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AGRONOMIC RESPONSE OF RAPESEED SEED AND OIL YIELD ON DIFFERENT MINERAL FERTILIZING SCHEME

Petrișoara Florina ȘUVET, Ștefan Laurențiu BĂTRÎNA, Laura Iosefina SMULEAC, Lucian Florin BOTOȘ, Adrian BORCEAN, Ilinca Merima IMBREA, Florin IMBREA

University of Life Sciences "King Mihai I" from Timisoara,
119 Calea Aradului Street, Timisoara, Romania

Corresponding author email: stefan.batrina@usab-tm.ro

Abstract

Rapeseed is a crop that has a significant agronomic response in terms of seed yield and oil content and yield. This study aims to assess the influence of fertilizer type, quantity and the combined effect of them on both seed and oil yield in the pedoclimatic conditions of Western Plain in Romania. The research was carried out on a chernozem soil with a weak acidic reaction and for biological material, it consisted of one rapeseed hybrid developed by Limagrain company, Astronom. The experimental field was uniformly fertilized at the same time with sowing with 200 kg/ha of 27:13.5:0 complex fertilizer and in order to assess the influence of fertilizers, in the spring, three graduations of fertilizers were used, as follows: a1 - E34 (10:24:0 + 0.1Zn + 0.1Br +20 SO_3); a2 - DAP (18:46:0) and a3 - 20:20:0. The results highlight the increase of both seed and oil yield, depending on the type of the fertilizer, with as much as 20% compared to the field average.

Key words*: rapeseed, oil, yield, fertilizers.*

INTRODUCTION

Autumn rapeseed, due to its use both in nutrition and as biofuel, as well as the yield determined by the level of production compared to the investment level, has experienced significant development in the last decade (Imbrea, 2017; Fridrihsone, 2020). Yields in rapeseed are dependent on levels of mineral fertilization, due to the high consumption of elements such as K_2O, N, P_2O_5, S, Mg, Ca, and B (Wang et al., 2010; Men et al., 2020) and soil moisture (Wick, 2012; Zhang et al., 2013; Eyni et al., 2020; Smuleac et al., 2020; Bečka et al., 2021).

Another important element of rapeseed fertilization is the rate of nutrient absorption, considering that the most intense absorption of macroelements and sulphur occurs from the resumption of vegetation (February-March) until flowering (Grosz, 2011; Suvet, 2021), as well as the fact that each element in particular has an important contribution to the expression of the potential of rapeseed production (Louvieaux, 2020).

Regarding the absorption of micronutrients, boron, zinc, and molybdenum have a special role in fruiting, flower formation, and pollination, reaching a maximum absorption during the flowering and silique formation period (Haneklaus, 1999; Bătrâna et al., 2021).

MATERIALS AND METHODS

The effect of the type of mineral fertilizer and the crop establishment period on the level of production, content, and oil yield, as well as the interaction between the experimental factors, was studied in a bifactorial experiment set up at the Didactical Farm (SDE) of University of Life Sciences "King Mihai I" from Timisoara in the agronomical year 2020-2021 on chernozem, which is the most common soil in the region. The experience was arranged according to the method of randomized blocks, with the following grading of the experimental factors: Factor A - type of mineral fertilizer, with three gradations: a1 - E34 (10:24:0 + 0.1Zn + 0.1Br +20 SO_3); a2 - DAP (18:46:0) and a3 - 20:20:0. Factor B - crop establishment period, with three gradations: b1 - 10-20.08, b2 - 21-31.08; and b3 - 1-10.09. The fertilizers were applied in fractions, 200 kg/ha of 27:13:5:0 at seedbed preparation and 200 kg of each of the three fertilizers in the spring. The rapeseed hybrid used was Astronom. The preceding crop was winter wheat.

RESULTS AND DISCUSSIONS

Table 1 presents the results of seed yield according to fertilization. The average seed yield recorded values ranging from 2841 kg/ha on agrofund a3 to 3626 kg/ha on agrofund a1.

