INTERNATIONAL SCIENTIFIC JOURNAL

MECHANIZATION IN AGRICULTURE & CONSERVING OF THE RESOURCES



Issue 5
2018

Year LXIV, ISSN print 0861-9638, ISSN web 2534-8450

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING INDUSTRY-4.0
BULGARIAN ASSOCIATION OF MECHANIZATION IN AGRICULTURE

PUBLISHERS

SCIENTIFIC-TECHNICAL UNION OF MECHANICAL ENGINEERING "INDUSTRY-4.0"
BUGLARINA ASSOTIOATION OF AGRICULTURAL MACHINERY

ISSN (PRINT) 0861-9638, ISSN (WEB) 2534-8450

YEAR LXIV ISSUE 5 / 2018

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APPLICATION OF ELECTRONIC SYSTEMS FOR CONTROL AND NAVIGATION IN AGRICULTURE

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Abstract: The agricultural machines become more and more complex and complicated systems aimed to produce cheaper and plenty of agricultural products. The modern farmers uses computer technology and equipment not only for monitoring and analysis of the financial results from his activity, but also for expert assessment of yields, state of soil, crops, animals, machinery, product parameters, climatic conditions. Being acquainted with the principles of operation, structure, parameters and modes of adjustment and work with such electronic systems is becoming an obligatory part of the training of agricultural production experts.
***KEYWORDS**: ELECTRONIC SYSTEMS, CONTROL, NAVIGATION, AGRICUTURAL MACHINES*

1. Introduction

Though slower at first, in the second half of the 20th century, electronics has been introduced at a growing pace to occupy a key position at every stage and level of agricultural production today. The modern farmer is using computer technology and equipment not only for monitoring and analysis of the financial results from his activity, but also for expert assessment of yields, state of soil, crops, animals, machinery, product parameters, climatic conditions. Every modern tractor and harvester is equipped with on-board computer, many computer modules and dozens of sensors, necessary for the precise and efficient work with these machines. Being acquainted with the principles of operation, structure, parameters and modes of adjustment and work with such electronic systems is becoming an obligatory part of the training of agricultural production experts.

2. Electronic systems for monitoring and control of precise and fused sowing

The most important technological parameters, which determine the quality and efficiency of sowing are: rate of sowing, depth of laying of seeds, pressure/vacuum of air flow (for pneumatic/vacuum seed drills), percentage of single, zero, double and triple sockets (for precise sowing). Measuring most of these parameters during work with electronic devices is done for the serial seed drills. The electronic systems in the seed drills can be classified in two groups (generations): first generation with basic functions and second generation – with extended capacities.

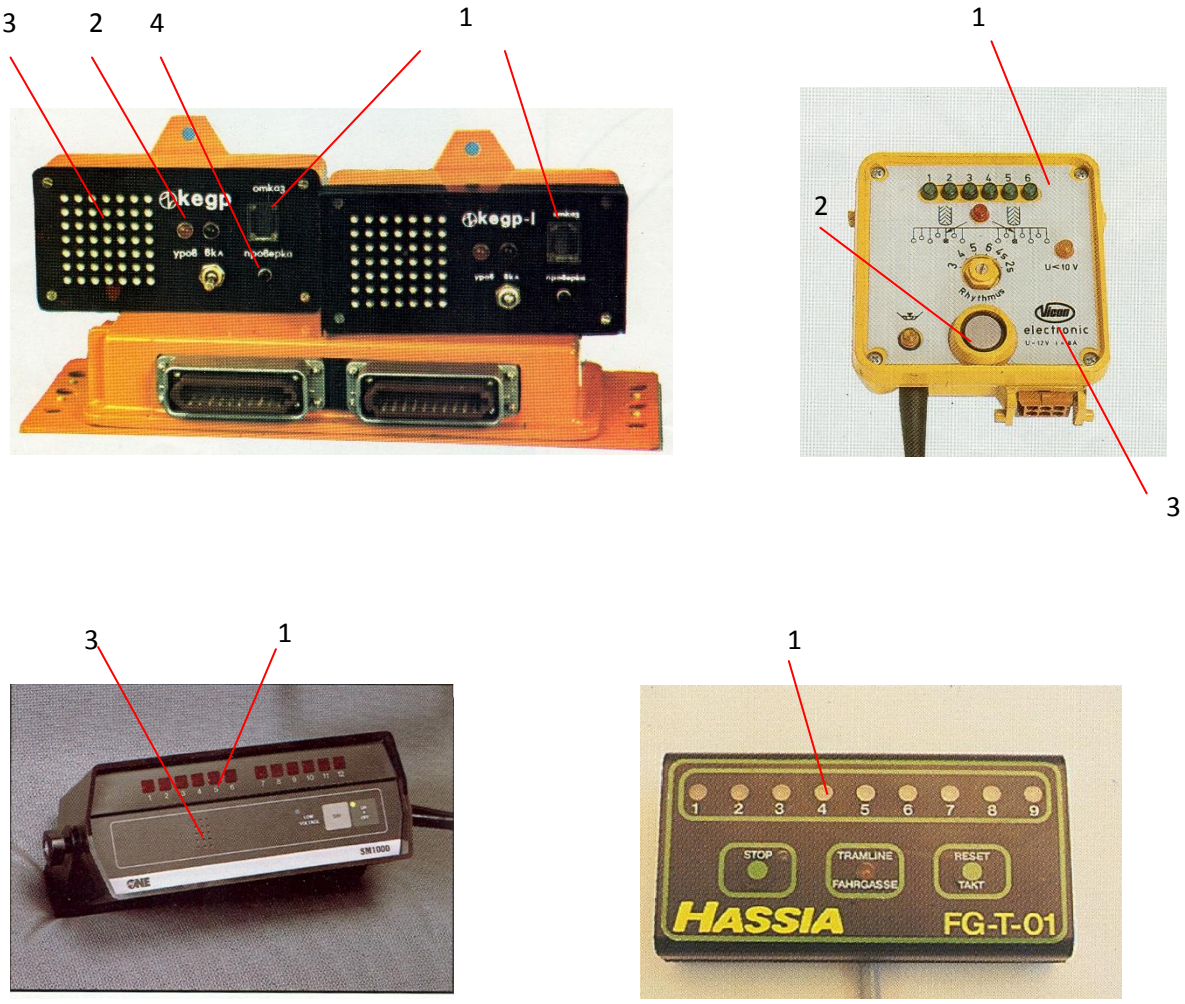


Fig. 1. Systems for control of first generation precise and fused sowing:
1 – light signal for non-sowing boot(s); 2 – light signal for minimum level in the seed box; 3 – sound signal for non-sowing boot(s); 4 – button for cable and sensor self-diagnostics

Controlling the flow of seeds through the boots is carried out by optical sensors. Infrared LEDs are used as light source while the receiver is a photodiode or phototransistor. The mounting location of the sensors is below the metering unit or in the boot (fig. 2).



Fig. 2. Mounting location of the seed sensor

Second generation electronic systems are microprocessor systems (controllers), which, besides fulfilling basic functions, can count the seeds planted by each boot, measure the area sown, calculate the instantaneous and average value of sowing rate, switch sections on and off (fig. 3).



Fig. 3. Second generation controllers:
1 – display; 2 - keypad, regulators; 3 – sound signalling device

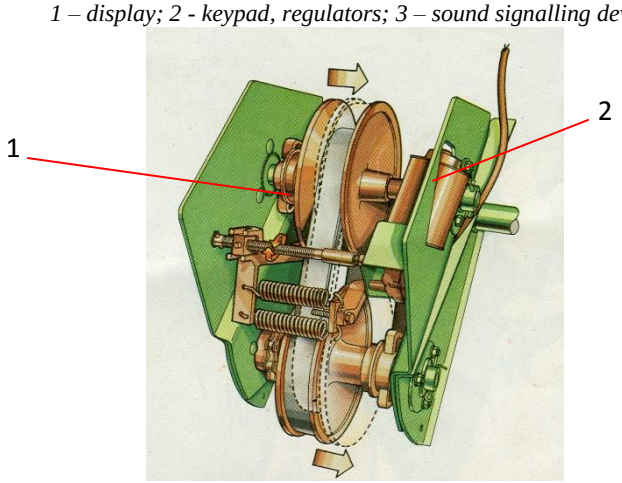


Fig. 4. Mechanism for regulating the distance between seeds (rate):
1- variator 2 – electric motor

3. *Calibration of the sensor for the distance covered by the seed drill and adjustment of seed sensors.*

One of the signals, sent to the seed drill controller by the sensor, is for distance covered. The sensor is normally

mounted on one of the seed drill's wheels. Most often inductive type of sensors are used (fig. 5). Using it, the computer can calculate the distance covered L, m and the area sown S, m^2:

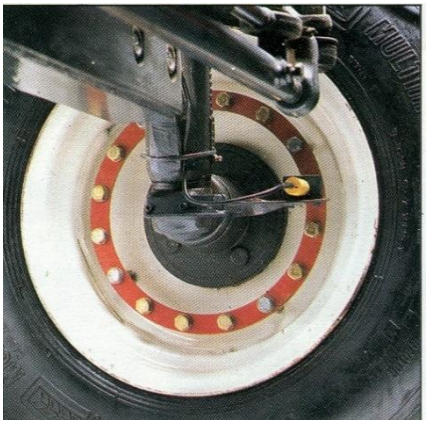


Fig. 5. Mounting location of the distance sensor

Sensitivity S of the optical sensor for seed flow has to correspond to the type of crop. For normal work of the sensors with specific size of seeds, it is necessary to adjust the value of the coefficient for amplifying their signal. The producers enclose in the Manual a table with calculated values S for each type of seeds sown and the operator should only enter the specific value in the system's memory. For example, for the electronic system MC 800G (fig. 6) of Gaspardo seed drills, the Table looks like it is shown on fig. 7.



Fig. 6. Control system MS 800G

Corn, sunflower	Beet	Soy beans	Small seeds
S=4-6	S=6-9	S=7-12	S=12-19

Fig. 7. Table for sensitivity S of the seed sensors

4. Technological requirements and main parameters of the processes and machines for spraying and fertilising.

The technologies and machines for spraying and fertilising used are different, depending on: the type and stage of development of the crop or plants; the production technologies to be used; the degree of infection, weed growth and the biological requirements of crops/plants, etc.

The most important technological parameters, defining the quality and efficiency of spraying and fertilising, are: rate (l/dka, кg/dka); uniformity of spraying/fertilising by working width and by area; mean diameter of drops; degree and uniformity of spraying the foliage.

5. Electronic systems for monitoring and control of machines for spraying and fertilising.

The electronic systems that control or manage the processes of spraying and fertilising are a standard part of equipment for the machines used for these processes in the developed countries. The reasons for this are: the high price of sprays and fertilisers, the environmental standards for the content of harmful substances introduced and strictly observed for agricultural products, the possibility of slowing growth or damaging crops with elevated rates of spraying and fertilising.

The most important technological parameters, determining the quality and efficiency of spraying and fertilising are: rate (l/dka, кg/dka), uniformity of spraying/fertilising by working width and by area, mean diameter of drops, degree and uniformity of spraying the foliage, liquid/air flow. Most of these parameters are measured at work by electronic devices for the serially produced machines for spraying and fertilising.

The electronic systems in the machines for spraying and fertilising can be classified in two groups (generations): first generation with basic functions and second generation – with extended capacities.

The representatives of the first group have unsophisticated construction and can be executed without the use of microprocessors.

The second generation electronic systems are of the microprocessor type (controllers), and besides the basic functions they can also perform:

- measuring of the spraying/fertilising rate
- regulating the rate from the cabin
- automatically maintaining the rate set and its uniformity

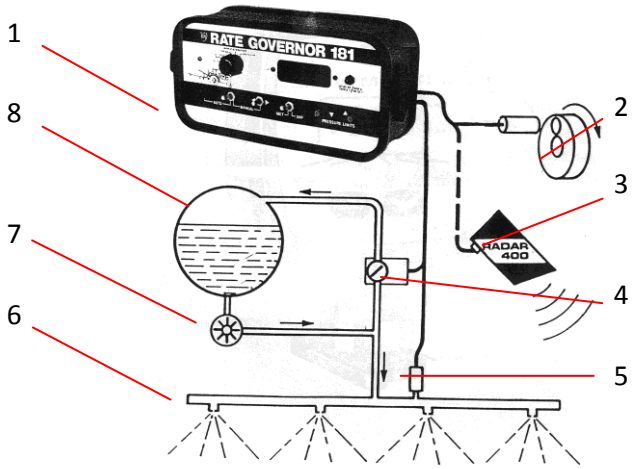


Fig. 8. Diagram of automatic sprinkler control system:
1 –electronic block; 2 – inductive speed (distance) sensor; 3 –optional radar speed (distance) sensor ; 4 – electronically controlled valve; 5 – pressure sensor; 6 – sprinkler bar; 7 - pump; 8 – working liquid container.

By continuous measuring of machine's speed and work pressure the electronic block determines whether the rate set by the operator is ensured. If necessary, a control signal is sent to the controllable valve for the respective pressure change. In this way, the system guarantees observing the rate and uniformity of spraying the work liquid with fluctuating speed of the machine, caused by the terrain or the state of the soil.

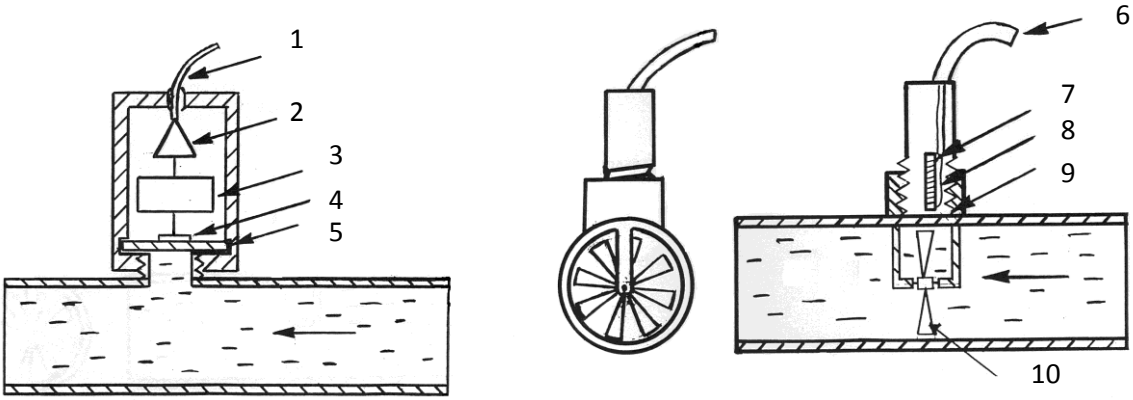
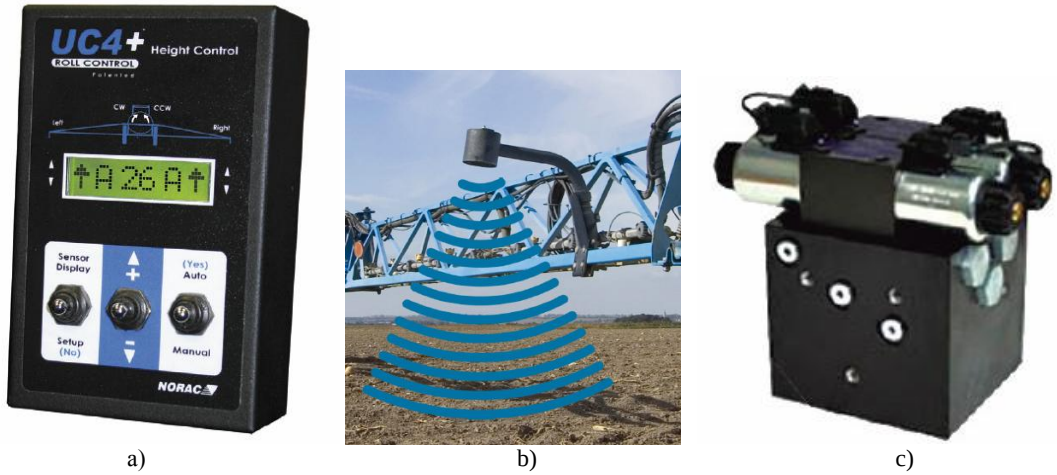


Fig. 9. Pressure and flow sensors:
1,6 – output cable, 2 – amplifier, 3 – temperature compensation, 4 – tensoresisto r, 5 – membrane, 7 – coil, 8 – magnet, 9 – clearance, 10 - fin

Machines with operational width of over 10 m are equipped with electronic systems for maintaining the height of the wings (fig. 10). The operator should set the desired working height to the soil surface or the crop from the control panel. This automatic control allows to maintain a constant height of spraying along uneven terrain, thus helping to achieve high quality results from the operation. Using such an electronic system allows machine spraying up to 40 m work width and up to 30 km/h working forward speed.



a) b) c)

Fig. 10. Elements of a system for maintaining the height of the wings:
a) – controller in the cabin; b) – ultrasound emitter and receiver of the wing; c) – proportional electro-hydraulic distributor

Contemporary models of electronic control systems for spraying and fertilising machines (fig. 11) have touch screen displays, including coloured ones, with a number of additional functions: switching on/off nozzles by sections, alerting for large deviations from the rate, recording the parameters at the time of spraying/fertilising on the SD card, possibility for connection to a GPS system and working on a variable rate card.



Fig. 11. New generation electronic systems for spraying and fertilising

The service staff should make some one-time adjustments to provide the correct operation of the system. For example, real data for the work width of the machine, type of nozzles, sensor parameters for pressure/ flow, rotational frequency of the pump, amount of work liquid in the tank and speed of movement should be entered into the controller's memory. These settings are only updated if other nozzles are mounted or a faulty sensor is replaced.

For some machines the type of nozzle is selected by a computer. Prior to starting work, the operator enters the desired value of the rate and the mean value of the machine's forward speed, using the keypad. By starting a nozzle selection menu, from the list on the display the appropriate type of nozzle can be selected, which would provide optimal operation at the desired rate and speed. The nozzles standardised under ISO have lettering and the respective colouring: A – orange, B – green, C – yellow, D – blue, E – red, F – brown, G – grey and H – white. For each nozzle, its work pressure is displayed. The nozzle which falls within the interval, calculated by the controller is selected (fig. 12). For the specific example from the figure, this is nozzle type E with work pressure 2.6 bar, which falls within the interval calculated from 1.2 to 4.7 bar.

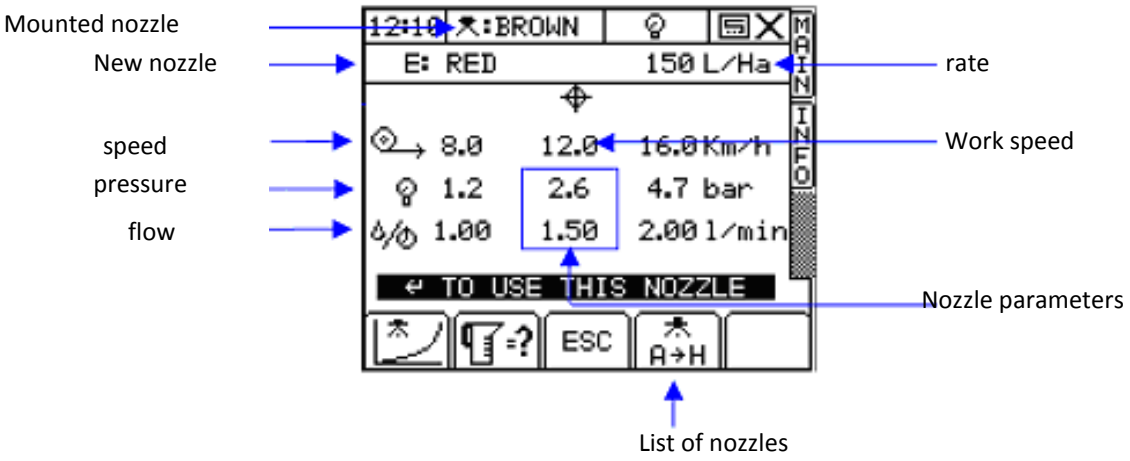


Fig. 12. Dialogue screen for nozzle selection

Another important setting to be performed by the operator is entering a real value of the solution's density. Through this value, the controller calculates the pressure, flow, controlling impacts and other parameters of the machine at work.

Due to wear of the nozzles, at the beginning of each working season for the machine, the flow sensor is calibrated. Electronic systems for precise rate control are fitted as a standard feature in the machines with a direct injection system for spraying (fig. 13 and 14) and ensure dynamic control over the solution parameters. Manual control is not applicable at all for such machines.

6. Electronic systems for control of machines with direct injection.

Modern technologies for precise and environmentally-friendly agriculture require the use of a new generation of spraying machines, in which the spraying solution is dosed through an injection pump and the concentration needed is obtained during operation.

Electronic systems have been designed for such machines (fig. 5.13), in which water flow is adjusted at the start of the operation by regulating the pressure valve.

