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EFFECT OF DROUGHT STRESS ON GROWTH OF SEEDLINGS ROOTS OF FOUR CROP SPECIES[1]

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Introduction

Crop plants develop root systems varying in their morphology, and these differences are closely related with the differentiation regarding the physiological functions of the particular root components [KONO et al. 1987; YAMAUCHI et al. 1996; WAISEL et al. 1996]. Research of the quanlitative and quantitative changes of the plants root system exposed to drought is rather limited. The soil environment is characterized by a greater stability in comparison with the atmosphere. In the soil, changes in various parameters (water content, temperature) occur at a lower rate in comparison with near-the-ground layer of the atmosphere, where the oscillations of the various climatic parameters may be high, and even produce shock effects in plants [HAMBLIN, TENNANT 1987; GREGORY et al. 1987; YAMAUCHI et al. 1996]. Other factors are the problems with methods of roots isolation from the soil, because both in field and pot experiments isolation of root from the soil is always connected with their damage. In the opinion of other authors, even very carefully performed isolation of the roots from soil caused a loss of a considerable amount of the roots. The losses refer, first of all, to the lateral roots, responsible for sorption functions. Relatively smaller are the losses regarding the main part of roots (tap root, seminal and nodal root) responsible for the distribution of the lateral roots in the soil profile [KONO et al. 1987; YAMAUCHI 1993; YAMAUCHI et al. 1996]. The use of root morphological traits in evaluation of plant drought tolerance was suggested repeatedly by O'TOOLE and BLAND [1987], LARSSON and GÓRNY [1988].

The structural and functional role of plant roots to effects of water deficit in soil and tissues on plant growth and crop yield should be discussed including the changes occurring in the overground parts of plants. The strategy of reducing the detrimental effects of the action of a stress factor is the resultant of responses of all the plant organs. Under a negative water balance in the tissues,

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the physiological mechanisms in both the root and overground parts are activated [SIDDIQUE et al. 1990; TARDIEAU, KATERJI 1991]. Some of those mechanisms are identical in the roots, stem and leaves, and their task is to maintain the cell turgor, limitation of the water loss by increase of water uptake, effective hydraulic conductance of xylem and inhibition of transpiration. The important group of factors responsible for plant tolerance to water stress comprises the anatomical and morphological features of plant tissues. Also it is believed that plants with xeromorphic features represent better adaptation of the plant species to drought. In the case of roots this does not refer extensively to the dimensions of the developed root system, but also its relation to the dimensions of the top plant parts [O'TOOLE, BLAND 1987; LORENS et al. 1987; RISTIC, CASS 1991; SIDDIQUE et al. 1990; LOSS, SIDDIQUE 1994]. In our earlier studies the importance of this relation was pointed out. The drought resistant cultivar of legume plants are able to maintain more advantageous values of this relation through intensive transport of the assimilation products to the roots [GRZESIAK 1990; GRZESIAK et al. 1989, 1990, 1992, 1996]. One of the important adaptations of roots to drought is the cells size of the root tissues and the number and dimensions of metaxylem elements. To the important physiological adaptations there belong: the increase of the osmoregulating properties of root cells, improving the effectiveness of absorption and exchange of water between the cells, the content of fatty acids in membrane lipids, the increase of their elasticity and the synthesis of the low molecular protectors and stress protein controlling the state of protoplast dehydration [POLJAKOFF-MAYBER 1981; TURNER 1993; RISTIC, CASS 1991]. The use of root morphological traits in evaluation of plant drought tolerance was suggested repeatedly [LARSSON, GÓRNY 1988].

The aim of this study was to estimate the variation of the morphological features of the root system of plants: triticale, maize, field bean and field pea and to determine the effects of soil moisture on the number and length of the root components of drought resistant and drought sensitive cultivars of the examined species.

