18N1OT plate 150 × 6 × 1.6 mm in size. At the same time, it was shown that for coatings deposited on the surface of parts whose deformation is constrained, tensile residual stresses always arise, which follows from the formula:

$$\sigma_{\text{op}} = \alpha_1 \text{E}_1 \text{T}_1(-R_1; 0), \qquad (10)$$

and for parts, the deformation of which is not constrained during the deposition process, both tensile and compressive residual stresses can occur in the coatings:

$$\sigma_{\text{op}} = \left[\alpha_1 \text{T}_1(-R_1; 0) - \alpha_2 \text{T}_{\text{cp2}}(R_1; 0)\right]\text{E}_1, \qquad (11)$$

Here and in equation (10), index 1 refers to the deposited layer, index 2 to the substrate; α is the coefficient of linear expansion; E - modulus of elasticity of the first kind; $\text{T}_1(\text{y}, \tau) = \text{T}_1(-R_1; 0) = \text{T}_{\text{CO}_2}(R; 0)$ – temperature change in the direction of the normal to the deposition surface (R_1 – thickness of the sprayed layer) and in time ($\tau = 0$ – moment of passage of the burner axis above the design point).

An analysis of formulas (10) and (11) shows that in order to reduce residual stresses in the deposited layer, it is necessary to decrease the temperature of the deposited surface. The latter can be achieved by increasing the deposition distance or the speed of the torch, or by cooling the substrate during deposition.

In order to control the tensile and compressive residual stresses described by equation (11), in addition to the above methods, it is recommended to preheat the substrate.

Conclusion

Thus, the analysis of the coating process using a compressed arc allows us to note that the conditions for the formation of a plasma metallization jet (torch design, type of plasma gas, arc power, spraying atmosphere, etc.) determine the speed and temperature of the particle before it hits the base surface. The particle temperature, in turn, predetermines (together with the physical state of the base surface at the time of contact) the degree of physicochemical interaction between the particle and the substrate, that is, ultimately, the adhesive properties of the coating.

In addition, the value of thermal stresses that appear in the coating as a result of shrinkage of the cooled particle and the difference in the thermal expansion coefficients of the base and coating depends on the ratio of the thermophysical constants of the coating material and the base. And, finally, for a coating formed in the process of high-temperature spraying of the coating material and with special methods of preparing the spraying surface (shot blasting, applying "carved threads", etc.), one more factor is added to these factors, determined by the forces of mechanical engagement of deformable particles for due to the filling of microroughnesses on the spraying surface.

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ცეცხლგამძლე ლითონების ზედაპირების პლაზმური მეთოდით დაფარვის ახალი ინოვაციური მეთოდი

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ანოტაცია. სტატიაში წარმოდგენილი მეთოდის გამოყენებით პლაზმური დაფარვის დროს უმჯობესდება ცეცხლგამძლე ლითონის ზედაპირის კოროზიის და ეროზიის მიმართ წინაღმდეგობის უნარი, ასევე იზრდება ცვეთამედეგობა და მაღალია თერმული და დინამიური წინაღმდეგობა,რომელიც საგრძნობლად აუმჯობესებს დაფარული ზედაპირის ფენის მდგრადობას სუბსტრატთან მექანიკურ და ქიმიური ურთიერთქმედების დროს.

Theories and experimental study of the Causes of losses during crop harvesting

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Abstract. The article discusses studies of the causes of biological and mechanical losses during the crop harvesting, quantity of biological and mechanical losses are determined under the performed studies and the reasons while machine harvesting of different crops.

Keywords: Losses, biological, mechanical, threshing, separation.

Introduction: Crop production in the purpose of the country agricultural ensurance is the main challenge, in order to provide the country crops (provisions and fodder), requires production of minimum 800 000 tones of crops in the country. Currently, according to Sakstat (Geostat) data, crop harvesting territories occupy 258,4 thousand ha and is produced 102,4 thousand tones of crops, accordingly, percent of self-sufficiency is 12,8.

