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Evaluation of the herbicide treatment on two common wheat varieties on the basis of mathematical-statistical analysis

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Abstract- A field experiment with two varieties of common wheat was conducted during the period 2012 - 2014 in the training experimental terrain at Trakiya University of Stara Zagora. An assessment of the impact of treatment`s different options on yield in common wheat variety "Enola" and "Iliko" was made with a two-factor analysis of variance. The effect of the treatment of herbicides was as follows: Axial one (pinoxaden + florasulam) - 1000; Axial 050 EC (pinoxaden) - 900 ml.ha^{-1}; Traksos 045 EC (pinoxaden + clodinafop) - 1200 ml.ha^{-1}; Logran 20 WG (triasulfuron) - 37.5 g.ha^{-1}; Lintur 70 WG (triasulfuron + dicamba) - 150 g.ha^{-1}.

With a high degree of confidence, it was established a statistically significant influence on the grain yield indicator, on the factor "variety", followed by the treatment options.

It was made an assessment of similarity and distance of the different options` influence on the wheat treatment (varieties "Enola" and "Iliko") and their grouping, based on main biometric identifiers by applying cluster analysis. Classification and grouping options are made by hierarchical cluster analysis, which allows the increase of the objectivity in evaluating the complex impact of the options of treatment on the structural elements of the two wheat varieties.

Index Terms- Herbicides, Wheat varieties, ANOVA, Cluster analysis, Dendrogram

I. INTRODUCTION

Modern conditions of the climate, on one hand, and the requirements of the global market, on the other hand, impose the search for mechanisms for increasing the productivity of crops and for improving the quality of grain from wheat. The introduction of varieties with high productivity and adaptability to the environmental conditions has a greater significance.

Ecological plasticity of varieties guarantees the stability of the productivity, that is why the choice of an appropriate variety is crucial for the efficiency of grain production. The proper variety structure, depending on the specific agro-ecological conditions of the region, can significantly increase yields and quality of production [1-3]. Yields and their structural elements are strongly influenced by the conditions of the year and the plasticity of the variety, considered [4].

Weeds control is an essential element of the complex agronomic techniques. Herbicides are the primary factor in modern integrated technologies for weeds control. Obtaining high yields of agricultural crops is impossible without their use [5-8].

The aim of the study is to assess the effect of the treatment on the yield in common wheat varieties "Enola" and "Illico".

II. MATERIALS AND METHODS

Filed study was conducted in the period 2012-2014, in the area of the training experimental field of Faculty of Agriculture, Trakia University, Stara Zagora. The soil type was characterized as a typical meadow-cinnamon soil. The profile power was 103-105 cm, with well-defined horizons. The humus horizon was clear and had a range 0-50 cm. According to the mechanical composition, the soil was sandy loam. The soil supply with organic and mineral substances in the layer 0-30 cm is reflected in Table 1.

The soil in the area has a slight acid reaction. It is with an average stock humus - 3.93%. The soil is averagely supplied with mineral nitrogen - 33.2 mg/1000g soil. Ammonia nitrogen is 13.6 mg/1000g soil and nitrate - 19.6 mg/1000g soil. There are also weak stocks of movable soil phosphorus - 3.9 mg/1000g. The movable potassium content is 44.0 mg/1000g soil, which characterizes the soil as a very well stocked with potassium. With these indicators and content of organic matter in arable layer of soil, it is suitable for growing grain cereals.

Table I: Content of organic and mineral substances in the arable layer of soil

Indicators	pH (KCi)	Humus, %	Mineral nitrogen mg/1000g soil	$N\text{-}NH_4$, mg /1000g soil	$N\text{-}NO_3$, mg/1000g soil	Assimilable P, mg/ 1000g soil	Assimilable K, mg/ 1000g soil
Values at moment betting of the experience	5.44	3.93	33.20	13.60	19.60	3.90	44.00

The study was set by the method of fractional plots. Two common wheat varieties - Enola and Iliко were examined. The effectiveness of some herbicides and herbicidal compositions was studied, which were applied separately or as a tank mix.
10 variants were tested for treatment of crops:

