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MORPHO-PHYSIOLOGICAL AND HORMONAL RESPONSE OF DIFFERENT WINTER WHEAT VARIETIES TO DROUGHT STRESS AT GERMINATION AND SEEDLING STAGE

MORFO-FIZIOLOŠKI I HORMONSKI ODGOVOR RAZLIČITIH SORTI OZIME PŠENICE NA SUŠNI STRES U FAZI KLIJANJA I KLIJANACA

J. Duvnjak, Lidija Brkljačić, Branka Salopek Sondi, Valentina Španić

ABSTRACT

Drought stress can have a significant influence on the reduction of wheat (*Triticum aestivum* L.) growth and development. This study investigated morpho-physiological, abscisic (ABA) and salicylic (SA) acids' responses of six winter wheat varieties (Rujana, Silvija, Fifi, Bubnjar, Anđelka and Pepeljuga) during the germination and seedling stage. Plants were exposed to 10 and 20% polyethylene glycol (PEG) solution for seven days. Certain morpho-physiological changes were observed under stress condition in comparison to controls, such as a reduction of germination energy (GE), shoot length, relative water content (RWC), increase of root growth, depending on varieties and stress intensity. ABA was increased in all cultivars confirming stress status of the plants. SA showed a tendency to decrease depending on the concentration of PEG and was positively correlated with shoot length and shoot dry weight. In the varieties Rujana, Anđelka, Fifi and Bubnjar a less significant decrease in germination energy was recorded, compared to Pepeljuga and Silvija.

Keywords: drought stress, hormones, winter wheat

SAŽETAK

Sušni stres može značajno utjecati na smanjenje rasta i razvoja pšenice. U ovom radu istraživan je morfo-fiziološki odgovor, te odgovor abscizinske (ABA) i salicilne (SA) kiseline šest sorti ozime pšenice (Rujana, Silvija, Fifi, Bubnjar, Anđelka and Pepeljuga) tijekom klijanja i faze klijanaca. Biljke su izložene 10 i 20 % otopini polietilen glikola (PEG) tijekom sedam dana. Od morfo-fizioloških parametara zabilježeno je značajno smanjenje energije klijanja, smanjenje duljine izdanka, smanjenje relativnog sadržaja vode, pojačani rast korijena ovisno o stupnju stresa u odnosu na kontrolne uvjete i sorti pšenice. Koncentracija ABA je povećana u svim sortama što potvrđuje prisutnost stresa u biljkama. SA je pokazala tendenciju smanjenja ovisno o koncentraciji PEG-a i bila je u pozitivnoj korelaciji s duljinom izdanka i suhom masom izdanka. Kod sorti Pepeljuga i Silvija zabilježeno je značajno smanjenje energije klijanja u odnosu na sorte Rujana, Anđelka, Fifi i Bubnjar.

Ključne riječi: sušni stres, hormoni, ozima pšenica

1. INTRODUCTION

Climate forecasts predict that the average global temperature will rise by 1-4°C by the end of this century (Driedonks et al., 2016), thereby resulting in reduction of productivity of important crops including wheat (*Triticum aestivum* L.). Drought stress is one of the most important abiotic stresses that affect growth and yield of wheat. It can occur in any growth stage, while drought tolerance in wheat at seedling stage tends to receive less attention. However, stress at any time can be very important, including germination and seedling stage (Akram, 2011). Furthermore, domestic wheat varieties are a valuable source of genetic diversity. They are adapted to the conditions of their origin and can therefore provide new sources of drought resistance for the development of new varieties adapted to climate change.

Drought presented as lack of water in the soil at the time of wheat sowing affects seed germination (Kizilgeçi et al., 2017). As a result of limited physiological functions in plants, decrease of leaf growth, stomatal conductance, photosynthetic capacity, nutrient uptake etc. occur (Fathi and Tari, 2016). Further, during germination stage, drought stress results in reduction of germination rate and percentage, leading to prolonged germination time (Delachiave and de Pinho, 2003). Wheat plants can adapt to drought conditions by activation of different molecular, biochemical or physiological processes (Kulkarni et al., 2017), and by changing morphological occurrence such as the formation of deeper roots (Chipilski et al., 2012). Also, response of plants to drought stress is manifested beside enhanced root growth in reduction of shoot growth (Yamaguchi and Sharp, 2010), resulting in increased root/shoot ratio.