Table 1. Seed yield by fertilizer type

Factor A Fertilizer type	Seed production		Difference [kg/ha]	Significance
	kg	%		
a1 - E34	3626	112.2	393	***
a2 - DAP	3231	99.9	-2	ns
a3 - 20.20	2841	87.9	-391	000
media	3233	100.0	ns	
DL 5% = 13.69 kg; DL 1% = 18.75; DL 0.1% = 25.55				

From the presented data, it can be observed that compared to the control - the average of the experiment (3233 kg/ha), two levels of fertilization resulted in statistically significant yield increases, at a1 and a3: the increase obtained at a1 was 393 kg, meaning that the production obtained at a1 exceeded the experiment's average by 12.2%, and at a3, around 391 kg, but the production is below the experiment's average, meaning that the increase is negative. Seed production according to the sowing period is presented in Table 2.

Table 2. Seed yield according to the sowing period

Factor B Sowing period	Seed production		Difference [kg/ha]	Significance
	kg	%		
b1 - 10-20.08	3201	99.0	-31	000
b2 - 20-31.08	3227	99.8	-6	ns
b3 - 1-10.09	3270	101.1	37	***
media	3233	100.0	mt	
DL 5% = 13.69 kg; DL 1% = 18.75; DL 0.1% = 25.55				

Compared to the control - the experimental average (3233 kg/ha), only in the variant sown in the first decade of September, the yield exceeded the control by 37 kg, a difference statistically significant as highly significant. In the case of the other two experimental variants, the yields obtained were below the experimental average. The seed production obtained at the interaction of factors A x B and the significance the production differences compared to the control are presented in Table 3.

Table 3. The seed production obtained with the A x B interaction
and the significance of the production differences compared to the control - average

Factor B Sowing period	Factor A -Fertilizer type											
	a1 - E34				a2 - DAP				a3 - 20.20			
	Crop		Diff. [kg]	Signif.	Crop		Diff. [kg]	Signif.	Crop		Diff. [kg]	Signif.
	kg	%			kg	%			kg	%		
b1 - 10-20.08	3605	111.5	372	***	3197	98.9	-35	00	2802	86.7	-431	000
b2 - 20-31.08	3623	112.1	390	***	3216	99.5	-17	ns	2842	87.9	-391	000
b3 - 0-10.09	3650	112.9	417	***	3280	101.5	47	***	2880	89.1	-353	000
Average	3233											
DL 5% = 23.71 kg	DL 1% = 32.48			DL 0.1% = 44.26								

Compared to the control - the experience average (3233 kg/ha), the following yields were obtained:

- Statistically significant increases for fertilization with a1 and a3, regardless of the sowing time. For fertilization with a1, the increase ranged between 372 kg [b1] and 417 kg [b3], meaning that the yield obtained at a1 exceeded the experience average by 11.5% [b1] and 12.9% [b3]. It is worth noting that for a3, the increases were negative, regardless of the sowing time.
- A highly significant increase was obtained for fertilization with a2, in sowing time b3, a significant increase in b1, and a non-significant increase in b2.

The influence of the type of fertilizer on seed production is shown in Figure 1.

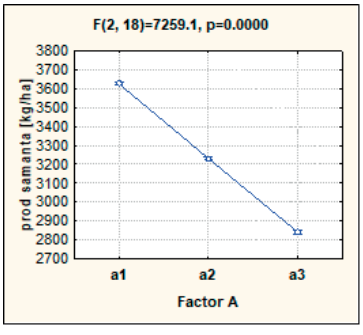

Figure 1. Seed yield variation according to the fertilization level [Factor A]

The seed production has a descending trend, varying between 3626 and 2840 kg. The type of fertilizer used has an influence on seed production, with the highest yield obtained in variant a1, fertilized with E34, and decreasing for variants a2 (DAP) and a3 (20:20:0). The differences in yields between fertilizer levels are statistically very significant [p<0.001].
The influence of sowing time on seed production is presented in Figure 2.

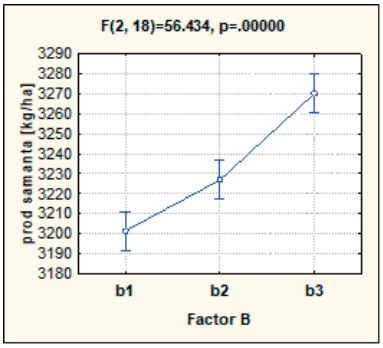

Figure 2. Seed yield variation according to the sowing period [Factor B]

The seed production increases with the sowing period, and the two variables are directly proportional. The evolution of seed production is ascending. The production varies between 3200[b1] kg and 3270[b3] kg. The increase in production from b1 to b2 is slower than the increase from b2 to b3.
The analysis of the results regarding the influence of the interaction between factors A x B [fertilizer type x sowing period] on seed production is presented in Figure 3