Material and methods

Experiments were carried out on 7 cultivars of triticale (Gabo, Wanad, Mieszko, MAH, Migo, Maja, Kargo), and 4 breeding forms of triticale (CHD-12, CHD-147, CHD-220, CHD-247), 8 single-cross maize hybrids (Pioneer C, Pioneer D, Pioneer E, Pioneer 3957, Funk's G4083, Garst 8344, TK619, Garset 8388), 7 cultivars of field bean (Bourdon, Bronto, Dino, Gobo, Nadwiślanski, Tibo, Victor) and 4 cultivars of field pea (Baroness, Mige, Miko, Solara). The plant material was obtained for maize from Austria, USA, Canada and Hungary; for field bean and field pea four cultivars were obtained from England and seven cultivars were obtained from Polish breeding stations. The cultivars and the breeding forms of triticale were obtained from Polish breeding stations (Małyszyn and Choryń).

The experiments for triticale and maize were carried out in air conditioned growth cabinet in the Phytotron Laboratory the of Agricultural University in

Cracow, and for field bean and field pea in a growth cabinet in the Crop Science Laboratory, University of Nagoya, under the following conditions: 25/20°C day/night temperature, 14 hours photoperiod, 70% relative humidity and 350 $\mu mol \cdot m^{-2} \cdot s^{-1}$ irradiance at soil level.

In experiment 1, only control (C) treatment was applied – soil moisture was maintained to 65% of field water capacity (FWC) by 49 days. In experiment 2, the treatment was as follows: C – control, soil water content was 65% FWC, D – drought, soil moisture was maintained at 35% FWC. In experiment 2, on the 21th day after sowing, the control (C) conditions were applied, then drought treatment (D) was started and applied for the next 14 days.

In experiments 1 and 2 the plants were grown in the root-box, and the pin board set was used according to KONO et al. [1987]. This set consisted of the following parts: a handy-type plexiglass root box (25.0 cm long, 47 cm high, 2.5 cm wide), a pin board for the root sampling, and a piece of perforated polyethylene sheet. The root boxes were filled with a mixture (1 : 1 : 3) of garden soil, peat and sand. Air dried soil substrate was sieved in 0.25 cm mesh and mixed with a compound fertilizer (N – 28 mg, P – 18 mg, K – 14 mg) per 1 kg of the soil substrate. Prior to sowing, the root boxes were soaked in water for 30 minutes and drained for 48 hours. A single pregerminated grain was planted at 3–4 cm depth. During the experiment, water was added 3 or 4 times per week, so that the original weight of the whole root box was maintained in each treatment.

Prior to measurements the sampled plant was cut into shoot and root. The roots were sampled after the soil in the root box was washed away by a gentle stream of water, and the root was preserved in FAA (formalin, acetic acid, ethylene alcohol) solution. The dry matter of the top part of the plant and all components of the root system were measured after drying at 65°C for 48 h.

Differences in the structure of roots exist between the mono and dicotyledons species. In dicotyledons, the main root system component is the tap root and lateral roots sprouting from the tap root. In monocotyledons, the main components of the developed root components are seminal, seminal advantage, nodal and lateral roots [PASSIOURA 1981; O'TOOLE, BLAND 1987; TARDIEAU 1993; WEISEL et al. 1996]. According to YAMAUCHI et al. [1987] cereal plants, distinguished two types of the root system, the scattered and the concentrated, and two types of 1st order lateral roots. Within the 1st order lateral roots there can be distinguished, type L (long) and type S (short). The laterals of type S are thinner, more numerous and have numerous branching laterals of the 2nd order, whereas the laterals of type L are thicker, less numerous and have fewer lateral branchings.

In experiment 1 and 2 each measurement of dry matter and morphological traits was made for 5 plants for each treatment.

Statistical analysis

The data were statistically analyzed (in experiment 1) by t-test at the 0.05 probability level and (in experiment 2) by mean standard deviation. Also in experiment 1, linear correlation analyses were used to determine the relationship between the drought susceptibility index (DSI), according to the data of [GRZESIAK et al. 1990, 1996] and the root morphological traits.

