THE ANALYSIS OF THE EXPERIMENTAL RESULTS AND OPTIMIZATION OF SEEDBED PREPARATION WITH WINTER WHEAT CROP

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ABSTRACT

The paper presents experimental results and the optimization of several variants for seedbed preparation for winter wheat crop. There are taken into account six technological variants for seedbed preparation and there were studied, after sowing, the soil penetration resistance and soil structural aggregates water stability as well as the fuel consumption per hectare, the yield and there were made recommendations on the best options for conservative tillages.

INTRODUCTION

The optimization of the working process of the agricultural machineries represents an important issue within the overall farm management, either small or large surfaces. The optimization, as a subject, is present both in mechanical works as well as in areas that do not assume mechanization as crop repartition, optimal alternation of crops, the optimization of water, gases and electricity nets, the optimization of product distribution nets, profit maximization, etc. Nevertheless, one way or another, the mechanical processes are present, more or less, in all optimization processes. In determining the surfaces there are accounted the mechanization requirements in order to minimize the consumed energy for distribution and transport.

The optimization of the working processes of the agricultural machineries is a major component even though the optimization parameters are different (the width and the length of the plots, the working speed, etc.) the final objectives are, the same, the ones of energetically domain of the working processes of machineries: the specifically energy consumption per surface unit, the fuel consumption per surface unit, the working capacity or their combinations.

Material and method

In order to establish the conservative tillage for winter wheat crop there were use already used machinery that complies with the required conditions.

For solving these problems there were proposed several mechanization variants of tillage and winter wheat seedbed preparation. These variants have been tried in order to establish which one of them is suitable in the highest degree for the concept of sustainable agriculture concept and ensure, firstly, the conservation and recovery of agricultural land. For this purpose, every variant of mechanization that includes unconventional technologies, the preserves the soil, that are performed by adequate machineries, will be compared with the control variant, where the classic technology will be applied, conventional for soil tillage yet the comparison will be made with other technologies, too.

Each variant of mechanical technology will comprise the tillage performed with the winter wheat crop and the machineries used for it. Here is the case for base tillage, shallow tillage for furrow and the seedbed preparation. Seldom, yet, tillage are reduced till total disparition of them, as the case of direct drilling (in stubble, in no till soil or unplowed soil).

As most of experimented technologies include combined, complex machineries with sowing equipments, there was established that the sowing work will be presented with all technologies, so that they could be compared between.

Within performed trials there were 6 experiments of tillage and drilling. The six variants are presented in the first table.

Table 1

Tillage and drilling trials for winter wheat

Machinery	variants
• Tractor Valtra T – 190 + reversible mouldboard plow Opal 140 • Tractor U-650 + light disk harrow GD – 3,2 + thorn harrow 2GCR-1,7 (3 passes) • Tractor U-650 + built on drill, SUP-29	V_1 (control)
• Tractor Valtra T – 190 + reversible mouldboard plow Opal 140 • Tractor Valtra T – 190 + complex aggregate AGPS-24DR (FRB-3 + drill SPU-24DR), 540 rev/min at tractor PTO	V_2
• Tractor Valtra T-190 + heavy disk harrow GDG-4,2 • Tractor Valtra T – 190 + complex aggregate AGPS-24DR (FRB-3 + drill SPU-24DR), 540 rev/min at tractor PTO	V_3
• Tractor U-650 + cisel PC-7 • Tractor Valtra T – 190 + complex aggregate AGPS-24DR (FRB-3 + drill SPU-24DR), 540 rev/min at tractor PTO	V_4
• Tractor Valtra T – 190 + soil loosening piece mounted on complex aggregate AGPS-24DR (FRB-3 + drill SPU-24DR), 540 rev/min at tractor PTO	V_5
• Tractor Valtra T-190 + combined machine for row tillage and drilling MCR-2.5 (no till), 1,000 rev/min at PTO.	V_6

The first variant, V1, has been considered as control due to the fact that it represents the classic tillage and drilling; it is used widely by farmers.