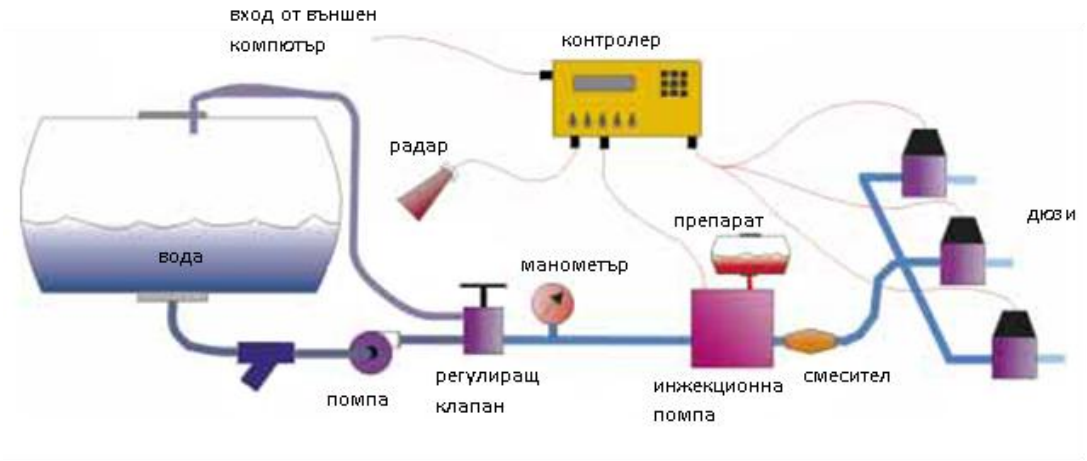
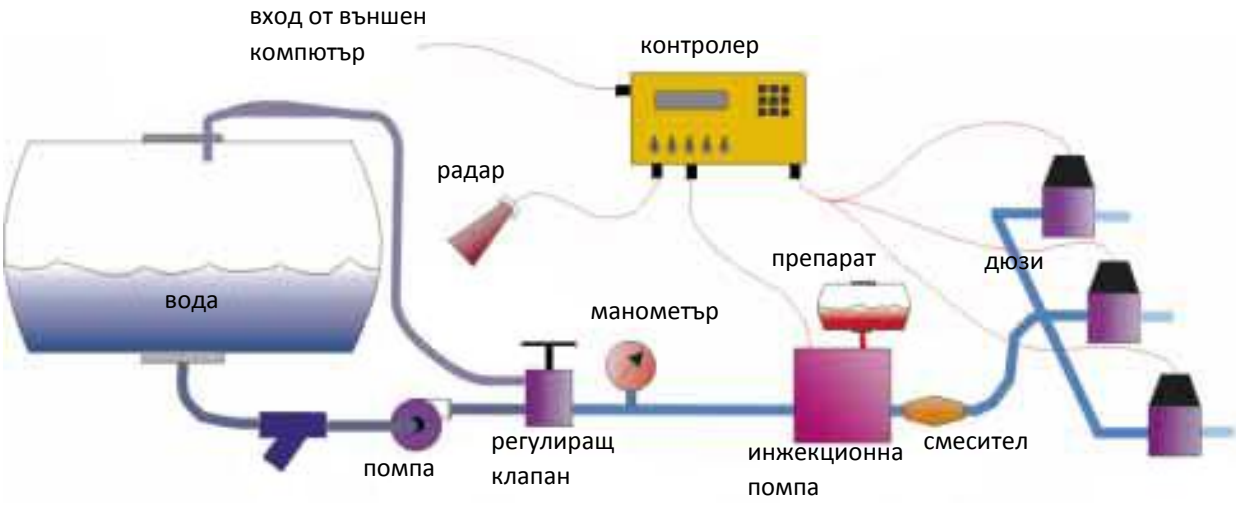


Fig.13. Control system for machines with direct injection of spray and constant water pressure

Introducing a second adjustable parameter (fig. 14), namely, the water flow, shortens the time to achieve the desired concentration of the solution and the norm for its application, which is a considerable advantage during treatments with variable rate. This increases the precision of machine operation when using an external computer.



Using machines with direct injection of spray and embedded electronic systems provides a number of technological, ecological and economic advantages. Highly accurate dosing at minimum costs is achieved through computer control of spray injection. The process is automatically controlled and the operator does not have a direct contact with the spray dosing organs, so for him the health risk is minimal. At the end of the work, the operator and the environment are less exposed to the risk of contact and contamination with toxic substances, because the tank contains pure water. The remaining substance for spraying remains undissolved and is often in its original container, which can be put aside and stored safely for further use.

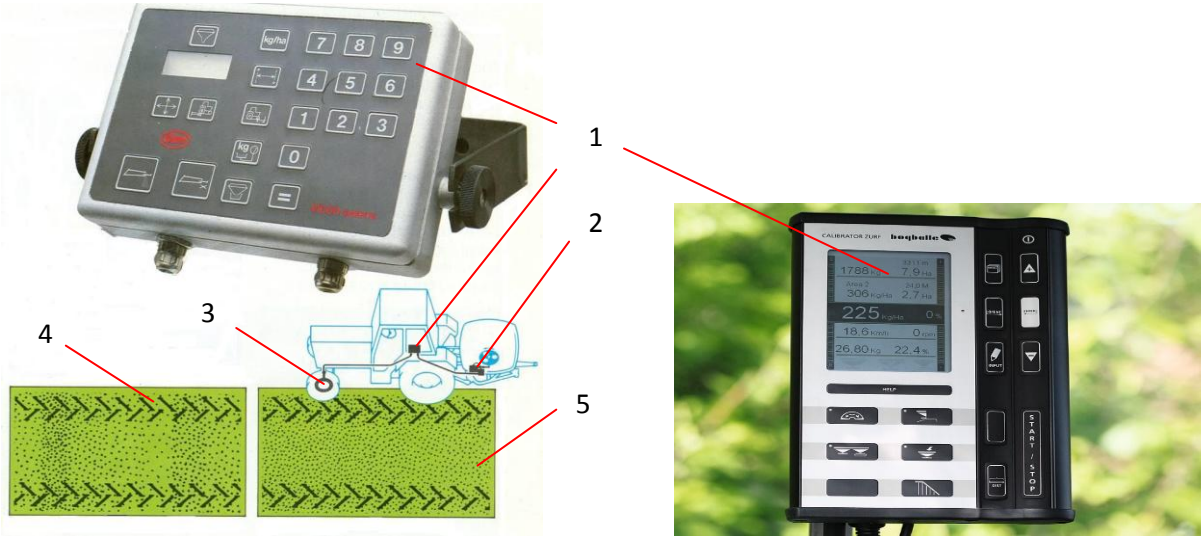


Fig. 15. Electronic control of machine for granulated fertilisation:
1 – controller, 2 – electrically controlled dispenser, 3 – speed sensor, 4 – system turned off, 5 – system turned on

Electronic systems of the type shown on fig. 15 are used in the machines for granulated fertilisation. The controller 1 sends a signal to the dispenser 2, to regulate the feeding of granules to the dispenser, depending on the changes in its forward speed, measured by the sensor 3. This guarantees an even distribution of the granules over the treated area, in compliance with the prescribed fertilisation rate.

In some models, sensors for the weight of fertiliser in the hopper are incorporated, which allows the system to calculate the rate of fertilisation at any moment and to maintain it precisely at the value set by the operator. For a construction with two disc dispensers, switching the rotation direction is introduced, as well as their individual start and stop. When such a system is equipped with a GPS navigation module, the framing of the field is carried out automatically, in compliance with the rate and its uniformity along the whole fertilised area.

7. Electronic systems in the tractors.

Using the achievements of microelectronics, all world producers are developing electronic systems, consisting of main (on-board) computer and subordinate computer modules for control of individual tractor units and the aggregate working machine.

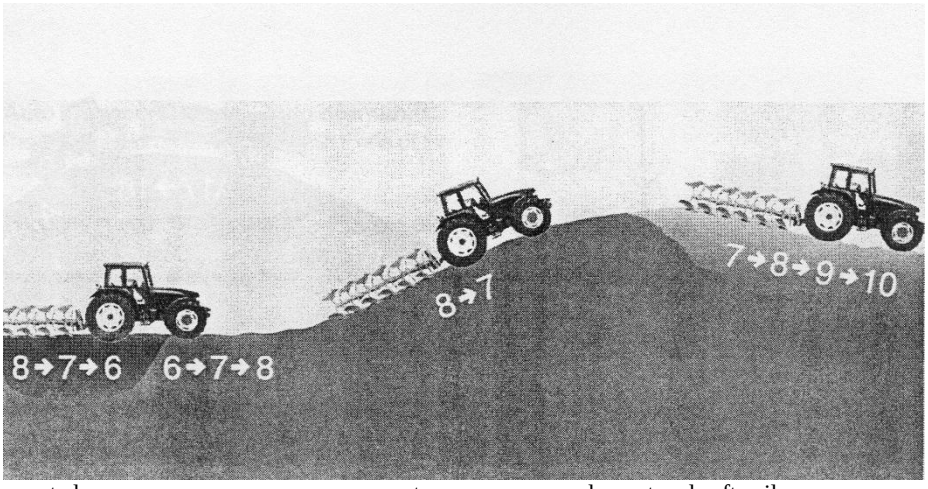
With the improvement of the element basis of electronics in the on-board computers in tractors, new features and functions are introduced – the displays are coloured, a slot for SD memory card is added. Features for automatic control of working machines, for recording the parameters and reporting in electronic form, for manual and automatic programming of the turns at the end of the field have been embedded and opportunities for connecting a GPS receiver and creating a map of the work done, etc.

The further development of on-board computers is related to gradual introduction of standards, e.g. ISOBUS, enabling the interconnections of electronic control modules for inventory of various manufacturers, building-in touch control displays, strong development of self-diagnostic system, adding modules for automatic driving and Internet connection.

The computer systems in tractors today are assigned many functions that can be classified in the following groups:

- related to control of the engine, transmission, towing system, chassis (maintaining constant speed and frequency of the engine), power take-off shaft;
- for an interactive information connection to the tractor driver – regulations, calibrations, monitoring of current values, signalling;
- for tractor driver counselling in terms of optimal and safe operation, technical service, etc.;
- for avoiding tractor accidents;
- providing reporting of results and costs;
- providing comfort to the tractor driver;
- for self-diagnostics of all controllers, executive devices, sensors and their cable connections;
- for determining the exact tractor and machine location;
- for automatic driving during field work and when turning at the edges of the field.

The systems for control of the engine operation automatically control the automatic fuel injection, thus helping to achieve fuel consumption reduction, as well as limiting harmful emissions into the atmosphere. In tractor series T6, T7 and T8 of New Holland, the system supports ECOBlue™ SCR (selective catalytic reaction) technology, where the control system injects a catalyst (aqueous urea solution) from a special tank into the exhaust gases to decompose the harmful nitrogen compounds. Thus a compliance with Tier 4A standard for environmental compatibility is achieved while eliminating exhaust gases recirculation leads to an increase of power and decrease of fuel consumption over 10 % from the Tier 3 standard. Producers also determine longer intervals for technical servicing of tractors, which are equipped with such electronic systems.



compacted zone ascent descent and soft soil

Fig. 16. Adaptive automatic gear switching

One of the controllers of the modern tractors is designed for precise control of the rear and front (if mounted) hinged systems (fig. 17). Through its console (fig. 18) the hinged system functions are set.

When performing operations, related to soil treatment, the mode of maintaining a constant load of the tractor leads to economic fuel consumption. The impact load and the wear on the machine's operating parts, the units of the hinged system, the transmission and the engine are reduced. The even load on the tractor reduces the vibrations in the cabin and the driver's fatigue.

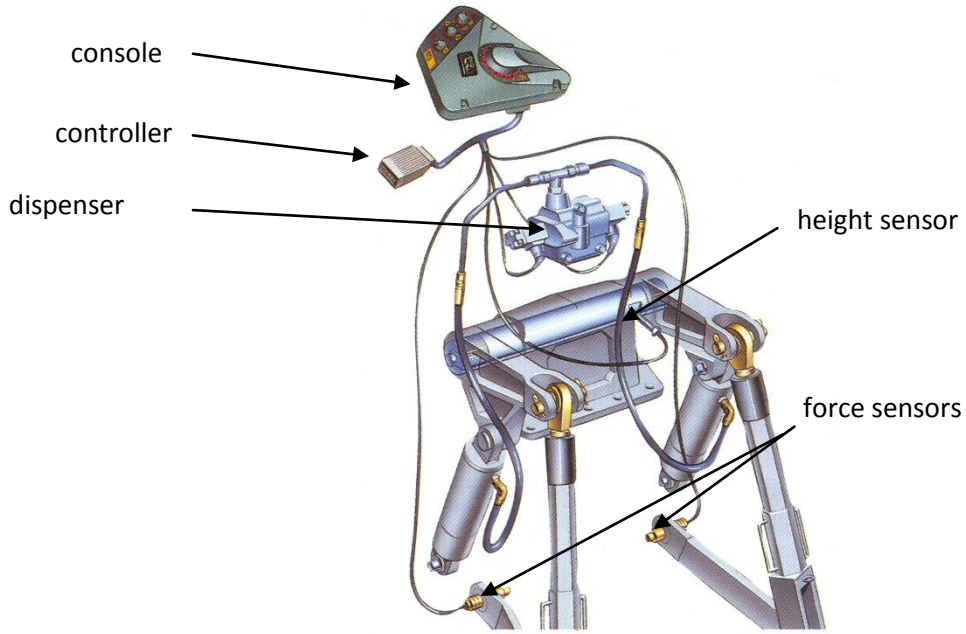


Fig. 17. Hinged electronically controlled system

Locking of the hinged system by the descent speed regulator has one more crucial role. In that position, the controller tracks the speed and if it exceeds a specific value (in most cases 8-10 km/h), it starts tracking the oscillations of the hinged system, caused by the machine. Through the regulator 3 (fig. 18) the tractor driver sets the maximum lifting height of the hinged system. This is necessary when working with mills, mowers, pneumatic seeders, and other machines driven by the power take-off shaft of the tractor through a transmission shaft, due to the limits to the rotation transmission angle. There should be height limitation when operating machines that don't have such drive, but would affect the cabin and other parts of the tractor if unrestrictedly lifted. When working with hinged ploughs, the lifting height should be the maximum possible and the regulator should be at extreme right position.

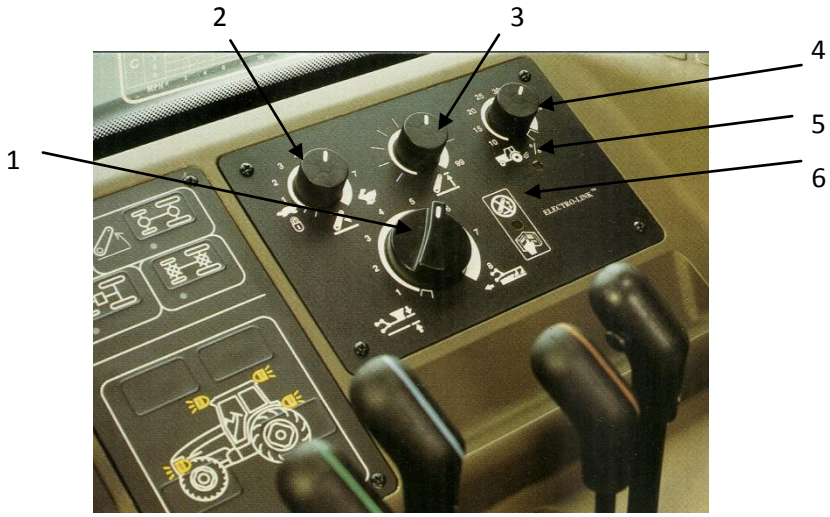


Fig. 18. Console for hinged system settings

In the tractors, equipped with a radar sensor for speed, the controller of the hinged system maintains also a function for automatic limitation of logging in tillage operations.

The main parameters of the tractor, observed on the driver's panel are:

- crankshaft rotation frequency; forward speed; power take-off shaft rotation frequency; distance, cultivated area, productivity; temperature of the engine and of the transmission oil; oil pressure in the engine and in the transmission;
- fuel consumption; engine hours; remaining time to maintenance.

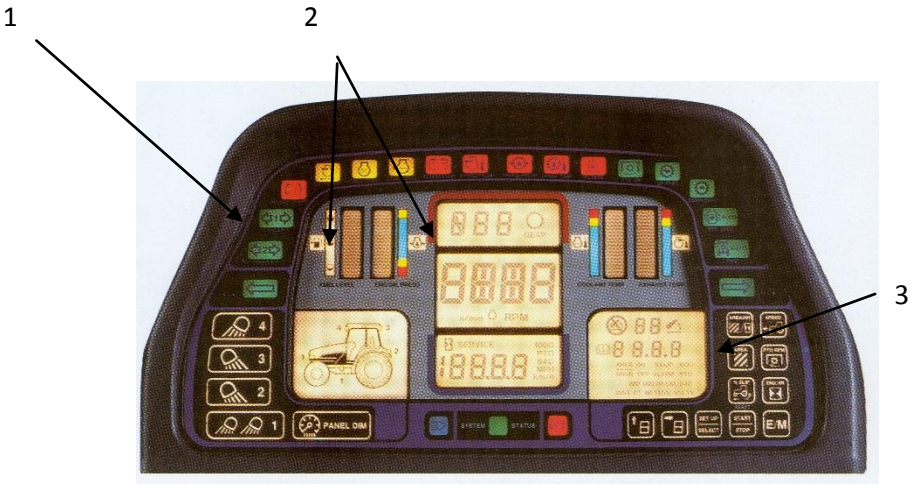


Fig. 19. Electronic instrument panel seen by the tractor driver

The layout of signal lamps 1, instrumentse 2 and keypad 3 (fig. 19) is in line with the ergonomic rules. The red light for pressure or oil temperature in the engine or in the transmission is always combined with the respective sound signal. This is a sign of a major accident and the tractor driver should immediately stop the tractor and turn off the engine. If this is not dine within a few dozens of seconds, the on-board computer turns off the engine by stopping the fuel flow. The manufacturers provide for the possibility for starting the engine after such a situation, but only to move the tractor a few metres with the purpose of taking it off the road and putting it on a platform.

Before the start of work the tractor driver needs to enter the values of inventory working width and the radius of the tractor rear wheel into the memory of the computer. These data are necessary for calculating and reporting the distance covered, logging, cultivated area, productivity, etc.

8. Computer diagnostics of failures.

In addition to driving the tractor and performing a number of manual or automatic adjustments, the on-board computer system performs internal self-control of dozens of parameters, related to its operational processes. Each current value obtained is compared to the nominal one and if there is a deviation from the allowed values, the self-diagnostic system shows on the electronic instrument panel display a failure code of the type Fxxx, where xxx is the number, identifying the specific failure.

Simultaneously, the system records the code in the failure memory log, together with the time and date of its appearance. A sound signal is also heard in the cabin. All failure codes are usually classified into three groups, depending on the severity of the failure. On the same sign a sound signal is emitted with a different rate of recurrence.

9. Calibration of electrical and hydraulic transmissions.

Another important task assigned to the on-board computer in the tractor is calibration of clutches in the electrical and hydraulic transmissions. This can be carried out in a semi-automatic or fully automatic mode. The requirements for performing the calibration are: the tractor should be stopped on an even terrain, the hand brake should be on, the engine should be working at the revolutions given in the instruction, all electric consumers and hydraulic devices should be switched off, the temperature of the transmission oil should be within the limits pointed in the instruction for calibration.

10. Electronic systems in harvesters.

Today grain harvesters are the most electronically mobile machines in agriculture. Several computer modules are integrated in them, as well as dozens of sensors and adjusting executive devices.

The driver of the harvester is not engaged and his tasks are to monitor the accurate work and to react in situations when the automation fails to work adequately or its automatic intervention is not foreseen.

The computer systems in grain harvesters are assigned numerous functions, which can be classified in the following groups:

- related to control of engine, headers, threshing and scrubbing systems, transmission and double transmission;
- for interactive information link with the driver – regulations, calibrations, monitoring of current values, signalling;
- tips to the driver in terms of optimal safety, maintenance, etc.;
- ensuring the harvester against accidents;
- ensuring reporting of operation and costs;
- providing comfort to the driver;
- for self-diagnostics of all controllers, executive devices, sensors and their cable connections;
- for measuring yield and grain loss;
- for automatic horizontal alignment of the harvester;
- for automatic load maintenance;
- for determining the exact location of the harvester and creating a map of yields;
- for automatic driving during operation on the field and turning at the edges.

Each of these functions or several of them are fulfilled by individual controllers, connected into a common CAN network, using unified standards for connection and communication. The engine control system controls the automatic fuel injection, thus reducing fuel consumption, as well as the harmful emissions into the atmosphere. One of the controllers in modern harvesters is designed for precise header control in operation and transportation. Automatic or manual correction signals are sent by this controller to the hydro cylinders, which move the header vertically or horizontally. The main problem while driving on the road is the oscillation of the header and that is why the header controller is assigned a function to suppress those oscillations actively (fig. 20). This mode enhances the stability of the machine, the comfort and safety of movement while allowing higher maximum speed.

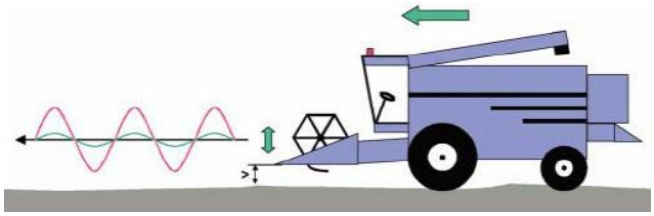
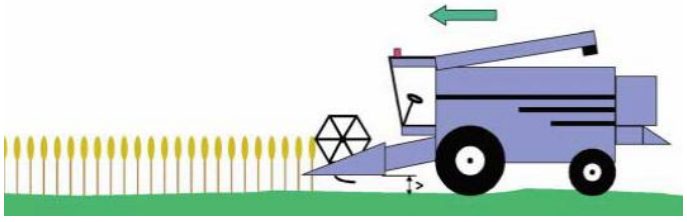


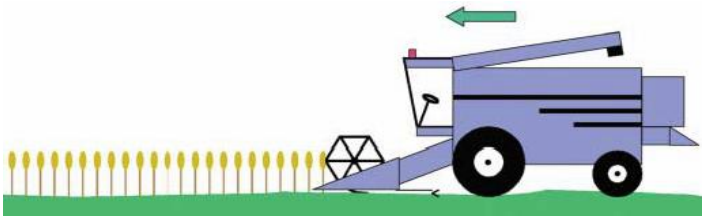
Fig. 20. Active suppression of header oscillations

The remaining automatic modes are used while the harvester is in operation and can be adjusted with precision by the driver, depending on harvest conditions. Most manufacturers offer three such modes:

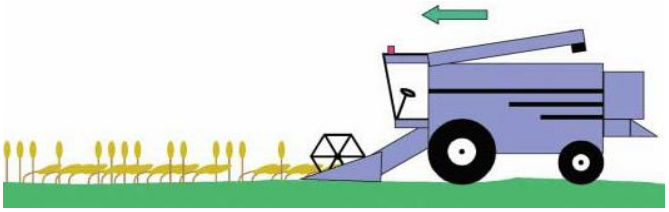
✓ keeping the header in a selected position relative to the harvester frame;



✓ copying the terrain(maintaining the header at a height adjusted to the field surface);



✓ maintaining the set header pressure to the soil.



According to the current safety standards, the computer system controls the harvester in two modes: transport (moving on the road) and operational (harvesting). It is the driver's responsibility to switch to transport mode once the machine leaves the field and joins the road with other vehicles, as well as to switch it off when the machine is in the field.

