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RESEARCH ARTICLE

Sustainable wheat production system under the influence of different fertilizers and climatic conditions

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ABSTRACT

The yield and quality of wheat (*Triticum aestivum* L.) grains are largely influenced by genotype, fertilization and climatic conditions. This study aimed to evaluate the effects of different fertilization treatments on grain yield, hectoliter weight and 1000-grain weight in four wheat genotypes during two growing seasons. Fertilization treatments included a control treatment without fertilizer application (F0), a combination of mineral (F1), mineral and microbiological (F2), microbiological (F3), as well as mineral, microbiological, organic fertilizers and lime (F4). The experiment was set up in a randomized block design with three replicates. Treatment F4 achieved the highest grain yields for the 'Ikona' genotype (6.45 and 7.37 t ha^{-1}), showing significant differences ($P < 0.01$) compared to the control. The ANOVA confirmed significant effects of year, genotype and fertilization on all investigated traits. Significant interactions between year and treatment were observed for grain yield ($P < 0.01$), while 1000-grain weight was affected by interactions between year, genotype and treatment ($P < 0.01$). Higher yields in the second season were attributed to more favorable rainfall distribution, although excessive pre-harvest rainfall reduced grain quality. The highest average values of hectolitre weight (76.60 and 74.20 kg hL^{-1}) and 1000-grain weight (45.07 and 41.33 g) were measured for the 'Ikona' genotype in F4. Positive correlations were found between grain yield, hectolitre weight and 1000-grain weight. The research results emphasize the importance of genotype selection and fertilization combination for achieving sustainable wheat production and stable grain quality in different agroecological conditions.

Key words: Climatic conditions, fertilization, hectolitre weight, 1000-grain weight, *Triticum aestivum*, yield grain.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cultivated crops in the world and occupies an important place in human nutrition. This crop accounts for approximately 20% of the total protein and calorie intake in the human diet, thus directly contributing to the health and standard of living of millions of people worldwide (Roa et al., 2024). In addition to its nutritional value, wheat serves as a primary ingredient in the production of various food products, including bread, pasta and bakery products, which makes it indispensable in the modern diet (Urošević et al., 2023; Golubev et al., 2023). Given the projected population growth of 9 billion by 2050, world food production needs to increase by 70% without creating a significant burden on the ecosystem (Thejesh et al., 2024). Increasing wheat yields and adopting sustainable production practices are critical to ensure continuity in food production (Ram and Kaur, 2024). Despite the fact that climate change poses significant challenges for wheat production, frequent and intense weather extremes, including droughts, heat waves and irregular distribution of precipitation, negatively affect grain yield and quality (Spinoni et al., 2018; Qi et al., 2022). Climatic conditions (temperature and precipitation) and fertilization are the two main factors that affect the yield and quality of wheat grains (Cammarano et al., 2022; Hlisnikovský et al., 2023). Fertilization, a key factor in crop production, significantly increases wheat yield and grain quality when applied appropriately. Although mineral fertilizers are very effective, their improper use can lead to depletion of soil fertility, acidification, salinization and other environmental problems (Zhang et al., 2022; Jiang et al., 2023). Alternatively, organic and biological fertilizers are increasingly recognized as sustainable options, ensuring long-term soil fertility and supporting microbial diversity (Janošević, 2021; Sini et al., 2024). Microbiological fertilizers play a significant role in modern agriculture by improving plant access to nutrients such as N and P and increasing resistance to abiotic stresses caused by climate change. These fertilizers facilitate symbiotic relationships between plants and beneficial microorganisms in the rhizosphere, leading to the exchange of bioactive compounds that improve crop growth, yield and quality (Cvikić et al., 2023). In addition to climatic and agronomic challenges, soil structure and agroecological conditions, such as regional climatic factors, soil organic matter content, pH and nutrient levels, significantly affect wheat productivity (Rajičić et al., 2020a; Ugrenović et al., 2021; Laidig et al., 2022). Excessive use of mineral fertilizers often leads to soil degradation, reduced fertility and increased production costs (Wang et al., 2019; Díaz-Pérez et al., 2023). In order to solve this problem, sustainable production systems focus on integrated fertilization management, including rational use of mineral fertilizers with increased application of organic and microbiological fertilizers.

