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THE INFLUENCE OF SOWING DEPTH AND OF PRECIPITATIONS ABOVE THE QUALITY AND THE YIELD OF AUTUMN WHEAT IN BOIANULUI'S MEADOW

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Abstract

Beside the yield gained of the autumn wheat's crop, the quality of it is the decisive factor of the seeding of a said kind or hybrid. The use of crop technology, but also of some recent innovations, lead to the improvement of the wheat crops. The cereal production is affected by the drought, one of the leading factors of abiotic stress, who is also affecting even tolerant crops. The constantly changing weather forces the farmers to adapt the crop technology specifically to the conditions of the local weather, the type of soil and the agricultural practices used to find the best strategy of seed distribution. This article presents the results of the effectuated studies with the purpose of determining the optimal depth of sowing in non-irrigable conditions and reduced precipitations in the southern part of the country. A year with water shortages is a different year when we can observe the influence of climate conditions over the growth of wheat crops at different depths.

Key words*: autumn wheat, precipitations, protein, soil, technology.*

INTRODUCTION

Winter wheat (*Triticum aestivum*) is one of the fundamental crops for European agriculture, being particularly important both from an economic perspective and from its food use. With a very high food share, it enjoys special attention from farmers due to the grains rich in carbohydrates and proteins, the long shelf life of the grains and the fact that they can be transported without difficulty. The stalks left after harvesting are used as a raw material in the manufacture of cellulose, as well as in animal feed or as organic fertilizer (Iancu et al., 2024).

With an average production of 4364 kg/ha in Romania, wheat is cultivated on 2,3 million ha (www.madr.ro). Wheat provides 28% of the world's edible dry matter and up to 60% of daily calories in developing countries (Cakmak, 2008). Food consumption is expected to double by 2050, in addition to the increasing requirement for high-quality food for a healthy diet (Singh et al., 2016). A rapid increase in the necessity of wheat products is also predicted worldwide (Rosegrant, 2003). The composition and nutritional quality of the wheat grain have a significant impact on human health and well-being, especially in developing countries. Therefore, factors an acting not only wheat yield, but also wheat quality, require more attention (Wang et al., 2011; Peleg et al., 2008).

To obtain a rich and quality crop, wheat sowing is an essential stage. The quality of production and its yield are influenced by a multitude of pedoclimatic and technological factors, among which the sowing depth and the precipitation regime play a decisive role. Local relief conditions, groundwater, vegetation, lithology determine the variety of soils in each area, which proves that the distribution of soils is determined not only by bioclimatic zoning but also by local factors, which sometimes play a fundamental role in the distribution of soils in each area and implicitly the yield of cultivated plants (Popescu et al., 2024).

Worldwide under different climatic conditions, the variation in wheat and maize yield is mainly attributed to cropping systems, soil fertility, fertilizers, weeds, pests and diseases management (Partal et al., 2023a; Partal et al., 2023b; Partal & Paraschivu, 2020; Velea et al., 2021).

Currently, by grouping agricultural land, in farms and associations of different sizes in terms of surface, there are no more uncultivated lands and the need to obtain quantitative and

qualitative productions has increased (Popescu et al., 2024). Texture as a physical property of the soil determined by the granulometric fractions, sand, clay dust, which enter its composition in different proportions, is stable in any soil conditions and plays a very important role in ensuring a proper relationship of the soil with water and air, to grow and develop plants (Bălan et al., 2024).

Depending on the soil moisture, soil type and texture, the soil-water depth is between 3-7 cm. Increasing sowing depths can enhance wheat establishment because of the higher soil-water content in the seed zone, resulting in better germination and emergence of seed lings (Mahdi et al., 1998; Schillinger et al., 1998). Soil functions may be directly or indirectly impacted by climate change. Thus, the farmland management exacerbates losses in soil multifunctionnality throughout Europe due to dry weather and rising temperatures (Sünnemann et al., 2023). Changes in temperature, precipitation, and moisture regime are examples of direct effects. Adaptations including tillage techniques, crop rotation adjustments, crops mixtures, pest and diseases management and irrigation might have indirect effects (Partal et al., 2023; Sărățeanu et al., 2023; Sălceanu et al., 2022).

