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TECHNICAL-TECHNOLOGICAL ASPECTS OF USING MACHINES AND TOOLS FOR NEW TECHNOLOGIES IN PLANT PRODUCTION

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Abstract: Agricultural production is complex process and it depends of various factors which can be controlled. Many of them can be improved by using of various means which are not friendly for environment and health of people. It is necessary to apply only those measures which can maintain and improve physical - mechanical, technological and microbiological properties of soil and also the nutritive potential of soil but will not be harmful for environment. The other part of this story demands decrease of energy necessary in the process of soil preparation. The machinery and tools for new technologies in plant production in Serbia is consisted of: vibrating subsoiler VR-5(7), universal self propelled machine for soil arrangement USM-5, draining plough DP-4 and universal Scraper land leveler, and it is developed to apply changed new technologies of soil preparation. This study gives description of machines, tools and technologies necessary for soil preparation in Serbia; this means preparation of soil surface and depth, special note is given to preservation of environment and improvement of soil potential, but also and how to decrease the energy necessary for the process of soil preparation.

Key words: agriculture, machines, technology, soil, energy, ecological aspects, Serbia.

Introduction

Agricultural production is complex process. It depends of various factors which can be totally or partly controlled. It is necessary to apply only those measures which can maintain and improve physical - mechanical, technological

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and microbiological properties of the soil, also the nutritive potential of soil and will not be harmful for environment. The types of soil which can easily be destroyed are those of heavy mechanical content. Serbia has 0.4 milions ha of these soil types and 0.35 of them are in Vojvodina (Raičević, D. *et al.*, 1995). According to the search results (Raičević, D. *et al.*, 1995) compaction of soil caused by machines' movements can decrease yield up to two times and tractive effort can be increased up to 1.9 times. The average total load (pressure) of machines on soil surface is 21 t/m^2 in usual process of wheat production and total surface of field is run over three times.

In production of corn the load (pressure) of machines is 30 t/m^2, so it is obvious what kind of influence this pressure has on soils of heavy mechanical content.

The new line of machines for new technologies in plant production is made and the problem of using these types of soils is solved by processes of soil arrangement and preservation of soil bio system. The new line is developed with a goal to improve mechanical - technological properties and to preserve the favorable potential of plant nutrition in soils of heavy mechanical content.

Soils of heavy mechanical content

Two types of soil of heavy mechanical content are common and those are types and sub types of fen's and meadow's humus (Figure 1 and Figure 2).

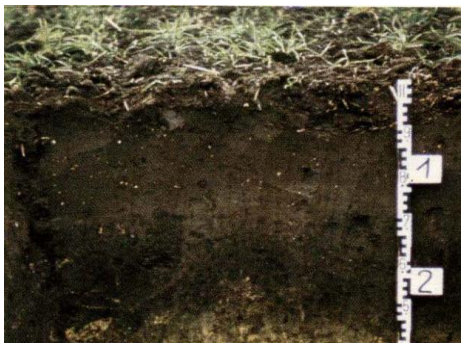

Fig. 1. - Fen's humus

Fig. 2. - Meadow's humus

According to basic morphological and physical mechanical properties this soil belongs to the class of heavy clay and has the average content of:

- Physical clay 78,30 %,
- Physical sand from 21,70 %,
- Water from 20,80 to 24,75%.

Marshy soils possess very unfavorable physical properties for plants' performances like as: heavy mechanical content, low porosity, increase values of penetration resistance, very unfavorable water, air and thermal properties, low infiltration rate for water as also the high mechanical resistance in cultivation. Mentioned properties also cause the very short term for cultivation.
The maintenance of these kinds of humus in appropriate state is very complex and their cultivation represents specific problem.

The special care must be addressed to spring cultivation of these soils. The damage can be made by motions of agricultural machines on moist soil, so the spring cultivation is very important moment for these soils.

These types of soil are very pressure sensitive, therefore is necessary to minimize operations on them. The positive results are got with application of new technologies.

Type and characteristics of soil influence on machinery selection, work regime and motive power consumption. On heavy soils is very hard to get necessary quality of cultivation (kibbling, start ploughing, etc.) beside the fact that results are minor and the energy consumption is higher.

The deficit of water in these soils can influence on increase of total and specific resistance for up to 50% and also to the quality of basic cultivation (Gasman, P. W., 1989). This is why the energy consumption for surface preparation of soil is much higher. The increased water content in soil causes adhesion of soil particles to machinery parts which increases the resistances, and tractor energy output, gives lower work quality and increases the energy consumption.