In order to select the tillage, with every variant there was determined, after winter wheat sowing, the soil penetration resistance, and water stability of the structural aggregates. We consider that these indicators, the soil penetration resistance and, especially, the water stability of soil aggregates (expressed as average diameter of structure aggregates and their water stability) are very important, because they are used for establishing the rate of thei destruction every technology is contributing on.

Also, for choosing the best tillage technology, there was calculated the fuel consumption per hectare for tillage and drilling.

There was considered, also, that with the selection of tillage there must be accounted the way plants grow and the yields. For this reason there was determined the number of emerged plants on a square meter, the plants height and, at the final, the seed yield per hectare.

With the choosing of tillage variants that should be recommended for extension in production there will be taken into account the following issues: the soil crushing degree with seedbed preparation, soil penetration resistance, the average diameter of the soil structural aggregates, the water stability of structural elements, the fuel consumption per hectare with tillage and drilling, the number of emerged plants per a square meter and the plants height, seed yield per hectare.

There was considered that the most important qualitative indicator of tillage is the soil crushing degree. The problems that rise with seedbed preparation have as a cause the unproper soil crumbling. The reduction of the soil crushing degree under the limit established by soil management requirements appears with seedbed preparation for winter crops.

As regard the energetical indicators and machinery exploitation there can be appreciated that the most important is the fuel consumption per surface unit.

Results and discussions

An important issue with the optimization of working processes of machinery is the one that could be taken as objective functions the qualitative parameters of performed works: the crushing degree, the average diameter of structural aggregates, the water stability of structural elements, the working depth, the working width, the state of emerged plants and the characteristics of their subsequent development, the burying degree of vegetal debris, the nutrient balance before and after tillage, etc.

The optimization of the working process using objective functions, at least for the time being, is not possible because there is not yet a theoretical link between geometrical and kinematic and dynamic characteristics of machinery and, especially, between soil features and plants that undergo the working process and this link is not in an acceptable form. Nevertheless, such theory will be proudly affected by the randomly character of the soil and plant works in different states of development. In these conditions, the only way to approach the problem is the experimental one which has two variants: laboratory and field. Of course, not every kind of determinations can be made in laboratory in an optimal regime yet all of them can be made in field at a real or reduced scale. The laboratory experiments or at a reduced scale can be made for reducing the costs for experimentation in order to determine several mechanical parameters of experimented soils by tillage. However, for determining the crop characteristics as objective functions, the only way to perform it are in field trials at a real scale.

In this paper, the experimental optimization was made for the selection of the best technological variant for seedbed preparation works and drilling out of wide range of technologies of this type (table 1). The optimization parameter with this case is the index of proposed technological variant from the first table, V_i, i=1,…6. Obviously, this index is calculated on the basis of several geometrical, mechanical and dynamic parameters or of other nature that characterize the machinery used for a specific variant. The objective functions, in an order chosen by author, are: the soil crushing degree with seedbed preparation, soil penetration resistance, the average diameter of the soil structural aggregates, the water stability of structural elements, the fuel consumption per hectare with tillage and drilling (which is an energetical parameter), the number of emerged plants per a square meter and the plants height, seed yield per hectare.

There is indicated to account that the objective functions that are considered in this chapter are influenced by factors that do not belong to mathematical models from paper because are not related with its specific. Among them there are: chemical treatments, by insecticides, clime conditions on the entire vegetation period, soil chemical composition, etc. For developing the optimal problem in such conditions there must be created a program based on scientific background from related domains: Plant Nutrition, Physics, Meteorology, Economy, Mechanics, Soil erosion and stability, Biology, etc. Such programs (WEPP, RUSLE) are called expert programs and they are produced by collaboration between specialists from different domains as the upward ones, along with mathematicians and IT specialists. There no global optimal solutions yet though there are trials.

a. The crushing degree

The soil management requirement is that the soil crushing degree to be at least 90%. There can be observed (figure 1) that the V1 does not comply with the requirement (yet, this is true for the soil and clime conditions of the experiment). There can be noticed that the V2 is on the limits and the other variants are satisfactory as regard the crushing degree. The best variant is V6, with 100%. As a result, the first objective function that was considered, the soil crushing degree perfectly operates the hierarchy, even eliminating one of the proposed variants.