Bearing in mind the mentioned challenges, this research aims to evaluate the importance of the selection of wheat genotypes within sustainable production systems in changing climatic and agroecological conditions. Special emphasis is placed on the interaction between climatic factors and integrated agronomic practices, including the application of environmentally friendly fertilizers, in order to ensure stable wheat production.

MATERIALS AND METHODS

Plant material and experiment design

A 2-yr experiment was conducted at a family farm in the village of Orašje, Vlasotince municipality (42°93´48´´ N, 22°09´55´´ E; 345 m a.s.l.), Serbia. The experiment followed a randomized complete block design with three replicates during the 2021-2022 and 2022-2023 growing seasons (Y) to evaluate wheat (*Triticum aestivum* L.) yield and grain quality. The base plot area was 500 m^2. Sowing was performed mechanically (3 November 2021, and 27 October 2022) under suitable weather conditions. The study used four winter wheat genotypes (G): ‘Anica’ (developed by the BC Institute, Zagreb, Croatia; G1), ‘Ikona’ (developed by Biogranum, Novi Sad, Serbia; G2), ‘Arnova’, and ‘Apilco’ (both developed by Limagrain Europe, France; G3 and G4 respectively). Genotype-specific seeding densities were applied: 650 seeds m^{-2} for ‘Anica’, 550 seeds m^{-2} for ‘Ikona’, and 450 seeds m^{-2} for ‘Arnova’ and ‘Apilco’, based on their growth characteristics. The experiment consisted of a control (F0) and four fertilizer treatments (T): F1: 300 kg ha^{-1} NPK fertilizer (16:16:16); F2: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax (Agrounik d.o.o., Šimanovci, Serbia); F3: 150 kg ha^{-1} Unimax; F4: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax + 4 t ha^{-1} lime fertilizer + 20 t ha^{-1} cow manure In early October 2021, after the maize (*Zea mays* L.) harvest, non-hydrated lime (CaO, 99% purity) at 4 t ha^{-1} and cow manure at 20 t ha^{-1} were applied to treatment F4 and incorporated into the soil to improve fertility. Other fertilizer treatments were applied at the recommended rates during plowing. Unimax is a microbiological fertilizer (4-8 mm granular form) containing *Bacillus megaterium* (3×10^7 cfu cm^{-3}) and *Azotobacter chroococcum* (1×10^7 cfu cm^{-3}) on a zeolite carrier. It enhances enzyme activity and nutrient availability. The NPK fertilizer (16:16:16) was supplied by Elixir Zorka (Serbia). Standard agricultural practices were applied during vegetation. Top-dressing with calcium ammonium nitrate (CAN, 27% N) at 150 kg ha^{-1} occurred during the 2-3 leaf stage (27 February 2022 and 1 March 2023), followed by a second application (70 kg ha^{-1}) during intense growth (20 March 2022 and 25 March 2023). Weed, pest, and disease control were conducted as necessary. Wheat was manually harvested at full maturity (6 July 2022 and 15 July 2023) after verifying moisture content using a handheld moisture meter (DICKEY-john, Auburn, Illinois, USA). Yields were adjusted to 14% moisture. Hectoliter weight and 1000-grain weight were determined in the Agricultural Advisory and Expert Service Laboratory, Leskovac, Serbia.

Soil characteristics

The experimental site lies within the Jablanica District in southeastern Serbia, characterized by Smonica soil. Soil analysis was performed in the laboratory in the Agricultural Advisory and Expert Service, Leskovac, determination pH (Kappen method), humus (Kotzmann method), total N (Kjeldahl method), and available P and K (Engner-Riehm Al method). The soil was acidic (pH 4.74 in KCl) (Table 1) with low organic matter content

(2.79%), medium N availability (0.13%), low P availability (11.40 mg 100 g^{-1} P_2O_5), and high potassium levels (32.10 mg 100 g^{-1} K_2O).

Table 1. Basic agrochemical analysis of the Smonica soil at the experimental location (Orašje).

