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RAPESEED CROP MANAGEMENT CONTRIBUTION TO YIELD INCREASE THROUGH SOIL WORKS SYSTEM AND FERTILIZING TREATMENTS

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Abstract

The study analyzed how elements of crop management can contribute to increasing the yield of the winter rape crop. Field research took place in the area of Satu Mare locality, Arad County, Romania, in the period 2022-2023. The field experiments were organized in farm conditions, with accessible agricultural technologies. Two soil working systems (Sws) were considered: a classic system of soil preparation by disc tillage (SwsA), and a system of soil preparation by direct seeding (SwsB). Four treatments (T) of nitrogen and sulfur fertilization (T1, T3 and T4) were applied to the background of each system, compared to a classic fertilization (T2). In the case of soil tillage SwsA system, rape yield average was $Y_{(AvgSwsA)}$ = 3,537.50 kg ha^{-1} (T4 treatment generated increase yield, ΔY = 380.50 kg ha^{-1}). In the case of soil tillage SwsB system, rape yield average was $Y_{(AvgSwsB)}$ = 3,795.00 kg ha^{-1} (T4 treatment generated positive growth, ΔY = 1,007.00 kg ha^{-1}). At the experiment level, the average yield was $Y_{(AvgSwsA\&B)}$ = 3,666.25 kg ha^{-1}. A significant yield increase was recorded only in the case of the T4 treatment, with $\Delta Y_{(SwsB-T4)}$ = 1,135.75 kg ha^{-1}. Multiparameter analysis (PCA, CA) facilitated distribution diagrams and classification of variants, under conditions of statistical safety (Coph.corr = 0.936). PC1 explained 40.35% of variance and PC2 explained 29.297% of variance. Mathematical models described the variation of yield (Y) in relation to biometric parameters of the plants ($p<0.001$, R^2 = 0.873 to R^2 = 0.989).

Key words: *crop technology management, mathematical models, rapeseed, soil works system, technological treatments, yield increase*

INTRODUCTION

Rapeseed (*Brasica napus* L.) is a crop plant with multiple values, cultivated primarily for oil production, being the second oleaginous plant worldwide, in this category of crop plants [5, 6, 13, 22].
Rapeseed is a plant with multiple values, from socio-economic and ecological perspectives. First of all, rapeseed is an oleaginous crop, and it is cultivated for the production of seeds, respectively oil.
Through its roots with a high absorption power, rape contributes to the absorption of heavy metals from the soil (e.g. cadmium) and has an important role in bioremediation techniques. Through the color of the flowers, they contribute to the color appearance of the agricultural lands, giving value to touristic objectives of an ecosystem nature. Through flowers, with a high content of nectar and pollen, it represents a main source of mellifera, but also of phytopharmaceutics (pollen used to extract some active principles - e.g. flavonoids, amino acids). The flour from the seeds is used to extract some active principles (e.g. istocyanates). The flour from the seeds and from the dry plants (secondary production from the harvest) is used in animal feed. Rape is also of interest in the biofuel industry (biodiesel).
Rapeseed can be cultivated for the purpose of protecting the soil, as a cover plant (especially for nitrogen retention), as well as for the purpose of green manure, with beneficial effects for the soil [6].
Some studies have looked at the utilization of seeds and oil cakes, but the utilization of rapeseed by-products such as straw has also been considered [8, 11, 18].
The content of bioactive substances in rapeseed is of increasing interest in recent

studies.

Laboratory studies have confirmed the functional role of rapeseed extracts in oxidative and metabolic processes, with perspectives for improved nutrition in animals and humans [1].

Based on a bibliographic study on the last decade, 2011 – 2021 (approx. 7617 scientific articles and reviews), it was found the increase in the number of articles and publications at the global level, the increase in cultivated areas, production and oil content in seeds [22].

In the analyzed studies and articles, aspects of the genetic nature of rapeseed plants, phylogeny, stress to abiotic factors, yield, oil content, seed meal, protein and fatty acid content, importance as biofuel, etc., were addressed [22].

Through studies of the rapeseed genome, aspects regarding genetic diversity were elucidated with implications in the traits of major importance of rapeseed plants [5]. Certain aspects regarding certain qualitative indices in rapeseed production (e.g. minimum erucic acid content, low level of glucosinolate), still require additional studies and research for certain clarifications [5].