The classic cultivation of soil represents the lacks which cannot be removed. Big parts (monoliths) of soil are broken down by ploughing of fen's soil of heavy mechanical content in dry conditions. These soils clods are very hard to kibble in period of pre sowing preparation, so the operations for pre sowing preparation must be repeated, so machinery passes over up to ten times and delivers hard pressure on previous prepared soil by its operational systems.

The soil is damaged by using of heavy machinery and especially in period of sugar beet and corn harvest, in late autumn, when the soil is too moist. Intensive pressures on soil made by machinery and the soil's turn over always to the same depth have led to the process known as "flowerpot production".

Substratum compaction of soil in deeper layers is much harder to remove. This substratum compaction is much more negative for longer period than the substratum compaction of surface.

The lacks of traditional technique and possibilities of improving them are numerous. One of the basic lacks of traditional soil cultivation methods is result known as "plough sole". This result is manifested by substratum compaction of layer which is located under working area of plough and by numerous movements of wheels along it.

The special techniques of cultivation must be developed and used in preparation of this soil type, so the negative consequences will be decreased. The line of machines and tools for new technologies in plant production is developed with a goal to remove or decrease negative consequences which are made by use of traditional methods and to meet the basic ecological aspects connected with soil and environment.

New technical technolgoical solutions of machinery and tools for use in plant production

The basic preparation of soils by ploughing and additional preparation by various types of sowing machines is common in Serbia nowadays (Raičević, D. *et al.*, 1995). The plough will create compact and plain furrow bottom on particular depth.

After many years of preparation by plough and numerous movements by machinery on soil surface, the substratum compaction of furrow bottom is increased and this creates hard, impermeable layer. This result is specially marked at soils of heavy mechanical content. The new horizon made like this has double negative properties:

- Doesn't pass the top water in lower horizons of soil which leads to unfavorable conditions for plants' development and the moisture content cannot be saved in drying period
- Doesn't allow the water movement from lower soil layers to upper layers which can enable water for plants in drying periods.

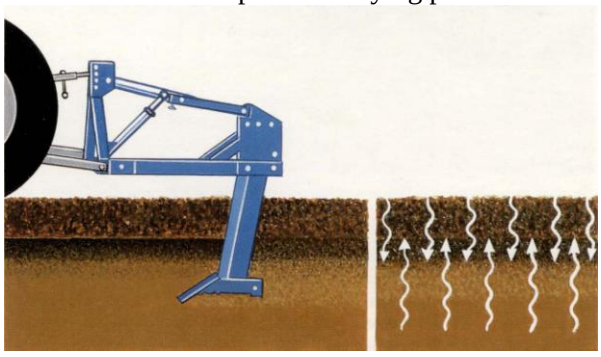

Fig. 3. - Example of subsoiler's work – ascending and descending moves of water through soil layers

Numerous researches here and in the world (Oljača, M. 1993; Oljača, V. M. 1994; Raičević, D. *et al.*, 1991; Raičević, D. *et al.*, 1995) showed the need of soil management in a way to ensure favourable water air conditions in soil or in

other words to improve the capactiy of accumulation and maintaining of natural moisture and its movement toward roots system of plants (Figure 3.) which reduces lack of falls in vegetative period.

Numerous technical solutions for machinery have been applying in the world (Raičević, D. *et al.*, 1995; Raičević, D. *et al.*, 2003; Radojević, R. *et al.*, 2006) for levelling and for deep tretment of soil and this was the reason for creation in Serbia of following machinery and tools:

- Machines for arrangement of soil surface (universal self propelled machine USM-5, Figure 4., and Scraper land leveler, Figure 5),
- Machines and tools for arrangement of soil deeper layers (draining plough DP-4, Figure 6 and vibrating subsoiler VR-5/7, Figure 7).

Fig. 4. - Universal self propelled machine USM-5

Fig. 5. - Scraper land leveler

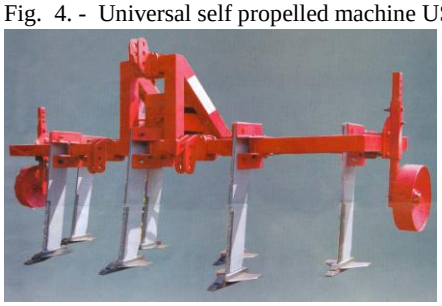

Fig. 6. - Draining plough

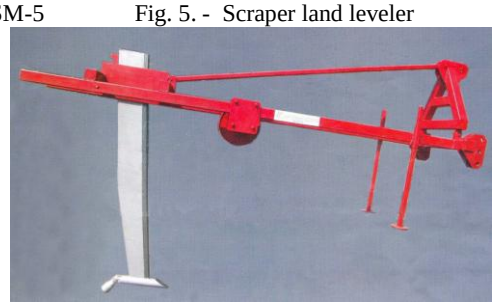

Fig. 7. - Vibrating subsoiler VR-5(7)

