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Productivity and quality of common wheat varieties (*Triticum aestivum* L.) in the climatic conditions of Southern Dobrudzha

Georgi Kostov*, Hristofor Kirchev

Agricultural University – Plovdiv, Bulgaria
***Corresponding author: georgikostovx@abv.bg**

Abstract

Wheat is one of the oldest agricultural crops and it is used for food by more than a half of the population on Earth. The economic importance of soft wheat and its contribution to human and livestock diets is undisputable. The aim of the current study was to determine the effect and interaction of factors such as variety and year on the yield and grain quality of common wheat varieties. With each subsequent harvest year, drought and an increase in the average daily temperature were observed, which proved to have an adverse effect on some indicators. The results showed that all four varieties have good productivity and quality during the observed harvest years and are suitable for growing in Southern Dobrudzha area, while at the same time the Sobel variety stood out. The results from the study imply that the test weight was influenced to a greater extent by weather conditions than by genotype.
***Keywords*:** wheat, varieties, productivity, quality, weather conditions, Dobrudzha

INTRODUCTION

Cereal crops, including wheat, are the basis of world agriculture. Wheat is the dominant crop in countries with temperate climate and is used for human and livestock food. It can be cultivated from the Arctic Circle to the Equator, and up to 4000 meters above sea level (Panayotov, 2021). In addition of being the major source of starch and energy, wheat also provides significant amount of components that are essential or beneficial to health, particularly protein, vitamins (especially B vitamins), dietary fibres and phytochemicals (Shewry & Hey, 2015).

Over the centuries, bread and other baked goods have become powerful symbols of culture, nutrition, economic stability, and well-being. The overall consideration of quality in particular region depends on its climatic conditions. They determine whether spring, winter or optional crops are economically viable for the producer, as well as the harvesting conditions, available processing technology and consumer expectations regarding end-use needs (Carson & Edwards, 2009). Wheat is grown in a wide diversity of varieties according to the region's climatic conditions and dietary traditions.

Productivity is a complex indicator and can be determined by several main factors, the influence of which has been studied to varying degrees. The modern knowledge of productivity is based on traits that can be grouped as follows: (1) root and root/biomass ratio; root power and penetration depth; (2) the stem as the bearer of the yield; sound and conforming to the conditions; (3) the class, as a classic architecture, determining yield; complex class; (4) the leaf system, its photosynthetic activity and longevity; (5) resistance/tolerance to the main stress factors – biotic and abiotic; (6) ratio between the main gene complexes Vrn, Pht, Rht, Fr, Tls and their influence on productivity; optimal stem-class-sibling combination (SST); (7) productivity selection methods (Panayotov, 2021).

The aim of the present study is to determine the effect and interaction of the factors variety and year on the yield and grain quality of wheat varieties, grown in the area of the town of General Toshevo.

MATERIALS AND METHODS

During the period 2021-2023, a field experiment was carried out under the climatic condition in South Dobrudzha, focusing on the area around General Toshevo in the Dobrich region. The following varieties of soft wheat were studied Annapurna, Katarina, Sofrou and Sobel (Table 1). The predecessor was sunflower (*Helianthus annuus* L.). The experiment was conducted using a block design with a plot size of 15 m^2 and four repetitions. Four French varieties were chosen because they are preferred among the agricultural producers in Bulgaria due to their high productivity.

The physical and chemical-technological quality indicators of grain, and the corresponding methods of analysis, that were determined included: test weight – ISO 7971-3:2019, 1000 g. (absolute) grain mass – BSS 13358 – 76, wet gluten yield (WGY) – BSS 13375-88, Gluten release – ISO 13375

Soil and climatic conditions

Chernozems are widely distributed across much of the hilly Danube Plain, partly on the North-Western plateau, and on the Dobrudzha and Ludogorie plateaus to the south. Chernozems cover approximately 2,250,000 hectares, or 20 % of Bulgaria` territory (Shishkov & Kolev, 2014).

Leached chernozems are the most prevalent soils of the chernozem group. They dominate the Danube region of Northeast Bulgaria (Penkov, 1996). In contrast to carbonate and typical chermozems, leached chernozems develop under slightly wetter and milder transitional continental climatic conditions, influenced by forest-steppe vegetation and heavier soil-forming materials such as medium to heavy sandy-clay loess. This soil type is characterized by a relatively well-developed soil profile, consisting of two main genetic horizons: a humus-accumulative horizon (up to 60 cm) and a carbonate-free transitional horizon (60-80; 90 cm).

Agroclimatic conditions

The study years were marked by diverse temperature and precipitation conditions, enabling the observation of the studied varieties' reactions regarding their quality indicators under varying agro-climatic circumstances. Climatographic data for the three crop years is provided below. (Fig. 1, Fig. 2 and Fig. 3).