When it is in transport mode, the machine blocks the following actions of the driver:

- lowering the header;
- turning on the drive of the header (cutting tool and winch);
- turning on the threshing device;
- rotating and turning on the unloading auger;
- turning on the double transmission (if there is any);
- turning on the lights;
- opening the hopper lids.

The main parameters of the harvester, observed on the front panel in transport mode are:

- the gear engaged;
- the speed;
- engine rotation frequency;
- fuel left;
- distance covered;
- hour of thresher;
- engine temperature;
- current date and time.

The main parameters of the harvester, observed on the front panel in operational mode are:

- the gear engaged;
- the speed;
- engine rotation frequency;
- rotation frequency of threshing drum;
- the counterdrum gap;
- fan rotation frequency;
- grain losses in straw and from the fan;
- level of grain returned for completion.

There is also a mode in which the harvesting parameters are visualised on the display.

An important function of on-board computers is the possibility to record the operations done in one shift, section, field, etc. In some models, this information is printed by a printer fitted in the cabin, in others, it is extracted electronically to the SD memory card. The output information includes data for: the area harvested in ha, productivity ha/h or t/h, fuel consumption, average yield t/ha, harvest and overlay time h etc. When the harvester is equipped with a mobile link to the Internet, this information can be obtained and analysed on a computer with an Internet connection at any time.

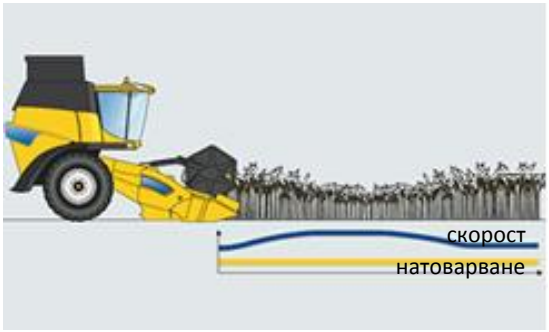


Fig. 21. Maintaining constant load

For automatic driving different principles are used, depending on the type of crops. For row crops there are systems for directing along the row trajectory (fig. 22).

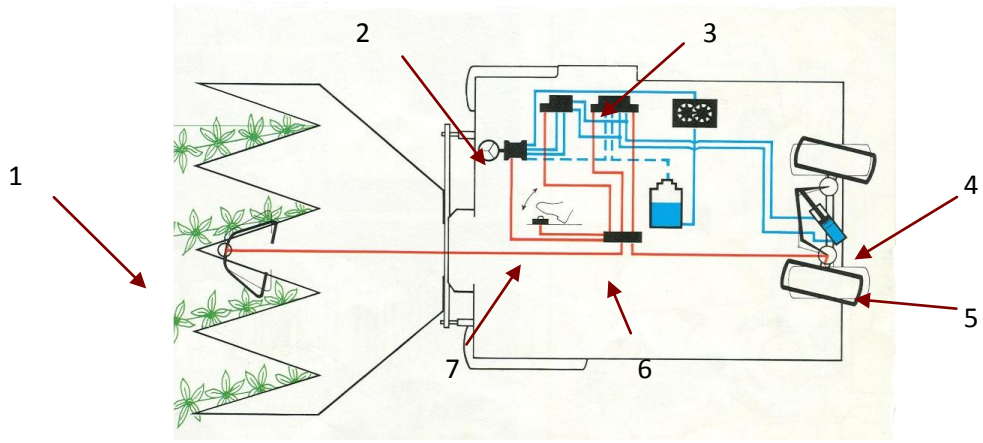


Fig. 22. Diagram for directing directing along the rows:
1 – direction sensor, 2 – steering wheel sensor , 3 – electric and hydraulic dispenser, 4 - steering wheel hydro cylinder, 5 – angle of wheels sensor, 6 – controller, 7 – key for manual/automatic mode

During harvesting of wheat, barley and other fused crops, the grain harvesters can be driven along the edge of the harvested or non-harvested area. Serial driving systems are implemented, which are equipped with a laser system for recognizing this track and automatically affect the steering system to guide the machine along it (fig. 23).

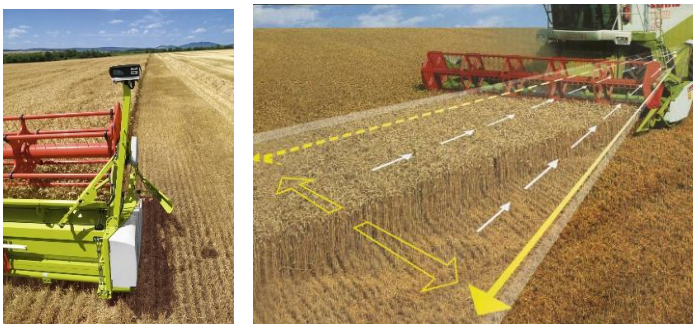


Fig. 23. Driving the harvester on the edge of the ravine

An important element of the modern harvester equipment is also the GPS navigation system. Identifying the coordinates of the machine at any moment with a precision of up to a few centimetres allows precise mapping of yields and automatic driving during operation.

The computer systems in the harvester have a special function for the so called calibrations. Through it, the driver enters numeric data for the working tools of the machine (width and type of header, type of counter drum, etc.), for precise calculation of operation parameters or adjustments. They are needed for the accurate operation of the automatic systems.

For example, the header calibration is carried out in several steps. The first one is calibrating of the header height sensor:

- the g-harvester stops at an even site;
- the engine runs at minimum speed;
- a manual mode for controlling the header is set;
- the header is placed in a horizontal position through the control buttons in transverse direction;
- the header is lowered until it touches the surface;
- a combination of buttons is pressed on the control joystick;
- the end of the relevant light or sound signal for successful calibration of the height sensor should be heard, which means that the controller has saved in its memory the signal for zero height.

At the second step, the oil pressure sensor for the oil in the hydraulic cylinders of the header is calibrated, following the respective procedure. At the third step the sensors for copying of the terrain, mounted at the two ends of the header are calibrated.

Calibration is obligatory in the following cases:

- when the type or size of header are changed, in order to maintain precisely its automatic modes and calculate correctly the harvested area;
- When the size of front wheels is changed, in order to accurately take into account the position of the header relative to the soil surface, to calculate the distance covered, the harvested area and the forward speed;
- when starting to harvest another crop, in order to determine correctly the humidity of the grain and the yield;

- when changing the counter drum and the sieves, in order to adjust them accurately;

- when there is a change of sensor, executive device (hydrocylinder, electric motor, electromagnetic valve) and controller, in order to enter the respective parameters in the computer memory. This is needed due to the presence of tolerable differences in the parameters of the new and the replaced components, or, if it is a controller – lack of specific data about the machine in its memory.

11. Controlled traffic of the aggregates in the field

Application environment. The increasing weight of agricultural aggregates is a factor, which should not be neglected, especially in the conditions of soil conservation agriculture. The pressure that such aggregates exert on the soil leads to unfavourable changes in the soil's properties. Thus, for example, clay soil loses half of its humidity when it is compacted to an extent when its bulk density increases from 1,4 g/cm^3 to 1,75 g/cm^3 [1]. Such negative consequences cannot be avoided in mechanized technologies, but they can be controlled and limited to a certain extent. One such possibility is provided by the system of controlled traffic of agricultural aggregates in the field.

Application and general provisions. The system of controlled traffic of agricultural aggregates separates the areas sown in the field from the tracks of the power machine, thus forming permanently separated zones there (fig. 24). Two main positions provide the opportunity to apply this system. The first one is related to the correct combination of the working widths with the transverse base (tracks of machines) of the machine and tractor attachments used in the production process. The second refers to the modes of driving, determining how to distinguish sections of the field.

Versions of the system for controlled traffic of the aggregates in the field. To identify the possible versions for controlled traffic in the field the diagram from fig. 24 is used. It comprises a sowing aggregate, a spraying machine and a harvester whose transversal bases (tracks) could be the same, but more often they are different.

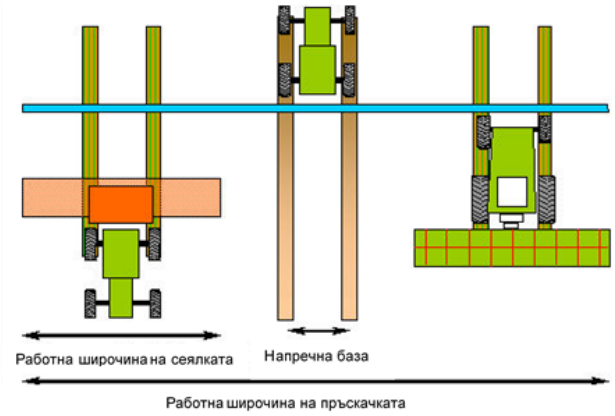


Fig. 24. Diagram for controlled traffic of the aggregates in the field

VERSION 1 – the power machines have the same tracks. To determine the traffic of the aggregates in the same tracks, it is important to set a certain proportion between their working widths. The width of the seed drill is the basic one and is assumed to be 6 m. If the widths of the other machines are the same or an integer multiples of this width, it means that they will move along the tracks, left by the two rows of seed drill wheels. In case their with is multiple of 1,5, 2,5 etc., they will alternate their traffic along the tracks left by the two rows of tires and the one left by the single row at adjacent passages.

VERSION 2 – the power machines have different tracks. Here too the seed drill's width is the determining factor. However, here this width is obtained by adding the transverse base of the tractor, to which the seed drill is attached and the transverse base of the harvester. Consequently, if the tractor's base is 1,5 m and the harvester's is 3,0 m, we obtain 4,5 m working width for the seed drill. In this case, the width of the header should be 4,5 m or 9 m, which ensures movement of the harvester along the tracks, left by one row of tractor wheels (fig. 25). Concerning the spraying machine, there are two options: it can move along the tracks left by the seed drill or those left by the harvester. In both cases the working width of the spraying machine should be an integer multiple of the seed drill's width.

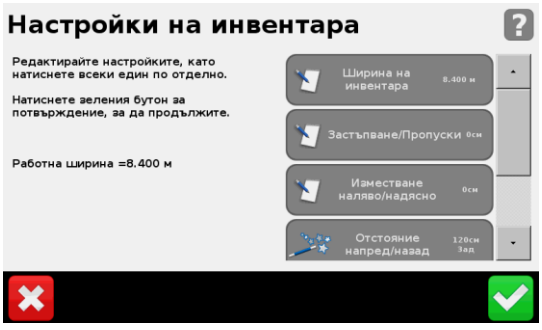


Fig. 25. Diagram for controlled traffic with different tracks

Irrespective of the version, its precision depends on the type selected for driving the machines. The most precise way to do it is to use automatic drive and GPS control. It is necessary to determine a model of navigation for the different operations (fig. 26) and the working width of aggregates id set according to the version of controlled traffic (fig. 27).



Fig. 26. Menu for choice of navigation



The system for controlled traffic of agricultural aggregates in the field should be viewed as a possible option of enhancing the effect of implementing soil conserving agriculture.

12. References

1. Hall, D.G.M., Reeve, M.J., Thomasson, A.J. and Wright, V.F. (1977) Water Retention, Porosity and Density of Field Soils. Soil Survey Technical Monograph No. 9, Rothamsted Experimental Station, Harpenden, UK, 75 pp.
2. https://www.deere.com/en/index.html
3. http://www.newholland.com/Pages/index.html

METHODOLOGY AND RESULTS OF EXPERIMENTAL STUDIES OF COMBINED UNIT FOR SUGAR BEET TOPS HARVESTING ON THE BASIS OF A ROW-CROP TRACTOR

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Abstract: *On the basis of an integrated wheel-type tractor (traction class 3.0), there was created the new combined machine and tractor unit carried out a continuous flat cutting of the sugar beet tops with a front mounted sugar beet tops cutting machine. To carry out this field experimental studies, a program and methodology was developed based on measurements of the remains of the tops on the heads of root crops after passing through the aggregate at a given rate of translational motion, the height of the installation of its rotary cutting mechanism above the level of the soil surface and the frequency of its rotation. The results of the study were statistically processed on a personal computer using regression and correlation analysis methods. Based on the developed methodology of the full-factor experiment, empirical mathematical models were constructed in the form of regression equations for the process of cutting the tops of sugar beet. According to the results of these calculations, it was found that the speed of the forward movement of the sugar beet tops cutting aggregate exerts the greatest influence on the mass of the remains of the tops on the spherical surfaces of the root heads, after a continuous main cut. In a lesser extent, this process is influenced by the rotational speed of the rotor of the sugar beet tops cutting machine and the height of the rotor installation above the soil surface level by means of two pneumatic copying wheels. According to the results of experimental studies, it has been established that the rational design and technological parameters of the process for harvesting sugar beet tops by a front mounted sugar beet tops harvesting machine with a rotary cutting apparatus is its rotation frequency equal to 960 rpm, the speed of the aggregate should not exceed 2.0 m.s^{-1}, and the height of the rotor installation should be as low as possible, not less than 0.02 m.*
KEY WORDS: SUGAR BEET TOPS, HARVEST, FLAT CUT, METHODOLOGY, EXPERIMENTAL RESEARCH.

1. Introduction

One of the key problems of the technological process of harvesting sugar beets is to remove and harvest the leaves and tops from the heads of sugar beet roots standing in the soil. Studies have shown that with modern technology harvesting of the leaves and tops of heads of sugar beet roots sometimes there is lost about 14-17% of the crop mass containing a sugar. Therefore, the problem of harvesting the tops and cleaning the heads of sugar beet roots from the remains of the tops without loss of the saccharіferous crop mass is an actual, economically justified scientific and technical problem. To solve this, it is necessary to develop a technique for experimental studies of such a combined machine-tractor unit that would allow cleaning the main sugar beet crop mass of the tops and cleaning the heads of sugar beet roots, while structural and technological implementation should ensure improved quality and technical and economic performance. The practical solution of this problem determines the relevance of this work.

The specified scientific and practical tasks of harvesting the main crop mass of the sugar beet tops and cleaning the heads of sugar beet roots standing in the soil can be solved by the development and application of combined machine and tractor units, the modular construction principle of which gives important advantages when used in production conditions [1].

The following scientific workers significantly contributed to the theory and practice of this issue in due time: Pogorevshshiy L.V., Bulgakov V.M., Toporovsky S.A., Gurchenko O.P., Tatyanko N.V. and other scientists [2-6].

At the same time, their theoretical studies, obtained dependencies and practical results are not sufficient to justify the design and technological parameters and operating modes of the combined sugar beet heads harvesting machine-tractor unit.

2. Preconditions and means for resolving the problem

2.1. Purpose of the study

The aim of the study is to develop a methodology for the experimental determination of rational parameters for cutting the sugar beet tops by a developed unit to ensure the required quality of harvesting the crop mass of sugar beet tops.

2.2 Solution of the examined problem

The subject of experimental studies are the sugar beet roots, tops and the working process of the cutting of the sugar beet root tops by a combined cutting machine.

The subject of experimental studies is the relationship between the quality indicators of the operation of the sugar beet tops harvester and its operating modes.

As a result of the processing of a priori information, theoretical studies and expert evaluation, it was established that the main input parameters for experimental studies (replaceable factors) are the rotor speed, the forward speed of movement of the aggregate and the position of the rotor above the soil surface. Other parameters that characterize the operation of the unit, as well as the characteristics of the research conditions, are unchanged, but controlled factors.

As an initial parameter for this process is considered the mass of the remains of the sugar beet root tops per unit area of the field.

Experimental studies of the influence of the operating modes of the sugar beet rots tops harvesting machine for continuous sensing less cutting of the tops, which are front mounted on the wheeled tractor, on the qualitative parameters of the removal of the tops consist in determining the influence of each factor separately and their interaction on the initial parameter and determining the regression dependence of this influence, which will characterize the change in the reduced the mass of the remains of the sugar beet roots tops on the surface of the head of the sugar beet roots, from the indicated parameters in the form of empirical mathematicians process models.

As a result, the mathematical model (the regression equation) of the influence of variable factors on the amount of non-cut leaves from the heads of sugar beet root by a sugar beet heads harvesting machine has the following general form:

$$Y = f(X1, X2, X3), \quad (1)$$

where $X1$ – rotation frequency of the rotor; $X2$ – aggregate forward speed; $X3$ – height of the rotor above the soil surface level.

Experimental studies involve the use of both standard and partial techniques:

- the methodology for determining the conditions for conducting of the research;
- a methodology for conducting laboratory and field studies to determine the effect of parameters and operating conditions of the sugar beet tops harvester on the quality of leaves removal;
- the methodology of conducting field research to assess the quality of the operation of the harvesting machine in the field conditions.

The methodology of the experimental research also consists the selection of the necessary instruments, equipment, adaptation and techniques that will be used in the experiments.

The laboratory-field experimental setup (1) developed for this purpose makes it possible to carry out in full the experimental studies of a new sugar beet heads harvest combination unit (Figure 1), with the possibility of changing the factors within the specified limits: the rotor speed with the help of the drive mechanism and the control of the tachometer; forward speed of a machine by means of a gear box of a tractor and the control of its actual value by a passed distance measuring wheel; height of installation of a rotor by the lever mechanism by using of a scale.

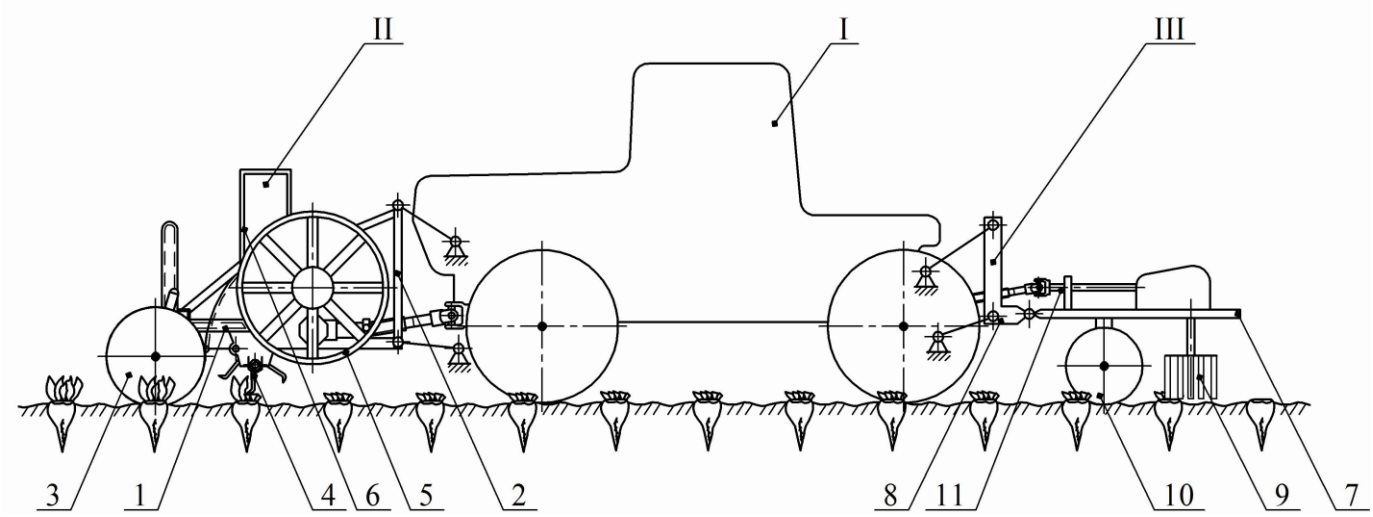

Fig. 1. *– Combined machine-tractor aggregate for the harvest of the sugar beet heads:*
I – tractor; II – front-mounted sugar beet head harvest machine: 1 – frame; 2 – carrying attachment; 3 – sensing wheel; 4 – rotary heads cutting mechanism; 5 – conveying-feeding working body; 6 – loading equipment; III – cleaner of the sugar beet heads from remains of the leaves: 7 – frame; 8 – carrying hitch; 9 – cleaning shaft; 10 – sensing wheel; 11 – drive

Table 1. Factors which have been studied on the front-mounted sugar beet root tops harvest mechine carried on universal wheel-type tractor

No.	Factor	Notation	Unit of measurement	The minimum value of the factor	The maximal value of the factor
1.	Forward speed of the tractor	*V*	$m \cdot s^{-1}$	0.5	2.5
2.	Speed of rotation of the cutting rotor	*n*	rpm	500	1000
3.	Height of the cutting of the sugar beet heads	*h*	m	0.02	0.15

The methodology for determining the conditions for carrying out the research of the sugar beet root tops harvesting machine is based on determination of the variety, yield and basic agrobiological characteristics of sugar beet, soil type, relief and micro relief, soil moisture content and hardness of the soil and other parameters that characterize the research site, according to the generally accepted method [7, 8]. From the point of view of high reliability of the results and their practical value, the research is conducted in the optimal agrotechnical terms for the harvesting of sugar beet.

So, for example, soil and climatic conditions (soil moisture content and hardness, soil type, including texture, relief and microroughness, clogging of the site) are determined according to the generally accepted methodology. Moisture content and hardness of the soil are determined in rows and rows between sugar beets in layers: from 0 to 10 cm, from 10 to 20 cm, from 20 to 30 cm.

The location of the heads of the sugar beet roots relative to the soil surface is determined from one side of the row by measuring the distance from the soil surface to the top of the head of the sugar beet root with a measurement error of ± 5 mm. Depending on the location of the heads, the measurement results may be with the «plus» sign or «minus» sign: the «plus» sign if the root crop is located above the soil surface level; a «minus» sign, if they are below the soil level.

The condition of the tops on the surface of the root head in the form of the layout of the leaves is determined in three test areas of 10 m in length on two adjacent rows. The leaf weight of the foliage is distributed by a visual survey of each plant in groups: cone, rosette, half-rosette. The data is processed to obtain a percentage of the amount of each of the groups from the total number of sugar beet roots.

The boundaries of variation of the main factors – the forward speed of the tractor; rotational speed of the rotary cutter; the height of the cutting of the tops (i.e., the height of the establishment of the sugar beet topper device above the soil surface) was determined on the basis of processing of literature sources and previous theoretical and experimental studies (Table 1).

Based on the calculations performed, previous studies and analysis of the aprioristic information, there was established levels of variation factors:

- speed of rotation of the cutting rotor: 500; 750; 1000 rpm;
- forward speed of the sugar beet heads harvester: 0.5; 1.5; 2.5 $m \cdot s^{-1}$;
- height of the cutting of the sugar beet heads: 0.02; 0.06; 0.10; 0.15 m.

