UDC: 575.22:633.111 https://doi.org/10.53040/gppb8.2024.47

CORRELATION OF YIELD WITH QUALITY INDICATORS FOR *TRITICUM AESTIVUM* L. GENOTYPES

Pravdziva Iryna*, *http://orcid.org/0000-0002-0808-1584*
Shadchyna Tamara, *http://orcid.org/0009-0002-1690-7566*
The V. M. Remeslo Myronivka Institute of Wheat, NAAS of Ukraine, Tsentralne, Obukhiv district, Kyiv region, Ukraine
**e-mail: irinapravdziva@gmail.com*

Summary. This article presents correlations between yield and wide range of quality indicators of genotypes *Triticum aestivum* L. They include physical indicators of grain quality, flour and bread quality indicators as well as rheological properties of dough. A significant influence of growing conditions on the strength and direction of the relationship between yield and grain quality indicators is noted. A number of varieties and breeding lines of winter bread wheat have been identified, which combine in one genotype a higher level of yield with correspondingly high grain quality indicators, which should be used in practical breeding to create new basic material.

Keywords: bread wheat, growing season conditions, yield, quality, grain, flour, dough, bread, correlation

Introduction

Winter wheat is one of the three most common food crops in the world [1]. The grain of this crop is one of the main food products for 35% of the world's population due to the optimal combination of micro and macro elements in it [2]. With the annual growth of the population on the planet, there is a need to increase the agricultural production, in particular wheat. Therefore, one of the main tasks of agricultural science and practice is to increase the gross harvest of high-quality grain [3]. The yield and quality of wheat grain depends on a number of such factors as morpho-biological features of the variety, soil and climatic conditions, techniques, etc. A higher level of yield of high-quality wheat grain is formed under the optimal ratio of all the factors [4].

An effective factor that determines the yield level of wheat is the variety. Due to timely varietal renewal, yield increase of wheat grain can reach up to 40–60% [5]. Currently, considerable success has already been achieved in increasing wheat yield by selecting the best genotypes as parental forms [6]. When creating a new competitive wheat variety, breeders need to combine in one genotype high yield with a complex of valuable properties, including grain quality indicators. This combination can be detected by correlations between certain features [7]. Determining statistically significant relationships makes it possible to identify indicators that can be factorial and used as criteria (markers) for selection to increase productivity and at the same time genetic improvement of other traits [8]. In breeding process, identifying the strength and direction of the relationship between yield and grain quality indicators will allow selecting genotypes characterized by groups of desired traits [9]. Thus, establishing correlations between individual traits is one of the fundamental principles of purposeful selection in practical breeding.

The purpose of the study is to identify correlations between yield and a wide range of grain quality indicators of new varieties and promising breeding lines of winter bread wheat (*Triticum aestivum* L.) and to identify genotypes with statistically significant relationships.

Materials and methods

The research was conducted during 2019-20–2022-23 in environment of the central part of the Forest-Steppe of Ukraine in the fields of the V. M. Remeslo Myronivka Institute of Wheat of the National Academy of Agrarian Sciences of Ukraine (MIW). There were evaluated 10 new

varieties (G1 Podolianka, G2 MIP Fortuna, G3 MIP Yuvileina, G4 MIP Nika, G5 MIP Roksolana, G6 MIP Feieriia, G7 MIP Aelita, G8 MIP Vidznaka, G9 MIP Darunok, G10 MIP Dovira) and four promising breeding lines of winter bread wheat (G11 Lutescens 37548, G12 Lutescens 60049, G13 Lutescens 60302, G14 Lutescens 60400), which were sown in three sowing dates (III decade of September, I decade of October, II decade of October) after five preceding crops (green manure, mustard, sunflower, corn, soybean).

The technology of growing winter wheat is conventional for the Forest-Steppe zone of Ukraine [10]. Plots were placed according to completely randomized scheme with four replications. Harvesting and recording of the harvest was carried out according to the methodology of the qualification examination of plant varieties for suitability for distribution in Ukraine [11]. Winter wheat grain quality indicators were determined at the Grain Quality Laboratory of MIW in accordance with conventional methods [12].

Correlation analysis was used for statistical processing of experimental data in order to identify genetic relationships between yield and grain quality indicators.

