THE INFLUENCE OF FLAG LEAF ON THE POTENTIAL PRODUCTION OF STRAW CEREALS (WHEAT, TRITICALE AND BARLEY)

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Abstract

The primary source for production in straw cereals (wheat, triticale and barley) is the accumulation of carbohydrates in the photosynthetic organs, mainly in the leaves. From this point of view, the flag leaf plays a vital role in the development of the grain and therefore it must benefit from protection throughout the growing season. Keeping the flag leaf green is a trait that allows cereals to maintain their photosynthetic capacity for a longer period of time after anthesis, especially under drought and heat stress conditions.

This study presents some partial experimental results from the SCDA Caracal (Dolj County, Romania) regarding the influence of the flag leaf on the potential production of straw cereals (wheat, triticale and barley). Thus, the potential production was greatly influenced by the area of the flag leaf and the ear, both the half-cut flag leaf, the fully cut flag leaf and the ½ cut ear resulted in very significant production reductions. Much more significant was the influence of precocity, regardless of the species and the surface of the flag leaf and ear. Medium early and late cultivars showed very significant increases in potential production compared to early cultivars.

Key words**: **wheat, triticale, barley, flag leaf, production

INTRODUCTION

Straw grains (wheat, triticale, barley) are an important source of nutrition throughout the world, being rich in non-nitrogenous extractive substances as well as proteins, fats, vitamins, etc. They have wide uses both in human food (as a basic food in the form of bread, pasta, etc.), and in animals, as well as a raw material for various industries.

Wheat is very important as a food product, providing a large part of the carbohydrates and proteins needed by humans and representing more than half of the calories consumed by mankind (Ișlicaru et al., 2021).

Wheat is the most widely distributed food crop in the world, being the staple food for about 40% of the world's population, with a major role in ensuring global food security (Zhou et al., 2018).

Triticale is a hybrid plant obtained by crossing wheat and rye, which combines the best qualities of the parental forms. The

purpose of crossing the two types of grain was to achieve the productivity, quality and disease resistance of wheat and the vigour of rye in one plant.

Barley is among the oldest cultivated plants, with the earliest historical sources showing that barley was cultivated as early as the Stone Age, with the beginning of agriculture. Barley grains are characterized by a unique blend of macronutrients, micronutrients and bioactive compounds. Macronutrients such as carbohydrates, the primary source of energy that fuels body functions, are inherent elements of barley grains (Kaur et al., 2024).

The straw cereals crop is one of the safest crops, being genetically structured to withstand low winter temperatures. They show a remarkable ecological plasticity, being cultivated even in unfavourable climatic and soil conditions.

The straw cereals brans are particularly valuable forage for dairy cows due to its richness in crude protein and carbohydrates. But contamination of feed with microorganisms in ruminants can cause multi-contamination, which prompts the immediate call for specific antibiotic treatments (Cola and Cola, 2021). However, the presence of antibiotics is prohibit in milk intended for human consumption to reduce the remote possibility of the emerge of antibiotic resistant organism in milk (Cola and Cola 2022, 2023).

Modern biotechnology has a significant potential to contribute to food security and sustainable development (De Souza and Bonciu, 2022 a, b). Biotechnological tools have highly contributed to the grains production and supply of improved quality seed to farmers.

Identification of plant species and varieties by morphological means is one of the main methods used in cereal breeding and provides the basis for the complete description of a variety. Production in cereal crops is due to complex physiological and biochemical processes, but it is essentially associated with the carbohydrate accumulation process of the grain filling phase which in turn is attributed to leaf functionalities (Biswal and Kohli, 2013).

The leaf is the major organ involved in the perception of light and the conversion of solar energy into organic carbon. The flag leaf is one of the primary sources of carbohydrates in cereals (Liu et al., 2021). In cereals, the importance of the flag leaf for contributing carbohydrate during seed fill is well documented. It is generally accepted that stems provide temporary storage of assimilates before and after anthesis, and contribute a significant amount of assimilates to the developing grain (Borrell et al., 1989).