As an indicators of the quality of the work, as indicated above, there were considered the remains of the tops on the heads of sugar beet roots, in $g \cdot m^{-2}$, which were determined by collecting all the residues (including those not cut off from the root heads of the part of the leaves) from the area of 1 m^2 after passage of the experimental mechanism and weighing on electronic scales with an accuracy of 1.0 g.

The power unit (tractor), in terms of its technical characteristics, must ensure the operation of the sugar beet heads harvester at the required operating speeds and at the level of adjustment of the running gear to the corresponding track width [12].

According to the established agrotechnical requirements, in the harvesting of sugar beet, the sugar beet root tops harvesting machines must ensure that the tops are not cut off from the level of green leaves and not more than 2 cm from the top of the head of the root, the number of roots with uncut tops should not exceed 8% of the total number, the number of roots with an oblique cut – up to 10%, the presence of parts of the heads of roots in the tops – up to 5%, and the maximum allowable contamination of the cut tops by soil is 0.5% [9].

To verify the quality of the process performed by the sugar beet root tops sampler studied, field experiments were carried out at rational values of the forward machine speed, rotor speed and shear height, which were established on the basis of the analysis of the obtained results of studies, according to the generally accepted methods [10].

The losses of the sugar beet tops, which are associated with the sugar beet roots from the test site after the passage of the sugar beet root harvester, is determined by cutting them manually.

The results of the experimental studies were processed according to the known method of statistical processing of research data [11] with further presentation in the form of functional and graphical dependencies, and also with the application of the adequate PC software.

3. Results and discussion

In accordance with the program and in according to the developed methodology, laboratory-field experimental studies of the effect of the parameters of the sugar beet tops harvester on the quality of root leaves removal were carried out in full.

Evaluation of the quality of the process performed by the sugar beet tops machine was carried out by cutting the remains of the tops from the sugar beet root and weighing them.

In general, during the research it was established that the experimental sugar beet top root harvesting machine provides a fairly high-quality and stable performance of the technological process, without clogging the working mechanism.

In order to assess the influence of the factors and the nature of their influence on the qualitative index of the work, we obtained dependencies in the form of a regression equation:

- in the simple form:

$$y = 49.39992 - 0.19953n + 167.3833V + 5035.927h, \qquad (1)$$

- in encoded form:

$$Y = 578.8905 - 49.8833\,X1 + 167.3833\,X2 + 327.3136\,X3. \qquad (2)$$

where V – forward speed of the tractor motion, $m \cdot s^{-1}$; n – speed of rotation of the cutting rotor, rpm; h – height of the cutting of the sugar beet heads, m.

It can be seen from equation (2) that the height of the cut has the greatest influence on the mass of the remains of the tops on the surface of the sugar beet heads when using a rotary sugar beet tops harvesting machine. the height of the installation of the rotary topping mechanism above the level of the soil surface, and the lowest is the rotor speed of the topping mechanism (cutter apparatus). In addition, an increase in the speed of the machine and the height of the cut will lead to an increase in the mass of the remains of the tops on the sugar beet root head, and the rotor speed, on the contrary, to a decrease, since for the factors in the equations, the «plus» sign (with the speed of the machine and the height of the cut) that with the increase of these parameters, the quantity of tops on the sugar beet root head will also increase, and the minus sign (at the rotor speed), on the contrary – with the increase in the factor, the quality of the removal of the sugar beet leaves will decrease.

Measurement of the field surface profile irregularities with the using of a profilograph showed that they have a high-frequency character with a period of approximately 0.7 m and an average amplitude of oscillations of 0.08 m. Similar results were obtained by other scientists in the studies, when the goal was to determine the state of the field surface profile [13].

For a more complete description of the process of removing the tops of a rotary sugar beet tops harvesting machine, due to the processing of the results of a multifactor experiment, a mathematical model is obtained in the form of a regression equation of the second degree:

$$\begin{aligned} Q = {} & -177.593 - 0.24224n + 530.8054V + 8680.805h + \\ & + 0.000179nn - 109.767VV - 6795.18hh - \\ & - 0.09602n - 1159.51Vh - 4.22748nh + 2.158437nVh, \end{aligned} \qquad (3)$$

Since the optimal values could not be determined unambiguously during the solution of the problem, an additional series of experiments was performed with a sugar beet head top height cut of 0.02 m and a rotor speed of 1000 rpm and with a change in the forward machine speed from 0.5 to 3.0 $m \cdot s^{-1}$ in increments of 0.5 $m \cdot s^{-1}$. The results of the study are shown in Fig. 2. According to the analysis, the results obtained are established that the rational values of the speed of movement of the sugar beet root tops harvester will be from 1.5 to 2.0 $m \cdot s^{-1}$.

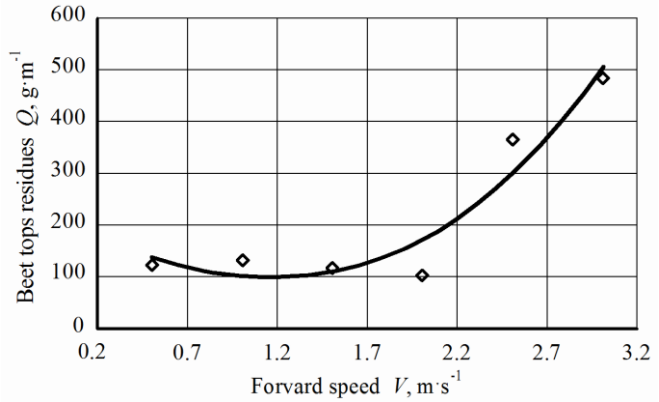

Fig. 2. *– Effect of the forward speed of the machine at a rotor speed of 1000 rpm and a height of cut of 0.02 m on a amount of the residues of the sugar beet root tops on the head of roots*

On the basis of the results obtained, field experiments were carried out on a sugar beet root tops harvest machine to assess the quality of its operation under production conditions at rational values of the process parameters.

To assess the quality of the work of the sugar beet root tops harvest machine in the production environment, the field studies of the machine were carried out at rational process parameters with the determination of the number of leaves tops on a root, roots with normal, high and low-cut tops, general and strong mechanical damage of the root, loss of sugar content and rooting out of sugar beet roots from the soil.

Based on the results of the field experimental studies that were carried out in the fivefold repetition shown in Table 2, it can be concluded that for these performance indicators, the sugar beet root tops harvest machine meets the agrotechnical requirements set for the root tops removal process. Especially, this applies to severe damage and knocking out sugar beet roots from the soil, since there were no such facts on the research sites.

Table 2. *Quality indicators of the function of a sugar beet root tops harvest machine*

No.	Indicators	Value according to the agrodemand	Values from experiments
1	Amount of leaves on the sugar beet roots, %	not more than 1.5	0,6
2	Correctly cutted sugar beet roots, %	not less than 85	95.3
3	Too low cutted sugar beet roots, %	not more than 5	3.2
4	Too high cutted sugar beet roots, %	not more than 10	1.5
5	Strongly mechanicaly damaged sugar beet roots, %	not more than 5	not occured
6	General damages of the sugar beet roots, %	not more than 20	1.5
7	Loss of sacchariferous mass, %	not more than 2	0.4
8	Knocking out sugar beet roots from the soil, %		not occured
9	Completeness of harvesting of sugar beet top leaves, %		96

Thus, according to the results of field experimental studies of the operation of the sugar beet root tops harvest machine in the field, when harvesting the tops with a continuous cutting, it can be concluded that the quality of the work corresponds to the agrotechnical requirements [9], and hence the expediency of using such an aggregate in production conditions.

4. Conclusions

1. The method of experimental researches of a sugar beet root tops harvest machine is carried out, which implements a continuous, uncopied cut of the main mass of the tops and the loading of the crop material into the vehicle, which involves: investigating the influence of the operating modes of the sugar beet root tops harvest machine on the quality of root tops removal; experimental determination in the field conditions of the main qualitative performance indicators.

2. It has been proved that the developed sugar beet root tops harvest combined unit in terms of performance in the field meets the qualitative indicators of work and agrotechnical requirements.

3. It has been established that the rational values of the process parameters at which qualitative removal of the tops will be achieved by the rotary cutter apparatus is the cut-off height of 0.02 m, the forward speed of the machine is from 1.5 to 2.0 $m \cdot s^{-1}$, the frequency rotor rotation is 1000 rpm.

5. References

1. Ihnatiev Y.I. Razrabotka novoj kontruktivno-technologicheskoj skhemy uborki sakharnoj svekly s ispolzovaniem pakhotno-propashnogo traktora. (In Ukrainian). Vestnik agrarnoj nauki, 2016, No., p. 67–71.

2. Pogorelij L.V., Tatjanko, N.V., Brej V.V. et al. Sveklouborochniej mashiny: (konstruktirovanie i raschot). (In Russian). Pod obshchej redakciej L.V. Pogorelogo. Kiev, Tekhnika, 1983, pp.168.

3. Bulgakov V. M., Adamchuk V.V., Nozdrovicky L., Boris M., Ignatiev E.I. Properties of the sugar beet tops during the harvest.Proceeding of 6th International Conference on Trends in Agricultural Engineering 2016. 7–9 September 2016, Prague, Czech Republic. p.102–108

4. Gurchenko O.P. Obosnovanie osnovnyh parametrov lopatnogo ochistitelja golovok svekly ot ostatkov botvy. (In Ukrainian). Selskokhozjajstvennye mashiny. Sbornik nauchnykh trudov. Luck, 1997, Vypusk 3, p. 30–37.

5. Toporovskij S.A. Obosnovanie tekhnologicheskgo processa i osnovnykh parametrov rabochego organa dlja uborky sakharnoj svekly bez kopirovanija golovok korneplodov. (In Russian). Dis. kand. tekhn. nauk., Kiev, 1988, pp.202

6. Bulgakov V.M. Sveklouborochnie mashiny. (In Ukrainian).Monografia, Kiev: Agrarnaja nauka, 2011, pp. 351.

7. OST 10.8. 6–2001. Standard otrasli. Ispytanija selskokhozjajstvennoj tekhniky. Mashiny dlja uborky svekly. Metody ocenky funkcionalnyh pokazatelej. (In Russian).

8. Khajlis G.A., Konovaljuk D.N. Osnovy projektirovanija i issledovanie selskokhozjajstvennyh mashin: Учебное пособие. (In Ukrainian). NMK, Kiev, 1992, pp.320.

9. Bosoj E.S. et al. Teorija, konstruktirovanie i raschot сельскохозяйственных машин. (In Russian).Moscow, Mashinostroenie, 1978, pp. 567.

10. Pogorelij L.V. Ocenka tekhnologicheskuh pokazeteelj raboty botvosrezajuahchih apparatov. (In Russian). Mekhanizacija i elektrifikacija socialisticheskgo selskogo khozjajstva. 1963, No.5, p. 49–50.

11. Dospekhov B.A. Metodika polevogo opyta (s osnovami statisticheskoj obrabotky rezultatov issledoavnij). (In Russian).Moscow, Agropromizdat, 1985, pp. 351.

12. Adamchuk V., Bulgakov, V., Nadykto, V., Ihnatiev,y., Olt J. Theoretical research into the power and energy performance of agricultural tractors. Agronomy Research. 2016. Volume 14. No 5, p. 1511–1518.

13. Kistechok O.D. Obosnovanie skhemy i parametrov pakhotnogo agregata s perednym i zadnymi navesnimi plugami. (In Ukrainian). Dis. kand. tekhn. nauk. TDATU, Melitopol, 2017, pp. 144.

SUSTAINABLE INNOVATION TECHNOLOGY: AN INSIGHT INTO THE EFFECTIVE USE OF BIOFERTILIZERS IN IMPROVING SOIL AND PLANT QUALITY

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Abstract: *The employment of inorganic fertilizers to overcome soil nutrient deficiency causes the depletion of microfloral diversity in the soil. Hence, there is a necessity to implement different eco-friendly strategies to maintain the nutrient level. In a series of experiments funded by SITINPLANT European Project, we have previously determined the interaction between the mycorrhizae and antagonistic biocontrol micro-organisms and their effect on diseases and plant nutrient uptake of several plants and trees. On the basis of the inferences obtained from that project, we are presently working on the utilization of mycorrhizal fungi and bacteria as organic fertilizers (i.e. biofertilizers) for wheat development. Our specific aim is to determine the strategies that may support to decrease the usage of commercial P fertilizers. The results of these experiments will provide an insight into the effective usage of different microorganisms for improving crop productivity and increasing food security.*

Keywords: BIOFERTILIZERS, MYCORRIZHAE, NUTRIENT DEFICIENCY

1. Introduction

Nearly 815 million people worldwide suffer from malnutrition. A large contributor to global malnutrition and hunger are the increasing effects of soil degradation on food production, causing food-price instability, land abandonment, and involuntary mass migration, leading millions into poverty (FAO, 2017). The global population is expected to reach 9.7 billion by 2050 (UN, 2015). Food production must increase by 70% (FAO, 2009) to meet demand, implicating greater agricultural inputs (e.g. fertilizers). While synthetic fertilizers do provide readily available nutrients such as Nitrogen, Phosphorus, and Potassium, they rarely provide much else (e.g. organic matter). Their lack of support of soil microbial life (Yu et al., 2016), the higher degree of environmental pollution associated with their over application in rural and urban landscapes (Bennett et. al, 2001), and the overall agricultural dependency of synthetic fertilizers, begs for a formidable substitute.

Biofertilizers or organic fertilizers are an ideal alternative and which research has shown, to be advantageous for higher yield and quality food production. Biofertilizers, are those microorganisms that under particular soil conditions enhance plant growth by facilitating nutrient acquisition. These organisms through microbial processes, such as nitrogen fixation or phosphate solubilization, help plants assimilate the necessary nutrients that would have been otherwise limited (Timmusk, 2017).

However there is a great pressure on the use of more chemical protectants and synthetic fertilizers aiming to increase agricultural productivity, European Union and Worldwide policies on the use of such chemicals in agriculture are becoming more and more limiting aiming to reduce their potential harmful effects on the environmental. New policies focus especially on the negative impacts of these chemicals on the soil complexity and the quality of the produce. Thus, renovations at every step of the agricultural practices are urgently required for more efficient use of natural soil resources (including minerals, water, etc.). The Sustainable Innovation Technology In Plant Nursery Processes Improving Plant Quality and Safety (henceforth referred to as SITINPLANT) project aimed to develop an innovative production process, through the use of biofertilizers, in the fruit tree nursery that would allow the production of plants more tolerant to pathogens and more efficient in utilizing soil mineral elements, thus addressing the European policies for controlling soil and the water pollution. The result of the SITINPLANT project lead to mycorrhizal inoculated micro-grafted or grafted root stocks fruit trees that were more tolerant of biotic and abiotic stresses in nurseries and orchards.

Based on the experiences one the nursery sector, our research lab was interested in examining the utilization of mycorrhizal fungi and bacteria as biofertilizers for wheat development. Though, the concept of soil microbial nutrient enrichment is nothing new, their effects prove to be highly variable and thus difficult to manage. Hence, in the last several decades research has centered on identifying plants with either high nutrient use efficiency or high nutrient acquisition efficiency, while more recent research has looked towards opportunities for manipulating specific plants and microorganisms to enhance nutrient uptake, use, and availability.

In soils where organic matter is low, and pH and lime content are high, P acquisition is primarily affected. Plants uptake phosphorus from the soil primarily as orthophosphate (i.e. hydrogen phosphate ion ($HPO42-$), dihydrogen phosphate ion ($H2PO4-$)) (Vance et. al., 2003; Mengel et al., 2001; Correll, 1998). Although phosphorus is an essential element for plants, because of these soil conditions, P has a lower solubility and rapid transformation into insoluble forms, making applied P only about 10-20% available for plant uptake (van de Wiel et. al, 2016). Phosphorus not bounded or assimilated by plants, can runoff into natural waters and cause eutrophication. Increased algal blooms may include toxic cyanobacteria, and the resulting reduction in oxygen levels can cause fish kills (Bennett et. al, 2001). Unfortunately, in countries like Turkey, a prominent global entity in cereal crop production, all of the aforementioned largely affect their agricultural soils and ergo crop production and economic profitability. In Turkey, and specifically in the Central Anatolian Region (CAR), wheat is the predominant cereal cultivar and consumes the most P-fertilizers (Çolakoğlu et al., 2005). Hence, our specific aim was to determine the strategies that may support to decrease the usage of commercial P fertilizers. For this reason, our first objective was to identify genotype-based Phosphorus Acquisition Efficiency (PAE). Two high and low P-efficient genotypes were identified and are currently being tested under field conditions.

2. Materials and Methods

2.1. SITINPLANT Project

The protocol for fruit tree production was developed by the Italian, Bulgarian and Turkish partners of the Project, in collaboration with SME-RTD, in estimating the qualitative, environmental, and economic benefits gained within the project. Experimental trials were conducted in Turkey and Bulgaria. Rootstocks and microorganisms used are described in Table 1. Three different inoculation methods were used: a) mixing *Trichoderma harzianum Glomus intraradices* with peat and incubating for a week before planting; b) mixing *T. harzianum* into peat and incubating for 20 days before planting; c) dissolving the inoculum into a solution and dipping the plants just before planting (dipping method). This was applied for *Trichoderma*, *Glomus*, and *Agrobacterium radiobacter*. The project duration was from September 2008 - December 2010.

Table 1: Rootstocks and microorganisms used in the SITINPLANT project.

Rootstock	Microorganisms
GF677 (Prunus persica x Prunus amygdalus), the most commonly used rootstock for peach, nectarine, plum and almond cultivars; Myrobolan 29C, a rootstock for plum and apricot cultivars; GiSeLa®6 a rootstock for sweet and sour cherry cultivars, and OHF 19-89 (Old Hom x Farmingdale) a rootstock for pear.	*Trichoderma harzianum* T-22 (a commercial and a fresh culture produced by Fitotechniki); *Trichoderma asperellum* B1 (a fresh culture produced by Fitotechniki) isolated from tomato roots by the University of Thessaloniki during the period of the SITINPLANT project; *Glomus intraradices*; *Agrobacterium radiobacter* K84 (a fresh culture produced by Fitotechniki). *Streptomyces lydicus* WYEC 108; *Bacillus subtilis* QST 713.

2.2 Biofertilizer Project – Selcuk University

The first phase of the project was genotype screening. Twelve commonly grown bread wheat genotypes from the Central Anatolian Region were selected for the Greenhouse Experimental Trial (see Table 2). Planting of the wheat seeds occurred during the 1st week of May 2017. The 12 bread wheat genotypes were placed in a random block design. There was a total of 8 different treatments (i.e. 0 ppm P: Control, Bacteria, Mycorrhizae, and Bacteria + Mycorrhizae; 50 ppm P: Control, Bacteria, Mycorrhizae, and Bacteria + Mycorrhizae; See Figure 1 below), with 3 replications for each genotype under every treatment. One (1) kg of a 2mm sieved air-dried soil was used, thus the trial was composed of a total of 288 pots.

Fertilized treatments were fertilized using DAP, at a concentration of 50 ppm P. Treatments containing bacteria (i.e. Bacteria 0 and 50 ppm P, as well as Bacteria + Mycorrhizae 0 and 50 ppm) were inoculated with 25 mL/pot of the bacteria solution (see Table 2 for Bacteria species). Treatments containing mycorrhizae were inoculated with 4.5 grams of a commercial mycorrhizae mixture per pot (see Table 2 for Mycorrhizae species).

Phosphorus Acquisition Efficiency (PAE) was calculated according to Noor et al., 2017, as shown below:

$$ARE\ (\%) = \frac{A - B}{C}\ x\ 100\%$$

$$ARE = Apparent\ Recovery\ Efficiency$$

$$A = Nutrient\ Uptake\ by\ Fertilized\ Plant\ (mg)$$

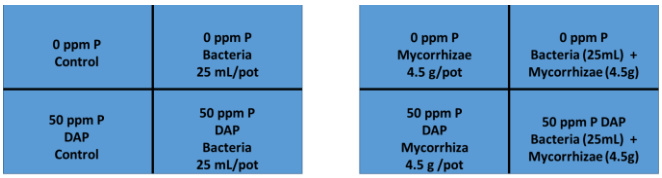
$$B = Nutrient\ Uptake\ by\ Unfertilized\ Plant\ (mg)$$

$$C = Amount\ of\ Fertilizer\ Used\ (mg)$$

Table 2: Plant, fungi, and bacteria varieties used in the greenhouse experimental design. AMF: Arbuscular Mycorrhizae Fungi.

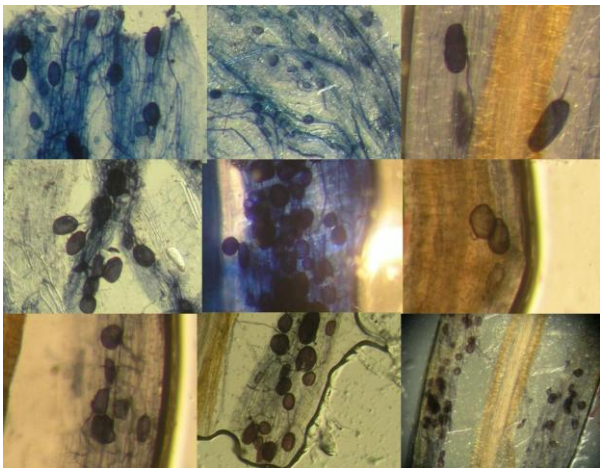
Bread Wheat		AMF*	Bacteria
Ahmetaga	Eser	*Rhizophagus irregularis*	*Pseudomonas fluorescens*
Altay 2000	Konya 2002	*Glomus aggregatum*	*Bacillus licheniformis*
Bayraktar 2000	Mufitbey	*Glomus mosseae*	*Bacillus pumilus*
Dagdas 94	Sonmez 2001	*Glomus clarum*	*Bacillus subtilis*
Demir 2000	Tosunbey	*Glomus monosporus*	
Ekiz	Yunus	*Glomus deserticola*	
		Glomus brasilianum	
		Glomus etunicatum	
		Glomus margarita	

Figure 1: Greenhouse Experimental Design Treatments



3. Results and Discussion

3.1. SITINPLANT Project



2.2 Biofertilizer Project – Selcuk University

Results determined the genotypes: Tosunbey and Bayraktar 2000 had the highest and lowest PAE respectively. According to Zhang et al. (2009), higher acquisition efficiency would imply higher grain yield under limited P supply. Although our current greenhouse trial results do not include yield, we expect similar results from our control group in the ongoing field trial to those of Doğan et al. (2014), who investigated the yield and other yield

components of various Turkish bread wheat varieties, including that of Tosunbey and Bayraktar 2000. Their study concluded that the highest yield per area was obtained from Tosunbey, whereas the lowest was obtained from Bayraktar 2000. In terms of the use of biofertilizers for improved P-acquisition, our results demonstrated that Bayraktar 2000's P-efficiency substantially increased with the addition of mycorrhizae. Ortas and Bykova (2018) confirmed this when their study showed both PAE and grain yield increases with mycorrhizal inoculation.