Phytohormones play versatile roles in regulation of plant growth and development (Jiang and Asami, 2018). One of the most important phytohormones under drought stress is abscisic acid (ABA) (Nakashima et al., 2014., Abhilasha and Choudhury, 2021), which is enhanced during drought and causes stomatal closure (Kim et al., 2010). As a result of stomata closure, intracellular water loss is prevented (Tuteja, 2007). Therefore, the main function of ABA seems to be the regulation of plant water balance and osmotic stress tolerance. Further, ABA helped the seed germinate only when conditions were suitable for germination (Tuteja, 2007). Along with ABA, salicylic acid (SA) also plays an essential role in modulating the plant response to drought (Miura and Tada, 2014), through various roles in physiological processes (Kumar, 2014). Objectives of this study were investigate the effects of drought application on morpho-physiological traits in six winter wheat varieties and to compare the performances of wheat varieties under drought in terms of ABA and SA concentrations during germination and seedling stage.

2. MATERIALS AND METHODS

2.1. Plant material

Six winter wheat varieties (Rujana, Silvija, Fifi, Bubnjar, Anđelka and Pepeljuga) of the Agricultural Institute Osijek were used to set up the experiment. Previously they were characterized in the research of Duvnjak et al. (2023).

2.2. Drought stress during germination and seedling growth stage

The experiment was set up under controlled conditions in plant growth chamber (Aralab, Rio de Mouro, Portugal) where temperatures were adjusted at 25/20°C day/night with a photoperiod of 16 hours. Each variety was planted in five replicates in two polyethylene glycol (PEG) stress treatments in addition to controlled treatment. The seeds were planted in glass jars on filter paper (40 seeds/jar). PEG at a concentration of 10 and 20% was used to simulate drought stress for seven days. During this period plants were watered daily in the controlled treatment with 10 ml of distilled water, while in treatment 1 (T1) 10 ml of 10% PEG solution was added daily and in treatment 2 (T2) 10 ml of 20% PEG solution was used.

2.3. Morphological traits and relative water content (RWC)

During germination and seedling stage, each trait was measured in replicates under controlled, 10 and 20% PEG treatments. Seed germination was tracked daily in five replicates during first four days of the experiment. Seeds were considered germinated when their radicle was more than 2 mm in length (Saleem et al., 2019). Germination energy (GE) was calculated in five replicates by formula:

$$GE = \frac{number\ of\ germinated\ seeds\ within\ 4\ days}{total\ number\ of\ planted\ seeds} x100$$

Shoot and root length (mm) was measured in ten replicates by ruler on 7th day of the experiment. Fresh and dry weight of shoots and roots were obtained in ten replicates by separately weighting them, and again 24 hours after drying in a lab dryer on 105°C.

2.4. Abscisic (ABA) and salicylic (SA) acids analysis

After plant tissue sampling, the samples were frozen in liquid nitrogen, lyophilized and extracted for ABA and SA determination in five replicates. Determination of ABA and SA in 90 wheat samples (six varieties in three treatments in five replication) was performed by the liquid chromatography with tandem mass spectrometry (LC-MS/MS) at the Department of Molecular Biology, Ruđer Bošković Institute, Croatia, according to the same method described previously in the research of Duvnjak et al. (2023).

2.5. Statistical Analysis

Samples were collected from each jar, and morphological parameters were measured ten replications, while ABA and SA concentration in shoots was measured in five replicates. Data were statistically analysed using Statistica software (version 14.). To test differences among mean values was used Fisher's LSD test at 5% probability level. Results of analysed traits were expressed as mean value of five replicates ± standard deviation, Correlation analysis were done by Spearman coefficient at p<0.05 and p<0.001, while principal component analysis was performed using Addinsoft XLSTAT (New York, USA).

3. RESULTS

During germination and seedling stage 10% PEG treatment resulted in significant decrease in the germination energy, compared to controlled treatment in three varieties (Silvija, Fifi and Pepeljuga), while 20% PEG treatment significantly reduced germination energy in all varieties, compared to controlled treatment. The relative decrease under 10% PEG treatment, compared to controlled treatment, for Pepeljuga, Silvija, and Fifi was 7.6, 7.3

and 6.5%, respectively. Further, under 20% PEG treatment varieties Silvija and Pepeljuga showed the highest relative decrease of germination energy, compared to control (15.3 and 13.0%) (Figure 1A).

