

Correlative Models between Balaton (B) and Atrium (E) Wheat Varieties, Nitrogen Doses and their Division in Seini – Maramures, 2009-2010

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ABSTRACT

This study is intended to demonstrate that in the pedoclimatic conditions from Seini – Maramures, some that are not very favorable to the wheat crop, the productivity it can be easily increased by applying a new fertilization management scheme and by using wheat varieties of different categories, but with a great plasticity to biotic and abiotic factors from the research region. To analyze the reaction of Balaton and Atrium wheat varieties at a specific nitrogen management, the method of demonstration plots has been used, with 14 variants of nitrogen fertilization, in different dosages and application phases. Obtained results have been statistically processed. It has been observed that for both varieties the nitrogen fractionation doesn't bring any increases at low doses (40-60 kg N/ha), but it is very efficient and demonstrated by the correlations performed at high doses (70-120 kg N/ha). Premium and A type wheat varieties, of provenance Austria, have been acclimatized and they can be successfully grown in the Seini area, as illustrated by the obtained yields.

Keywords: *fertilization, nitrogen doses, wheat, yield.*

INTRODUCTION

According to Teixeira Filho et al. (2011), obtaining high yields in wheat crop is determined by two major factors: the use of varieties with high productive potential and the implementation of a nitrogen fertilization optimal management. The optimum nitrogen supply is essential for obtaining high yields, with a high level of protein (Orloff et al., 2012).

Studies undertaken over the years have shown that the wheat consumes 20-25 kg nitrogen/ton of production, and in the case of premium grain the required quantity of nitrogen to obtain 14.5 to 18.0% wheat protein is of 24 kg/ton (Berca, 2011; Horoias et al., 2015).

Continuous change of climatic conditions, plus that of wheat genetics, both for A (high quality) and E or P (elite – premium, high protein content) categories, are making absolutely necessary a new

rethinking of nitrogen management. Research are mandatory since new varieties permanently arise, cultivars that can be very well used in certain regions, provided that they comply the breeders indications, especially the ones regarding their requirements to nutrition (Yousaf et al., 2014).

Whereas the wheat crop is particularly extensive in Romania and the research area is one where no such studies have been conducted so far, the topic has been considered as original and of national interest. Relatively poor soils from Seini can be successfully used for the cultivation of wheat, observing several amendments.

MATERIALS AND METHODS

To analyze the reaction of A and premium wheat type to a specific nitrogen management it has been proceeded to the settlement of an experimental field with location in subdivided

plots of 2nd order with factor 1 – variety and factor 2 – levels and phases of nitrogen application. The following varieties have been used:

- Balaton – bakery variety group (A), no aristae;
- Atrium – premium variety of Capo family, semi-late.

Corn has been chosen as a preceeding crop, because the previous practice revealed a better quality of tillage after maize compared with herbs.

Land preparation consisted of:

- harrowing (with a heavy disk) after the corn harvest;
- plowing at 20-25 cm;
- seedbed preparation with a easy disk;
- sowing with a seeder SU₂₉ at 3-4 cm depth.

All variants have been fertilized with P₅₂N₁₂ in autumn, on a 5 tons CaCO₃ amendment, after which the following variants of nitrogen nutrition were pursued, in spring:

$V_1 = N_{40}$ - at the entry into vegetation

$V_2 = N_{60}$ - at the entry into vegetation

$V_3 = N_{80}$ - at the entry into vegetation

$V_4 = N_{100}$ - at the entry into vegetation

$V_5 = N_{120}$ - at the entry into vegetation

$V_6 = N_{20} + N_{20}$ - entry into vegetation + start of the sprouts

$V_7 = N_{30} + N_{30}$ - entry into vegetation + start of the sprouts

$V_8 = N_{40} + N_{40}$ - entry into vegetation + start of the sprouts

$V_9 = N_{50} + N_{50}$ - entry into vegetation + start of the sprouts

$V_{10} = N_{60} + N_{60}$ - entry into vegetation + start of the sprouts

$V_{11} = N_{20} + N_{20} + N_{20}$ - entry into vegetation + start of the sprouts + boot phase

