
PhD THESIS

Behavior of winter wheat grown in different cropping systems, fertilization levels and phytosanitary treatments

(SUMMARY OF THE PHD THESIS)

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INTRODUCTION

Global warming also has negative effects on wheat production, one of the most important crop species, and it is imperative to find technological solutions that contribute to their mitigation by obtaining stable, rich and qualitatively superior harvests.

The growth and development of the wheat crop, the plant that occupies large areas of land, as well as the production and quality of seeds will be affected differently, depending on the cultivation areas and their particularities given by the type of soil, the thermal regime and rainfall.

Being a complex quantitative character, the production of grains depends both on the cultivated genotype and on the environment and, of course, on the interaction that is established between them.

The tillage system also has a significant effect on the quantity and quality of grain. Taking into account the importance of ensuring food security and implicitly the role that wheat has in it, through this paper we aimed to identify some technological solutions that could contribute to the stability and quality of wheat harvests in the Transylvanian Plateau.

The experiment carried out is particularly complex due to the fact that it follows four tillage systems (classic - ploughing, minimum - chiseling, minimum - disc and direct sowing - no tillage), three treatment variants for disease and pest control (seed; seed + 1 foliar treatment; seed + 2 foliar treatments) and three levels of fertilization.

The main purpose of the research is to evaluate the influence of tillage systems, different types of fertilization and treatments for disease and pest control on the production level and quality of the Andrada winter wheat variety, created at the Turda Agricultural Research and Development Station.

The research aims to establish an optimal cultivation technology for the cultivation of this wheat genotype by obtaining high, stable and quality productions.

The biological material taken in the study was represented by the Andrada winter wheat variety, which was sown in the experimental field of the Technology Laboratory of the Turda Agricultural Research and Development Station, in two distinct agricultural years.

Purpose, objectives, material and research method

The purpose of the research is to use a technology that ensures a superior quality, but also a high and stable production of the wheat crop.

The objectives of the doctoral thesis were the following:

- **Determination of soil moisture according to the tillage system.**

- **Determination of the specific resistance of the soil to penetration before sowing and after harvesting.**
- **Establishing the temperature and precipitation conditions during the experimentation period and their influence on the winter wheat crop.**
- **Determination of the influence of experimental factors on the main agronomic traits and quality indices of the winter wheat variety Andrada based on the values obtained for sample F.**
- **Establishing the influence of the experimental year on biometrics, production and TKW in winter wheat:**
 - Influence of the year on the size of green plants, root, number of fertile siblings, size of plants at maturity, number of grains/ear and mass of grains/ear;
 - Influence of the year on TKW and production capacity.
- **Establishing the influence of the tillage system on biometrics, production, TKW and main quality indices for winter wheat:**
 - Influence of the year on the size of green plants, root, number of fertile siblings, size of plants at maturity, number of grains/ear and mass of grains/ear;
 - The influence of the tillage system on the TKW and production capacity;
 - The influence of the tillage system on the quality indices.
- **Establishing the influence of the fertilization system on production, TKW and main quality indices in winter wheat:**
 - Influence of fertilization level on TKW and production capacity;
 - Influence of fertilization level on quality indices.
- **Establishing the influence of phytosanitary treatments on production, TKW and main quality indices for winter wheat:**
 - Influence of phytosanitary treatments on TKW and production capacity;
 - Influence of phytosanitary treatments on quality indices.
- **Establishing the influence of the triple interaction between the studied technological factors on production, TKW and main quality indices for winter wheat:**
 - The influence of triple interaction on TKW and production capacity;
 - The influence of triple interaction on quality indices.

Comportarea grăului de toamnă cultivat în diferite sisteme de cultură, nivele de fertilizare și tratamente fitosanitare

- Establishing the stability of the production capacity according to the tillage system, the level of fertilization and the phytosanitary treatments applied.
- Determination of the degree of septoric attack in the four tillage systems, 3 levels of fertilization and 3 treatments

The multifactorial experiment that followed the influence of the tillage system, of the different levels of nitrogen fertilization, but also of phytosanitary treatments on important agronomic traits in winter wheat was located at SCDA Turda, in two different agricultural years from a climatic point of view (2020-2021, 2021-2022), the method of placing the experiment being the subdivided plots with two repetitions (Fig. 1.). The area of the experimental plot was 216 m2, from each experimental variant 16.8 m2 (12 m L x 1.4 m L) was harvested.

