INFLUENCE OF VARIETY AND AGROECOLOGICAL CONDITIONS ON CHARACTERISTICS OF WHEAT

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Abstract. *Wheat production is under pressure due to climate change, increasing input production and higher demand for grain. Successful production depends on certain factors such as agroecological conditions, technical management and genotype, i.e., variety. The main goal was to determine yield, yield components and other morphological and agronomic characteristics of different wheat varieties and to analyze weather conditions during the 2020/2021 vegetative season. The research was conducted on agricultural holding in eastern Croatia according to RCB design in three replications. In general, the weather during 2020/2021 did not deviate too much compared to the observed long-term mean, but significant deviations in distribution were recorded during individual months. The precipitation deviation ranged from -99.7 % (June) to + 51.0 % (December), while air temperature oscillations were even more pronounced. The implemented agrotechnics were in accordance with the profession's recommendations for adequate plant protection and mineral fertilization. The analysis of variance revealed significance for five out of nine properties studied (number of grains per ear, 1000 grain mass, hectolitre mass, plant height and ear length). The average yield of all five varieties in this survey was 9.36 t ha^{-1}. Each variety had certain advantages in terms of one and/or more characteristics, as the yield differences were not statistically justified. By sowing high yield varieties of different seed companies, it is possible to achieve higher and more stable yields, which is the goal of every production. Choosing the right varieties of wheat for a particular area is also important due to the increasingly pronounced climate changes.*

Keywords*: wheat, variety, weather conditions, yield, properties*

INTRODUCTION

Wheat is one of the most abundant cereals in the world, both in terms of arable land and production (FAOStat, 2024). It is used as human food, raw material for various industries, and animal feed. Wheat provides around 19% of calories and 21% of protein daily for humans (TADESSE ET AL., 2019). Considering the exponential growth of the population, the need for wheat will be more pronounced in the future, especially in developing countries (OECD/FAO, 2019; HONGJIE ET AL., 2019). However, wheat cultivation is under pressure. Increasing production costs, especially seeds, pesticides and mineral fertilizers, negative weather fluctuations, climate change, and increased demand for wheat are just some of the issues that need to be addressed.

Nowadays, the successful production of wheat is mostly influenced by weather conditions, applied agricultural techniques, and the selection of varieties. For agricultural producers, the choice of wheat varieties is difficult. On the plant variety catalogues of the Republic of Croatia, depending on the year, there are between 150 and 200 species, and with the common EU variety list, that number is much higher. However, the choice of variety can significantly contribute to tolerance to weather conditions and positively influence yield stability. For example, based on forty Croatian wheat genotypes grown under water deficit conditions, the yield decrease was from 14% to 50% (BARIĆ ET AL., 2008). Generally, the strong interaction of environmental factors on yield and yield stability through the wheat varieties was shown (IVANOV ET AL., 2018; MANDEA ET AL., 2019).

The research aimed to determine yield (t ha^{-1}), yield components (plant density, number of grains per ear and 1000 grains mass), morphological and agronomic properties (hectoliter mass, plant height, ear length and ear mass) of five different varieties of winter wheat grown during the 2020/2021 growing season.

MATERIAL AND METHODS

Field experiment

The field experiment was set up on October 31, 2020, on the arable area of the family farm "Pro farm Mandić" in east Croatia (Osijek-Baranja county) according to RCB design in three repetitions. A total of five varieties of winter wheat from different seed companies were used. Bologna and Falado belong to Syngenta company, Kraljica and El Nino belong to Agricultural Institute Osijek company and Maja to Agrigenetics company. According to the recommendation, Kraljica and El Nino were sown in the amount of 330 kg ha^{-1}, Maja in the amount of 235 kg ha^{-1}, and Falado and Bologna in the amount of 230 kg ha^{-1} and 220 kg ha^{-1}, respectively. After the sunflower harvest, 250 kg ha^{-1} of mineral fertilizer 0:20:30 (NPK) was applied, and a total of three top dressings were done during vegetation season. The first was done on March 7, 2021, with 190 kg ha^{-1} of CAN (calcium ammonium nitrate, 27% N), the second on March 30, 2021, with 175 kg ha^{-1} of CAN and the third was done on April 20, 2021, with 150 kg ha^{-1} of CAN. A total of 172 kg ha^{-1} of nitrogen, 50 kg ha^{-1} of phosphorus and 75 kg ha^{-1} of potassium were applied. Further, Lector Delta and Filon 80 EC herbicides were used for weed control, Impact C, Zakeo Extra and Prosaro 250 EC fungicides were used for plant diseases, and Karate Zeon insecticide was used against pests.