Some studies have analyzed the oil yield and the protein content in the seeds, compounds with high importance for the food industry and animal feed. Aspects regarding the rapeseed culture technology were also analyzed, especially for the reduction of harvest losses [13].

The importance of rape in the structure of crop plants, as a component of agricultural rotations and rotations, for maintaining soil fertility and sustainable production, was considered and confirmed [5].

Rapeseed was studied in relation to the prevailing diseases and pests, with the formulation of crop rotation and placement schemes and the communication of farmers on these aspects, for ecological protection solutions, in the context of restrictions on the use of pesticides [21].

In the context of the EU, rape is a crop of high importance for oil, fodder, biodiesel, with a weight of about 63% in oil crops for the year 2017 [19]. Romania is among the largest rapeseed producers in the EU, after France, Germany and Poland [19].

Rapeseed is a crop with high nutrient requirements, which requires complex fertilization for high yields.

In an extensive study, nitrogen use efficiency (NUE) was evaluated in a large group of modern rapeseed genotypes, as a result of the importance of this nutrient in rapeseed production [17]. The authors of the study communicated the increase in NUE in relation to the increase in plant biomass until flowering, and the increase in primary yield components. The study authors also reported a negative correlation between high seed yields and seed oil content ($r = -0.49$ at high N level; $r = -0.39$ at low N level).

The importance of the rape crop, within agricultural crops, was analyzed from an ecological perspective, with a role in soil protection against erosion [9]. The authors of the study concluded that rapeseed, in comparative studies with other crops, had the best effects in soil protection against the erosion process, with ecological and economic benefits, and also with a positive impact on agricultural sustainability, under the study conditions.

Certain rapeseed genotypes were analyzed in relation to certain agricultural practices and categories of crop management inputs (e.g. dose of rapeseed at sowing, fertilization etc.) [12]. The study considered for the analysis a representative number of farms (100 farms, according to the authors), and the authors concluded which are the variables that showed high importance in relation to yield, and which can be improved for agricultural practices.

The profitability of rapeseed crop is variable, in relation to socio-economic and environmental factors, closely dependent on the management of farms and agricultural crops, and especially in relation to mechanization, according to some studies [6].

The present study analyzed the influence of the disc tillage system (SwsA) compared to the direct seeding system (SwsB), associated with four fertilization treatments, on the yield of the rape crop, and found models (mathematical, and graphic format) to rape yield estimate in relation to the biometric parameters of the plants.

MATERIALS AND METHODS

The study analyzed the influence of some crop technology elements management on yield and some plants biometric parameters in rapeseed. The research took place in the area of Satu Mare locality, Secusigiu Commune, Arad County, Romania, in the period 2022-2023. The field experiments were organized in specific farm conditions, with accessible agricultural technologies.

Two soil work systems (Sws) were considered; A, a classic soil preparation system through disc working - SwsA (two works, Case IH QUADTRAC 470hp tractor, Väderstand Spirit, 12.5 cm); B, a land preparation system by direct sowing - SwsB (direct sowing in stubble, John Deere, MZURI Pro Till, 33.3 cm).

Sowing was done on August 22 year 2022, for both systems, at a depth of 2-3 cm. The hybrid DK Expectation was cultivated.

During the growing season (year 2023), crop protection was done by treatments with Caramba (1 L ha^{-1}), Inazuma (0.14 kg ha^{-1}).

Fertilization was done when preparing the land and establishing the culture (in relation to the SwsA, SwsB systems) with complex fertilizers (NPK 15:15:15; DAP18:46:0) in a dose of 200 kg ha^{-1}. On September 25, sulphur (2 L ha^{-1}) was applied, and in the first decade of October, boron was applied (2 L ha^{-1}). In early November, complex fertilizer 1.5 L ha^{-1} (P, K, Mg, Zn) was applied. In February 2023, urea (N 46.6 %) was applied at a dose of 200 kg ha^{-1}, and in March, ammonium nitrate (N 34.4 %) was applied at a dose of 200 kg ha^{-1}. On March 25, sulphur was applied (1.5 L ha^{-1}).

The four treatments (T), on each tillage system, were represented as follows: T1 – sulphur treatment in spring (1.5 L ha^{-1}); T2 – autumn fertilizations; T3 – ammonium nitrate in spring (200 kg ha^{-1}); T4 – ammonium nitrate (200 kg ha^{-1}) and sulphur (1.5 L ha^{-1}) in spring. Aspects from the experimental field are presented in Photo 1.

