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ASPECTS OF USING MACHINERY AND TOOLS IN CONTEMPORARY PLANT PRODUCTION - MARSH SOILS CASE

SUMMARY

Intensification of agricultural production remains the major threat to the ecology of agro-ecosystems impairing the state of soil, water and air and reducing biological diversity in agricultural landscapes. This production is a complex process where cultivation plays an important role. Land degradation induced by large-scale equipment is of growing concern causing damage to the subsoil structure and may lead to harmful soil compaction. It is necessary to apply measures which can preserve or improve physical-mechanical, technological and microbiological properties as well as nutritive potential of soil, being at the same time environmental friendly. The machinery and tools that are often used in plant production in Republic of Serbia are the following: vibrating subsoiler VR-5/7, universal self-propelled machine for soil arrangement USM-5, draining plough DP-4 and universal scraper land leveller. Those machines are tested on Marsh soil type. A description of the machines, tools and technologies necessary for soil preparation, with special note on preservation of soil properties, together with techniques based on decrease of the power energy necessary for the process of soil preparation is presented.

Key words: machinery and tools, marsh soil, power energy.

INTRODUCTION

Agricultural production is complex process. It depends of various factors which can be fully or partially controlled. It is necessary to apply only those measures which can maintain and improve physical - mechanical, technological 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. Republic of Serbia has 0.40 million ha of these soil types and 0.35 of them are in Vojvodina, according to Vučić (1992) and Savić, Malinović, Nikolić (1993).

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The soils of heavy mechanical content have high potential fertility with good chemical properties and very bad physical mechanical properties according to their characteristics and therefore represent special problem during their cultivation. Maintaining of water and air potential during vegetation is limited factor of agricultural production on such types of soils, beside the other factors.

Above mentioned properties need to be improved in a way to create favourable relations between macro and micro porosity for better accumulation of soil moisture in area where the plants' root system is developing. To achieve this it is necessary to increase the total porosity of these soil types, because the filtration of water is very slow and when the intensity of falls is increased this can lead to creation of ponds, so the normal growth of plants is disabled. In drying seasons the plants cannot get adequate quantity of water because of this.

To ensure appropriate conditions for plants' growth and development on arable soils of heavy mechanical content it is necessary to apply appropriate agro technical measures.

The application of unsuitable measures can cause degradation of these soil types, so the soil is disabled to be the perfect environment for plant growing, to be the regulator of water - air regime and the important filter for environment preservation. Intensive agricultural production (Oljača, M., 1993) needs agricultural machines and equipment which can lead to soil degradation by their moves, primarily infested by the phenomena of soil compaction (Oljača, M., 1993, O'Sullivan M F, *et al.*, 1999). This phenomenon is especially marked in soils of heavy mechanical content.

Previous results and examinations showed that the soil of heavy mechanical content treated like this had lower yield of agricultural cultures and on the other side fuel consumption and tractive efforts were increased. According to the search results (Raičević *et al.*, 2005) 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 pressure of machines on soil surface is 21 t/m^2 in usual process of wheat production and total surface is run over three times. In production of corn the 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 (Oljača 1993, 1994).

Previous described processes which are occurred on soils of heavy mechanical content are specially marked on those surfaces which are not treated by adequate agricultural techniques. Unfavourable ecological processes and qualitative cultivation are in direct link with applied agricultural technique.

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 favourable potential of plant nutrition in soils of heavy mechanical content.

MATERIAL AND METHODS

Experimental researches of a tillage soil with clayey mechanical type composition were carried out on the grounds of the PKB Corporation, Belgrade, Padinska Skela, (position 44° 56′ N, and 20° 26′ E), on a parcel with of Marsh soil type. Basic physical properties of the soil were determined by method J.D.P.Z. (1971). The mechanical composition of the soil was determined by the pipette method, and the samples were prepared using sodium pyrophosphate was determined by method J.D.P.Z. (1971).

