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RESEARCH ON THE RELATIONSHIP BETWEEN PRECOCITY AND YIELD FOR THREE SPECIES OF STRAW CEREALS (WHEAT, TRITICALE AND BARLEY) TESTED ON THE CARACAL CHERNOZEM

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Abstract

The study of the precocity-yield relationship was carried out through two components: correlation of heading date - yield using data from national comparative crops for 3 species (wheat, triticale, barley) tested in the period 2020-2023 and the influence of species and growing season on yield, with data from a two-factor experiment, where the precocity groups tested for each species were differentiated from each other by +3-5 days (early to medium) and 8-14 days (medium to late). The results obtained showed that for none of the species in any of years was there a correlation between precocity expressed in days from January 1st and yield, mainly due to the fact that the varieties tested were not highly differentiated in terms of growing season. There were no differences regarding yield for wheat and triticale, but differences were obvious regarding yield for wheat and barley (20.19 q/ha) and triticale and barley (23.73 q/ha). About growing season, there were differences between the yields of medium-early, as well as medium-late varieties, but no differences were highlighted between the yields of early-late varieties.

***Key words**: correlations; precocity; straw cereals; yield.*

INTRODUCTION

Cereals represent the phytotechnical group of plants with the largest area of distribution in all growing areas in the world (Paunescu et al., 2021; Roșculete et al., 2023). Cereal straw is an abundant agricultural by-product in Europe (Björnsson and Prade, 2021; Ișlicaru et al., 2021).

The importance and advantages of cereal crops (wheat, triticale, barley and others) include many considerations, described below.

For almost half of the world's population, bread made from wheat flour is the staple food and wheat grains are the raw material for a wide range of agri-food products (Erenstein et al., 2022).

Wheat bran from the milling industry is used for feeding animals because it is high in protein, fat and minerals. A cow's milk production is determined by the nutritional ingredients of the feed ration (Cola and Cola, 2021a).

Straw from the harvesting of straw cereals can be used for feeding animals (as an alternative source of energy) or as bedding in stables, in pulp mills or for making organic fertiliser. In fact, straw is the most important by-product of straw cereal production and is an important source of animal feed. Thus, the use of concentrated fodder (wheat, corn, barley) in the feed of dairy cows it favors, in certain limits, the quantitative and qualitative production of milk (Cola and Cola, 2020). However, the avoidance of cereals contaminated with various fungi must be taken into account (Cola and Cola, 2021b).

Straw cereals are good pre-seed for most crop plants. Some authors suggest cultivation of intermediate crops as an alternative approach that would allow both unrestricted straw removal and contribute to soil organic matter build-up (Björnsson and Prade, 2021). Also, the integration of several technological processes, such as straw cutting, shredding, and incorporating it into the soil with simultaneous application of nitrogen and phosphorus fertilizers, increases the economic efficiency of grain production (Halko et al., 2023).

Achieving economically efficient crops with the biologically optimal potential of cereal varieties cannot be conceived today without effective integrated diseases, pests and weeds control (Zhao, 2024). Generally, all these are influenced by climate change which, in addition, can affect the dynamics and population structure of plants, crop yield and quality (Dima et al., 2023; Sălceanu et al., 2023; Sărățeanu et al., 2023) as well as host-pathogen relationship (Paraschivu et al., 2022; Paraschivu et al., 2023).

The precocity of straw cereal crops makes them suitable for all growing areas (Iacob et al., 2023). The range of straw cereals is characterized by: good disease resistance, stress tolerance, optimal production potential and meeting market requirements (protein content, milling qualities, etc.). Some authors reported that by studying the phenology of cereals and trees, the importance of the precocity of cereals respect to tree budburst may be assessed as strategy to escape to excessive shading (Arenas-Corraliza et al., 2022). The conditions of water stress at pre-anthesis stages can influence straw cereals growth and results in yield losses (Al-Ajlouni et al., 2016; Dodig et al., 2014).

The pre-anthesis period in wheat is critical for growth of plant organs including leaves, stems, spikes and roots (Xie et al., 2016). At grain filling stage, a proportion of biomass is available to the grain development (Shakhatreh et al., 2001). It is also desirable that this proportion is high to obtain better yields and a higher harvest index. Harvest index also depends on the availability of water during grain filling and carbohydrates that stored before anthesis (Bogale and Tesfaye, 2016).

From a breeding perspective, cereals cultivars need to be improved for further genetic gain (Bonciu et al., 2021). Conventional breeding has been mainly based on grain yield, and the resistance to biotic and abiotic stresses (Xie et al., 2016). On the other hand, combining conventional plant improvement techniques with those of molecular biology through the prism of molecular markers technology is one of the most important methods in modern agriculture to ensuring global food security (De Souza and Bonciu, 2022a, 2022b).

The grain weight has been improved and contributed most to yield gain, especially in recent decade (Wu et al., 2018). For numerical components, yield progress has been associated with an increase in grain number rather than individual grain weight (Sanchez-Garcia et al., 2013; Xie et al., 2016). Grain number is mainly determined by the preanthesis floret survival within spikelets. (González-Navarro et al., 2015).

