UDK 633.11(496.5)

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WHEAT: IN SEARCH OF DIVERSE FEATURES TO SUCCESSFULLY COPE WITH A CHANGING WORLD

SUMMARY

Among the many challenges agriculture faces today, the main one remains the issue of agricultural plant adaption to the expected trends of climate change.

As predicted by climate models, this phenomenon is expected to increase the frequency and magnitude of extreme climatic events. This implies that more intense and prolonged rainy as well as dry periods are likely to strike the globe. Albania is projected to be one of the most affected countries by this phenomenon, as compared to the other countries in Europe and Central Asia.

Albania recently faced this type of extreme event, in autumn 2010, when vast arable lands were inundated. Under these conditions, the planting of the wheat culture in the central part of the country had to be postponed until the first days of January 2011, when we planted several wheat varieties irradiated with gamma rays aiming at genetic improvement by means of the mutation induction approach. Given these conditions, one of the main goals of our study became the selection of genetic lines that were less influenced by forced late planting. Following this idea, the next year the seeds of the first generation were again planted in the first days of January 2012.

In this paper we will present the performance of some physiological, biometric and yield elements of the LB7 variety whose irradiated variants seem to have performed better than control plants. For comparison purposes, we are also going to use control and irradiated plants planted in Lushnja plots during the first days of December, which is considered the normal planting time.

Key words: wheat, heavy rainfall, climate change, photosynthetic pigments, yield

INTRODUCTION

The adaption of agricultural plants to the climatic and pedological conditions of different regions is an issue that has drawn the genetic improvers' attention for decades. Nevertheless, this issue remains strongly linked with

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present day concerns such as the provision of food security and sustainable use of natural resources. Nowadays, due to the prediction of the most up-to-date global climate models regarding an increasing trend in the frequency and magnitude of extreme climatic events all over the globe (WB, 2009), the adaption of these plants with the expected trend of these predicted changes poses one of the greatest challenges of all genetic improvement programs.

This adaption is even more necessary/essential in Albania, which, as compared to other countries in Europe and Central Asia, is projected to be more affected by this phenomenon, second only to Russia (WB, 2009), and as such, it is more likely to be greatly threatened by such extreme events. In other words, more intense and prolonged rainy, as well as dry periods are predicted to strike this country.

Wheat is an important agricultural plant greatly linked to a state's economy and security (Mike and Davies, 1997). Due to its high energy content, it is extensively utilized in the food industry and other light industries. Moreover, its use as a biofuel is being promoted as well, as a means to reduce the use of the fossil fuels for energy purposes (Mike and Davies, 1997), and as a consequence trap the emissions of greenhouse gases in the atmosphere.

The planting of this culture (winter varieties) is being threatened by the rainfall intensity and duration occurring notably in the autumn period due to the climatic features of this country. As such, successful adaption to the new climate conditions so that the planting, growth and the yield of this culture won't be affected remains a great challenge.

Albania was faced with such an extreme event in autumn 2010 when vast arable lands were inundated. Under these conditions, the planting of the wheat culture in the central part of Albania was delayed until the first days of January. This was the period when we planted some wheat varieties irradiated with gamma rays in Valias (20 km from Tirana, northwest) aiming at genetic improvement of these varieties by means of the mutation induction approach, which remains a good method to increase genetic variability (Stamo et al., 2011) and to gain new cultivars, characterized by new and interesting features such as shorter and stronger stalks, higher resistance against specific diseases, and better technological quality of grain (Kar et al., 1986; Jensen, 1991; Stamo, 1999; Maluszynski et al., 2000). Alongside this experiment, the same varieties treated with the same doses were planted at the beginning of December in Lushnja (60 km from Tirana, southwest), which is considered the normal time for planting due to its mild climate.

Given the planting conditions, one of the main goals of our study became the selection of lines that were less influenced by forced late planting. In the next year the grains of the first generation were planted not only in the compliant time for planting (November), but also in the first days of January.

This paper presents the outcomes of the LB7 variety, which produced the best results. Several physiological, morphological, and yield features are analysed, where the physiological and morphological ones in the end of the anthesis stage and the yield ones in the end of vegetative period are analysed. The results revealed in the irradiated plants are then compared with the results revealed by the un-irradiated plants in the same field (Valias planted for control and comparison purposes). At the same time, the performance of all versions of the irradiated and control plants planted in Valias has also been compared with the plants planted in Lushnje in the first days of December. The same vegetative stage has been analysed in both fields.