The studied variety of the Marsh soil is with a deep 0-100 cm. Table 1 shows the mechanical composition and basic soil physical properties (Radojević *et al*, 2006), of the studied soil.

Table 1. Basic properties of Marsh Soil

Mechanical composition and texture class of the soil							
Soil horizon	Depth (cm)	Fine send 0,2-0,02 (mm)	Silt 0,02-0,002 (mm)	Clay <0,002 (mm)	Silt+Clay <0,02 (mm)	Texture class of Soil	
A_h	0-20	24.90	33.20	41.90	75.10	Clay	
A_h	30-50	25.30	35.40	39.30	74.70	Clay	
GB_{Ca}	80-100	23.10	38.60	38.60	77.20	Clay	
Basic physical properties of the soil							
Soil horizon	Depth (cm)	Specific mass Mgm^{-3}	Soil bulk density Mgm^{-3}	Total porosity % vol	Reten. capacity % vol	Current moisture % vol	Psysiol. moist. % vol
A_h	0-20	2.68	1.315	51.12	42.70	21.75	20.95
A_h	30-50	2.68	1.315	51.12	42.20	21.92	20.91
GB_{Ca}	80-100	2.70	1.339	50.74	42.80	22.01	20.79

Type of soil of heavy mechanical content is common and those are types and sub types of fen's and meadow's humus (Figures: 1 and 2).

Figure 1. Fen's humus.

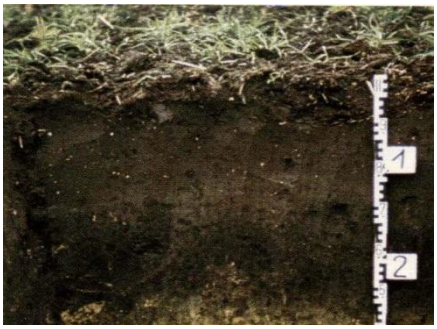

Figure 2. Meadow's humus

According to basic morphological and physical mechanical properties this soil belongs to the class of heavy clay, and has the important average content of: Physical clay 75%; Physical sand 25 %; Water 21-22% (Table 1).

Fen's soils (marshy land) possess very unfavourable physical properties for plants' performances like as: heavy mechanical content, low porosity, important values of penetration resistance, very unfavourable 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 (Oljača, 1993, 1994; O'Sullivan *et al.*, 1999). 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, 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 clods are very hard to kibble in period of pre sowing preparation, so the operations of disk harrowing and other 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 saturated.

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.

Technological solutions of machinery and tools for use in plant production – Marsh soil case

The basic preparation of soils by ploughing and additional preparation by various types of sowing machines is common in Republic of Serbia nowadays (Radojević *et al.,* 2006). 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 unfavourable 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.