1. Control - no treatment with herbicides;
2. Axial one - 1000 $ml.ha^{-1}$;
3. Lintur + Traksos 150 $g.ha^{-1}$ + 1200 $ml.ha^{-1}$ - tank mixture;
4. Logran + Traksos 37.5 $g.ha^{-1}$ + 1200 $ml.ha^{-1}$ - tank mixture;
5. Lintur + Axial 150 $g.ha^{-1}$ + 900 $ml.ha^{-1}$ - tank mixture;
6. Logran + Axial 37.5 $g.ha^{-1}$ + 900 $ml.ha^{-1}$ - tank mixture;
7. Lintur + Axial 150 $g.ha^{-1}$ + 600 $ml.ha^{-1}$ - separate treatment;
8. Lintur + Traksos 150 $g.ha^{-1}$ + 1200 $ml.ha^{-1}$ - separate treatment;
9. Logran + Axial 37.5 $g.ha^{-1}$ + 600 $ml.ha^{-1}$ - separate treatment.
10. Logran + Traksos 37.5 $g.ha^{-1}$ + 1200 $ml.ha^{-1}$ - separate treatment;

The following method was used: the treatment of sowing-seed was made by tank mixtures spray and by separate spray. The bringing in of a tank mixture meant that the solution of plant protection chemicals was prepared together, i.e. herbicides were dissolved in one container and the treatment was carried out simultaneously. In the separate treatment, Logran was brought as a first herbicide, or Lintur respectively, and after a week the crops were treated with another medicine (Traksos and Axial), as it was set out by methodology.

A hierarchical cluster analysis was made by the method of the intergroup connection [9,10].

Data processing was carried out with the statistical program SPSS.

III. RESULTS AND DISCUSSION

With regard to the climate, the region, where the experimental field is located, refers to the European continental climate area and the transitive continental sub-area. It includes the region of East Central Bulgaria with the Thracian lowland. The winter season is relatively soft and warm. The altitude of the training experimental field is 160m. The slope of the terrain is characterized as flat, with a slope of 3%.

Years of field research differ significantly according to their probability of precipitation (Table. 2). The last year was characterized as humid, with provision of P - 2.0%. The first and second years of the experiment were characterized as medium moist with provision respectively of 34.8 % and 48.8 %. The amount of precipitation throughout the year was distributed very unevenly (Fig. 1). Temperatures stocks were high in the three years as of the study. Regarding the air temperature and the provision, the years were characterized as warm, respectively, with provision 6.7 %, 9.0 % and 13.7 %.

In the first economic year there were registered minus values of the daily average temperatures during the winter months - January and February. There were registered temperatures below -10 ° C. The reported permanently lower values contributed to the stop of the culture vegetation, but did not cause plants freezing. The measured temperatures in April were higher (17%) of the rate for the month (12.0 °C). Permanently higher daily average temperatures favored the development of plants. During the third year there were registered permanently higher temperatures during the autumn-winter months (Fig. 2).

Table II: Meteorological factors for the region of Stara Zagora

Factor		**Average for the period**	**2011/12**	**2012/13**	**2013/14**
Σ N	mm	556.5 mm (average for 85)	617.0	548.6	1054.6

	P %		34.8	48.8	2.0
Σ T°	° C	160.5 ° C (average for 85)	162.6	163.8	160.5
	P %		9.0	6.7	13.7

Σ N – precipitations, Σ T° – temperature,
P % - provision of the meteorological factors;