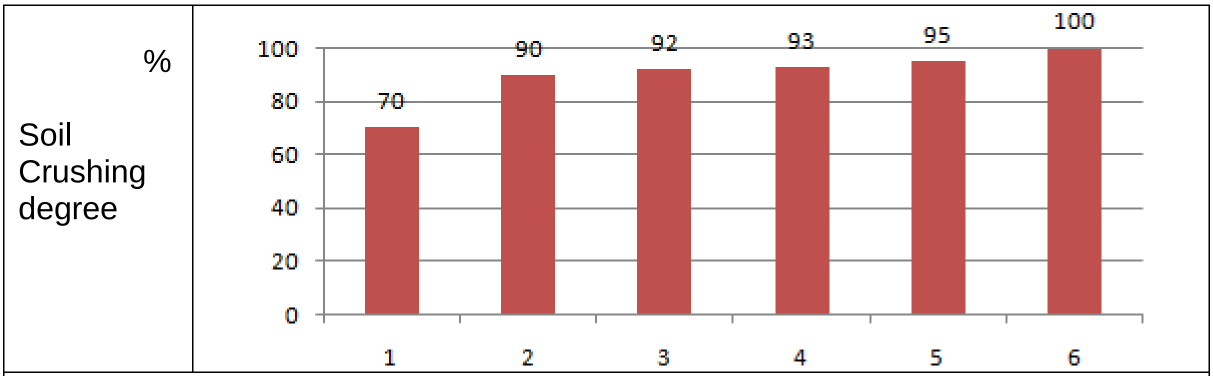

Fig. 1 Variant

There must be mentioned that with the actual state of our knowledge, the crushing degree cannot be estimated theoretically, for this reason the field trial being necessary.

b. The soil penetration resistance (SPR)

The values of the soil penetration resistance with the 6 variants on three horizons of soil depth are plotted in figure 2. The requirements establish three classes of soil penetration resistance:

- Very low, SPR under 11 daN/cm^2;
- Low, SPR between 11 daN/cm^2 and 25 daN/cm^2;
- Average, SPR between 25 şi 50 daN/cm^2.

Due to the fact that all determined values from figure 2 are under 11 daN/cm^2, there results that all proposed technological variants belong to the class of very low SPR. Also, this soil feature (penetration resistance) is influenced by soil characteristics, taking into account the SPR before tillage. This way, we consider that as regard the correct characterization of soil penetration resistance, very important is the relative penetration resistance that is calculated as average difference between its value before tillage and after tillage at the same soil depth. This way can be put in light the effect of tillage on soil. If, for the time being this method is not used, there is advisable, for the future to be used for testing.