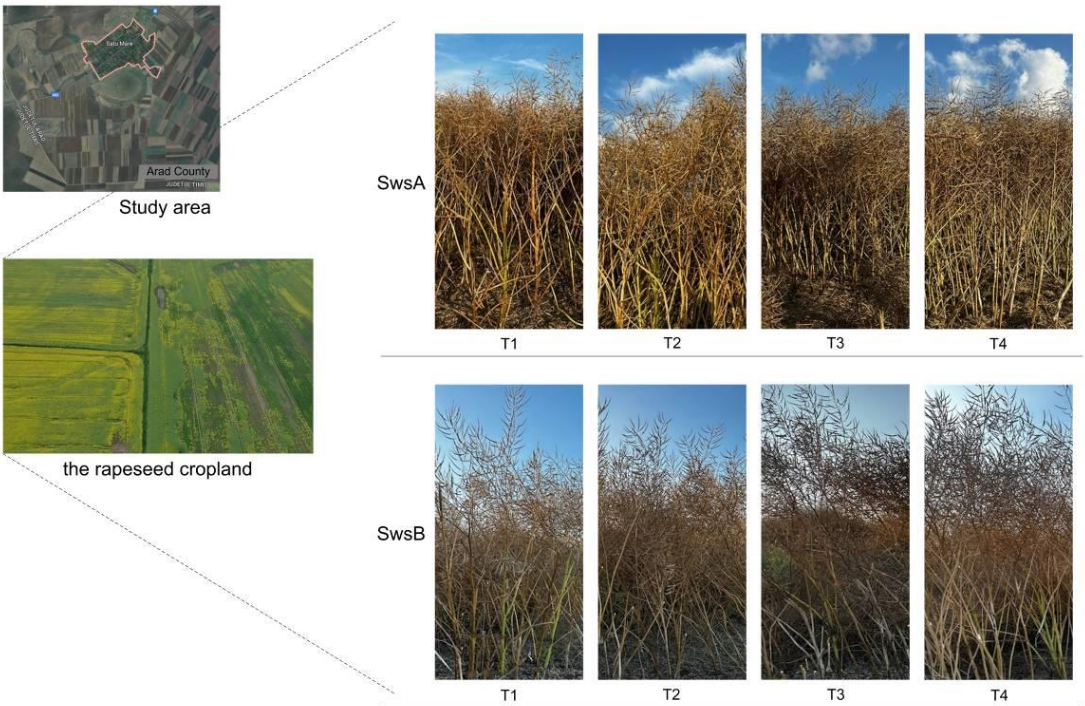

Photo 1. Aspects regarding the location of the study, the rape crop and the variants at the time of harvesting
Source: original photos taken by authors.

The influence of the two tillage systems (SwsA, SwsB) and the applied treatments on some plant biometric parameters, and rapeseed yield was analyzed. For this, the height of the plants (Ph, cm), the diameter of the stem (Sd, cm), the number of branches (Bn) were determined. At physiological maturity (BBCH 99) [10], the experimental variants were harvested. Depending on the degree of branching of the plants, the height of the branching and the insertion height of the siliques, harvesting was done at variable heights. Associated with the harvesting process, the harvesting height (Hh, cm) was determined. The yield was determined on each experimental variant. The surface of an experimental variant was 480 m^2 (20 x 24 m).

The production data were analyzed in relation to the biometric parameters of the plants, on the two tillage systems and applied treatments.

Relevant mathematical and statistical analyzes were made and appropriate analysis tools were used [7, 20].

RESULTS AND DISCUSSIONS

Rapeseed crop developed differently in the two systems of soil work and applied treatments. The variation of some biometric parameters of the plants was recorded, with importance in defining rapeseed yield. Thus, in the case of the SwsA work system (disc tillage), the height of the rapeseed plants (Ph) varied between Ph = 160 – 190±6.57 cm. The plant stem diameter (Sd) varied between Sd = 1.73 – 2.06±0.07 cm. The number of branches (Bn) varied between Bn = 8.00 – 16.00±1.71. In relation to the height of the plants and the position on the plant where the branches started, the harvesting height (Hh) varied between Hh = 18 – 25±1.49 cm. In the disc tillage variant (SwsA), the rapeseed yield was between Y = 3,119 – 3,918±163.47 kg ha^{-1}.