Before harvest, in the full ripening stage, plant sample was taken manually for each variety and repetition. Plant density was determined by counting all ears from 1 m^2. The 1000 grain mass (g) and hectoliter weight (kg hl^{-1}) were analyzed with the apparatus Perten AM 5200-A. Additionally, a total of 30 plants were taken to analyze morphological traits. Plant height (cm), ear length (cm), number of grains per ear and ear mass (g) were determined by measuring with a meter, separating, weighing on an analytical balance and counting grains. Yield was calculated on 14% grain moisture.

Meteorological data

Average monthly air temperature (°C) and monthly precipitation (mm) during the 2020/2021 wheat growing season, as well as long-term mean (LTM) for the period from 1991 to 2020, were collected at the Đakovo meteorological station of the Croatian meteorological and hydrological service.

Statistics

The results were processed using the computer programs Excel and SAS Software 9.1.4. (SAS Institute Inc., 2003). Statistical processing of data on the investigated properties was carried out by individual analysis of variance with the use of the F test. The significance of the differences between the average values of the examined factors and the treatment was assessed by LSD.

RESULTS AND DISCUSSIONS

For successful wheat production, about 600 - 700 mm of well distributed precipitation is needed (KOVAČEVIĆ AND RASTIJA, 2014). During the winter months, wheat does not need too much precipitation because it is in the phase of slow growth, while the needs increase during the transition from the tillering phase to the elongation phase and beyond. Compared to the long-term mean, the 2020/2021 growing season was average in terms of weather conditions with certain deviations. In winter, when wheat needs water in smaller quantities, precipitation was significantly higher than the annual average (Table 1). In such conditions, water retention

on the surface is dangerous, which causes increased wheat mortality and less plant density. In the spring period, the amount of precipitation was almost optimal for the growth and development of wheat, but a distinct deficiency occurred in June when only 3 mm of precipitation fell. In the context of air temperatures, higher temperatures were recorded in the period from December to February (2.34 °C) compared to the LTM, while in the spring period (March-May), they were lower than the LTM by 1.7 °C. Considering that wheat is in that period in III., IV., V. and VI. organogenesis phase, lower temperatures can have a positive effect on the better formation of ear length and the number of flowers in spikelets.

Table 1.

Monthly amounts of precipitation (mm) and average air temperature (℃) during 2020/2021 and long-term average (LTM) from 1991 to 2020

Year / Month	X	XI	XII	I	II	III	IV	V	VI	VII	Total
	Precipitation (mm)										
2020/2021	81.1	25.0	92.9	73.0	39.6	36.2	64.1	66.7	2.9	48.3	529.8
LTM	68.9	62.6	61.4	53.3	48.2	49.1	55.1	69.8	87.2	62.7	618.3
Deviation %	+17	-60	+51	+36	-18	-26	+16	-5	-97	-23	-14
	Air temperatures (°C)										Average
2020/2021	12.7	6.4	4.2	2.8	5.2	6.4	9.8	15.4	23.6	25.2	11.2℃
LTM	11.8	6.8	1.8	0.7	2.7	7.1	12.4	17.2	20.9	22.6	10.4 ℃
Deviation %	+8	-6	+33	+300	+93	-10	-21	-11	+13	+12	+8

Analysis of variance shows statistical significance for 5 of the 9 investigated properties (Table 2). As the most important characteristic, the yield was not significant, indicating that all tested varieties are equally good. Furthermore, the analysis of variance determined the difference between the kernel number per ear, 1000 grain mass, hectoliter mass, plant height, and ear length. The highest F value was determined for the hectoliter weight, followed by the 1000 grain mass and the kernel number per ear, and the lowest for yield.