Depth	pH KCl	Hummus	N	P_2O_5	K_2O	$CaCO_3$
cm		%	%	mg 100 g^{-1}	mg 100 g^{-1}	
0-30	4.74	2.79	0.13	11.40	32.10	0.84

Meteorological conditions

The meteorological station Leskovac served us to obtain data on the amount of precipitation and average temperatures (Figure 1). Average temperatures and precipitation during the 2021-2022 and 2022-2023 growing seasons were compared to the multi-year average (1961-2020). Total rainfall was significantly lower during the 2021-2022 season (354.1 mm) compared to the multi-year average (529.4 mm), especially during October-March (100 mm). This moisture deficit negatively affected crop performance, while in the 2022-2023 season. Recorded higher amounts of precipitation (512 mm), but irregular distribution of precipitation delayed the harvest and reduced grain quality in June 2023.

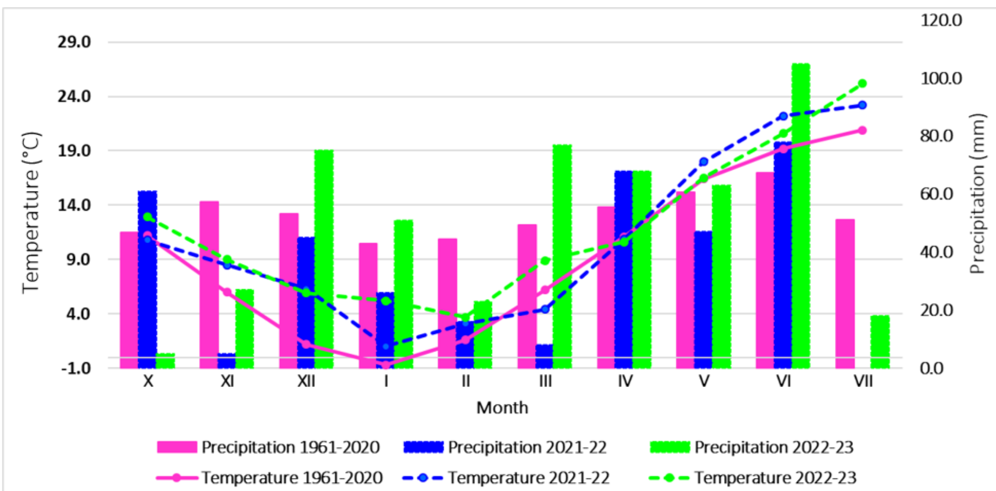

Figure 1. Mean monthly air temperatures and sum of precipitation at the experimental location (Leskovac, Serbia) during the experiment (2021-2023) in comparison to the multi-year average (1961-2020).

The average air temperature exceeded the multi-year average by 1.5 °C in 2021 and 2.6 °C in 2022, especially in critical growth stages. Monthly precipitation and temperature deviations were analyzed to assess their impact on wheat growth, confirming previous findings on the sensitivity of wheat to climate variability.

Statistical analysis

Data were subjected to ANOVA using SPSS Statistics 26.0 (IBM, Armonk, New York, USA). Least significant difference (LSD) tests at 5% and 1% significance levels determined treatment effects. Pearson's correlation coefficients were calculated to assess relationships among variables, with significance tested at 5% and 1% levels.

RESULTS AND DISCUSSION

Climatic conditions, especially during the growing season, have a significant impact on crop yield, especially when the interaction of several parameters is manifested (Wei et al., 2021; Simon et al., 2023; Mazibuko et al., 2024). In the paper of Glamočić et al. (2022) wheat yields varied during the examined period and were largely determined by the weather conditions that prevailed during different growing seasons. Studies conducted in the UK show that total rainfall in October, February and June and mean temperature in November and April significantly affect winter wheat yields (Addy et al., 2020). Figure 2 presents the average grain yield of wheat under different fertilization treatments over a 2 yr period. Following the statistical analysis of the data, the results illustrate the significance and interaction of the factors year, genotypes, and various fertilization treatments on the examined wheat grain parameters. The highest average grain yields were recorded for the wheat genotype 'Ikona' in both years of the study (6.45 and 7.37 t ha^{-1}) under treatment F4, which involved the application of a combination of manure, limestone, microbiological fertilizer and mineral fertilizer. In the control treatment (F0), which received no fertilization, the lowest average yields were observed across all tested genotypes, particularly in genotype 'Anica' during the first year of study (3.12 t ha^{-1}), followed by 'Arnova' and 'Apilco' with average grain yields of 3.24 t ha^{-1}. The increase in average grain yield in treatment F4 was significantly notable compared to the control treatment (F0) for all tested genotypes. In both years of research, treatment F2, which involved a combination of microbial and mineral fertilizers, yielded a greater average grain yield across all four wheat genotypes compared to treatment F3, which utilized only microbial fertilizer. Significant differences in grain yield among the examined wheat genotypes were influenced by the meteorological conditions prevailing during the growing seasons (Table 2). Factors examined individually, such as year (67.672**), genotype (5.087**), and applied fertilization treatments (434.076**), exhibited very significant impacts on wheat grain yield. However, the interaction among these factors did not show significant differences in the achieved average grain yields, except for the interaction between year and treatment, which demonstrated a very significant effect on the obtained average grain yield (3.159**).

