PhD THESIS

Study of an assortment of varieties and lines of autumn barley at SCDA Livada

(SUMMARY OF DOCTORAL THESIS)

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INTRODUCTION

The main destination of barley production is animal feed, both through the use of grains in various forms but also of the many by-products, especially straw. Achieving high productions of barley, stable and superior from a qualitative point of view, requires the cultivation of several valuable genotypes, with high production capacity, with superior qualitative characteristics, resistant to diseases and adapted to different environmental conditions.

Knowing the biological properties and productivity elements of barley varieties that determine the level of the harvest, is of particular interest in technology research aimed at quantitative and qualitative increase in production, as well as in breeding research for the creation of varieties with superior properties.

Evaluation of the stability of production and the main elements of productivity in order to highlight the best genotypes that ensure high and quality production in different environmental conditions, establishing the varieties of autumn barley that are the most productive for the north-west area of Romania and highlighting the role of 12.5 cm and 25 cm sowing distance on productivity and production elements.

The importance, use and evolution of barley

Worldwide, the area cultivated with barley is 57.2 million ha, and the average production is 24.7 q/ha (https://www.fao.org/documents/card). The nutrients in barley grains are highly digestible by all animal species and provide a high nutritional value at the same time. Barley in the form of grains is specific for the feed of fattening animals, young animals, as well as dairy animals. In the feeding of dairy or growing animals, barley corrects corn in the aspect of protein quality, and in the feed of fattening pigs, it corrects corn in the aspect of meat quality.

Barley used in animal feed, pure or mixed, is an important source of green mass for fresh consumption in the form of silage or hay. In the young phase, barley plants contain, in addition to large amounts of carbohydrates, appreciable amounts of protein. A high fodder value of barley is correlated with as little weed content as possible, usually below 10% of the grain weight. In order to reduce the weed content, the problem of creating bare varieties was raised, and last but not least, the creation by improvement of some varieties in which the edges of the blades break as close as possible to the point of insertion during harvesting, at threshing or even before (caduceus edges).

Agrotechnics of barley culture

To determine the sowing depth, the soil moisture at the time of sowing and the soil texture are taken into account. For autumn barley and sorghum, the sowing depth is between 3 and 4 cm (maximum 5 cm), and for spring sorghum between 2 and

3 cm. Sowing depths should not exceed the indicated limits, because the plants sprout with difficulty, especially if a crust forms. Barley has a lower penetration power compared to wheat and as such it is sown more superficially compared to it. Sowing depth influences both the sowing-emergence interval and subsequent plant development (MUTEAN *et al.,* 2014). Sowing earlier causes the plants to develop too strongly until the winter, especially in warm and long autumns, which makes the barley plants less resistant to winter conditions, also favoring the attack of fusarium wilt and powdery mildew. , as well as the attack of aphids, flies and cicadas that transmit different forms of viruses, very harmful to barley.

The delay in sowing means that the barley plants do not harden and have a low resistance to frost. Spring orzoaica is sown very early, in the first emergency, as soon as the land has been cleared and can be worked. Delaying the sowing of spring barley leads to production losses and a decrease in quality for beer, by obtaining smaller grains with a lower content in starch and higher in protein (MUTEAN *et al*., 2008).

The objectives

The general objective of the doctoral study, first of all, reflects the complex of characteristics that the new varieties must possess in order to achieve large and constant productions, of quality corresponding to different areas of use, in the context of an accentuated diversity of culture conditions, with zonal variations and appreciable annuals. In order to treat this complex field as completely as possible, we have addressed the following specific objectives:

Evaluation of production stability and the main productivity elements in order to highlight the best genotypes that ensure high and quality productions in different environmental conditions.

Establishing the varieties of autumn barley that are the most productive for the north-west area of Romania.

Highlighting the role of the sowing distance of 12.5 cm and 25 cm on the elements of productivity and production.

Identification of varieties suitable for use in animal feed, in the form of green mass.

Evaluation of the production potential of barley varieties and lines, in order to promote and recommend those best adapted to the pedoclimatic conditions specific to the area.