4. Conclusion

We are particularly interested in determining the effect PAE will have on the grain yield of Bayraktar 2000, where Tosunbey and Bayraktar 2000 are currently, being compared under varying amounts of DAP fertilizer (i.e. 0, 2, 4, and 8 kg/da P) and biofertilizer applications (i.e. Bacteria, Mycorrhizae, and Bacteria + Mycorrhizae) in a field trial at the Bahri Dagdas International Agricultural Research Institute. We anticipate similar results to the greenhouse trial from the current field study being conducted.

The widespread use of microbial products and/or high P-efficient genotypes in commercial agriculture, especially in countries where access to minerals is restricted, would greatly decrease our global consumption of P fertilizers, improve crop productivity, and increase food security. In this way, selecting wheat genotypes or any other crops with high PAE or enhancing the P uptake efficiency using biofertilizers, would be an effective strategy towards overall agronomic profitability

References

1. Noor, Sobia & Yaseen, Muhammad & Naveed, Muhammad & Ahmad, Rashid. (2017). Effectiveness of diammonium phosphate impregnated with Pseudomonas putida for improving maize growth and phosphorus use efficiency. Journal of Animal and Plant Sciences. 27.

2. Zhang H, Huang Y, Ye X, Shi L, Xu F (2009) Genotypic differences in phosphorus acquisition and the rhizosphere properties of Brassica napus in response to low phosphorus stress. Plant and Soil. 320:91-102.

3. Ortas I, Bykova A (2018) The Effect of Mycorrhiza Inoculation and Phosphorus Application on Phosphorus Efficiency of Wheat Plants. Communications in Soil Science and Plant Analysis 49: 1199-1207.

4. Dogan Y, Togay Y, Togay N (2014) Türkiye'de Tescil Edilmiş Bazı Ekmeklik Buğday (Triticum aestivumL.) Çeşitlerinin Mardin - Kızıltepe Koşullarında Verim ve Bazı Verim Özelliklerinin Belirlenmesi. Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi 24: 241- 247

5. Jasinski, Stephen M. (2016). US Department of the Interior, US Geological Survey. Mineral commodity summaries 2016.

6. Van Kauwenbergh, Steven J. (2010). World phosphate rock reserves and resources. Muscle Shoals: IFDC, 2010.

7. Eraslan, F., İnal, A., Güneş, A., Erdal, İ., & Coşkan, A. (2009). Türkiye'de Kimyasal Gübre Üretim ve Tüketim Durumu, Sorunlar, Çözüm Önerileri ve Yenilikler. Süleyman Demirel Üniversitesi, Ziraat Fakültesi, Toprak Bilimi ve Bitki Besleme Bölümü, Isparta

8. Güçdemir, İ. H. (2006). Türkiye gübre ve gübreleme rehberi. Güncelleştirilmiş ve genişletilmiş 5. Baskı. Tarımsal Araştırmalar Genel Müdürlüğü, Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü Yayınları.

9. Çolakoğlu, H., Çokuysal, B., & Çakıcı, H. (2005). Türkiye'de Gübre Üretimi ve Tüketimi. Tarımda Potasyumun Yeri ve Önemi, 13.

10. Correll, D. L. (1998). The Role of phosphorus in the eutrophication of receiving waters: A review. Journal of Environmental Quality 27, pp. 261 – 266.

11. Mengel, K. ve Kirkby, E. A., 2012, Principles of plant nutrition, Springer Science & Business Media, p

12. Vance, C. P., Uhde- Stone, C. ve Allan, D. L., (2003). Phosphorus acquisition and use: critical adaptations by plants for securing a nonrenewable resource, New Phytologist, 157 (3), 423-447.

13. van de Wiel, C. C. M., van der Linden, C. G. ve Scholten, O. E., 2016, Improving phosphorus use efficiency in agriculture: opportunities for breeding, Euphytica, 207 (1), 1-22.

FAO, 2017, The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security, Food Agriculture Organization of the United Nations, p.

FAO, U., 2009, How to feed the world in 2050, Rome: High-Level Expert Forum.

United Nations 2015. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables p. 1-66.

NEW PLANT GROWTH STIMULATOR - HUMATPHOSPHATE

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Abstract: *The results of vegetative and field tests of the new plant growth stimulator - humatophosphate in various agricultures are presented. It is shown that humatophosphate exerts a strong influence on the growth of the root system of plants, on the formation of the leaf surface, increases the number of fruits and improves the commercial quality of the fruit.*

Key words: *HUMATPHOSPHATE, GROWTH STIMULATOR, AGROCHEMICAL TESTS*

1. Introduction

Heteroauxin, cornevin, succinic acid, epine, biostim, silk, immunocytophyte, zircon, cytovit, gibberellin and other humic compounds are most often used as a plant growth stimulant.

Humic substances have a beneficial effect on the physical properties of the soil: the moisture capacity of light soils increases and the water permeability of heavy soils improves, the structure improves, and its density decreases. There is an increase in the microbiological activity of the soil, both in the first year of fertilizer use and subsequently. Simultaneously with the increase in the number of microorganisms, the enzymatic activity of the soil also increases. In turn, this increases the mobility of soil nutrients. Thus, the use of humic compounds significantly alters the conditions of soil nutrition of plants, causing an active intensification of the processes of mobilization of nutrients in the form assimilated for plants.

2. Materials and methods

Plant treatment by growth stimulator was conducted conformity with methodological guidelines (Lebedintseva et al., 1994).

3. Results

We propose a new plant growth stimulator is humatphosphate (HPh). (Aldabergenov et al. Patent of the Republic of Kazakhstan No. 29519). Humatphosphate consists of humic substances (humic and fulvic acids), as well as ammonia and phosphorus. Humatphosphate was obtained on the basis of brown coals, sodium (potassium) humate and ammophos (Kazakhstan). The interaction of sodium (potassium) humate with ammophos proceeds according to the acid-base mechanism with the participation of phenol and alcohol OH groups of sodium humate and hydrogen ions of acid orthophosphate anions with the formation of a stable polymeric humatphosphate complex (Kalenova et al., 2015).

A technology was developed and a mini-plant for the production of humate-phosphate was built in the Almaty region. Humatphosphate is produced both in liquid and solid form. In solid form, the humatphosphate is an amorphous powder of black color, readily soluble in water, does not compact during storage. Other components can be added depending on the need to create the right balance between organic and mineral constituents.

Ammophos has pH = 4.42, sodium (potassium) humate has pH=10.36, and humatphosphate has pH= 6.30 - 6.35, its density is 1.077 g/cm^3.

Humate-phosphate for three years passed an agrochemical test on the strawberry variety "Sweet Charlie" at the Institute of Fruit Growing and Viticulture (Almaty, Kazakhstan). It was found that humatphosphate has a positive effect on the growth processes of strawberries (Table 1). The height of strawberry bushes increased by 27.4% in fertilized variants at $N_{50}P_{50}K_{25}$ kg/ha of active ingredient and by 39.6% at $N_{100}P_{100}K_{50}$ kg/ha compared to the control. The same pattern is observed in the influence of the biopreparation on the size of the leaf plate and the total leaf surface of the bush. If the control surface of the bush is 240 cm^2, then on fertilized variants it increased in 1,6 - 1,8 times. The weight of one berry increased by 1.3 times, the number of berries increased by 1.8 times, and the yield from one shrubbery increased by 2.3 times.

Table 1 - Basic indicators of strawberry productivity

№ of experiment	Experiments	Height of bushes, cm	Total area of leaves on a bush, cm^2	Number of berries, pcs / bush	Weight of one berry, g	Yield from one bush, g	NPhK content in soil		
							N-hydrolyzed, mg/ / 100 g of soil	P_2O_5, mg/ 100 g of soil	K_2O, mg /100 g of soil
1.	control	19,7	247,6	4	2,1	8,4	4,87	3,25	47,9
2.	$N_{100}P_{100}K_{50}$	24,1	286,4	6	3,5	21,0	6,14	3,80	53,19
3.	HPh	22,8	320	5	3,8	19,0	3,30	10,15	43,01
4.	HPh+ $N_{100}P_{100}K_{50}$	21,5	259,2	6	3,7	22,2	4,00	8,70	50,69
5.	HPh + ½ $N_{100}P_{100}K_{50}$	20,9	223,2	5	2,8	14,0	3,36	7,45	49,71

Agrochemical tests have shown that humatphosphate has more biological activity than ammophos and sodium humate when used separately, which is explained by the mutual influence of the mineral and organic component of the fertilizer. Humatphosphate forms soil aggregates that retain moisture well and increase the digestibility of the mineral part of the fertilizer, the dark brown color of the biopreparation, accumulates more heat, in comparison with ammophos, thereby contributing to the faster development of the plant. Donor-acceptor groups that form part of the humatphosphate form stable complexes with toxic,

radioactive elements that adversely affect the ecological situation in nature.

Also, vegetative experiments were conducted on the influence of the stimulator on growth processes, the formation of the leaf surface, the commercial qualities of fruits and the apple yield of the "Voskhod" variety.

Analysis of the results shows that humatphosphate has a positive effect on growth processes:

a) the average length of one sprout increased by 16.8%, the number of fruit sprouts in apple trees increased by 20.3%;

b) on the formation of the leaf surface, i.e. on the average area of one sheet, which increased by 6.6%;

c) the fruit qualities of apple fruit, the average weight of the fetus increased by 9.35% compared to the control, the number of fruits in grades increased by 21% and 22.2%, respectively, and the number of fruits of the third grade decreased by 64%.

A laboratory experiment was established to determine the activity of the HPh on the process of rooting beans according to the method of R.Kh. Turetskoy in the laboratory of the Institute of Horticulture and Viticulture.

Sprouts of beans in solution are presented in Figure 1. The main indicators of physiological activity are: the number of roots, the nature of the formation of roots, the length of the stem on which the roots are laid.



Figure 1 *- Bean sprouts in solution*

To study the effect of the concentration of humatphosphate on the physiological parameters of the bean, a vegetation experiment was conducted with different concentrations of the HPh (Table 2).

Table 2 - Physiological activity of beans depending on the concentration of humatphosphate

Experiments	Number of roots, pcs.	Length of the first root, cm	Length of roots, cm
Control (H_2O)	4,6	0,8	3,7
HPh (1 ml/100 ml H_2O)	27	1,8	48,6
HPh (2 ml/100 ml H_2O)	22	0,6	13,2
HPh (3 ml/100 ml H_2O)	the beginnings of roots	-	the beginnings of roots

The introduction of humatphosphate in a ratio of 1 ml of humatphosphate per 100 ml of water has the greatest effect on the physiological activity of the bean. Thus, the number of roots, the length of the first root, the total length of the roots significantly exceed the identical parameters of the control experement options and other concentrations of the SHPh. At a ratio of 1 ml of humatphosphate per 100 ml of water, a powerful root system is formed by the development of additional accessory roots. The number of roots at this concentration is almost 5 times the control experiment option, and the length of the roots, respectively, 14 times. At higher doses (3 ml of humate-phosphate per 100 ml of water), the humatphosphate causes a reduction in the roots, which are manifested in the form of the beginnings of roots.

Based on the obtained data, the concentration of humatphosphate in 1 ml of humatphosphate per 100 ml of water was transferred to the field experimental scheme "Soft wheat, Lubava 5" variety in Kostanai area in "Zhanahai" farm are located on an area of 20 hectares.

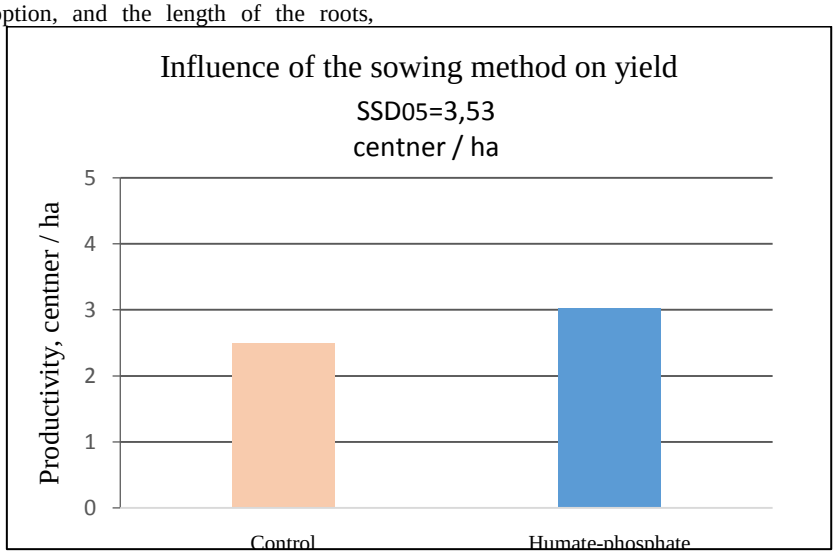

Figure 2 *- Comparative analysis of wheat yield growth*

The introduction of humatphosphate as a growth stimulator leads to an increase in the yield of wheat by 5-6 centner/ha (figure 2).

4. **Conclusion**

Humatphosphate can be recommended for application to fruit, berry, technical and vegetable crops.

5. Literature

1. Lebedintseva A.M., Tyutery L.S. Strategy and tactics of using protective-stimulating compounds for processing seeds of agricultural crops "Agrochemistry", 1994. №10. - P. 76-80.
2. Patent of the Republic of Kazakhstan No. 29519. "Method for obtaining a liquid organomineral fertilizer", C05F 11/02, C05B 15/00, Bul. № I1 of 09.15.2016
3. Bubish Sh., Kalenova A.S., Endibaeva D.A.. The mechanism of formation of sodium humatophosphate /Materials of the International Conference "Chemical Technologies of Functional Materials", Novosibirsk, 2015- P.47.

With the support of the Science Foundation
Ministry of Education and Science
of the Republic of Kazakhstan
№195 of December 22, 2016

ECOLOGICAL AND ECONOMICALLY EFFECTIVE AGRICULTURE THROUGH CREATING ENERGY LEVELS OF SOIL MOISTURE IN FIELDS

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Abstract. *The report deals with the perspectives for developing ecologically based biological agriculture in Bulgaria, the European Union and the other countries. Innovative technology (for computerized monitoring the soil water deficit and scheduling the irrigation) replaces the periodical local (point) measurements of soil moisture. Its application helps to be taken into account the physiological features of crop, creating appropriate energy level of soil moisture through ecologically accepted watering technique in each agricultural crop field. It ensures to be obtained the scientifically planned amount and quality of crop yield, saving on average 30 % of irrigation water and one third of nutrients added for plants.*

New universal estimation of crop water status, current computerized monitoring of the water deficit in root zone of soil, and exact management of productivity are possible to be accomplished.

Data were obtained under field conditions over 30-year research period. Fundamental physical laws and recent Bulgarian and foreign world-top scientific achievements were aggregated and applied to be created the new scientific basis of the technology.

The obtained results showed the successful applications of: (a) the new hydro-physical index and the method for its determination under both non-irrigation and irrigation conditions and (b) the Technology for Monitoring, Estimating and Managing (TMEM) of the water status of this layer in irrigation rural activities, taking into account the European ecological requirements. The technology is easily applied as Decision Support System (DSS) in irrigation agriculture.

KEY WORDS*: SOIL WATER STATUS, ENERGY LEVEL OF MOISTURE, PHYSIOLOGICAL IRREVERSIBLE PROCESS.*

1. Introduction

For the first time in the world agricultural science and practice, we can practically control the physiological processes in cultural plants. These processes concern the water and nutrients uptake by plants. New biophysical index (L) of soil moisture energy levels, method for its determination and new scientific basis and ecological technology are recently developed [1, 2, 3]. Applying the offered Decision Support Ecotechnology (in research version) during a period of 8 years, the precise schedules include 3.125 times of watering on average less with total irrigation norm equal to on average 2780 m^3/ha (or 29.5 % less amount of water) than tradition [4, 5, 6, 7]. We obtained 12 ± 0.5 t/ha of grain under appropriate N, P and K nutrition for each year (Table 1). We recommend L = 15 $(J/kg)^{½}$ to be realized in agricultural practices [8].

2. Problem discussion

Enormous losses of energy, fuels, water, fertilizers and human labour are due to the lack of current representative monitoring and integrated scientific management of farmer activities in each agricultural field under irrigation. We offer a new scientific tool to solve these cardinal problems in the world agricultural practices. Moreover, this tool will help the modern research for creating and examining new sorts and hybrids. ***It will significantly reduce or completely remove the pollution caused by the agricultural activities in each field under irrigation around the world.***

The recent achievements in biophysics of plant populations and the application of biophysical approach contributed to be created the Computerized Decision Support Ecotechnology (CDSE). It is possible to be created a version of this universal Computerized Decision Support Ecotechnology (CDSE) for Monitoring, New Estimating and Managing Agroecosystem Water Status as a market product friendly for farmers and agrarian associations. Its application will ensure economically-efficient crop production and environmental protection.

3. Objective and research methodologies

The aim is to overcome the risk coming from the influence of the most important water factor during growing season on agroecosystem productivity. This risk can be completely removed applying the ecotechnology under conditions of ecologically-acceptable irrigation technical facilities and available water resources. The minimum total needed amount of water and its precise distribution during each growing season to obtain a planned crop yield can be reached using the offered Computerized Decision Support Ecotechnology (CDSE). This ecotechnology is recommended for farmers, who can organize good technical implementation of the agricultural activities in their crop fields.

The offered ecotechnology ensures the amount of planned crop yield to be obtained and helps the exact determination of nutrient rates necessary for the formation of planned crop yield. *It ensures significant increase of yield and great reducing of irrigation water, human labour, and other costs* [8]. The ecotechnology is based on new complete scientific biophysical basis, which includes: 7 current daily meteorological indices twice a week; physical characteristics of the soil profile; biological function for each crop; fundamental (physical and biological) laws and established regularities of the soil-crop-atmosphere processes [1, 8]. We established the maize susceptibility of each stage of ontogenesis and we included it in the scientific basis of the ecotechnology (Fig. 1).

A stage	B stage	C stage	D stage
Germination, formation of first and second roots and five leaves 50 % Extreme-critical (ec)	Extending cone of growth and formation of new leaves 20 % Important (i)	Flowering, insemination and maize-cob formation 50 % Extreme-critical (ec)	Active phases of filling the grain 30 % Critical (c)

Fig. 1. *Scheme of ontogenesis stages based on the maize susceptibility to decrease the amount of grain yield when reducing the soil moisture. The percentages show the decrease of yield amount at lowering ΔL_{ec} = 30 $J^{1/2}/kg^{1/2}$ of the energy level of soil moisture only at the corresponding stage and keeping the genetically optimal level at all other stages. The yield losses at the separate stages are irreversible damage that accumulates till the end of growing season. The experimental data are obtained and verified during a period of 30 years*

4. Results and Discussion

In some agricultural practices for example, the farmers plan 10 t/ha maize-grain amount of yield. They calculate the fertilizer (N, P, K, microelements) rates and bring these nutrients in soil. In fact, they obtain 6.5-7.0 t/ha. That means 30-35 % losses of fertilizers, which are not used for plant nutrition. Those losses pollute the environment (water in rivers, lakes, dams, etc. and underground water). Applying the new offered ecological technology, the farmers significantly reduce or completely remove these losses and protect the environment.

The ecotechnology currently takes into account the following physical and biological characteristics:

1. Momentary and marginal (allowed by the chosen energy level) water deficit in the root zone; 2. Reference and real evapotranspiration; 3. Dew point temperature; 4. Daily solar radiation; 5. Average 24 hours wind speed; 6. Crop biological function; 7. Current increase of root zone depth; 8. Participation of underground water in the process of evapotranspiration; 9. Periodical estimation of expected date and и norm of watering for keeping the chosen energy level of soil moisture; 10. Efficiency of irrigation (net-norm/loss of water); 11. New indices of drought degree; etc.

Based on precise field experiments over a period of 30 years, we established the dependence of maize grain yield (Y, t/ha) on the energy level L (J/kg)$^{1/2}$ (Figs. 2 and 3). The equation for yield mass (obtained without irrigation and under irrigation schedule currently determined by us using the ecotechnology) is:

(1) $Y = 19.45 – 0.55\ L.$

The general form of this equation is: $Y = A – B\ L$, where A и B are the coefficients characterizing the crop physiological features. The correlation coefficient is equal to R = –0.980.