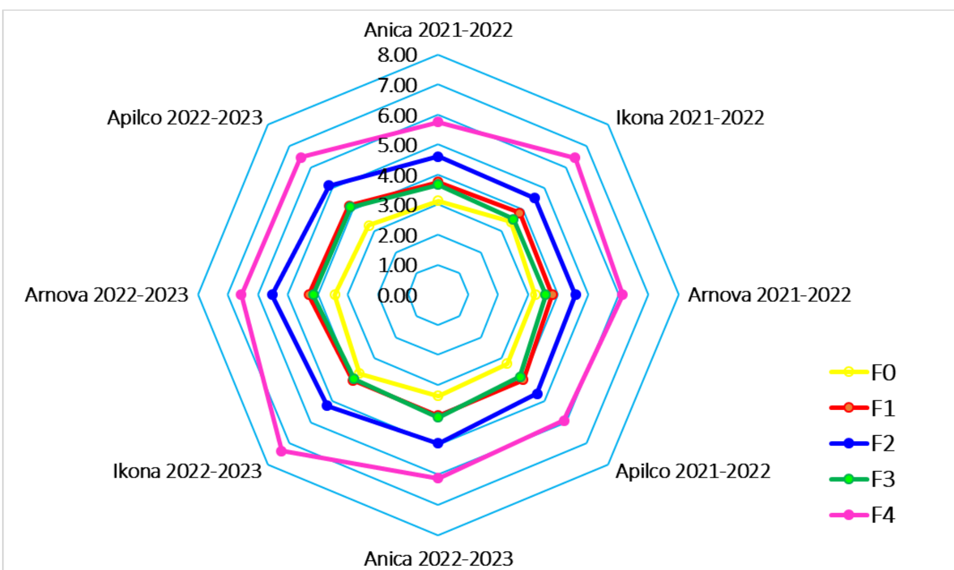

Figure 2. Average values of grain yield (t ha^{-1}) of tested wheat genotypes Anica, Ikona, Arnova, Apilco in different treatments of the combination of fertilizers. F0: control; F1: 300 kg ha^{-1} NPK fertilizer (16:16:16); F2: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax; F3: 150 kg ha^{-1} Unimax; F4: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax + 4 t ha^{-1} lime fertilizer + 20 t ha^{-1} cow manure - treatments with different combinations of fertilizers applied in a 2 yr period (2021-2023).

Table 2. ANOVA for grain yield of wheat genotypes grown in a 2 yr period with the application of different fertilization treatments. df: Degrees of freedom; MS: mean squares; F: F-statistic (F-value); Sig.: significance level (p-value): $^{**}P < 0.01$; $^{ns}P > 0.05$.

Factors	df	MS	F	Sig.	LSD ($P < 0.05$)	LSD ($P < 0.01$)
Year, Y	1	5.181	67.672**	0.000	0.101	0.133
Genotype, G	3	0.390	5.087**	0.002	0.142	0.189
Treatments, T	4	33.232	434.076**	0.000	0.159	0.211
Y × G	3	0.096	1.248ns	0.289	0.201	0.267
Y × T	4	0.189	2.473ns	0.050	0.225	0.298
G × T	12	0.242	3.159**	0.001	0.318	0.422
Y × G × T	12	0.043	0.565ns	0.854	0.450	0.597
Total	120					