For such a small land as Georgia, while such a low coefficient of self-sufficiency, the most significant is the loss of the crops, which is caused during a harvesting process.

At present in Georgia are registered 628 units of crop harvesting combines of different mark and model, from which 60% age 30 year, old Russian combines, which have losses around 10-15%. Losses are great also in European combines, the reason is that the operators, because of lack of training, have no skills of their correct exploitation, this leads to the fact that the practice shows that common losses reach 8-10% that is a big number.

The problem of reducing crop losses has always been and still remains a problem for the farmers producing the crops. If considering that increase of crop producing in Georgia, based on the food safety, has a great significance and priority, performance of controlling the harvesting terms and loss, is extremely important.

General Part

The practice, as well as the theoretical studies have shown that during machine harvesting of the crops, there are two types of losses – biological and mechanical. If we perform exact classification, it will be imaged as follows : (image 1).

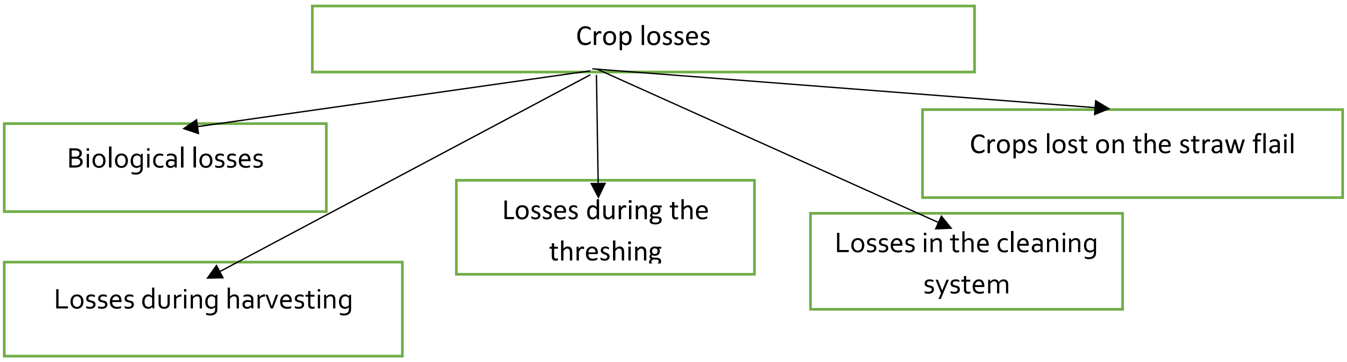

Fig. 1. Structure of the crop loss

It must be noted that general reason of technical loss is the combine harvester and thrasher part's disordered operation, therefore, technical condition and exploitation terms of the combine determine the quantity of technical losses, and the quantity of operating combines have the impact on the quantity of biological losses. (lack of combines in harvesting period) their technical condition and exploitation terms.