In the harvest year 2020/2021, the highest rainfall was recorded in June (162.7 mm), and the highest air temperature occurred in July (22.8℃). February had the least precipitation (13.2 mm), while the lowest air temperature was recorded in January (3℃). The average precipitation for the period was 59.9 mm, and the average air temperature was 10.44℃ (Fig. 1).

In the harvest year 2021/2022 the highest precipitations were recorded in October (89.2 mm), and the highest air temperature occurred in June (20.6℃). July had the least precipitation (5.8 mm), while the lowest air temperature was recorded in January (1.6℃). The average rainfall was 41.65 mm, with an average air temperature of 9.69℃ (Fig. 2).

Table 1. Characteristics of the tested common wheat varieties

Variety	Type	Breeder	Country
Annapurna	Lutescens	Limagrain	France
Katarina	Lutescens	Saaten Union International	France
Sobel	Lutescens	Caussade Semences (now Lidea)	France
Sofrou	Erythrospermum	Lidea	France

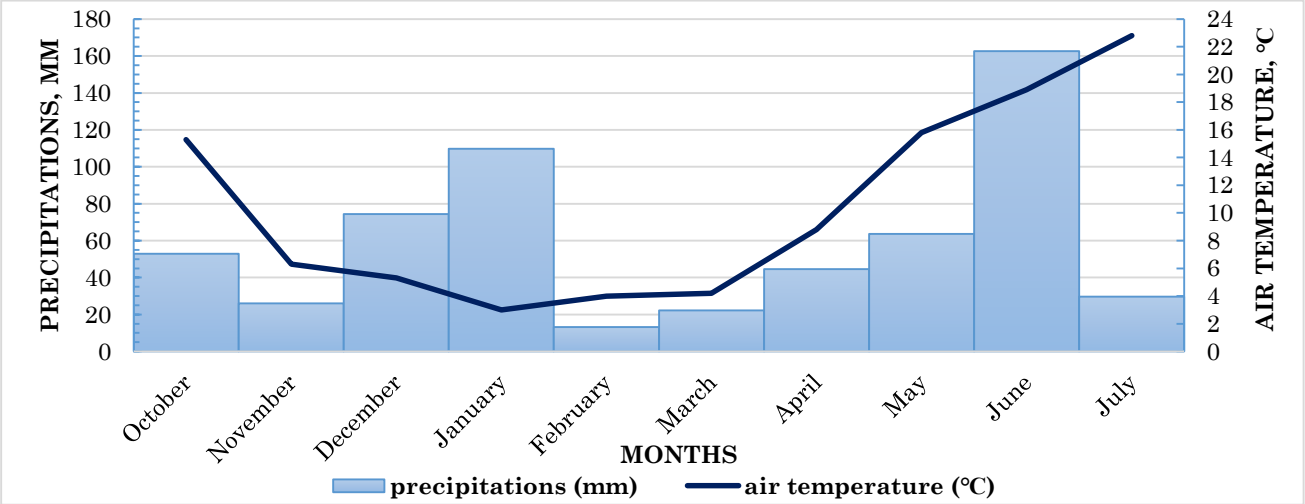

Figure 1. Climatogram for the 2020/2021 harvest year.

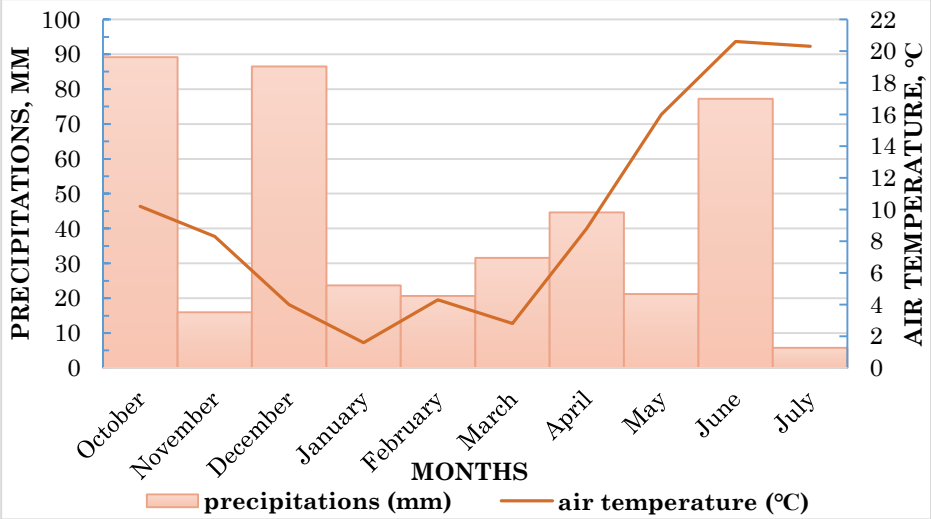

Figure 2. Climatogram for the 2021/2022 harvest year.