Evaluation of production stability and the main productivity elements in order to highlight the best genotypes that ensure high and quality production in different environmental conditions, quantifying, through variance analysis, the influence of the variety and environmental conditions on the phenotypic manifestation of the main elements of productivity

Improving culture technology by identifying varieties and lines of barley suitable for sowing in different technological variants, in order to adapt culture technology according to the destination of the culture, for fodder or industrial processing, but also according to the needs and possibilities of farmers.

Improving the technological quality by highlighting some genotypes resistant to mycotoxin-generating pathogens, thus creating conditions for the integration of barley culture as a source of raw material both for feed and for industrial food processing

Identification of genotypes, in the environmental conditions of the north-west of the country, with high capacity for twinning and maintaining a large number of fertile siblings until harvest, thus generating high yields.

The particularities of the natural environment in which the research took place

The place of the experiments was the Livada Agricultural Development Research Station, located on longitude $23^{0}03'$, latitude $47^{0}54'$ and absolute altitude 130 m.

The zonal climate is generally a typical continental climate of the NW area of Romania, where SCDA Livada is located, according to the KÖPPEN climate classification, it falls into the Cfbx climate province, being characterized by a moderate temperate-continental climate. The multi-year mean temperature for 56 years is 9.8^{0}C.

Material and method

The research that is the subject of the paper was started in the fall of 2015 and continued until the summer of 2018, carrying out a comparative study on productivity elements, some morphological characters, physiological traits and the production achieved, at different sowing distances, at a assortment of varieties and lines of autumn barley in pedoclimatic conditions from S.C.D.A. Orchard.

The experience was located in the station's research field within comparative crops for complex ecological testing, the research being carried out in the field and in the laboratory.

The experience had 2 experimental factors:

Factor A – autumn barley variety or line (8 varieties and 17 lines, 25 genotypes in total)

Factor B-sowing distance between rows (12.5 cm, respectively 25 cm between rows).

25 barley cultivars were studied:

-6 varieties of autumn barley with 6 rows of grains per ear: Dana, Cardinal FD, Univers, Amethyst, Emerald, Simbol

-9 lines of autumn barley with 6 rows of grains per ear: F8-9-12, F8-20-10, F8-2-12, F8-3-01, F8-3-12, F8-4-12 , F8-6-12, F8-19-10, Standard 1

-two varieties of autumn barley with 2 rows of grains per spike (barley): Andreea, Artemis

-8 lines of autumn barley with 2 rows of grains per spike (barley): DH267-126, F8-101-12, F8-117-10, F8-106-10, F8-114-11, DH320-3, DH375-4, Standard 2

Observations and determinations made

Density at emergence: count of emerged plants per quarter square meter, in each repetition, reported per square meter.

Winter resistance: by the number of plants killed in a quarter of a square meter, reporting to a square meter, for each repetition and giving marks according to the FAO scale, where 1=very good, 9=Very poor.

Growth rate: measuring plants at three different points for each repetition in the phase of intense vegetative growth (April).

Disease resistance: the Colb scale was used to score disease resistance: grade 0= no attack; 1=attack 1-3%; grade 2=attack 4-10%; grade 3=attack 11-25%; grade 4=attack 26-50%; grade 5=attack 51-75%; grade 6 = 76-100% attack.

The height of the measuring plants with a graduated ruler at the moment of full ripening, from the soil surface to the tip of the ear, exclusive of the aristles. Measurements were performed at three different points for each repetition

In the laboratory, determinations were made regarding:

- the weight of the grains per plot;
- humidity at harvest;
-calculation of production per surface unit at 14% humidity;
-the number of grains/spike;
- weight of grains/ear (g);
- mass of 1000 grains (g);
- hectoliter mass kg/hl;

To determine the number of grains/ear from each variant, 25 ears/3 repetitions were harvested. The spices were processed by hand. The total number of grains was divided by the number of ears resulting in the number of grains per ear.

All grains were weighed using a precision balance, the resulting value was divided by the number of analyzed ears.

To determine the mass of 1000 grains, four samples of 500 grains each were counted, averaged and reported to 1000 grains.

