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RESEARCH ON THE INFLUENCE OF DIFFERENT DOSES OF NITROGEN AND PHOSPHORUS ON YIELD AND QUALITY INDICES ON CORN SEEDS, UNDER PEDOCLIMATIC CONDITIONS AT A.R.D.S. SECUIENI

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Abstract

The experience was in the experimental field of the A.R.D.S. Secuieni, and it was a bifactorial experience, of the 5 x 5 type, in five repetitions so that A factor was represented by different doses of phosphorus (a1 - P_0; a2 - P_{40}; a3 - P_{80}; a4 - P_{120}; a5 - P_{160} kg P_2O_5/ha), and B factor was represented by different doses of nitrogen (b1 - N_0; b2 - N_{40}; b3 - N_{80}; b4 - N_{120}; b5 - N_{160} ,kg N/ha). On average, during the ten years of testing, the productions varied within quite wide limits, from 6252 kg·ha^{-1}, in the variant in which no dose of fertilizer was applied (control - N_0P_0), and the maximum was recorded in the variant in which the dose of fertilizer administered was $N_{160}P_{160}$ active substance, whose production was 9319 kg·ha^{-1}. As for the protein content, it was different from one year to another, the minimum was obtained in the N_0P_{40} variant, in 2019, being 8.1%, and the maximum was obtained in the variant for which the applied dose of fertilizer was $N_{160}P_{120}$, with a protein content of 13.8%.

Key words*: corn, fertiliser, nitrogen, phosphorus, yield.*

INTRODUCTION

Over the last two decades of the 20th century and the first decade of the 21st century, the average corn yield in the world has increased by 70%. This increase has been the result of constant progress in the breeding and development of increasingly fertile hybrids, application of different types and forms of fertilizers, but also the development of agricultural machines that are used to perform the necessary technological operations (Starcevic et al., 2006; Egli, 2008; Assefa et al., 2017).

The current problems in agriculture require the expansion of research in the field of field crop technologies, and obtaining productions under conditions of economic efficiency and protection of the environment is a permanent concern (Lazin, 2014).

Maize (*Zea mays* L.), a plant with great economic value, occupies a large share in the food security of the population, this being a staple food, all over the globe, both in human and animal food. In addition to food and feed, it can also be used in complementary fields: biofuel and as a source of basic raw materials for the food industry, for example, starch, oil, protein, alcoholic beverages, food sweeteners, cosmetics (Ram & Jabeen, 2016).

The fertilization is an important part of the cultivation technologies. The results obtained by the agricultural research and practice have highlighted the influence of this technological link on the qualitative, and quantitative, but even on the economical side of resulted crops (Lupu et al., 2014).

It is well known that nitrogen significantly influences the growth and development of plants. Knowledge of the physiological mechanisms that contribute to the absorption and use of nitrogen are particularly important to increase the efficiency of the use of this chemical element (Agapie et al., 2021).

When nitrogen availability is low in the soil, the plant preferentially supports the growth of nodules and the activity of fixing nitrogen, so when the level of nitrates in the soil is high, the plant stimulates the lateral growth of the roots to absorb the nitrates more efficiently (Saito et al., 2014).

Phosphorus and potassium, applied unilaterally, does not influence the quality of crops, they are used only as a substrate for nitrogen. The best results are obtained by the combined application of the three macro elements, both in terms of productivity and grain quality (Agapie et al., 2018).

Previous studies have also shown changes in root growth with different P fertilizer placements, affecting crop response under drought stress conditions (Hansel et al., 2017a; Hansel et al., 2017b).

Commercial fertilizers containing nitrogen, together with manure, have a large impact on maize production (Xia et al., 2021).

Croitoru (2012) considers that by increasing the doses of fertilizers progressively, increases the yield of corn grains per unit surface and the protein content of the grain, ultimately resulting in an increase in the amount of protein produced per hectare.

The quality and level of production are the result of the interaction between the supply of soil nutrition and the variation of climatic conditions (Pintilie & Sin, 1974; Frye & Thomas, 1991).