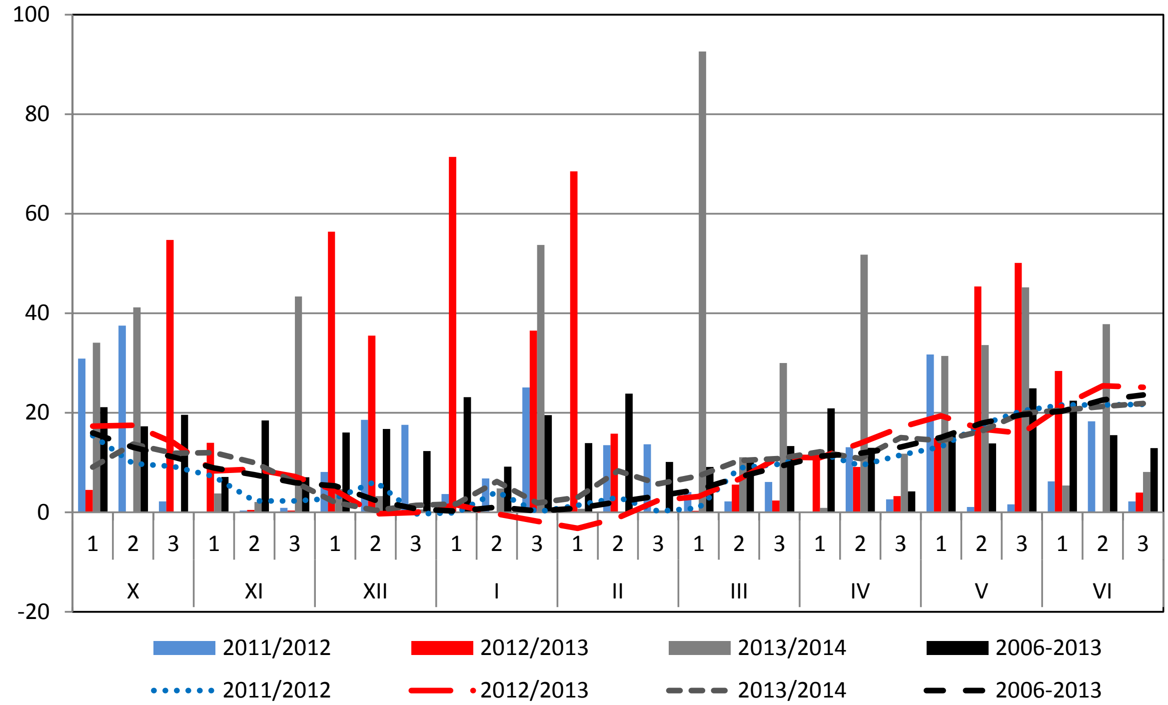

Figure 1. Climate graph for vegetation period of common wheat for the period of 2011-2014 filed study area of the city Stara Zagora

Long-year research determined this area as suitable in terms of moisture provision. In the three experimental years the nature and amount of precipitation were extremely different. Wheat wais provided with sufficiently with easily accessible moisture throughout the growing season. In the first year`s autumn of the field study the amount of rainfall was unevenly distributed (table 2). In October, the amount of precipitation was 70.6 mm, at a rate of rainfall for the month 44.16 mm. In November it decreased - only 1.3 mm. This amount was extremely insufficient, but thanks to moisture stockpiling the previous month, wheat was sufficiently humid. In March and April rainfall was again below the monthly norm. However, the seeds had enough moisture for their germination and sprouting.

In the autumn of the economic year 2013-2014 rainfall varied from 8.6 to 75.3 mm. The amount and distribution of rainfall throughout the growing season of wheat provides enough moisture, easily accessible for the development of culture. During the critical phases of development, wheat does not suffer from water deficit and one can talk about water logging. There were registered 133.7 mm in March, the tendency of exceeding the norm continued in the remaining three months of vegetation. The amount of rainfall during the third economic year was 28.2% above the norm.

A two-factor analysis of variance was made to assess the importance and the power of influence of "treatment", "biometric identifiers" and their interaction on the studied wheat varieties. The experimental data were statistically processed by the computer software MS Excel. Assessment of the influence power of the factors was calculated by Plohinski method [11]. It was defined as part of the inter-group variation in total variation. It works with the sum of squares and was calculated as follows:

$h_x^2 = \frac{D_x}{D_y}$, where D_x - the sum of the squares of the factor x, D_y - total sum of squares (SS). It was established, with a high degree of confidence, a statistically significant influence on the interaction of two factors "treatment" and "biometric identifiers" and their interaction in the two wheat varieties.

The conducted dispersive analysis for the influence of factors “variety”, “treatment options” and their interaction on the yield of wheat variety "Enola" and "Iliко" are presented in tables 3, 4 and 5. Table 3 summarizes the results from the analysis of wheat varieties yield data for the first experimental year. A greatest impact on the variation of the trait has the variety with influence of 77 %, followed the variants of irrigation with 15 %. The interaction of the two factors is expressed less (p≤0.01).

Table III: Two-way analysis of variance factors: A - variety and B - variants of treatment on the yield of wheat in 2012

Source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	Strength influence
Variety (A) ***	50477735.15	1	50477735.15	616774.32	0.000	4.08	77%
Variants of treatment (B)***	9917053.88	9	1101894.88	13463.77	0.000	2.12	15%
Interaction **	5234272.92	9	581585.88	7106.25	0.004	2.12	8%
Errors	3273.66	40	81.84				
*****, **, * -** proven respectively p≤0.001, p≤0.01 and p≤0.05; n.s. – unproven							

For indicator "yield" in 2013 (table 4), there was a strongest influence of the factor “variant of treatment” with dominant influence of 45% and a clear credibility p≤0.001 on climate indicator. On the second place it was the variety influence of 31% and 24% - respectively, the interaction of two factors.