$V_{12} = N_{20} + N_{30} + N_{30}$ - entry into vegetation + start of the sprouts + boot phase

$V_{13} = N_{30} + N_{30} + N_{40}$ - entry into vegetation + start of the sprouts + boot phase

$V_{14} = N_{30} + N_{40} + N_{50}$ - entry into vegetation + start of the sprouts + boot phase

Tests on soil determined that N_{min} in autumn wouldn't required a nitrogen intake and that it has been applied only in the absence of a suitable formulation of the nutritional product on the market.

The control version (Mt) of the experience remains the autumn variant with basic fertilizers applied under the last disk of seedbed preparation. Here, Mt = P₅₂N₁₂.

A total of 14 fertilization variants with different nitrogen fertilizing doses and application phases in each of the two varieties have been used. It results 2 x 14 = 28 variants.

Sowing has been performed in large plots, of 0.5 ha. For yield evaluation were detached, randomly, 4 repetitions in each plot, 4 x 10 = 40 m² (32 rows x 10 m length). The plot outside the randomization was harvested with a large harvester, while the 4 repetitions of each parcel were then harvested with a small combine, type experiences one.

Samples of about 1 kg of each variant have been collected, shipped to the laboratory and analyzed by a Infratec machine. Results (calculated in kg/ha) were then entered in tables, after they have been brought to the standard parameters.

The used statistics was:

1. Two-dimensional variance analysis - varieties + fertilizers with separation of the factors influence. They established DL for 5, 1 and 0.5% and also the significance of the difference (through T distribution testing).

2. Analysis of the production functions for the accumulation of biomass for production according to the formula:

$$x = f(a \times b) \quad (1)$$

where:

x = yield;

a = variety;

b = fertilization level.

3. Correlation analysis, of the correlation coefficients and reports between doses of fertilizers and yield, respectively of the quality parameters determinants. For this, particular programs were used. The results were presented in tables and graphs.

RESULTS AND DISCUSSION

Experiments with varieties and fertilizers were treated as bifactorial type, where:
A factor = varieties (Balaton and Atrium),
B factor = fertilizers, dosage and application moments.

To establish the influence of varieties they were compared with each other and their behavior is presented in Tab. 1. The comparison was made in relation to the average of the varieties and experience, that is 3.27 t/ha. Among varieties, a higher production was achieved with

Balaton variety, 61 kg/ha more than the average (statistically insignificant) and 122 q/ha more than the variety Atrium, harvesting difference very close to the limit of significance for the probability of 95% (DL = 1.229 t / ha).

Compared to what we find in the literature (Berca, 2011) and the on the Probstdorfer's company website, we see that the difference between the two varieties is less than in the south part of Romania, where in the experiences of Alexandria and Modelu, it was of 400-500 kg/ha. However, for the East Maramures is encouraging that the Atrium variety, a very high quality variety, could achieve very high yields, being well acclimatized to the area.

The influence of different doses of nitrogen and moments of application to the average of the two varieties is presented in Tab. 2. We note that the control (fertilizer, factor B) was the rich

in phosphorus treatment applied in autumn, on a 5 tons CaCO_3 amendment. The control version obtained a yield of only 1810 kg/ha, a low production, which indicated from the outset the need for nitrogen and an efficient management of its composition.

From Table 2 we draw the following conclusions:

1. Application in early spring of nitrogen doses from 40 to 120 kg/ha increased the yield with 2330 kg/ha, increases that statistically are of a highly significant level.

The low dose of N_{40} is wasted in the nitrogen needs of the plant, it is insufficient, small and insignificant, bringing an increase of only 430 kg/ha.