MATERIAL AND METHODS

Given the common opinion among researchers who consider the seeds of plants to be the best organ for mutation induction purposes (Uslu et al., 2007), the seeds of the varieties selected as objects of our study were treated with gamma radiation in three different doses of 15Kr, 20Kr and 25Kr. The radiation was realised in the Centre of Applied Nuclear Physics with a Cs137 source and 476, 2 R/min dose potency. The seeds were planted in two experimental plots as previously mentioned. The main difference between the two experiments was in the time of planting where in Lushnje it was 5 December 2010, considered the normal planting time, and in Valias 7 January 2011 was considered forced late planting. The planting was based on a complete randomized block design consisting of similar agronomic works in both plots.

As objects of the study, 20 leaves in each plot were collected randomly in every developmental stage and analysed in order to estimate the photosynthetic pigment concentration utilising the non-destructive spectrophotometric approach (Lichtenthaler, 1987). The collected leaves were extracted with 85% acetone (Academic Press, 1976; Kraja et al., 2000) and measured for the optical densities by means of a spectrophotometer (4802H UV/VIS Double Beam) in E663 nm, E644 nm and E452.5 nm wavelengths. The calculation of the photosynthetic pigment content was based on the equations of Rebelen (Hunt, 1982; Shehu, 2004; Lichtenthaler, 1987). In order to estimate the photosynthetic system performance of the plants, the rate of change in the concentration of chlorophyllous (each: a, b) and carotenoid pigments (sum: x+c) was calculated as a percentage against the control plants. In other words, the concentration of the analysed pigment was supposed to be 100% and then the increase or decrease of the concentration in irradiated plants was calculated.

Biometric features such as plant height and leaf surface were measured and calculated in each analysed stage. The yield elements were measured and analysed as well by the end of the growing season. The correlation coefficient between several features using SPSS 17 software was then analysed.

Physiological, morphological and yield features were analysed, the physiological and morphological ones at the end of the anthesis stage and the yield ones at the end of the vegetative period. The results retrieved from the irradiated plants were compared to the results retrieved from the un-irradiated plants which were planted for control and comparison purposes. At the same time, these plants were compared with the plants planted in Lushnje in the first days of December, considered to be the normal planting time. The purpose of the second comparison was mainly to verify the effect of late planting in the control and irradiated plants grown in the experimental plot of Valias (Tirana region). The selected variety, whose key results are presented in this paper (LB7), was chosen amongst other studied varieties, taking into account the higher performance revealed in the irradiated plants mainly with the purpose of late planting opportunities that it can possess. The results of the M1 generation plants have been chosen for presentation in this paper.

RESULTS AND DISCUSSION

As is already known, the photosynthetic pigment concentration is of great importance with regard to the organic matter synthesis in plants in which the chlorophyll a (chla) plays the direct role in this synthesis and the other pigments, chlorophyll b (chlb) and the carotenoids (Crtx and Crtc), play the role of accumulating the required energy in order to carry out this process (Kraja et al., 2000). With regard to this indicator widely used as an important physiological indicator for estimating plant wellness, the anthesis stage is considered to be the key stage proven to show great correlation with plant development and yield in cereal grains (Kunpu et al., 2009).

Taking into consideration the abovementioned facts, the pigment concentrations in the anthesis stage (mg g^{-1}) have been calculated and shown graphically in Figure 1 as revealed in both experimental plots (Valias and Lushnje).

The figures reveal the average of the pigment sums (Chla, Chlb, Crtx and Crtc) as revealed in each plot for every type of radiation.

The comparison of the revealed values in the sum of all photosynthetic pigments helps us estimate the values between the irradiated forms and control. The main purpose of presenting this graph in this paper was to show the effect of late planting in the Valias plot plants which were not irradiated, and to help us estimate the possibilities of selecting between the genetic lines of the irradiated forms with less effect in these planting conditions. This can be done overall when comparing the performance of the control plants in this field (late planting) with those of the Lushnje field (normal planting). When analysing the control plants' (not irradiated) performances of pigment content in this graph, it is distinctly apparent that the negative influence of late planting in the field of Valias as compared to the field of Lushnje is as expected. On the other hand, the good performance of this feature is quite obvious even in all the irradiated forms planted in Valias in late conditions. Moreover, these values are not only much higher when compared to the control plants, but they arrive and even exceed (15Kr forms) the control plants in the Lushnje plots too.