Results and discussion

The years of the study were contrasting in hydrothermal regime with uneven distribution of precipitation by months (Table 1). During the research period, an increase in air temperature by 1.0–2.6 °C was observed compared to the average long-term (ALT). An insufficient amount of precipitation was noted in the 2019-20 and 2021-22 vegetation seasons (respectively 64.5 and 80.5% of ALT) and an excessive amount in 2022-23 (132% of ALT). The conditions of the 2020-21 in terms of the amount of precipitation (102.2% before ALT) were close to the average long-term.

Table 1

Average monthly values of air temperature (°C) and amount of precipitation (mm) during the period of research, 2019-20–2022-23

Growing season	Month												Indicator	
	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII		
Air temperature, °C													Average, °C	± to ALT*
2019-20	20.4	15.8	11	4.8	2.8	0.8	2.4	6.6	9.5	12.8	21.7	21.7	10.9	+2.6
2020-21	21.1	18.6	13.3	3.8	-0.3	-2.3	-4.7	2.3	7.7	14.5	20.2	23.3	9.8	+1.5
2021-22	20.5	13.2	7.6	4.8	-1.1	-1.2	1.7	2.3	8.4	14.6	20.7	20.4	9.3	+1.0
2022-23	21.6	12.9	8.2	3.8	0.2	-0.1	-0.5	5.2	9.3	15.5	19.7	20.9	9.7	+1.4
ALT	19.6	14.5	8.3	2.3	-2.2	-4.4	-3.4	1.5	9.1	15.3	18.7	20.2	8.3	-
Precipitation, mm													Sum, mm	% of ALT
2019-20	10	12	7	17	37	20	40	15	48	92	57	21	376	64
2020-21	8	21	22	28	38	57	49	28	47	87	100	111	596	102
2021-22	88	19	18	26	63	23	9	11	86	29	42	55	469	80
2022-23	88	118	30	81	43	11	28	45	85	21	39	184	773	132
ALT	59	51	34	40	43	36	31	34	44	52	79	81	584	-

Note: ALT, the average long-term value for 1980–2019.

It should be noted the significant influence of growing weather conditions on yield and grain quality indicators of winter wheat, as well as on the variability of correlation coefficients between yield and grain quality indicators in the years of the study (Table 2). During the four years of the

study, positive statistically significant correlations of yield were found only with the 1000 kernel weight (r = 0.17–0.46). Reliable positive relationships of yield with varying strength were obtained with the test weight (r = 0.38–0.61) and grain vitreous (r = 0.25–0.51) in three years; with protein content (r = 0.30–0.49), sedimentation value (r = 0.14–0.40), wet gluten content (r = 0.31–0.59), gluten deformation index (r = 0.35–0.37) and water absorption capacity of flour (r = 0.19–0.41) in two years. Under different growing season conditions, the relationship between yield and bread quality indicators was noted to be unequal in strength and direction. Negative statistically significant relationships of yield with deformation energy (r = -0.31), dough tenacity (r = -0.28) and dough elasticity index (r = -0.23) were revealed in one of the years, namely in 2019-20, in other years these relationships were insignificant.

O. Yu. Leonov et al. [13] and S. Khazratkulova et al. [14] also observed significant variability of the correlations of yield with grain quality indicators depending on the hydrothermal conditions of the year and the soil-climatic zone of cultivation. According to the results of research by M. I. Ullah [6], direct correlations of yield with the 1000 kernel weight were also found. In literary sources, the issue of combining in one wheat genotype a higher level of yield with a simultaneous increase in protein and gluten content remains debatable. Although individual studies indicate the possibility of this combination [15], however, the majority of scientific works show inverse relationships between yield and grain protein content [16, 17].

Table 2

Correlation coefficients between yield and grain quality indicators of *Triticum aestivum* L. in the years of the study ($p \leq 0.05$)

Growing season	TKW	TW	VT	PC	SE	WGC	GID	W	P/L	P	Ie	WA	VB	PB	BE
2019-20	0.17	0.39	ns	ns	ns	ns	0.35	-0.31	-0.20	-0.28	-0.23	ns	0.22	0.24	ns
2020-21	0.19	ns	0.25	0.30	ns	0.31	ns	ns	-0.16	ns	ns	0.19	-0.32	-0.28	-0.26
2021-22	0.46	0.61	0.51	ns	0.14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2022-23	0.41	0.38	0.40	0.49	0.40	0.59	0.37	ns	ns	ns	ns	0.41	-0.17	-0.16	-0.19

Note: TKW – 1000 kernel weight, TW – test weight, VT – grain vitreous, PC – protein content, SE – sedimentation value, WGC – wet gluten content, GDI – gluten deformation index, W – deformation energy, P/L – alveogram configuration ratio, P – dough tenacity, Ie – dough elasticity index, WA – water absorption of flour, VB – volume of bread, PB – porosity of bread crumb, BE – bread evaluation score, ns – non-significant relationship.