At the dose N_{60} , the crop enhance reaches 810 kg/ha and is distinctively significant, while from doses of 80 kg to 120 kg N/ha to be obtained

Tab. 1. Influence of the variety on the level of wheat yield (Caraintertrans Seini, 2009-2010)

Variety	Yield		Difference		Significance
	t/ha	%	t/ha	%	
Balaton	3.29	100.61	0.02	0.61	
Atrium	3.25	99.39	-0.02	-0.61	
General average	3.27	100.00	0.00	0.00	Control

Tab. 2. Influence of different doses of nitrogen and moments of their application for the Balaton and Atrium varieties, Seini, 2009-2010

No. crt.	Fertilization	Yield		Difference		Significance
		t/ha	%	t/ha	%	
0	Martor $P_{50}N_{20}$ in autumn	1.81	100.00	0.00	0.00	Control
1	N_{40} at T_1	2.24	123.76	0.43	23.76	
2	N_{60} at T_1	2.62	144.75	0.81	44.75	**
3	N_{80} at T_1	3.04	167.96	1.23	67.96	***
4	N_{100} at T_1	3.55	196.13	1.74	96.13	***
5	N_{120} at T_1	4.14	228.73	2.33	128.73	***
6	$N_{20}(T_1) + N_{20}(T_2)$	2.34	129.28	0.53	29.28	*
7	$N_{30}(T_1) + N_{30}(T_2)$	3.03	167.40	1.22	67.40	***
8	$N_{40}(T_1) + N_{40}(T_2)$	3.61	199.45	1.80	99.45	***
9	$N_{50}(T_1) + N_{50}(T_2)$	3.86	213.26	2.05	113.26	***
10	$N_{60}(T_1) + N_{60}(T_2)$	4.15	229.28	2.34	129.28	***
11	$N_{20}(T_1) + N_{20}(T_2) + N_{20}(T_3)$	2.59	143.09	0.78	43.09	**
12	$N_{20}(T_1) + N_{30}(T_2) + N_{30}(T_3)$	3.27	180.66	1.46	80.66	***
13	$N_{30}(T_1) + N_{30}(T_2) + N_{40}(T_3)$	4.01	221.55	2.20	121.55	***
14	$N_{30}(T_1) + N_{40}(T_2) + N_{50}(T_3)$	4.75	262.43	2.94	162.43	***

harvest increases from 1230 to 2330 kg/ha. The efficiency of a kg of nitrogen is as follows:

- at 40 kg/ha: 10.75 kg grains/1 kg N;
- at 60 kg/ha: 13.50 kg grains /1 kg N;
- at 80 kg/ha: 15.37 kg grains /1 kg N;
- at 100 kg/ha: 17.40 kg grains /1 kg N;
- at 120 kg/ha: 19.41 kg grains /1 kg N.

We believe that, even at 120 kg N/ha, we could not reach the full potential of these soils nutrition, given the dire poverty of the land and the inability to install the associative nitrogen-fixing bacteria, *Azospirillum brasilense*.

2. Given that the nitrogen fractional doses are applied, according to the methodology, in T_1 and T_2 the following results are obtained:

- by fractionation the dose of 40 kg N ($20 + 20$) a plus of 100 kg/ha crop is obtained, due to the factor "time of application", the option exceeding $DL_{5\%}$ and becoming significant;
- by splitting the dose of 60 kg N ($30 + 30$) a plus of 410 kg/ha crop was obtained, yield increasing to over 3000 kg/ha, a very significant growth;
- by splitting the dose of 80 kg N ($40 + 40$) an additional 570 kg/ha yield is added, solely due to the factor "time of application", an increase statistically assured at a very significant level;
- by splitting the dose of 100 kg N/ha ($50 + 50$), a yield bonus of only 203 kg/ha is obtained, and by subdividing the dose of 120 kg N/ha basically no increase exists anymore.

We conclude that, at high doses of nitrogen, their fractionation becomes useless.