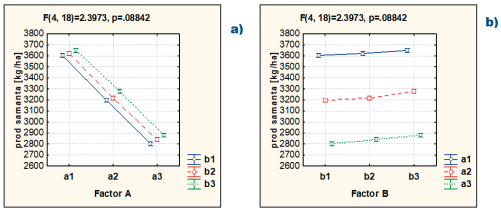

Figure 3. Seed yield variation [A x B]

Regardless of the sowing time, the seed yield has a decreasing trend as the level of fertilization increases.
The highest yield is obtained in a1, while the lowest is in a3.
The yields obtained in a1, at the three sowing times varied between 3605-3650 kg/ha, in variant a2 between 3200-3300 kg/ha, and those in variant a3 varied between 2802-2880 kg/ha.
Figure 4 presents the contribution of the experimental factors and their interaction in achieving the production.

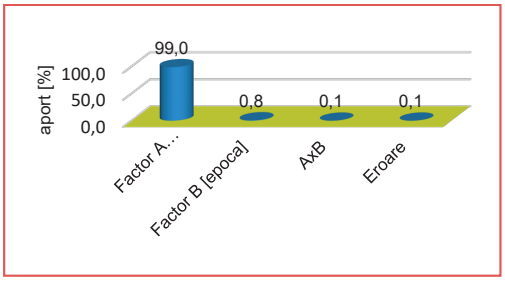

Figure 4. The contribution of factors A [fertilizer type], B [sowing period], and the interaction of A x B

Factor A [fertilizer type] contributes to the production in a proportion of 99.0%, factor B [seeding time] contributes with 0.8%, and the interaction A x B with 0.1%. Therefore, the highest contribution is made by the type of fertilization factor, followed by factor B [seeding time] and the interaction A x B.
The oil content depending on the type of fertilization, seeding time, and the interaction A x B is presented in Table 4.
Based on the type of fertilization, the oil content varied between 42.3% (20:20:0) and 44.1% (E34). The average experience recorded a value of 43.1%, and only in variant a1 (E34) was there a statistically significant increase of 1% compared to the average.
The sowing period determined oil content ranging from 42.9% (second decade of August) to 43.2% (last decade of August and first decade of September).

Table 4. Oil content depending on the type of fertilization, the sowing period and the A x B interaction

Experimental factor	Factor levels	Oil content [%]	Std.Err.	-95.00%	+95.00%	Diff. [%]	Signif.
Factor A [Fertilizer type]	a1 - E34	44.1	0.123779	43.79100	44.36187	1.0	***
	a2 - DAP	43.0	0.221703	42.47740	43.49990	-0.1	ns
	a3 - 20.20	42.3	0.115329	41.99917	42.53107	-0.8	000
	Average	43,1				mt	
	DL 5% = 0.36 %; DL 1% = 0.49; DL 0.1% = 0.67						
Factor B [sowing period]	b1 - 10-20.08	42.9	0.306068	42.17330	43.58489	-0.2	ns
	b2 - 20-31.08	43.2	0.297936	42.53226	43.90634	0.1	ns
	b3 - 0 - 10.09	43.2	0.305181	42.52806	43.93556	0.1	ns
	Average	43,1				mt	
	DL 5% = 0.36 %; DL 1% = 0.49; DL 0.1% = 0.67						
AxB Interaction							
Factor A	Factor B						
a1 - E34	b1 - 10-20.08	44.1	0.034264	43.91871	44.21356	1.0	**
	b2 - 20-31.08	44.0	0.207695	43.10638	44.89366	0.9	**
	b3 - 0 - 10.09	44.2	0.364435	42.59511	45.73118	1.1	**
a2 - DAP	b1 - 10-20.08	42.2	0.173968	41.43612	42.93317	-0.9	00
	b2 - 20-31.08	43.5	0.188647	42.73541	44.35877	0.4	ns
	b3 - 0 - 10.09	43.2	0.121145	42.71298	43.75547	0.1	ns
a3 - 20.20	b1 - 10-20.08	42.4	0.160351	41.69659	43.07646	-0.7	0
	b2 - 20-31.08	42.1	0.116490	41.60957	42.61199	-1.0	00
	b3 - 0 - 10.09	42.3	0.317024	40.93403	43.66211	-0.8	0
	Average	43,1					
	DL 5% = 0.62%; DL 1% = 0.85; DL 0.1% = 1.15						

Regarding the interaction between factors, compared to the control - the average experience, the following increases were obtained: a distinct significant increase in fertilization type a1 (E34) regardless of the sowing period, a distinct significant increase in type a2 (DAP) in the b1 period (second decade of August), while the increases in the b2 (last decade of August) and b3 (first decade of September) periods were not significant. In the case of fertilization type a3 (20:20:0), a distinct significant increase was obtained in b2 (last decade of August), while the increases in b1 (second decade of August) and b3 (first decade of September) periods were significant.

