PhD THESIS

Research on the influence of the application of some innovative fertilizers to maize cultivation in the Transylvania Plain

PhD student **Gabriel BARȘON**

Scientific coordinator **Prof.univ.dr. Marcel M. DUDA**

1. Corn

1.1. Economic importance

In terms of cultivated areas, corn ranks second in the world and first in production, being surpassed only by wheat. Together with wheat, corn is the most important cereal in the world (SOARE et al., 2018). what makes them. Due to its production potential, the highest among cereals, it is known worldwide as the queen of cereals (TAJAMUL et al., 2016).

1.4. The situation of maize areas and productions in Romania

In three decades, the area reserved for cultivation has never fallen below 2 million hectares. Instead, in 10 years (1992, 1992, 1995, 1996, 1997, 1998, 1999, 2000, 2003, 2004), the surface was more than 3 million hectares, the absolute record being registered in 1992, when 3.3 million ha were cultivated with corn grains (https://www.lumeasatului.ro/articole-revista/ agrotehnica / 7471-evolution-of-corn-areas-and-crops-in-the-last-30-years.html)

In 2019, the largest areas with corn were registered in the South-Muntenia region (534,443 ha), followed by the South-East (502,721 ha).

By counties, the largest areas with corn were found in Arad (198,249 ha), Timiş (165,643 ha), Călăraşi (127,300 ha), Brăila (125,418 ha), Ialomiţa (112,242 ha), Botoşani (108,669 ha), Buzău (106,283 ha) and Tulcea (101,749 ha) (https://www.lumeasatului.ro/articole-revista/agrotehnica/7471-evolutia-suprafetelor-si-recoltelor-de-porumb-in-ultimii-30-de- ani.html).

In 2019, by development regions, the largest harvests were recorded in South Muntenia (3,579,476 tons) and West (3,337,845 tons).

The highest productions were made in the most favorable years from a climatic point of view, respectively, 2018 - 7,644 kg / ha, 2019 - 6,502 kg / ha and 2017 - 5,959 kg / ha. Over 4,000 kg per unit area were also obtained in 1991 - 4,072 kg / ha, 1997 - 4,171 kg / ha, 2004 - 4,441 kg / ha, 2010 - 4,309 kg / ha, 2011 - 4,525 kg / ha, 2013- 4,488 kg / ha and 2014 - 4,770 kg / ha. The negative record was recorded in 2007, when farmers harvested an average of 1,526 kg of corn per hectare, followed by 2000, with 1,603 kg / ha. For 2019, by development regions, the highest averages per hectare come from the Western area (https://www.lumeasatului.ro/articole-revista/agrotehnica/7471-evolutia-suprafetelor-si-recoltelor-de-porumb -in-the-last-30-years.html).

2. The role of fertilizers in the growth and development of corn cultivation

Mineral nutrients make a major contribution to increasing maize crop production and maintaining soil productivity, as well as preventing soil degradation. Improving the nutritional status of plants by applying fertilizers and maintaining soil fertility has been the critical step in food production since the beginning of the "Green Revolution", both in developed and developing countries (HUANG et al., 2020).

2.1. Classification of fertilizers

Fertilizers are natural or synthetic products, mineral or organic, simple or complex, applied in the soil, on the soil or on the plant and intended to complete the nutrient reserve of the soil, to ensure the normal growth of plants.

Classification of fertilizers:

- by their nature: mineral fertilizers and organic fertilizers;
- according to the method of obtaining: chemical or synthetic fertilizers and natural fertilizers
- according to the size of the doses in which they are used: fertilizers with macroelements (N, P, K, S, Mg), applied in doses of tens or even hundreds of kg active substance (sa) / ha, usually every year, and fertilizers with microelements, applied of the order kg element / ha once every few years.
- according to the number of essential nutrients that interest the fertilization system: simple fertilizers, with a single essential element of interest for fertilization, and complex or mixed fertilizers, with two or more essential elements.
- according to the conditioning method: solid fertilizers (crystallized, powder, granules, in the form of tablets), liquid fertilizers and fertilizers in the form of suspensions (BUDOI, 2001).