Flag leaf traits are considered to have an important role in grain filling of grassy cereals under drought conditions. Thus, physiological, morphological and biochemical traits of flag leaves are involved in determining grain yield and biomass (Biswal and Kohli, 2013; Liu et al., 2015; Racz et al., 2022).

The flag leaf provides the main source of assimilates necessary for plant growth and ear development in straw cereals. Maintaining the green state of the flag leaf is a trait that allows the grass cereal to maintain its ability to photosynthesize for a longer period of time.

After Alpuerto et al. (2021), an increase in grain yield largely depends on the level of C transported from vegetative tissues. At low N, a large quantity of C reserves is available at anthesis, leading to increased grain yield rather than grain protein content. At high N, the amount of C reserves is limited at anthesis, resulting in an elevation of grain protein content per grain.

Alongside climate impact, a range of regional and global political and economic factors intensify food insecurity and long term vulnerability in certain regions.

Worldwide, pathogens have threatened small cereals production due to their ability to rapidly evolve and overcome introduced resistance and/or develop tolerance to chemical treatments posing constant challenges to disease management and leading to average annual yield losses of 21,5% (Cotuna et al., 2021, 2022; Paraschivu et al., 2015, 2021, 2023).

MATERIALS AND METHODS

Straw cereals and wheat in particular, will continue to play an essential role in providing an adequate and affordable intake of calories and protein.

The main objective of this study was to presents some partial results from the experimental field at SCDA Caracal (Dolj County, Romania) regarding the influence of the flag leaf on the potential production of straw cereals (wheat, triticale and barley).

A trifactorial experience in 3 repetitions was located at Caracal in the fall of 2022.

The biological material used consisted of:

- Wheat cultivars with differentiated earing: Twilight, Carom and Bogdana;
- Triticale cultivars with differentiated earing: 11588T2-23, Utrifun and Inspector;
- Barley cultivars with differentiated earing: F 8-4-12, Amethyst and Onyx.

The statistical processing of the experience was done with the statistical analysis program specific to trifactorial experiences based on the methodology presented by N. Săulescu (PSUB 3). The influence of the studied factors (species, vegetation period, surface of the flag leaf) and the interaction species x vegetation period x surface of the flag leaf, on the potential production, was interpreted.

Several post hoc tests have been formulated, and most of them give similar results. Among these, the Newman-Keuls test was used to identify samples that have different means from each other.

RESULTS AND DISCUSSIONS

Cereals are the world's dominant crops. Drought creates a water deficit that can affect all parts of life, but has the greatest impact on agricultural production (Hunter et al., 2017; Paunescu et al., 2021, 2023, Yu et al., 2018). Thus, drought affects 60% of the wheat production in high-income countries and 30% in least developed countries (Ahmad et al., 2018). To keep up with the demand, modern strategies need to be developed to increase wheat yield under this changing environment (Bonciu et al., 2021; Dihoru et al., 2023; Roșculete et al., 2021).

The cuticle serves as a barrier that protects plants against abiotic and biotic stresses but, according to some authors, the geographic pattern suggests that other wax layer characteristics besides glaucousness may be important in conferring tolerance to abiotic stresses (Würschum et al., 2020).

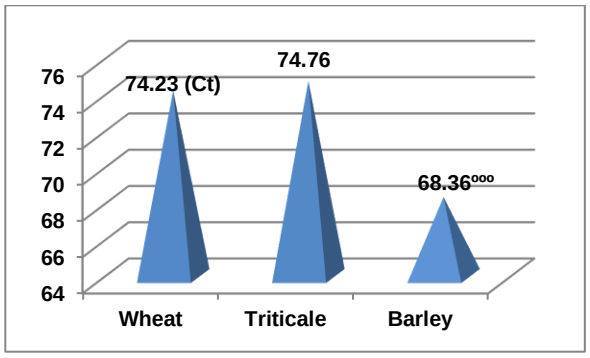
A trifactorial experience (which is the subject of a doctoral thesis) in 3 repetitions was located at Caracal. In the 2022-2023 agricultural year, average monthly temperatures were positive, with values between 2.8^0C (December) and 21.4^0C (June). Precipitation totalled 456.8 mm during the entire vegetation period, the multiannual average being 389.5 mm. On the other hand, the relative air humidity recorded at the beginning of the vegetation period an average value of 75.5% (October) and 80.6% in June.