3. If nitrogen is applied in 3 different phases ($T_1 + T_2 + T_3$), the situation is as follows:

- it is not justified, primarily economic, lower dose fractionation (40 kg N) and then we started with 60 kg N dose fractionation (version 11). In this case, the added bonus is 780 kg wheat/ha, out of which 370 kg/ha is solely due to the factor "time of application" in Phase 3;
- by fractionating the dose of 80 kg N/ha, this increase is not found anymore;
- splitting the dose of 100 kg N/ha brings, however, an increase in T_3 of only 50 kg wheat/ha, while the fractionation of the dose of 120 kg N/ha adds a bonus yield of 600 kg/ha, an increase that is statistically insured and very important to achieve our desired production levels in the enterprise.

Fig. 1 gives us an overview of the effect of increasing nitrogen rates applied at the T_1 moment,

in early spring, as well as the efficiency expressed in production grows, for the dose fractionation (T_2 and T_3).

The largest production increase is obtained by fractionation the high dose of 120 kg N/ha, modeled as follows: 30 kg at T_1 + 40 kg at T_2 + 50 kg at T_3 .

The interactive behavior of varieties and fertilizers is presented in Tab. 3 and Tab. 4. For a better separation of the best options it was used, for comparison, the experience average:

$$\bar{m} = \bar{x} = 3.27 \text{ t/ha} = 3270 \text{ kg/ha} \quad (2)$$

From Table 3, which presents the Balaton's variety behaviour to different doses of fertilizers and time of their application, it results that:

- from the whole group of N applied in early spring (T_1) only the N_{120} dose significantly stands out from the average (840 kg/ha);
- from the group of variants applied in two fractionations ($T_1 + T_2$), N_{100} ($50 + 50$), with an extra 570 kg/ha and N_{120} ($60 + 60$) with a significant increase of 720 kg/ha stand out, statistically ensured as a very significant level;
- from the group with 3 application of nitrogen, significantly distinct from the average answered the variant N_{100} ($30 + 30 + 40$), with an increase of 720 kg/ha and very significant the N_{120} variant ($30 + 40 + 50$), adding 1410 kg/ha. This variant is kept as working model for the management of nitrogen application on Balaton wheat variety.

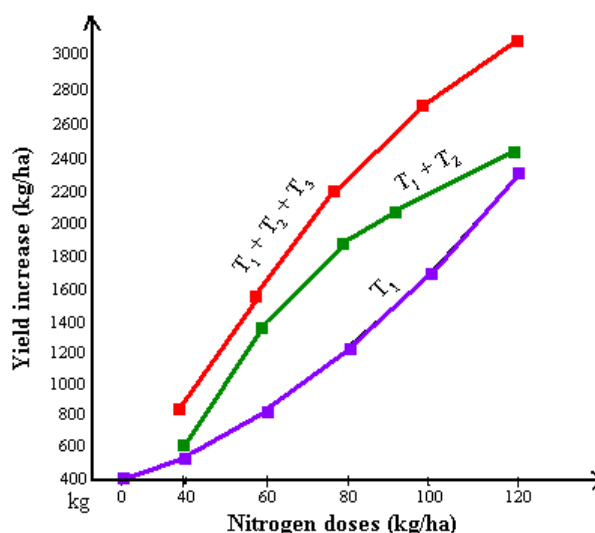


Fig. 1. Effect of nitrogen doses and application moments by fractionation over the average of the Balaton and Atrium varieties, Seini, 2009-2010

For Atrium variety the results are listed in Tab. 4.