In the modern agriculture, the importance of using chemical fertilizers is undeniable. In the structure of chemical fertilizers, those with nitrogen occupy the main place due to their contribution in determining the yield increase, as well as due to the weight with which they participate in the applied fertilization formulas (Mihăilă et al., 1996; Dumitraşcu et al., 2003; Petcu et al., 2003).

MATERIALS AND METHODS

The experience was placed in 2012-2022, at the Agricultural Research and Development Station Secuieni (A.R.D.S. Secuieni) on a typical cambic phaeoziom (chernozem) soil, with medium texture, characterized as being well supplied with phosphorus (P_2O_5 - 39 mg/kg) and mobile potassium (K_2O - 161 mg/kg), moderately supplied with nitrogen, the soil nitrogen index being 2.1, weakly acidic, with pH values (in aqueous suspension) of 6.29 and poorly fertile, with a humus content of 2.3% (Leonte et al., 2021). The experience was placed in a three year rotation: wheat - corn - beans, in a field with no irrigation conditions.

The experience it was set up according to the method of subdivided type, in which the large plot is the dose of phosphorus (0, 40, 80, 120 and 160 kg P_2O_5/ha), and the small one, the dose of nitrogen (0, 40, 80, 120 and 160 kg N/ha). During the experiment, the fertilization was done with ammonium nitrate and superphosphate, and the amount of fertilizer used corresponded to the dose of phosphorus and nitrogen.

In the field, in this case, the cultivation technology specific to the conditions in Central of Moldavia was used, and the data obtained was interpreted statistically according to the method of variance analysis (Ceapoiu, 1968; Jităreanu, 1999).

The analysis of the temperatures and precipitations evolution in the Secuieni area during the vegetation period of corn shows that is becoming increasingly hot and drier, and meteorological extremes can cause very large losses in agriculture.

From the analysis of the average monthly temperature, it resulted that there is an increasing trend compared to the multiannual average, with the deviations recorded in the ten years reaching values from 0.3°C (2013/2014) to 2.2°C (2014/2015) (Table 1).

The temperatures during the corn vegetation season, in the ten years of experimentation, compared to the multiannual average of the last 60 years, five years were normal, four years were warm, and one year was warmer (Table 1).

Table 1. Registered temperatures at A.R.D.S. Secuieni during corn vegetation period

Year	May	Jun.	Jul.	Aug.	Sept.	Dev.
2012/2013	17.7	19.9	20.5	20.4	14.2	0.6
2013/2014	15.5	18.2	20.8	20.6	15.8	0.3
2014/2015	16.6	20.1	22.8	22.4	18.4	2.2
2015/2016	14.9	20.3	21.7	20.6	17.3	1.1
2016/2017	15.8	20.3	20.4	21.2	16.3	0.9
2017/2018	17.8	20	20.3	21.5	16.3	1.3
2018/2019	15.3	21.3	20.1	21.2	16.2	0.9
2019/2020	13.9	20	20.9	22.2	18	1.1
2020/2021	14.7	19.2	22.2	20.5	14.4	0.3
2021/2022	16.3	20.7	22.2	22.7	14.7	1.4
Monthly average	15.9	20.0	21.2	21.3	16.2	1.0
Multiannual average 60 years	15.4	18.9	20.4	19.7	15.1	
Deviations	0.4	1.1	0.8	1.6	1.1	

Under the aspect of precipitation during the entire vegetation period of the corn crop, the deviations from the multiannual average were varied, their distribution was uneven, especialy on the growth and development phenophases of the plant.
The smallest deviations compared to the multiannual average of the same period were 14.5 mm (2018), and the largest deviations were 203.9 mm (2015) (Table 2).