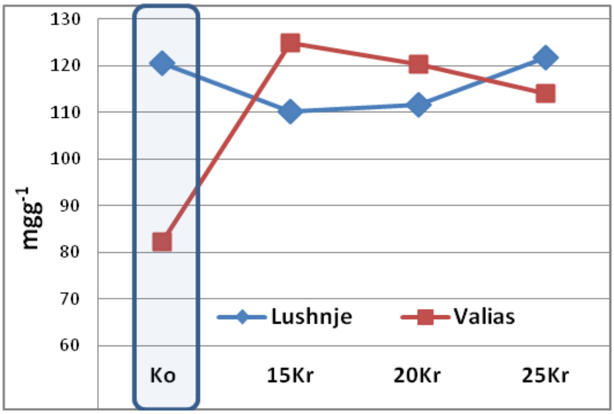

Figure 1: Comparison of the trends of the sum of photosynthetic pigments (chlorophyllous and carotenoids) in irradiated versus control plants in the anthesis stage in both agricultural plots

As a second step, evaluation of the different roles of each pigment with regard to organic matter synthesis and resistance in plants aiming at detecting the good result or malfunction of the photosynthetic system in the analysed plants, the rates of increase and decrease in concentration of each pigment against the control have been analysed. In this calculation, the pigment concentration in the control plant leaves of Valias is considered to be 100%.

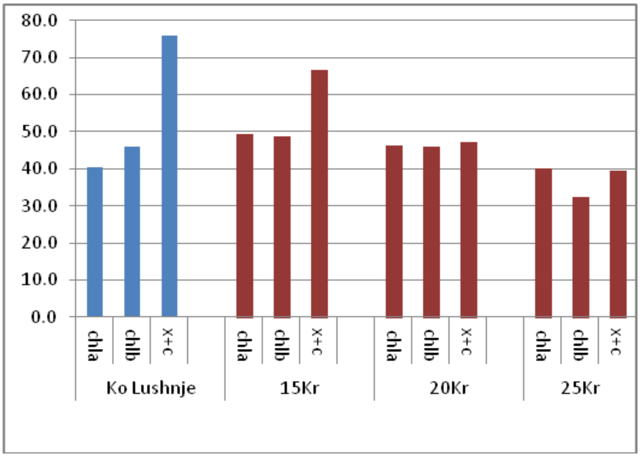

Figure 2: The rates of increment and decrease of every analysed pigment as compared to control Valias plants, in control Lushnje and in radiated plants Valias (average values)

Figure 2 shows the values revealed in the irradiated plants of Valias as compared to Valias control plants, at the same time showing the rate of change of the control plants in Lushnje (planted at normal time) as compared to Valias (planted late). Apparently, the values of the three key elements analysed are nearly the same in the plants belonging to the 15Kr dose radiation group when compared to those of the control in Lushnje. Meanwhile, the difference in plants belonging to the other irradiation groups consists of the carotenoid content, which is known to play a big role in plant resistance to stress.

After having evaluated this important physiological feature, we examined two morphological features, plant height and leaf surface area. Based on the studies carried out over the years in the field of genetic mutation induction, there have often been recorded genetic mutations in these generally considered polygenic features (Mugnozza et al., 1972). Moreover, these features are known to have high effects on yield results which, according to many researchers, are not of low importance. Thus, plant height is often strongly linked with lodging (Konzak, 1988; Xhuveli, 1980), while the leaf surface increases the photosynthetic process rates (Malo, 2000). The results revealed by the LB7 variety at the same analysed stage (the end of anthesis) are presented in Figure 3. As shown in that figure, the leaf surface has undergone a considerable reduction in the plants treated with doses 25Kr. While the other doses (15 and 20Kr) induced a slightly negative effect, which is not important if the higher range of variation between leaves induced by radiation is taken into consideration (the high possibility of selection).