It is noteworthy that for the fertilization levels of a2 (DAP) and a3 (20:20:0), the increases are below the average experience, meaning negative increases.

The influence of the type of fertilization on the oil content is presented in Figure 5

The oil content decreases with the level of fertilization, the two variables being inversely proportional. The trend of the oil content is descending. The oil content varies between 44% and 42.3%. The differences between the levels of fertilization are highly significant [p<0.001]. The influence of the sowing period on the oil content is shown in Figure 6.

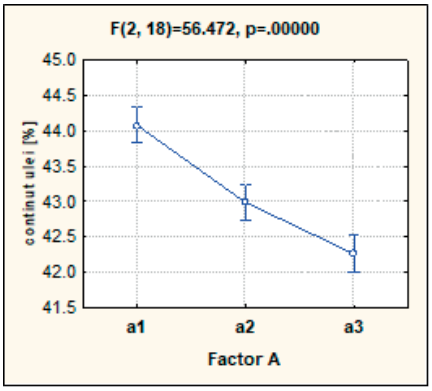

Figure 5. Oil content variation for the three types of fertilizers [factor A]

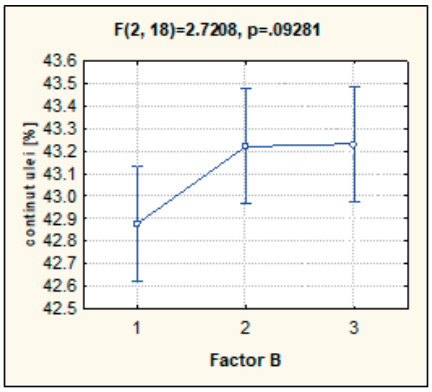

Figure 6. Oil content variation for the three sowing periods [factor B]

The oil content increases with the sowing period, thus from b1 (the second decade of August) to b2 (the last decade of August), there is an upward trend [increasing from 42.9% to 43.2%], while from b2 (the last decade of August) to b3 (the first decade of September), the oil content registers approximately the same value [from 43.22% to 43.23%]. The analysis of the results regarding the influence of the interaction between the factors AXB [fertilization x sowing period] on the oil content is shown in Figure 7.

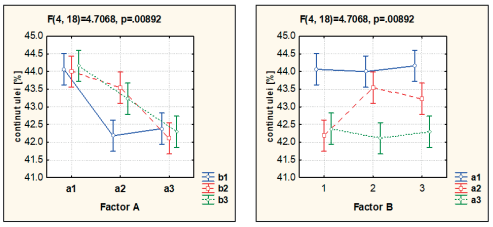

Figure 7. Oil content variation [A x B interaction]

Regardless of the sowing period, the oil content has a decreasing trend with respect to the fertilization level, with the exception of the b1 period (the second decade of August) which has a decreasing trend from a1 (E34) to a2 (DAP), and from a2 (DAP) to a3 (20:20:0), the trend is ascending. The highest oil content is obtained at a1 (E34), while the lowest is at a3 (20:20:0). The oil contents obtained at a1 (E34) for the three sowing periods ranged from 44.1% to 44.2%, with a decreasing trend from b1 (the second decade of August) to b2 (the last decade of August), and an ascending trend from b2 (the last decade of August) to b3 (the first decade of September), with values ranging from 44.1% [b1], 44.0% [b2] and 44.2% [b3]. The same trend applies to a3 (20:20:0). The oil content for a3 (20:20:0) ranged from 42.4% [b1], 42.1% [b2], and 42.3% [b3]. The contribution of the factors A [type of fertilization], B [sowing period], and the interaction of AxB in achieving the oil content is presented in Figure 8.