Corresponding to the SwsB work system (direct sowing), the height of the rapeseed plants (Ph) varied between Ph = 150 – 175±5.54 cm. The plant stem diameter (Sd) varied between Sd = 1.50 – 1.87±0.08 cm. The number of branches (Bn) varied between Bn = 12.00 – 15.00± 0.65. In relation to the height of the plants and the position on the plant where the branches started, the harvesting height (Hh) varied between Hh = 19 – 26±1.78 cm. Under the conditions of the SwsB system (direct sowing), rapeseed production varied between Y = 3,192 – 4802±352.26 kg ha^{-1}. The average values recorded for the biometric parameters of the plants, and for the rapeseed yield, in relation to the two tillage systems and the applied treatments, are presented accordingly in Table 1. The standard error (SE) values for each parameter and tillage system are also presented.

The experimental data showed statistical safety, and the presence of variance was confirmed in the data set (ANOVA Test, Alpha = 0.001), Table 2. The level of correlation between rapeseed yield and plant parameters was analysed, on the two tillage systems, Table 3.

Table 1. Experimental data recorded on rapeseed culture, DK Expectation hybrid

Crops technology elements		Ph	Sd	Bn	Hh	Y
Soil work system	Treatments	(cm)	(cm)	(no)	(cm)	(kg ha^{-1})
SwsA	T1	165	2.00	8	25	3,119
	T2	190	2.00	14	18	3,560
	T3	170	1.73	12	20	3,553
	T4	160	2.06	16	20	3,918
	SE	±6.57	±0.07	±1.71	±1.49	±163.47
SwsB	T1	150	1.50	12	24	3,192
	T2	160	1.87	14	19	3,471
	T3	170	1.80	13	19	3,715
	T4	175	1.73	15	26	4,802
	SE	±5.54	±0.08	±0.65	±1.78	±352.26

Source: original data from the experiment.

Table 2. ANOVA Test values

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	83798036	4	20949509	377.289	3E-28	5.8764
Within Groups	1943426	35	55526.45			
Total	85741462	39				

Source: original data.

Table 3. Correlation coefficient values

Soil works system SwsA					
	Ph	Sd	Bn	Hh	Y
Ph					
Sd	-0.058				
Bn	0.130	0.228			
Hh	-0.584	0.119	-0.833		
Y	-0.098	0.129	0.967	-0.730	
Soil works system SwsB					
	Ph	Sd	Bn	Hh	Y
Ph					
Sd	0.576				
Bn	0.757	0.611			
Hh	0.084	-0.636	0.218		
Y	0.868	0.259	0.840	0.536	

Source: original data.

In the case of the SwsA work system (disc tillage), there was a very strong, positive correlation between yield (Y) and plants branching number (Bn), r = 0.967, and a moderate, negative correlation between yield (Y) and harvest height (Hh), r = -0.730. Strong, negative correlation was recorded between plant branching (Bn) and harvesting height (Hh), r = -0.833. In the case of the SwsB work system (direct sowing), there was a strong, positive correlation between yield (Y) and plant height (Ph), r = 0.868, and between yield (Y) and branching number (Bn), r = 0.840. A moderate correlation was recorded between branches number (Bn) and the height of the plants (Ph), r = 0.757). In the case of both tillage systems, other correlations, of lower intensity, were recorded between the analyzed parameters, Table 3.

According to PCA, the diagram in Figure 1 resulted, in which the variants given by the tillage systems (SwsA, SwsB) and treatments (T1 to T4) were distributed according to the values of the considered parameters. PC1 and PC2 together explained 69.647% of variance.

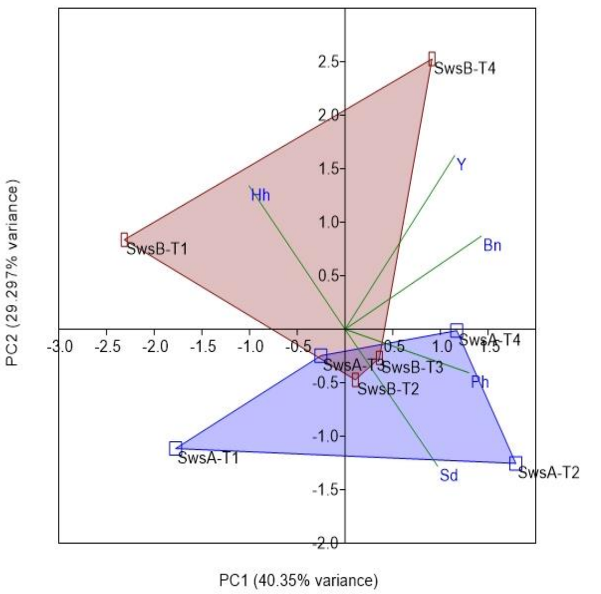

Fig. 1. PCA diagram regarding the distribution of the variants, in the experimental conditions, rape crop
Source: original figure.

