# INFLUENCE OF TECHNOLOGICAL FACTORS ON QUALITY AND YIELD ELEMENTS OF ANDRADA WINTER WHEAT VARIETY, CULTIVATED IN TRANSLYLVANIA PLAIN CONDITIONS

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***Abstract:*** *The influence of the genetic factor in the quality of the harvest is well known. However, increasing the quality of winter wheat by creating new varieties is a long process, so the aim of this study is to identify some technological factors that could improve the grain chemical composition. For evaluating the influence of tillage system, fertilization and phytosanitary treatment on wheat seed quality, a field experiment based on a split plot design was conducted at Research and Development Station for Agriculture (RDSA) Turda, in 2020-2021 agricultural year. Andrada winter wheat variety was used as biological material. Seeds of Andrada winter wheat variety were analyzed in laboratory using NIR (Tango, Bruker) for: Ash [%], G, Gluten [%], HlWeight [kg/hl], L [mm], Moisture [%], P [mm], P/L, Protein [%], Protein_DM [%], W [Jx10E-4], Zeleny [ml]. Quality was influenced by fertilization and phytosanitary treatment, small variation depending on tillage system being identified. In the no-tillage system, when the mineral fertilizer $N_{134}P_{48}K_{48}$ and when seed treatment and two foliar treatments were applied maximum values were obtained for: prorein content (11.69%), gluten content (22.4%) and Zeleny index (33 ml). In terms of hectoliter weight, the highest value of 77.75 kg/hl was obtained in the classical crop system, when fertilization with complex fertilizer $N_{88}P_{48}K_{48}$ together with seed treatment and one foliar treatment were applied. In terms of yield elements, the negative relationship between quality and yield is highlighted, namely if in the „no tillage system" good results for quality were obtained, in classic system, high values for plant height, number of grains/spikes, grain weight/spike and for spike length compared to „minimum" or „no tillage" were identified.*

***Keywords****: fertilization, seed quality, tillage system, winter wheat.*

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world, in terms of area under cultivation and production (Behzad and Amani, 2020; Jarecki and Czernicka, 2022). Wheat grains are a major source of nutrients in human and animal diets, with its contribution in terms of protein content per year reaching up to sixty million tons (Bunta and Cosma, 2023).

As one of the staple foods in the world, it is grown in different growing areas around the world and thus is often exposed to various biotic and abiotic stressors that cause yield reduction (Racz et al., 2022). In the context of current climate change, precipitation and temperatures show large and unpredictable fluctuations during the wheat growing period (Gorinoiu et al., 2022), so the technological factors could improve yield and yield quality.

Research conducted so far has shown that in addition to climatic factors, wheat production and quality depend on genotype, but also on compliance with crop-specific technology, especially fertilization (Agapie et al., 2021). Fertilization, as an important part of winter wheat cultivation technology, helps the poorly developed root system expand and have a greater capacity to absorb nutrient reserves from the soil (Leonte et al., 2021). Following their research, Swify et al., (2024) hypothesize that chemical fertilizers, especially nitrogen-based, play an essential role in protein synthesis, significantly affecting the quality of the wheat crop.

The application of nitrogen in an advanced phase of wheat favours the accumulation of protein in grains to the detriment of high yields (Sowers et al., 1994), which is why the split application of nitrogen fertilizers is quite often used, when aiming to increase the protein concentration in the grains and improve the quality of the harvest.

Another technological factor contributing to the production and quality of the wheat harvest is the tillage systems (Cox and Shelton, 1992; Woźniak and Soroka, 2018).

Lately, conservative tillage systems have become part of cereal cultivation technology, because as De Carcer et al. (2019) say, conservative agriculture is emerging as a potential alternative for maintaining crop productivity, soil fertility and environmental sustainability.

The production of high-quality cereals and the achievement of a yield at maximum capacity is possible if the crops are provided with optimal conditions for growth and development (Hellemans et al., 2018). This can be achieved by using appropriate agrotechnical measures such as fertilization, plant protection and appropriate tillage methods (Wesołowska et al., 2022). The way the soil is processed can alter both the quality and productivity of the grains, since any changes in the physicochemical and biological properties of the soil affect the growth and development parameters of the crop (Williams et al., 2008).