The cereal yield is influenced by several genetic factors: genetic factors of floral development and inflorescence architecture (Sreenivasulu and Schnurbusch 2012), control of flowering time (Cockram et al. 2007), aspects of senescence, and nutrient remobilization (Distelfeld et al. 2014), traits associated with phenology and photosynthesis (Valluru et al. 2014), etc.

In this context, the purpose of this paper was to show the relationship between precocity and yield for three species of straw cereals (wheat, triticale and barley) tested on chernozem soil.

MATERIALS AND METHODS

Data from national comparative crops for 3 species (wheat, triticale, barley) tested in 2020-2023 and data from a bifactorial experiment in 2023 were the basis for the study of the earliness-yield relationship on the Caracal chernozem. The study was carried out through two components: the correlation between heading date and yield (first data set) and the influence of species and growing season on yield (second data set).

Each of the comparative cultures had 15 variants in 3 replicates for each species in each test year.

The bifactorial experiment had as factor A - the species with 3 gradations (wheat, triticale, barley) and as factor B - the growing season with 3 gradations (early, medium and late). It was also sown in 3 replications. For wheat, the cultivars with differentiated sprouting were Amurg variety (early), Caro line (medium, 3-4 days more than early variety) and Bogdana variety (late, 7-8 days more than early variety). For triticale, the cultivars with differentiated sprouting were line 11588T2-23 (early), variety Utrifun (medium, 4-5 days more than the early line) and variety Inspector (late, 14-15 days more than the early line). For barley, the cultivars with differentiated sprouting were line F 8-4-12 (early), variety Ametist (medium, 3-4 days more than the early line) and variety Onix (late, 7-8 days more than the early line).

All experimental plots had a harvestable area of 5sqm. Medium input cropping technology was used, representative for the area.

Notations were made on the date of the sowing (when 70% of the spikes were sown in a plot) which was then converted into days from January 1st to heading. All variants were harvested, moisture at harvest was determined, yield was then expressed in q/ha and brought to the STAS moisture of 14%.

Interpretation of the results was done using the correlation coefficient and the Newman Keuls test.

The climatic data presented gives a full picture of the conditions under which the study was conducted. Between 1 October 2019 and 30 June 2020, 436.2 mm of precipitation was recorded, 46.7 mm more than the multi-year average.

Between 1 October 2020 and 30 June 2021, 547.2 mm of precipitation was recorded, 158.1 mm more than the multi-year average. The abundant rainfall recorded in December, January, February and March allowed for strong plant growth. In May and June, the total of 158.8 l/m^2 was conducive to grain filling, a phenophase that is extremely important for shaping yield.

Between 1 October 2021 and 30 June 2022, common to both components studied, 364 mm of rainfall was recorded, only 25.5 mm less than the multiannual average, but with uneven distribution.

Rainfall in October (101.4 mm) contributed to good seedbed preparation and uniform plant emergence. Heavy rainfall, above normal, was recorded only in December and April; otherwise, there was a reduction in rainfall from -9 mm in November to -55.5 mm in June.

In the autumn-winter months, temperatures were much higher than the multi-year average, while from May onwards, temperatures were above normal, coupled with a lack of precipitation just at the time of grain filling.

RESULTS AND DISCUSSIONS

I. Correlation heading date - yield

The results obtained from the study of the correlation between spiking date and yield showed that in none of the species, in none of the test years, there was any correlation between earliness expressed in days from January 1st to heading and yield, mainly due to the fact that the varieties tested were not highly differentiated in terms of growing season (Table 1).

Table 1. Correlation coefficients by varieties and test years

Species/year of testing	**Production interval (q/ha)**	**Precocity interval (heading - days from January 1st)**	**Correlation coefficient (r)**	**Significance**
Wheat 2021	66.7-101.0	131-136	0.500	-
Wheat 2022	65.1-85.7	131-138	-0.408	-
Wheat 2023	29.2-62.1	125-135	-0.273	-
Triticale 2021	67.8-91.1	127-135	0.200	-
Triticale 2022	72.4-92.0	127-134	0.150	-
Triticale 2023	38.4-68.2	125-131	-0.029	-
Barley 2021	56.7-97.0	122-131	-0.440	-
Barley 2022	25.9-53.6	120-127	-0.030	-
Barley 2023	43.0-74.9	119-127	0.286	-
P values for GL = 13: P5% = 0.55; P1%=0.68				

It can be seen that the direction of the correlation was both positive (high yield in late-seeded wheat in 2021, triticale in 2021 and 2022 and barley in 2023) and negative (high yield in medium wheat in 2022 and 2023, triticale in 2023 and barley in 2021 and 2022). Considering that there is no significance, it can be concluded that on the Caracal chernozem, for the species tested, the distribution of cultivars according to the date of spiking is predominant in one class. In the class of extreme limits (very early and very late), the distribution is very low.