3. Objectives pursued

In order to achieve this general objective, three main directions have been pursued:

3.1. The influence of differentiated fertilization on biological traits in three commercial maize hybrids.

3.2. Quality and quantity of maize production, depending on the fertilization applied.

3.3. The attack of *Fusarium* sp. and *Ostrinia nubilalis* in commercial maize hybrids, depending on the fertilizer applied.

4. Particularities of the natural environment in which the experimentation took place

4.7 Thermal and pluviometric regime in years of experimentation

Due to the recorded temperatures, 2018 was characterized as a warm year and in terms of falling precipitation it was a normal year. 2019 was a warm year, in terms of temperatures and normal, in terms of rainfall, with a water deficit in June and July. In 2020, the recorded temperatures slightly exceeded the 60-year average, but from a rainfall point of view, most of the precipitation fell in July, exceeding the 60-year monthly average by approximately 100 mm.

5. Material and methods used

5.1. Biological material - TURDA 332 - FAO 380, TURDA 344 - FAO 380, PR37N01 - FAO: 380 corn hybrids.

5.2. Field research methods

Factor A: year

♦ A1 - 2018; ♦ A2 - 2019; ♦ A3 - 2020

Factor B: corn hybrid

♦ B1. Turda 332; ♦ B2. Turda 344; ♦ B3. Pioneer PR 37N01;

Factor C: fertilization

♦ C1. Basic fertilization; ♦ C2. Eurofertil Top 51 NPK; ♦ C3. Synertec NK35 N; ♦ C4. Fertiactyl Starter; ♦ C5. Rootip Basic + Power; ♦ C6. Novatec Classic.

5.3. Observations and determinations made

5.3.1 Observations and notations

Biometrizations in the field: ►plant height; ►the insertion height of the cob; ►number of leaves above the cob, ►the width of the leaves; ►length of leaves.

Biometrization at harvest and after harvest:

►frequency and intensity of Fusarium sp .; ►MBB was determined; ►hectolitre mass; ►quality analyzes (100 g / variant); ►the frequency of Ostrinia nubilalis attack has been calculated.

5.3.2 Determinations performed

► qualitative indices were determined using the NIR Tango apparatus.

5.4. Statistical-mathematical methods used

- the attack of fusariosis and corn borer was noted in percentages
- the chemical composition of the grain (starch and protein) were given in percentages (%);
- the production was expressed in kg / ha, for the statistical processing and for the graphic representation the expression in t / ha was used;
- statistical calculation, graphical representation and correlations were made using POLIFACT and EXCEL programs.

6. Results and discussion

Mineral fertilizers, chemical or organic, are components that increase productivity and help plant development. In this thesis we proposed a study on the effect of differentiated fertilization on the quality and quantity of maize production, on some biological characteristics but also their influence on the attack of the main diseases of maize (fusariosis) but also the pest *Ostrinia nubilalis*.

6.1. Results on the effect of differentiated fertilization on biological traits in the studied hybrids

6.1.1. Results regarding the size of the plants and the insertion height of the cob

In the climatic conditions of the three experimental years, the height of corn plants had different heights, from 2.38 m in 2018 to 2.73 in 2020. The three hybrids in 2018 had the lowest height , and the climatic conditions in 2019 and 2020 favored corn plants, the highest average size was recorded in 2020. Among the hybrids studied, the highest hybrid was Turda 344, with an average height of 2.66 m.