According to the results of our previous studies [18] and other scientists [19], it was established that the strength and direction of the relationship between traits depends not only on the growing conditions, but also on the genotype. Therefore, correlation coefficients between yield and grain quality indicators were calculated for all varieties and breeding lines of winter wheat.

Varieties and breeding lines of winter wheat with stable direct correlation coefficients between yield and individual grain quality indicators over the years have been singled out (Fig. 1). Namely, reliable direct correlations of yield with the 1000 kernel weight over four years were found in the G7 MIP Aelita variety (r = 0.24–0.48) and the breeding line G11 Lutescens 37548 (r = 0.13–0.90) ; with test weight – in varieties G3 MIP Yuvileina (r = 0.38–0.64), G6 MIP Feeriia (r = 0.45–0.67), G9 MIP Darunok (r = 0.15–0.71) and breeding line G12 Lutescens 60049 (r = 0.18–0.74); with grain vitreous – in varieties G5 MIP Roksolana (r = 0.13–0.55), G6 MIP Feeriia (r = 0.24–0.72) and breeding line G14 Lutescens 60400 (r = 0.14–0, 77); with protein content – in varieties G1 Podolianka (r = 0.16–0.61), G2 MIP Fortuna (r = 0.28–0.84), G5 MIP Roksolana (r = 0.35–0.59), G6 MIP Feeriia (r = 0.15–0.65), G9 MIP Darunok (r = 0.13–0.83), G10 MIP Dovira (r = 0.26–0.57); with deformation energy – in the variety G9 MIP Darunok (r = 0.13–0.71) and the breeding line G12 Lutescens 60049 (r = 0.31–0.45); with a sedimentation value – in varieties G1 Podolianka (r = 0.18–0.76), G2 MIP Yuvileina (r = 0.25–0.65), G6 MIP Feeriia (r = 0.14–0.49),

G10 MIP Dovira (r = 0.13–0.50); with wet gluten content – in varieties G1 Podolianka (r = 0.22–0.69), G2 MIP Fortuna (r = 0.29–0.86), G5 MIP Roksolana (r = 0.32–0.83), G6 MIP Feeriia (r = 0.19–0.55), G8 MIP Vidznaka (r = 0.35–0.63), G9 MIP Darunok (r = 0.19–0.76), G10 MIP Dovira (r = 0.15–0.60); with dough tenacity – in the selection line G12 Lutescens 60049 (r = 0.15–0.66); with the water absorption capacity of flour – in the varieties G7 MIP Aelita (r = 0.23–0.59), G9 MIP Darunok (r = 0.40–0.82), G10 MIP Dovira (r = 0.13–0.52). Therefore, a number of varieties and breeding lines have been created and selected today, which combine a higher level of yield with the corresponding high grain quality indicators in one genotype. Such genotypes are valuable breeding material for use in the breeding process when creating new starting material.