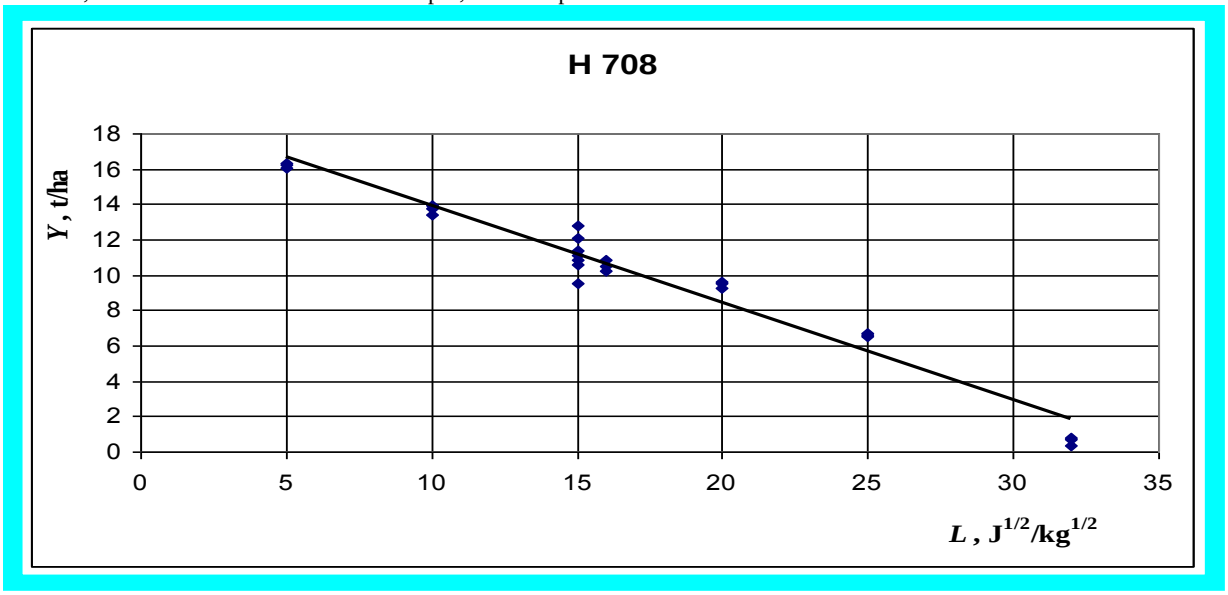

Fig. 2*. Dependence of maize (H 708 hybrid) grain yield (Y, t/ha) obtained at appropriate N, P and K rates on the energy level L (J/kg)*$^{1/2}$*. Correlation coefficient is equal to R = –0.98*

The crop physiological features are as follows.

● Gradual reduction of the water supply in the soil root layer from the field capacity (FC) to the wilting point (WP) causes *irreversible physiological processes* with increasing intensity in the plant organism. The cardinal problem related to these processes can be solved, applying the ecotechnology.

● The degree of plant irreversible damage is different at the various mentioned stages under conditions of one and the same moisture reduction of the same soil (Fig. 1).

● The plant irreversible damages caused at all stages are accumulated during the growing season. These damages irreversibly limit the amount and quality of crop yield,

irrespective of the increase in soil moisture caused by subsequent irrigation or rainfall.

● The irreversible physiological defeat depends on the energetic status of moisture in soil. This energetic status corresponds to different moisture contents in soils of diverse mechanical composition.

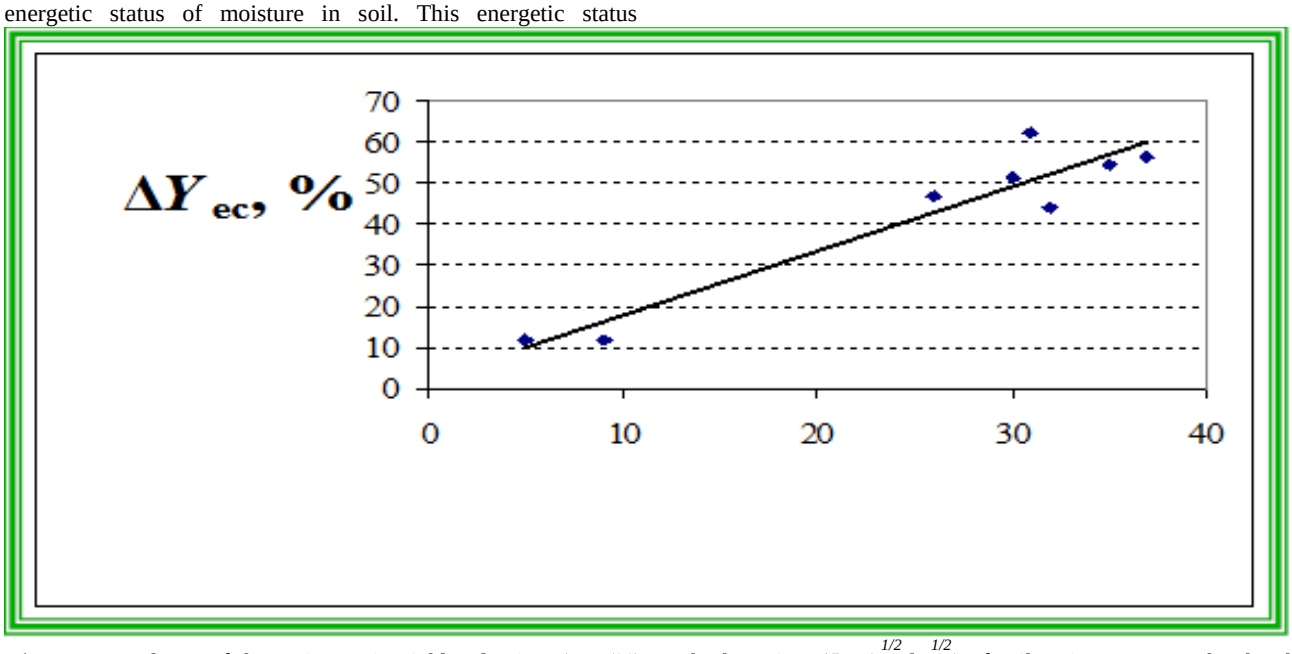

Fig. 3. *Dependence of the maize-grain yield reduction ΔY_{ec} (%) on the lowering ΔL_{ec} ($J^{1/2}/kg^{1/2}$) of soil-moisture energy level only at the extreme-critical C stage of plant*

Table 1. Average amounts of maize (H-708) grain yield (t/ha) obtained under different rates of fertilizing, depending on the energy level L (J/kg) $^{1/2}$ of soil water status (Lom, Bulgaria)

Rate of fertilizing	Levels L of soil water status				
	L = 5	L = 10	**L = 15**	L = 22	L = 26
$N_{34}\ P_{45}(3)\ K_{16}$	**16.21 Genetically put in hybrid**	14.61	12.96	9.90	5.87
$N_{28}\ P_{32}(3)\ K_{12}$	15.63	13.71	**11.91 Recommended yield for practice**	9.71	5.60
$N_{22}\ P_{23}(3)\ K_{8}$	15.00	12.56	11.46	8.70	6.77
$N_{0}\ P_{0}(3)\ K_{0}$	12.08	10.03	9.46	7.54	5.97

5. Conclusions

Applying the Decision Support Ecotechnology, we are precisely establishing the needed irrigation schedule currently during growing season each year to create the necessary universal energy level L = 15 $(J/kg)^{1/2}$ of soil moisture through its implementing. This level is recommended by us for all soils and crops in the agricultural practices.

The level L = 5 $(J/kg)^{1/2}$ of soil moisture belongs to the Biological Optimum of Plant Soil Water Comfort. We recommend it to be created in field using the offered ecotechnology in order to obtain the crop yield, which is genetically possible for new sorts and hybrids. This study provides information for the practice of competency-based management.

Dependence of the maize yield on the introduced universal estimate is established for the first time in agricultural

sciences and practices. The application of DSS (research version) showed higher efficiency compared to the traditional irrigation regime. The maize grain yield increased on average more than 70 %, implementing the DSS schedules to maintain the energy level $L = 15\ J^{1/2}/kg^{1/2}$ of water status, which took into account the meteorological features of each year and saved on average (over eight years) 29.5 % of irrigation water in comparison with the traditional irrigation regime for considered crop and region.

The research version of ecotechnology was tested in field experiments over 30 years. The complex scientific base and many results are accepted by scientists working at the University of California (USA); University of Moscow (Russia); Land Reclamation Institute of Sindos (Thessaloniki, Greece); University of Beijing (China); Aegean University of Izmir (Turkey); Institute of Water Problems and National Institute of Meteorology & Hydrology, both at Bulgarian Academy of Sciences, Sofia (Bulgaria); and Poushkarov Institute for Soil Science, Agrotechnology and Plant Protection, Sofia (Bulgaria).

6. References

[1] Christov, I. Theoretical Basis for Crop Water Management. International Agricultural Physics, 5, (3-4), 1989, 261-268.

[2] Christov, I. Energy Levels of Soil Moisture and Biolproductivity. International Agricultural Physics, 6(1-2), 1992, 89-94.

[3] Christov, I. D. Estimation of Agroecosystem Water Status and Formation of Plant Water Supply in Soils. Monograph, Series Ecology, PublishScieSet-Eco, Sofia, 2004, p. 216, ISBN 954-749-044-3.

[4] Christov, I. Management of Agroecosystem Water Status. Part 1. New Complex Scientific Base. J. of Balkan Ecology, 11(1), 2008a, 5-22.

[5] Christov, I. Management of Agroecosystem Water Status. Part 2. Organization of Decision Support System (DSS) Application and Advantages. Journal of Balkan Ecology, 11(2), 2008b, 137-148.

[6] Christov, I. Management of Agroecosystem Water Status. Part 3. Adequacy of Decision Support System (DSS). J. of Balkan Ecology, 11(3), 2008c, 229-240.

[7] Christov, I. Management of Agroecosystem Water Status. Part 4. Relationships among Soil Moisture Energy Level, Soil Water Properties and Biological Features of Crop. J. of Balkan Ecology, 11(4), 2008d, 341-350.

[8] Christov, I. Monitoring and Management of Agroecosystem Water Status for Protecting Environment and Establishing Sustainable Agriculture. PublishScieSet-Eco, Sofia, 2012, p. 262, ISBN 978-954-749-098.

IMPACT OF GREEN MANURE AND STRAW ON BIOGENIC ELEMENTS LEACHING IN LUVISOL

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Abstract: *The paper presents summarized results of lysimetric experiments intended to determine the impact of green manure crops and straw on chemical elements leaching (N, K, Ca, Corg) and of atmospheric precipitation infiltration in sandy loam Luvisol. Lysimeter surface area is 1.75 m^2, the test soil layer is 0.60 m. It was determined that under climatic conditions of Lithuania, cover crops for green manure reduce atmospheric precipitation infiltration in sandy loam soil during autumn, and the effects of nutrient leaching depend on the plant species. Fabaceae plants clover (Trifolium pratense L.) stimulate nitrogen leaching, while Poaceae orchard grass (Dactylis glomerata L.) and Brassicaceae fodder radish (Raphanus sativus L.) lessen it. Incorporation of green manure biomass does not alter potassium and calcium leaching, but substantially reduces the organic carbon leaching.*

Key words: *LYSIMETERS, LEACHING, PERCOLATING, GREEN MANURE, STRAW, NITROGEN, ORGANIC CARBON*

1. Introduction

Percolating moisture regime is typical in many Western and Eastern European countries, and percolated precipitation significantly influences chemical composition of groundwater and river runoff. Lithuania is characterized by a temperate climate with a mean long-term (1961–1990) annual precipitation value of 664 mm, an annual mean air temperature of 6.0 °C. Such relationship between temperature and precipitation conditions leaching soil moisture regime in soil and is favourable for organic matter mineralisation.Agricultural lands, where various agro-technical measures are used for crop yield enlargement, very negatively affect the quality of underground water basins and reservoirs (Kutra et. al., 2006; Adomaitis et. al., 2010; Sørensen and Rubæk, 2012; Cicek et al., 2015).

The use of green manure increases the accumulation of organic carbon in arable soil layer, but the newly formed mobile humic substances can be leached from the upper layer and increase groundwater contamination (Arlauskiene et. al., 2009; Sleutel et. al., 2006). During decomposition of organic fertilizers many other chemical elements (phosphorus, potassium, calcium) are also mineralized; they can be washed out by atmospheric precipitation into the deeper layers of soil or water and adversely affect the state of water bodies (Bhogal et. al., 2009; Pappa et. al., 2011; Randall et.al., 2012). The intensity of these processes depends on the soil properties (especially texture and saturation with chemical elements), plants cultivated, hydrothermal conditions as well as the abundance of precipitation. Studies of agro-technical measures, regarding the peculiarities of geographic location of the soil and climate, are essential in order to systematically assess their impact not only on crop yield and product quality, but also on environmental sustainability, especially on the changes in the nutrient leaching resulting from the use of mineral and organic fertilizers.

This paper presents the summarized data on results of agro-chemical experiments regarding the impact of green manure and straw on migration of chemical elements and of atmospheric precipitation infiltration.

2. Material and methods

2.1. Site description

Experiments were performed at the Vokė Branch of the Lithuanian Research Centre for Agriculture and Forestry ($54^0 37'$ N, $25^0 08'$ E). Lysimetric equipment consists of a cylindrical concrete structure with a surface area of 1.75 m^2, the test soil layer is 0.60 m. Lysimeters are filled with sandy loam (sand 66%, silt – 16%, clay 18%) *Haplic Luvisol (*World Reference..., 2015). Thickness of the soil A horizon is 0.26 m. Underneath the arable layer there is a 0.09 m El and 0.25 m thick B horizon.

2.2. Experiments design

1 experiment. Iinfluence of intermediate crops for green manure and straw on a filtration of an atmospheric precipitation and chemical elements leaching.

Scheme of the experiment: 1. control (without added organic matter) 2. barley sraw + N30, 3. post-crop fodder radish (*Raphanus sativus* L.) + N30, 4. undersown red clover (*Trifolium pratense* L.). Plant segment: spring barley (*Hordeum vulgare* L.) → potato (*Solanum tuberosum* L.). The barley was fertilized with $N_{60}P_{60}K_{60}$, potatoes with $N_{90}P_{60}K_{90}$. In the years following the addition of green manure potato was cultivated.

2 experiment. The effect of different timing of undersowing plants and cereal straw incorporation into soil on nutrient leaching.

Scheme of the experiment: 1. no wintering plants (control), crushed barley straw inserted in autumn 2. no wintering plants, crushed barley (*Hordeum vulgare* L.) straw mulch inserted in spring 3. red clover (*Trifolium pratense* L.).for green manure and barley straw mulch (inserted in spring) 4. orchard grass (*Dactylis glomerata* L.) for green manure and barley straw mulch (inserted in spring). The impact of straw and green manure on nutrient leaching was studied in the chain barley → potatoes. The barley was fertilized with $N_{60}P_{60}K_{60}$, potatoes with $N_{90}P_{60}K_{90}$.

In each experiment, each treatment was replicated three times every year.

2.3 Methods of chemical analyses.

The leachate was analysed for the chemical element concentration (mg L^{-1}): nitrates (NO_3^-) – by colorimetric (LST EN ISO -13395-2000), potassium (K^+) by photometric method (ISO 9964:1998), calcium (Ca^{2+}) – atomic absorption (ISO 7890-86), total organic carbon (TOC) – ISO-8245:1999 method.

3. Results

3.1 Influence of intermediate crops for green manure and straw on a filtration of an atmospheric precipitation and chemical elements leaching.

The aim of the experiment was to evaluate the impact of undersowing (red clover), post crop (fodder radish) green manure as well as barley

straw with N_{30} additives on nitrogen, potassium, calcium and organic carbon leaching in sandy loam soil when biomass is plowedunder in autumn.

It was determined that in Lithuania cover crops (fodder radish, red clover) can reduce the rainfall infiltration by an average of 7.9-9.0 % a year, and during the autumn period – up to 16.5-16.9 %. Macdonald et. al. (2005) also note that early sown cover crops effectively reduce rainfall infiltration and leaching of nitrogen in light textured soils.

Results of the experiment showed that despite lower infiltration in soil with post crop plants, clover biomass plowed under in autumn, compared with barley stubble, increases nitrogen leaching by 11.5 % ($P < 0.05$) on average, because the clover biomass adds around 260 kg ha^{-1} N into the soil (Table 1). Post crop fodder radish produce different effect on nitrogen leaching. Unlike clover, fodder radish in autumn intensively use mineral nitrogen from soil and fertilizers for biomass formation, and it significantly reduces (31.9 %, $P < 0.05$) nitrogen leaching in the autumn and per year. Similar data was published by Constantina et al. (2010).

Table 1. *The effects of straw and green manure on chemical elements leaching in sandy loam Luvisol*

Treatment	Leaching kg ha^{-1} $year^{-1}$			
	N	K	Ca	C_{org}
Without organic matter	69.8	11.04	102.4	10.6
Straw + N_{30}	78.8	10.23	154.0	9.9
Fodder radish + straw + N_{30}	52.9	8.98	126.5	8.3
Red clover + straw	77.8	11.17	168.6	8.5
LSD_{05}	3.56	1,403	16.43	1.98

Under hydrothermal conditions of Lithuania, incorporation of nitrogen fertilizers (N_{30}) in autumn in order to promote straw mineralization processes increased nitrogen leaching by 9.0 kg N ha^{-1} on average. Fodder radish for green manure substantially reduce the leaching of calcium, as it is associated with lower rainfall infiltration. Potassium leaching increases after clover biomass is plowed under (+22.8 %, $P < 0.05$).

Various humic substances are formed in soil during the green manure biomass decomposition processes. It was revealed that after 6 years of the experiment, due to incorporation of green manure, the content of humus in soil increased by 0.03-0.14 % on average. The formed mobile humic substances can be leached out of the upper soil layer. Depending on hydrothermal conditions, 1.97-14.9 kg C_{org} ha^{-1} leach from the sandy loam *Luvisol* per year. Incorporation of green manure slightly increased average annual concentrations of C_{org} in the infiltrate, however, due to lower rainfall infiltration in the soil with cover crops, leaching of organic carbon decreased by 2.1-2.3 kg C_{org} ha^{-1}.

3.2. The effect of different timing of undersowing plants and cereal straw incorporation into soil on nutrient leaching

The aim of the experiment was to evaluate the impact of green manure (red clover and orchard grass) and straw mulching on reduction of precipitation infiltration over the period of autumn-winter-early spring as well as chemical elements leaching when the biomass is ploughed in spring.

It was determined that undersown crops stronger reduce rainfall infiltration during the period of their intense growth (summer and autumn) and when rainfall exceeds SCN. For example, during rainy autumn of 2011 undersown clover reduced the infiltration by 71 %, compared with barley crop, and during the rainy summer of 2013 orchard grass reduced the infiltration by 248 %. If precipitation is close to the SCN, undersown crops produce no significant influence on the infiltration. Therefore, the summarized data of the whole study period (2008-2014) show that in sandy soils undersown crops did not substantially reduce the rainfall infiltration during the autumn- winter-early spring period (Table 2).

Table 2. *The effect of undersown green manure crops and straw mulch incorporated into the soil in spring on the leaching of chemical elements*

Treatment	Infiltration rates l m^{-2}	Leaching kg ha^{-1} $year^{-1}$			
		N	K	Ca	C_{org}
No wintering plants, barley straw incorporated in autumn	336	21.3	13.1	84.4	23.5
No wintering plants, barley straw incorporated in spring	368	24.5	13.9	96.9	20.7
Red clover for green manure and barley straw mulch (incorporated in spring)	328	31.8	12.4	83.8	20.4
Orchard grass for green manure and barley straw mulch (incorporated in spring)	333	16.7	12.1	85.8	20.9
LSD_{05}	21.6	12.8	3.72	8.18	2.99

Nitrogen leaching losses after the undersown crops had been ploughed in spring depended on nitrogen content incorporated with biomass, plant species and decomposition time. Almost five times larger amount of nitrogen got into soil with clover biomass (7.54 g N m^{-2}) than with orchard grass (1.53 g N m^{-2}) and considerably more than with barley stubble (0.27 g N m^{-2}). Larger amount of nitrogen in biomass resulted in increased leaching. In the infiltrate from the soil fertilized with clover green mass the average annual nitrate concentration was by 30.5 % higher compared with straw incorporation in spring and by 92.7 % higher compared with the infiltrate of soil with the incorporated orchard grass biomass.

Studies on the dynamics of nitrate concentration revealed that the impact of undersown orchard grass on nitrate leaching reduction became evident in summer, and after the barley harvest the nitrate concentration substantially decreased. Average data of the years of undersown crops cultivation show that orchard grass reduces nitrate concentration in infiltrate up to 4.7 mg l^{-1} (control variant –- 18.9 mg l^{-1}), and in winter up to 2.9 mg l^{-1} (control variant – 24.8 mg l^{-1}). This experiment confirmed the results obtained by other researchers (Thomsen, 2005; Rinnofner et. al., 2008; Constantin et. al., 2010; Sapkota et. al., 2012) on the efficiency of grasses (orchard grass, ryegrass) to effectively reduce nitrate leaching.

The impact of symbiotic nitrogen-accumulating plants (clover) on nitrate leaching was different than of orchard grass. During the years of undersown clover cultivation slight increase in nitrate concentration (+5.1 mg l^{-1}), compared with the control, was recorded already during the summer, and the considerable increase in concentration (+43.9 mg l^{-1}) was recorded during the summer of the following year, when mineralization of the incorporated clover biomass became more intensive. According to Cookson et al. (2002), decomposition of clover biomass is intense even at a temperature of +2 ^{0}C, therefore in order to prevent nitrogen leaching losses, nitrogenous organic residues

must be incorporated in spring and not in autumn. According to the dynamics of nitrate concentration changes, intense biomass decomposition proceeded for about 6 months and during this period, with sufficient rainfall, mineralized nitrogen leaches into groundwater. When barley straw without nitrogen additive was used for fertilization, the nitrogen leaching made 21.3-24.5 kg N ha^{-1}. Straw incorporation period (autumn or spring) had no significant influence on nitrogen losses (P> 0.05). The impacts of green manure on nitrogen losses vary depending on the plant species. Red clover, accumulating more nitrogen in their biomass, increased its leaching as well. Nitrogen losses in soil fertilized with clover biomass increased by 49.3 % (P> 0.05) on average, compared with straw incorporation in autumn, and by 29.8 % (P> 0.05) compared with straw incorporation in spring. The main nitrogen leaching took place during the year of undersown crops incorporation; the increase leaching 66.9 %. During the years of undersown crops cultivation and plant residues mineralization in autumn - winter period the nitrogen leaching just slightly increased (16.3 %). During the years of undersown orchard grass cultivation, compared with barley field, the nitrogen leaching losses decreased by 39.4% on average, and in comparison with undersown red clover – even twice (P <0.05). The following year, when decomposition of orchard grass biomass was in progress, the nitrogen leaching was similar to that of straw incorporation, but by 80.5 % lower as compared to red clover (P <0.05). Results of these investigations correspond to data, received in the experiments executed in Denmark, Sweden, Finland and Norway (Valkama et. al., 2015).