In this context, the aim of the paper was to study the impact of the tillage system and fertilization of winter wheat, cultivated in the pedoclimatic conditions of the Transylvanian Plateau, on the quality of the harvest in order to identify an optimal fertilization variant that would provide the best quality results, in interaction with conservative tillage systems.

## MATERIAL AND METHODS

An experiment was conducted at Research and Development Station for Agriculture (RDSA) Turda to analyse the influence of soil tillage system, fertilization and treatments and on the grains quality of Andrada winter wheat variety (Figure 2). The previous plant crop was soybeans. Because of the rains registered in September and October 2020 (Figure 1), the sowing of wheat was conducted on the second decade of november with the Directa 400 seed drill, at a seeding rate of 550 germinating seeds/m$^2$, with a depth of 4 cm and rows spaced at 18 cm. Both the low temperatures in April and high temperatures form June coroborated with the dry weather negatively influenced the winter wheat plants development.

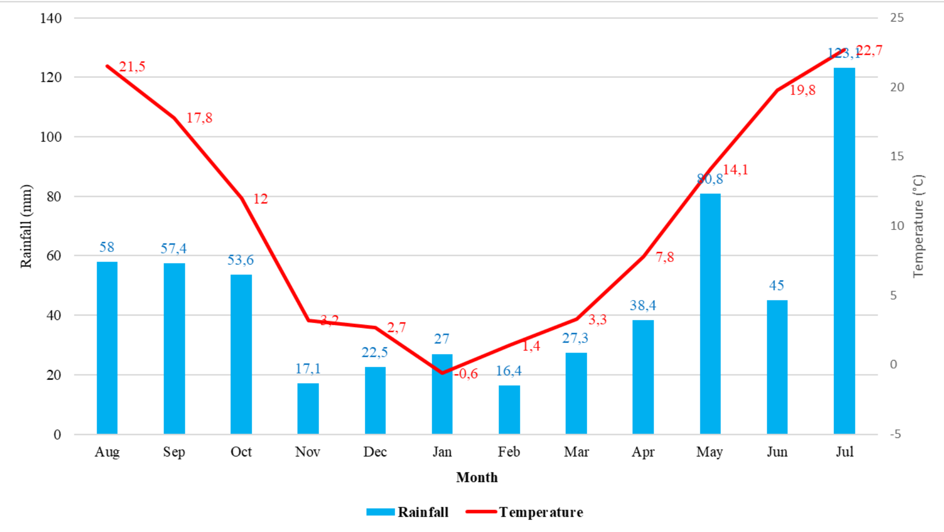


**Figure 1. Temperature and rainfall bewteen August 2020- July 2021 (RDSA Turda)**

The experiment was placed on Chernozem soil with low fertility and a neutral pH of 6.7. Based on the subdivided plot method, the experiment followed the three factors mentioned above, with the following graduations:

**Fetilization factor (F), with three graduations for nitrogen:**

F1: $N_{48}P_{48}K_{48}$ kg/ha a.c. (active substance)- applied at the sowing time.

F2: $N_{88}P_{48}K_{48}$ kg/ha a.c. (active substance)- applied in the first decade of April.

F3: $N_{134}P_{48}K_{48}$ kg/ha a.c. (active substance)- applied at the end of the second decade of May.

**Tillage system factor (S), with 4 graduations:**

S1: classic (CS), when ploughing system was studied;

S2: chisel (MC), when minimum soil preparation with chisel was used;

S3: disc (MD), when minimum soil preparation with disc was used;

S4: no tillage (NT), when sowing without soil preparation.

**Treatment factor (T), with 3 graduations:**

T1: seed treatment (0.14 l/ha Sekator + 0.6 l/ha Dicopur + 1.2 l/ha Stabilan + 0.6 l/ha Falcon + 0.2 l/ha Mavrik + 1.0 l/ha Tonivit).

T2: seed (T1) + one foliar treatment (0,8 l/ha Prosaro + 0,2 l/ha Apis), applied in the last decade of May.

T3: seed (T1) + two foliar treatments (T2 + Nativo 0,7 l/ha + Apis 0,2 l/ha + Lithovit Forte 1,0 kg/ha + 250 l water/ha), applied in the first decade of June.