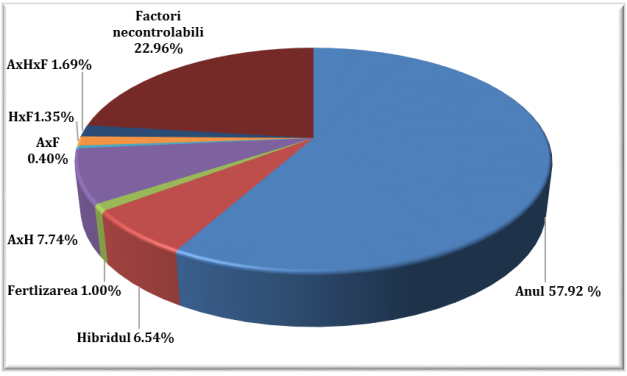

Fig. 6.1 The factors contributing (%) involved in plant size (2018-2020)

Figure 6.1 shows the statistical-mathematical analysis of the share of factors involved in plant growth (plant size). The figure shows the predominant action of climatic conditions (57.92%) being followed by the interaction of hybrid x x (7.74%) and the genetic factor (6.54%). A much lower participation in the total variance with close relative values is found in the case of interactions between factors (year x hybrid x fertilization 1.69%, hybrid x fertilization 1.35%) (Fig. 6.1).

6.1.2. Results on the number of leaves above the cob, the length and width of the leaves

The data from the literature reveal that most of the characters that are of agronomic interest show a continuous variability, being polygenically controlled (COPÂNDEAN ANA, 2012). Although it is a genetically determined character, the number of leaves superior to the cob, can change every year depending on the size of the plants, in the plants with a higher height and the number of leaves above the cob is higher. Regarding the average number of leaves above the cob in the three hybrids studied, from the data presented in table 6.11 we can conclude that there are no significant differences between them, but the hybrid with the most leaves above the cob was PR37N01, with an average of 5.75 leaves. Fertilization variants had a different influence on the number of leaves above the cob, most of the upper leaves of the cob were noted in the variant where NPK + CAN was applied (5.76 leaves) and the lowest number of leaves above the cob was noted in the variety in which fertilization was done with Novatec Classic (5.57).

Table 6.11

The average of leaves number above the cob to commercial hybrids (2018-2020)

Nr.crt	Hibridul	Nr. frz. deasupra	% față de	Dif. față de mt.	Semnif. dif.

No.	Hybrid	șt. Leaves no. above the cob	martor % to control	Dif. to control	Signif. of the dif.
1.	PR37N01	5.75	100.0	0.00	Mt.
2.	Turda 332	5.60	97.4	-0.15	-
3.	Turda 344	5.59	97.3	-0.16	-
DL (p 5%)				0.16	
DL (p 1%)				0.22	
DL (p 0.1%)				0.31	

6.2. Results on the effect of differentiated fertilization on productivity traits in the studied hybrids

6.2.1 Results on the mass of a thousand grains

Table 6.27

The influence of climatic conditions on the TKW to commercial hybrids

Nr.crt No.	Anul Year	MMB TKW (g)	% față de martor % to control	Dif. față de mt. Dif. to control	Semnif. dif. Signif. of the dif.
1.	Media	294	100.0	0.00	Mt.
2.	2018	321	109	27	***
3.	2019	254	86	-40	000
4.	2020	307	105	13	**
DL (p 5%)				7.64	
DL (p 1%)				12.64	
DL (p 0.1%)				23.66	

Table 6.29

The influence of fertilization variant on the TKW

Nr.crt No.	Varianta de fertilizare Fertilization variant	MMB TKW (g)	% față de martor % to control	Dif. față de mt. Dif. to control	Semnif. dif. Signif. of the dif.
1.	NPK +CAN	290	100.0	0.00	Mt.
2.	Eurofertil+CAN	306	105.4	14	**
3.	NPK+Sinertec	297	102.2	7	-
4.	NPK +CAN+Fertiactyl Starter	294	101.4	4	-
5.	NPK+CAN+Rootip+Energevo	295	101.7	5	-
6.	Novatec Clasic	281	96.9	-9	-
DL (p 5%)				9.70	
DL (p 1%)				12.83	
DL (p 0.1%)				16.58	

In the climatic conditions of 2018 and 2020, the mass of one thousand grains was higher, with very significant positive differences compared to the control (table 6.27). in 2019, the low rainfall in June and July negatively influenced the grain formation, so that their weight was lower, with very significant negative differences compared to the control.