Regarding the year 2023, the months of August - October were dry. Sowing was done late, after a successful application of

watering to help the preparation of the germinal bed.

The potential production was calculated based on the number of ears/m^2 in each plot and the weight of the grains per ear according to their origin: plants with intact flag leaf, plants with flag leaf cut in half, plants with flag leaf completely cut and plants with spike cut ½ but with whole flag leaf.

In 2023, the influence of the species on potential production stood out, so that barley showed a very significant decrease in production. The triticale species was at the level of the control - the wheat species (Figure 1).

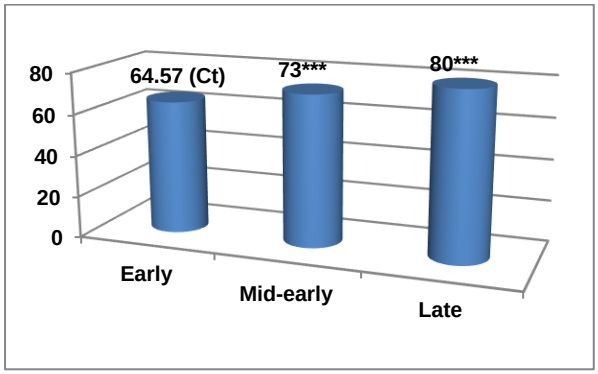


LD 5% = 1,54 q/ha; LD 1% = 2,54 q/ha; LD 0,1% = 4,75 q/ha

Figure 1. Influence of species (A factor) on potential production (q/ha) in wheat, triticale and barley, regardless of earliness and surface of flag leaf and ear.

Much more significant was the influence of precocity, regardless of the species and the surface of the flag leaf and spike.

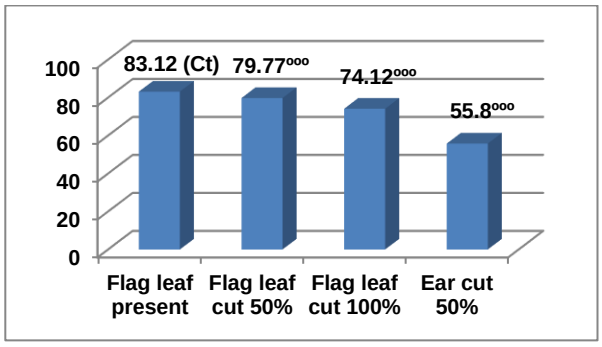
The mid-early and late cultivars showed highly significant increases in potential yield compared to the early cultivars (Figure 2). In general, the precocity of straw cereals makes them suitable for all cultivation areas, especially if they meet the market requirements: good disease resistance, stress tolerance and optimal production potential.



LD 5% = 1,51 q/ha; LD 1% = 2,12 q/ha; LD 0,1% = 2,99 q/ha

Figure 2. Influence of precocity (B factor) on potential production (q/ha) in wheat, triticale and barley, regardless of species and flag leaf and spike area.

The potential production was greatly influenced by the area of the flag leaf and the ear, both the half-cut flag leaf, the fully cut flag leaf and the ½-cut ear resulted in very significant production reductions (Figure 3).



LD 5% = 1,23 q/ha; LD 1% = 1,64 q/ha; LD 0,1% = 2,13 q/ha

Figure 3. Influence of flag leaf surface and spike (C factor) on potential yield in wheat, triticale and barley, regardless of species and earliness.

Percentage-wise, they did not have such a large share. Reducing the flag leaf by half its area reduced production by 4%. The total lack of the flag leaf led to the reduction of production by 11% and the halving of the spike caused a damage of 36% of the production (Figure 4).