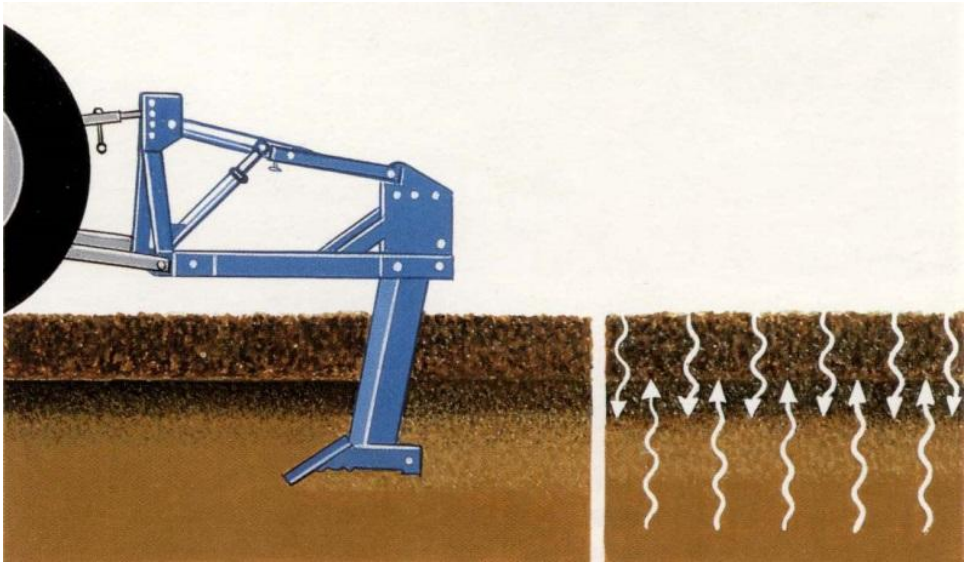

Figure 3. Example of subsoiler’s work – ascending and descending moves of water through soil layers of heavy mechanical content after cultivation.

Numerous researches in Serbia and all over the World (Oljača, 1993, 1994; Raičević *et al.,* 1995, 1997, 2005; Savić *et al.,* 1993), showed the need of soil management in a way to ensure favourable water air conditions in soil or in other words to improve the capacity 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 is in application in the World (Savić *et al*, 1993; Harun and Engin, 2006; Martínez *et al.*, 2012; Kasisira and Plessis, 2006) for levelling and for deep treatment of soil and this was the reason for creation of following machinery and tools:

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

Figure 4. Universal self-propelled machine USM-5

Figure 5. Scraper land leveler

Machines and tools for arrangement of deeper soil layers

Working units have given results during many years of use in Serbia (Oljača, 1993, 1994; Raičević *et al.*, 1995, 1997, 2005; Savić *et al.,* 1993). 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 (Figures 6 and 7).

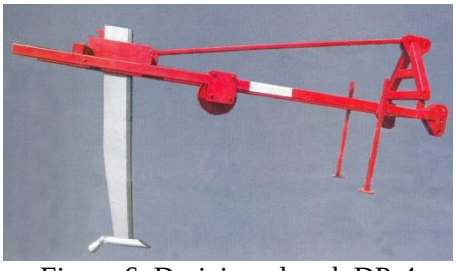

Figure 6. Draining plough DP-4

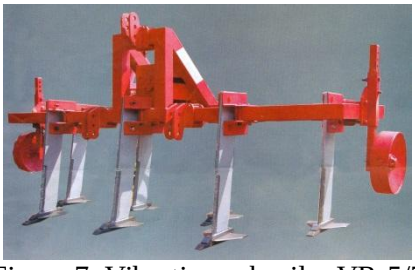

Figure 7. Vibrating subsoiler VR-5/7

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 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.

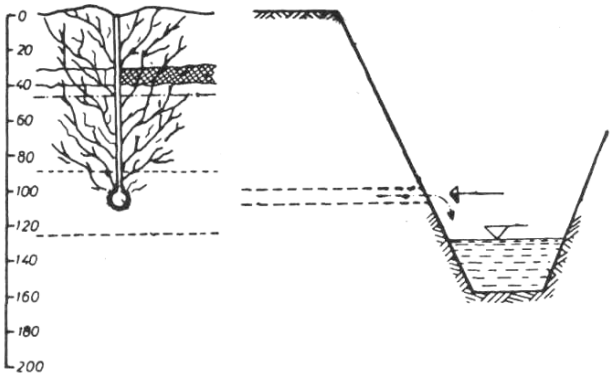

Figure 8. The scheme of mole's drainage.

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 and working velocity of 6 km/h, necessary traction 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.

Technical solution of vibrating subsoiler VR-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, according Raičević *et al.*, 2005; Qin, 2008.
- Better conditions for air and thermal regime of soil which is precondition 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, according Savić *et al.*, 1993.

Figure 9. Working element of vibrating subsoiler VR-7

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 5-7, mass of 1.70t, and working velocity of 4-5 kmh, necessary traction 200-300 kW.