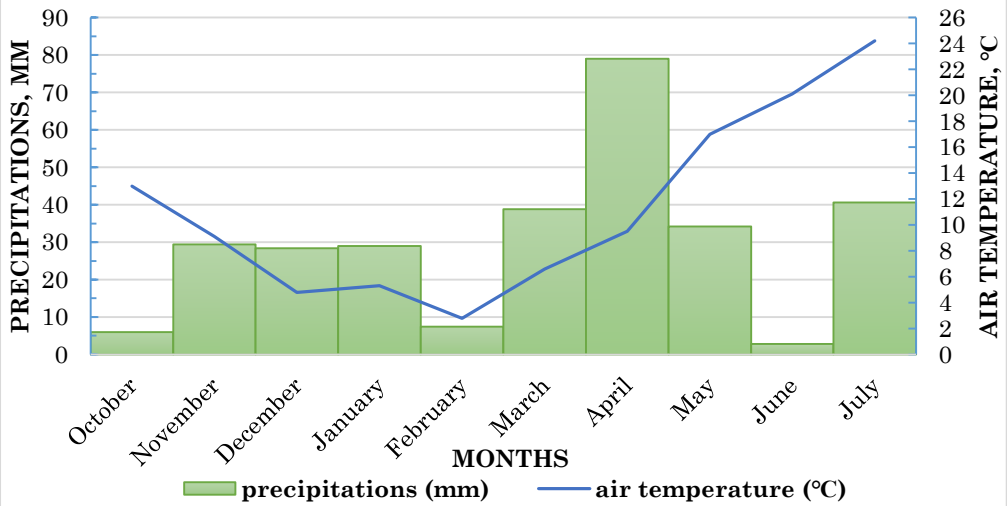

Figure 3. Climatogram for the 2022/2023 harvest year.

In the harvest year 2022/2023, the least precipitation was recorded in July (2.8 mm), while the lowest air temperature occurred in February (2.8℃). April had the highest precipitation (79 mm), while the highest air temperature occurred in July (24.2℃). The average precipitation for the period was 29.56 mm, and the average air temperature was 11.24℃ (Figure 3).

RESULTS AND DISCUSSION

Productivity is the primary parameter which determines the economic quality of a particular variety. The studied varieties differed in terms of grain yield obtained during the years of the study (Table 2). In 2021, the Sobel variety achieved the highest yield at 6.92 t/ha. In 2022, the Sofru variety produced the highest yield with 6.65 t/ha, while in 2023 the Annapurna variety had the highest yield at 5.40 t/ha.

During the three years of the study, the Katarina variety recorded the lowest yield with 6.24 t/ha in 2021, 4.96 t/ha in 2022, and 3.80 t/ha in 2023. On average, for the period 2021-2023, the Katarina variety had the lowest yield (5.00 t/ha), while the Sobel variety achieved the highest yield (5.907 t/ha). The ranking of the varieties by productivity in descending order is as follows: *Sofru* > *Sobel* > *Annapurna* > *Katarina*.

The hectoliter mass of the tested soft wheat varieties ranges from 76 to 81.1 kg (Table 3). When it was below 72 kg, it was considered as not suitable for obtaining flour. It was found that the hectoliter mass does not influence the baking qualities since wheats with high hectolitre mass have low baking qualities. For the same variety grown under different agrophones, the grain with a higher hectoliter weight has better baking qualities. This is attributed to its protection or the ability to reach the variety` potential under specific conditions. The hectoliter mass of tested varieties in all three years were higher than the minimum for flour production (72 kg).

The ranking of the varieties in terms of their hectoliter weight averaged over the three vintage years in descending order is as follows: *Sobel* > *Katarina* > *Sofrou* > *Annapurna* (Table 3).

Table 2. Grain yield (t/ha)

Variety	**Year**			***Average for the variety***
	2021	***2022***	***2023***	
Annapurna	6.30	5.81	5.40	*5.836*
Sobel	6.92	5.95	4.85	*5.907*
Sofrou	6.75	6.65	5.11	*6.17*
Katarina	6.24	4.96	3.80	*5.00*
LSD 5%	*286*	*302*	*295*	*294*

Table 3. Test weight of grain, kg.