It follows that:

- Atrium variety responds better to fertilizer through significant production and very

significant ones for the doses of N_{100} , N_{120} respectively, from a single application in early spring, with an increase of 590 or 890 kg/ha in addition to the average;

Tab. 3. Fertilizer rates and application times influence on the Balaton variety yield, Seini, 2009-2010

No. crt.	Fertilization	Yield		Difference		Significance
		t/ha	%	t/ha	%	
0	Martor $P_{50}N_{20}$ in autumn	1.93	59.02	-1.34	-40.98	o o o
1	N_{40} at T_1	2.29	70.03	-0.98	-29.97	o o o
2	N_{60} at T_1	2.50	76.45	-0.77	-23.55	o o
3	N_{80} at T_1	2.91	88.99	-0.36	-11.01	
4	N_{100} at T_1	3.25	99.39	-0.02	-0.61	
5	N_{120} at T_1	4.11	125.69	0.84	25.69	***
6	$N_{20}(T_1) + N_{20}(T_2)$	2.53	77.37	-0.74	-22.63	o o
7	$N_{30}(T_1) + N_{30}(T_2)$	3.10	94.80	-0.17	-5.20	
8	$N_{40}(T_1) + N_{40}(T_2)$	3.65	111.62	0.38	11.62	
9	$N_{50}(T_1) + N_{50}(T_2)$	3.84	117.43	0.57	17.43	*
10	$N_{60}(T_1) + N_{60}(T_2)$	4.20	128.44	0.93	28.44	***
11	$N_{20}(T_1) + N_{20}(T_2) + N_{20}(T_3)$	2.89	88.38	-0.38	-11.62	
12	$N_{20}(T_1) + N_{30}(T_2) + N_{30}(T_3)$	3.49	106.73	0.22	6.73	
13	$N_{30}(T_1) + N_{30}(T_2) + N_{40}(T_3)$	3.99	122.02	0.72	22.02	**
14	$N_{30}(T_1) + N_{40}(T_2) + N_{50}(T_3)$	4.68	143.12	1.41	43.12	***
	General average	3.27	100.00	0.00	0.00	Control

Tab. 4. Fertilizer rates and application times influence on the Atrium variety yield, Seini, 2009-2010

No. crt.	Fertilization	Yield		Difference		Significance
		t/ha	%	t/ha	%	
0	Martor $P_{50}N_{20}$ in autumn	1.69	51.68	-1.58	-48.32	o o o
1	N_{40} at T_1	2.20	67.28	-1.07	-32.72	o o o
2	N_{60} at T_1	2.74	83.79	-0.53	-16.21	o
3	N_{80} at T_1	3.18	97.25	-0.09	-2.75	
4	N_{100} at T_1	3.86	118.04	0.59	18.04	*
5	N_{120} at T_1	4.16	127.22	0.89	27.22	***
6	$N_{20}(T_1) + N_{20}(T_2)$	2.16	66.06	-1.11	-33.94	o o o
7	$N_{30}(T_1) + N_{30}(T_2)$	2.95	90.21	-0.32	-9.79	
8	$N_{40}(T_1) + N_{40}(T_2)$	3.58	109.48	0.31	9.48	
9	$N_{50}(T_1) + N_{50}(T_2)$	3.88	118.65	0.61	18.65	*
10	$N_{60}(T_1) + N_{60}(T_2)$	4.10	125.38	0.83	25.38	***
11	$N_{20}(T_1) + N_{20}(T_2) + N_{20}(T_3)$	2.30	70.34	-0.97	-29.66	o o o
12	$N_{20}(T_1) + N_{30}(T_2) + N_{30}(T_3)$	3.05	93.27	-0.22	-6.73	
13	$N_{30}(T_1) + N_{30}(T_2) + N_{40}(T_3)$	4.03	123.24	0.76	23.24	**
14	$N_{30}(T_1) + N_{40}(T_2) + N_{50}(T_3)$	4.83	147.71	1.56	47.71	***
	General average	3.27	100.00	0.00	0.00	Control

- the variants with divided doses, from 40 to 120 kg N/ha on $T_1 + T_2$ bring significant increases to the dose of N_{100} (+610 kg/ha) and very significant at N_{120} (60 + 60), with an increased level of 830 kg wheat/ha, up by almost 300 kg/ha than the similar version of the Balaton variety;
- a similar behavior with Balaton is also encountered at the Atrium variety in the triple doses, but with higher yields and with a lower overall crop mode:

$N_{100}(30 + 30 + 40)(T_1 + T_2 + T_3) = +760 \text{ kg wheat/ha}$ compared to the experience mean, statistically assured increase at the significantly distinct level and

$N_{120}(30 + 40 + 50)(T_1 + T_2 + T_3) = \text{maximum yield increase of } 1560 \text{ kg wheat/ha}$ and provided statistically at a very significant level, the biggest gain obtained in the experience.