The Boian Plain, characterized by fertile soils and a specific rainfall regime, constitutes an optimal framework for evaluating the influence of these variables on the performance of winter wheat.

This paper aims to examine the impact of sowing depth and rainfall on grain quality and yield of winter wheat, in the context of the specific agroecological conditions of the Boian Plain. The research aims to identify the optimal parameters for maximizing production and improving its quality.

Drilling is an advisable sowing method due to its uniform population per unit area. As seeds are place data uniform depth and covered with soil, high germination and uniform stands are expected (Tanveer et al., 2003). In recent years, the new planting pattern of wide precision has been widely adopted. This new planting pattern of wide precision sowing changes the seed dispersal from planting all seeds in a line, as done in drilling and dibbling, to separating single grains from each other (Dandan et al., 2013; Bian et al., 2016).

MATERIALS AND METHODS

Soil and climatic description

The experiment was carried out in the Boian Plain located in southern Romania, part of the Romanian Plain, on a chernozem type soil with a humus content favorable to cereals of 3,9 in horizon A at a depth of 0-30 cm, in horizon B it decreases significantly to 1,3 at a depth of 30-60 cm. In horizon A the following values were determined: DA - 1.21 g/cm^3, pH 6.4. In horizon B the values DA - 1.38 g/cm^3, pH 5.8. The apparent density, total porosity of the soil, $CaCO_3$ content, soil reaction play an important role both in seed germination and in the development and fruiting of agricultural crops as well as in the amount and quality of the productions obtained (Bălan et al., 2024).

Due to the recent climate changes that led to excessive drought, this experiment was carried out over two years, with two different sowing dates and three sowing depths, respectively 4, 6 and 8 cm, to observe the quality of the wheat grains. The sowing was carried out with a precision seeder, thus respecting the planting depths.

The two wheat varieties studied are Glosa and Boema created at the Fundulea Agricultural Research and Development Institute, productive wheat varieties with high drought tolerance. The sowing of the experiment was done for all variants in the first and last decade of October, with a density of 500 germinable grains/m^2. In both years of experimentation, the plots had 30/8 m and 240 m^2 respectively.

Regarding quality, samples were taken and determined using NIRS (Near-Infrared Spectroscopy) analysis, a modern technique used for the rapid and non-destructive determination of the chemical composition of feed, cereals and other agri-food products. The parameters determined were: Protein, Starch (%), Sugar (%), NCGD (%), Fiber Fat (EE) (%), Fah_as. These parameters are determinants for the baking quality and industrial use of wheat.

RESULTS AND DISCUSSIONS

Climatic aspects

The area is characterized by a temperate-continental climate and variable precipitation. The lack of adequate autumn precipitation can

delay the sowing of wheat crops in environments where irrigation is not available.
The year 2022 is in third place in the top of the warmest years in Romania. The monthly amount of precipitation (mm) in October 2022 was 15 mm short compared to the multiannual average of 46.0 mm with a deviation of -16.8 mm being characterized among the driest months since the determinations were made, and the average monthly temperature (ºC) was 13.6º C, a temperature considered high. This lack of precipitation caused the germination of wheat throughout the experience was affected, having an impact on the normal development of the plants and therefore on the quality of the grains. The month of November had an average monthly temperature of 8.6ºC being considered among the warmest November with a deviation of 3.6ºC. Very low precipitation amounts from a pluviometry point of view were recorded in February, namely 13.2 mm with a deviation of -14.7 mm. Also, the high temperatures of both the soil and the air in this month caused the biological rest of the wheat to be interrupted, and the growth processes were resumed. In all the spring months, the precipitation amounts were within satisfactory limits, which made the moisture reserve fall within a range close to optimal. Throughout the vegetation period, the average monthly temperatures were higher than the multiannual average (Table 1).