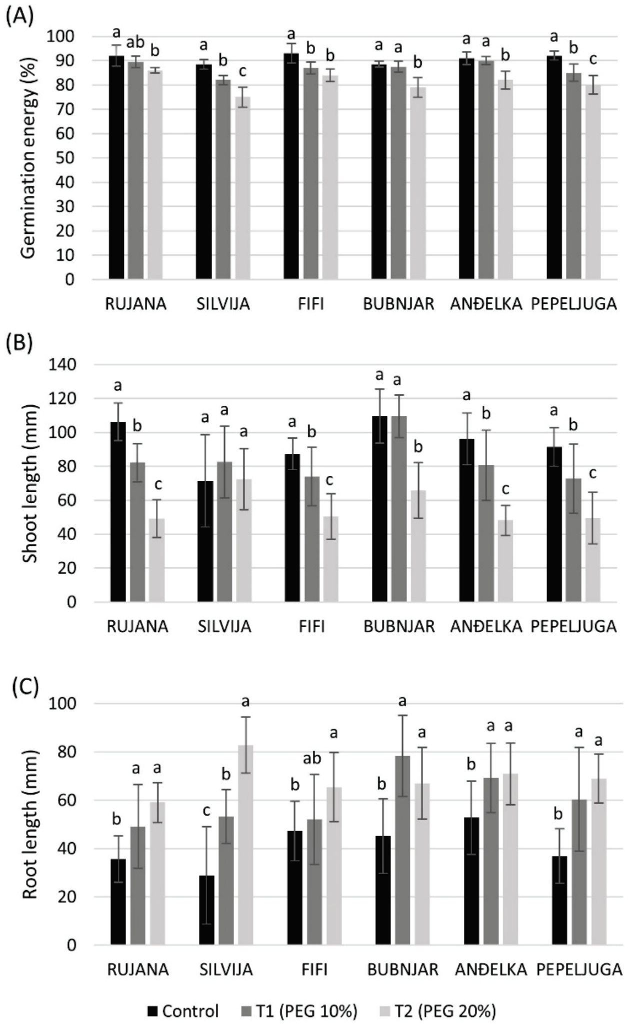

Figure 1 Germination energy (A), shoot length (B) and root length (C) during germination and seedling stage of six winter wheat varieties in three treatments

Graf 1. Energija klijanja (A), duljina izdanka (B) i duljina korijena (C) u fazi klijanja i klijanaca šest sorti ozime pšenice u tri tretmana.

The shoot length was the longest under controlled treatment, followed by significant reduction under 10% PEG treatment, for varieties Fifi, Anđelka, Pepeljuga and Rujana by 15.2, 16.2, 20.6 and 22.6%, respectively. However, the shoot length decreased steadily with the increase of PEG concentration at 20% for all varieties, except for Silvija, compared to controlled treatment. The highest relative decrease of shoot length under 20% PEG treatment, compared to control, was recorded for Rujana (53.7%) (Figure 1B).

In the control, significantly the shortest root length was recorded for all varieties, compared to 10 and 20% PEG treatments, except for Fifi that kept root length at the same significant level under control and 10% PEG treatment. Among the treatments, the longest root length was recorded with 20% PEG treatment, followed by 10% PEG treatment. Only the variety Silvija significantly increased root length under 20% PEG treatment, compared to 10% PEG treatment. Under 20% PEG treatment, all varieties significantly increased root length, compared to controls, where the relative increase was mostly pronounced in Silvija (186.5%) (Figure 1C). Under 10% PEG treatment, the fresh weight of shoots was significantly reduced in Pepeljuga, Anđelka, and Rujana by 30.9, 29.7 and 22.7%, respectively, compared to controlled treatment (Figure 2A), while dry weight of shoots remained at the same significant level in all varieties (Figure 2B). Moreover, the fresh and dry weight of shoots were significantly reduced in all varieties due to 20% PEG stress treatment, compared with the controls, except for Silvija, Anđelka and Bubnjar in dry weight of shoots. Fresh weight of roots was not significantly changed under both PEG treatments, compared to controlled treatment, except for Anđelka that significantly decreased it under 10% PEG treatment, compared to the control (Figure 2C). Varieties Rujana, Bubnjar and Anđelka significantly increased dry weight of roots under 10% PEG treatment, compared to the control, while the dry weight of roots increased dramatically in all varieties under 20% PEG treatment, compared to controls, except for Pepeljuga (Figure 2D). When compared to the controlled treatment, the RWC under 20% PEG treatment was significantly reduced in Fifi and Bubnjar for 38.8 and 27.4%, respectively, while Pepeljuga significantly reduced it under 20% PEG treatment, compared to 10% PEG treatment (Figure 2E).