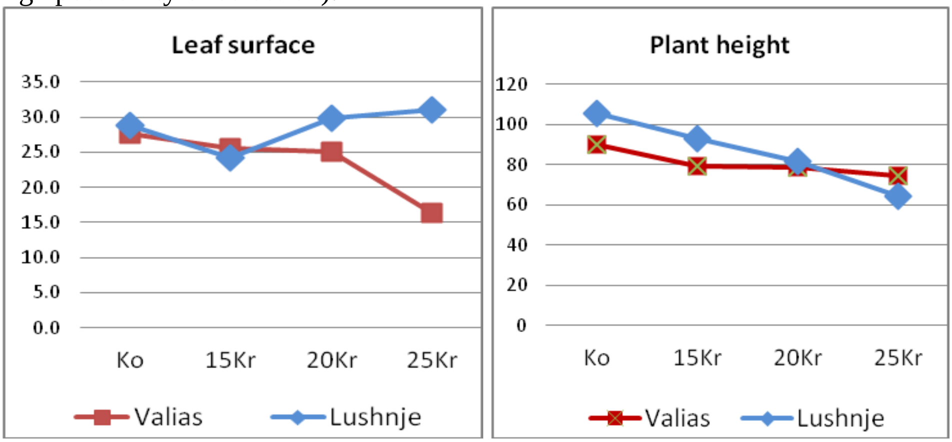

Figure 3: Average values of some morphological features in the anthesis stage in the two analysed plots, control and irradiated plants:
a) leaf surface, b) plant height

It is worth pointing out the apparent higher values revealed in the leaf surface of the irradiated plants (20 and 25Kr) in Lushnje.

Regarding plant height, a reduction of this feature was observed in the irradiated plants, which has enabled the selection of dwarf and semi-dwarf lines, bringing about a reduction of the lodging phenomena of wheat plants which often occurs in the spring time (Malo, 2000)

Regarding the yield elements revealed at the end of the vegetative period, while the irradiated plants grown in the experimental field of Lushnje have not produced positive results when compared to the control values, the irradiated plants grown in Valias exhibited satisfactory values when compared to the control plants grown in this field. Thus, the yield indicators have performed nearly the same way as the physiological indicators analysed in the anthesis stage photosynthetic system.