Thai et al. (2020) determined that different fertilization regimes significantly affected barley yield (11%), annual climatic conditions (55%), and their interaction effects (8%). Jelic et al. (2015) found significant impacts of weather conditions on the yield and quality of winter wheat grain. The combined use of NPK fertilizers, lime, and manure positively influenced grain yield and yield components of winter wheat. According to the results of this research, the highest yield of different genotypes was achieved in the variant where all four types of fertilizers were included. The combination of mineral fertilizers and manure facilitates easier N availability in the soil, which is the most critical nutrient affecting wheat yield accumulation, thereby enhancing yield. Achieving optimal wheat yields faces challenges such as unfavorable soil characteristics and inadequate rainfall during critical growth stages, leading to yield reductions. In their 35 yr study, Zhang et al. (2022) noted that adequate fertilization reduces yield fluctuations in wheat. According to the findings of Cvijanović et al. (2022), significant influences on yield levels were attributed to varieties and the interaction of Density × Variety, while treatments during fertilization had a notable impact. Previous research results indicate the need for continuous determination of the quantities and ratios of nutrients required under specific agroecological conditions, especially since the amount of applied N interacts with soil reaction and agrometeorological conditions. According to Rajičić et al. (2020a) and Tmušić et al. (2021), the response of wheat to fertilization with 80 and 120 kg N ha^{-1} compared to unfertilized treatments was significantly more pronounced in unfavorable years. The same authors emphasize that wheat grown on acidic soils has significantly higher productivity when fertilized with NPK fertilizers compared to soils that are not of acidic reaction.

Figure 3 presents the average values of the hectoliter weight of wheat according to fertilization variants across different growing seasons. The highest average hectoliter weight values were measured in the genotype 'Ikona' during the first year of investigation for treatments F4 (76.60 kg hL^{-1}) and F2 (76.03 kg hL^{-1}). In the second year, average values for the same genotype and treatments were somewhat lower (74.20 and 73.07 kg hL^{-1}). For treatment F1, which involved fertilization with complex mineral fertilizer, lower hectoliter weight values were recorded, particularly in the second year of the study for genotype 'Anica' (65.33 kg hL^{-1}). In the control variant (without fertilizer application), all investigated wheat genotypes achieved significantly lower average hectoliter weight values compared to the fertilization treatments. Regarding the impact of year and meteorological conditions during the growing season, higher hectoliter weight values were recorded for all genotypes in the first year of investigation. The lowest average hectoliter weight values during the 2 yr study were established in the control variant without fertilization for genotype 'Anica', ranging from 64.47 kg hL^{-1} in the second year to 65.17 kg hL^{-1} in the first year. Conversely, the highest hectoliter weight values in the control variant were recorded for genotype 'Apilco' in the first year of the investigation (72.10 kg hL^{-1}) and for genotype 'Ikona' in the second year (71.67 kg hL^{-1}). The data obtained from Table 3 indicate a significant influence of all factors, both individually and in their mutual interactions. Based on the ANOVA data, it can be concluded that the impact of the year (4176.970**), genotype (6037.310**), and treatments (928.363**) on hectoliter weight was very significant, and the interaction of all three factors demonstrated a significant effect (7.341**) on hectoliter weight. The hectoliter weight of grains is significantly influenced not only by genotype but also by the growing environment and the type and amount of fertilizer applied, which is a key factor affecting yield quantity and quality. However, it must be aligned with climatic and soil conditions and the requirements of the variety

(Terzic et al., 2018; Rajičić et al., 2020a; Biberdžić et al., 2021; Cvijanović et al., 2022). Tmušić et al. (2021) point out that genotype, environment, and the interaction of Genotype × Environment influence hectoliter weight.

