EXPERIMENTAL STUDY OF STRIP TILL MACHINE

Mitev[1]. G.V., Kr. Bratoev[1]

“Angel Kanchev”University of Ruse, 8 Studentska Str. 7017 Ruse, Bulgaria

Abstract: *Strips tillage machine with simultaneous fertilizing in the depth of processing is examined. The experiments were carried out by standard methods known as the theory of the experiment, at the same time is determined and the optimization task with which to establish the optimum setting of the machine. The results obtained show that the machine corresponds to all requirements, the best results are achieved at a speed of 9,0km / h and a depth of 0,25m.*

Keywords: strip till, soil productivity, agricultural machines

Introduction

It was found that as a result of the annual deep tillage of the soil, due to the structural features of the machines with which they are applied immediately below the plow layer is formed compacted horizon called. "Plow pan". This phenomenon has caused excessive compaction of the soil, to prevent the ingress of solid and becomes an obstacle difficult to overcome for the development of roots in the depth of penetration of air, water and nutrients.

Deep plowing emerged as one of the main causes of soil degradation in recent decades. More and more tangible for producers effect of decreasing soil fertility, manifested mainly in reducing organic matter content.

This requires the application of such technology for growing crops where along with maintaining high yields should be monitored and conservation of soil fertility. One of the areas is the application of technologies for production with reduced number of tillage. Wherever possible, the turning of the soil layer is replaced with subsoiling, but without inverting the layers (so scarifying the soil). The purpose of this study consists in application of a reduced number of the treated soil using deep handling of soil in strips. Regarding the objective of the study has the following main tasks:

• Study the work process of stripe working tolls.
• Optimizing the operating mode of stripe till machine.

Material and Methods

To conduct production research as experimental model used for subsoiling tillage in strips produced by the company "Unverferth", USA, Figure 1. The machine is designed for deep tillage in strips, after appropriate reorganization and introduction of solid mineral fertilizers in the depth of processing. The working width of the machine is 4,2 m. Structural width of 4.2 m is imposed by Engine Power indicators tractors. Usually this type of tillage needed 47-50 kW of power for operating authority. Used tractors with a capacity of about 280-300 kW, [2,4,6].

On the frame are six working body with them cultivators subsequent sections, and above them are volume of fertilizer regulations. The maximum working depth of tines that can handle the soil is 0,60 m. It is set by means of two pneumatic support wheels across the width at both ends of the frame.

Through parallelogram mechanism after every working body hanging cultivator section in which a pair of disks closes the groove and then moving them tines mixed and aligned and the soil surface. At the base of the hoppers for fertilizer are six fertilizer apparatus of the grooved type, that through flexible tubes bind to the solid pipes rigidly attached to the rear of steam each working body. Fertilizer equipment the machine can provide fertilizer rate to 500 kg /ha, 1,4,9].

For normal operation of the machine it needs to be aggregated with a tractor, providing 30 ÷ 45 kW of power to the working section. Joining energetic means going through the three-point lifting device mounted on the machine frame.

Conducted preliminary studies related to the choice of control factors influencing processes in basic research, but also with justification indicators (parameters optimization).

Research in the field of processed soil indicate that the mechanical and handling affect too many factors. In general they can be grouped as constructive and kinematic factors related to physical - mechanical properties of the soil.

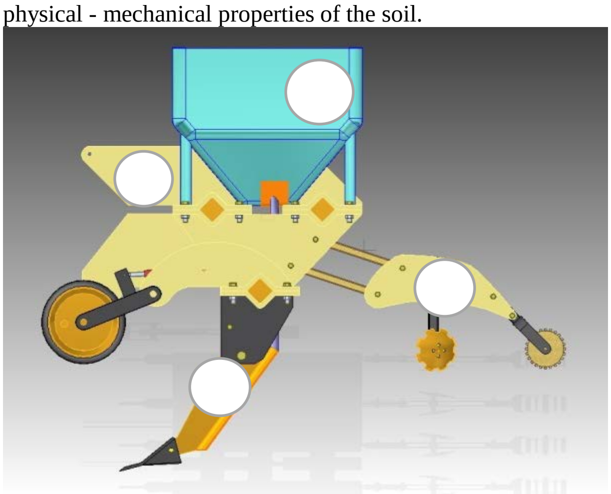

Fig. 1. Strip till machine with fertilizer system: 1 frame of the machine; 2 fertilizer regulations; 3 deep ripening working body; 4 cultivator section

The most commonly used controllable factors in machines for soil cultivation are: operating speed of the machine; the depth of processing and the angle of attack in order to break up large aggregates subsoil. The majority of the physical and mechanical properties of the soil appear random factors which are constantly modified in the course of its processing. Such factors include humidity, hardness, abrasion, organic matter content, stickiness and others. This multitude of factors acting simultaneously makes the process of probabilistic processing.