Table 1. The meteorological parameters in the experimental period 2022-2023

Specification	Month	Oct	Nov	Dec	Ian	Feb	Mar	Apr	May	June	July	Aug	Sept	Average Total
Temperature °C	Monthly Average	**13.7**	**8.6**	**2.8**	**4.0**	**3.6**	**7.7**	**10.6**	***16.4***	**21.2**	**25.8**	**25.7**	***21.5***	**13.4**
	Multiannual Average Last 30 Years	11.7	5.1	0.3	-1.3	0.8	6.0	12.0	*17.7*	21.6	22.8	23.5	18.1	11.6
	Deviation	**+4.2**	**+3.1**	**+3.6**	**+0.4**	**+7.2**	**+2.8**	**+2.9**	***-0.5***	**+4.4**	**+4.4**	**+3.3**	**+2.1**	**+1.8**
Precipitation mm	Amount Monthly	**15.0**	**78.8**	**33.8**	**103.4**	**13.2**	**20.8**	**68.8**	***78.6***	**44.4**	**120.0**	**40.8**	***35.8***	**653.4**
	Multi annual Media Last 30 Years	46.0	37.0	39.1	30.8	26.3	34.2	47.8	*58.6*	69.7	62.1	46.6	43.5	541.7
	Deviation	**-16.8**	**+87.2**	**-17.7**	**-4.0**	**-14.7**	**-11.8**	**-21.8**	***+13.2***	**-38.1**	**+33.1**	**-40.6**	**-24.5**	**+111.7**

Regarding the years 2023-2024, we can say that this was a year with a deficit in precipitation, in October when the experiment was established the deviation was -16.8 mm. The precipitation in November of 124.2 mm made the soil moisture reserve satisfactory. Throughout the winter and spring, the amount of precipitation was deficient, which affected plant development. As in the previous year, February recorded the least precipitation, 11.7 mm, recording a deviation of -14.7 mm. The amount of precipitation 71.8 mm recorded in May helped during this period when water requirements are maximum because it is in the phenological phases of earring, flowering, formation and filling of the grain. Monthly temperatures recorded positive deviations throughout the vegetation period. However, May 2024 was highlighted by average temperatures below the multiannual averages of the last 30 years, with a negative deviation of -0.5^0C (Table 2).

Table 2. The meteorological parameters in the experimental period 2023-2024

Specification	Month	Oct	Nov	Dec	Ian	Feb	Mar	Apr	May	June	July	Aug	Sept	Average Total
Temperature °C	Monthly Average	**15,9**	**8,2**	**3,9**	**0,9**	**8,0**	**8,8**	**14,9**	***17,2***	**26,0**	**27,2**	**26,8**	***20,2***	**14,8**
	Multiannual Average Last 30 Years	11,7	5,1	0,3	-1,3	0,8	6,0	12,0	*17,7*	21,6	22,8	23,5	18,1	11,6
	Deviation	**+4,2**	**+3,1**	**+3,6**	**+0,4**	**+7,2**	**+2,8**	**+2,9**	***-0,5***	**+4,4**	**+4,4**	**+3,3**	**+2,1**	**+3,2**
Precipitation mm	Amount Monthly	**21,4**	**124,2**	**21,4**	**26,8**	**11,6**	**22,4**	**26,0**	***71,8***	**31,6**	**95,2**	**6,0**	***19,0***	**477,4**
	Multi annual Media Last 30 Years	46,0	37,0	39,1	30,8	26,3	34,2	47,8	*58,6*	69,7	62,1	46,6	43,5	541,7
	Deviation	**-16,8**	**+87,2**	**-17,7**	**-4,0**	**-14,7**	**-11,8**	**-21,8**	***+13,2***	**-38,1**	**+33,1**	**-40,6**	**-24,5**	**-64,3**

Production and quality

In 2023, the highest production was recorded for the Glosa variety in the variants shown at a depth of 4 cm, respectively 5720 kg/ha and 5280 kg/ha in the variant shown at a depth of 6 cm. The variant shown at 8 cm recorded a production of 3080 kg/ha, significantly reduced compared to the other two depths tested. The differences between the two varieties were small, the Boema variety gave yields of 5720 kg/ha when shown at 4 cm and 5280 kg/ha at 6 cm. The variant is shown at a depth of 8 cm recorded 3980 kg/ha. Regarding the yields obtained at the two showing dates, the yields were similar (Table 3).