Table 2. Registered precipitation at A.R.D.S. Secuieni during corn vegetation period

Year	May	Jun.	Jul.	Aug.	Sept.	Dev.
2012/2013	51.4	146	76.4	42	42.6	26.5
2013/2014	96.2	66.6	91.1	37	9.2	-31.8
2014/2015	5.6	34	51	12.6	24.8	-203.9
2015/2016	120	161	4	32	48.6	33.9
2016/2017	59.4	49.4	72.2	23	55.2	-72.7
2017/2018	23.4	140	138	4	11.8	-14.5
2018/2019	95	55.8	46.6	20.4	64.8	-49.3
2019/2020	69.6	72.6	39	51.2	60.4	-39.1
2020/2021	31.4	79.4	51.6	76.8	9.2	-83.5
2021/2022	20.8	56.6	35.2	15.2	31	-173.1
Monthly average	57.3	86.2	60.5	31.4	35.8	-60.8
Multiannual average 60 years	64.3	84.7	80.6	58	44.3	
Deviations	-7	1.5	-20	-26.6	-8.5	

RESULTS AND DISCUSSIONS

Climatic conditions during the growing season are the main factor that determines the crop yield, especially in areas where the only source of water is from rainfall and groundwater and even the extreme temperatures can significantly reduce crop yield.
The average yields recorded after the application of different doses of phosphorus (40, 60, 80, 120, 160 kg P_2O_5/ha) indicate that the corn reacts well to this element compared to the control variant (P_0), and the yield differences obtained in the four fertilized variants have statistically ensured and interpreted as highly significant (Table 3).

Table 3. The influence of phosphorus doses on corn yield

Doses P	Yield average kg·ha^{-1}	Relative yield %	Diference	Signifiance
P_0	7391	100	-	Mt.
P_{40}	7723	104	332	***
P_{80}	8089	109	698	***
P_{120}	8338	113	947	***
P_{160}	8270	112	879	***

Phosphorus fertilizers brought increases in yields of 4 to 13% representing 332 to 947 kg·ha^{-1}.
The fertilization of the corn crop with different doses of nitrogen shows an increase in yield from one dose to another, compared to the unfertilized variant (control), but the highest yields were obtained in the variants where the applied doses were 120% (1695 kg·ha^{-1}) and 160% (1979 kg ha^{-1}) active substance, yields that were statistically ensured and interpreted as being very significant.
The increases of yield obtained by applying nitrogen fertilizers were higher than those achieved by applying phosphorus fertilizers and represented 12-29% of their value (Table 4).

Table 4. The influence of nitrogen doses on corn yield

Doses N	Yield average kg·ha^{-1}	Relative yield, %	Dif.	Semnif.
N_0	6816	100	0	Mt.
N_{40}	7631	112	815	***
N_{80}	8055	118	1239	***
N_{120}	8511	125	1695	***
N_{160}	8795	129	1979	***

During 2012-2022, the yields obtained in the corn crop recorded variations due to the combination of fertilizers used, the size of the dose administered but also due to the weather conditions.
Thus, in the ten years of testing, the yields achieved at the unfertilized variant (N_0P_0), varied from 2503 to 8486 kg·ha^{-1}, the average of the period being 6252 kg·ha^{-1} (Table 5).
Compared to this, the increases in yield achieved by applying fertilizers ranged between 10% to 49%, representing 648 to 3097 kg ha^{-1}.
It was noted that nitrogen fertilizers brought higher yield increases the higher the phosphorus agrofond was applied.
Thus, the nitrogen fertilizers in a dose of N_{40} - N_{160} on the P_0 agrofond, achieved yield increases of 12 to 19%, representing 731 to 1213 kg·ha^{-1}; on the P_{40} agrofond, increases of 10 to 27%, representing 648 to 1707 kg·ha^{-1}; on the P_{80} agrofond increases of 13 to 38% representing 830-2380 kg·ha^{-1}; on the agrofond of P_{120}, increases of 21 to 43% representing 1315-2398 kg·ha^{-1} and on the agrofond of P_{160}, increases of 24 to 49% representing 1470 to 3067 kg·ha^{-1} (Table 5).