At the end of the growing season, 25 plants were analysed in laboratory for: plant height, number of grains/ spike, grain weight/spike and spike lenght. Using the Wintersteiger combine harvester for experimental plots, with a working width of 1.4 m, at the end of July, the experiment was harvested. From each experimental variant, wheat seeds were analyzed in the laboratory for quality indices (Ash [%], G-swelling index, Gluten [%], HlWeight [kg/hl], L-extensibility [mm], Moisture [%], P- dough tenacity [mm], P/L [], Protein [%], Protein_DM

[%],Zeleny [ml], using near-infrared spectrophotometry (Tango, Bruker). Experimental data was proceed with Polifact for ANOVA, Past4 for chemometric analysis and with Microsoft excel for graphic presentation.

**Figure 2. Aspects of experimental field (original)**

## RESULTS AND DISCUSSIONS

By analysing the experimental data in terms of protein and ash content (Table 1) obtained in the Andrada winter wheat variety, in the experiment that studied the influence of the tillage system, fertilization and phytosanitary treatments on quality, it can be seen that for the ash content were obtained close values in all experimental variants, even if the F test had statistical significance. The highest ash content (1.60%) was recorded in the minimum disc tillage variant, on the background of $N_{134}P_{48}K_{48}$ fertilization, and by applying seed treatment followed by two foliar treatments on vegetation.

In terms of protein content, it registered a variation between 9.70-11.69%. By minimizing tillage system, there was an increase in protein content, in the no tillage variant being obtained the highest value (10.63%). At the opposite pole is the classic variant, with ploughing, where, on average, the protein content accumulated in the grain was 10.24%. The maximum of the experiment of 11.69% was reached in the no-tillage version, when the mineral fertilizer $N_{134}P_{48}K_{48}$ and when seed treatment and two foliar treatments were applied. If in the no tillage system, high values for protein content was obtained when N134P48K48 fertilizer was applied, in the other three soil systems experimented, maximum values for this quality parameter was obained when N88P48K48 was tested.

According to studies by Amato et al. (2013), the protein content of wheat grains varies between tillage systems, with the best results in the conventional system, with a lower grain content attributed to the minimality system and the lowest content being for direct sowing. These findings are in opposition with ours, because of the interaction established between the genetic factor, weather conditions from the growing season together with the technological factors. All these play an important role in achieving the quality of the harvest.

Research by Cheţan et al., (2024) indicates that protein content increased with increasing doses of N from 12.41 to 14.72%, with the lower value attributed to the control, a fact also observed by other researchers (Woźniak and Gontarz, 2011; Debaeke et al., 1996) which have shown that fertilization, or lack thereof, is of major importance in shaping the quality of wheat production.

From the values obtained for test F, the protein content was influenced more by the level of fertilization and phytosanitary treatments applied and less by the variant of tillage system practiced. An experiment conducted by Wozniak and Rachon (2020), in order to study the influence of three different tillage systems on wheat yield and quality, highlights that quality varied more by year than by technology used. Regarding fertilization, comparable results with ours were obtained by Hlisnikovský and Kunzová (2014), which pointed out that protein content was influenced by the application of mineral and organic fertilizers.

Regarding the gluten content and Zeleny index (Table 2), a statistically very significant variation is observed depending on fertilization and phytosanitary treatments, while tillage technology led to a smaller variation, only in the sedimentation index. It is noted the high-quality value of the seeds harvested in the no tillage system compared to the other experienced tillage systems.

The highest gluten content (22.4%), respectively the highest value for the Zeleny index (33 ml) were reached in the no tillage experimental variant, when the maximum dose of mineral fertilizer together with a seed treatment and two phytosanitary treatments were applied. A four percent increase in the Zeleny index was recorded in the no tillage variant, compared to the classic variant in which the ploughing was performed. In the same experimental variant, gluten content recorded an 5.9% increase compared to the classic tillage system. As in the case of protein content, gluten had the best values when the second fertilization variant was applied

(N88P48K48), in the first three tillage systems (CS, MC, MD. When no tillage was experimented, high value for this quality parameter was obtained when N134P48K48 complex fertilizer was experimented.

Research conducted by Gaweda and Halineriz (2021), showed that the Zeleny index, correlated with ecological and technological factors, had higher values in the system without tillage than in the conventional tillage system, and results reported by Jug et al., (2011) showed that protein and gluten content and sedimentation index values were less influenced by tillage systems. Authors such as Wesołowska et al., (2022) obtained higher values for the Zeleny index in conventionally worked plots, and in minimum systems they had significantly lower values, by up to 5.2-10.0% than in the classical system.