This shows that Atrium premium variety reacts better to dose fractionation and placing a large fraction at the time T_3 . In addition to the increase of yield, also a higher quality is obtained with much higher quantity of protein.

All increases are very significant. The Atrium variety reacts better to higher doses of nitrogen fractionation than the Balaton variety.

According to the methodology for calculating correlations presented in 2D (x, y), $y = f(x)$, we use a special program – Curve 2D. For Balaton variety the results are shown in Fig. 2, Fig. 3 and Fig. 4.

In Fig. 2 is presented the correlation between the production of grain expressed as kg/ha depending on the dose of nitrogen applied in T_1 , i.e. once at the beginning of the vegetation of the

plants. We note that the yield reacts relatively slowly for Balaton on the range 0-50 kg N/ha, rises steeply on the range 50-75 kg N/ha and abruptly on the 85-120 kg N/ha range.

The double fractionation ($T_1 + T_2$) at doses of 0-120 kg N/ha in the form of correlation is shown in Fig. 3. The function is a polynomial Fourier Series 4 x 2 type and is statistically ensured by a $r^2 = 0.85$ ratio. So, the possibility of retrieving this results under similar conditions is 85%. In 15% of cases other results can be obtained (Hera, 1972).

Evolution on curve is slow on the range 0-40 kg N/ha, slightly increased for the 40-100 kg N/ha range, with a flattening trend in the range 80-100 kg N/ha and a sharp increase in the range of 100-120 kg N/ha. It does not appear to be necessary to fractionate in two the dose of 100 kg N, but the model shown fractionation of doses greater than 100 kg N/ha.

Triple fractional doses should occur even at lower doses (see Fig. 4). The correlation is almost linear, but in substance is a function type Polynomial Fourier series 2 x 2, ensured by a high correlation ratio (0.876) and with a correlation coefficient $r = \sqrt{0.876} = 0.936$ and higher (very significant).

The curve shows that we can equally divide doses of 80, 100 and 120 kg N/ha, with big gains generated by the later application. The curve serves, basically, as a nomogram, which can help us estimate production based on the model available for nitrogen fattening. We recommend N_{120} model (30 + 40 + 50) and with extrapolation to 125-130 kg N/ha, in which case production continues

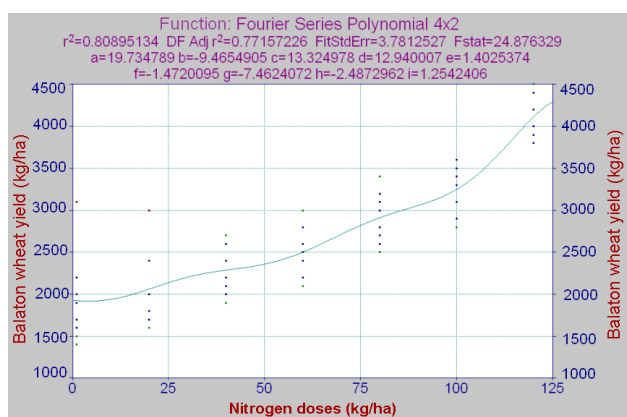


Fig. 2. Influence of nitrogen doses (T_1) on the yield of Balaton wheat – Seini, 2009-2010