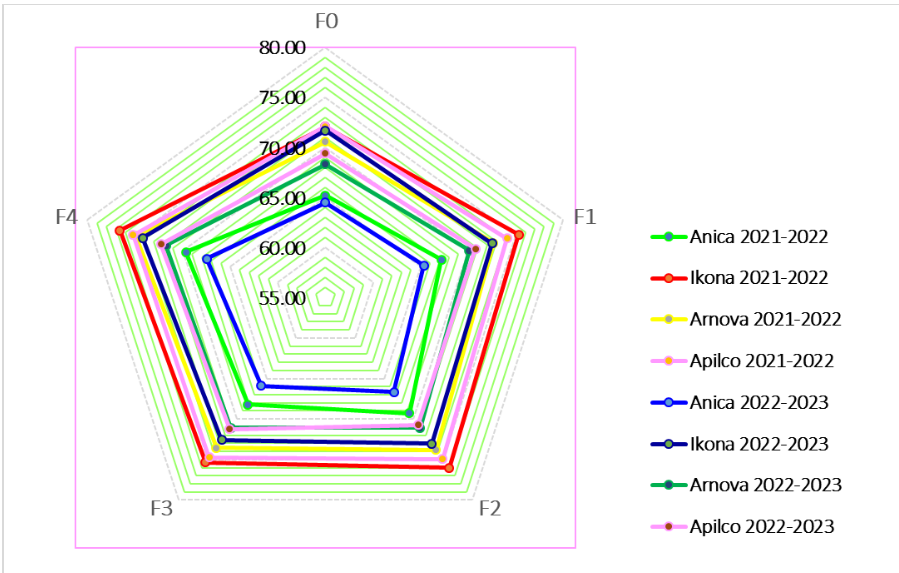

Figure 3. Average values of hectoliter weight (kg hL^{-1}) of tested wheat genotypes Anica, Ikona, Arnova, Apilco with different fertilization treatments. F0: control; F1: 300 kg ha^{-1} NPK fertilizer (16:16:16); F2: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax; F3: 150 kg ha^{-1} Unimax; F4: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax + 4 t ha^{-1} lime fertilizer + 20 t ha^{-1} cow manure - treatments with different combinations of fertilizers applied in a 2 yr period (2021-2023).

Table 3. ANOVA for hectoliter weight of wheat genotypes grown in a 2 yr period with the application of different fertilization treatments. df: Degrees of freedom; MS: mean squares; F: F-statistic (F-value); Sig.: significance level (p-value); $^{**}P < 0.01$.

Factors	df	MS	F	Sig.	LSD ($P < 0.05$)	LSD ($P < 0.01$)
Year, Y	1	192.533	4176.970**	0.000	0.078	0.103
Genotype, G	3	278.284	6037.310**	0.000	0.110	0.146
Treatments, T	4	42.792	928.363**	0.000	0.123	0.164
Y × G	3	2.712	58.846**	0.000	0.156	0.207
Y × T	4	2.20667	47.873**	0.000	0.174	0.231
G × T	12	0.49194	10.673**	0.000	0.247	0.327
Y × G × T	12	0.33839	7.341**	0.000	0.349	0.463
Total	120					

Figure 4 presents the values of the 1000-grain weight across growing seasons and various fertilization treatments. The 1000-grain weight as an important component of wheat grain yield is influenced by many factors during the growing season such as agroecological conditions, application of mineral fertilizers, and sowing time (Lüy et al., 2023). This parameter largely depended on the meteorological conditions that prevailed during the vegetation period, which indicates higher achieved values for different genotypes in the first year in variants with a combination of fertilizers. In the first year of testing, meteorological conditions were more favorable and favored the hectoliter weight parameter to achieve higher values for all four wheat genotypes. The highest values for the 1000-grain weight during the 2 yr study were observed in the F4 treatment, which was treated with a combination of mineral, microbiological, and organic fertilizers with lime. The genotype 'Ikona' achieved the highest 1000-grain weight in both growing seasons under the F4 treatment (45.07 g in 2021-2022 and 41.33 g in 2022-2023). Other examined genotypes also exhibited the highest average 1000-