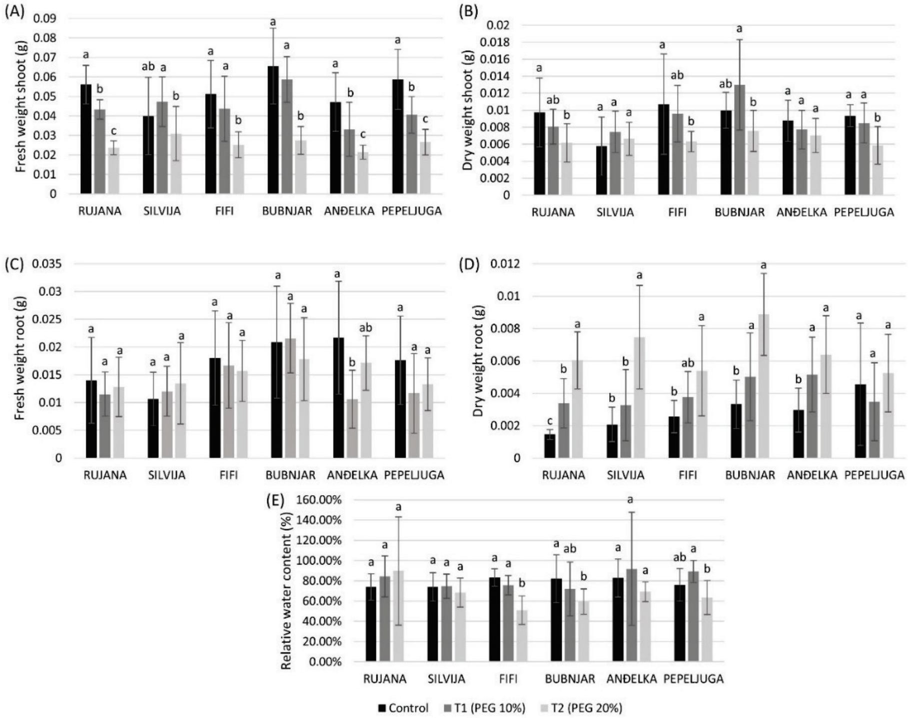

Figure 2 Fresh and dry weight of shoots (A, B) and roots (C, D), and relative water content (E) during germination and seedling stage of six winter wheat varieties in three treatments

Graf 2. Svježa i suha masa izdanka (A i B) i korijena (C, D) i relativan sadržaj vode (D) u fazi klijanja i klijanaca šest sorti ozime pšenice u tri tretmana.

The results revealed that ABA was significantly increased in shoots of all varieties by 20% PEG treatment, compared to control plants, except for Silvija (Figure 3A). Varieties Bubnjar (0.9112 ng/mg DW), Rujana (1.0492 ng/mg DW) and Pepeljuga (1.0353 ng/mg DW) had the highest concentration of ABA under that treatment among other varieties. The same varieties in shoots exhibited the highest relative increase of ABA under 20% PEG treatment, compared to control (846.5, 451.8 and 478.8%, respectively). Variety Bubnjar in shoots also had the highest non-significant increase of ABA concentration under 10% PEG treatment (204.0%), compared to control, while Silvija slightly non-significantly decreased ABA under 10% PEG treatment, compared to controlled treatment.