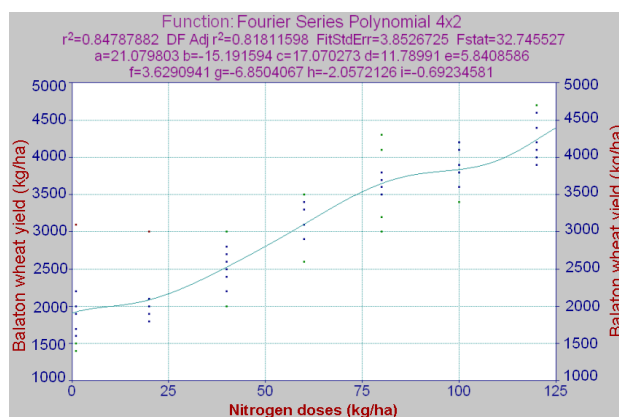


Fig. 3. Influence of nitrogen doses ($T_1 + T_2$) on the yield of Balaton wheat – Seini, 2009-2010

to grow based on the economic substance of the treatment.

For Atrium variety, the correlation results of the three models are shown in Fig. 5, Fig. 6 and Fig. 7. We have already shown that the variety Atrium response to fertilizer is somewhat higher as the Balaton and by a statistically ensured high correlation ratio and thus also of a very high correlation coefficient (0.874).

The range where the function is highly increased is the range of N_{50} - N_{100} , for a single application at the beginning of the vegetation (Fig. 5). Increasing the dose to N_{120} , for a single application, seems less convincing.

Fractionation in two-stage application of the doses and dose-correlation production of this model is shown in Fig. 6, which states:

- no need of fractioning ($T_1 + T_2$) for doses up to 50 kg N/ha;

- an emphasized need for fractionation in the rest of the development range of doses (50-100 kg N/ha), although the evolution curve is slightly different than the previous one, because here we have a function of Fourier Series Polinomyal 3×2 , the difference between them not being very significant.

In Fig. 7 is showed the correlation between nitrogen rates in their triple fractional model $T_1 + T_2 + T_3$ and the Atrium wheat variety yields, resulting in the following:

- it is not required a triple dose fractionation up to 60 kg N / ha. In this case, the nitrogen may be applied in one or maximum two steps, with small increases in production;
- the triple dose fractionation after the model $T_1 + T_2 + T_3$ is very useful at doses above 80 kg N/ha, fractionation achieving spectacular effects at N_{100} - N_{120} , as in the extrapolation.

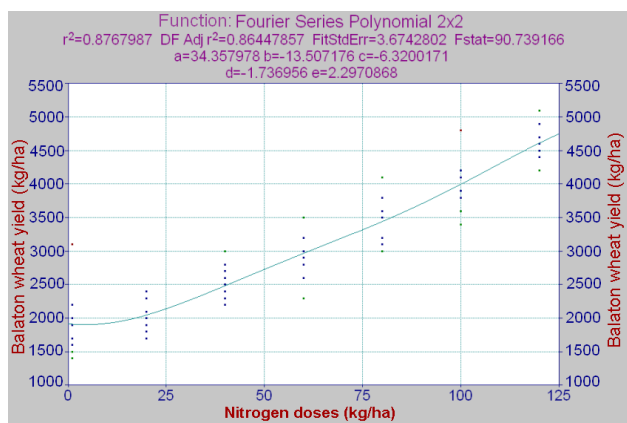


Fig. 4. Influence of nitrogen doses ($T_1 + T_2 + T_3$) on the yield of Balaton wheat – Seini, 2009-2010