II. Bifactorial experience varieties x growing season

In order to better highlight the relationship between earliness and yield, the second experience was studied.

Table 2. Yield according to the growing season, regardless of the tested varieties

The growing season	Species yield (q/ha)			Average
	Wheat	Triticale	Barley	
Late	72.93	48.46	46.92	56.10 (m1)
Early	55.53	68.63	47.69	57.28 (m2)
Medium	73.03	94.97	46.30	72.15 (m3)

In terms of growing season, there were differences between the yields of medium and early varieties (14.87 q/ha) and medium and late varieties (16.05 q/ha), while there were no differences between the yields of early and late varieties (1.18 q/ha), regardless of the varieties tested (Table 2).

The results interpreted by the Newman Keuls test method (Table 3 and Table 5) showed that there were no differences in wheat and triticale yields, but differences were evident between wheat and barley yields (20.19 q/ha) and between triticale and barley yields (23.73 q/ha). While there are differences in growing season between wheat and barley, between triticale and barley these are not so obvious. However, yield differences do exist, suggesting that for these species, they are based on their biology and changes in yield elements, especially those related to the spike.

Table 3. Results of the Newman Keuls test for the growing season

The averages difference	The value of the difference	Corresponding value from the table		Comparison of differences
m1-m2	1.18	k=3; n=4	5.04	no differences
m1-m3	16.05	k=3; n=4	5.04	there are differences between averages
m2-m3	14.87	k=2; n=4	3.93	there are differences between averages

The corresponding values from the Newman Keuls table: for k=3; n=4 is 5.04; for k=2; n=4 is 3.93.

Generally, the genotypic differences in yield are most frequently associated with those in grains per m^2 (Slafer et al., 2014) and genetic gains in yield were influenced by improvements in this component (González-Navarro et al., 2015).

On the other hand, the results show a very small difference in yield between wheat and triticale, even with a small lead for the latter. (Table 4).

Other authors' results suggest similar conclusions. Thus, according to Méndez-Espinoza et al. (2019), the harvest index was not significantly different between triticale and bread wheat.

Table 4. Yield depending on the tested varieties, regardless of the growing season

Varieties	Yield depending on the growing season (q/ha)			Average
	Early	Medium	Late	
Barley	47.69	46.30	46.92	46.97 (m1)
Wheat	55.53	73.03	72.93	67.16 (m2)
Triticale	68.63	94.97	48.46	70.69 (m3)

Table 5. Results of the Newman Keuls test for varieties

The averages difference	The value of the difference	Corresponding value from the table		Comparison of differences
m1-m2	20.19	k=3; n=4	5.04	there are differences between averages
m1-m3	23.72	k=3; n=4	5.04	there are differences between averages
m2-m3	3.53	k=2; n=4	3.93	no differences

The corresponding values from the Newman Keuls table: for k=3; n=4 is 5.04; for k=2; n=4 is 3.93.

The simulation of cultivars differing in flowering time showed that in drier climates earlier flowering cultivars increase potential yield while in warming climates later cultivars increase yield (Ludwig and Asseng, 2010). On the other hand, the rice grain yield in clay soil was higher than in sandy loam soil (Dou et al., 2016).

Cormier et al. (2013) reported a higher genetic progress towards winter wheat at high N that became however similar once the effect of precocity and quality class are taken into account in the model. Other authors' results suggest that some factors between germination and the appearance of the second main stem leaf must be responsible for the greater early vigor for barley compared with that of wheat (Lopez-Castaneda et al., 1995). Also, the higher yield of triticale has been attributed to higher radiation use efficiency, greater biomass at anthesis and maturity, and a larger number of grains per spike compared to bread wheat (Estrada-Campuzano et al., 2012).

Marti et al. (2007) shows that under Mediterranean conditions, the only feasible way to extend the reproductive period to wheat is through an earlier start to the reproductive stage, which is assessed via the date of stem elongation. Other results suggest that the date of commencement of stem elongation was the phenological trait that best correlated (negatively) with grain yield (Lima et al., 2021). On the other hand, a trend toward greater precocity, mainly during the reproductive stages, led to shorter phenology and to an overall reduction in the crop cycle duration (Soriano et al., 2018). However, from a breeding perspective, cereals cultivars need to be improved for further genetic gain (Xie et al., 2016). The results obtained in our experience suggest that the triticale varieties can be an alternative to the wheat crop on chernozem soil in the Caracal area.

CONCLUSIONS

The earliness-yield relationship can be revealed with much greater accuracy by experimenting with cultivars that are highly differentiated in terms of date of cropping.

On the Caracal chernozem, for the varieties tested, the distribution of cultivars according to the heading date is predominantly in one class.

From the point of view of the growing season, there were differences between the yields of medium and early and medium and late cultivars, while there were no differences between the yields of early and late cultivars, regardless of the varieties tested.

The results interpreted by the Newman Keuls test method showed that there were no differences in yield between wheat and triticale, but differences were evident between wheat and barley, as well as between triticale and barley.

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