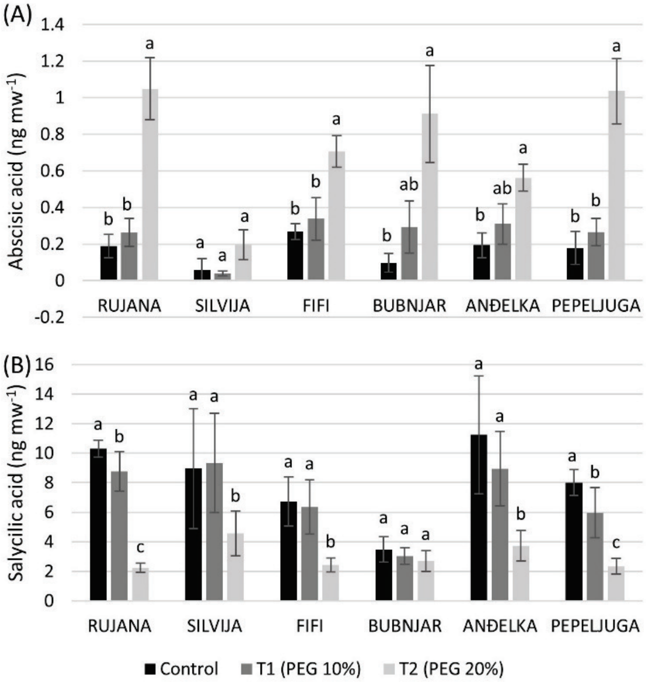

Figure 3 Concentration of abscisic (A) and salicylic (B) acid in shoots during germination and seedling stage of six winter wheat varieties in three treatments

Graf 3. Koncentracija abscizinske (A) i salicilne (B) kiseline u izdancima u fazi klijanja i klijanaca šest sorti ozime pšenice u tri tretmana.

The SA concentration in shoots of Rujana and Pepeljuga was considerably reduced by 10% PEG treatment, compared to controls, while 20% PEG treatment significantly decreased SA concentration in shoots of all varieties, except for Bubnjar, where SA was only slightly, non-significantly changed between treatments (Figure 3B). Under 10% PEG treatment, the reduction was the most pronounced in shoots of Pepeljuga (25.5%), and the least non-significantly in Fifi (5.7%), compared to controlled treatment. Silvija showed slight increase of SA concentration under 10% PEG treatment, compared to controls. Under 20% PEG treatment, the reduction of SA in shoots was greatest in Rujana (78.3%) and Pepeljuga (70.7%) and least non-significantly reduced in Bubnjar (22.3%), compared to the controlled treatment.

3.1. Correlation and principal component analysis

Correlation analysis showed that germination energy was in significant positive relation with shoot length and its fresh and dry weight, RWC and SA, while negative correlation was obtained with root length and its dry weight. Shoot length was in positive significant correlation with germination energy, fresh and dry weight of shoots, and with SA, but in negative significant correlation with dry weight of roots and ABA. Root length was in negative significant correlation with germination energy, fresh weight of shoots, and SA. Fresh weight of shoots was in positive significant correlation with germination energy, shoot length and SA, while negative correlation was obtained with root length and its dry weight, and ABA. Dry weight of shoots was positively correlated with germination energy, shoot length and its fresh weight and fresh weight of roots. Dry weight of roots was negatively correlated with germination energy, shoot length and its fresh weight, and SA, while it was positively correlated with root length and ABA. RWC was positively correlated with germination energy (Table 1).

Table 1 Correlation analysis of ten investigated traits in three treatments during germination and seedling stage

Tablica 1. Korelacijska analiza deset ispitivanih svojstava u tri tretmana tijekom faze klijanja i klijanaca.

	Germination energy	Shoot length	Root length	Fresh weight shoot	Dry weight shoot	Fresh weight root	Dry weight root	Relative water content	Abscisic acid	Salicylic acid
Germination energy	1	0.66**	-0.67**	0.64**	0.60**	0.16	-0.70**	0.59**	-0.4	0.59*
Shoot length		1	-0.43	0.95**	0.84**	0.41	-0.64**	0.32	-0.65**	0.52*
Root length			1	-0.55*	-0.27	0	0.79**	-0.32	0.58*	-0.51*
Fresh weight shoot				1	0.82**	0.4	-0.68**	0.28	-0.70**	0.48*
Dry weight shoot					1	0.58*	-0.42	0.33	-0.28	0.27
Fresh weight root						1	0.02	-0.25	0.03	-0.17
Dry weight root							1	-0.38	0.71**	-0.74**
Relative water content								1	-0.18	0.36
Abscisic acid									1	-0.74**
Salicylic acid										1