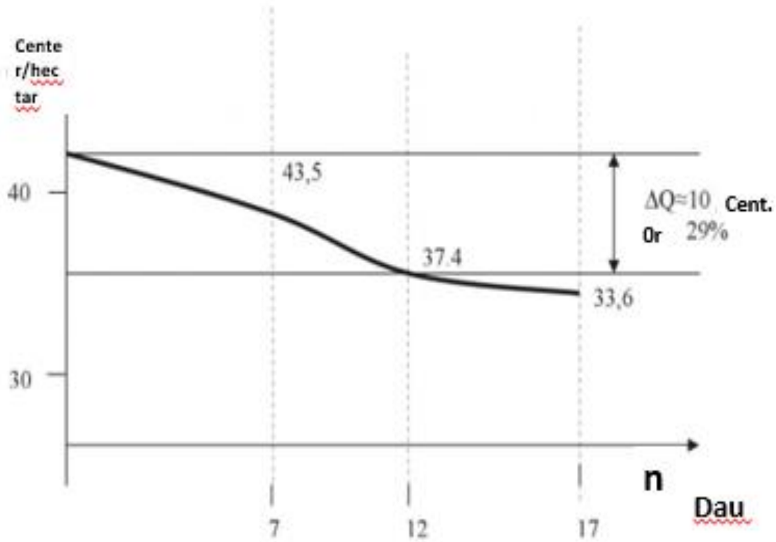

Fig. 2. Dependance of crop agrobiological losses on the duration of harvest

These factors mainly determine the quantity of technical losses, and the quantity of operating combines have the impact on the quantity of biological losses. (lack of combines in harvesting period) their technical condition and seasonal load on each combine. For example, it's been more than 10 years that seasonal load on combines in Germany is 33 ha/ per season, and in the USA 68 ha/per season. Therefore, large crop producing companies in the developing countries, determine the temps of harvesting not according to the quantity of combines, but according to the period they perform timely storing, cleaning and sorting of harvest for farther storage.As our studies have shown (image 2, table 1), most of their biological loss of their crops is performed from 8 to 15th day of complete ripeness of the crop. Before this period and after this period, daily losses decrease.

Table 1 shows the data of the crops of different culture and species, scattered in the field, depending on the harvesting terms.

Losses of the crops, depending on harvesting terms

Table 1.

Duration of harvesting days	Fall barley		Spring barley		Spring wheat		Fall wheat		Oats	
	Crop loss while harvesting									
	p/ha	%	p/ha	%	p/ha	%	p/ha	%	p/ha	%
4-7	1,0	3,2	1,4	4.1	1.0	6.7	0.7	2.8	4.4	16.1
8-10	2,4	8,4	3,0	9.1	2.1	10.5	0.8	3.0	5.9	21.6
11-13	3,0	14,2	4,9	16.2	2.7	17.1	2.2	8.7	7.3	26.8
14-16	3,8	15,2	5,0	17.3	3.3	29.7	4.0	15.7	7.8	28.6

As the table shows, while harvesting most crops, losses are more after 8-10 days.

During 2020-2021 experiments were performed on the lands of Zurab Tetvadze, 50 ha of well cared lands were selected fir crops and the average harvest was 2,5-3,5ha. Harvesting was performed by German combine KLASS "DOMINATOR-140.

Schedule 1 and table 1 analysis shows that while planning harvesting activities, great practical importance lies on the peculiarities of development of the ripening phases of the crop on the ear, duration of ripening phase. These factors are very changeable and depend not only on crop types and species peculiarities, but also on environmental conditions. Fir example in Kakheti region (Shiraki valley) which has dry and hot weathers, the ear ripens maximum in a week, and in high density regions (Shida Kartli, Samtskhe Javakheti) it needs up to 20 days. After a complete ripeness of the ear, the crop starts over ripening and at this time the crop loses its biological, technological, biochemical, physical and mechanical features and nutritional quality, it falls down easily, that at the final stage causes a fast decreased biological harvest.

As for the mechanical losses, they appear mainly in the thrashing part of combine, change in wide range, depend on harvesting conditions and operation regime. Mainly the losses as the unthashed mass in the straw and chaff 0,1 – 0,3%, the loss as a free crop correspondingly 0,2 – 0,7 % and 0,4 – 0,7%, harvesting caused losses vary while harvesting wheat in the ranges from 0,7* (overstock 3%) up to 2,5% (50% overstock), while harvesting barley from 0,8%(3%) to 4,1% (6,5%) -. The studies have shown that the harvester harvests the field in the ranges of possible losses (1%), when the volume of field overstock is 10%. While harvesting barley and wheat, the crops are grained in the ranges between 1,5%-10-12%.

Generally, it may be said that general reasons of crop mechanical losses are incomplete cut of the stalk and harvesting, incorrect interference of the combine operating bodies, selection of operating regimes and incomplete control of technological processes because of the low qualification of combines.