In terms of phytosanitary treatments, generally, high values were obtained for these two important quality parameters when seed treatment and two foliar treatments were experimented. Studies by Andruszczak (2017) and Rachoń et al. (2015) indicated that chemical protection of crops can significantly increase the value of the Zeleny sedimentation index and increase the protein content of cereals but does not significantly affect gluten and starch content.

**Table 1. ANOVA test for protein and ash content of Andrada winter wheat variety, as influenced by fertilization, tillage system and treatment**

| Tillage system factor (S) | Fertilization factor (F) | Quality indices | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ash content (%) | | | | Protein on DM content (%) | | | |
| | | Treatmeant factor (T) | | | | | | | |
| | | seed treatment | seed treatment + 1 foliar treatment | seed treatment + 2 foliar treatments | Mean | seed treatment | seed treatment + 1 foliar treatment | seed treatment + 2 foliar treatments | Mean |
| CS | $N_{48}P_{48}K_{48}$ | 1.52 | 1.50 | 1.52 | 1.51 | 10.09 | 9.79 | 10.26 | 10.05 |
| | $N_{88}P_{48}K_{48}$ | 1.46 | 1.44 | 1.42 | 1.44 | 10.67 | 10.30 | 10.61 | 10.53 |
| | $N_{134}P_{48}K_{48}$ | 1.51 | 1.48 | 1.52 | 1.50 | 10.28 | 9.75 | 10.38 | 10.14 |
| Mean | | 1.50 | 1.47 | 1.49 | 1.49 | 10.35 | 9.95 | 10.42 | 10.24 |
| MC | $N_{48}P_{48}K_{48}$ | 1.51 | 1.49 | 1.46 | 1.49 | 9.74 | 10.46 | 10.70 | 10.30 |
| | $N_{88}P_{48}K_{48}$ | 1.48 | 1.46 | 1.51 | 1.48 | 10.51 | 10.53 | 10.48 | 10.51 |
| | $N_{134}P_{48}K_{48}$ | 1.43 | 1.46 | 1.46 | 1.45 | 10.66 | 9.53 | 10.92 | 10.37 |
| Mean | | 1.47 | 1.47 | 1.48 | 1.47 | 10.30 | 10.17 | 10.70 | 10.39 |
| MD | $N_{48}P_{48}K_{48}$ | 1.55 | 1.47 | 1.48 | 1.50 | 9.70 | 10.41 | 10.15 | 10.09 |
| | $N_{88}P_{48}K_{48}$ | 1.48 | 1.47 | 1.52 | 1.49 | 10.60 | 10.55 | 11.29 | 10.81 |
| | $N_{134}P_{48}K_{48}$ | 1.45 | 1.44 | 1.60 | 1.50 | 10.80 | 11.04 | 9.70 | 10.51 |
| Mean | | 1.49 | 1.46 | 1.53 | 1.50 | 10.37 | 10.67 | 10.38 | 10.47 |
| NT | $N_{48}P_{48}K_{48}$ | 1.45 | 1.50 | 1.48 | 1.48 | 9.81 | 10.18 | 10.50 | 10.16 |
| | $N_{88}P_{48}K_{48}$ | 1.46 | 1.46 | 1.44 | 1.45 | 11.21 | 10.67 | 10.41 | 10.76 |
| | $N_{134}P_{48}K_{48}$ | 1.53 | 1.52 | 1.46 | 1.50 | 11.29 | 9.87 | 11.69 | 10.95 |
| Mean | | 1.48 | 1.49 | 1.46 | 1.48 | 10.77 | 10.24 | 10.87 | 10.63 |
| LSD | | p 5% 0.04<br>p 1% 0.06<br>p 0.1% 0.09 | | | | p 5% 0.34<br>p 1% 0.49<br>p 0.1% 0.70 | | | |
| F test | | S | T | F | | S | T | F | |
| | | 8.02 | 7** | 9.34** | | 22.94* | 41.88*** | 38.71*** | |