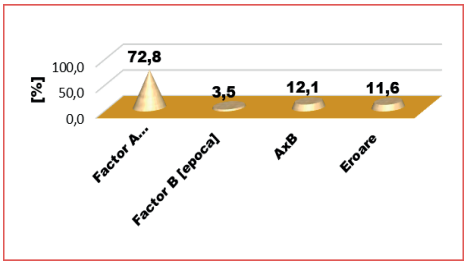

Figure 8. The contribution of factors A [type of fertilizer], B [sowing season], and the A x B interaction

Factor A [type of fertilizer] contributes to achieving the oil content by 72.8%, factor B [sowing season] contributes by 3.5%, and the A x B interaction by 12.1%. Therefore, the greatest contribution is made by the fertilizer factor, followed by the A x B interaction and the B [sowing season] factor.

The oil production according to the type of fertilizer, sowing season, and A x B interaction is presented in Table 5.

Table 5. Oil crop depending on the type of fertilization, the sowing period and the A x B interaction

,Experimental factor	Factor levels	Oil crops [%]	Std.Err.	-95.00%	+95.00%	Diff. [%]	Signif.
Factor A [Fertilizer type]	a1 - E34	1598	4.60179	1587.468	1608.692	202	***
	a2 - DAP	1389	10.70854	1364.392	1413.780	-7	ns
	a3 - 20.20	1201	5.16708	1188.938	1212.769	-195	000
	Average	1396					
	DL 5% = 9.29 kg; DL 1% = 12.73; DL 0.1% = 17.34						
Factor B [sowing period]	b1 - 10-20.08	1375	58.25851	1240.653	1509.342	-21	00
	b2 - 20-31.08	1397	57.39366	1264.709	1529.409	1	ns
	b3 - 0 - 10.09	1416	56.92218	1284.700	1547.225	20	***
	Average	1396					
	DL 5% = 9.29 kg; DL 1% = 12.73; DL 0.1% = 17.34						
AxB Interaction							
Factor A	Factor B						
a1 - E34	b1 - 10-20.08	1588	2.933613	1575.843	1601.088	192	***
	b2 - 20-31.08	1594	4.966161	1572.567	1615.302	198	***
	b3 - 0 - 10.09	1612	8.448273	1575.490	1648.190	216	***
a2 - DAP	b1 - 10-20.08	1349	5.579258	1324.789	1372.801	-47	000
	b2 - 20-31.08	1401	7.056626	1370.138	1430.863	4	ns
	b3 - 0 - 10.09	1418	1.191520	1412.835	1423.088	22	*
a3 - 20.20	b1 - 10-20.08	1188	5.223971	1165.256	1210.210	-208	000
	b2 - 20-31.08	1197	2.154135	1187.474	1206.011	-199	000
	b3 - 0 - 10.09	1218	6.740849	1189.083	1247.090	-178	000
	Average	1396					
	DL 5% = 16.09 kg DL 1% = 22.04 DL 0.1% = 30.04						

The highest oil yield (1598 kg/ha) was obtained in the a1 (E34) fertilization variant, where the highest seed yield and oil content were also achieved. The yield increase of 202 kg/ha is statistically significant. In the a2 and a3 fertilization variants, the oil yield was below the experimental average (1396 kg/ha).

Regarding the influence of the sowing season on oil yield, compared to the experimental average (1396 kg/ha), the highest yield was obtained in variant b3 (the first decade of September) with 1416 kg/ha, a difference of 20 kg/ha, which is statistically very significant.

The interaction between the type of fertilizer and the sowing season influenced the oil yield. The highest oil yields ranging from 1588 -1612 kg/ha were obtained in the a1 (E34) fertilization variant in all three sowing seasons. The yield differences ranging from 192 kg/ha to 216 kg/ha are statistically very significant. For the other fertilization levels in interaction with the sowing season, except for the a2 (DAP) variant and the b3 sowing season (the first decade of September), where a yield increase of 22 kg/ha was obtained compared to the experimental average, statistically significant, the oil yield did not exceed the experimental average.

The influence of fertilization on oil yield is presented in Figure 9.