**-significant at 0.01; *-significant at 0.05

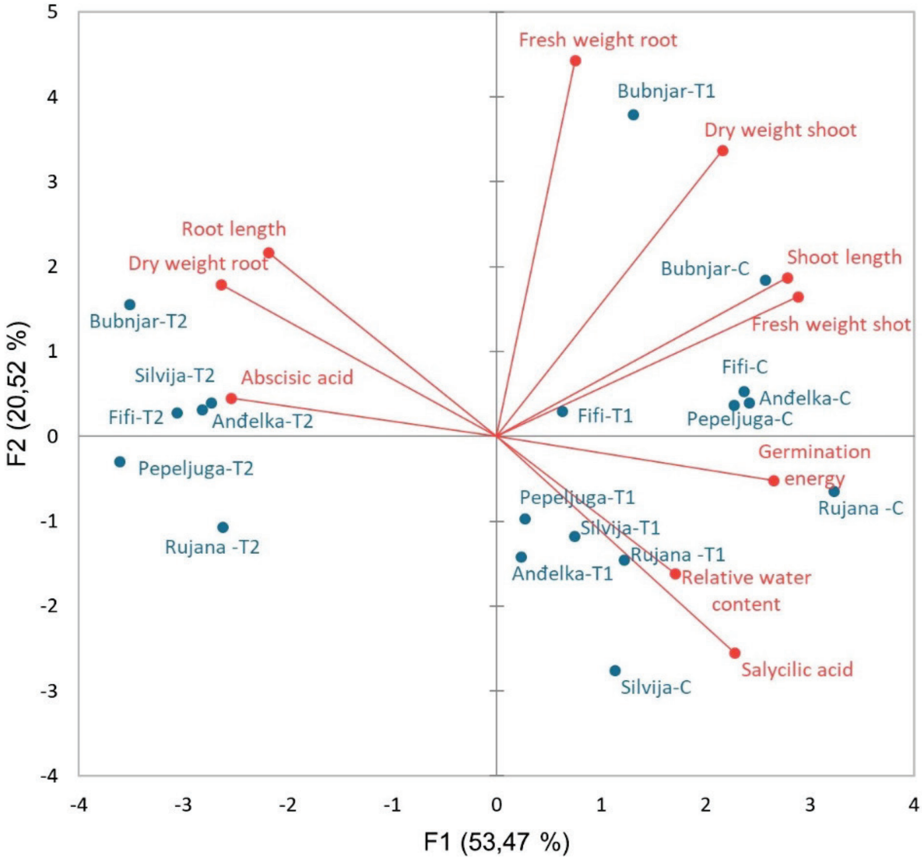

Figure 4. Principal component analysis (PCA) showing the relationship of morpho-physiological traits and stress hormones at germination and seedling stage six winter wheat (Rujana, Silvija, Fifi, Anđelka, Bubnjar and Pepeljuga) under two drought regimes (T1 and T2) and control (C). PCA was performed on the correlation matrix of average values of morpho-physiological attributes (dry weight root, fresh weight root, root length, dry weight shoot, fresh weight shoot, shoot length, RWC, germination energy), and con-centrations of stress hormones (abscisic acid and salycilic acid).

Slika 4. Analiza glavnih komponenti (PCA) koja pokazuje odnos morfo-fizioloških svojstava i hormona stresa u fazi klijanja i klijanaca šest sorti ozime pšenice (Rujana, Silvija, Fifi, Anđelka, Bubnjar i Pepeljuga) u dva sušna tretmana (T1 i T2) i kontroli (C). PCA je provedena na korelacijskoj matrici prosječnih vrijednosti morfo-fizioloških svojstava (suha težina korijena, svježa masa korijena, duljina korijena, suha težina izdanka, svježa težina izdanka, duljina izdanka, RWC, energija klijanja) i koncentracijama stresnih hormona (abscizinska kiselina i salicilna kiselina).

The Scree plot of the PCA (Figure 4) showed that the first five eigenvalues corresponded to the whole percentage of the variance in the dataset. In this study, out of a total of 10 components, five had eigenvalues > 0.3. These five principal components explained approximately 93.55% of the total variability. According to PC analysis, the variance in the eigenvalues was the greatest for PC1 (5.35) and PC2 (2.05) (Table 2).