**Table 2. ANOVA test for gluten content and Zeleny index of Andrada winter wheat variety, as influenced by fertilization, tillage system and treatment**

| Tillage system factor (S) | Fertilization factor (F) | Quality indices | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gluten content (%) | | | | Zeleny (ml) | | | |
| | | Treatment factor (T) | | | | | | | |
| | | seed treatment | seed treatment + 1 foliar treatment | seed treatment + 2 foliar treatments | Mean | seed treatment | seed treatment + 1 foliar treatment | seed treatment + 2 foliar treatments | Mean |
| CS | $N_{48}P_{48}K_{48}$ | 17.55 | 16.20 | 17.60 | 17.12 | 23.50 | 22.00 | 26.00 | 23.83 |
| | $N_{88}P_{48}K_{48}$ | 19.85 | 18.25 | 19.45 | 19.18 | 27.50 | 25.00 | 25.00 | 25.83 |
| | $N_{134}P_{48}K_{48}$ | 17.95 | 16.85 | 18.35 | 17.72 | 26.50 | 21.50 | 25.50 | 24.50 |
| Mean | | 18.45 | 17.10 | 18.47 | 18.01 | 25.83 | 22.83 | 25.50 | 24.72 |
| MC | $N_{48}P_{48}K_{48}$ | 16.20 | 17.90 | 18.85 | 17.65 | 23.50 | 26.50 | 27.00 | 25.67 |
| | $N_{88}P_{48}K_{48}$ | 17.95 | 18.60 | 18.85 | 18.47 | 25.50 | 25.00 | 26.00 | 25.50 |
| | $N_{134}P_{48}K_{48}$ | 19.20 | 15.90 | 20.05 | 18.38 | 26.00 | 21.00 | 29.50 | 25.50 |
| Mean | | 17.78 | 17.47 | 19.25 | 18.17 | 25.00 | 24.17 | 27.50 | 25.56 |
| MD | $N_{48}P_{48}K_{48}$ | 16.35 | 17.60 | 17.35 | 17.10 | 22.00 | 25.00 | 23.50 | 23.50 |
| | $N_{88}P_{48}K_{48}$ | 18.65 | 18.75 | 20.95 | 19.45 | 28.00 | 27.00 | 33.00 | 29.33 |
| | $N_{134}P_{48}K_{48}$ | 18.05 | 20.20 | 16.00 | 18.08 | 27.50 | 29.00 | 23.50 | 26.67 |
| Mean | | 17.68 | 18.85 | 18.10 | 18.21 | 25.83 | 27.00 | 26.67 | 26.50 |
| NT | $N_{48}P_{48}K_{48}$ | 17.05 | 17.20 | 18.40 | 17.55 | 22.50 | 24.00 | 27.50 | 24.67 |
| | $N_{88}P_{48}K_{48}$ | 20.30 | 19.40 | 19.30 | 19.67 | 29.50 | 27.00 | 25.00 | 27.17 |
| | $N_{134}P_{48}K_{48}$ | 21.15 | 16.55 | 22.40 | 20.03 | 32.00 | 21.50 | 33.00 | 28.83 |
| Mean | | 19.50 | 17.72 | 20.03 | 19.08 | 28.00 | 24.17 | 28.50 | 26.89 |
| LSD | | p 5% | | 1.20 | | p 5% | | 2.93 | |
| | | p 1% | | 1.68 | | p 1% | | 4.11 | |
| | | p 0.1% | | 2.38 | | p 0.1% | | 5.82 | |
| F test | | S | T | F | | S | T | F | |
| | | 6.32 | 32*** | 52.72*** | | 24.23* | 25.28*** | 17.7*** | |

The hectolitre weight of Andrada winter wheat variety (Figure 2) was greater than 75 kg/hl in all experimental variants (Figure 3). The highest value of 77.75 kg/hl was obtained in the classical crop system, when fertilization with complex fertilizer $N_{88}P_{48}K_{48}$ together with seed treatment and one foliar treatment were applied. In this case, statistically, the difference was significant compared to the variant in which only seed treatment was applied. In general, the best values for this parameter were obtained in the variant in which the complex fertilizer $N_{134}P_{48}K_{48}$ was applied, regardless of the tillage system of the soil.