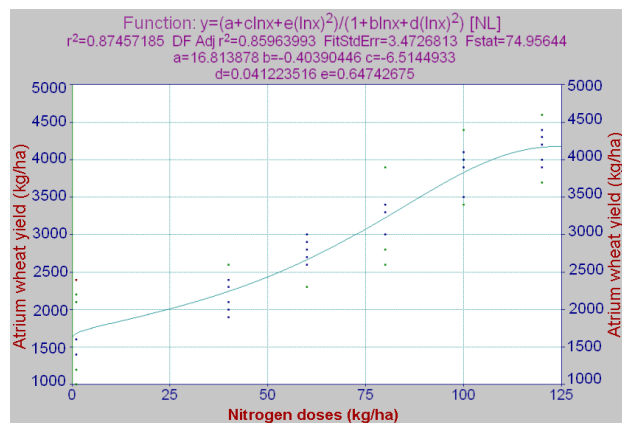


Fig. 5. Influence of nitrogen doses (T_1) on the yield of Atrium wheat – Seini, 2009-2010

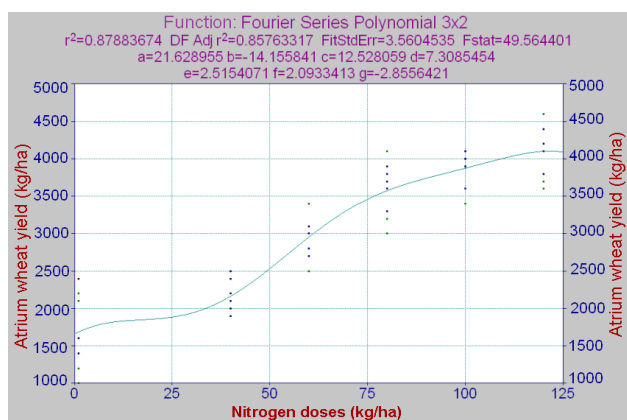


Fig. 6. Influence of nitrogen doses ($T_1 + T_2$) on the yield of Atrium wheat – Seini, 2009-2010

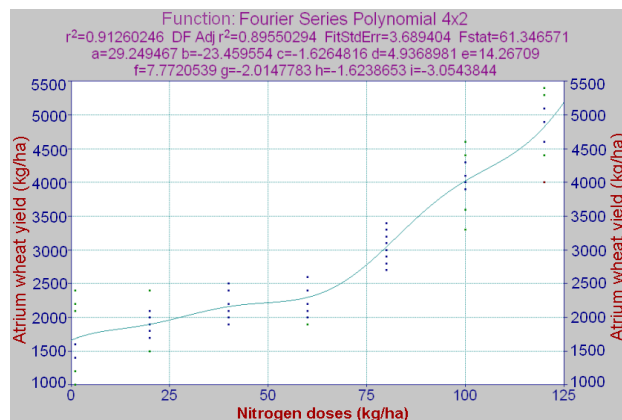


Fig. 7. Influence of nitrogen doses ($T_1 + T_2 + T_3$) on the yield of Atrium wheat – Seini, 2009-2010

The fractionation doesn't affect the washing and agrochemical soil parameters (Gaina and Burlacu, 2005). It was already established by Bilteanu (2003) that high doses of nitrogen requires fractionation, but it was known that premium varieties react so well through production and quality when the 3rd dose is higher and applied at the time T_3 . Becker and Pomberg (2007) emphasize, in turn, the need to implement the nitrogen obtained by industrial fixation in divided doses;

- we also point out that, by extrapolating the function in Fig. 7, at doses of 150 kg N (divided by the same ratio), yields of up to 5600 kg grains/ha can be obtained.

CONCLUSION

"A" and premium type wheat varieties, provenance Austria, were acclimatized and can be successfully grown in the Seini area. The two wheat varieties under study (Balaton and Atrium) capitalize different the nitrogen doses received, depending on the quantity, fractionation and application moments.

Balaton variety reacts better to low doses and less to the triple fractionation of nitrogen doses. Double fractionation led to significantly superior results. At the opposite, Atrium variety has a slow reaction towards low doses, but it is very effective at high doses and it responds significantly to high dose fractionation respond (100 and 120 kg N/ha). Atrium variety hasn't reached its maximum yield in the experienced nutrition patterns.

Soils being very poor and with a reduced biological activity, synthetically fixed nitrogen was extremely well capitalized.

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