Additional fertilization has differently influenced the mass of a thousand grains. As we can see in table 6.29 this parameter had values higher than the control in four of the experimental variants, but only in the variety to which Eurofertil + CAN was applied, it exceeded the control with statistical assurance differences (306 g) (table 6.29).

6.2.3 Yield results

Production is genetically determined but is largely influenced by climatic conditions during the growing season and applied technology. Climatic conditions often positively or negatively influence the yields obtained from crops. Against the background of the climatic conditions in 2018, the average production was 10965 kg / ha, with a distinctly significant negative difference compared to the control (table 6.39). In the climatic conditions of 2019, the productions were low, the average per experience did not exceed 8000 kg and the difference from the control was very negative. This can be explained by the low rainfall in June and July and the very high average temperatures in these months. In 2020, the highest productions were obtained with very significant positive differences compared to the control (table 6.39). Regarding the average production of the three hybrids studied, we can see that only the Turda 344 hybrid had a lower average value, with very significant negative differences compared to the control hybrid (Table 6.40).

Table 6.39

The influence of climatic condition on the corn yield

Nr.crt No.	Anul Year	Producția Yield (kg/ha)	% față de martor % to control	Dif. față de mt. Dif. to control	Semnif. dif. Signif. of the dif.
1.	Media	10293	100.0	0.00	Mt.
2.	2018	10965	106.5	672	**
3.	2019	7482	72.7	-2811	000
4.	2020	12432	120.8	2139	***
DL (p 5%)				381	
DL (p 1%)				630	
DL (p 0.1%)				1179	

Table 6.40

Yield average of commercial hybrids (2018-2020)

Nr.crt No.	Hibridul Hybrid	Producția Yield (kg/ha)	% față de martor % to control	Dif. față de mt. Dif. to control	Semnif. dif. Signif. of the dif.
1.	PR37N01	10478	100.0	0.00	Mt.
2.	Turda 332	10608	101.2	130	-
3.	Turda 344	9794	93.5	-684	000
DL (p 5%)				252	
DL (p 1%)				353	
DL (p 0.1%)				498	

The share of participation of experimental factors in the formation of production is presented in Figure 6.7. In the three experimental years, the greatest influence on the production had the climatic conditions, the involvement of this factor in obtaining the production was in the proportion of 84.09%. The hybrid also contributed in higher percentages, 2.49%, the interaction between it and the climatic conditions (year x hybrid 2.44) but also the interaction between year x fertilization (2.86%) (figure 6.6).

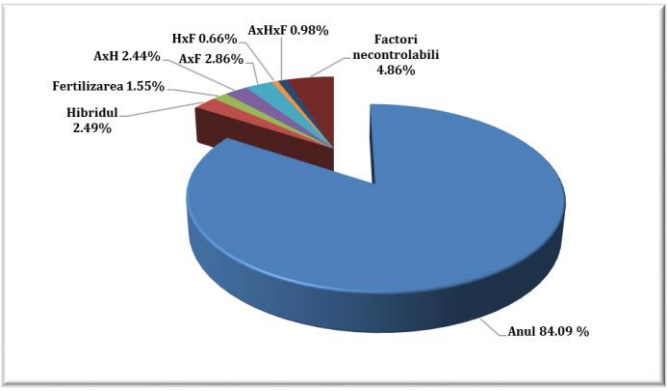

Fig. 6.6 The factors contributing (%) involved in corn yield (2018-2020)

Figure 6.7 shows the positive relationship that exists between the mass of a thousand grains and production. The positive relationship between the two parameters is also confirmed by the value of the regression coefficient "r", which is statistically assured. In the figure we can see that the highest values of production are found next to the high values of MMB.