Cluster analysis, based on yield (Y), led to the dendrogram in Figure 2, under conditions of Coph. corr. = 0.936.

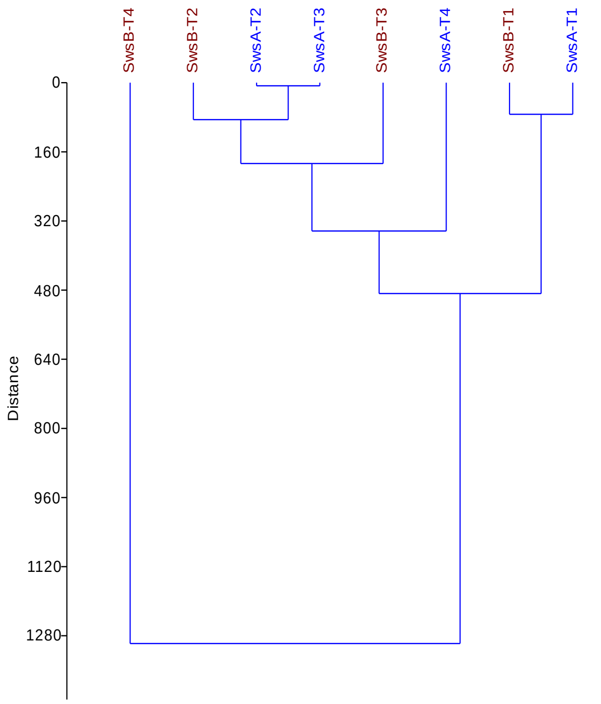

Fig. 2. Dendrogram for the classification of the experimental variants based on rape yield
Source: original figure.

The differentiated positioning of the SwsB-T4 variant was found, in the case of which the highest yield was recorded (Y = 4,802±352.26 kg ha^{-1}).

The other variants were grouped within a cluster, with several sub-clusters. A sub-cluster included some variants, in descending order of yield: the variant SwsA-T4 with the yield of 3,918 kg ha^{-1}, followed by the variants (((SwsA-T2, SwsA-T3), Swb-T2), SwsB- T3) with the yield between 3,471 - 3,715 kg ha^{-1}.

With a lower yield level, the SwsA-T1 and SwsB-T1 variants followed in the same sub-cluster, which presented yield levels between 3,119 - 3,192 kg ha^{-1}.

The SDI index values are presented in Table 4. According to the SDI values, the highest level of similarity was recorded between the SwsA-T2 and SwsA-T3 variants, with the SDI value SDI = 7.

Table 4. SDI values in relation to rapeseed yield

	SwsA-T1	SwsA-T2	SwsA-T3	SwsA-T4	SwsB-T1	SwsB-T2	SwsB-T3	SwsB-T4
SwsA-T1	0	441	434	799	73	352	596	1,683
SwsA-T2	441	0	7	358	368	89	155	1,242
SwsA-T3	434	7	0	365	361	82	162	1,249
SwsA-T4	799	358	365	0	726	447	203	884
SwsB-T1	73	368	361	726	0	279	523	1,610
SwsB-T2	352	89	82	447	279	0	244	1,331
SwsB-T3	596	155	162	203	523	244	0	1,087
SwsB-T4	1,683	1,242	1,249	884	1,610	1,331	1,087	0

Source: original data.

The regression analysis was used to estimate rapeseed yield, in relation to different biometric parameters determined in the plants, under the influence of soil work system, and applied treatments.

In relation to plant height (Ph) and stem diameter (Sd), the regression analysis led to equation (1), under conditions of $R^2 = 0.873$, F = 13.7946, p<0.001.