The hectoliter mass was determined with the help of the 1l samovar scale, and for better accuracy the grain volume was weighed with precision scales.

The different sowing distance between the rows allowed highlighting the reaction of the tested genotypes to this technological element.

In the classic variant of sowing at 12.5 cm between rows, the maximum productions were: 5473 kg/ha in 2016 for the DH 375-4 line; 6837 kg/ha in 2017 for the Smarald variety and 5177 kg/ha in 2018 for the Cardinal FD variety

When sowing in rare rows, at 25 cm, the maximum productions recorded were: 5786 kg/ha for the Amethyst variety in 2016; 6002 kg/ha in 2017 for the Simbol variety and 4784 kg/ha in 2018 for the Artemis variety

High yields in both sowing variants were registered by the varieties: Cardinal (5384 kg/ha at 12.5cm between rows and 5066 kg/ha at 25 cm between rows), Amethyst (5532 kg/ha at 12.5cm between rows and 5147 kg /ha at 25 cm between rows), Emerald (5631 kg/ha at 12.5 cm between rows and 5119 kg/ha at 25 cm between rows) and Artemis (5067 kg/ha at 12.5 cm between rows and 4983 kg/ha at 25 cm between rows).

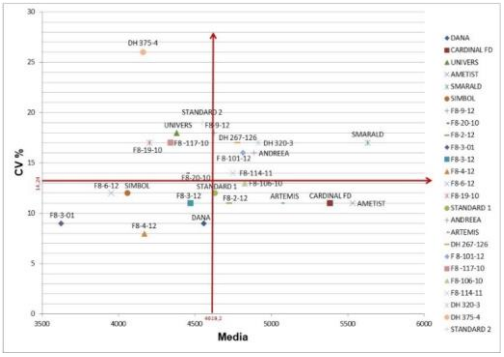

Figure 1 The relationship between production (q/ha) and CV /% in 25 barley genotypes sown at 12.5 cm, Livada 2016-2018

Sowing distance between rows did not significantly influence plant height. The stability of this character expressed by the coefficient of variability, of a maximum of 15-16%, confirms the preponderant influence of the genotype. The Dana variety, along with the F8-117-10, DH 320-3 and DH 267-126 lines, have a height of over 100 cm and a very good stability. Also with good stability (CV ≤10%) we can mention the Andreea and Artemis varieties, but also the F8-101-2 and Standard 1 lines.

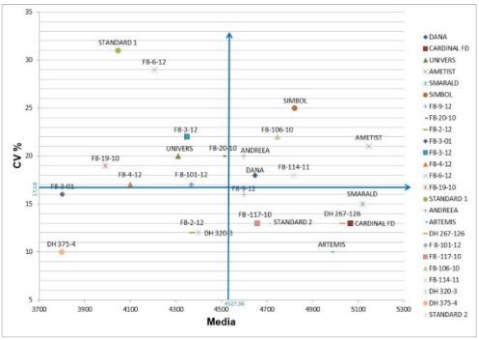

Figure 2 The relationship between production (q/ha) and CV /% in 25 barley genotypes sown at 25 cm, *Livada 2016-2018*

The mass of 1000 grains recorded the highest value, of 51.13 g in the DH 320-3 line in the case of sowing at 12.5 cm between rows and 54.92 g in the case of sowing at 25 cm between rows in the F8-117- line 10

Good values for the weight of 1000 grains (MMB) in both sowing variants were determined in lines F8-117-12 (54.92 g at 12.5 cm between rows and 48.63 g at 25 cm between rows), F8-106-10 (52.23 g at 12.5 cm between rows and 45.35 g at 25 cm between rows), and F8-114-11 (52.35 g at 12.5 cm between rows and 44, 82 g at 25 cm between rows).

In the variant for sowing at 25 cm between rows, all 25 tested genotypes had MMB above 40g

Lines F8-106-10, F8-114-11, DH 375 -4 and Standard 2 had the hectoliter weight (MH) above 60 kg/hl regardless of the sowing distance between the rows. - An essential condition for obtaining large and stable productions is the choice of the most suitable genotypes, adapted to the cultivation area.