If all the mentioned reasons are solved, the combine is completely hermetized and technological process is under a perfect and exact permanent control, when the productivity is 4t/ha, while harvesting with the combine, total loss should not be over60 kg/ha.

While harvesting the crops, the expected losses can be determined ad according to theoretical as well s experimental methods.

Experimental method – it is a pre-estimation of the result, received after performing the determined technological process.

Technological losses may be determined according to which method – division or direct combining is the harvesting performed. Total loss while divisional harvest is determined with the formula:

Пр = Пп + Пм

Where: Пп – is the loss of harvester, Пм – loss of thrasher.

Total loss while combining harvest is determined with the formula:

Пп = Пж + Пм

Where Пж – is the harvester loss, Пм – loss of thrasher.

The loss of directly the thrasher is determined as the sum of the following losses:

Пм = Пнк + Псс + Пнп + Псп

Where: **Пнк -** loss in unthrashed ears in the straw;
Псс – loss as a free crop in the straw;
Пнп – loss as unthrashed ear in the chaff;
Псп - loss as a free crop in the chaff;

The greatest impact on mechanical losses has selection of the optimal height of cutting the stalk from the ground surface. (image 3)

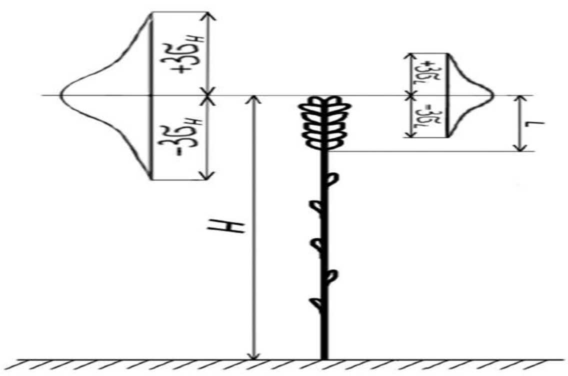

Fig. 3. Scheme of selecting optimal height of cutting the stalk

At the moment of theoretical estimation of the height of cutting the stalk, we need to know measured characteristics of the harvested crop. In this purpose we have studied variable statistics method, which determined measure characteristics of the crops, widely growing over the country, which is given in the table N2.

Measure characteristics of the crops growing in Georgia.

Table 2.

crop	Species	Length of the stalk cm		Length of the ear cm	
		minimum	maximum	minimum	maximum
Rye	various	71	157	9	12
Fall wheat	various	78	110	8	12
Spring wheat	various	80	140	7	10
Spring barley	various	64	100	6,5	8
Fall barley	various	60	125	5,5	10
Average size **M**		70,6	126,4	7,2	10,4
average sq. bend ***δ***		19,8	21,2	1,4	1,6
Variation coefficient %		22,0	20,4	18,5	18,7

By using the data given in table 2, we can theoretically determine average characteristics of stalk cut height in different cases:

When the stalk is the highest and the ear is of minimum length

Hcp = (Hmax + 3·σH) – (Lmin – 3·σL) =(108,6 + 3·24,3) – (8,1 – 3·1,6) = 178, 2 cm.

When the stalk is the minimum height and the ear is the maximum height

Hcp = (Hmax – 3·σH) – (Lmin + 3·σL) =(97,8 – 3·21,1) – (9,33 + 3·1,8) = 9,77 cm.

When there is an average meaning of the highest stalks and short ears

Hcp = Hmax – Lmin =108,6 – 8,1 = 100,5 cm.

When there is an average meaning of low stalks and long ears.

Hcp = Hmin – Lmax = 87,8 – 9,33 = 78,47 cm.

As in the country there are various crop harvesting combines, was performed a comparative test of the combines of the most quantity, in order to determine the losses. While the experiment, the loss was recorded under the method widely used in world practice and by using latest measuring devices.. the outcomes of the experiment is given below (Table 3).

Indicators of testing the crop harvesting combines on losses

Table 3.