Table 2 Principal component analysis abscisic and salicylic acid on morpho-physiological responses of different winter wheat

Tablica 2. Analiza glavnih komponenti abscizinske i salicilne kiseline na morfo-fiziološki odgovor različitih sorti ozime pšenice.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Eigenvalue	5.347	2.052	0.827	0.790	0.339	0.243	0.192	0.118	0.073	0.020
Variability (%)	53.470	20.516	8.273	7.904	3.388	2.429	1.918	1.177	0.729	0.196
Cumulative (%)	53.470	73.985	82.258	90.162	93.550	95.979	97.898	99.075	99.804	100.000

Table 3 Factor loadings for wheat abscisic and salicylic acid on morpho-physiological responses

Tablica 3. Utjecaj morfo-fiziološkog odgovora na faktore abscizinske i salicilne kiseline

Contribution of the variables (%):					
	F1	F2	F3	F4	F5
Germination energy	12.869	0.493	0.225	27.259	6.497
Shoot length	14.145	6.375	0.444	5.591	0.379
Root length	8.734	8.556	22.642	11.301	2.144
Fresh weight of shoot	15.257	4.934	0.824	0.715	12.980
Dry weight of shoot	8.549	20.765	3.706	0.250	1.432
Fresh weight of root	1.039	35.932	3.041	4.898	22.680
Dry weight of root	12.753	5.878	4.193	1.359	6.968
Relative water content	5.321	4.794	64.787	4.638	0.247
Abscisic acid	11.831	0.373	0.064	36.129	0.006
Salycilic acid	9.503	11.900	0.073	7.860	46.665

PCA shoved PC1 accounted for 53.47% of variation with fresh shoot weight (15.26) and shoot length (14.15) being the major factors (Table 2 and 3), while PC2 accounted for 20.52% variation with fresh root weight (35.93) and dry shoot weight (20.77) as major factors. For PC3 major contributions were attributed to relative water content (64.79) and root length (22.64), while the major contribution of PC4 had abscisic acid (36.13) and germination energy (27.26). The maximum values for various traits in PC5 were salycilic acid (46.67) and fresh root weight (22.68).

The PCA biplot showed that absicisic acid, root dry weigh and root length were closely located on opposite side of GE, RWC and SA indicating that there was direct negative relation between abscisic and salycilic acid (Figure 4).

Group in low right quadrant consisting of two varieties from controlled treatment (Silvija and Rujana) and four varieties (Bubnjar, Fifi, Anđelka and Pepeljuga) in upper right quadrant positively contributed to PC1, while group drought treatment T1 that positively contributed to PC1 consisted of four varieties (Pepeljuga, Silvija, Anđelka and Rujana) in lower right quadrant and two varieties (Bubnjar and Fifi) in upper right quadrant. Positive contribution to PC2 was obtained by four varieties in control treatment (Bubnjar, Fifi, Anđelka and Pepeljuga) in right upper quadrant, and by group of two varieties (Bubnjar and Fifi) in right upper quadrant under drought treatment T1, and group of four varieties (Bubnjar, Silvija, Fifi and Anđelka) in left upper quadrant under drought treatment T2 (Figure 4).

4. Discussion

As a result of drought stress, a different response of winter wheat seedlings was recorded, it was more pronounced with stronger drought stress (20% PEG treatment), and it depended on the variety and severity of drought stress. The current study investigated the mechanisms underlying the correlation of two endogenous levels of stress hormones, ABA and SA, and morpho-physiological traits, at germination and seedling stage.

According to Gurvich et al. (2017) germination and seedling phase is the critical stage in establishment of the grain yield. Drought can delay germination, whereas significant changes in seedling physiology and morphology can occur (Yang et al., 2016). Therefore, to understand the adaptation of wheat to drought, the first step is to study the effect of drought in germination and seedling stage, taking account that germination is a complex mechanism where ABA could suppress radicle emergence by inhibiting cell wall loosening and cell elongation (Gimeno-Gilles et al., 2009). PEG treatments affected negatively germination energy at all varieties (Rujana, Fifi, Anđelka, Bubnjar, Pepeljuga and Silvija) in a dose dependent manner. Thus, 20% PEG decreased germination energy 6.9, 10.7, 11.0, 12.0, 15.0 and 18.0%, respectively.