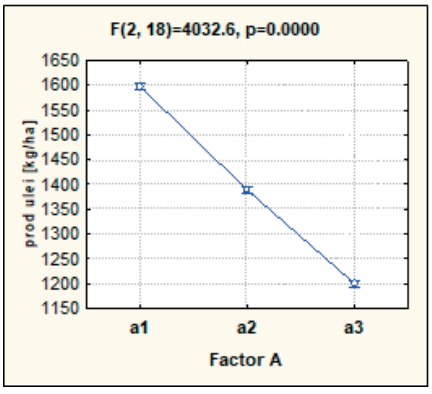

Figure 9. Oil yield variation depending on used fertilizer [Factor A]

The oil yield decreases with the level of fertilization, with the two variables being inversely proportional. The oil yield exhibits a decreasing trend. The yield varies between 1600 kg/ha (a1 - E34) and 1200 kg/ha (a3 -20:20:0). The differences in yield between fertilizer levels are highly significant [p<0.001]. The influence of sowing time on the yield of oil is shown in Figure 10.

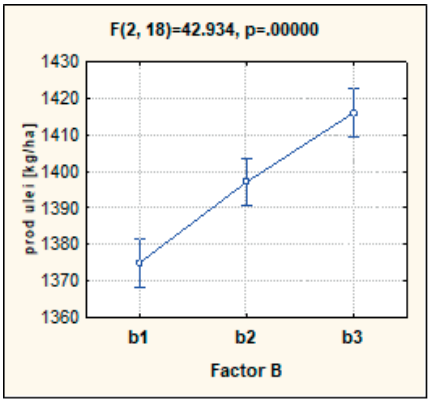

Figure 10. Variation of oil yield at the three sowing times [factor B]

The oil yield increases with the sowing period, the two variables being directly proportional. The trend of oil yield is ascending. The yield ranges from 1375 kg/ha (B1 - second decade of August) to 1416 kg/ha (B3 - first decade of September). The analysis of the results regarding the influence of the interaction between factors A x B [type of fertilization x sowing period] on the oil yield is presented in Figure 11.

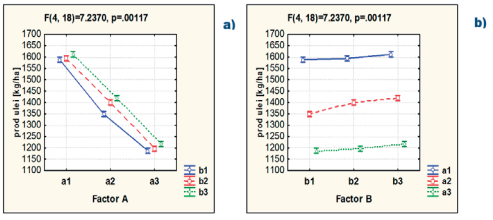

Figure 11. Variation of oil yield [A x B interaction]

Regardless of the sowing time, the oil yield shows a decreasing trend with increasing fertilizer level. The highest yield is obtained with a1 (E34) and the lowest with a3 (20:20:0). The yields obtained with a1 (E34) at all three sowing times varied between 1590 kg/ha (second decade of August) and 1610 kg/ha (first decade of September), while those obtained with a3 (20:20:0) varied between 1200 kg/ha (second decade of August) and 1220 kg/ha (first decade of September).

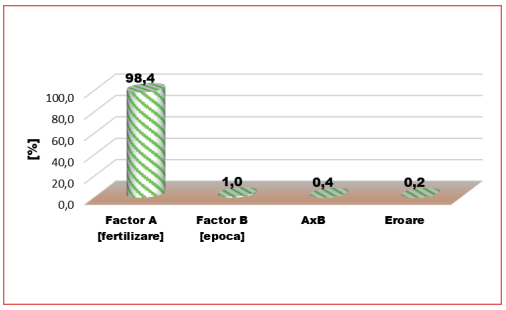

Figure 12. Contribution of factors A [fertilization], B [sowing time] and their interaction A x B

Factor A[fertilization] contributes to production achievement in proportion of 98.4%, factor B [sowing period] contributes with 1.0%, and interaction A x B with 0.4%. Therefore, the greatest contribution is made by factor A[fertilization], followed by factor B[season] and interaction A x B.

CONCLUSIONS

Analyzing the production results, oil content, and oil production depending on the type of fertilization and sowing time, important conclusions can be drawn to support rapeseed farmers in the western part of the country. Regarding fertilization, the highest production (3233 kg/ha) was obtained in the case of fertilization with E34 (10:24:0 + 0.1Zn + 0.1Br + 20 SO_3), a fertilizer that, along with nitrogen and phosphorus, contains zinc, boron, and sulfur. As for the highest oil content (44.1%) and the highest oil production (1598 kg/ha), they were also obtained in the variant fertilized with this type of fertilizer. In recent years, due to climate change and especially the lack of soil moisture during the germination period, farmers in the western part of the country have started to sow rapeseed crops in the second half of August. The results of the study show that the highest and most secure rapeseed yields for the climatic conditions in the researched area are obtained in the variant sowed in the first decade of September (3650 kg/ha). This period also produced the highest oil content and the highest oil production (1416 kg/ha). Regarding the interaction between the type of fertilizer and the sowing period, the best results were obtained in the variant fertilized with E34 (10:24:0 + 0.1Zn + 0.1Br + 20 SO_3) and sowed in the first decade of September, with a seed production value of 3650 kg/ha, oil content of 44.2%, and oil production of 1612 kg/ha.