Table 3. Production results obtained for wheat crops in 2023 and 2024

Year	Variety	Depth/ Date sown 10 Oct	Production/ kg/ha	Depth/ Date sown 20 Oct	Production / kg/ha
2023	Glosa	4 cm	5720	4 cm	5650
		6 cm	5280	6 cm	5000
		8 cm	3980	8 cm	3860
	Boema	4 cm	5670	4 cm	5200
		6 cm	5050	6 cm	4850
		8 cm	3700	8 cm	3680
2024	Glosa	4 cm	4820	4 cm	4650
		6 cm	4480	6 cm	4360
		8 cm	3650	8 cm	3400
	Boema	4 cm	4770	4 cm	4600
		6 cm	4470	6 cm	4350
		8 cm	3420	8 cm	3280

The year 2024 recorded, due to the drought that is increasingly felt, lower productions compared to the previous year by approx. 1000 kg/ha for all variants. Thus, the lowest productions were recorded for the variants that were sown at a depth of 8 cm, which denotes the idea that the humidity that would be found with the increase in the sowing depth does not guarantee better production. The lowest production was recorded for the Boema variety, the variant sown at a depth of 8 cm, respectively 3680 kg/ha.

Interpreting the parameters analyzed for the two wheat varieties in 2023, it results that the protein varies between 12.207% and 12.657 %, values that fall into the category of good quality wheat for baking. At all depths, when sowing on October 20 compared to October 10, the Glosa variety presents slightly higher protein values, varying between 12.657% and 12.386%. In contrast, for the Boema variety, higher protein values were recorded at early sowing October 10 at a depth of 4 cm, the situation being reversed at greater depths. We can also observe that when sowing on October 20, the Glosa variety exceeds the Boema variety in protein content as follows: at a depth of 4 cm the difference is 0.056%; at a depth of 6 cm, it is 0.018 %, and at a depth of 8 cm, it has a value of 0.053%. The average differences at the three depths are 0.042%, which represents the average advantage of the Glosa variety over Boema in terms of protein content at the showing on October 20.

For both varieties, a clear trend of decreasing protein content is observed with increasing sowing depth. The highest protein values are recorded at a depth of 4 cm, and the lowest at a depth of 8 cm. The Glosa variety presents slightly higher protein values than Boema at all sowing depths, with the largest difference of 0.056% at a depth of 4 cm.

Starch, which serves as the main source of energy for animals and humans, is a crucial parameter for breadmaking quality and milling yield and varies between 57.537% and 61.198%. Especially when shown early, the Boema variety generally has higher starch values compared to Glosa. When shown on October 10, the maximum starch value of 61.198% is recorded for the Boema variety at 4 cm depth. In Glosa, early snowing causes an increase in starch with depth, from 57.537% to 60.944%. The starch values for the sowing on October 20 are more homogeneous for both varieties.

Digestibility shows values varying between 89.284% and 93.181%, the Boema variety shows the maximum value of 93.181% at a depth of 4 cm shown on October 20. For the sowing on October 10, digestibility increases with depth for the Glosa variety, but the Boema variety generally shows higher values. The

nutritional quality and processing are given by fiber content varying between 1,3307 and 2,6308. The maximum values of 2,6308 and 2,3154 are recorded for the Boema variety shown at 4 cm and 6 cm on October 20. The ash content, an indicator of mineral content, varies between 1,1418 and 2,2438. Glosa has higher ash values compared to Boema at both sowing dates, thus, the maximum value of 2,2438 is recorded at Glosa 4 cm at the sowing date of October 10 (Table 4).