Choosing genotypes that respond well to the 25 cm sowing distance allows for an economy in terms of the amount of seed used per unit area with real chances of obtaining very good grain yields.

The varieties Univers, Artemis and the lines F8-9-12, F8-20-10, F8-4-12, F8-106-10, F8-114-11 achieve similar performances regardless of the distance between the rows; Cardinal, Amethyst, Emerald, Andrea and lines F8-2-12, F8-3-12, F8-19-10, Standard 1, F8-101-12, DH 320-3, DH 375-4 have better behavior in the classic sowing variant, while the Dana variety and the lines F8-3-01, F8-6-12, DH 267-126, F8-117-10, Standard 2 achieved better productions when sowing in rare rows, respectively at 25 cm.

The Dana, Cardinal, Univers, Amethyst, Smarald, Andrea, Artemis varieties along with the F8-3-01, F8-20-10, F8-3-12 lines make good use of the pedoclimatic conditions in the north-west of the country and allow obtaining fodder crops superior in terms of quantity and quality

By applying phytosanitary treatments, the quantity and quality of the harvests obtained can be greatly improved, both in terms of grain production and the quality of fodder.

The application of appropriate doses of fertilizers can influence, along with the variety/line, the percentage of fallen plants and implicitly the quantity and quality of the harvest obtained.

The classic sowing distance for the barley crop is 12.5 cm. This distance can be increased without reducing production if suitable genotypes are used. The varieties Univers, Artemis and the lines F8-9-12, F8-20-10, F8-4-12, F8-106-10, F8-114-11 achieve similar performances regardless of the distance between the rows; Cardinal, Amethyst, Emerald, Andrea and lines F8-2-12, F8-3-12, F8-19-10, Standard 1, F8-101-

12, DH 320-3, DH 375-4 have better behavior in the classic sowing variant, while the Dana variety and the lines F8-3-01, F8-6-12, DH 267-126, F8-117-10, Standard 2 achieved better productions when sowing in rare rows, respectively at 25 cm.

The choice of genotypes that react well to the sowing distance of 25 cm allows to achieve an economy in terms of the amount of seed used per surface unit with real chances to obtain very good grain yields.

The most effective method of preventing plant fall is to grow fall-resistant varieties. In order not to be exposed to fall, it is necessary to take into account the fall resistance of the cultivated variety when establishing the barley culture technology.

The attack of foliar pathogens on the barley culture manifests itself differently from one year to another, causing significant harvest losses. The study and knowledge of the reaction of barley varieties to the multiple causes that cause increasing damage are of particular importance today as a result of the increase in the number of physiological races of pathogens. The degree of attack produced by foliar pathogens was different from one year to another, being influenced both by the level of precipitation and the thermal regime recorded during the growing season.

Chemical treatments are essential for grain health. In addition to the optimal timing of the treatment, the products used are just as important, so that the optimal combination of active substances and a well-developed protection technology can ensure not only a perfect phytosanitary condition, but also higher yields good quality.

To obtain high productions of dry matter (% SU) the distance of 12.5 cm between the rows is recommended.

For high productions but also high values of MMB, MH, the number and weight of grains/ear, the distance of 25 cm between rows is recommended.

For the northwest area, the following genotypes are recommended: Dana, Univers, Amethyst, Emerald, Symbol for barley with 6 rows; Andrea and Amethyst for 2-row barley. Tested lines can only be recommended after approval.

Testing the genotypes of different crop species in this area provides relevant information to both breeders and farmers regarding adaptability and yield stability.

The number and weight of grains/ear are traits that depend not only on the cultivar but are also influenced by environmental conditions, plant culture and the position of the grains in the ear.

In the 2016-2018 testing period, the number of grains per spike oscillated between 16.17 for the Standard 2 line and 37.07 for the Smarald variety for genotypes sown at 12.5 cm between rows and for genotypes sown at 25 cm between rows between 17 .43 grains per spike in F line 8-101-12 and 41.03 in Cardinal Fd variety.

The control variety Dana, which shows good stability for this character, was surpassed only by Amethyst and Emerald in terms of the number of grains per spike, but with statistically uncertain values, the other genotypes had a lower number of grains per spike in the classic variant of sowing.