Variety	**Year**			***Average for the variety***
	2021	***2022***	***2023***	
Annapurna	77.5	77.0	76.0	*76.83*
Sofrou	78.0	78.3	77.9	*78.06*
Sobel	81.1	78.5	78.8	*79.47*
Katarina	80.2	80.0	77.4	*79.2*
Average for the year	*79.2*	*78.45*	*77.53*	

Table 4. Mass of 1000 grains, g

Variety	Year			*Average for the variety*
	2021	***2022***	***2023***	
Annapurna	50.20	51.72	43.44	*48.45*
Sobel	54.63	50.00	47.37	*50.67*
Sofrou	49.68	45.97	43.89	*46.51*
Katarina	47.25	46.73	48.64	*47.54*
Average for the year	*50.44*	*48.61*	*45.84*	

Table 5. Wet gluten yield (WGY), %

Variety	Year			*Average for the variety*
	2021	***2022***	***2023***	
Annapurna	27.0	25.5	22.8	*25.1*
Sobel	29.1	22.6	24.5	*25.4*
Sofrou	28.0	21.4	23.0	*24.13*
Katarina	30.2	20.4	30.7	*27.1*
Average for the year	*28.58*	*22.48*	*25.25*	

The highest hectoliter mass was recorded during the 2020/2021 harvest year, coinciding with the greatest level of precipitation. Similarly, the lowest hectoliter mass was observed in the 2022/2023 harvest year, which experienced the least amount of precipitation.

The mass of 1000 grains is one of the important indirect indicators characterizing the properties of the grain - its technological value and its quality as seed material (Ivanova & Kirchev, 2018). This indicator characterizes the fullness and density of the grain.

The absolute mass of the grain changed under the influence of the conditions of the year, with the heaviest grain on average for the varieties in the first year of the study – 50.44 g, and with the lowest mass per 1000 grains – 45.84 g in the dry year of 2023. The mass of 1000 grains is a varietal characteristic, with the highest absolute mass being the grain of the Sobel variety – 50.67 g, and the lowest absolute weight being the grain of the Sofrou variety – 46.51 g.

Gluten is the main component of the wheat grain, which determines the possibility of producing quality bread from wheat flour. Its quantity determines the bread quality, which makes it one of the main bakery quality indicators (Ivanova & Kirchev, 2018). It is assumed that each variety synthesizes specific gluten, which is different from the gluten of other varieties.

The ranking in descending order of soft wheat varieties of wet gluten yield (%) averaged from the three crop years is as follows: *Katarina* > *Sobel* > *Annapurna* > *Sofrou* (Table 5). Weather conditions affect the amount of gluten (Ivanova & Kirchev, 2018). The highest content of wet gluten in the wheat grain accumulates in the first year (28.58%), followed by the third year of the study (25.25%), while the lowest amount was estimated in the second year – 22.48%. The main indicator determining the quality of gluten is its release (Ivanova and Kirchev, 2018).

Grain becomes unsuitable for bread production when gluten relaxation exceeds 10 mm. The highest recorded value over the three years was 10.0 mm in 2021 for the Katarina variety, placing it at the threshold (Table 6). The lowest gluten relaxation was observed in the Annapurna variety (7.27 mm), while the highest was recorded for the Katarina variety (9.73 mm).

Table 6. Gluten release, mm

Variety	Years			*Average for the variety*
	2021	***2022***	***2023***	
Annapurna	6.5	9.0	6.3	*7.27*
Sobel	7.4	9.4	6.6	*7.8*
Sofrou	7.7	9.2	6.3	*7.73*
Katarina	10.0	9.7	9.5	*9.73*
Average for the year	*7.9*	*9.33*	*7.18*	

The lowest quality gluten was formed in 2022, averaging 9.33 mm. The studied varieties exhibited varying gluten quality, with the lowest gluten yield recorded for the Annapurna variety (7.27 mm), and the highest for the Katarina variety (9.73 mm).

CONCLUSIONS

The yield of the four varieties varies, and, when arranged in descending order, is as follows: Sofrou > Sobel > Annapurna > Katarina. The fact that all four varieties produce grain of relatively similar density demonstrates that test weight is influenced far more by weather conditions than by genotype. It has been established that dry years result in a lower 1000-grain mass, whereas the highest 1000-grain mass is observed in years with sufficient moisture. The data reveal a direct proportionality between precipitation levels and grain test weight, indicating that inadequate rainfall during the growing season negatively impacts wheat grain formation. The experiment also shows that drier years lead to higher grain protein content, and, as a protein component, gluten is closely linked to the grain's protein content. The highest gluten release was observed in 2022, a year with neither excessive moisture nor extreme dryness. Based on the experiment, it can be concluded that, under the climatic conditions of Southern Dobrudzha, the highest productivity and quality are achieved in years with favorable rainfall.

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