Research conducted by Cociu and Alionte (2011) showed that the tillage system has no significant influence on the hectolitre mass (HW), and those conducted by Partal (2022) showed that in the variant where the basic procedure was autumn ploughing, the highest HW values were obtained. In the same study, additional fertilization, both mineral and organic, leads to an increase in this index, with significant values compared to basic fertilization.

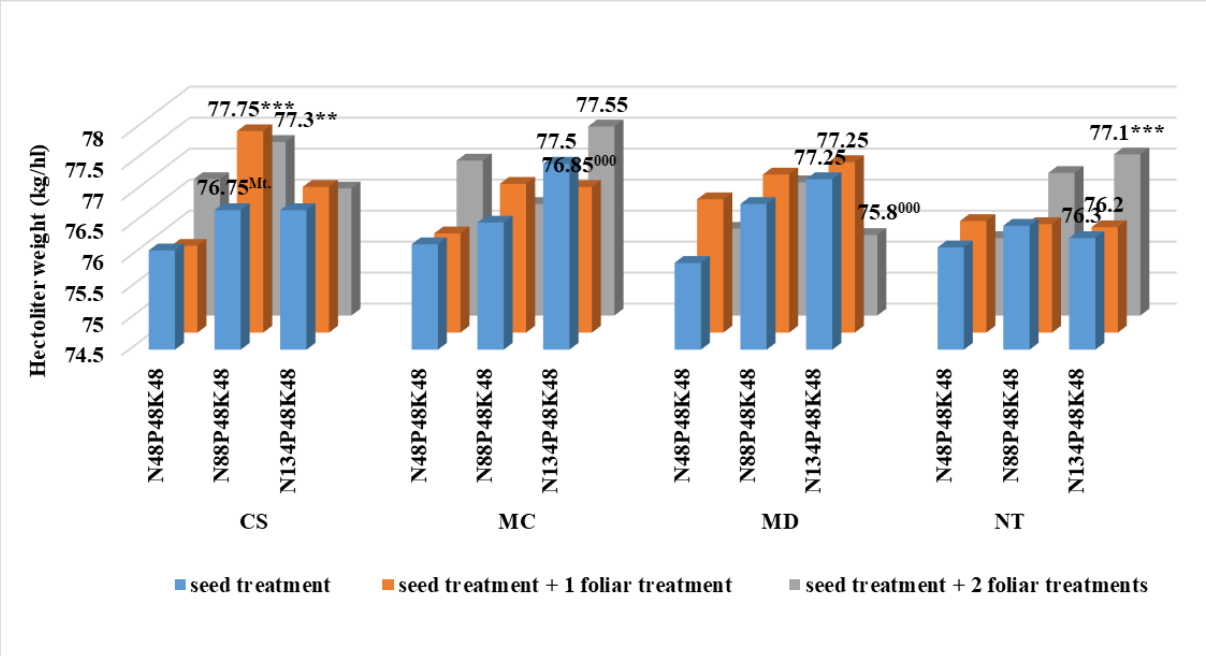


**Figure 3. T x S x F interaction influence on hectolitre weight in Andrada winter wheat variety**

In terms of yield components (Table 3), a significant influence of tillage system on plant height was observed. While by reducing soil tillage a decrease of 12.7 cm when no tillage was applied compared to the classic one was identified, the number of grains/spike, grain weight/spike and spike length had small variation in all four experimented systems, with higher values when ploughing was practiced.

**Table 3. ANOVA test for plant height, number of grains/ spike, grain weight/spike and spike lenght, as influenced by tillage system**

| Tillage system factor | Number of grain/ spike | Grain weight/ spike (g) | Spike length (cm) | Plant height (cm) |
|---|---|---|---|---|
| **CS** | 41.75$^{Ct.}$ | 2.27$^{Ct.}$ | 8.7 | 95.9 |
| **MC** | 41.30$^{ns}$ | 2.18$^{ns}$ | 8.2 | 88.10 |
| **MD** | 41$^{ns}$ | 2.06$^{ns}$ | 8.8 | 84.40$^{0}$ |
| **NT** | 40$^{ns}$ | 2.13$^{ns}$ | 8.5 | 86.8$^{0}$ |
| **LSD** | P 5% 12.58<br>P 1% 23.11<br>P 0.1% 51.20 | P 5% 1.81<br>P 1% 3.33<br>P 0.1% 7.37 | P 5% 3.01<br>P 1% 5.52<br>P 0.1% 12.23 | P 5% 8.41<br>P 1% 15.44<br>P 0.1% 34.22 |
| **F test** | 0.07 | 0.04 | 0.15 | 9.37* |

Based on Principal component analysis (PCA) and cluster analysis for twelve quality features obtained in Andrada winter wheat variety depending on fertilization, close and positive relationship between protein content, Zeleny index, gluten and alveograph parameters were identified (Figure 4).