Table 2.

Analysis of the variance of the investigated parameters

	Average	F value	Pr > F	$LSD_{0.05}$	Coefficient of variation
Yield	9.36	0.47	0.7547	ns	13.43
Plant density / m²	716	1.18	0.3775	ns	15.75
Kernel number / ear	35.7	15.40	0.0003	3.56	5.48
1000 grain mass	34.7	16.75	0.0002	3.53	5.59
Hectoliter mass	79.38	48.39	<.0001	1.79	1.24
Ear mass	52.43	2.51	0.1082	ns	8.97
Plant height	63.6	6.78	0.0066	4.93	4.26
Ear length	7.78	5.16	0.0162	0.47	3.35

In our research, the average yield of wheat grains was relatively high (9.36 t ha^{-1}) if compared with the average level of the Republic of Croatia. The main reason can be a relatively high number of ears per m^2. The highest yield was achieved in Falado (10.15 t ha^{-1}), followed by the Bologna (9.46 t ha^{-1}), El Nino (9.26 t ha^{-1}) and Maja (9.01 t ha^{-1}). The lowest yield was achieved by the variety Kraljica (8.86 t ha^{-1}), which is unexpected because it is a variety with a high fertility potential (Figure 1). Furthermore, two of the three yield components showed significance based on the variance analysis. On average, 36 kernels per ear were achieved with variation from 43 (Bologna) to 31 (Kraljica). Also, the average value of

the 1000 grain mass was 35.3 g and varied from 27.7 g to 42.6 g. The highest value was achieved by the varieties Maja and Falado (41.4 g and 37.4 g), followed by the variety El Nino (32.7 g), Kraljica (31.5 g) and variety Bologna with the lowest average of 1000 grain mass (30.4 g). ILJKIĆ ET AL. (2019) emphasize the role of yield components and their complementarity effect.