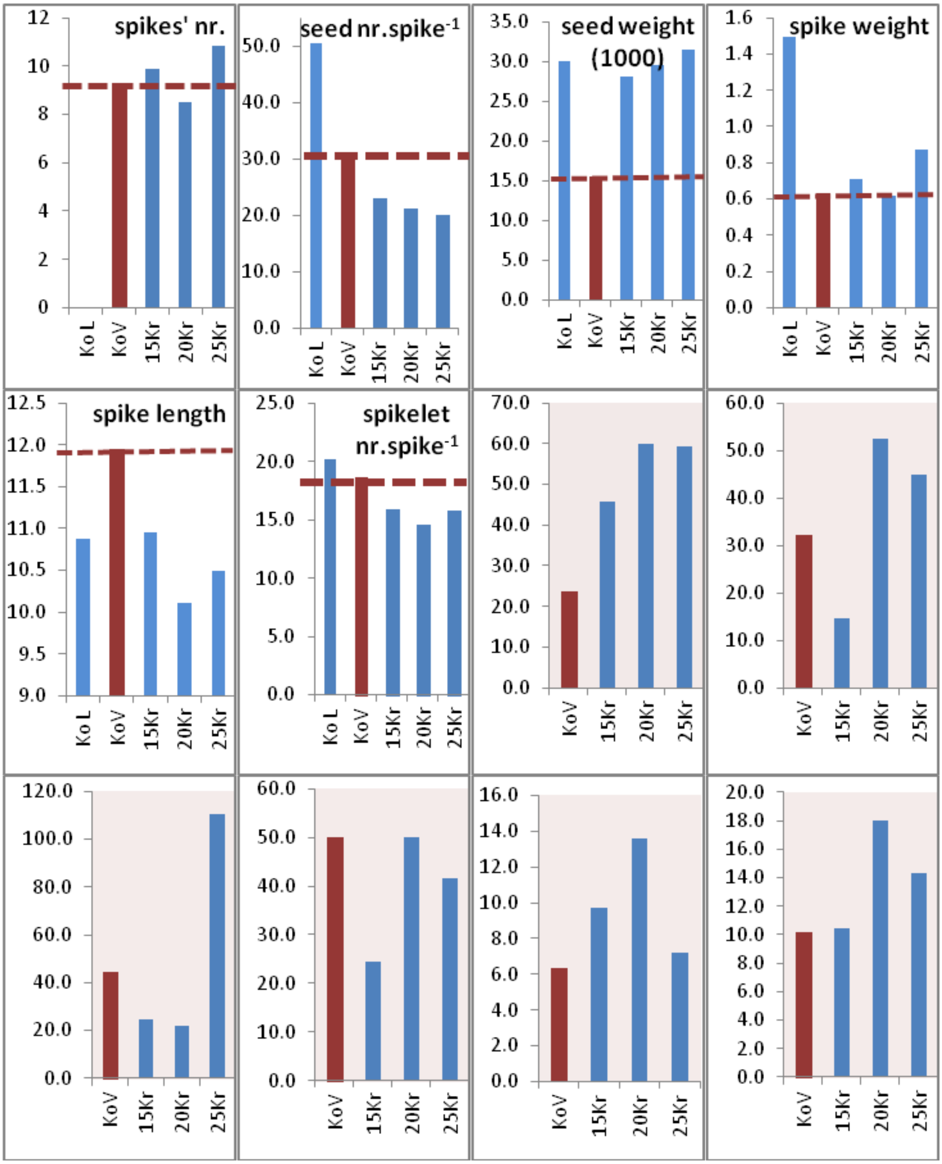

Figure 4: Yield elements at the end of the vegetative period: average (above), CV (below)

The fourth figure shows the average values and the coefficient of variation as revealed in the analysed yield elements. The irradiated plants show a diminished number of seeds per spike, which is widely considered as a random effect of irradiation in the first generation of irradiated plants due to the physiological damage. As such, it might not be considered a negative effect of irradiation. Nevertheless, this element is drastically diminished especially when compared to the Lushnje control values, which are introduced in this graph in order to show the normal planting values of the analysed elements, and thus detect the effects of late planting revealed in the control irradiated plants in Valias. It is also worth mentioning that even though the irradiated plants reveal a diminished number of seeds per spike, the CV is high enough (except in 15Kr irradiated plants) to enable the selection of lines with a higher performance of this element. In fact, this element will be analysed better in the second generation because, as mentioned before, it is highly influenced by the physiological damage following irradiation.

The grain weight has increased drastically in all versions of irradiation, and has even reached the values revealed in Lushnje plants planted at the normal time. The number of spikes in the plants, strongly linked to the grain weight of a complete plant, is augmented as well, both in the average and CV values.

Table 1: Correlation coefficient between the yield indicators themselves, and between them and plant height in the Valias plot.

Var.	Ko					15Kr					20Kr					25Kr				
Tiparet	Pl. hight	Spikes nr./pl	Seed wght/sp	Seed nr./sp	Seed wght/pl	Pl. hight	Spikes nr./pl	Seed wght/sp	Seed nr./sp	Seed wght/pl	Pl. hight	Spikes nr./pl	Seed wght/sp	Seed nr./sp	Seed wght/pl	Pl. hight	Spikes nr./pl	Seed wght/sp	Seed nr./sp	Seed wght/pl
Pl. hight	**1**	**.681***	**.508**	**-.346**	**.508**	**1**	**-.401**	**-.075**	**-.556**	**-.194**	**1**	**.663***	**.510***	**.477***	**.751****	**1**	**-.228**	**-.684***	**-.278**	**.085**
Spikes nr./pl		**1**	**.772****	**.056**	**.772****		**1**	**.703***	**.818****	**.309**		**1**	**.322**	**.423**	**-.014**		**1**	**-.046**	**-.108**	**.667***
Seed wght/sp			**1**	**.253**	**1.000****			**1**	**.429**	**.439**			**1**	**.897****	**.677***			**1**	**.500**	**-.443**
Seed nr./sp				**1**	**.253**				**1**	**.549**				**1**	**.626***				**1**	**-.084**
Seed wght/pl					**1**					**1**					**1**					**1**

*. Correlation is significant at the 0.05 level (1-tailed).
**. Correlation is significant at the 0.01 level (1-tailed).
Where: Pl.hight - plant height; spikes nr/pl - spikes number plant^{-}; seed wght/sp - seed weight spike^{-}; seed nr/sp-seed number spike^{-}; seedwght/pl-seed weight plant^{-}

In Table 1 the correlation coefficients between yield elements of Valias plants are shown. The plants irradiated with the 20Kr dose openly reveal a significantly positive correlation of the plant height with all the yield features, especially with the weight of the plant, where the weight of the plant is considered only the weight of the seeds of a plant. In other words, in this variant of irradiation, the height increase runs parallel with the increase in spike number of the plant, the increase in grain number of the spike and the increase in the weight of the main spike and all spikes of the plant. Given this variation we will tend to select lines with great stature, whose stubble could also be used for bioenergetic purposes in accordance with high yield performance. In other words, among the second generation plants, we will select tall plants which will be tested in the future for their sustainability against lodging.