Table 4. Variation of wheat quality parameters depending on variety, depth and sowing time 2022-2023

Variety	Depth/ Date sown 10 Oct	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah_as
Glosa	4 cm	12,603	57.537	1.4681	89.284	2,1678	1.4952	2,2438
	6 cm	12,523	59.72	0.84841	90.273	1,7502	1.1921	1,5901
	8 cm	12,355	60.944	0.98477	90.376	1,4451	1.2191	2,1746
Boema	4 cm	12,594	61.198	1.3463	91.415	1,3307	1.2104	1,7957
	6 cm	12,416	59.763	0.21491	90.241	1,8549	1.3241	1,5766
	8 cm	12,207	60.183	0.82987	90.257	1,8509	1.2275	1,6534
Variety	Depth/ Date sown 20 oct	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah_as
Glosa	4 cm	12,657	60.49	0.75394	89.664	1,5176	1.2046	2,1954
	6 cm	12,531	59.75	1.777	90.119	1,5778	1.2301	1,8891
	8cm	12,386	59.695	1.1676	90.27	1,8174	1.0707	2,0516
Boema	4 cm	12,601	60.867	0.7195	93.181	2,6308	0.8113	1,1418
	6 cm	12,513	58.309	0.42983	89.449	2,3154	1.0993	1,4315
	8 cm	12,333	59.378	0.79453	90.046	1,6942	1.4423	1,9351

The comparison between varieties and showing dates shows that at a depth of 4 cm, the Glosa variety shown on October 20 has a maximum protein value of approximately 12.99%, slightly higher than the Glosa variety shown on October 10, approximately 12.98%. Regarding the performance of the Glosa varieties, it generally has a higher protein content than the Boema variety at all sowing depths (Figure 1). The 4 cm depth is optimal for maximizing protein content in both varieties, regardless of the sowing date. If for agrotechnological reasons a deeper sowing is necessary, the Glosa variety shown on October 10 seems to maintain a higher protein content at 8 cm depth compared to the other variants. The differences in protein content, although apparently small (around 0.3-0.5%), can have a significant impact on the commercial value of wheat and its classification into quality categories.

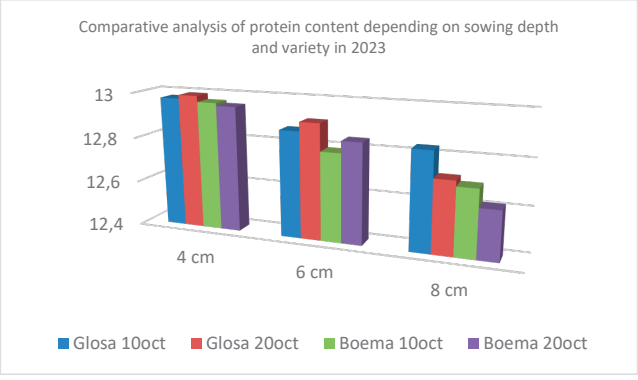

Figure 1. Comparative analysis of protein content depending on sowing depth and variety in 2023

The results of the parameters analyzed for the 2024 productions recorded a protein content varying between 12.617% for Boema shown on October 10 and 12.992% for Glosa shown on

October 20, both shown at a depth of 4 cm. In general, the protein content decreases with increasing sowing depth for both varieties and both sowing dates. The starch content shows relatively close values for both varieties, the maximum value of 59.988% was recorded for the Boema variety shown at a depth of 6 cm on October 10. In the Glosa variety, starch decreases with depth on both showing dates. In general, there is no clear correlation between showing depth and starch content. The highest sugar content value is 2.0164% and is recorded in the Boema variety shown at 4 cm on October 20. The sugar content values are generally lower at a depth of 6 cm for both varieties when sown on October 10. Digestibility varies between 89.032% and 94.161% respectively, the value recorded in the Boema variety sown at 4 cm depth on October 10, a value that indicates excellent digestibility. Also, the value of 92.455% recorded in the Glosa variety show at 6 cm depth on October 10 shows high digestibility. When shown on October 20, the fiber content increases with depth for both varieties. The minimum values are recorded at a depth of 4 cm for both varieties when shown on October 20. The fat content varies between 1.0265% for the Glosa variety shown at 4 cm depth on October 10 and respectively 1.4423% recorded for the Boema variety sown at 8 cm depth on October 20. These values are relatively homogeneous, with no clear trends related to depth or slowing date. The ash content varies between 1,1267 and 2,1625, the highest value being recorded for the Boema variety sown at 4 cm depth on October 10. When sowing on October 20, the Boema variety presents higher values at all sowing depths (Table 5).