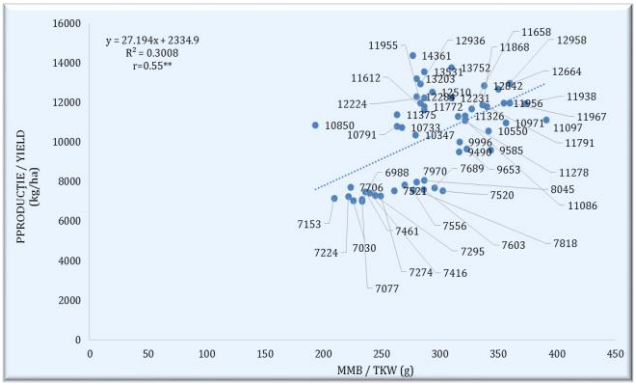

Fig. 6.7 The realtion between yield and TKW (2018-2020)

6.3. Results on the effect of differentiated fertilization on production quality

An overview of the negative relationship between protein content and production is provided by Figure 6.9. The inclination of the regression line confirms once again this inverse link between production and protein, the value of the regression coefficient being statistically assured as very significant negative.

The positive relationship between production and starch content is shown in Figure 6.11. The value of the regression coefficient is statistically assured, very significantly positive. In the figure it can be seen that the highest values of production are correlated with the highest values of starch content.

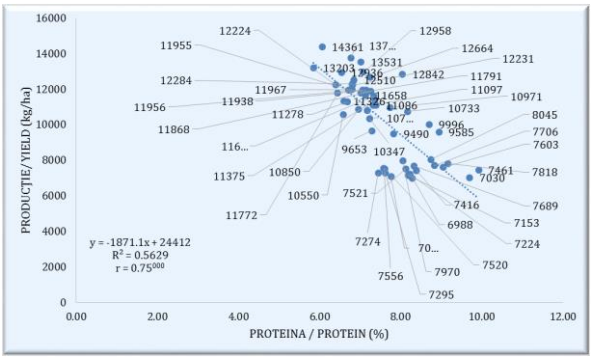

Fig. 6.9 The realtion between yield and protein content (2018-2020)

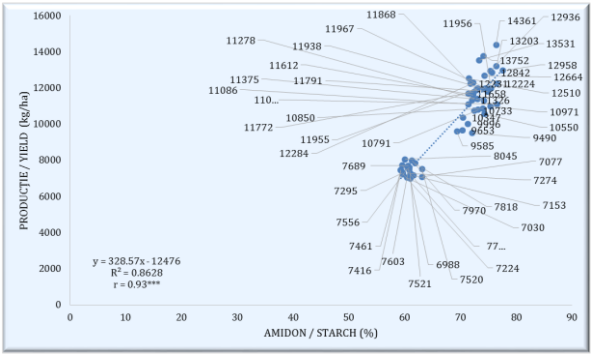

Fig. 6.11 The realtion between yield and starch content (2018-2020)

6.4. Results regarding the effect of differentiated fertilization on the attack of *Fusarium* sp. and *Ostrinia nubilalis Hübn.*

Figure 6.16 shows the relationship between the frequency and intensity of Fusarium sp. and productions from the three experimental years. The attack of fusariosis on cobs did not significantly influence the production of the three corn hybrids, under experimental conditions, confirmed by the inclination of the regression line but also by the values of the regression coefficient that were not statistically assured.

There is an inverse relationship between the frequency of Ostrinia nubilalis attack and the production of maize hybrids, confirmed by the inclination of the regression line and the value of the regression coefficient (r = 0.4100), a statistically significant negative value (figure 6.17). From the data presented in the figure we can conclude that at a lower frequency of the attack of the corn borer, lower yields were obtained, depending on climatic conditions and applied fertilization.