The quality of the principal tillage is judged primarily by the degree of fragmentation of soil aggregates and the degree of insertion of plant residues in the soil. So when testing machines for basic tillage, they are used as parameters of optimization, ie Y_1 - degree of plowing of crop residues and Y_2 - the amount of soil aggregates, [3,5,8,10], .

Of the numerous factors that influence these parameters with the greatest weight is the operating speed of the machine and the depth of tillage. As the study carried machine and direct import of solid mineral fertilizers is desirable to check whether the pilot process would not have filed disruptions in the flow of the main process (tillage). It follows from this that as a first control factor includes the operating speed of the machine -x_1, and as a second factor is the depth of processing -x_2. The influence of all other factors not participate as manageable in experiments reported by aggregate impact of confounding factors.

In accordance with the tasks conducted active experiment. By its nature, it is a multifactor regression analysis conducted during the field experiments.

In the fixed values of control factors x_i (i = 1,2 ..., m), by the action of the unguided (disturbing) factors W_k (k = 1,2 ..., q) each of the parameters (responses) Yj (j = 1 2 ..., p) the output will be random in nature. If controllable factors are quantitative (measurable), the general appearance of the relationship between parameters Y_j (j = 1,2 ..., p) and control factors is represented by the so-called. "Function response" [11]:

$$E\left[Y_j / x_1,...,x_m\right] = \varphi(x_1, x_2,...x_m), \quad (1)$$

where $E\left[Y_j / x_1, x_2,...x_m\right]$ is the conditional mean value of parameter Yj.

The equation (1) is called the regression equation, and the surface that it describes the - surface of the response. The type of function $\varphi(x_1, x_2,...x_m)$ depends on the nature of change of parameters Y_j in the selected area of change the factors $x_1, x_2,...x_m$. In carrying out the multi-factor experiments, which has the character of an optimization problem to obtain the type of the equation (1) using a polynomial model of the second level which m when the factor has the form:

$$\tilde{y} = \sum_{i=0}^{m} \beta_i x_i + \sum_{i,k=1}^{m} \beta_{ik} x_i x_k + \sum_{i=1}^{m} \beta_{ii} x_i^2, \quad (2)$$

where $\beta_0, \beta_1,....\beta_m$ are the parameters of the regression coefficients of the model.

It should be borne in mind that the polynomial model simply approximated with some accuracy function $\varphi(x_1, x_2,...x_m)$ in a small range of variation of control factors. One of the major tasks of any experimental study is seeking zoom function response based on the received experimental data. This may be a good approximation, it is necessary attempts to hold a special scheme - run the experiment. With many good properties are the plans of type Bm, [11,12,13].

Since the selected control factors were quantified, then to find a mathematical model of the research process (main tillage) using regression analysis [86, 89, 90].

Because of the possibility of error in experimental data and because of their finite number are determined not true model $\beta_0, \beta_1,....\beta_m$ parameters and their estimates.. Therefore, to describe the area of optimum parameters optimization separately for each expression (2) is presented in the form:

$$\hat{y} = b_0 + \sum_{i=1}^{m} b_i \overset{o}{x}_i + \sum_{i,k=1}^{m} b_{i,k} \overset{o}{x}_i \overset{o}{x}_k + \sum_{i=1}^{m} b_{ii} \overset{o}{x}{}_i^2, \quad (3)$$

To determine the optimum mode of operation of the test machine is used by the method of optimization of the desirability function [13].

For this purpose, the target function of Y_1 and Y_2 is represented by a generalized function of desirability, which is of the type [90]:

$$D = \sqrt{d_1.d_2}, \quad (4)$$

Where d_1 and d_2 are private functions desirability defined by the equation:

$$d = \exp\left[-\exp\left(-Y^{`}\right)\right] \quad (5)$$

In determining the function of desirability some restrictions are used: $Y_1 \geq 90\%$ and $Y_2 \leq 25\%$. For indicator Y_1 restriction provides the necessary degree of plowing of crop residues in the field, and to limit Y_2 provides agro-technical requirements for the size of soil aggregates after treatment. For the summary function of desirability is sought after model type [21]. The summary function of desirability is determined for two series of experiments. Thus, from the values obtained for her look the most and determine the optimum values of factors. The possible values for summary function of desirability are listed in Table 1.