Table 5. Variation of wheat quality parameters depending on variety, depth and sowing time 2023-2024

Variety	Depth/ Date sown 10 Oct	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah_as
Glosa	4 cm	12,976	59.802	1.0629	89.741	1,7551	1.0265	1,7594
	6 cm	12,869	59.497	0.59616	92.455	3,2863	1.27	1,7036
	8 cm	12,654	59.243	0.56947	89.772	2,0132	1.1003	1,6528
Boema	4 cm	12,966	58.504	1.6537	94.161	4.4442	1.2539	2,1625
	6 cm	12,790	59.988	0.40881	90.012	1,8479	1.1267	1,1267
	8 cm	12,695	58.916	0.48617	89.33	1,8338	1.1127	1,7731
Variety	Depth/ Date sown 20 oct	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah_as
Glosa	4 cm	12,992	59.945	1.064	89.672	1,3451	1.0391	1,7144
	6 cm	12,909	59.228	0.97033	89.653	1,7812	1.161	1,7563
	8cm	12,719	59.207	0.80891	89.032	2,1808	1.2378	1,5113
Boema	4 cm	12,954	58.982	2.0164	90.613	1,4459	1.1514	2,0277
	6 cm	12,842	58.477	1.0849	89.408	2,1567	1.3599	1,697
	8 cm	12,617	59.819	1.3439	90.346	1,7708	1.1164	1,7078

The variation of protein content in the two varieties at the three sowing depths and the two periods shows a clear trend of decreasing protein content with increasing sowing depth for all combinations of variety-sowing date. The optimal depth for maximizing protein content is 4 cm for both varieties, regardless of sowing date. The best option for obtaining a high protein content is Glosa shown on October 20 at a depth of 4 cm. The differences between protein values at 4 cm and 8 cm are significant, approximately 0.3-0.4% and although they may seem small, they can have a significant impact on the qualitative classification of wheat and, implicitly, on the market price (Figure 2).

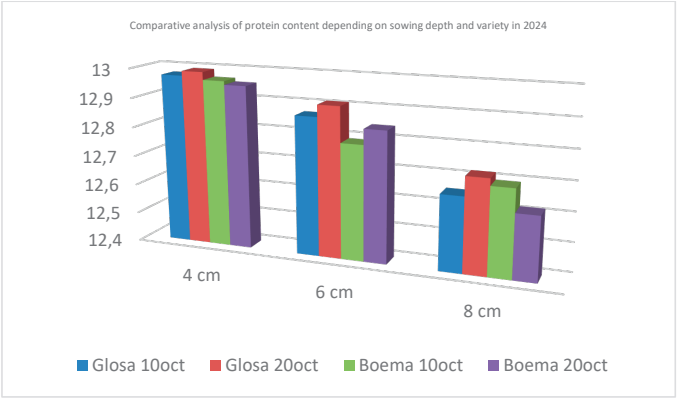

Figure 2. Comparative analysis of protein content depending on sowing depth and variety in 2024

CONCLUSIONS

Over the two years, the experimental results showed that the three sowing methods used produced statistically similar results in the main measured parameters. Variability in the rainfall regime affects crop yield, especially in years with below-average rainfall. The lack of adequate autumn rainfall can delay the sowing of wheat crops in environments where irrigation is not available. Wheat grown in the Boian Plain has a high potential to produce high-quality grains with a significant protein content, due to the combination of fertile soils, favorable climate and appropriate agricultural practices. In order to maintain this potential, it is essential to adopt measures that counteract climatic variability and support the sustainability of the region's soils. Regarding the optimal depth for breadmaking quality, it seems to be 4 cm for both varieties, with proteins decreasing with increasing depth. Influence of sowing date for Glosa, sowing on October 20 favors protein accumulation. For Boema, early sowing on October 10 at a depth of 4 cm provides the best protein-starch balance. Glosa has advantages for bakery due to its protein-starch balance, while Boema has superior starch and digestibility values.

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