The three-factor interaction species (factor A) x precocity (factor B) x surface of the flag leaf and spike (factor C) greatly influenced production. In most combinations, the

potential production was greatly diminished, mainly very significantly.

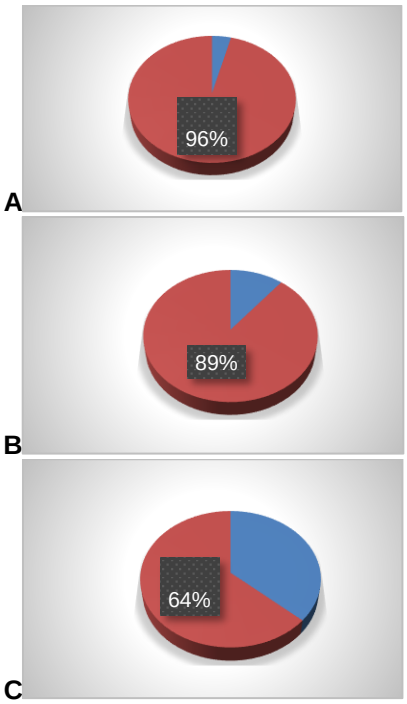


Figure 4. The graphic representation of the production according to the surface of the flag leaf and the spike by percentages: A – the flag leaf cut in half at the spikering; B – flag leaf completely cut at the spikering; C – spike cut in half at spikering and flag leaf whole

Compared to the whole leaf, only the triticale cultivars with ½ cut flag leaf and 100% cut flag leaf showed very significant increases in potential production.

Compared to the control - the wheat species, the early variety with the whole flag leaf, the barley species showed statistically assured increases in the medium-early varieties and the late varieties with the whole flag leaf and with the ½ cut flag leaf.

After Racz et al. (2022), flag leaf removal had a significant influence on the accumulation of grain protein and the wet gluten content, the variability of these quantitative traits being also influenced by the climatic conditions. Also, the defoliation of the flag leaf blade increased the contribution of assimilates to the grain from the stem and the chaff under normal conditions (Alvaro et al., 2008), and the removal of these affected the grain yields under normal or water-limiting conditions (Cruz-Aguado et al., 1999).

In a large-scale study, Würschum et al. (2020) analysed the genetic architecture of flag leaf glaucousness in a panel of 1106 wheat cultivars of global origin. The analysis revealed a large amount of variation, ranging from glossy, non-glaucous to fully glaucous flag leaves with the entire abaxial and adaxial leaf surfaces showing strong glaucousness. The genotypic variance of flag leaf glaucousness and the genotype-by-location interaction variance were both significant (Würschum et al., 2020).

Flag leaf glaucousness has been hypothesized as an important component of drought tolerance (Bennett et al., 2012). According to Deák et al. (2011), tolerant wheat genotypes had lower stomatal density and significantly smaller leaves than the sensitive ones.

The results reported by Blake et al. (2007) suggest that flag leaf characteristics had heritability greater than 0.70 for all traits. Most of characters has high heritabilities and expected genetic advance (Ahmed et al., 2004).

Flag leaf characteristics provide a potential target for selection. Thus, selection for a long duration of green flag leaves can result in gains in cereals yield potential.

Figure 5. Images from the experimental field

CONCLUSIONS

The conclusions resulted after processing the data obtained in the first year of testing. They cannot suggest recommendations, but can at most be regarded as findings.

The precocity-production relationship can be highlighted with much greater accuracy by experimenting with cultivars that differ greatly in terms of ripening date.

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

There is very little difference in terms of productivity between wheat and triticale, even with a small advance of the latter. The triticale species can be an alternative to the wheat crop on the black soil in the Caracal area.

The potential production was greatly influenced by the area of the flag leaf and the ear, both the half-cut flag leaf, the fully cut flag leaf and the ½ cut ear resulted in very significant production reductions.

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