Table 1a; Tabela 1a

Morphological root traits of triticale and maize plants grown in control conditions of soil moisture
Mean, variation range and coefficients of correlation (r) between the root traits and drought susceptibility index (DSI)

Wybrane morfologiczne cechy korzeni pszenżyta i kukurydzy rosnących w kontrolnych warunkach zawartości wody w glebie
Wartości średnie, zakres zmienności oraz współczyniki korelacji (r) pomiędzy cechą korzeni a wskaźnikiem wrażliwości na suszę (DSI)

Root trait; Cecha korzeni	Mean Średnia t-test (0.05)	Range Zakres	Correlation coeff. „r” Współ. kor. „r”	Mean Średnia t-test (0.05)	Range Zakres	Correlation coeff. „r” Współ. kor. „r”
	triticale (7 cultivars and 4 breeding forms) pszenżyto (7 odmian i 4 formy hodowlane)			maize (8 single-cross hybrids) kukurydza (8 mieszańców pojedynczych)		
Total root dry matter ($g \cdot plant^{-1}$) Całkowita sucha masa korzeni ($g \cdot roślina^{-1}$)	4.81 *	3.34–5.21	–0.65*	9.02 *	8.05 11.18	–0.56 NS
Shoot to root dry matter ratio (S/R) Stosunek s.m. części nadz. do s.m. korzeni (S/R)	1.82 *	1.69–1.95	0.69*	1.75 *	1.52–1.98	0.84 **
Length of seminal root (cm) Długość korzenia nasiennego (cm)	39.1 NS	37.3–42.2	–0.43 NS	44.1 NS	43.2–46.0	–0.56 NS
Number of lateral roots Liczba korzeni bocznych	180.2 *	173.2–195.6	–0.35 NS	242.6 *	212.2–276.1	–0.52 *
Total length of lateral roots on seminal root (cm) Całk. dlugość k. bocznych na k. nasiennym (cm)	1306.1 *	1198.1–1423.8	–0.43 NS	1298.1 **	1143.5–1374.3	–0.73 *
Number of L-type lateral roots Liczba korzeni bocznych typu L	155.2 *	143.8–167.2	–0.74 **	156.1 *	135.2–175.8	–0.50 *
Number of S-type lateral roots Liczba korzeni bocznych typu S	25.0 *	19.6–31.5	–0.56 NS	76.5 *	71.3–82.7	–0.35 NS
Density of lateral roots on seminal root ($no \cdot cm^{-1}$) Gęstość k. bocznych na k. nasiennym ($no \cdot cm^{-1}$)	4.60 *	3.76–5.38	–0.42 NS	5.50 *	5.11–6.42	–0.51 NS

*, ** – significant differences at the 0.05 or 0.01 level respectively; różnice statystycznie istotne dla poziomu 0,05 lub 0,01
NS – insignificant differences; różnice statystycznie nieistotne

Table 1b; Tabela 1b

Morphological root traits of field bean and field pea plants grown in control conditions of soil moisture
Mean, variation range and coefficients of correlation (r) between the root traits and drought susceptibility index (DSI).

Wybrane morfologiczne cechy korzeni bobiku i grochu rosnących w kontrolnych warunkach zawartości wody w glebie. Wartości średnie, zakres zmienności oraz współczyniki korelacji (r) pomiędzy cechą korzeni a wskaźnikiem wrażliwości na suszę (DSI).

Root trait; Cecha korzeni	Mean Średnia t-test (0.05)	Range Zakres	Correlation coeff. „r” Współ. kor. „r”	Mean Średnia t-test (0.05)	Range Zakres	Correlation coeff. „r” Współ. kor. „r”
	field bean (7 cultivars) bobik (7 odmian)			field pea (4 cultivars) groch (4 odmiany)		
Total root dry matter (g·plant^{-1}) Całkowita sucha masa korzeni (g·roślina $^{-1}$)	3.18 *	3.05–3.37	–0.63 NS	0.84 NS	0.74–0.97	–0.97 *
Shoot to root dry matter ratio (S/R) Stosunek s.m. części nadz. do s.m. korzeni (S/R)	2.31 *	1.70–2.89	0.70 NS	1.83 NS	1.71–2.00	0.62 NS
Length of tap root (cm) Długość korzenia palowego (cm)	24.7 NS	22.4–26.4	0.28 NS	19.8 NS	17.4–22.6	0.70 NS
Number of lateral roots Liczba korzeni bocznych	178.8 *	148.0–201.0	–0.85 *	49.8 *	46.6–53.9	–0.27 NS
Total lateral roots length (cm) Całkowita długość korzeni bocznych (cm)	4636.4 *	3775–5675	–0.96 **	1767 *	1632–2040	–0.65 NS