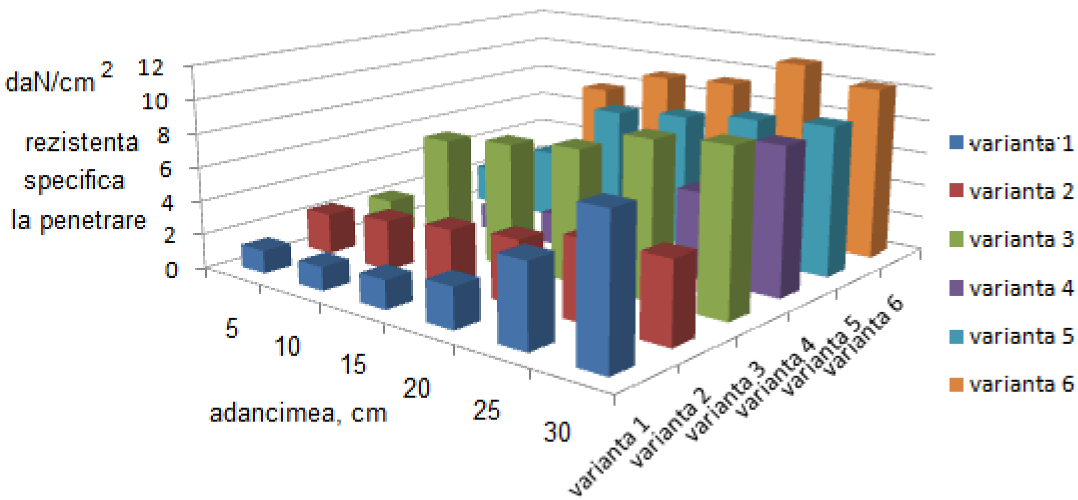

Fig. 2. Soil penetration resistance in function of soil depth and technological variant.

c. Weighted average diameter of soil structural aggregates

This parameter (objective function of the optimization process or the selection of the best technological variant) was measured on three horizons of depth, 0 – 10 cm, 10 – 20 cm and 20 – 30 cm. The agronomical requirement is that the structural aggregates between 2 and 5 mm to prevail in samples. Seldom are accepted aggregates a little bigger than 5 mm. From the third figure there can be noticed that, generally, the agronomic requirement is satisfied. However, if the recommendation would be strictly 2-5 mm, then the V6 , otherwise, very valuable, would be eliminated. Our recommendation would be that this parameter, too, (objective function of work quality) to be measured before and after tillage and then to calculate the weighted average relative diameter. This way, there will be accounted both the soil type and its state before tillage as regard the weighted average diameter of structural aggregates.

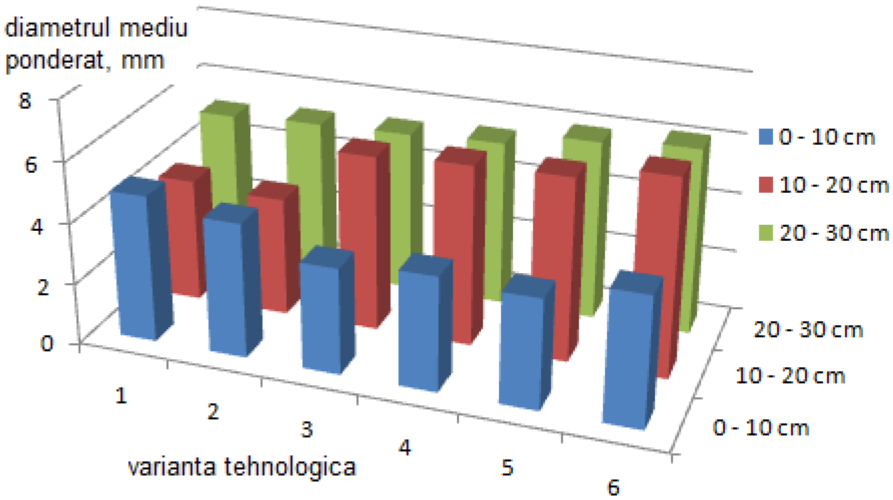

Fig. 3. The variation of the weighted average diameter of structural aggregates on technological variants and soil depth.

d. The water stability of soil structural aggregates

The fourth considered objective function is the water stability of structural aggregates. It was measured on three depths, the same with the weighted average diameter of structural aggregates. From the fourth figure there can be noticed that the water stability of structural aggregates increases along with the depth, except V1 and V2 where minimal water stability is recorded in the middle horizon (10-20 cm). From agronomical point of view, if the water stability of structural aggregates has values between 40 and 60% it is called very high and if these values exceeds 60% the water stability becomes extremely high. From the forth figure we can notice that all variants recorded very good water stability of structural aggregates.