Incorporation of straw, red clover and orchard grass biomass in spring, compared with traditional straw incorporation in autumn, had no significant impact on potassium and calcium leaching but reduced organic carbon leaching by 2.6-3.1 kg C ha^{-1}. The decrease was due to lower C_{org} concentration and lower rainfall infiltration in the crop with undersown clover. Investigations of Vinter et. al. (2006) showed the opposite trends. They have determined that clover biomass incorporation in spring increased the dissolved organic matter leaching from sandy loam and coarse sandy soils.

4. Conclusions

1. Under climatic conditions of Lithuanian undersown and post crop green manure plants substantially reduce rainfall percolation during their intense growth period. However, undersown crops have only slight effect on average annual percolation reduction.
2. The impact of cover plants for green manure on nitrogen leaching depends on their nitrogen consumption. Plants that during autumn period consume a lot of mineral nitrogen (orchard grass, fodder radish) reduce its leaching by 45-47 % (P <0.05) on average per year. Red clover increase nitrogen stocks in the soil resulting in higher nitrogen leaching (67 %, P <0.05) during the biomass decomposition.
3. Biomass of cover plants for green manure does not increase the potassium, calcium leaching (P> 0.05) and reduces the leaching of organic carbon (P <0.05).

5. Literature

1. Adomaitis T., J. Mažvila, Z. Vaišvila, J. Arbačiauskas, A. Antanaitis, J. Lubytė, D. Sumskis The effect of long-term fertilisation on anion leaching. Žemdirbystė=Agriculture, 1(97), 2010, p.71–82.
2. Arlauskienė A., S. Maikštėnienė, A. Šlepetienė The effect of catch crops and straw on spring barley nitrogen nutrition and soil humus composition. Zemdirbyste-Agriculture, 96 (2),2009, p.53–70 (in Lithuanian, English summary)
3. Bhogal A., F.A. Nicholson, B.J. Chambers Organic carbon additions: effects on soil bio-physical and physico-chemical properties. European Journal of Soil Science, 60, 2009, p. 276–286.
4. Cicek H., J.R Thiessen Martens, K.C. Bamford, M.H. Entz Late-season catch crops reduce nitrate leaching risk after grazed green manures but release N slower than wheat demand. Agriculture, Ecosystems & Environment, 202, 2015, p. 31–41.
5. Constantin J., B. Mary, F. Laurent, G. Aubrion, A. Fontaine, P. Kerveillant, N. Beaudoin Effects of catch crops, no till and reduced nitrogen fertilization on nitrogen leaching and balance in three long-term experiments. Agriculture, Ecosystems & Environment 35 (4), 2010, p. 268–278.
6. Cookson W.R., I.S. Cornforth, J.S. Rowarth Winter soil temperature (2–15°C) effects on nitrogen transformations in clover green manure amended or unamended soils; a laboratory and field study. Soil Biology and Biochemistry, 34 (10), 2002, p. 401–1415.
7. Kutra G., K. Gaigalas, A. Šmitienė Land use influence on nitrogen leaching and options for pollution mitigation. Zemdirbyste-Agriculture, 93(4), 2006, p.119-129.
8. Macdonald A.J., P.R. Poulton, M.T. Howe, K.W.T Goulding, D.S. Powlson The use of cover crops in cereal-based cropping systems to control nitrate leaching in SE England. Plant and Soil, 273, 2005, p. 355-373.
9. Pappa V. A., R.M. Rees, R.L. Walker, J.A. Baddeley, C.A. Watson Nitrous oxide emissions and nitrate leaching in an arable rotation resulting from the presence of an intercrop. Agriculture, Ecosystems & Environment, 141 (1-2), 2011, p. 153–161.
10. Randall N. P, L.M. Donnison, P.J. Lewis How effective are slurry storage, cover or catch crops, woodland creation, controlled trafficking or break-up of compacted layers, and buffer strips as on-farm mitigation measures for delivering an improved water environment? Environmental Evidence, 1, 12, 2012.
11. Rinnofner T., J.K. Friedel, R. De Kruijff, G. Pietsch, B. Freyer Effect of catch crops on N dynamics and following crops in organic farming. Agronomy for Sustainable Development, 28, 2008, p. 551-558.
12. Sapkota T.B., M. Askegaard, M. Lægdsmand, J.E. Olesen Effects of catch crop type and root depth on nitrogen leaching and yield of spring barley. Field Crops Research, 125, 2012, p. 129–138.
13. Sleutel S., S. De Neve, T. Nemeth, T. Toth, G. Hofman Effect of manure and fertilizer application on the distribution of organic carbon in different soil fractions in long-term field experiments. European Journal of Agronomy, 25 (3), 2006, p. 280-288.
14. Sørensen P., G.H. Rubæk Leaching of nitrate and phosphorus after autumn and spring application of separated solid animal manures to winter wheat. Soil Use and Management, 28(1),2012, p.1-11.
15. Thomsen I. K. Nitrate leaching under spring barley is influenced by the presence of a ryegrass catch crop: Results from a lysimeter experiment. Agriculture, Ecosystems & Environment, 111(1–4), 2005, p. 21–29.
16. Valkama E., R. Lemola, H. Känkänen, E. Turtola Meta-analysis of the effects of undersown catch crops on nitrogen leaching loss and grain yields in the Nordic countries. Agriculture, Ecosystems & Environment, 203, 2015, p. 93–101.
17. Vinther F.P., E.M. Hansen, J. Erikse Leaching of soil organic carbon and nitrogen in sandy soils after cultivating grass-clover swards. Biology and fertility of soil, 43, 2006, p. 12-19.
18. World Reference Base for Soil Resources 2014. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome. 2015.

PRIORITIZING OF SOIL AND WATER RESOURCES MANAGEMENT SCENARIOS USING MULTI-CRITERIA DECISION MAKING TECHNIQUE

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Abstract: *Watershed sources management is considered as a new principle for development planning and management of water and soil resources emphasizing on various criteria of the region to sustainable livelihoods and without vulnerability of plant and the residents of an area. Aiming at management of soil and water resources with scenario building approach, current study has evaluated and prioritized biological management options in the study area. With a choice of four biological management activities, scenarios were developed and then criteria weighting and ultimately the best management option selection was carried out using analytic hierarchy process (AHP). The results indicated that social, ecological, economic and physical criteria were respectively prioritized from one to four and scenario number 16 was identified as the best scenario and the first priority.*

Keywords*:* SOIL AND WATER, BIOLOGICAL MANAGEMENT, VEGETATION SCENARIO, ANALYTIC HIERARCHY PROCESS.

1. Introduction

The difficulty of environmental and natural resources management is reflected in the comprehensive management related studies [see for example 1-7]. Integrated catchment management as an approach that try to solve catchment issues based on sustainable development [8]. Integrated catchment management is globally acknowledged as a good method for the management and planning of water, soil, and related resources, and finally achieve to ecosystem sustainability as a result. Considering the condition and nature of watersheds as an especial class of management systems, integrated catchment management provides a framework for integrating knowledge and various aspects of the social, economic, and environmental sciences into assessment, planning and management [9]. Assessment, planning and management will improve through an exact understanding and trade-off analysis of consequences from the implementation of various management scenarios on various spatial and temporal scales.

Operationally, watershed source modeling and management must deal with characteristics that are not easy to explain and components that may involve both qualitative and quantitative factors. In terms of scope, management may include geographic areas where boundaries are simply not recognizable or socioeconomic areas that influence different interests of stakeholders, each of whom has his own requests and socio-economic requirements [10]. In view of these difficulties, this research suggests techniques based on multi criteria decision making (MCDM) for undertaking such a complicated management process. MCDM methods are deliberately developed for complex problems such as watershed management.

Many scientists have researched about the application of various techniques such as MCDM in watershed modeling and management [11-15]. Al-Rashdan et al., [16] reports application of MCDM to prioritize in projects to improve the environmental quality of the Jordan River. Flug et al., [17] reports on use of MCDM to choose water flow options for Glen Canyon Dam in Colorado to provide recreation, biodiversity, fishing and cultural activities. Qureshi and Harison [18] reports application of AHP to determine how five stakeholder groups ranked four riparian vegetation options for the Johnston River Catchment in North Queensland, Australia. The main goal of current study was to apply a MCDM method which to be applied for integrated catchment management and to determine the best management scenario.

2. Materials and Methods

Study area

The Delichay catchment, located in the north of Iran Central Plateau (Eastern North of Tehran province), has an area of about 350 Km^2. Its geographic position lies between 52° 10′- 52° 25′ E longitude and 35° 30′- 35° 50′ N latitude, and its elevation ranges from 1400 to 3900 m MSL.

Developing biologically-based management scenarios

Firstly, sources of runoff and sediment problems over the Delichay watershed were identified in land management units. These units were determined according to slope, geological formation, land use, vegetation cover, soil condition and erosion. The next stage was to list all possible actions to alleviate effects of these conditions for each land management unit. Implementation of every management activity was studied according to the condition of each unit in terms of including technical (as mentioned above e.g. slope, geology …), socio-economic condition and time possibilities.

After simultaneous management actions in the study area were ascertained, all feasible management actions were determined considering the limitations existing in the watershed. The four biological actions including sowing, seeding (based on slope condition with machine and without machine), and grazing management were determined for the Delichay catchment. These four actions were combined, which led to 16 (2^n) various management scenarios (Table 1).

Table 1: *Suitable area for biological management activities of the Delichay catchment.*

Biological activity	Suitable area
Seeding (Using machine)	Rangelands with semi-deep to deep and moderate soil textures, moderate vegetation density and severe erosion, slope less than 20%
Seeding (Without machine)	Rangelands with semi-deep and moderate soil textures, moderate vegetation density and severe erosion, slope less than >40%
Sowing	Rangelands with semi-deep and moderate soil textures, moderate vegetation density and severe erosion, slope more than 20-40%
Grazing management	Rangelands with light to semi-heavy soil textures, moderate vegetation density and low soil erosion, various slopes

Modeling integrated catchment and management using a fuzzy AHP approach

Compared with other MCDM techniques on AHP analysis is comparatively simpler. In the current research, AHP analysis method was applied for assessing and prioritizing biological management scenarios in the Delichay watershed in Iran Central Plateau.

3. Results and discussion

Analysis of biological management actions

Study criteria and indices were identified according to priority. The relative weight of each chosen criteria was extracted from the AHP technique based on a pairwise evaluation of the options. Different weights were given to the criteria based on 4 various aspects that might be selected by experts who are involved and have enough knowledge about the study area issues or by some of the stakeholders who are part of the village councils in the study area. The normalized weights of the criteria and comparative weighting of management actions into criteria are shown in Tables 2 and 3.

Table 2: *Normalized and ranked weights of the criteria of the study area management.*

Criteria	Ecologic	Social	Physical	Benefit	Cost
Weight	0.210	0.223	0.198	0.191	0.178
Rank	2	1	3	4	5

Table 3: *Comparative weighting of management actions into criteria in the study area management.*

Criteria		Ecologic	Social	Physical	Benefit	Cost
Actions	Sowing	0.23	0.31	0.21	0.24	0.21
	Seeding (Using machine)	0.17	0.12	0.26	0.02	0.58
	Seeding	0.21	0.27	0.16	0.24	0.12
	Management	0.39	0.3	0.37	0.5	0.09

Finally, the normalized weights of indicators were multiplied by their weights and summed up to determine the best scenario(s). The results of prioritization of management actions in various weighing aspects are indicated in Tables 4.

According to the results, social criteria are the first priority compared with other criteria. Social criteria are strongly dependent on the stakeholder contribution rate in implementing the suggested management actions; because stakeholders may participate in rangeland improvement projects as unskilled workers during the seasons they are not busy with agriculture and animal husbandry activities. In fact, they have more free time and interest to receive revenue by working in these projects. Since the council members of the villages were educated and had enough knowledge of the positive outcomes of management actions, they were interested in improving degraded rangeland for soil and water conservation. Ecological and physical criteria contributed almost 24% and 18%, respectively. These results refer to the priority of social problems, even compared with economic criteria for decision making and implementing improvement projects for watershed management.

Table 4: *Prioritization of management scenarios of Delichay management.*

Number	Scenarios	Weighs based on AHP	Priority
1	Base case	0.00571	16
2	Grazing management	0.07752	7
3	Seeding (using machine)	0.02859	13
4	Seeding	0.01761	15
5	Sowing	0.04359	12
6	Seeding (machine) & grazing management	0.07399	8
7	Seeding (machine) & seeding	0.02607	14
8	Seeding & sowing	0.05309	10
9	Grazing management & seeding	0.08117	6
10	Grazing management & sowing	0.09902	2
11	Seeding (machine) and sowing	0.05004	11
12	Seeding (machine), seeding and grazing management	0.08367	5
13	Seeding (machine), seeding & sowing	0.06058	9
14	Sowing, seeding (machine) & grazing management	0.09552	4
15	Sowing, seeding & grazing management	0.09672	3
16	Seeding (machine), sowing, seeding & grazing management	0.10524	1

Analysis of the results, according to the weighted sum method, showed the priority levels of the scenarios as related to the overall objective. In most parts of the research area, scenario 16 received the highest score; it was ranked first, followed by scenario 10. This means that the stakeholders of the Delichay watershed are interested in reclaiming rangeland areas. The best priority of scenario 16 was directly related to social criteria, especially incomes from working in suggested management actions. Scenario 15 was determined as the third choice, making it higher in priority than scenario 14, because of the effects of the sowing implementation area, which included about 42% of the total research area. In fact, the effects of the implementation of scenario 15 which included sowing activities on four indices (ecologic, social, physical, and income) was more effective.

4. Conclusion

From the overview and vital reviews of MCDM explained in the last parts of this manuscript and the discussion regarding other possible approaches, it is obvious that MCDM suggests an appropriate decision-making and planning structure for watershed management. Because it is essentially robust, it is also able to supply a suitable framework that serves well in connecting the gap between the more structured and analytical quantitative approach and the soft qualitative planning approach.

The results of implementing management actions for watershed management may appear in various spatial patterns of land cover. The MCDM approach is a suitable method for dealing with the variability associated with land cover patterns resulting from management performance [19].

Criteria selection and determination is directly related to national and regional strategies. Thus, to apply the achievements of the current study, these strategies must be taken into consideration. This guarantees the suitability and feasibility of the consequences. This method occurs with the fact that watershed systems are dynamic and complicated and it is not an easy task to capture all of the disciplinary elements involved in management of natural resources catchment-wide.

Acknowledgement

Support for this research provided by the International Desert Research Center (IDRC), University of Tehran is greatly appreciated.

References

[1] I.W. Heathcote, Integrated watershed management. John Wiley and Sons, 1998.

[2] A.J. Jakeman and R.A. Letcher, Integrated assessment and modelling: features, principles and examples for catchment management, Env. Mod. Soft., 18 (2003) 491-501.

[3] H. Van Delden, T. stuczynski, P. Ciaian, M.L. Paracchini, J. Hurkens, A. Lopatka, Y. Shi, O. Gomez Prieto, S. Calvo, J. Van Vliet and R. Vanhout, Integrated assessment of agricultural policies with dynamic land use change modelling, Eco. Mod., 221 (2010) 2153-2166.

[4] R.A. Kelly (Letcher), A.J. Jakeman, O. Barreteau, M.E. Borsuk, S. ElSawah, S.H. Hamilton, H.J. Henrikson, S. Kuikka, H.R. Maier, A.E. Rizzoli, H. Van Delden and A.A. Voinov, Selecting among five common modelling approaches for integrated environmental assessment and management, Env. Mod. Sof., 47 (2013) 158-181.

[5] G.F. Laniak, G. Olchin, J. Goodall, A. Voinov, M. Hill, P. Glynn, G. Whelan, G. Geller, N. Quinn, M. Blind, S. Peckham, S. Reaney, N. Gaber, R. Kennedy, A. Hughes, Integrated environmental modeling: a vision and roadmap for the future, Env. Mod. Soft. 39 (2013) 3-23.

[6] M. Cinelli, S.R. Coles and K. Kirwan, Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment, Eco. Ind., 46 (2014) 138–148.

[7] H. Chakroun, Z. Lili Chabaane and S. Benabdallah, Concept and prototype of a spatial decision support system for integrated water management applied to Ichkeul Basin, Tunisia, Wat. Env. J., 29 (2015) 169–179.

[8] A.R. Keshtkar, A. Salajegheh, A. Sadoddin and M.G. Allan, Application of Bayesian networks for sustainability assessment in catchment modeling and management (Case study: The Hablehrood river catchment), Eco. Mod., 268 (2013) 48–54.

[9] C. Fulcher, T. Prato and Y. Zhou, Economic and environmental impact assessment using a watershed management decision support tool Knowledge and subtopics on watershed management issues. San Diego (USA) ESRI, 1997.

[10] G.A. Mendoza and R. Prabhu, Fuzzy methods for assessing criteria and indicators of sustainable forest management, Eco. Ind., 3 (2003) 227–236.

[11] J. Bromley, N.A. Jackson, O.J. Clymer, A.M. Giacomello and F.V. Jensen, The use of Hugin to develop Bayesian networks as an aid to integrated water resource planning, Env. Mod. Soft., 20 (2005) 231-242.

[12] A. Sadoddin, R.A. Letcher, A.J. Jakeman and L.T.H. Newham, A Bayesian decision network approach for assessing the ecological impacts of salinity management, Mat. Com. Sim., 69 (2005) 162-176.

[13] R.A. Letcher, B.F.W. Croke, A.J. Jakeman and W.S. Merrit, An integrated modelling toolbox for water resources assessment and management in highland catchments: model description, Ag. Sys., 89 (2006) 106-131.

[14] A. Benzerra, M. Cherrared, B. Chocat, F. Cherqui and T. Zekiouk, Decision support for sustainable urban drainage system management: A case study of Jijel, Algeria, J. Env. Man., 101 (2012) 46-53.

[15] C. Gutzler, K. Helming, D. Balla, R. Dannowski, D. Deumlich, A. Knierim, W. Mirschel, C. Nendel, C., Paul, S. Sieber, M. Glemnitz, U. Stachow, R. Wieland, A. Wurbs, P. Zander, A. Starick, Agricultural land use changes – a scenario-based sustainability impact assessment for Brandenburg, Germany, Eco. Ind., 48 (2015) 505–517.

[16] D. Al-Rashdan, B., Al-Kloub, A., Dean and T., Al-Shemmeri, Environmental impact assessment and ranking the environmental projects in Jordan. Eu J. Oper. Res., 118 (1999) 30-45.

[17] M. Flug, H.L.H., Seitz and J.F., Scott, Multicriteria decision analysis applied to Glen Canyon Dam, J. Wat. Res. Plan. . Manag., 126 (2000) 270-276.

[18] M.E. Qureshi and S.R. Harison, A decision support process to compare riparian revegetation options in Scheu Creek catchment in North Queensland, J. Env. Manag., 62 (2001) 101-112.

[19] A. Sadoddin, V. Sheikh, R. Mostafazadeh and M.Gh. Halili, Analysis of vegetation-based management scenarios using MCDM in the Ramian watershed, Golestan, Iran, Intl. J. Pl. Prod., 4 (2010) 1-12.

HYDROMETRIC MONITORING OF RIVERS IN CONDITIONS OF EHTREME PHENOMENA-METHODICAL AND TEHNOLOGICAL INOVATIONS

ХИДРОМЕТРИЧЕН МОНИТОРИНГ НА РЕКИТЕ В УСЛОВИЯ НА ЕКСТРЕМАЛНИ ЯВЛЕНИЯ-МЕТОДИЧНИ И ТЕХНОЛОГИЧНИ ИНОВАЦИИ

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Abstract: *High water levels in the conditions of extreme events are a characteristic phase of the river runoff in the order of several hours passing huge volumes of water. The drainage is characterized by turbulent state, significant velocities and depths, which change rapidly and cause pronounced uneven and unsteady process. Water quantities may exceed a few hundred times their annual average, causing large spills in river valleys, and the deep depth and dragging force of the stream are a natural disaster causing huge damage with the possibility of human casualties.*

KEYWORDS*: MEASURMENT, WATER LEVEL,RIVER ,VELOCITIES, WATER QUANTITY*

1.Introduction

Discharge is the volume of water moving down a stream or river per unit of time, commonly expressed in cubic feet per second or gallons per day. In general, river discharge is computed by multiplying the area of water in a channel cross section by the average velocity of the water in that cross section.

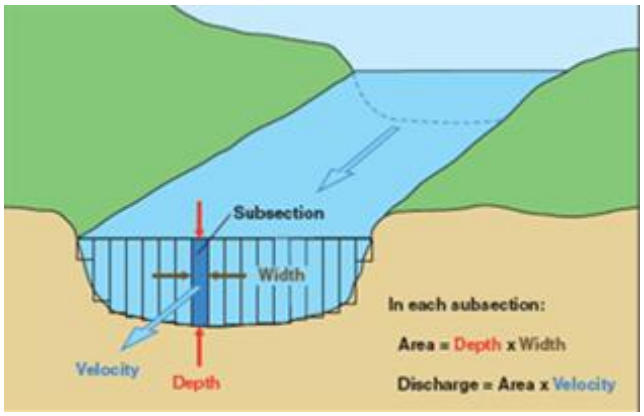

Fig.1. *Determining the discharge of water in the river or open channel;*

Determining the discharge of water in the open river or open channel , comparison of modern innovative hydrometric methods.

Method for calculation;

(1)$A = H * h$

A-area of the cross section of each vertical; H-Depth;
h-weight of each vertical;

(2)$Q = A * V$

Q-amount of water for 1 second; *A-area of the cross section of each vertical; V- main speed in each verticals;*

2.Precounditions and means for resolving the problem

The problem is that in flood conditions the water quantity can't be measured due to high speeds, an innovative method must be sought. The universal hydrometric propellers shown in Figure2 are currently used. These hydrometric propellers have rotating axle elements, fins, bearings that can be damaged by a stone block and huge trees.[1],[2]



Fig2. *Horizontal-shaft propeller-type current meter;*

A current meter is a device with a rotor which revolves at a speed which is a function of the local velocity of flow. By placing the current meter at a point in the stream and recording the number of revolutions over a known period of time, the velocity at that point can be determined from the revolution-velocity rating of the current meter. The number of revolutions of the rotor is obtained by an electrical circuit through a contact which completes the circuit at a selected number of revolutions. The electrical impulse produces an audible signal in a buzzer or is registered on an electrical counter. The time is determined by a stop watch or by a timer built into the counting instrument. There are two common types of current meters, the cup-type and the propeller-type .We use propeller-type current meter consists of a propeller revolving about a horizontal shaft, two bearings in an oil chamber, the current-meter body containing the electrical contact, tail-piece with-vane, and means of attaching the instrument to the suspension equipment. The current meter may be provided with one or several propellers which differ in pitch and diameter.[3]

2.1 Experimental stand

An experimental stand for the measurement of surface speeds of rivers and canals was carried out under conditions of high water levels at station HMS №23850, near Karanci with a water level of 382cm. The experiment is performed in parallel with 50 kg of hydrophobic torpedo and a hydrometric propeller with a propeller diameter of 80 mm. The aim is to compare the results obtained from different types of devices, as well as to know if the amount of water at surface speeds and depths. We will use device for Surface Speed and dept. Devices is install on the top of the bridge, measure speed surface, depth, in each verticals.