Table 5. The influence of phosphorus and nitrogen fertilizers on corn yield, in the period 2012-2022

A x B	Variation limits of yield kg·ha^{-1}	Yield average kg·ha^{-1}	Rel. yiel d %	Dif.	Sem.
N_0 P_0	2503-8486	6252	100	-	-
N_{40} P_0	4123-9638	6983	112	731	***
N_{80} P_0	3767-10072	7358	118	1106	***
N_{120} P_0	2814-10261	7456	119	1204	***
N_{160} P_0	2310-10130	7465	119	1213	***
N_0 P_{40}	2800-10109	6900	110	648	***
N_{40} P_{40}	3237-10647	7405	118	1153	***
N_{80} P_{40}	2414-11687	7636	122	1384	***
N_{120} P_{40}	2146-12200	7929	127	1677	***
N_{160} P_{40}	1848-11486	7959	127	1707	***
N_0 P_{80}	2496-10874	7082	113	830	***
N_{40} P_{80}	2880-12687	7933	127	1681	***
N_{80} P_{80}	3196-12450	8183	131	1931	***
N_{120} P_{80}	2656-13494	8632	138	2380	***
N_{160} P_{80}	1598-12501	8382	134	2130	***
N_0 P_{120}	2311-11842	7567	121	1315	***
N_{40} P_{120}	3200-12102	8239	132	1987	***
N_{80} P_{120}	2168-13517	8542	137	2290	***
N_{120} P_{120}	2040-13539	8950	143	2698	***
N_{160} P_{120}	1716-13347	8853	142	2601	***
N_0 P_{160}	2449-12216	7722	124	1470	***
N_{40} P_{160}	3237-12216	8390	134	2138	***
N_{80} P_{160}	2880-13440	8788	141	2536	***
N_{120} P_{160}	1763-13815	9125	146	2873	***
N_{160} P_{160}	2781-14065	9319	149	3067	***

Correlating the doses of phosphorus applied, with the average yields obtained in the ten years of testing, it is observed that there is a direct link between them, the correlation coefficient being statistically ensured and interpreted as distinctly significant (Figure 1).

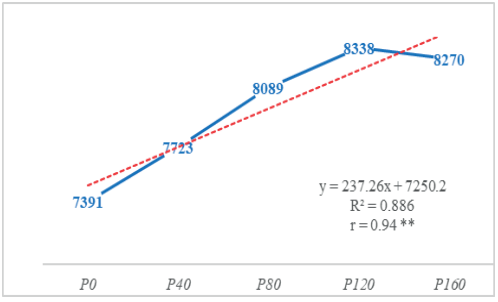

Figure 1. Correlation between yield and phosphorus doses

Regarding the correlation between the applied nitrogen doses and the yield level, which is of the form y = 483.66x + 6510.6, a direct, very close correlation is shown between the two elements with a very significant correlation coefficient (Figure 2).

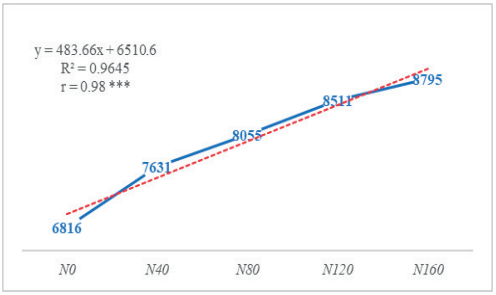

Figure 2. Correlation between yield and nitrogen doses

Following the determinations made regarding the quality of the corn kernels, the protein content varied within quite large limits, from 8.7% in the variant in which the dose of fertilizer administered was $N_{120}P_{40}$, and the maximum (12.1% protein) was recorded in the $N_{120}P_{40}$ variant (Figure 3).

The highest protein content was obtained in the variant in which the dose of nitrogen administered was 120% active substance, on a phosphorus agrofond of 40 to 120%.

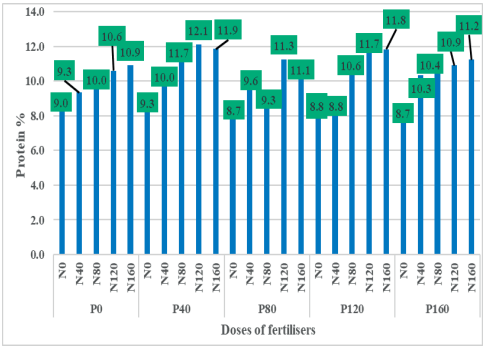

Figure 3. The protein content (%) of corn by applying fertilisers with nitrogen and phosphorus

The doses of fertilizers applied based on nitrogen and phosphorus had a very small influence on the content in the oil, thus the lowest value (3.5%) was obtained in the variant unfertilized (N_0P_0 - control) and the maximum of 4% oil content it was recorded in the variants for which the nitrogen dose was 40 respectively 80% on an 80% phosphorus agrofond (Figure 4).