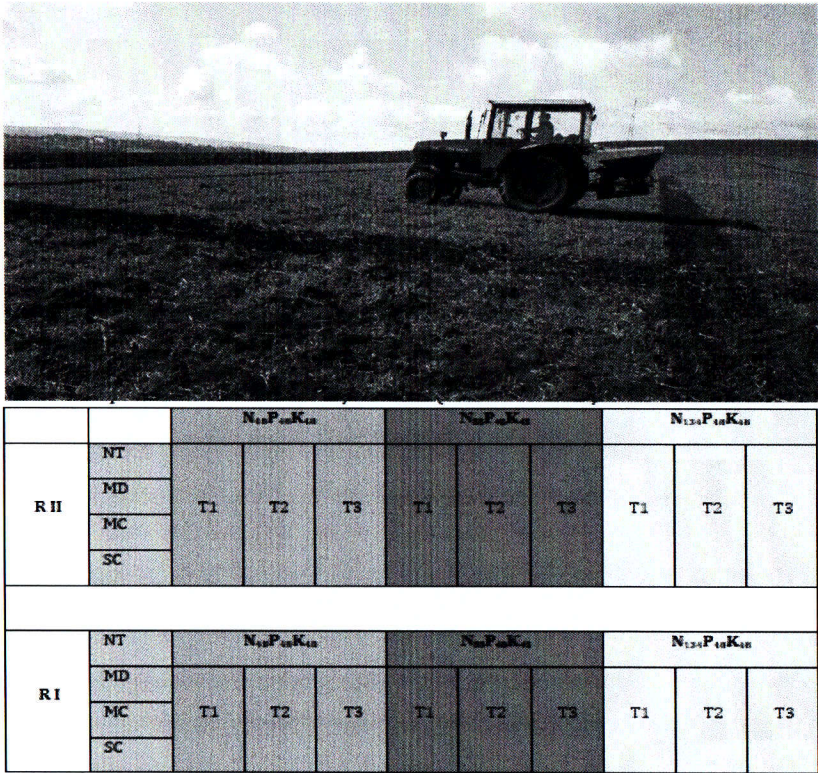


Fig. 1. Experimental design

- Conclusions on soil moisture according to the tillage system

In general, higher values of water moisture in the soil were observed in the no tillage variant compared to the other three soil systems experimented. By reducing soil tillage, characterized by fewer passes with agricultural machinery, the degree of soil

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compaction decreased and the water retention capacity increased, this being beneficial to crop plants that manage to carry out their growth and development stages in optimal conditions.

- **Conclusions on the specific resistance of soil to penetration before sowing and after harvesting**

Based on the experimental results obtained both before the establishment of the crop and after the release of the land, the specific resistance of the soil to penetration determined before sowing and after harvesting varied within the four soil systems analyzed. The values obtained in the no tillage (NT) variant, at the 9 depths, were approximate regardless of the time when it was determined. In general, in SC, before sowing, the penetration resistance had lower values, the minimum of the experiment of 180 kpa being recorded on the depth of 5 cm, in the superficial layer of the soil.

- **Conclusions on temperature and precipitation conditions during the experiment period and their influence on the winter wheat crop**

In the first experimental year, rainfall in the autumn of 2020 delayed the establishment of the crop. Although the weather conditions in the autumn of 2021 were favorable for the establishment of the wheat crop in good conditions, the subsequent evolution of the weather had repercussions on the growth and development of the plants, reflected in the level of production obtained. In both years, there is a general trend of cooling the air temperature in the spring months followed by an increase above the multiannual average in summer. All these aspects, combined with the lack of water or the uneven distribution of rainfall during the wheat vegetation period, negatively influence the good development of the plants and, implicitly, the production obtained.

- **Conclusions regarding the influence of experimental factors on the main agronomic traits and quality indices of the winter wheat variety Andrada based on the values obtained for sample F**

Based on the values of the F sample, it was observed that the grain production varied very significantly depending on the level of fertilization applied and the phytosanitary treatments, while the hectoliter mass, as well as the gluten, the Zeleny index and the protein content varied very significantly depending on the fertilization applied.

The biometrics carried out on the Andrada winter wheat variety grown in two different years and four different cropping systems indicate a very significant variation in the size of the plants at maturity depending on the two factors studied. Also, the rooting of wheat plants depended to a statistically very significant extent on the tillage system practiced. It is observed that in the two experimental years, the size of green plants, the number of fertile brothers, the number of grains/ear and the mass of grains per ear determined for the Andrada winter wheat variety varied, but the values of the F sample are not statistically ensured.