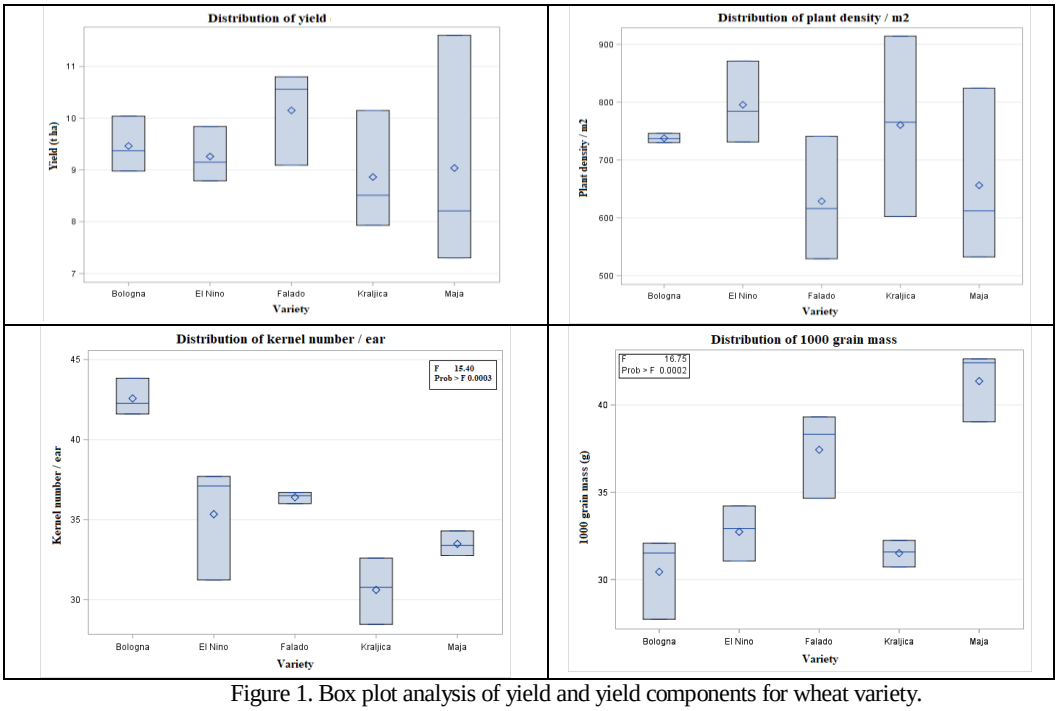

Figure 1. Box plot analysis of yield and yield components for wheat variety.
The rhombus in the column represents the average value.

The hectoliter mass is an important agronomic trait, especially in the context of grain purchase. However, the average value of hectoliter mass in the research was a very low 77.58 kg hl^{-1}. The Falado variety had the lowest hectoliter (64.96 kg hl^{-1}), while the Maja had the highest hectoliter mass (83.93 kg hl^{-1}). Other morphological traits are not directly connected to the yield but can indirectly positively or negatively impact yield. For example, plant height or ear length. The average plant height was 63.6 cm and ranged from 68.7 cm (Falado) to 60.5 cm (El Nino). The ear length varied from 8.13 cm (Falado) to 7.47 cm (Bologna). Generally, in our experiment, the variety with the highest grain yield (Falado) had the highest plant, the longest ear and the ear mass. Maeoka et al. (2020) stated that wheat yield is mostly associated with plant density, kernel number per ear, kernel weight and reduced plant height.

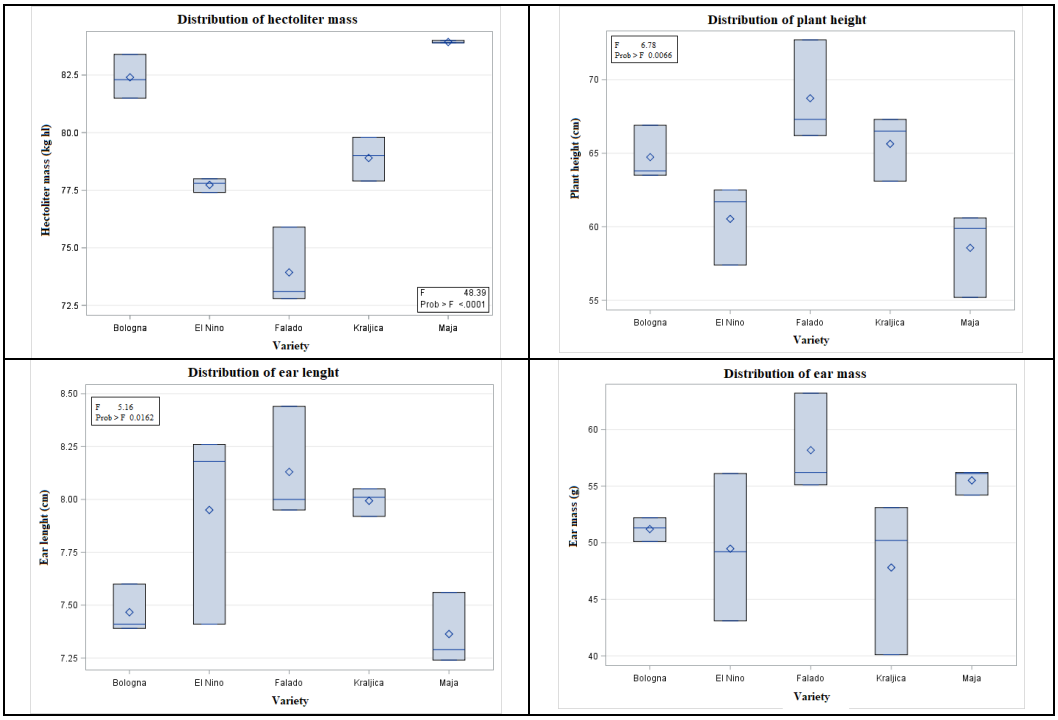

Figure 2. Box plot analysis of agro-morphological properties for wheat variety.
The rhombus in the column represents the average value.