Machines and tools for arrangement of deeper soil layers

Working units have given results during many years of use in Serbia (Gill, W. R. 1971; Chen, Y., Cavers, *et.al.*, 2005; Raičević, D. *et al.*, 1992; Raičević, D. *et al.*, 1994). These parts showed important advantages against traditional methods of soil treatment by plough, especially for deeper layers of

soil of heavy mechanical content. The line of these machines and tools (draining plough DP-4 and vibrating subsoiler VR-5(7), uses the above mentioned working units (Figure 6 and 7).

Technical solution for draining plough DP-4 gives the solution for the problem of draining water surplus from compressed horizons of heavy mechanical content soil and its connection with constant drainage and drainage canals.

- This solution enabled the production of groundwater canals – drains, their linking with surface horizon and with zone for filtration of pipes' drainage. The surplus of top water passes through treated in to the lower layer and comes to canals which lead to opened canals (Figure 8).
- The working units known as "thorn" and "cannonball" are used for production of ground profiled canal and it is located on long bar. This position ensures good start of underground canals' production.

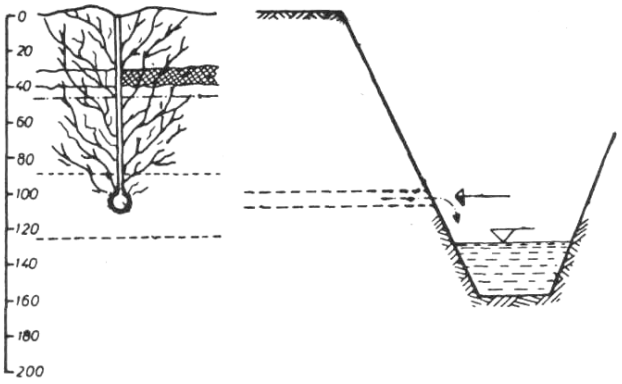

Fig. 8. - The scheme of mole's drainage

The drainage plough DP-4 (Figure 6) is consisted of main working organ prop which is connected for main bar. At the end of main working organ prop the "thorn" is set, and it is linked with free part of working organ known as "cannonball".

The cannonball has bigger diameter than thorn and it serves for stabilization of soil canals' profile around the formed canal. The drainage plough is attached to tractor by system for transfer and has following technical characteristics: the working depth of 0.6-1.5m, length of 3m, drain diameter of 8cm, mass of 900 kg, necessary energy output is 140-250 kW.

The described technology of work was very good for soils of heavy mechanical content and it has removed all unfavourable properties of this soil type, also had very favourable effect on ecology.

The other machine from this line named as vibrating subsoiler VR-5(7), (Figure 7) has specially constructed working units (Figure 9) by which we can improve the mechanical properties of soil and the air water regime of heavy mechanical content soil.

Fig. 9. - Working units of vibrating subsoiler VR-5(7)

Technical solution of vibrating subsoiler VR-5(7), (Figure 7) ensures the arrangement of deeper soil layers and it is constructed for operations of subsoiling in a way to ensure:

- Better conditions of water permeability of heavy mechanical content soil, so the water will be properly arranged along profile and surplus is passing to deeper horizons.
- Better conditions for air and thermal regime of soil which is condition for better and regular plants' development
- Better conditions for plant nutrition because plant roots must be able to absorb nutrients along the whole root system,
- Better conditions so that plant can use water by whole root system,
- To minimize the invested energy up to 30% because the resistance is lesser Raičević, D. *et al.*, 1994.

VR-5/7 is consisted of basic frame on which are attached the props of working units. At the ends of prop the working units are attached. The vibrator is attached to basic frame powered by hydro motor and vibrations are carried to working units by prop and frame.

Technical characteristics of vibrating subsoiler are: working scale up to 4.3m, working depth up to 0.6m, number of working units is 5 or 7, mass of 1700 kg, and working velocity of 4-5km/h, necessary tractor energy output 200-300 kW.

Ecological aspects of described machines for soil arrangement of deeper layers are numerous:

- Improvement of soil properties of heavy mechanical content soil necessary for plant nutrition
- Preserving of this type of soil
- To minimize degradation of soil in process of treatment
- to save the energy in process of cultivation
- to decrease the pollution of environment and soils which can be caused by agricultural machines .