Comportarea grâului de toamnă cultivat în diferite sisteme de cultură, nivele de fertilizare și tratamente fitosanitare

- **Conclusions on the influence of the experimental year on biometrics, production and TKW in winter wheat:**

From the experimental data obtained, the plant size of the Andrada wheat variety was 3 cm larger in the first experimental year compared to the second. Compared to the control average of the experiment, the differences were statistically insignificant.

Regarding the number of fertile siblings, an element of productivity, on average, in the two experimental years, the winter wheat plants had about 2 siblings, the differences from the average being statistically insignificant, with slightly higher values recorded in the agricultural year 2020-2021, compared to 2021-2022. As in the case of the other bioemetrizations, although the differences were insignificant between years, the rooting of wheat plants was better in the first experimental year (8.73 cm).

The size of the winter wheat plants from the Andrada variety registered values 6 cm higher in the first year (91 cm) compared to the second year (85 cm). Compared to the average of the years considered a witness of the experience (88 cm), the differences were not statistically ensured, but they were close to the significance threshold $p \leq 5\%$. From the results obtained, the influence of environmental conditions on this agronomic property is obvious.

In the two experimental years, the number of grains/ear varied very little in the Andrada wheat variety, being, on average, 40, with small and insignificant differences compared to the control. Again, slightly higher values are observed in the first year, compared to the second.

From the analysis of the influence of the experimental year on the mass of grains per ear of the Andrada winter wheat variety, it is observed that values close to the average were obtained in both experimental years, with a slight superiority identified in the agricultural year 2020-2021 compared to the agricultural year 2021-2022. On average, values of 2 g/ear were obtained.

Even if it can vary depending on environmental conditions, it seems that the involvement of the genetic factor is greater when it comes to grain size, the TKW values of the Andrada winter wheat variety being almost 48 g, regardless of the year.

The involvement of the thermal factor and precipitation in the formation of wheat crops is known. Based on the results obtained in the experiment located at SCDA Turda, the superiority of the first experimental year in which the production obtained had an increase of approximately 300 kg/ha is observed, being almost 6800 kg/ha compared to the agricultural year 2021-2022 in which the Andrada variety obtained a production of 6440 kg/ha.

- **Conclusions on the influence of the tillage system on biometrics, production, TKW and main quality indices for winter wheat:**

Regarding the size of the plant depending on the tillage system, the highest value of 54.15 cm was obtained in the classic tillage system, followed by the minimum

system with chisel (47.05), the minimum disc system (45.8) and, at the opposite pole, the variant in which the soil was not tilled (NT- 45.15).

For root length, a weaker rooting of plants, statistically ensured as significantly negative, was also identified in the case of the MC system compared to the system in which ploughing was practiced.

Compared to green plant size and root length, the best results for the average number of fertile siblings/plant (2) were obtained in the no tillage variant. Even if in the minimum systems with disc and chisel, respectively, the values obtained were lower than the classical tillage system, the number of siblings/plant varied insignificantly within the present experiment depending on this technological factor.

On average, in the two experimental years, 3 fertilization systems and 3 phytosanitary treatments, the size of the plants of the Andrada wheat variety had the highest value, of about 96 cm in the classic tillage system. With a negative difference of almost 13 cm compared to the control, in the no tillage version, the wheat plants had the smallest size (83 cm), a difference statistically ensured as very significantly negative.

For the number of grains/ear, it was observed that this is a fairly stable character, largely influenced by the genetics studied, its variation depending on the tillage system being small and insignificant. On average, in the two experimental years, three levels of fertilization and three phytosanitary treatments, the lowest value for the number of grains/ear (40) was recorded in the no tillage system, with two less compared to the classic system, which was considered.

As in the previous case, the differences between the four crop systems studied on the grain mass/ear of the Andrada winter wheat variety were insignificant, the highest value being obtained in the minimum system in which the soil was processed with the chisel.

A situation similar to that encountered in the case of the mass of grains/ear is also identified for the values obtained for the mass of 1000 grains. The best results were obtained in the no tillage variant (48.12 g), but the differences between the four systems were very small and statistically insignificant.

The maximum production of 7019 kg/ha was obtained in the classic cropping system. Compared to this value, a reduction in yield by 573 kg/ha, a distinctly significant negative difference compared to marto, was identified in the no tillage system in which the Andrada winter wheat variety, in the two years, three levels of fertilization and three phytosanitary treatments had, on average, a production of 6446 kg/ha.

Also, reductions in production by 607, respectively 493 kg/ha compared to the control were also identified in the MD and MC systems, differences ensured as distinctly significantly negative.