N	Combine mark	Producer country	Width of harvester mods. m	Cut height	loss %	Loss type
1	**Sk -5**	Russia	5	30	8.7	Crop, ear
2	**polesie**	Belarus	5	25	5.7	Crop, ear
3	**Claas**	Germany	5	22	3,0	crop
4	**New Holland**	Italy	4,5	22	3,0	crop
5	**deuH far**	Germany	5	22	2,8	crop
6	**Veqtor**	Russia	6	25	4,3	ear

7	**Sammpo**	Finland	4,5	27	3.5	Crop, ear
8	**Jon Deree**	USA	6	25	2,5	Crop

As the table shows the least loss has the combine produced in the USA Jon Deree -1450CWS.

Conclusion

1. The studies have shown that most biological losses of ear cultures are from 8 to 15th day of the crop ripening. Before this period and after this period, daily losses decrease.
2. General reason of crop mechanical loss is incomplete cut of the stalks and their gather, incorrect interference of combine's operating bodies, selection of operating regimes and incomplete control of technological processes, because of the low qualification of combines.
3. Average measuring characteristics of the crops mainly growing in Georgia are stalk minimum length 70,6 cm, maximum length 126,4 cm, ear minimum length 7,2 cm, maximum length 18,7 cm.
4. The least of losses of the combine used in Georgia has the combine produced in the USA John Deere -1450 cws.

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ანოტაცია. სტატია ეხება მარცვლეული კულტურების მოსავლის აღების დროს დანაკარგების სახეების და რაოდენობის დადგენის თეორიულ და ექსპერიმენტალურ მეთოდს, კვლევის შედეგად დადგენილია რომ მარცლეული კულტურის მოსავლის აღების დროს ადგილი აქვს ბიოლოგიურ და მექნიკურ დანაკარგებს , ბიოლოგიური დანაკარგები გამოწვეულია მოსავლის აღების აგროვადების დარღვევის გამო და პირდაპირპროპორციულია აგროვადების გადაცილებისა, ხოლო მექანიკური დანაკარგები ძირითადად გამოწვეულია ამღები კომბაინის არსწორი რეგულირების შედეგად, ასევე დსტატიაში შესწავლილია ქვეყანასი გავრცელებული მარცვლეული კულტურების ზომითი მახასიათებლები, და არსებულიკომბაინების შედარებითი გამოცდების შედეგები დანაკარგებზე.

Moisture-retaining, erosion-proof, soil compactor profilator

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As a result of the steady increase of the planet's population, global warming and unpredictable political-military actions, the threat of humanity's food and, above all, grain is significantly increasing. In this regard Georgia is in a particularly difficult situation. Enough to say that the share of grain supply does not exceed 15-19%. By the decision of the government, the above figure should be increased to 50%. Given that extensive development resources are virtually non-existent, the only way is to introduce modern technologies and advances to scientists.

From the various ways of increasing yields, today we will discuss the issue of soil fertility and moisture supply. By reducing erosion and introducing moisture-retaining technologies.

According to science, 46% of arable land in Georgia is completely or partially degraded by water and wind erosion, and this figure is steadily increasing. The result is a significant reduction in crop harvest.

The main reason for this is the location of a large part of the agricultural land on different slopes and ploughing the land - by reversing the traditional clod. The loss of fertile layer in eroded areas is on average 10-15 tons per hectare. In order to reduce erosion, the scientists have developed (1) numerous measures and technical means. The basic is - cultivation of the soil across the slope, ploughing with chisels without turning the clod, zero and minimal cultivation, formation and connection of catchments and cracks, arrangement of terraces, compaction of the area, etc.

As it is known, in unirrigated areas sown with cereals, agro-technical requirements include soil compaction with special rollers.

Due to compaction, the soil tightens and its drying decreases, which promotes the rapid emergence of seeds.

On the other hand, with the onset of heavy rainfall, it sinks slightly into the compacted soil, rapidly shifting in the direction of slope inclination and thus only a small portion of the rainfall remains to provide the plant with moisture.