Table 1.

Values on the scale of desirability

Desirability	Values on the scale of desirability
Excellent	1,00
Very good	1,00-0,8
Good	0,8-0,63
Satisfied	0,63-0,4
Not satisfied	0,4-0,3
Bad	0,3-0
Very Bad	0

Essential to the reliability of the test results is the exclusion of conflicting mode of study experienced machine. Such a regime at the trials is the process of scratching deep loosening tools. Determine the length of this section are the way of the detachable machine to the linkage of the tractor and constructive set back corner of the working bodies. This mode is removed in the region corresponding to the path of scratching of deep loosening element not conducting measurements. The duration in various attempts multifactor experiment at a constant length of the test section is amended in the range of 95÷150s depending on the set speed of the unit. Within this interval, the experimental installation process strips right length as 142,8 m early not involved in measurements due to the above mentioned reasons.

Studies are conducted under real field conditions, subject to agro-technical deadlines and comply with the soil - climatic conditions for the implementation of the agricultural event.

Firld experiments are made in sections of the field, which is piled previous culture and has not carried out then treated soil. The machine is aggregated with a tractor power 265 kW, equipped with a navigation system for guiding field. This provides the necessary distance between border clubs in treated soil strips, which should be sown the seeds of the crop. The depth of working of the soil is adjusted by screw mechanisms mounted on two support wheels of the machine, taking into account their sinking into the soil, which is from 0.02 to 0.04 m.

The speed of the machine is set by the experiments conducted and regulated by mechanics, Managing tractor selects the appropriate gear from the gearbox the energy machine.

Reporting the optimization parameter Y_1 is done using a square measuring frame size of the country equal to the width of the treated strip. Initially, the framework is put in place individual attempts before treatment and defines an area covered with debris. After crossing the machine in test points in the treated areas, measuring frame is repositioned and define the areas over which remained non putted into the soil plant debris.

Reporting parameter Y_2 it using a screen classifier for soil aggregates. Take soil samples from treated areas that are weighed before placing them in the classification, and after passing through it weighed rest of the sieve fraction.

The preconditions under which the experiments were conducted are presented in Table 2. The studies were conducted in farmland ET "Renaissance". Lozenets, Municipality of Krushari, Dobrich.District.

Table 2.
Measured values of the indices immediately before conducting experiments

Indicator	Dimension	Value
Soil: Carbonite chernozem	-	-
Power of the organic horizont. Flat field, depth 0.60 -0.90 m	m	0,60 – 0,90
Mechanical structure - sandy-loam to light clay	-	-
Prticle size 0,25 -0,05 mm	%	8
Below <0.001 mm	%	15
pH	-	6,0 – 6,8
Organic matter content	%	2.4 – 1,6
Cultivated area – flat		
Direction of cultivation		
Previous Crop – Winter wheat		
Height of cutting the stems at harvest	m	0.20 – 0.25
Available crop residues	%	100
Condition of the field. Stubble, heavily padded.	t/m^3	1,65-1.75
Set up the tillage depth	m	0.25 - 0.35
Absolute Soil Moisture	%	18
Soil density before the tillage in the range of 0.01 – 0.80 m	t/m^3	1,68-1,70
Crop residue depth leave on the soil surface	m	0.07 – 0.11
Degree of Uniformity of the crop residue spread out	%	90

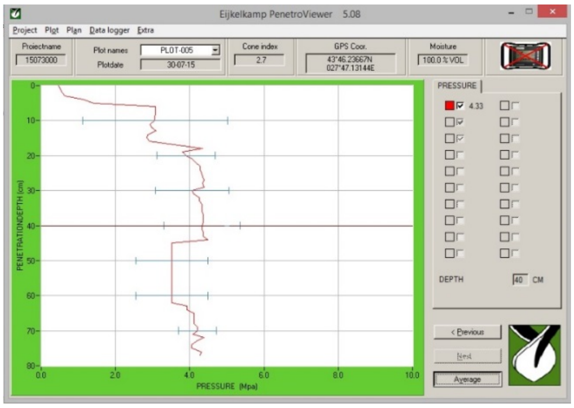

Fig. 2. Diagram hardness of the soil before switching on the machine for soil cultivation in strips

The surface layer of the soil is heavily compacted Fig. 2. The measurements made by the instrument for measuring the hardness of the soil in the range of 0 - 0.80 m, indicate that there are two levels of sealing.