Comportarea grâului de toamnă cultivat în diferite sisteme de cultură, nivele de fertilizare și tratamente fitosanitare

The hectoliter mass of the Andrada winter wheat variety, through the technology applied, varied quite little depending on the tillage system, the highest value was identified in the minimum tillage system with the chisel and the lowest value was obtained in the no tillage system.

From the experimental results obtained for the Andrada winter wheat variety, on average, on the three levels of fertilization, following the application of phytosanitary treatments, a value higher by approximately 1% of the gluten content compared to the classic cultivation system was identified in the experimental version in which the no tillage system was studied.

For the Zeleny index, the minimization of the works and the adaptation of the cultivation technology to the current requirements, led to higher values for this parameter that was framed in the range: 24.72-26.89 ml, with differences statistically ensured as distinctly significantly positive in the minimal or no soil tillage variants compared to the classic variant in which the plowing was carried out.

The protein content, one of the most important quality indices of wheat, took values in the range of 10.24-10.62 % in the four cropping systems experimented. A slight improvement of this parameter by performing minimal tillage of the soil, respectively in the no tillage variant were identified compared to the classic system in which the plowing was carried out.

Regarding the ash content, the values obtained on the three levels of fertilization and three phytosanitary treatments were almost identical, regardless of the soil tillage system used.

- **Establishing the influence of the fertilization system on production, TKW and main quality indices in winter wheat:**

Higher values for TKW were obtained, on average, in the two years, four tillage systems and three phytosanitary treatments, in the version in which the maximum dose of nitrogen (N134P48K48) was applied. The experiment minimum of 46.95 g was identified when the complex fertilizer was applied concomitantly with sowing (N48P48K48).

Compared to the control variant in which a production of 6292 kg/ha was obtained, the additional fertilization with N was found in production increments of 422 kg/ha in the second experimental variant, respectively 506 kg/ha in the variant in which the complex fertilizer N134P48K48 was applied.

The hectoliter mass varied quite little depending on the level of fertilization applied. For the gluten content, a difference provided as very significantly positive, with an increase of 1.75% compared to the basic fertilization was identified in the variant in which an additional nitrogen fertilization was applied in the spring.

An increase in the Zeleny index was observed by 2.58 ml in the second fertilization variant, respectively by 1.96 ml in the third. The differences have

statistical significance being ensured as very significant, respectively distinctly significantly positive compared to the control.

From the experimental data obtained for the Andrada winter wheat variety, on average in the four tillage systems and three phytosanitary treatments, a very significant positive increase of 0.5% compared to the basic fertilization was observed in the version in which the complex fertilizer N88P48K48 was applied.

Compared to the quality indices previously analyzed, the ash content fluctuated slightly depending on the fertilization applied, in the variants with N applied in spring, values slightly lower than the control were obtained, results that were not statistically assured.

- **Establishing the influence of phytosanitary treatments on production, TKW and main quality indices for winter wheat:**

In general, the TKW determined for the Andrada winter wheat variety varied slightly depending on the phytosanitary treatment factor.

In the experiment, based on the data obtained, a distinctly significant positive increase in production was obtained, with an increase of 162 kg/ha, in the third variant in which seed treatment was applied plus a foliar treatment applied in the bellows phenophase (IS + FG) and an ear treatment applied after pollination (IS + FG).

The MH was approximately 77 kg/hl in all variants, and the gluten content ranged from 17.78% (T2) to 18.85% (T3).

With regard to the Zeleny index determined for winter wheat seeds from the Andrada variety grown in four systems and on three different fertilisation levels, an increase of 0.88 ml, provided as distinctly significantly positive compared to the seed treatment, was observed when foliar treatments were applied in the bellows phenophase, respectively in the ear, applied after pollination. The intervention with a phytosanitary treatment in the bellows phase had the effect of decreasing the Zeleny index by 1.58 ml, a very significantly negative difference compared to the control.

For the protein content, the behavior of the Andrada winter wheat variety following the application of additional phytosanitary treatments on vegetation is similar to that of the other quality indices, and the ash content was similar regardless of the applied treatment.

- **Establishing the influence of the triple interaction between the studied technological factors on production, TKW and main quality indices for winter wheat:**

Regarding the influence of the triple interaction between technological factors on the TKW, a statistically significant negative decrease was observed in the classic tillage version, on the third fertilization agrofund (N134P48K48) and the phytosanitary treatment variant in which vegetation was intervened both in the bellows phenophase and after pollination, at the ear. In this case, the TKW of wheat seeds was 46.40 g compared to 49.33 g, a value obtained in the classic tillage system, the third fertilization option.