Positive aspects of described machines for soil arrangement of deeper layers are numerous and we must note following:

- 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 this can be caused by agricultural machines during their work.

Machines for arrangement of soil surface

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 11) which ensures solution for surface soil arrangement and it is constructed for:

- arrangement and levelling 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 then by board to move the soil from one spot to another with depression;
- ways – to plough surface and then 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 then level by board.

Figure 10. Scraper land leveller

Figure 11. Universal self-propelled machine USM-5

USM-5 (Figure 11) 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 levelling 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 leveller (Figure 10) and it has many purposes, working bite is 5,5 m and testing is still undergoing, according (Raičević *et al.*, 2005; Savić *et al.*,1993; Martínez, *et al.,* 2012).

The basic characteristic of this technical solution of leveller is new construction. The working levelling board is applicable for direction and height, so this leveller can be used for leveling of terrain, arrangement of way's network and ways for transfer of mobile systems for irrigation, levelling of micro

depressions 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 in period of bigger moisture content in soil.

Figure 12. The example of heavy soil in which process the above mentioned methods are used

CONCLUSIONS

One thousand ha of arable soil is lost annually by various processes of soil degradation (Raičević *et al.*, 2005; Savić *et al.*,1993; Martínez, *et al.*, 2012) 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 drainage 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 are necessary processes 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.

- After this process the air capacity of the soil is higher and stipulates the work of aerobic microorganisms, hastening the breakdown of cellulose and increase the soil breathing.
- 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.

The potential of soil can be better used by using of machines and tools for new technologies in plant production on soils of heavy mechanical content. This figure shows the example of heavy soil treated and prepared for further cultivation (Figure 12).

The potential of soil can be better used by using of machines and tools for new technologies in plant production on soils of heavy mechanical content. This Figure shows the example of heavy soil treated and prepared for further cultivation (Figure 12).

The performances of this new machinery and tools line showed the perfect working potential, saving of energy, care for ecology, preserving and improving of environment for plant nutrition, decrease of soil degradation caused by treatment.

Perfect performances, saving of power energy, ecological aspects, improvement of soil properties for plant nutrition, preservation of soil are some of the aspects that can put this line of machinery and tools on first place when we speak about treatment and preparation of soil with heavy mechanical treatment.

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ASPEKTI UPOTREBE MAŠINA I ORUĐA U SAVREMENOJ POLJOPRIVREDNOJ PROIZVODNJI, SLUČAJ RITSKE CRNICE

SAŽETAK

Uspešna i savremena poljoprivredna proizvodnja je kompleksan proces i zavisi od niza različitih faktora na koje se može uticati. Veliki broj faktora utiče na poljoprivrednu proizvodnju, koja se može poboljšati upotrebom raznih sredstava, a koja generalno mogu nepovoljno uticati na osobine zemljišta. Obzirom da se zemljište intenzivno koristi, prvenstveno treba primenjivati takve tehničke mere obrade koje će održavati ili poboljšavati fizičko-mehaničke osobine zemljišta.

Istovremeno, neophodno je težiti smanjenju potrošnje pogonske energije u procesu pripreme zemljišta. Istraživana linija mašina i oruđa koja se koristi u biljnoj proizvodnji sastoji se od: vibracionog razrivača VR-5/7, univerzalne samohodne mašine za uređenje zemljišta USM-5, drenažnog pluga DP-4 i univerzalnog skreperskog ravnjača. Razvijena je sa namerom primene nove-izmenjene tehnologije obrade zemljišta. U ovom radu su opisane mašine, oruđa i tehnologije pripreme zemljišta tipa ritska crnica (lokacija/pozicija: 44° 56′ N, and 20° 26′ E), po površini i dubini, uz naglasak očuvanja i poboljšanja potencijala i osnovnih osobina zemljišta, kao i smanjenja potrebne pogonske energije u postupku pripreme zemljišta.

Ključne reči: mašine i alati, ritska crnica, pogonska energija.