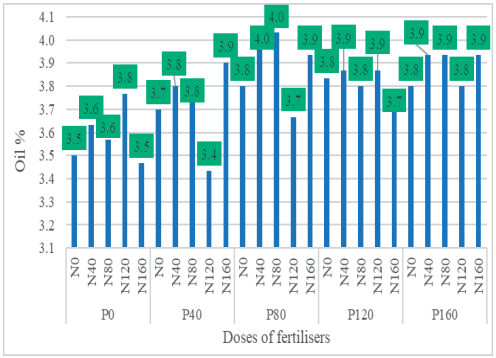

Figure 4. The oil content of corn by applying fertilisers with nitrogen and phosphorus

Regarding the starch content of corn, it varied from 70.1% in the variant in which the administered dose of fertilizer was $N_{120}P_{160}$ to 74.1% in the case of variant in which the administered dose was N_0P_{160} (Figure 5).

It can be concluded that nitrogen has an influence on the content in starch, because it decreases with the increase in the dose of fertilizer, both in the agrofond where no dose of phosphorus is applied, and in those where it was applied (Figure 5).

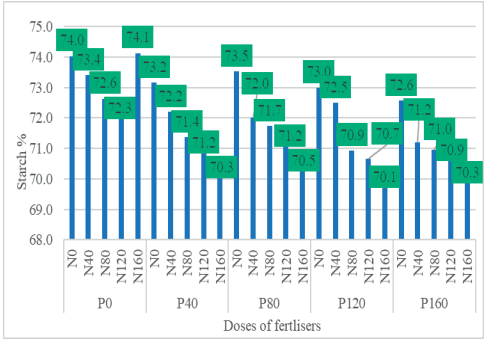

Figure 5. The starch content of corn by applying fertilisers with nitrogen and phosphorus

In average, in the ten years of testing, the values of the thousand kernel weight (TKW) at corn, varied within very wide limits from 271 grams at the variant with the dose of N_0P_{40} active substance, to 336.5 grams at the variant with $N_{160}P_{160}$ (Figure 6).

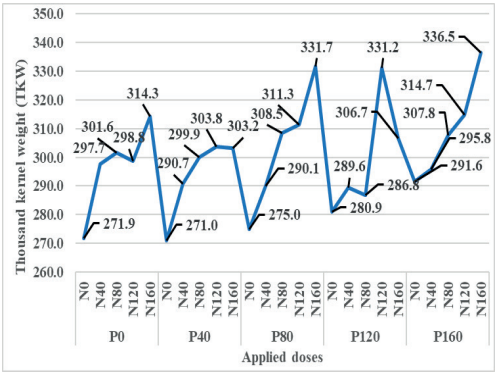

Figure 6. Influence of different doses of fertilisers on thousand kernel weight at corn (TKW)

CONCLUSIONS

In the ten years of research, the yields obtained in the corn crop recorded variations due to the combination of used fertilizers, the size of the dose administered but also the weather conditions, this explaining the very large differences in yield, from 1598 kg/ha ($N_{160}P_{80}$) up to 14065 kg/ha ($N_{160}P_{160}$).

On average, the yield obtained on the maize crop brought yield increases of 12 to 49% representing 731 to 3067 kg·ha^{-1}.

The interaction of phosphorus fertilizers on production brought increases of 4 to 12% (332-879 kg·ha^{-1}), and those with nitrogen increased by 12 to 29% (815-1979 kg·ha^{-1}).

Following the correlation between the obtained corn yields and the phosphorus and nitrogen doses applied, direct correlations were established between them, statistically ensured and interpreted as distinctly significant and very significant.

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