Comportarea grăului de toamnă cultivat în diferite sisteme de cultură, nivele de fertilizare și tratamente fitosanitare

For grain production, a variation of this quantitative character was identified between 5426 kg/ha (the variant in which the minimum soil tillage system was practiced with chisel, on the fertilization level N134P48K48 and when applying a foliar treatment on vegetation) and 7800 kg/ha (the classic soil tillage system + N88P48K48 + two additional treatments on vegetation, in the bellows phase, respectively in the spike). Within the classic tillage system, in the version in which only the basic fertilization was applied, the application of phytosanitary treatments had the effect of a significantly positive increase (470 kg/ha), respectively a very significant positive increase (765 kg/ha) compared to the production obtained in the version in which only the seeds were treated (6331 kg/ha).

Regarding seed quality, in general, MH ranged between 75.75 kg/hl (no tillage + basic fertilization with triple 48 + seed treatment and a foliar treatment on vegetation) and 77.75 kg/hl (classic system + N88P48K48 + seed treatment and a foliar treatment on vegetation).

The gluten content varied due to the complementary action of the three factors ranging from 15.90 % (minimum tillage system with disc + N134P48K48 + seed treatment and one treatment applied to vegetation) to 22.40 % (no tillage + N134P48K48 + two treatments applied to vegetation).

The Zeleny index was in the range of 21 ml and 33 ml, the maximum value was obtained in the minimum tillage system with the disc + N88P48K48 + seed treatment and two foliar treatments on vegetation. In general, in the version in which the classic tillage system was studied and in the no tillage version, the application of phytosanitary treatments on vegetation led to a decrease in the Zeleny index.

By applying phytosanitary treatments, an improvement of the grain protein was recorded in the no tillage system both in the version with basic fertilization and by applying the maximum dose of nitrogen in conjunction with the application of the seed treatment, followed by two treatments on vegetation, in bellows phenosis, respectively on the ear, after pollination.

If the analysis of the ash content under the influence of each factor studied did not lead to significant differences, the triple interaction seems to have a more pronounced effect on the variability of this parameter. Thus, in the experiment located at SCDA Turda, the ash content of the Andrada winter wheat variety was between 1.42% and 1.60%. The lowest value was identified within the classic cropping system, by applying type N88P48K48 fertilization and seed treatment followed by foliar treatment. At the opposite pole was the variant with the work executed with the + N134P48K48 + T3 disc.

- **Establishing the stability of the production capacity according to the tillage system, the level of fertilization and the phytosanitary treatments applied.**

From the analysis of the stability of the production capacity according to technological factors, it was observed the existence of better productions in 2020-

2021, in the classic crop system, on the level of fertilization N134P48K48 and at the application of seed treatment followed by two foliar treatments on vegetation.

- **Determination of the degree of septoric attack in the four tillage systems, 3 levels of fertilization and 3 treatments**

The presence of septoria in the experimental variants was noted on June 1st, and a similar degree of attack was identified in the 4 tillage systems, 3 treatments applied and 3 levels of fertilization.

Recommendations

It is recommended to adopt the minimum tillage of the winter wheat crop in the growing areas of the Transylvanian Plateau in order to increase the water reserve in the soil, while improving the structure and texture of the soil and against the background of ensuring good yields and superior quality indices.

In the case of intensive agriculture, for the Andrada winter wheat variety, we recommend adopting the classic soil tillage system, with good nitrogen-based fertilization and at least seed treatment, so as to ensure sufficient protection of the crop against diseases and pests.

In less favorable years for wheat cultivation, with episodes of drought and high temperatures, it is recommended to minimize tillage, the production and quality results being satisfactory in this case.

For the stability of the production obtained, we recommend the classic soil tillage system, the application of nitrogen doses of 134 kg/ha etc., on a P48K48 background as well as the performance of a seed treatment and two foliar treatments, one in the bellows phase, and the other in the ear phase, after pollination.

Originality

The originality of the present work lies, first of all, in the complexity of the experiment that followed the influence of 4 technological factors on the production of winter wheat:

1. Experimental year with 2 graduations;
2. Tillage system with 4 graduations,
3. The level of fertilization, with 3 graduations;
4. Phytosanitary treatment with 3 scratches.

Also, the novelty aspect consists in the determinations made, the observations during the vegetation period, the analyzes regarding the quality indices, the state-of-the-art equipment used for the determinations.