The first level is in the range of 0.07 - 0.15 m. This type of seal is obtained after passage of heavy machinery on wet soil, i.e. during the retraction of the production.

In the second level, the soil is heavily compacted in depth between 0.24 - 0.43 m. This indicator shows tillage reversed layers - deep plowing, as subsoil is compacted over limits.

The analysis of these studies and determine the depth to be conducted to determine the quality of the machine for soil cultivation in strips without turning the layers. The specified working depth is 0.25 and 0.35 m.

The summarized experimental data are presented in Table 3.

Table 3.
Overall experimental data with data processing software "Statistics"

No: of the experiment	x_1 Km/h	x_2 cm	Y_1 %	Y_2 %
1	2	3	4	5
1	7	25	90.90	22.40
2	7	35	60.40	19.80
3	7	30	90.79	26.80
4	8	25	92.30	17.20
5	8	35	92.40	13.80
6	8	30	92.40	16.20
7	9	25	94.00	13.50
8	9	35	94.00	13.00
9	9	30	92.80	14.20

where

x_1 is the operating speed of the MTA, km / h;

x_2 - the depth of treatment, m;

Y_1 - the degree of plowing of crop residues%;

Y_2 - resulting yields, kg / ha;

Y_3 - soil aggregate size greater than 50 mm,%.

The results of the regression analysis are presented in Table 4.

Table 4.
Results of regression analysis of the second degree model for Y_1

N=9	Обобщение на регресионния анализ за зависима променлива. Regression Summary for Dependent variable: Y_1 R=0,98512209 R^2=0,97046553 Adjusted R^2=0,92124142 F(5,3)=19,715 p<0,01678 St. Error of estimate =0,36918					
	b^*	St. error of b^*	b	Std. Error of b	$t(3)$	$p - value$
Intersept			20,74222	20,95735	0,98974	0,395269
x_1	12,5927	2,846452	19,12833	4,32375	4,42402	0,021448
x_2	-1,6283	2,282085	-0,49467	0,69330	-0,71350	0,527034
x_1x_2	-1,8164	1,219249	-0,05500	0,03692	-1,48980	0,233048
x_1^2	-10,7334	2,751485	-1,01833	0,26105	-3,90094	0,029902
x_2^2	2,6627	2,064657	0,01347	0,01044	1,28967	0,287592

Table 4 shows that the significance level α = 0,05, are significant factors $b_1 = 19,128$ and $b_{11} = -1,01$.. This shows the strong influence of factors x_1 on parameter Y_1. The influence of x_2 on Y_1 is significantly less. (See p-value at which the values are greater than 0.05).

The coefficient of determination e $R^2 = 0,97$. I.e. 97% of cases amending Y_1 due to controllable factors and describes the model of the second degree, who include all odds model has the following specific type, equation 6.

$$Y_1 = 20,74 + 19,13x_1 - 0,49x_2 - 0,055x_1x_2 - 1,018x_1^2 + 0,0135x_2^2 \quad (6)$$

The graphical representation of the model shown in Figure 3. The surface of the model Minimax and in-depth analysis is necessary to make a section through line at the same level figure 4.