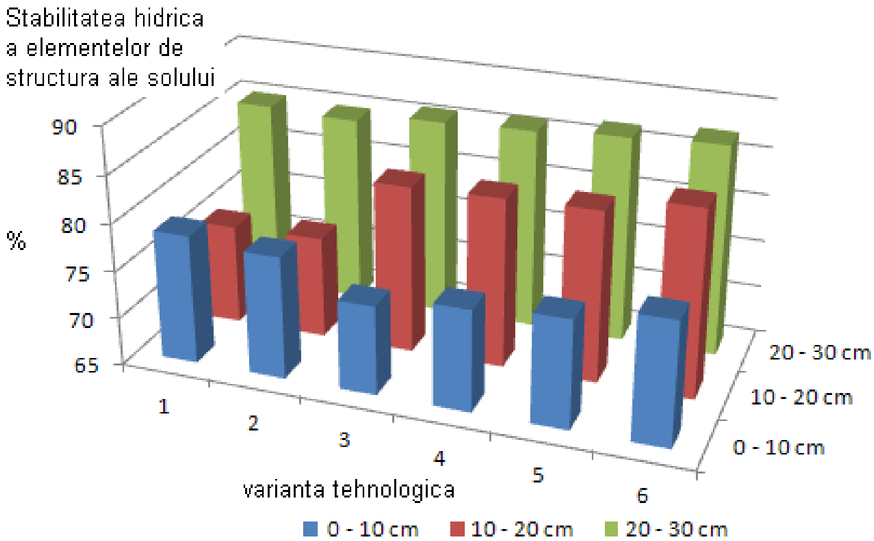

Fig. 4. The variation of water stability of structural aggregates in function of technological variants and soil depth.

e. The fuel consumption on surface unit (ha)

This parameter is very important for every mechanized work and it is a parameter and a objective function that is characteristic for energetic space (domain) of working processes of machinery. The graph in figure 5 represents the fuel consumption per surface unit. There can be observed that the best variant is V6. We mention that these experiments have not been done for previously theoretical optimal values of working parameters so that between these values and the optimal ones that are indicated by theoretical calculus could be some differences.