*, ** – significant differences at the 0.05 or 0.01 level respectively; różnice statystycznie istotne dla poziomu 0,05 lub 0,01
NS – insignificant differences; różnice statystycznie nieistotne

Results and discussion

All examined cultivars of 4 crop species were obtained from a seed production station and were not characterized by the breeders with respect to their requirement of water supply and the quantitative index of their drought tolerance. More information concerning the drought tolerance of the examined cultivars was collected during field experiments carried out under conditions of simulated soil irrigation and soil drought [GRZESIAK 1990, 1996]. The mean drought susceptibility index (DSI) obtained in field experiments is given in brackets along with the list of the tested cultivars.

For triticale, Gabo (0.40), Wanad (0.52), Mieszko (0.52), MAH (0.50), Migo (0.56) Maja (0.49), Kargo (0.61), CHD-12 (0.58), CHD-147 (0.53), CHD-220 (0.38) and CHD-247 (0.41). For maize, Pioneer C (0.48), Funk`s G4083 (0.49), Garst 8344 (0.50), Pioneer 3957 (0.51), TK619 (0.67), Garset 8388 (0.69), Pioneer E (0.74), and Pioneer D (0.75). For field bean, Bourdon (0.27), Bronto (0.45), Dino (0.38), Gobo (0.30), Nadwiślanski (0.29), Tibo (0.41) and Victor (0.46). For field pea, Baroness (0.46), Mige (0.38), Miko (0.31) and Solara (0.30).

Quantitative analysis of morphological characteristics of the root system structure in the examined cultivars was carried out in experiment 1. The results of measurements of selected root morphological features, of plants growing in control conditions and also values of the correlation coefficients between roots traits and drought susceptibility index (DSI), are presented in table 1a and table 1b. From the obtained data, it follows that in none of the examined plants, any common feature significantly correlated with the value of the DSI, could be found, except for the relation between the dry matter of plant top parts to root (S/R) in triticale and maize. The drought resistant triticale cultivars and maize hybrids in comparison with the sensitive one were characterized by a smaller, thus a more advantageous (S/R) ratio. In field bean and field pea cultivars, the correlation coefficients of this characteristics with the DSI were high, but statistically insignificant.

Also significantly correlated with DSI in triticale were the total root dry matter and the number of L-type lateral roots, in maize – the number and total length of lateral roots, in field beans the number and total length of lateral roots, and in field pea – only the total root dry matter.

Tables 2, 3 and 4 show the results of experiment 2 concerning the effect of drought on number and length of root components in drought resistant and drought sensitive cultivars. Soil drought did not cause any changes in the number of seminal roots in triticale cultivars and maize hybrids, and the number of tap roots in field bean and field pea cultivars. In the drought sensitive cultivars there could be observed a greater reduction of the length of the seminal root of triticale and maize and tap root of field bean and field pea cultivars than in drought resistant cultivars. In triticale breeding form and maize hybrids, both the drought resistant and drought sensitive hybrids reacted in a similar way, by inhibiting the growth of the seminal root (Tab. 2 and Tab. 3). On the other hand, the reduction of the number of L-type and S-type lateral roots in drought resistant (CHD-220) triticale form was much smaller in comparison with drought sensitive (CHD-12) breeding form. In maize hybrids, the reaction of drought resistant hybrid Pioneer C was a smaller reduction of the number and length of the particular root components in comparison with the drought sensitive hybrid Pioneer D (Tab. 3).