The cultivars Cardinal Fd, Smarald and lines F8-3-12 and F8-20-10 outperformed the Dana control with distinctly and highly significant positive values in the case of sowing in rare rows; the varieties Amethyst and Simbol with a higher number of grains, but with statistically uncertain differences, in the rest of the genotypes the number of grains per spike was lower than the control Dana.

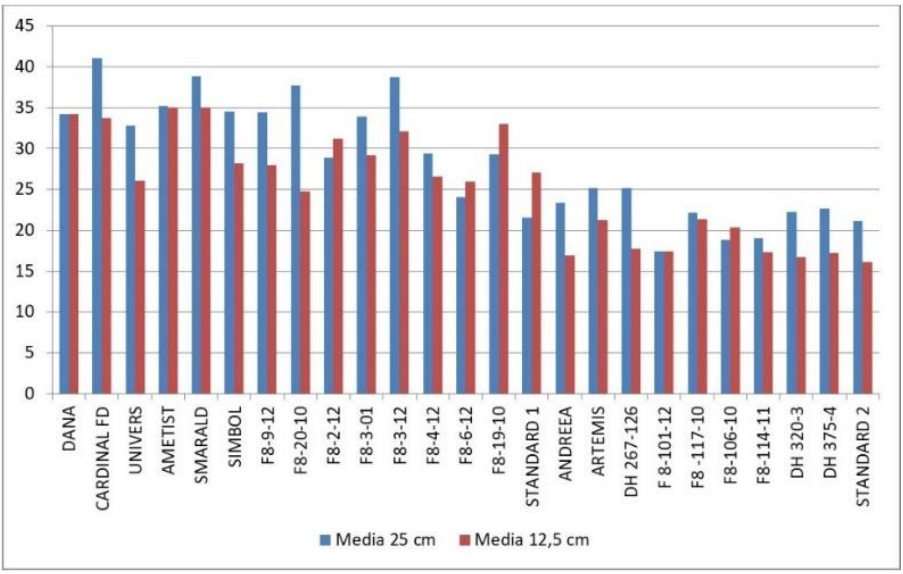

Figure 3 Average number of grains/ear in 25 barley genotypes sown at 12.5 cm and 25 cm between rows, *Livada 2016-2018*

Conclusions and recommendations

In the NW area of the country, where SCDA Livada is located, the presence of acidic soils is a specific feature that requires the use of certain species / varieties / hybrids and specific technologies.

Barley is a suitable crop for the pedoclimatic conditions in the north-west of the country, the area where SCDA Livada is located, especially if we take into account the advantage of clearing the land quite quickly but also taking into account its multiple uses.

Choosing the most suitable genotypes can only be done by testing and evaluating them in different climatic conditions (at least three years of cultivation).

Adaptability and stability of production and main characters are arguments for the selection of the most suitable genotypes in the test area.

The most productive genotypes, from the 25 tested, in the period 2016-2018, were: Cardinal FD, Amethyst and Smarald.-productions: Smarald (5631kg/ha), Amethyst (5532kg/ha), Cardinal FD (5384 kg/ha).

The control variety Dana was surpassed with significant values by the genotypes: Cardinal FD (+824kg/ha), Amethyst (+972 kg/ha) and Smarald (+1071 kg/ha) in the classic version to be sown at 12.5 cm between rows and of the same varieties in the case of sowing in rare rows, but without statistically guaranteed values with lower values, respectively +417 kg/ha (Cardinal FD); +499 kg/ha (Amethyst) and +471kg/ha (Emerald).

The varieties Amethyst, Cardinal FD and Artemis stood out for both good production capacity and stability, the coefficient of variability was within 11-12%.

The Smarald variety, which recorded the highest production (5631 kg/ha), is characterized by an average stability, the CV for grain production was 17%.

Grain production is a highly complex trait influenced by a multitude of genetic and environmental factors. The main productivity elements are also significantly involved in achieving this character.

The average number of spikes oscillated within fairly wide limits, from 379 spikes/m2 in the Dana variety to 1104 spikes/m2 in the F8-114-11 line.