On the other hand, ash content is negative corelated with all studied indices. Strong negative correaltion was established between ash content and: gluten content, protein content and Zeleny index. Generally, comparable results were obtained when $N_{88}P_{48}K_{48}$ and $N_{134}P_{48}K_{48}$ fertilizers were applied, higher than the values obtained when $N_{48}P_{48}K_{48}$ fertilizer was studied.

In terms of alveograph parameters, maximum values for L (53.46 mm), P (66.08 mm) and W (134.63 Jx10E-4) were obtained when N88P48K48 was experimented. For G parameter, the values obtained varied between 15.37 in the N48P48K48 fertilizer variant and 16.43 in the N88P48K48 experimental variant.

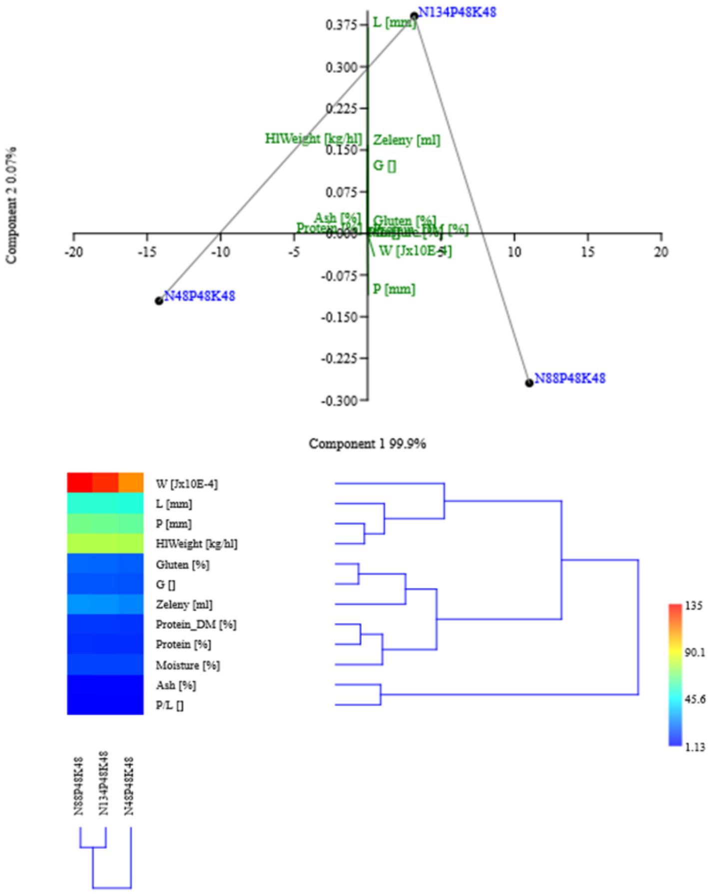


**Figure 4. Chemometric approach for wheat quality depending on fertilization**

## CONCLUSIONS

Quality of Andrada winter wheat variety was influenced by technological factors.

An increase in quality was observed when tillage system was minimized and when higher doses of nitrogen were applied.

In the no tillage variant was obtained the highest value for protein content (10.63%).

For ash content the maximum value of 1.60 was obtained in MD tillage system when N134P48K48 was applied. The ghihest gluten content (22.40 %) was identified in NT system in the variant with N134P48K48 complex fertilizer. Close and positive relationship between protein content, Zeleny index, gluten and alveograph parameters were identified.

A decrease of 12.7 cm for plant height was identified when no tillage was applied compared to the classic one.

Even if quality could be improved by appropriate technology, genetic factor plays an important and esential role in obtaining quality harvest that can be recommended in feed or in food industry.

In terms of yield elements, if in the „no tillage system” good results for quality were obtained, in classic system, high values for plant height, numebr of grains/spike, grain weight/spike and for spike length compared to „minimum” or „no tillage” were identified.

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