CONCLUSIONS

This experiment aimed to assess the impact of different wheat varieties on yield, yield components, and agronomic and morphologic traits. Analysis of variance showed significance for the number of grains per ear, 1000 grain mass, plant height, ear length and hectoliter weight, while other properties, including yield, were not significant. The Falado variety achieved the highest yield, the longest ear, the tallest plant and the largest ear mass. El Nino achieved the highest plant density, Bologna had the highest number of grains per ear and the hectoliter weight, and Maja had the highest 1000 grain mass. Our study has shown that each variety had some advantage in the context of one or more properties. We suggest that sowing high-yielding varieties from different seed companies is possible to achieve higher and more stable yields, which is the goal of every production.

BIBLIOGRAPHY

BARIĆ, M., KERFŠA, S., HABUS JERČIĆ, I., HAVRDA, S., GELENCIR, D., 2008 - Evaluation and characterization of Croatian winter wheat genotypes (*T. aestivum* L.) for drought tolerance. Cereal Researcher Communication 36:1031–1034.

FAOStat, 2024 – Food and Agriculture Organization of the United Nations, Crops and livestock products. https://www.fao.org/faostat/en/#data/QCL (accessed on March 18, 2024)

HONGJIE, L., TIMOTHY, D.M., INTOSHC, R.A., YANG, Z., 2019 - Breeding new cultivars for sustainable wheat production. The Crop Journal, 7(6): 715-717.

ILJKIĆ, D., GRBEŠA, A., RUKAVINA, I., JUKIĆ, G., ŠUNJIĆ, K., ORKIĆ, V., RASTIJA, M., 2019 - Influence of variety on yield, yield components, agronomic properties and grain quality of winter

wheat (in Croatian). Proceedings of 54 Croatian and 14 international symposium of agriculture. Vodice, Croatia. 309 – 313.

IVANOV, G., UR, Z., DELCHEV, G., 2018 - Evaluation of yield and stability of varieties of common winter wheat grown under the conditions of organic and conventional agriculture. New Knowledge. 7(2), 266-272.

KOVAČEVIĆ, V., RASTIJA, M., 2014 – Cereals (in Croatian). Faculty of agriculture Osijek. Osijek.

MAEOKA, R.E., SADRAS, V.O., CIAMPITTI IA, DIAZ, D.R., FRITZ, A.K., LOLLATO, R.P., 2020 - Changes in the Phenotype of Winter Wheat Varieties Released Between 1920 and 2016 in Response to In-Furrow Fertilizer: Biomass Allocation, Yield, and Grain Protein Concentration. Frontiers in Plant Sciences, 10:1786.

MANDEA, V., MUSTĂŢEA, P., MARINCIU, C-M., ŞERBAN, G., MELUCA, C., PĂUNESCU, G., ISTICIOAIA, S-F., DRAGOMIR, C., BUNTA, G., FILICHE, E., VOINEA, L., LOBONŢIU, I., DOMOKOS, Z., VOICA, M., ITTU, G. & SĂULESCU, N. N., 2019 - Yield components compensation in winter wheat (Triticum aestivum L.) is cultivar dependent. Romanian Agricultural Research. 36:1-7.

OECD/FAO, 2019 - OECD-FAO Agricultural Outlook 2019-2028, OECD Publishing, Paris / Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.1787/agr_outlook-2019-en

TADESSE, W., SANCHEZ-GARCIA, M., GIZAW ASSEFA, S., AMRI, A., BISHAW, Z., OGBONNAYA, F.C., BAUM, M., 2019 - Genetic Gains in Wheat Breeding and Its Role in Feeding the World. Crop Breed Genet Genom, 1, e190005: 1-28.