In order to significantly reduce erosion and maximize retention of incoming rainfall in the soil, we have modernized grain-sown areas, soil compaction, serial production roller.

This avoided the need to create new equipment and introduce it into the machine system, which significantly increased production costs.

Fig. 1 shows a photograph of an experimental sample of a soil compactor profilator.

When the prophylactic rolls over, it forms small bays (pits) in the soil. Precipitation generated during rain or snowmelt can not be diverted in the direction of inclination, but rather accumulates intensively in the bays and flows downwards, creating a solid supply of moisture. After saturation with moisture the bay is filled and thus forms a kind of drip reservoir where moisture is gradually supplied to the root system.

Fig. 1. Experimental sample of the profilator.

1-Compactor roller; 2-Cam; 3-Pillar.

When the prophylactic rolls over, it forms small bays (pits) in the soil. Precipitation generated during rain or snowmelt can not be diverted in the direction of inclination, but rather accumulates intensively in the bays and flows downwards, creating a solid supply of moisture. After saturation with moisture the bay is filled and thus forms a kind of drip reservoir where moisture is gradually supplied to the root system.

The machine is very simple and reliable in operation. Its main technical-operational characteristics are given below:

2. Area of application: not irrigated areas located on slopes of 0-12 degrees. (0 to 20 degrees when using a mining tractor)

1. Machine type- Modernized complete compactor roller
2. Roller’s diameter --- 700 mm
3. Length of Roller ---- 1400 mm
4. Number of cams ---- 9 to 18
5. Cams dimensions a) 150x11,5x80 b)300x 11,5x 80
6. Layout-- a) Linear b) Zigzag
7. Number of rolls --- a) Experimental-1 b) Serial - 3
8. Profilator mass - from 350 to 1100 kg
9. Inert mass --- water or ballast up to 500 and 750 kg
10. Required power 12-15 kW
11. Working speed from 1 to 2 m / s
12. Specific pressure on cams a) in statics - 0.25 MPa b) in dynamics - 0.37 MPa
13. Operational production a) Experimental -0.5 h / h b) Serial 1.5 h / h.

It should be noted that the basic parameters of the profilator are selected in a way that the area between the selected bays is compacted in accordance with the requirements of the serial machine, which on the other hand significantly eliminates land reclamation in the resulting bays.

Laboratory and agricultural tests were performed on the experimental sample of the profilator. Soil background-ploughed, cultivated area (Fig.2).