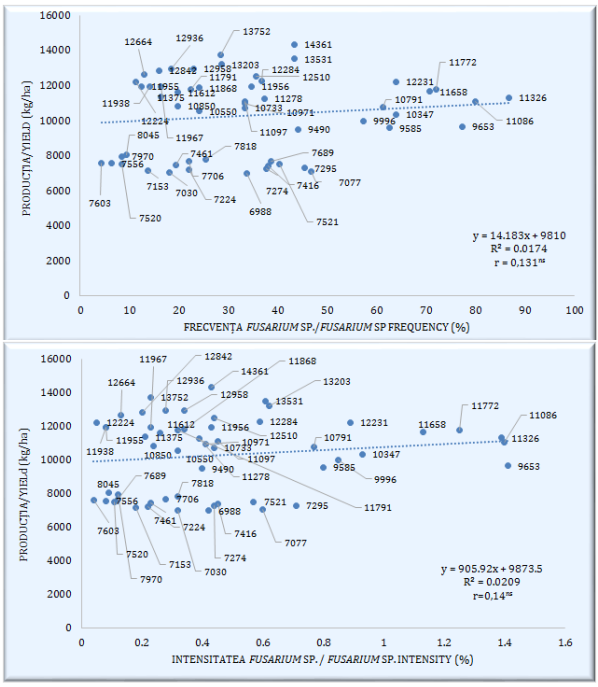

Fig. 6.16 The relationship between the frequency and intensity of the Fusarium sp attack of. and production (2018-2020)

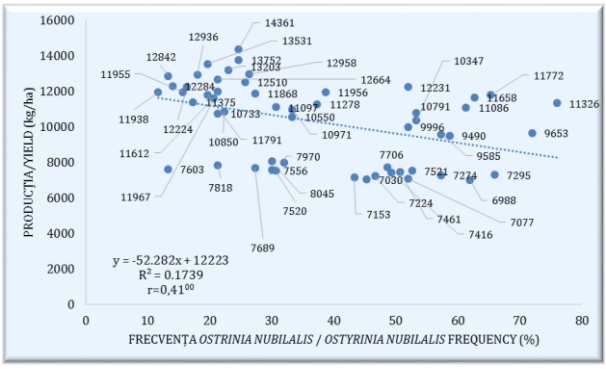

Fig. 6.17 The relationship between the of *Ostrinia nubilalis* attack and yield (2018-2019)

7. Conclusions

Following this study, the following conclusions can be drawn:

❖ in 2019 there was a slight increase in plant size values only for the variant to which NPK + CAN + Fertiactyl Starter was applied, a significant positive difference; against the background of the climatic conditions from 2020, the highest value of the plant size was registered for the variant to which Eurofertil + CAN was applied, (2.79 m);

❖ most of the upper leaves of the cob were noted in the variant to which NPK + CAN was applied (5.76 leaves); the PR37N01 hybrid had the highest number of leaves

superior to the cob, in all fertilization variants (5.62-5.89);

❖ the average mass of one thousand grains was the highest in the variant to which Eurofertil + CAN was applied;

❖ the highest value of the mass of one thousand grains was registered for the hybrid PR37N01, by fertilization with NPK + CAN + Fertiactyl Starter;

❖ the application of innovative fertilizers lead to higher production increases, especially in interaction with a favorable year from a climatic point of view; fertilization in 2018 and 2020 brought higher production increases to the control, in most fertilization options;

❖ the average protein content of the three hybrids differs, the hybrid with the lowest protein content was Turda 332 and at the opposite pole was the Turda 344 hybrid with a higher protein content;

❖ additional fertilization influenced the protein content, in the variant to which NPK + CAN + Rootip + Energevo was applied, the protein content was the highest (7.83%) and in the variant in which Novatec Clasic was applied, the protein content was the lowest (6.98%);

❖ the conditions from the years of experimentation influenced the production of corn but also the starch content; there was a decrease in starch content in 2019 (60.80%), the year in which the lowest productions were registered and an increase in 2018 and 2020 years in which the productions were also higher;

❖ in the climatic conditions of 2018, the attack of Fusarium sp. in all three hybrids and in all experimental variants;

❖ the most favorable year for the Ostrinia nubilais attack was 2018, the frequency of the cob attack being 48.44%.

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