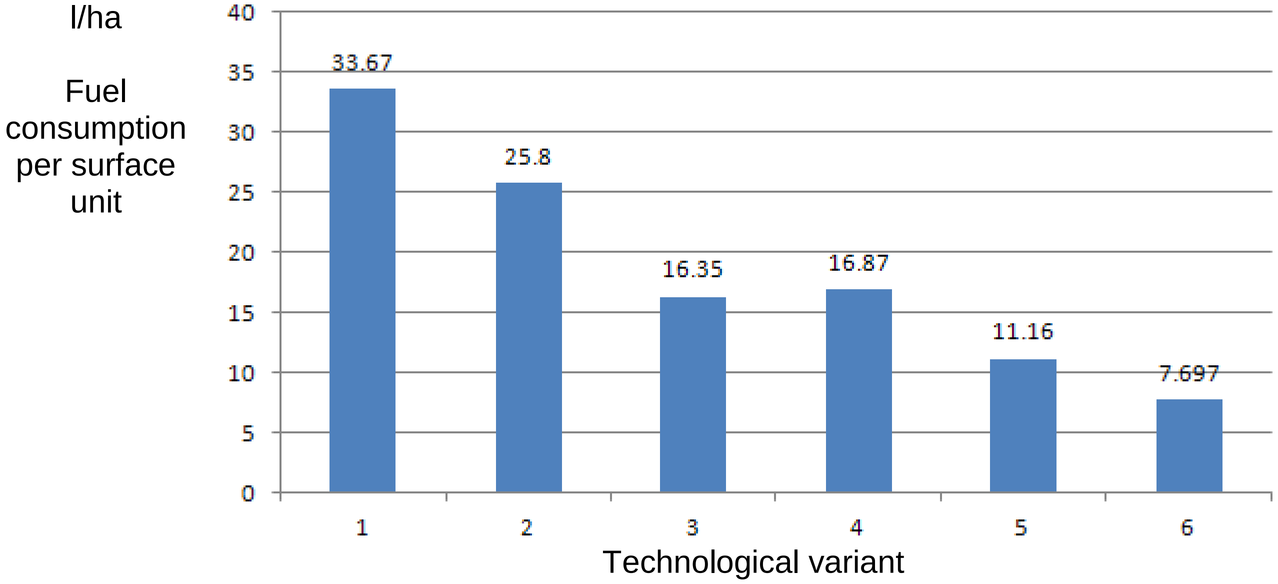

Fig. 5. The variation of the fuel consumption per surface unit in function of technological variant (tillage and drilling).

f. The number of emerged plants per 1 square m and their height.

The number of emerged plants per m^2 is a performance parameter for entire applied technology. For this reason, we have to account for the value of this objective function (the number of emerged plants per m^2) can contribute factors that are not accounted in this study as, for instance, the quantity and quality of fertilizers, insecticides or other applied treatments, soil chemical composition, etc. From data presented in figure 6 the best values have been recorded with V6.

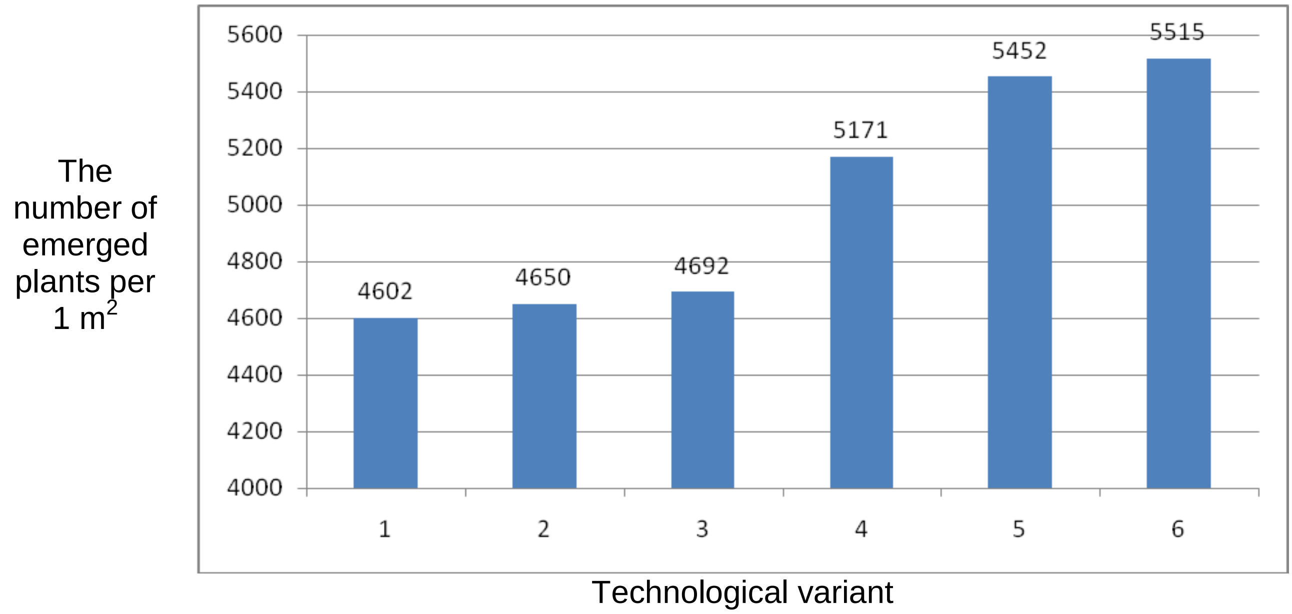

Fig. 6. The variation of the number of emerged plants per square meter in function of the technological variant.