2.2. Figure of the experimental set of the bridge



Fig.3 *Station HMS №23850, river Qntra-karanci , experimental set of the bridge;*

The experimental setup shows that the devices measure in the same position as recorded in the Hydrometer literature. This crane lab is used to measure high levels, but it can't be used anywhere because of infrastructure problems. We usually use it to measure from road bridges. Measurement data is recorded in a book, then processed according to established standards, and also based on measured, velocity and depth, the water quantity is calculated.

2.3 RQ-30 Radar device

The RP-30 Radar Profiler, a mobile measurement system, is used to measure the surface velocity profile of rivers and canals. To achieve maximum mobility we offer different mobile mounting devices that will suit any situation. The measurement data are transferred in real time to a laptop by an integrated Bluetooth transmitter in the RP-30. The results can be viewed immediately on the computer screen during the measurement.[4]



Fig.4 *Install mobile device on the bridge near to Rilski manastir, river Rilska, station number 51450*

After measuring the velocity and depth in each vertical, the water quantity is calculated by means of software, this quantity is an important indicator as well as for farmers, so it is extremely important for forecasting large floods and for the economy in these regions

3. Experimental data from the conducted measurement

Station HMS №23850, river Qntra-Karanci.

Geography Karantsi

The village of Karantsi is 4.6 km northeast of the town of Polski Trambesh, to the left of the third-class road to the village of Orlovets (6.8 km). Car travel to the municipal center is about 6 minutes. It is located on the east bank of the Yantra River

Table 1. *Station HMS №23850, river Qntra-Karanci*

Vertical №	**Distance**	**Depth**	**Area**	**Velocity (average)**	**Discharge**
-	m	m	$м^2$	м/s	$м^3/s$
Start point	0	0	0	0	
2	4	0.42	1.68	0	0
3	8	0.52	2.08	0.246	0.511
4	12	0.97	3.88	0	0
5	16	1.55	6.22	0.538	1.732
6	20	1.80	7.20	0.479	3.448
7	24	2.50	10	0.468	4.680
8	28	2.70	10.8	1.156	12.480
9	32	2.90	11.6	1.447	16.785
10	36	3.67	14.68	1.664	24.427
11	40	3.65	14.60	1.706	24.901
12	44	4.08	16.32	1.495	24.398
13	48	5.00	20.00	1.385	27.713
14	52	5.55	22.20	1.521	33.781
15	56	4.94	19.76	1.558	30.779
16	60	4.28	17.12	1.696	29.035
17	64	4.70	18.80	1.328	24.966
18	68	4.42	17.68	1.043	18.440
19	72	3.67	14.68	0.899	13.207
20	76	2.60	10.40	0.440	4.579
21	80	1.0	4.0	0.157	0.630
End point	83	0	0	0	0
					Total:Q 296.492

The measurement data are presented in The measurement was carried with a hydrometric propeller and a torpedo of 50 kg. A subsequent measurement with the RQ-30 radar system was carried out.

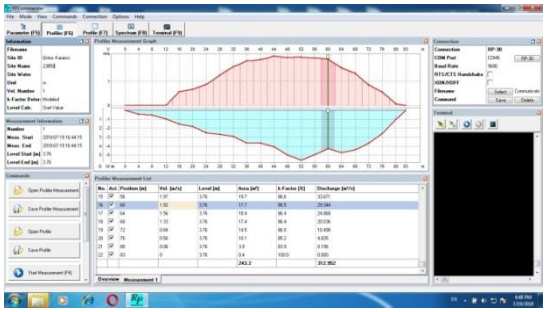

Fig.5 *Measurement with Doppler radar RQ-30*

Fig.5 Preview of the measured values of the River Qntra -Karanci , speed profile, and river bed profile. The software allows you to exclude some verticals. Corrective parameters are set depending on the river bottom, large- size stones, sandy bottom, medium-sized stones.

3.1.Profil measurement(velocity of flow)-Qntra -Karanci

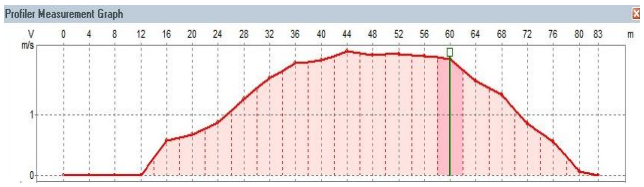

Fig.6 *Velocity of flow of the river in each vertical.*

The value of the river width is plotted horizontally, and the value of the speed flow. There are theories that make a connection between the speed profile and the deep river profile. The higher the depth in the section, the faster it is. In some cases this may be true and wrong. The figure in Figure 5 shows this dependence, in this river. It is very important to note that in the high water the vertical velocity profile is variable. In this case, the depth profile and the speed profile are complementary (they are respectively inverted) mirror to each other. surface velocity is greater, and there are a number of measurements that have adopted the following dependencies for correlation parameters. At a depth above 0.45, consider the following speeds to determine the mean vertical velocity: Surface speed, velocity with factor 0.2 (depth), 0.6 (depth), 0.8 (depth). and speed down.[4] These coefficients are used when measuring with a torpedo-type universal current meter . In our measurement, the radar automatically uses these parameters and determines what coefficient to set. The coefficient ranges from the recommended K factor is (0.70 to 0.90) In our measurement, the radar automatically uses these parameters and determines what coefficient to set. The coefficient varies in recommended values. K factor (0.70 to 0.90) influences also the geometric shape. Example if there is a corrected bottom or irrigation channel.

Determination of the main velocity

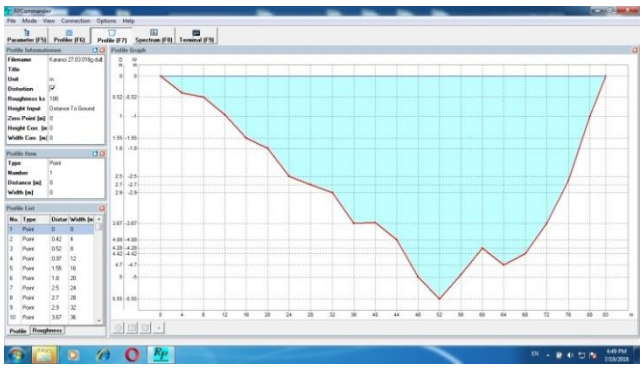

Fig.7 Cross section profile Qntra -Karanci

3.2 Cross section profile

The prediction for the determination of the discharges is the cross sections profile. Either the cross section is known due to topographical survey or it has to be determined in advance. This can be performed with staging in different verticals or by measurements with an ADCP boat. Before the measurement the cross sections is divided into different sectors. The individual sectors are defined by positions where the measurement of the surface velocity is performed.Fig.7 Cross section profile on the horizontal is the length of the river, and the vertical is the depth of the river.

3.3Discharge Calculation

The discharge is determined for every sector individually

(3)$Qi = Ai * v(mean).i$

Qi- discharge of sector i[m^3/s]

Ai cross section area of the sector i[m^2]

Vm_i- mean flow velocity of sector i[m/s^2]

3.4K factor

In the sector the flow velocity at the water surface is measured .This velocity is not the mean velocity. Therefore a correction factor has to be implemented to calculate the main velocity from the surface velocity.

(4)$v_m = k * v^i$

k-k- factor ,dimensionless correction factor

Vm- mean flow velocity[m/s]

Vi –local flow velocity at the water surface[m/s]

3.5.Calculation

The calculation of the partial discharge with a k –factor is determined from equation (3)

(5)$Q_i = A_i * k_{i*} V_i$

Qi- discharge of sector i[m^3/s]

Ki-k-factor of sectors I;

Vi-local velocity at the water surface of sector i[m/s^2]

3.6.Total discharge is the sum of the partial discharges of the individual sectors.

(6)$Q = \sum Qi$

Qi – discharge [m^3/s]

Qi – discharge of the individuals i sectors [m^3/s]

4.Experimental data from the conducted measurement

Measurement was made on the Rilska River HMS№51450 Data:09/03/2018 at the Rila Monastery, while the river was at low water level at that time, the purpose of the measurement is to compare it at low levels, according to the measurement with a universal hydrometric propeller

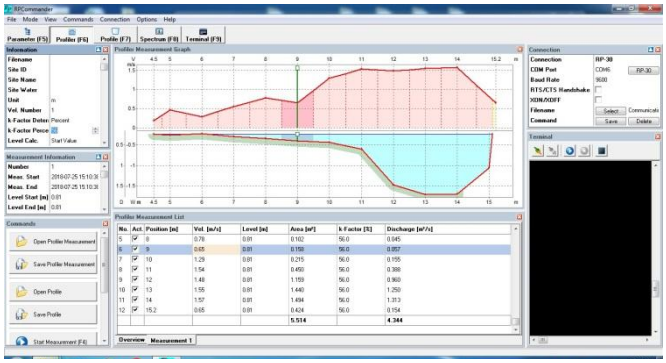

Fig.8 *Cross section profile the river Rilska*

The figure shows that the measured amount of water is 4.344 cubic meters, and the measured by a universal hydrometric propeller is 4.318 cubic meters. There is little difference in the measured values, but this is due to the different measurement methods.

Table2. *Station HMS№51450 the Rilska River.Measurement with universal current meter.[4]*

Vertical №	**Distance**	**Depth**	**Area**	**Velocity (average)**	**Discharge**
-	m	m	$м^2$	м/s	$м^3/s$
Start point	0	0	0	0	0
1	4.5	0.24	1.08	0.193	0.208
2	5	0.26	0.13	0.458	0.059
3	6	0.23	0.23	0.286	0.065
4	7	0.30	0.30	0.548	0.164
5	8	0.34	0.34	0.807	0.274
6	9	0.38	0.38	0.397	0.150
7	10	0.40	0.40	1.296	0.518
8	11	0.62	0.62	1.544	0.957
9	12	0.60	0.60	1.485	0.890
10	13	0.62	0.62	1.553	0.962
11	14	0.64	0.64	1.578	1.009
End point	15	0.70	0.70	0.852	0.596
					Total:Q 4.318

5.Conclusion

Modeling of the k-factor is a dimensionless correction factor to calculate the mean velocity from the measured surface velocity. Usually the k –factor is in the range of 70 to 90 but can deviate strongly due to geometrical influences. The main velocity is determined theoretically using the formula by Darcy –Weisbach.In that case of field measurements, they are very good results and the system can be used as a measuring device for large quantities of river (floods). The system allows the input of parameters of stones or large rock fragments as it generates its correction coefficients.

6.Literature

[1] Plamen Ninov - Determination of characteristic high flow at ungauged river stretches using hydrographic characteristics of the region and at monitored stretches, Bulgarian Journal of Meteorology and Hydrology, book. 5, vol. 17, 2012

[2] Plamen Ninov., Tziavtka Karagiozova, 2010, Development Of The Hydrological Model For The Upper Vit Watershed By HEC-HMS With Regard To Identification Of Missing High Waves, In:Proceedings of Fourth International Conference onWater Observation and Information System for Decision Support BALWOIS2010, Ohrid, Republic of Macedonia 25 to 29 May 2010. Full papers-CD. p.9

[3] Assoc. Prof. Dr. Eng. Vladia Subkova Institute of Soil Science, Agrotechnology and Plant Protection WATER MEASURING DEVICES FOR THE OPEN CHANNELS OF THE IRRIGATION SYSTEMS

[4] Prof. Dr. Eng. Evelin Simeonov Monev - Engineering Hydrology and Hydraulics - Hydrological and Hydraulic Calculations, Water Supply Equipment, Correction, Drainage, Inspection and Targeting of Overflow Systems.

Websites:

1. OTT Hydromet

http://www.ott.com/en-us/products/water-flow-56 19.07.2018

2. SEBA HYDROMETRIE

https://www.sebahydrometrie.com/products.html?L=1&tx_sebaproducts_sebaproducts%5Bproduct%5D=43&tx_sebaproducts_sebaproducts%5Bprimarycategory%5D=2&tx_sebaproducts_sebaproducts%5Bsecondarycategory%5D=&tx_sebaproducts_sebaproducts%5Baction%5D=show&tx_sebaproducts_sebaproducts%5Bcontroller%5D=Product&cHash=e95087c41e7c59186b3a03fa8043a756

3. sommer MESSTECHNIK

http://www.sommer.at/en/products/water/rq-30-rq-30a 19.07.2018

WATER PURIFICATION FROM DIFFERENT POLLUTANTS BY ACTIVATED CARBONS

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Absract: *Nanoporous activated carbons were prepared by hydropyrolysis processing from various biomass precursors – apricot stones, been pods, bamboo, etc. The obtained carbon adsorbents are distinguished with moderately high surface area and prevailing microporous structure. Their properties determine their application as effective adsorbents for removal of organic (phenols, etc.) and inorganic pollutants (metal ions, etc.).*

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1. Introduction

Due to their highly porous structure and large adsorption capacity, activated carbons are widely used as adsorbents in technologies connected to pollution abatement in water and gases in chemical industry, pharmaceutical and food industries, etc. Activated carbons have often been synthesized from precursors based on expensive and depleting fossil fuels, but they can be prepared easily from biomass or agricultural by-products, and the cost will be lower. In the last years appeared many reports, dedicated to the preparation of activated carbons from various cheap and alternative precursors - coal, agricultural by-products and other biomass materials, polymer materials, etc. [31-42].

The subject of this work is: preparation carbon adsorbents from different polymer and biomass waste; characterization of the samples; effective application for removal of metal ions and organic pollutants from waters.

2. Experimental

Different precursor were used to prepare carbon adsorbents:

- polymers – polyolefin wax, phenol-formaldehyde resin, etc.
- agricultural wastes - *coconut shells, apricot stones, almond shells, grape seeds, olive stones and pulp, cherry stones, bamboo, been pods, straw etc.*

Low rank coal *lignites*

Preparation of synthetic carbons: The precursor was heated up to 115°C until melting 98%. H_2SO_4 was added by drops with continuous stirring, and the mixture was heated up to 160°C. The obtained solid product was washed with water, dried at 150°C, and carbonized at 600°C.

Biomass and synthetic carbon was subjected to **hydropyrolysis procedure** using the installation presented in Fig. 1.

Chemical activation with K2CO3: The initial material was ground to 0.5mm particle size. The activation process involved mixing of the initial material and the activating agent in water, in a ratio reagent to precursor material of 4:6. The mixing was performed at room temperature under stirring for 12 h. After mixing, the slurry was subjected to drying at 110 ◦C overnight. The chemical-loaded sample was then carbonized in a N_2 atmosphere. Carbonizationwas carried out by heating the sample at 10 ◦C min^{-1} from room temperature up to 950 ◦C, and then heated at this temperature for 10 min. After cooling under N_2, the carbonized product waswashed to remove the residual chemical. The final product was then dried at 110 ◦C (activated carbon B).

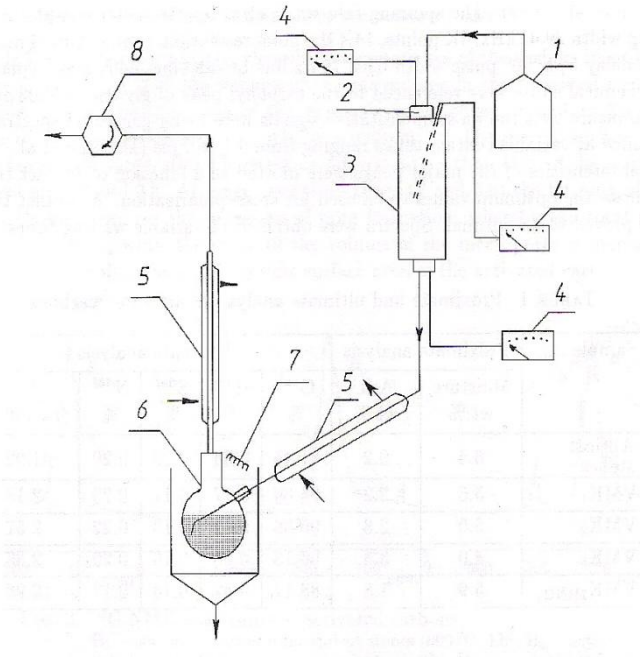

Fig. 1

3. Results and Discussion

	C-AS	C-SFH	C-BeP	C-BePA*	C-CornCob
BET, m^2/g	850	350	258	1580	500
phenol	172		130		89
p-nitro-phenol	179				
naphthalene	30		85	300	
ethylactetate	160	180			

Fig. 2*. Adsorption capacities (mg/g) of carbons adsorbents form biomass towards different organic pollutants in aqueous solution*

	C-POW	C-POW-PhF	C-CTP-F	C-CTP-F-O	C-CTP-F-O
BET, m^2/g	800	1100	1173	487	
phenol				155	126
m-amino-phenol			165	110	85
p-nitro-phenol			152	132	97
pentachloro-phenol		22			
naphthalene			19		
methyl orange	269				
bromophenol blue	106				
ethylactetate	200		450	250	

Fig. 3. *Adsorption capacities (mg/g) of synthetic carbons adsorbents form biomass towards different organic pollutants in aqueous solution*

	BET, m^2/g	Hg	Pb	Cu	Zn	Cd	Ni	Mn	As
C-POW	513	196							
C-CTP-F	678	149							
C-CTP-F-O	487	136							
C-F	1100	174							
C-PAS-F70	1000	154						47	
C-PAS-F70-O	480	132						102	
C-PAS-F50-O	291							97	
C-PAS-F30-O	268							79	
C-PAS	980							38	
C-Coal M	620	92							
C-Coal Se	460	54							
C-Coal So	610	105							
C-Coal B	520	37							
C-AnWa*	1260	129							
C-BaPe	810	-	-			-	-	-	1.01
C-POP 1	1030							21	1.39
C-POP 2*	1850							-	0.85
C-POS *	1610							-	0.73
C-POP 1-O	732							32	0.21
C-BePo	258							23	1.34
C-ChSt	835						120	46	0.89
C-ApSt	1175		133	30	86	135	90	33	0.69
C-GrSt	485							40	14	0.39
C-CSh	980		83	20	83	124			
C-Coal Ch	750		52	16	72	110			

* prepared by chemical activation

Fig.3. Adsorption capacities (mg/g) of carbon adsorbents towards different metal ions in aqueous solution

4. Conclusions

The results show that obtained nanoporous carbon adsorbents demonstrate high adsorption capacity towards phenols and other organic substance.

The obtained nanocarbons are also applied for effective removal of toxic metal ions from waters.

The adsorption capacities of activated depend on porous parameters and surface chemistry (basic/acidic nature of the surface functionalities).

5. Literature

1. Gergova, K.; Petrov, N.; Eser, S. Adsorption properties and microstructure of activated carbons produced from agricultural by-products by steam pyrolysis. *Carbon* **1994**, *32*, 693-702.
2. Savova, D.; Apak, E.; Ekinci, E.; Ferhat Yardim, M.; Petrov N.; Budinova, T.; Razvigorova, M.; Minkova, V.; Biomass conversion to carbon adsorbents and gas. *Biomass Bioen.* **2001**, *21*, 133-142.
3. Bacaoui, A.; Yaacoubi, A.; Dahbi, A.; Bennouna, C.; Phan Tan Luu, R.; Maldonado-Hodar, F.J.; Rivera-Utrilla, J.; Moreno-Castilla, C., Optimization of conditions for the preparation of activate carbon from olive waste cakes. *Carbon* **2001**, *39*, 425-432.
4. Ryu, Z.; Rong, H.; Zheng, J.; Wang, M.; Zhang, B. Microstructure and chemical analysis of PAN-based activated carbon fibers prepared by different activation methods. *Carbon* **2002**, *40*, 1144-1147.
5. Park, S.-J.; Jung, W.-Y. Preparation and structural characterization of activated carbons based on polymer resin. *J. Colloid Interface Sci.* **2002**, *250*, 196-200.
6. San Miguel, G.; Fowler, G. D.; Sollars, C. J. A study of the characteristics of activated carbons produced by stream and carbon dioxide activation of waste tyre rubber. *Carbon* **2003**, *41*, 1009-1016.
7. Tamai, H.; Kouzu, M.; Yasuda, H. Preparation of highly mesoporous and high surface area activated carbons from vinylidene chloride copolymer containing yttrium acetylacetonate. *Carbon* **2003**, *41*, 1678-1681.
8. Khezami, L.; Chetouani, A.; Taouk, B.; Capart, B. Production and characterization of activated carbon from wood components in powdered: cellulose, lignin, xylan. *Powder Technol.* **2005**, *157*, 48-56.
9. Ania, C. O.; Parra, J.-B.; Arenillas, A.; Rubiera, F.; Bandosz, T. J.; Pis, J. J. On the mechanism of reactive adsorption of dibenzothiophene on organic waste derived carbons. *Appl. Surf. Sci.* **2007**, *253*, 5899-5903.
10. Petrov, N.; Budinova, T.; Razvigorova, M.; Parra, J.-B.; Galiatsatou, P. Conversion of olive wastes to volatiles. *Biomass Bioen.* **2008**, *32*, 1303-1310.
11 Budinova, T.; Savova, D.; Tsyntsarski, B.; Ania, C. O.; Cabal, B.; Parra, J.-B., Petrov, N. Biomass waste-derived activated carbon for the removal of arsenic and manganese ions from aqueous solution. *Appl. Surf. Sci.* **2009**, *255*, 4650-4657.
12. Asasian, N.; Kaghazchi, T.; Soleimani, M. Elimination of mercury by adsorption onto activated carbon prepared from the biomass material. *J. Ind. Eng. Chem.* **2012**, *18*, 283-89.