grain weight under the F4 combined fertilizer treatment, particularly in the first year of the study. Approximate values for the 1000-grain weight were established under the F1 treatment, where only mineral fertilizer was applied, for the genotypes 'Anica' and 'Ikona' (41.40 g) in the first year of the research. In the treatment with the combined application of mineral and microbiological fertilizers (F2), approximate values for the 1000-grain weight were determined for the genotypes 'Arnova' and 'Apilco' in both examined years. Under the F3 treatment, where only microbiological fertilizer was applied, approximate values for the 1000-grain weight were established for 'Anica' and 'Arnova' (38.67 g) in the second year of the study. The highest values for the 1000-grain weight across all examined fertilization treatments and growing seasons were recorded for 'Ikona'. When analyzed individually, all factors (Table 4) had a significant impact on the 1000-grain weight of wheat, whereas the interaction between the year of testing and fertilization treatments (2.257^{ns}) was nonsignificant concerning the average values of the 1000-grain weight among all four genotypes. The interaction between genotype and treatments showed a significant impact ($r = 2.416^{*}$), while the interaction among the three factors-year, genotype, and treatments ($r = 3.520^{**}$) exhibited significant differences in the average values of the 1000-grain weight among the four wheat genotypes. The research results are in agreement with the results (Temneanu and Margitas, 2019) showed a synergistic effect of organo-mineral fertilizers in achieving a higher value for 1000-grain weight. The ANOVA conducted by Rajičić et al. (2020b) identified a significant difference in the 1000-grain weight between growing seasons and fertilization treatments, as well as the interaction between fertilization treatments and growing seasons. The findings align with those of other researchers who assert that the 1000-grain weight is genetically determined; however, this trait is influenced by the growing season and fertilization methods (Terzic et al., 2018; Rajičić et al., 2023). Cvijanović et al. (2022) found a highly significant difference in the interaction between years and treatments. These authors concluded that year, genotype and treatments significantly impacted the 1000-grain weight. The correlation coefficients based on all examined traits of wheat grains during the 2 yr research period under various treatments showed positive values.

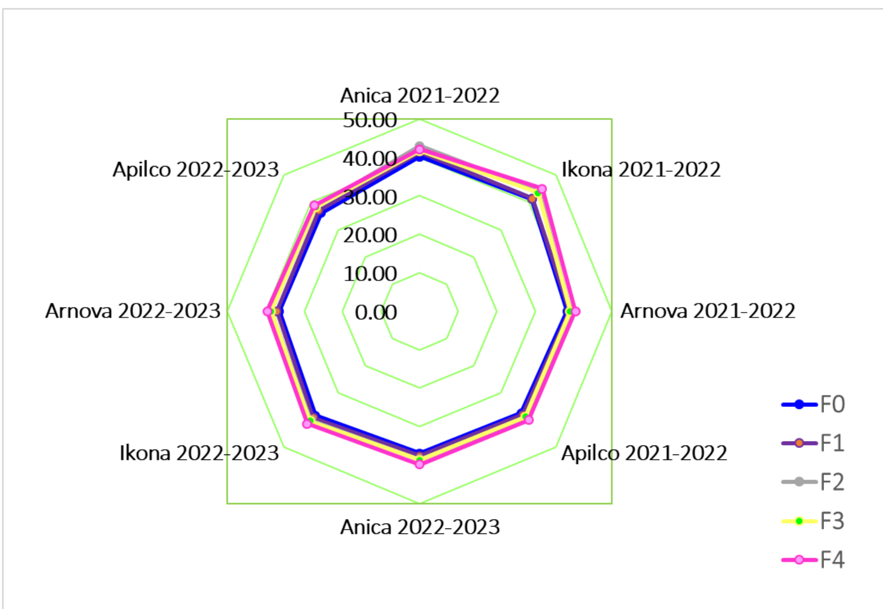

Figure 4. Average values of 1000-grain weight (g) under the influence of different combinations of fertilization in wheat genotypes Anica; Ikona; Arnova; Apilco. F0: control; F1: 300 kg ha^{-1} NPK fertilizer (16:16:16); F2: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax; F3: 150 kg ha^{-1} Unimax; F4: 150 kg ha^{-1} NPK + 150 kg ha^{-1} Unimax + 4 t ha^{-1} lime fertilizer + 20 t ha^{-1} cow manure - treatments with different combinations of fertilizers applied in a 2 yr period (2021-2023).

Table 4. ANOVA for 1000-grain weight of wheat genotypes grown in a 2 yr period with the application of different fertilization treatments. df: Degrees of freedom; MS: mean squares; F: F-statistic (F-value); Sig.: significance level (p-value); $^{**}P < 0.01$; $^{*}P < 0.05$; $^{ns}P > 0.05$.