Our data showed that shoot growth of young seedlings was negatively affected by PEG treatments in all varieties except variety Silvija. Contrary, root growth was induced by osmotic stress in all varieties, but most significantly in variety Silvija. Under 20% PEG treatment, all varieties significantly increased root length, compared to controls, where relative increase was mostly pronounced in Silvija. Stress hormone ABA is well known stress marker in drought and other abiotic stresses having protective role in photosynthetic apparatus by regulating transpiration rates and maintains cellular turgorby controlling stomatal opening and closure (in concert with other phytohormones), induces osmoprotectant accumulation, activates ROS detoxification mechanisms, and modifies ion transport (Finkelstein, 2013; Fahad et al., 2015). Similarly, ABA level was increased in plants growing under salinity stress and also in heavy metals pollution sites (Sharma and Kumar, 2002). ABA was increased significantly in all wheat varieties except variety Silvija although there was also a trend of ABA increase. Variety Silvija did not significantly change concentration of ABA in shoots between treatments, and therefore it had the highest root increase under 10 and 20% PEG treatments, compared to control plants, as well as no significant changes occurred in shoot length between treatments. This is in agreement with comparative research of *Brassica* plants under drought and salinity stress that showed positive correlation of the ABA increase level, compared to corresponding controls and stress level that plants experienced (Pavlović et al. 2018, 2019). It was reported previously that in cereal seedlings, inhibition of root growth was mediated by an enhanced ABA level, while inhibition of coleoptile elongation was also mediated by ABA through repression of ethylene (Ma et al., 2014). Correlations between ABA increase and plant tolerance were somehow controversial in literature and obviously depended on plant species.

In the current research, shoot length and its fresh and dry weight were positively correlated. Variety Bubnjar significantly decreased germination energy, shoot length and its fresh weight only under 20% PEG treatment, while it significantly increased root length under 10 and 20% PEG treatments. It is important to note that variety Bubnjar had the highest non-significant increase of ABA concentration in shoots under 10% PEG treatment and highest significant increase under 20% PEG treatment.

This might suggest that drought-resistant varieties accumulate far more ABA upon drought in comparison to more sensitive species in an attempt to cope with drought. It might be concluded that all varieties, except Silvija, increased ABA in shoots under 20% PEG treatment that enabled more or less desiccation tolerance that was evident in drought stress.

SA is another well-known stress hormone although the role of SA is still unclear, since some investigators have reported an enhancement of drought tolerance by SA application, whereas others claimed a reduction in the drought tolerance. It was reported that under normal conditions SA increased the growth of shoots and roots in the seedlings of soybean (Gutierrez-Coronado et al., 1998). Our data showed that SA had trend of decrease in dose dependent manner with the concentration of PEG although all changes are not statistically significant. SA was not significantly changed in shoots of Bubnjar between treatments, while all other varieties significantly reduced it under 20% PEG treatment, compared to control shoots. Also, correlation analysis proved that SA was in significant positive correlation with shoot length and its fresh weight.

It was previously concluded that hormones do not act alone, but interrelated by synergistic or antagonistic cross-talk, so that they can modulate each others biosynthesis or responses (Peleg and Blumwald, 2011). In the research of Meguro and Sato (2014) it was concluded that SA antagonized ABA by blocking expression of *OsKRP* genes. In the current research at seedling stage, it was also evidenced that ABA and SA act more or less antagonistically in all varieties, except in the most resistant variety Bubnjar and in Silvija, the most susceptible variety to drought. This was also supported in the current research by significant negative correlation between ABA and SA (Table 1).

6. CONCLUSIONS

Winter wheat varieties were evaluated for drought tolerance at the germination and seedling stage by measuring morpho-physiological traits and concentrations of stress hormones (ABA and SA) in wheat seedlings. Certain morpho-physiological changes were observed under stress conditions in comparison to controls, such as a reduction of germination energy, shoot length, RWC etc., depending on varieties and stress intensity. ABA was resulting in inhibition of development of the leaves and producing longer roots especially in drought susceptible varieties under heavier drought stress (20% PEG treatment). Conversely, SA negatively correlated with root length and its dry weight, but did not significantly change between treatments in more resistant variety to drought.

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Author's addresses - Adrese autora:
Jurica Duvnjak, Msc
Corresponding author e-mail: jurica.duvnjak@poljinos.hr
Valentina Španić, PhD
Agricultural Institute Osijek,
Juzno predgradje 17, 31000 Osijek

Branka Salopek Sondi, PhD
Lidija Brkljačić, PhD
Ruđer Bošković Institute,
Bijenička cesta 54, 10000 Zagreb

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