Machines for arrangement of soil surface

Two machines from this line of new technologies in plant productions (universal self propelled machine USM-5 and Scraper land leveler) are constructed for arrangement of soil surface. One of the basic reasons for this type of soil arrangement is to arrangement of micro depressions made by previous treatment and breaking of big aggregates (monoliths) in a way to ensure free work of machines which are used in further process of production.

The first machine from this group is universal self propelled machine USM-5 (Figure 10) which ensures solution for surface soil arrangement and it is constructed for:

- Arrangement and leveling of parts' surfaces – it is done at once. The first step is to plough the surface layer by subsoiler or by disc working units and than by board to move the soil from one spot to another with depression, ways – to plough surface and than place the soil from one spot to another with depression, machine USM-5.

Fig. 10. - Universal self propelled

- Ways – to plough surface and than place the soil from one spot to another with depression,
- Production and arrangement of soil ways on parcels, made for mobile irrigation systems – rough surface and big clods of soil can be broken down by subsoiler and than level by board.

USM-5 (Figure 10) is consisted of basic frame on which the engine and cabin for control are located. The front and back wheels are powered by hydro motors. The leveling board is attached to frame and it can be set by bar manually or by hydraulic cylinder. The subsoiler or disc harrow is attached to the front of machine. The width of working bite is 5.2m, and power of motor is 250 kW.
The other machine from this group is Scraper land leveler (Figure 11) and it has many purposes, working bite is 5,5 m and testing is still under going (Raičević, D. *et al.*, 1994). The basic characteristic of this technical solution of leveler is new construction. The working leveling board is applicable for direction and height, so this leveler can be used for leveling of terrain, arrangement of way's network and ways for transfer of mobile systems for irrigation, leveling of microdepressions etc.). The machine can break big soil aggregates which can be found usually on the soils of heavy mechanical content as the consequence of basic treatment done.

Fig. 11. - Scraper land leveler

Conclusion

In Serbia, one thousand ha of arable soil is lost annually by various processes of soil degradation (Raičević, D. *et al.*, 1995; www.caseih.com), so it is necessary to improve the conditions for plant production on soils of heavy mechanical content. This means to improve the physical mechanical properties, water air and other soil properties.

The limited factor in plant production is water-air regime of soil and it is necessary to use dranaige plough DP-4 and vibrating subsoiler VR-5(7), which will enable improvement of all relevant soil parameters.

Having on mind all the above mentioned fact it can be concluded:

That work by subsoiler with mole drainage is necessary process in a way to improve the production capacity of defective soils of heavy mechanical content.

By these methods of cultivation the volume of treated soul is higher, as the consequence of crushing,

The better conditions for root system growth and better penetration of roots in the deeper layers of soil are made by subsoiler.

The leveling of soil surfaces enables the efficient application of other agrotechnical means with better work velocity and better results

The application of above mentioned technology is improving the physical, chemical and biological properties of soil and has positive influence on crops' growth.

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TEHNIČKO-TEHNOLOŠKI ASPEKTI UPOTREBE MAŠINA I ORUĐA ZA NOVE TEHNOLOGIJE U BILJNOJ PROIZVODNJI

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R e z i m e

Poljoprivredna proizvodnja je kompleksan proces i zavisi od niza različitih faktora na koje se može uticati. Veliki broj faktora koji utiču na poljoprivrednu proizvodnju može se poboljšati upotrebom raznih sredstava koja generalno nepovoljno utiču na životnu sredinu i zdravlje ljudi. S obzirom da se zemljište intenzivno koristi, prvenstveno je potrebno primenjivati takve mere koje će održavati i poboljšavati fizičko-mehaničke, tehnološke i mikrobiološke osobine kao i hranidbeni potencijal i pritom neće biti štetne sa ekološkog apekta. Na drugom mestu neophodno je težiti smanjenju potrošnje energije u procesu pripreme zemljišta. Linija mašina i oruđa za nove tehnologije u biljnoj proizvodnji sastoji se od: drenažnog pluga DP-4, vibracionog razrivača VR-5/7, univerzalnog skreperskog ravnjača i univerzalne samohodne mašine za uređenje zemljišta USM-5, razvijena je sa namerom primene nove-izmenjene tehnologije obrade zemljišta. U ovom radu su opisane mašine, oruđa i tehnologije pripreme zemljišta po površini i dubini, uz naglasak ekološkog aspekta u smislu očuvanja i poboljšanja potencijala zemljišta, kao i smanjenja potrebne energije koja se utroši u postupku pripreme zemljišta.

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