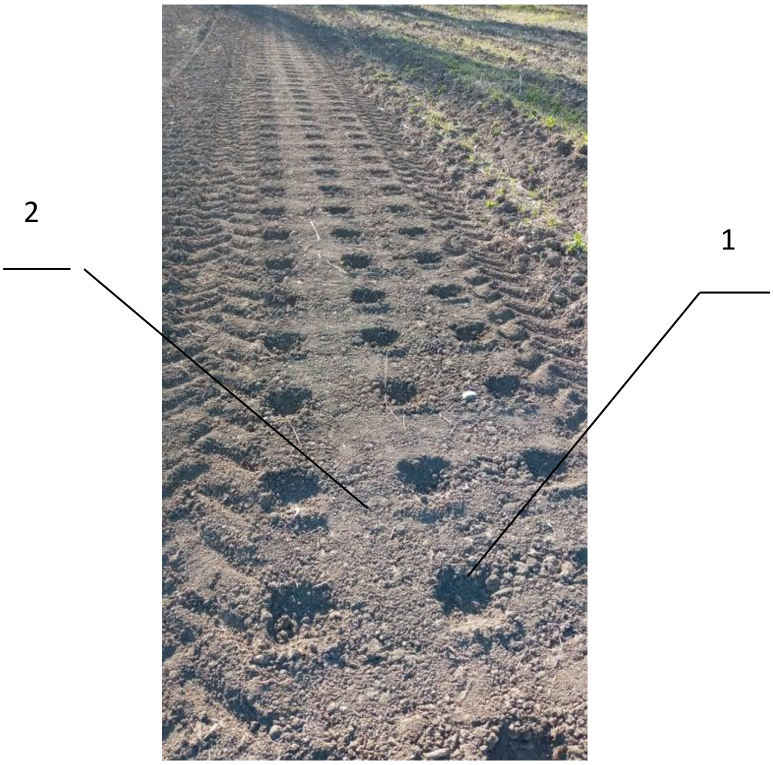

Fig. 2. Shows a photograph of bay collecting sediment created in the soil with a profilator.
1 - Moisture retaining bays 2. Rammed zone remaining between the bays.

Examinations have shown that the water-retaining resource of such bays is 650-700 tons per hectare, which is approximately in line with the norm per hectare of irrigation. After appropriate changes in the parameters of the working bodies, it is planned to test the profilator in corn and sunflower crops, as well as in areas located on perennial crops and on pastures.

The final results will be presented at the end of the year after a large-scale production test.

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საქართველოს სოფლის მეურნეობის სამეცნიერო-კვლევითი ცენტრი, თბილისი, საქართველო

ანოტაცია. წყლისმიერი და ქარისმიერი ეროზიის ზეგავლენით მნიშველოვნად მცირდება ნიადაგის ნაყოფიერება და შესაბამისად ს.ს. კულტურების მოსავლიანობა, ზიანი ადგება გარემოს.

ეროზიის ძირითადი მიზეზია ფართობების მდებარეობა ფერდობებზე და ნიადაგის ხვნა

ბელტის გადაბრუნების გზით.

მეცნიერების დასკვნით საქართველოში ეროზირებულია საერთო ფართობის 46% და ეს პროცესი განუხრელად იზრდება.

განხილულია მეცნიერების მიერ შემოთავაზებული ეროზიის შემცირების რეკომენდაციები და ტექნიკური საშუალებები.

ფერდობებზე მდებარე ურწყავ ფართობებში, ეროზიის შემცირებისა და მოსული ნალექის ნიადაგში ტენშეკავებულობის უზრუნველყოფის მიზნით, შემოთავაზებულია ნიადაგის სრული სატკეპნი საგორავების მოდერნიზაციით მიღებული კონსტრუქცია- ნიადაგის სატკეპნი პროფილატორი, რომელზედაც განლაგებულია სპეციალური მუშტები.

ტრაქტორზე აგრეგატირებული პროფილატორი გადაგორებისას, ნიადაგში ტკეპით წარმოქმნის მცირე უბეებს (ორმოებს). მოსული ატმოსფერული ნალექი, გროვდება უბეებში და ჩაედინება რა სიღმეში, ქმნის ტენის მარაგს. ტენით გაჯერების შემდეგ, უბე ივსება და წარმოადგენს ერთგვარ რეზერვუარს, საიდანაც წყალი თანდათანობით მიეწოდება მცენარის ფესვთა სისტემას.

ამგვარად ერთის მხრივ არსებითად მცირდება ეროზიის პროცესი, ხოლო მეორეს მხრივ მოსული ნალექი რჩება ნიადაგში და კვებავს მცენარეს. ექსპერიმენტალური ნიმუშით შექმნილი უბეების რაოდენობა შეადგენს 60 000-ს, ხოლო ტენშეკავების რესურსი 650-700ტნ-მდე ერთ ჰა-ზე.

პროფილატორის სამეურეო გამოცდებმა გვიჩვენა დადებითი შედეგები მისი გამოყენება მუშა ორგანოების ოპტიმიზაციის შემდეგ იგეგმება არამარტო ერთწლიან, ასევე მრავალწლიან რიგთაშორისებშიც და საძოვრებზე.

საკვანძო სიტყვები: ტეშემკავებლობა, პროფილატორი, ეროზია, ნიადაგის ტკეპნა, სატკეპნი საგორავი.