A similar quality parameter is the plants height that is presented in the figure 7. There can be noticed, in the same order of proposed technological variants, as for plants density from figure 6.

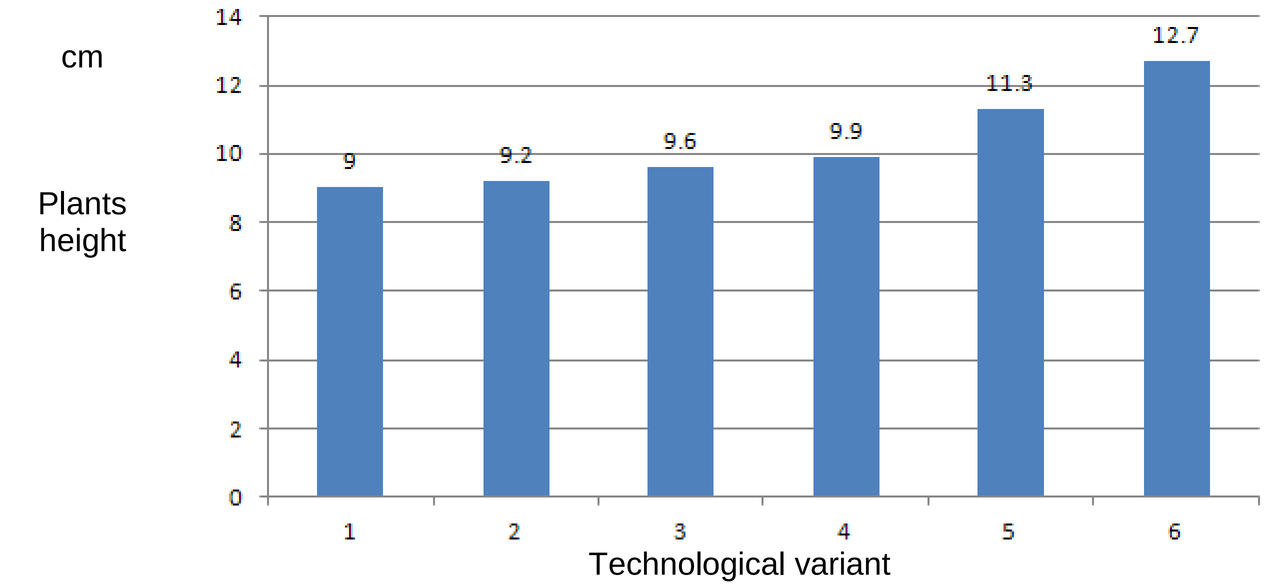

Fig. 7. The variation of the plants height in function of technological variant.

g. The grain yield per hectare

This parameter of quality, as the previous ones, is influenced by many parameters, some of them not entering in our study. The data are presented in the figure 8. With this case, too, there can be noticed that the V6 variant is the best. Moreover, the performance order is the same.