Table IV: Two-way analysis of variance factors: A - variety and B - variants of treatment on the yield of wheat in 2013

Source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	Strength influence
Variety (A) ***	14107990.94	1	14107990.94	8641.17	0.000	4.08	31%
Variants of treatments (B)***	20443954.55	9	2271550.51	1391.33	0.000	2.12	45%
Interaction ***	10873867.17	9	1208207.46	740.03	0.000	2.12	24%
Errors	65305.92	40	1632.65				

The results, obtained for this indicator "yield", gave reliable variances for the factor “variety”, with force of impact - 89%, and the options of treatment had reliability rate (p≤0.01). The interaction of these two factors was statistically less expressed (Table 5).

Table V: Two-way analysis of variance factors: A - variety and B - variants of treatment on the yield of wheat in 2014

Source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	Strength influence
Variety(A) ***	44133811.35	1	44133811.35	49541.24	0.000	4.08	89%
Variants of treatment (B)**	3408160.42	9	378684.49	425.08	0.003	2.12	7%
Interaction **	2150204.82	9	238911.65	268.18	0.005	2.12	4%
Errors	35634	40	890.85				

According to the one-way ANOVA, as well as the conducted analysis for the impact of the two factors (variety and options of treatment) separately, and their interaction, the impact on grain-yield index was statistically proven at a very high degree of reliability (p≤0.001). A greatest impact on the variation of the trait had a variety factor (89 %) in 2014, followed by the variety factor (77 %) for 2012. The second treatment factor was less expressed with force of impact (45 %) in 2013 and the interaction between them (24 %) 2013.

The cluster analysis is a statistical generalizing method, which aim is to assess the impact of individual factors. In this study, an assessment was made for the similarity and the remoteness of the impact of different options treatment for common wheat (variety "Enola" and "Iliko") and their grouping, based on main biometric indicators with the application of a cluster analysis. The experimental data from the 3-rd field experiment was analyzed, including 10 variants of herbicide and herbicide mixtures treatment.

The evaluation of the tested products was made on the basis of the following parameters: plant height, length of ears, number of ears, number of grains in an ear, weight of the grains in an ear, mass of 1000 seeds and specific weight.

Grouping of the studied variants was performed by hierarchical cluster analysis. Used is the method of intergroup binding [9,10].

$$D(x,y)=\sqrt{\sum_{i=1}^{n}(x_i-y_i)^2}$$

A dendrogram was constructed by which graphically presented the generated clusters. The dotted horizontal line of the dendrogram showed the rescaled distance at which clusters are formed.

Following the cluster analysis, it was clear that the impact of treatment on biometric identifiers in wheat variety "Enola" was grouped in three main clusters. The results are presented in tables, with the steps of combining the clusters and the inter-group distances (Table 6), and by the dendrogram (Fig. 2 and 3).

Table VI: Combing of clusters and inter-group distances

Variety Enola				Variety Iliko			
Steps	Combined clusters		Coefficients	Steps	Combined clusters		Coefficients
	cluster 1	cluster 2			cluster 1	cluster 2	
1	2	8	2.661	1	3	5	2.711
2	2	6	3.698	2	3	4	3.421
3	1	9	6.530	3	2	3	6.607
4	4	7	7.454	4	6	9	6.619
5	3	10	7.713	5	2	8	8.920
6	4	5	9.679	6	2	6	9.435
7	1	3	10.294	7	1	2	10.977
8	1	2	13.713	8	1	10	16.689
9	1	4	17.769	9	1	7	28.180

Results for variety "Enola" showed that the options were divided into three clusters. The first cluster with very close results included options 2,8,6 and the second variants - 1,9,3,10. The next stage they combined with the first cluster. They were with a greatest similarity in all tested indicators and a least euclidean distance between them. The third cluster included 3 options: 4.7 and 5. The control for all variants was the farthest one from options 4, 2, 3, and option 9 was the closest one to the control. The options that were close to other indicators are 2, 6 and 8. The other equally effective options are 4 and 7, 3 and 10 (Fig. 2).