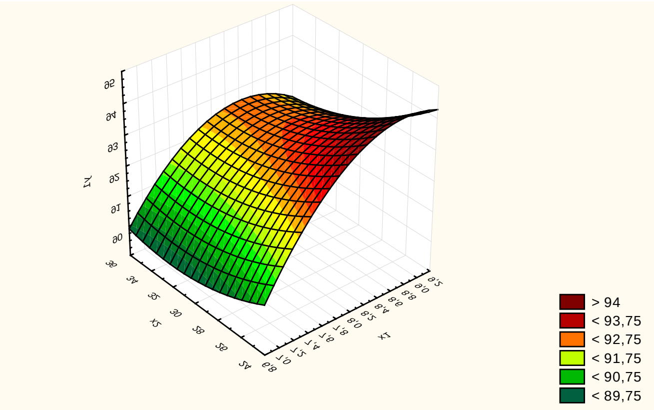

Figure 3. Surface response $Y_1 = f(x_1,x_2)$

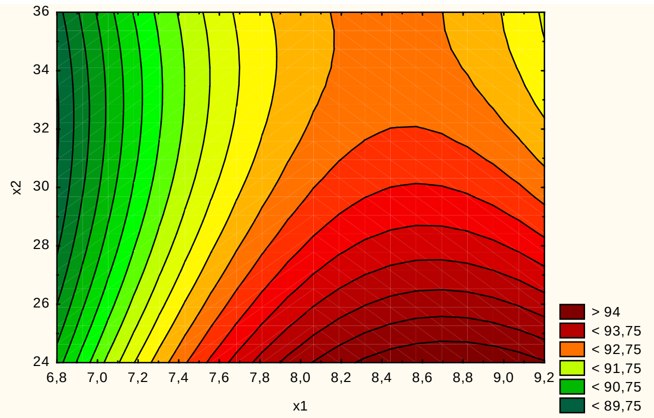

Figure. 4. Lines with the same level $Y_1 = f(x_1,x_2)$=*const*

The lines at the same level it is clear that large amounts of Y_1 are obtained at higher speeds and lower working depth of the tines. Regression analysis parameter $\boldsymbol{Y_2}$

Table 5

Regression analysis parameter Y_2

N=9	Обобщение на регресионния анализ за зависима прменива Y_2. Regression Summary for Dependent variable: Y_2, R=0,84264071 R^2=0,71004336 Adjusted R^2=2,9359,0949					
	b^*	St. error of b^*	b	Std. Error of b	$t(6)$	$p - value$
Intersept			52,200	12,025	4,340	0,0048
x_1	-0,843	0,21983	-4,583	1,1985	-3,824	0,80046
x_2	0,0580	0,21983	0,0633	0,2397	0,2642	0,80046

From Table 5 it is apparent that the influence of x_1 (operating speed) on Y_2 (size of soil aggregates) has been demonstrated. With increasing x_1 - Y_2 reduced.

It is obvious that the surface is Minimax Figure 5. The regression equation has the following full record:

$$Y_2 = 187,27 - 56,13x_1 + 4,78x_2 + 2,95x_1x_2 + 0,15x_1^2 - 0,01x_2^2 \quad (7)$$

In this case, the best value factors, or some of them are the boundaries of the field of climate factors. This is shown by the lines of equal responses presented in Figure 6.

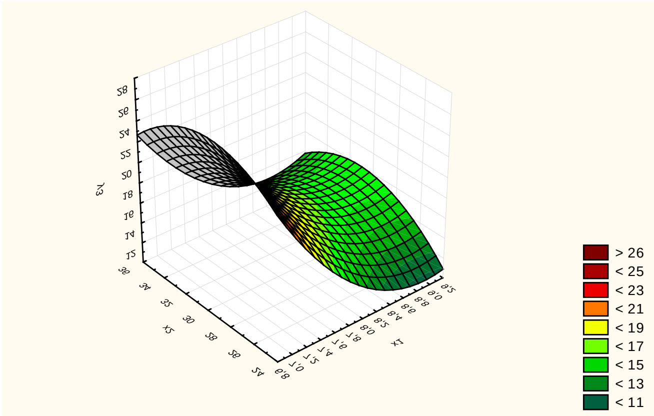

Fig. 5. surfaces of response $Y_2 = f(x_1,x_2)$

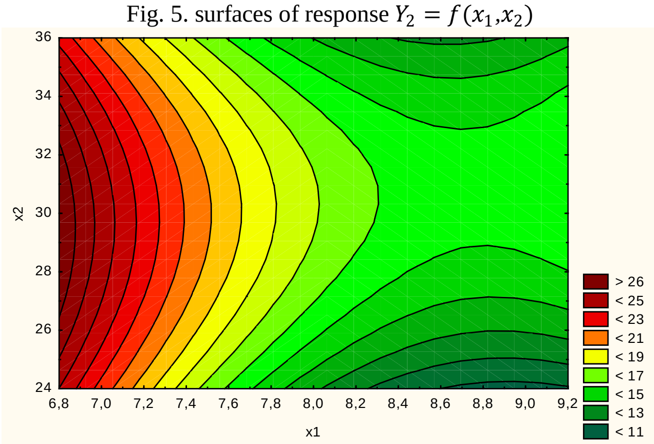

Fig. 6. Lines of uniform response $Y_2 = f(x_1,x_2)$=*const.*

On the lines of uniform response (Fig. 6) it is apparent that small values of Y_2 (i.e., greater crushing of soil components) is obtained at higher speeds and smaller working depth of the working organs.

The total extreme of the two functions is found by performing optimization of workflow summary function of desirability. Data from optimization performed are presented in Table 6 and in Figure 7.

Table 6.