The graphic distribution of rape yield (Y, kg ha^{-1}) variation depending on plant height (Ph) and stem diameter (Sd) is presented in Figure 3 (3D format) and in Figure 4 (isoquants format).

$$Y = ax^2 + by^2 + cx + dy + exy + f \qquad (1)$$

where: Y – rapeseed yield (kg ha^{-1});
x – plant height (Ph, cm);
y – stem diameter (Sd, cm);
a, b, c, d, e, f – coefficients of the equation (1);
a= 5.22143419;
b= 6814.81614359;
c= -648.93998848;
d= 70377.62606243;
e= -591.87546601;
f= -4704.31790162

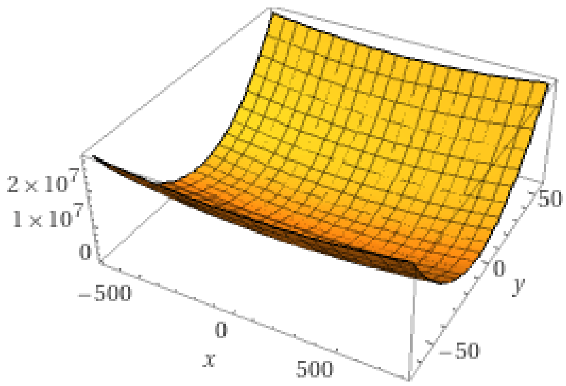

Fig. 3. 3D model of rapeseed yield variation (Y) in relation to Ph (x-axis) and Sd (y-axis)
Source: Original graph.

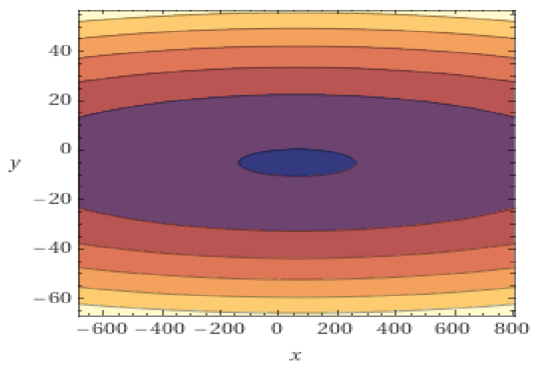

Fig. 4. Model in isoquants format, for rapeseed yield variation according to plant height (x-axis), and stem diameter (y-axis)
Source: Original graph.

The variation of rapeseed yield (Y, kg ha^{-1}), depending on the stem diameter (Sd) and harvesting height (Hh), was described by equation (2), under conditions of $R^2 = 0.887$, $F = 15.7083$, $p<0.001$.

The graphic distribution of rape yield (Y) according to Sd and Hh is presented in Figure 5 (3D format) and in Figure 6 (isoquants format).

$$Y = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: Y – rapeseed yield (kg ha^{-1});
x – stem diameter (Sd, cm);
y – harvesting height (Hh, cm);
a, b, c, d, e, f – coefficients of the equation (2);
a= -23784.84282611;
b= -70.13126398;
c= 125677.09487622;
d= 6427.92449275;
e= -1733.66887783;
f= -183227.32967028

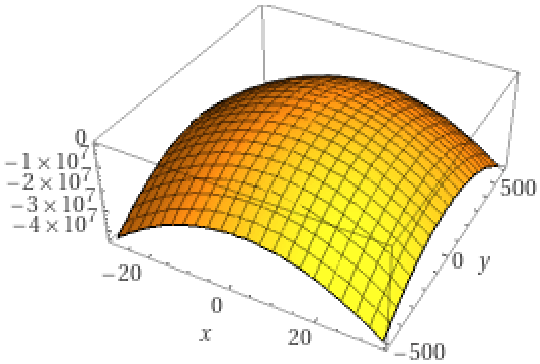

Fig. 5. 3D model of rape yield variation (Y) in relation to Ds (x-axis), and Hh (y-axis)
Source: Original graph.

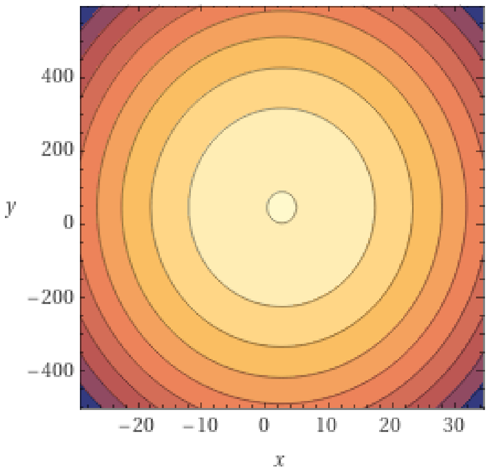

Fig. 6. Model in the form of isoquants of rape yield variation (Y) in relation to Sd (x-axis), and Hh (y-axis)
Source: Original graph.