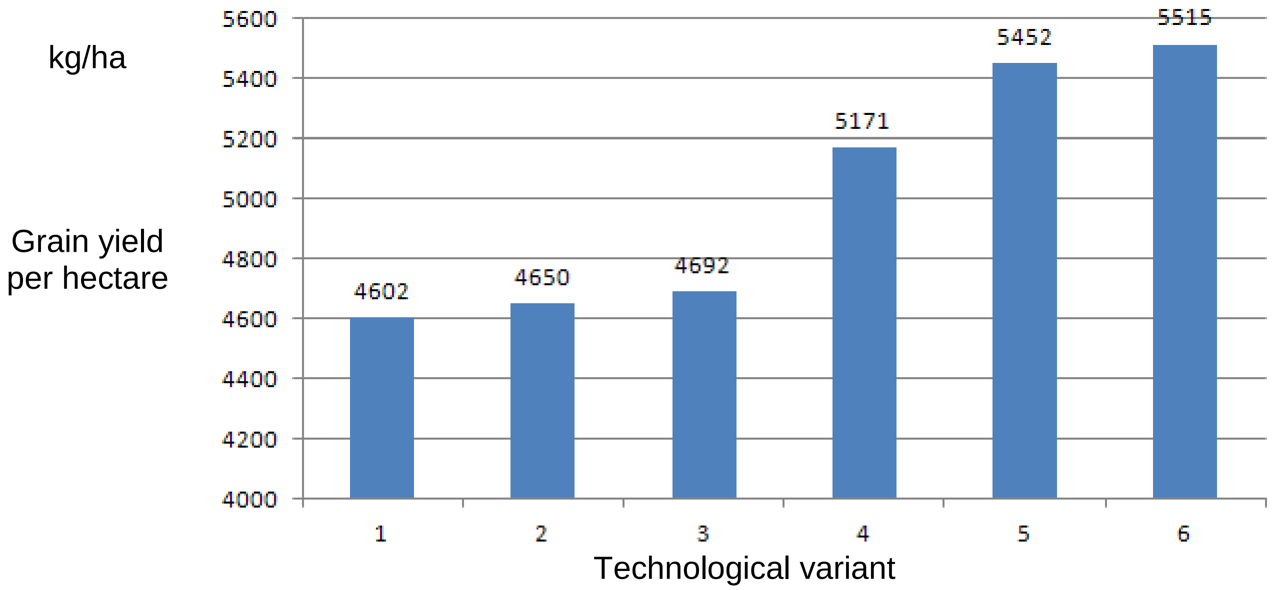

Fig. 8. The variation of grain yield in function of the technological variant.

CONCLUSIONS

This paper presents several optimizations of objective functions for tillage and seedbed preparation operations with different technological variants.

- → With technology variants V2 ... V5 the soil crushing degree with seedbed preparation operation is proper. Nevertheless, with the case of V1 variant the soil crushing degree do not comply by far with the agronomical requirements;
- → There was noticed that the soil penetration resistance that has been determined the day after wheat crop drilling is „very low" (very good) with all 6 variants. The lowest values have been recorded with V1 and the highest ones with V6. There was considered that with all technological variants there are good conditions for wheat plants roots growth;
- → The weighted average diameter of the soil structural aggregates is proper for all 6 technological variants and for all three soil strata, With the case where the moldboard plow was not used the highest value (the best) of this indicator has been recorded with V6 and the lowest one with V3 (the explanation is that with V6 the soil was less disrupted);
- → The water stability of soil structural aggregates is very good with all variants. Within the group of variants where the moldboard plow has not been used, the highest value (the best) has been recorded with V6 and the lowest, with V3;
- → The fuel consumption per hectare with soil tillage and drilling that was determined with all 6 variants for winter wheat crop is proper. The highest fuel consumption has been recorded with V1 (control) and the lowest, with V6. With V6 the fuel consumption per hectare is 4.4 times lower than V1;
- → The lowest values of the emerged plants per square meter and of plants height have been recorded with V1 and the highest ones, with V6. The values of these two parameters are higher with the case of variants where the moldboard plow has not been used;
- → The highest grain yield has been obtained with V6 which was no tilll and the lowest with V1 where the classic system of soil tillage has been used. With the V4, V5 and V6 variants the grain yield increased in comparison with the control variant by 12.36 – 19.84%;
- → With the case of proper conditions for conservative tillage (with no moldboard plow) we consider that suitable variants are: V6, V5 and V4. If V6 cannot be applied, then V5 should be used; when V5 cannot be used the V4 variant should be used;
- → If there are no conditions for conservative tillage or plowing is needed (moldboard plow) there should be used V2. The V1 (control) should be avoided because the fuel consumption per hectare is very high and the crushing degree with seedbed preparation is not proper being under the minimal limit established by agronomic requirements.

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