Results obtained for summary function of desirability

	1 x1	2 x2	3 D
1	1	1	0,616999
2	-1	1	0,254702
3	1	-1	0,764495
4	-1	-1	0,279304
5	1	0	0,642522
6	-1	0	0,189018
7	0	1	0,559031
8	0	-1	0,770853
9	0	0	0,589063

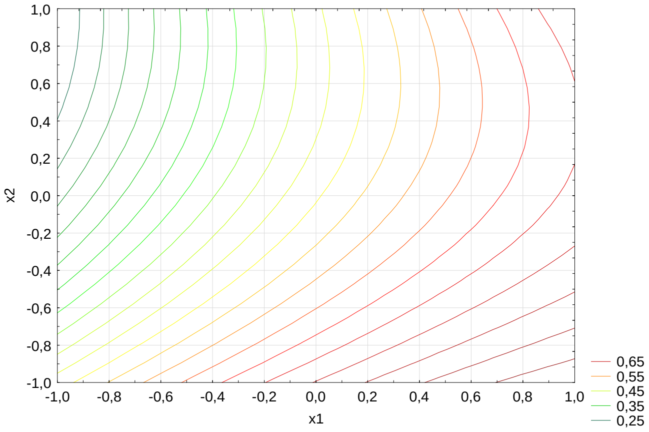

Figure 7. Lines at the same level for the function of desirability

From the data in Table 4.8 shows that in the seventh experience levels factors provide a very good function of desirability (D = 0,8), wherein the values of the parameters satisfy the constraints of the optimization: $Y_1 \geq 90\%$ and $Y_2 \leq 25\%$. Lines presented at the same level in Figure 7 shows that the optimal operation of the machine is achieved at levels of factors $x_1 = 1$ and $x_2 = -1$.. Expressed in natural units, these levels correspond to 9,0 km / h and 0,25 m. From these two factors with greater weight on achieving optimum performance of the machine is x_1, since its exclusion from the model summary function of desirability, the coefficient $R^2 = 0{,}1$, while off x_2 - $R^2 = 0{,}42$.

Conclusion

The survey indicates that the appropriate adjustments made processing machine for processing strips of soil with simultaneous application of mineral fertilizers in depth corresponds to the agricultural requirements. From the resulting regression models for the studied parameters shows that to achieve the best possible results must be preferred to work at a higher speed. This is confirmed by the conducted optimization problem, which shows good results at a speed of 9,0km / h and a depth of 0,25m.

Sources:

1. Alexandrov, V. et all, 1967. Manual for design of Agricultural Machines, Machinostroenie, Moskow, v.2
2. Daskalov, Dj., J. Demirev, Hr. Beloev, 1995. Manual for Agricultutal Machines, part I.
3. Demirev, J., Kr. Bratoev, 2012. Agricultural Machines, I., Ruse,
4. Dimitrov, P., A. Lazarov, D.Dimitrov, Hr. Beloev, P. Radulov, S. Valchinkov.2008. Antierosion technique for maize growing on slopy fields. Agricultural Academy, Ruse Press, p.59
5. Georgiev, I.,1973. Fundamentals of similarity and modeling of agricultural equipment. Zemizdat, Sofia,
6. Vagin, A. et all. 1977. Mechanization and protection of soil from water erosion I not chernozem area, Kolos, Leningrad, 1977.
7. Galushka, I., I. Ovchinnikov. 1967. Device for local injection of fertilizers in orchards. Mechanization and Electrification of the Agriculture, Urogaj, Kiev, 8:,
8. Markov, N., 1986. Study on chisel working bodies of machines for deep loosening of soil waterlogged surface. Abstract, Sofia, 1986
9. Mitev, G.V., A. Pavlikianova, Kr. Bratoew, St. Manushkov, 2011. Study of soil mixes for water holding materials. Proceedings of Scientific Publications, Ruse University "Angel Kanchev", p. 231-234.
10. Mitkov, A., D. Minkov, 1989. Statistical Methods for study and optimization of the Agricultural Machines, Ist part.
11. Mitkov, A., D. Minkov, 1989. Statistical Methods for study and optimization of the Agricultural Machines, IInd part.
12. Mitkov, A., 2011. Theory of the experiments, Dunav Press, Ruse.
13. Panov, I., V. Vetrohin, 2008. Physical fundamentals of the soil mechanics, Kiev.
14. Fishstenko, G., 1967. Mechanization of irrigation the underplough soil layers. Mechanization and Electrification of the Agriculture, Jrojai, 8:23-25
15. Srivastava ,A. K et al. 1993. Engineering principles of agricultural machines. American Society of agricultural engineers

.