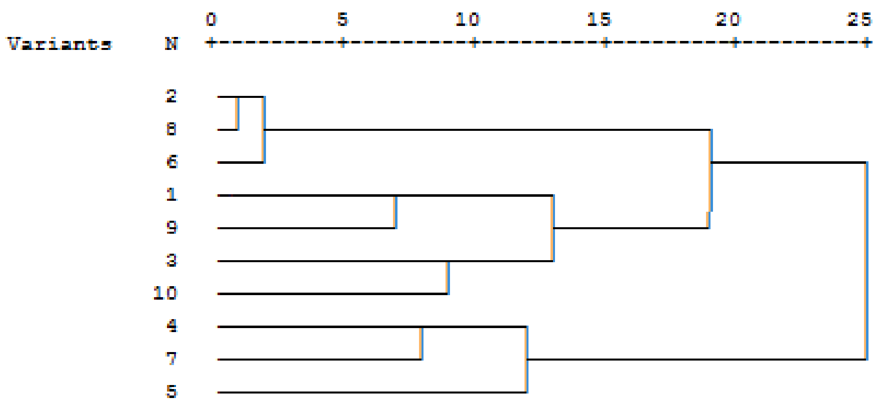

Figure 2. Hierarchical cluster analysis of a variety Enola - dendogram based on average intergroup distances

Results for variety "Iliko" showed that the options were allocated again in two main clusters. The first cluster with very close range included two sub-clusters, one is again with 2, 5, 4, and, later, variant 2 joined (Fig. 3). The second cluster consisted of one main cluster of variants 8, 6, 9 and 1.

The dendrogram showed that for the variety "Iliko", the control of all parameters, was the furthest one from the variants 7, 10, 2, and the closest one to the control was var. 2. The variants, similar to other indicators, were variants 3, 5, 4 2 and 3, 6 and 9. Intergroup distances between these variations showed that they differed on the overall assessment of the examined indicators.

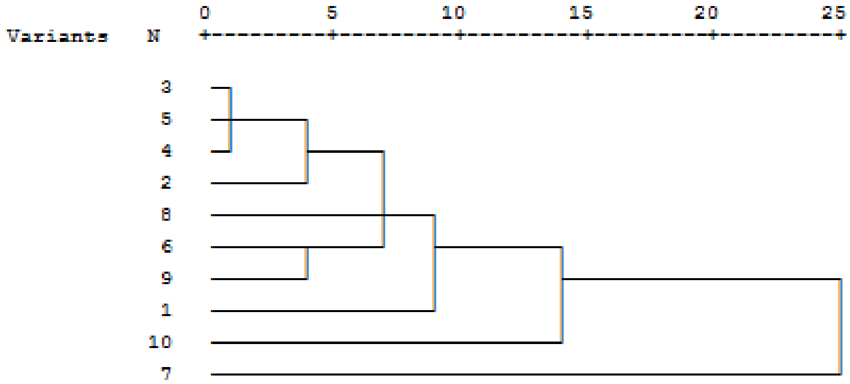

Figure 3. Hierarchical cluster analysis of a variety Iliko - dendogram based on average intergroup distances

According to the classification and grouping options, a hierarchical cluster analysis allows the increase of objectivity in evaluating the complex impact of treatment options on biometric identifiers of the two wheat variants.

IV. CONCLUSIONS

The following conclusions can be made by the conducted examination and analyzes:

According to the two-way analysis of variance, and considering the impact of the two factors (variety and variants of treatment) separately, and their interaction, it was statistically proven a very high degree of reliability ($p \leq 0.001$) of the impact on grain yield index. “Variety” had the greatest impact on the variation of the trait factor, the force of impact was by 31 % to 89 % on average - 65.7%. Classification and hierarchical cluster analysis of grouping options allowed the increase of objectivity in evaluating the complex impact of the treatment options on the structural elements of the two wheat varieties.

REFERENCES

[1] Cheleev D, Todorov S. and Belcheva L. Plant Science, 5-6, (1993), 17-23.
[2] Tzenov N., Kostov K. and Todorov I. Field Crops Studies, 5,(2), (2009), 261-273.
[3] Ilchovska M. and Ivanova I. Agricultural Science And Technology, 6, (1), (2014),14-16.
[4] Georgieva Hr., Tsankova D. and Samodova A. Field Crops Studies. 1, (2004), 51-56.
[5] Chhokar R, Sharma R, Jat G, Pundir A and Gathala M (2007) Effect of tillage and herbicides on weeds and productivity of wheat under rice–wheat growing.
[6] Delye C., Garden J. A. C., Boucansaud K., Chovel B. and Petit C. Weed Research, 51, (5), (2011), 433-437.
[7] Dospatliev L. Science & Technologies, 2,(3), (2012), 156-159.
[8] Delchev Gr. Ecology and Safety, 6,(2), 338-347.
[9] Ward J. H. Journal of the American Statistical Association. 58, (1963), 236-244.
[10] Duran B and Odelle P. Cluster analysis. Moskow. (1977).
[11] Lakin G. Biometrics, Higher School. Moscow. (1990).

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