The variation of rapeseed yield (Y, kg ha^{-1}), according to the harvesting height of the plants (Hh), and the number of branches per plant (Bn), was described by equation (3), according to $R^2 = 0.989$, $F = 197.4476$, $p<0.001$. Representation of yield variation (Y) depending on the harvesting height (Hh) and the number of branches (Bn) is presented in Figure 7 and Figure 8.

$$Y = ax^2 + by^2 + cx + dy + exy + f \quad (3)$$

where: Y – rapeseed yield (kg ha^{-1});
x – harvesting height (Hh, cm);
x – branches number (Bn);
a, b, c, d, e, f – coefficients of the equation (3);
a= 17.92173538;
b= 62.79883259;
c= -1952.16941825;
d= -3446.49314339;
e= 88.10722297;
f= 46652.73146913

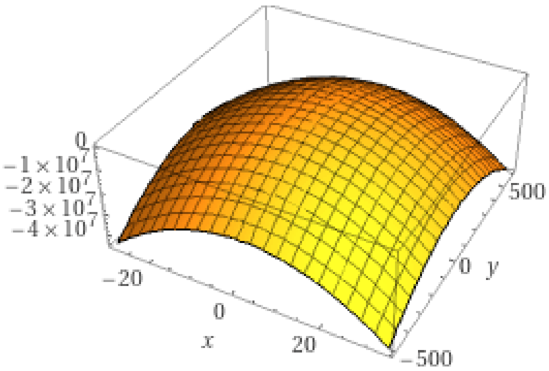

Fig. 7. 3D model of the rapeseed yield (Y) distribution, in relation to Hh (x-axis) and the Bn (y-axis)
Source: Original graph.

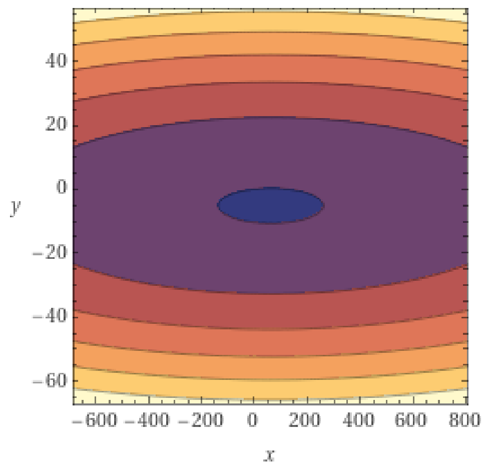

Fig. 8. Model in isoquants format regarding yield (Y) distribution, in relation to the Hh (x-axis), and Bn (y-axis)
Source: Original graph.

The variation of rapeseed yield (Y) was analyzed on each soil work system depending on the applied treatments, as well as between tillage systems.

In the case of the SwsA tillage system (disc tillage), the rapeseed yield had the average value $Y_{(AvgSwsA)}$ = 3,537.50 kg ha^{-1}. The yield increase, generated by the applied treatments (T1 to T4) was positive, close to the average in the case of the T2 and T3 treatments, and above the average value (ΔY = 380.50 kg ha^{-1}) in the case of the T4 treatment. Negative growth was recorded, associated to the T1 treatment (ΔY = -418.50 kg ha^{-1}).

In the case of the SwsB tillage system (direct sowing), the average yield value was $Y_{(AvgSwsB)}$ = 3,795.00 kg ha^{-1}. Compared to the average yield value, treatments T1, T2 and T3 led to negative differences, between ΔY = -603.00 kg ha^{-1} (T1) and ΔY = -80.00 kg ha^{-1} (T3). Only associated to the T4 treatment, the yield of rape registered a positive increase, compared to the average value, ΔY = 1,007.00 kg ha^{-1}.

At the level of the experiment, considering both tillage systems, the average yield value was $Y_{(AvgSwsA\&B)}$ = 3,666.25 kg ha^{-1}. Compared to the average value of the experiment, in the case of SwsA, the T4 treatment generated a positive increase in yield, $\Delta Y_{(SwsA\text{-}T4)}$ = 251.75 kg ha^{-1}, and the T1, T2 and T3 treatments generated negative increases.