REFERENCES

Bătrîna, Ş. L., Jurcoane, Ş., Imbrea, I. M., Pop, G., Popescu, I. M., & Imbrea, F. (2021). Nutritive Quality of Camelina Varieties with Special Focus on Oil. *Scientific Papers. Series A. Agronomy, LXIV*(1), 212–216.

Bečka, D., Bečková, L., Kuchtová, P., Cihlář, P., Pazderů, K., Mikšík, V., Vašák, J. (2021). Growth and yield of winter oilseed rape under strip-tillage compared to conventional tillage. *Plant Soil Environ*, 67.

Eyni Nargeseh, H., Aghaalikhani, M., Shirani Rad, A. H., Mokhtassi-Bidgoli, A., Modarres-Sanevi, A. M. (2020). Comparison of 17 Rapeseed Cultivars under Terminal Water Deficit Conditions Using Drought Tolerance Indices. *JAST, 22(2)*, 489–503.

Fridrihsone, A., Romagnoli, F., Cabulis, U. (2020). Environmental Life Cycle Assessment of Rapeseed and Rapeseed Oil Produced in Northern Europe: A Latvian Case Study. *Sustainability, 12*. 5699.

Grosz, D., Borcean, I., Tabara, V., Imbrea, F., Marian, F. (2011). Researches regarding the interaction between cultivating variety-fertilized-planting distance between rows at the oilseed rape. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture, 68(1)*, 144–148.

Haneklaus, S., Paulsen, H. M., Gupta, A. K., Bloem, E., & Schnug, E. (1999). Influence of sulphur fertilization on yield and quality of oilseed rape and mustard. In *Proceedings of the 10th International Rapeseed Congress,* 26–29.

Imbrea, F.., Jurcoane, S., Pop, G., Imbrea, I.M., Botos, L., Crista, F., Smuleac, L. (2017). Valorising municipal sludge as fertiliser in *Camelina sativa* L. Crantz. *Journal Romanian Biotechnological Letters, 22*(4), 12762–12766.

Louvieaux, J., Leclercq, A., Haelterman, L., Hermans, C. (2020). In: Field Observation of Root Growth and Nitrogen Uptake Efficiency of Winter Oilseed Rape. *Agronomy, 10*. 105.

Men, S., Chen, H., Chen, S. et al. (2020). Effects of supplemental nitrogen application on physiological characteristics, dry matter and nitrogen accumulation of winter rapeseed (*Brassica napus* L.) under waterlogging stress. *Sci. Rep., 10. 10201*. https://doi.org/10.1038/s41598-020-67260-7

Şmuleac, L., Rujescu, C., Şmuleac, A., Imbrea, F., Radulov, I., Manea, D., Ienciu, A., Adamov, T., Paşcalău, R. (2020). Impact of Climate Change in the Banat Plain, Western Romania, on the Accessibility of Water for Crop Production in Agriculture. *Agriculture, 10*(10). 437.

Suveţ, P. F., Şmuleac, L. I., Botoş, L. F., Paşcalău, R., Bătrîna, Ş. L., Borcean, A., Imbrea, F. (2021). Research on the influence of technological links on oil rapeseed production. *Scientific Papers. Series A. Agronomy, LXIV*(2), 321–324.

Wang, Y., Lu, J., Li, X., Liu, W., Ma, C., Gao, X. (2010). Effects of drought stress during overwintering on fertilizer use efficiency of rapeseed (*Brassica napus*). *Plant Nutrition and Fertilizer Science, 16*(5), 1203–1208.

Wick, K., Heumesser, C., Schmid, E. (2012). Groundwater nitrate contamination: Factors and indicators. *J. Environ. Manag., 111*. 178–186.

Zhang, H., Berger, J.D., Milroy, S.P. (2013). Genotype×Environment Interaction Studies Highlight the Role of Phenology in Specific Adaptation of Canola (*Brassica napus*) to Contrasting Mediterranean Climates. *Field Crops Res., 144*. 77–88.