In the 15Kr version of irradiated plants, quite the opposite has been revealed. A slight negative correlation of plant height with all yield elements has been shown even though not significant. The number of spikes shows a very high correlation with the number and weight of grains in the main spike. Under such conditions, we will try to select, between the M2 plants, dwarf and many spikes which seem to be strongly linked with other yield elements. In this way, we aim to select plants with high durability against lodging and better yield performance.

As for the correlation data in the 25Kr version, the results are more scattered. However, the negative correlation between height and production elements dominates as in the 15Kr radiated plants, with the only exception the entire weight of the plant grains, which has a very slight positive correlation which is not significant. The spike number also reveals a negative correlation with the number and weight of grains of the main spike.

CONCLUSION

1. With regard to late planting: Negative impact over almost all the analysed features was observed in the control plants which were not treated with radiation as compared to the control ones planted at the normal time. There were much less negative impacts in the late planting as observed in the irradiated plants.

The radiation caused positive impacts in physiological and yield features.

2. With regard to genetic diversity: *The coefficient of variance is considerably increased in all analysed features of irradiated plants.*

3. With regard to morphological features: Reduced plant height was shown in all irradiated versions when compared to the control, enabling the selection of dwarf lines with good resistance against lodging. Tall plants with lots of stubble for energy use purposes can be selected due to the high range of values observed and coefficient of variance, CV. According to the correlation coefficient between yield features and yield performance: dwarf plants with good yield performance can be selected among 15 and 25Kr plants and tall plants with good yield performance can be selected among 20Kr plants. These selected plants will be tested for their resistance against lodging as well.

The radiation has caused positive results with regard to morphological features such as reduced plant or increased plant height.

4. The results have to be proven on M2 generation plants as well.

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PŠENICA: U POTRAZI ZA RAZLIČITIM OSOBINAMA RADI PRILAGOĐAVANJA SVIJETU KOJI SE MIJENJA

SAŽETAK

Jedan od glavnih izazova sa kojima se poljoprivreda suočava danas, jeste adaptacija poljoprivrednog bilja na očekivane trendove klimatskih promjena.

Kao što predviđaju klimatski modeli, očekuje se povećanje učestalosti i obima ekstremnih klimatskih događaja. To podrazumijeva da će zemljinu kuglu vjerovatno pogoditi intenzivnije i dugotrajnije padavine, kao i periodi suše. Kada je riječ o ovom fenomenu, predviđanja su da je Albanija jedna od najugroženijih zemalja, u poređenju sa ostalim zemljama Evrope i Centralne Azije.

U stvari, Albanija se nedavno, tačnije u jesen 2010. godine, suočila sa jednom takvom ekstremnom situacijom kada su poplavljene ogromne površine obradive zemlje. U tim uslovima, sjetva kulture pšenice u centralnom dijelu zemlje je morala biti odložena za prve dana januara 2011.godine, kada je zapravo zasijano nekoliko sorti pšenice tretiranih gama zracima u cilju njihovog genetskog unapređenja putem indukcije mutacije. Imajući u vidu ove uslove, jedan od glavnih ciljeva naše studije je izbor linija na koje će prinudna, kasna sjetva imati slabiji uticaj. Rukovodeći se ovom idejom, sljedeće godine je sjeme prve generacije ponovo zasađeno u prvim danima januara 2012.

Iz tog razloga, mi ćemo predstaviti određene fiziološke, biometrijske i karakteristike prinosa sorte LB7, čije su ozračene varijante očigledno bolje reagovale od kontrolnih biljaka. Da bismo izvršili upoređivanje, koristićemo kontrolne i ozračene biljke posijane u Lushnja parcelama prvih dana decembra, što se smatra normalnim terminom za sjetvu.

Ključne riječi: pšenica, obilna kiša, klimatske promjene, fotosintetički pigment, prinos