In the case of the SwsB tillage system, treatments T3 and T4 generated positive yield increases, and treatments T1 and T2 led to negative increases in yield. A significant yield increase was recorded only in the case of the T4 treatment, with $\Delta Y_{(SwsB\text{-}T4)}$ = 1,135.75 kg ha-1. The data series resulted by calculation, for the average values, and for the increase in rapeseed yield, according to the tillage systems (SwsA, SwsB) and applied treatments (T1 - T4), are presented in Table 5.

Table 5. Yield increase (ΔY) given by the tillage systems and the treatments applied, the rape culture, the DK Expectation hybrid

	Y (AvgSwsA)	ΔY	Y (AvgSwsB)	ΔY	Y (AvgSwsA&B)	ΔY
SwsA-T1	3,537.50	-418.5	-	-	3,666.25	-547.25
SwsA-T2		22.5	-	-		-106.25
SwsA-T3		15.5	-	-		-113.25
SwsA-T4		380.5	-	-		251.75
SwsB-T1	-	-	3,795.00	-603		-474.25
SwsB-T2	-	-		-324		-195.25
SwsB-T3	-	-		-80		48.75
SwsB-T4	-	-		1,007.00		1,135.75

Source: original data.

From the analysis of equations (1), (2) and (3), and the graphic representations regarding the variation of rapeseed yield in relation to biometric parameters determined in the plants, it was found that the plants stem diameter (Sd), and the number of branches on the plants (Bn), had a significant weight in the definition of rapeseed yield. It can be appreciated, under the conditions of the present study, which the technological elements that positively influenced the diameter of the plants stem, and the number of branches on the plants, contributed positively to the increase in rape yield, the DK Expectation hybrid.

In the conditions of the present study, the T4 treatment ensured high yield in both tillage systems (SwsA, SwsB), with the best yield in the conditions of the SwsB system.

Crop plants were analyzed and studied through different methods and techniques [14, 15], in order to provide data and information for improving management at the crops, land plots and farms level.

In relation to the specifics of crops and the destination of production, different fertilization systems were studied, in order to optimize agricultural technologies [3, 4]. Soil work systems are also in the attention of researchers, for conservation purposes for the soil, as well as for the optimization of costs in the whole of agricultural technologies [2, 3, 16].

Some studies have communicated how aspects of mechanization in agricultural technologies contribute to increasing productivity and agricultural yields. Thus Fu et al. (2016) [6], communicated the variable rate of productivity in rape, in relation to socio-economic and environmental factors, closely dependent on the management of farms and crops and especially in relation to mechanization.

In the context of current concerns, the present study provides information on the yield variation of the rape crop, according to tillage systems, and fertilization treatments, and thus contributes to the series of information and the database, in order to optimize agricultural technologies.

CONCLUSIONS

The study highlighted, through valuable results, how the yield of the rapeseed crop varied according to the tillage systems (SwsA and SwsB), and the applied treatments (T1 to T4).

The direct seeding system (SwsB) ensured better conditions for the growth and development of the rapeseed crop, quantified by better yield (ΔY = 1,135.75 kg ha^{-1} compared to the average production on the two tillage systems, $Y_{(AvgSwsA\&SwsB)}$ = 3,666.25 kg ha^{-1}).

Among the four applied treatments (T1 to T4), treatment 4 (T4) generated greater increases in rapeseed yield, in the case of SwsA tillage system (ΔY = 380.50 kg ha^{-1}), and in the case of SwsB tillage system - direct sowing (SwsB, ΔY = 1,007.00 kg ha^{-1}).

The applied treatments, in the form of fertilizers (the same doses), were better valorised in the case of the SwsB soil work system, as a result of the localized application (starter fertilization, near the seeds and the plants row). It can also be considered the lower cost of establishing the crop associated with the SwsB system, by reducing the number of soil works and associated costs. In addition to these economic benefits, the ecological benefit of conservation works on the soil, can also be considered.

The PCA and CA analysis explained the presence of variance in the set of experimental data, and the classification of variants, in relation to the rape yield, and biometric parameters considered.

Mathematical models resulted by analysis, and graphical models (3D, isoquants), described in statistical safety conditions, and represented suggestively, the variation of rape yield in relation to the considered biometric parameters.

Based on the recorded results, the study recommends the direct seeding system to the rape crop (SwsB) for agricultural practice, with economic and ecological benefits.

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