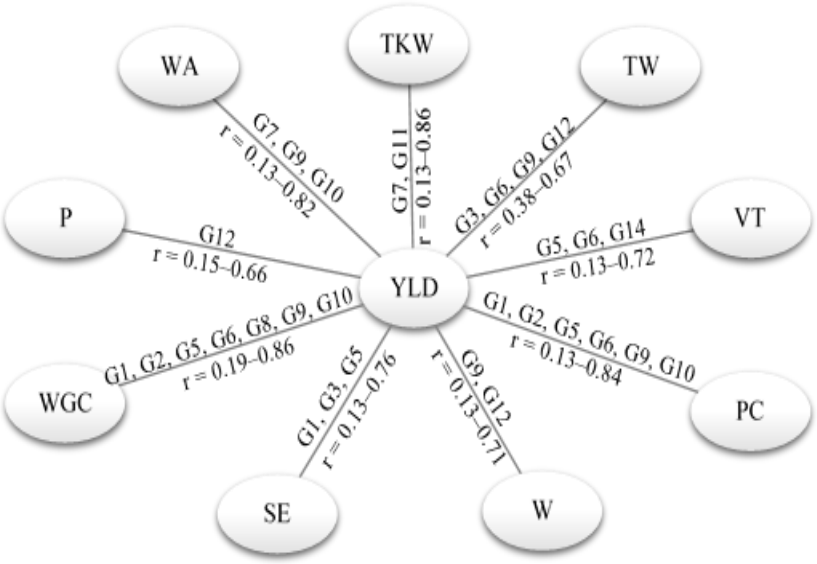


Figure 1. Stable for 2019-20–2022-23, direct statistically significant relationships between yield and grain quality indicators for genotypes of *Triticum aestivum* L.

Note: TKW – 1000 kernel weight, TW – test weight, VT – grain vitreous, PC – protein content, W – deformation energy, SE – sedimentation value, WGC – wet gluten content, P – dough tenacity, WA – water absorption of flour, G1 - Podolianka , G2 – MIP Fortuna, G3 – MIP Yuvileina, G5 – MIP Roksolana, G6 – MIP Feieriia, G7 – MIP Aelita, G8 – MIP Vidznaka, G9 – MIP Darunok, G10 – MIP Dovira, G11 – Lutescens 37548, G12 – Lutescens 60049.

Conclusions

Direct and inverse statistically significant relationships of varying strength (-0.31 < r < 0.61) of yield with grain quality indicators of *Triticum aestivum* L. were found. Reliable direct relationships of yield with 1000 kernel weight (r = 0.17– 0.46) were obtained in four years of the study; with test weight (r = 0.38–0.61) and grain vitreous (r = 0.25–0.51) in three years; with protein content (r = 0.30–0.49), sedimentation value (r = 0.14–0.40), wet gluten content (r = 0.31–0.59), gluten deformation index (r = 0.35–0.37), and water absorption capacity of flour (r = 0.19–0.41) in two years.

Varieties and breeding lines of *Triticum aestivum* L. with stable over the years and statistically significant direct correlations of yield with quality indicators were selected, as follows: with 1000 kernel weight G7 MIP Aelita, G11 Lutescens 37548; with test weight G3 MIP Yuvileina, G6 MIP Feeriia, G9 MIP Darunok, G12 Lutescens 60049; with grain vitreous G5 MIP Roksolana, G6 MIP Feeriia, G14 Lutescens 60400; with protein content G1 Podolianka, G2 MIP Fortuna, G5 MIP Roksolana, G6 MIP Feeriia, G9 MIP Darunok, G10 MIP Dovira; with deformation energy G9 MIP Darunok, G12 Lutescens 60049; with sedimentation value G1 Podolianka, G2 MIP Yuvileina, G6 MIP Feeriia, G10 MIP Dovira; with wet gluten content G1 Podolianka, G2 MIP Fortuna, G5 MIP Roksolana, G6 MIP Feeriia, G8 MIP Vidznaka, G9 MIP Darunok, G10 MIP Dovira; with

dough tenacity G12 Lutescens 60049; with water absorption capacity of flour G7 MIP Aelita, G9 MIP Darunok, G10 MIP Dovira. Thus, the identified genotypes of *Triticum aestivum* L. should be used in practical breeding to create competitive varieties of winter bread wheat.