Factors	df	MS	F	Sig.	LSD ($P < 0.05$)	LSD ($P < 0.01$)
Year (Y)	1	144.760	805.218**	0.000	0.154	0.204
Genotype (G)	3	62.576	348.073**	0.000	0.218	0.289
Treatments (T)	4	28.647	159.348**	0.000	0.244	0.323
Y × G	3	11.766	65.449**	0.000	0.308	0.409
Y × T	4	0.406	2.257ns	0.067	0.345	0.457
G × T	12	0.434	2.416*	0.009	0.487	0.646
Y × G × T	12	0.633	3.520**	0.000	0.689	0.914
Total	120					

Figure 5 presents the significant correlations of the examined traits. A positive and highly significant correlation was established between grain yield and hectoliter weight ($r = 0.290^{**}$), grain yield and 1000-grain weight ($r = 0.318^{**}$), and between hectoliter weight and 1000-grain weight ($r = 0.399^{**}$). Positive and very strong correlation coefficients were also determined by Terzić et al. (2018). The yield of wheat grains is influenced by the 1000-grain weight (Djuric et al., 2018).

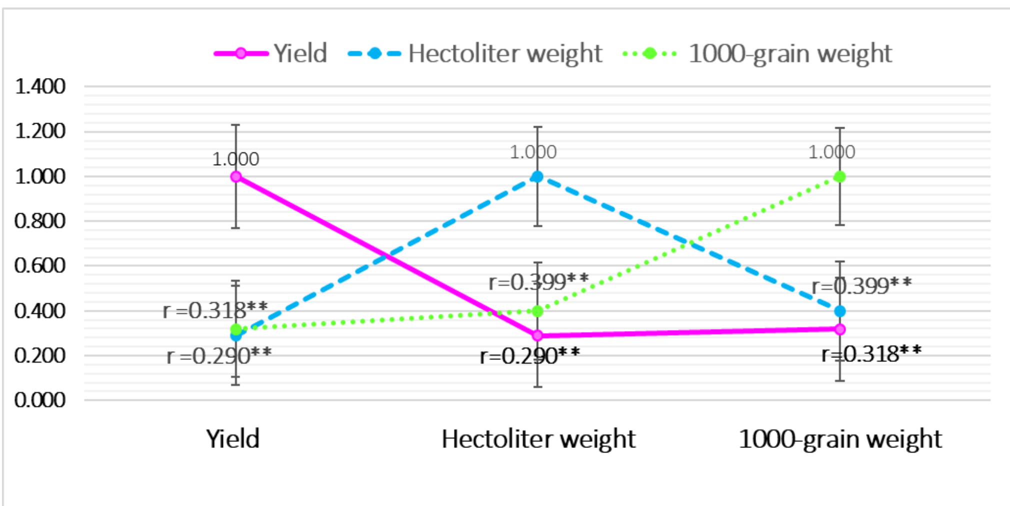

Figure 5. Coefficients of correlation between yield, hectolitre weight and 1000-grain weight. **Correlation is significant at the 0.01 level.

CONCLUSIONS

The results clearly show a significant influence of genotype and fertilizer on wheat yield and grain quality. The tested wheat genotypes reacted differently to the applied treatments, whereby combined application of mineral, microbiological fertilizer, lime and cow manure (F4) achieved the best results in terms of grain yield and quality. During the first production year, a significant increase in yield components was achieved in the F4 treatment, with values of 76.60 kg hL^{-1} and 45.07 g. Also, the best yield was achieved in the F4 treatment, where a significantly higher yield was achieved, which emphasizes the importance of integrated nutrient management to achieve optimal wheat yields. The results also highlight the significant role of climate factors in determining wheat yield components. The study area, characterized by low rainfall during critical stages of plant growth and development during the 2021-2022 production year, further highlighted the need for appropriate agrotechnical measures to mitigate climate-induced variability. The results suggest that fertilization strategies that emphasize the importance of both mineral and organic fertilizers, along with the application of amelioration measures, are key to achieving stable wheat yields in areas characterized by large temperature fluctuations and uneven distribution of precipitation during the growing season. The research contributes extremely important insight when choosing a combination of fertilizers that will be applied for wheat production in different climatic conditions, on land of different fertility.

Author contribution

Conceptualization: J.S., V.R., B.Š. Methodology: D.T., K.L. Software: B.Š. Validation: I.T., V.R., B.Š. Formal analysis: J.S., I.T., K.L. Investigation: I.T., M.U. Resources: J.S. Data curation: B.Š., M.U. Writing-original draft: K.L., J.S., B.Š. Writing-review & editing: V.R., D.T. Visualization: J.S. Supervision: V.R., M.U. Project administration D.T. Funding acquisition: D.T., V.R. All co-authors reviewed the final version and approved the manuscript before submission.

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