References

1. Ibrahem, N. T. (2023). A climate-crop-spectral approach for wheat adaptation with climate changes in the arid and semiarid regions. In: R. O. WANYERA, M. WAMALWA (Eds). *Wheat*. IntechOpen. doi: 10.5772/intechopen.109477
2. Zahra, S. T., Tariq, M., Abdullah, M., Azeem, F., Ashraf, M. A. (2023). Dominance of *Bacillus* species in the wheat (*Triticum aestivum* L.) rhizosphere and their plant growth promoting potential under salt stress conditions. In: *PeerJ*., *11*, Article e14621. doi: 10.7717/peerj.14621
3. Kryzhanovskiy, V. G. (2022). Peculiarities of grain quality formation of winter wheat varieties in the Right Bank Forest Steppe. In: *Scientific Reports of NULES of Ukraine, 1*(95). doi: 10.31548/dopovidi2022.01.008 [In Ukrainian]
4. Jaisi, S., Thapa, A., Poudel, M. R. (2021). Study of correlation coefficient and path analysis among yield parameters of wheat: a review. In: *INWASCON Technology Magazine, 3*, 01–04. doi: 10.26480/itechmag.03.2021.01.04
5. Fanin, Ya. S., Litvinenko, M. A. (2023). Yield and elements of plant productivity in modern domestic and foreign varieties of winter durum wheat. In: *Podilian Bulletin: agriculture, engineering, economics*, *38*, 70–77. doi: 10.37406/2706-9052-2023-1.10 [In Ukrainian]
6. Ullah, M. I. (2021). Grain yield and correlated traits of bread wheat lines: Implications for yield improvement. In: *Saudi Journal of Biological Sciences*, *28*(10), 5714–5719. doi: 10.1016/j.sjbs.2021.06.006
7. Haleem, A., Hassan, G., Iqbal, A. et al. (2022). Genetic variability and correlation analysis in F_2 wheat populations. *Sarhad Journal of Agriculture*, *38*(2), 398–408. doi: 10.17582/journal.sja/2022/38.2.398.408
8. Orlyuk, A. P. (2012). Genotypic correlations between productivity and component characters of soft winter wheat under different environmental conditions. In: *Taurida Scientific Herald*, *78*, 62–71. [In Ukrainian]
9. Kadam, D. J., Karwar, S. H., Jadhav, P. S. (2022). Correlation analysis for different characteristics in wheat. *The Pharma Innovation Journal*, *11*(1), 98–100.
10. Siroshtan, A. A., Kavunets, V. P. (Eds). (2019). Production of pre-basic, basic and certified winter and spring wheat seeds. Myronivka: N. p. [In Ukrainian]
11. Ukrainian Institute for Plant Variety Examination (2016). Methodology for the qualification examination of plant varieties for suitability for distribution in Ukraine. General part (4th ed., rev.). Vinnytsia: FOP Korzun D. Yu. [In Ukrainian]
12. Tkachyk, S. (Ed). (2017). Technological assessment of crop production of varieties of agricultural species. *Methodology for the qualification examination of plant varieties. Methods of determining plant production quality indicators* (3rd ed., rev. and enl.) (pp. 5–64). Vinnytsia: FOP Korzun D. [In Ukrainian]
13. Leonov, O. Yu., Usova, Z. V., Buryak, L. I., Padalka, O. I., Yarosh, A. V. (2016). Variability of bread wheat grain quality parameters in relation to weather conditions. In: *Collected scientific articles of PBGI–NCSCI*, *27*(67), 141–155 [In Ukrainian]
14. Khazratkulova, S., Sharma, R. C., Amanov, A. et al. (2015). Genotype × environment interaction and stability of grain yield and selected quality traits in winter wheat in Central Asia. *Turkish Journal of Agriculture and Forestry*, *39*(6), 920–929. doi: 10.3906/tar-1501-24
15. Tsenov, N., Gubatov, T., Yanchev, I. (2022). Evaluation of heritability and genetic advance of some quality parameters in common wheat (*Triticum aestivum* L.) under genotype by environmental interaction. In: *Agricultural Science and Technology*, *14*(2), 12–26. doi: 10.15547/ast.2022.02.015

16. Rathod, S. T., Pole, S. P., Gawande, S. M. (2019). Correlation and path analysis for quality and yield contributing traits in wheat (*Triticum aestivum* L.). In: *International Journal of Current Microbiology and Applied Sciences*, *8*(6), 456–461. doi: 10.20546/ijcmas.2019.806.051
17. Öztürk, I. (2022). Assessment of environment effect on yield component in barley (*Hordeum vulgare* L.) genotypes under rainfed conditions. In: *Scientific Papers of the Institute of Bioenergy Crops and Sugar Beet*, *30*, 6–14. doi: 10.47414/np.30.2022.268939
18. Pravdziva, I. V., Vasylenko, N. V., Khoroshko, N. M. (2023). Interrelationships between yield and grain quality indicators of varieties and breeding lines of *Triticum aestivum* L. In: *Plant Varieties Studying and Protection*, *19*(4), 216–224. doi: 10.21498/2518-1017.19.4.2023.291222
19. Liubych, V. V., Novikov, V. V., Leshchenko, I. A. (2020). Technological properties of grain of different wheat types depending on the genotype. In: *Taurida Scientific Herald. Series: Rural Sciences, 144*, 63–69. doi: 10.32851/2226-0099.2020.114.9 [In Ukrainian]