Table 2; Tabela 2

Effect of soil drought on number and length of particular components of the seminal root in the sensitive (CHD-12) and resistant (CHD-220) breeding form of triticale
Mean values ±standard deviation

Wpływ suszy glebowej na liczbę i długość poszczególnych komponentów korzenia nasiennego wrażliwej na suszę (CHD-12) i odpornego na suszę (CHD-220) formy hodowlanej. Wartości średnie ± odchylenie standardowe

Root system components Element systemu korzeniowego	Treatment Obiekt	Number; Liczba		Length (cm); Długość (cm)	
		CHD-12	CHD-220	CHD-12	CHD-220
Seminal root Korzeń nasienny	Control; Kontrola	1.0±0.00	1.0±0.00	34.8±1.18	35.0±1.11
	Drought; Susza	1.0±0.00	1.0±0.00	29.4±0.87	34.1±0.43
	%C	100.0	100.0	84.5	97.4
Lateral roots L-type Korzenie boczne typu L	Control; Kontrola	193.3±7.78	191.7±4.43	1079.6±13.76	1187.2±22.11
	Drought; Susza	162.6±8.21	180.6±5.60	870.2±25.01	1161.1±13.11
	%C	84.1	94.2	80.6	97.8
Lateral roots S-type Korzenie boczne typu S	Control; Kontrola	24.1±1.11	27.6±1.13	277.6±18.62	289.2±10.23
	Drought; Susza	20.1±2.02	28.7±1.25	237.6±10.56	276.4±11.12
	%C	83.4	104.0	85.6	95.6

The cultivars of field bean and field pea responded to drought in a similar way. The disadvantageous effect on the number and length of lateral roots was more distinct in drought sensitive cultivars Victor and Baroness in comparison with the drought resistant cultivars Gobo and Solara (Tab. 4).

As a results of evolution and plant breeding, crop plants developed different root systems. Root growth is influenced by soil type, cultivation, soil water and nutrient content, and temperature [Hamblin, Tennant 1987; Yamauchi et al. 1996]. During the vegetative phase of the plant growth, the roots are the dominating „sink" for assimilates. This tendency is reversed at the generative phase of the plant growth, and under favourable water conditions, at harvest, the roots represent about 10 percent of the total biomass at maturity, whereas under drought conditions this value attains as much as 60 percent [Hamblin, Tennant 1987]. Smucker [1984] demonstrates the essential differences in the structure of the root system of monocotyledons and dicotyledons. According to this author, the roots of cereals are characterized by an extensive root system, great variation of the morphological features that use water slowly, contrary to the legume plants, characterized by a less extensive root system that uses water rapidly. Richards [1991] stresses the importance of the differences in wheat root morphology in plants grown under soil water shortage conditions. Siddique et al. [1990], Loss and Siddique [1994] have shown that the modern varieties of wheat, used now by Australian farmers, characterized by great tolerance to water supply, have just about two times higher rooting coefficient than the older wheat varieties.

Table 3; Tabela 3

Effect of soil drought on number and length of particular components of the root system in the resistant (Pioneer C) and sensitive (Pioneer D) maize hybrids
Mean value ± standard deviation

Wpływ suszy glebowej na liczbę i długość poszczególnych komponentów systemu korzeniowego odpornego na suszę mieszańca (Pioneer C) i wrażliwego na suszę mieszańca (Pioneer D).
Wartości średnie ± odchylenie standardowe

Root system component Element systemu korzeniowego	Treatment Obiekt	Number; Liczba		Length (cm); Długość (cm)	
		Pioneer D	Pioneer C	Pioneer D	Pioneer C
Seminal root Korzeń nasienny	Control; Kontrola	1.0±0.00	1.0±0.00	25.1±0.99	29.0±0.54
	Drought; Susza	1.0±0.00	1.0±0.00	23.8±0.77	27.7±0.18
	%C	100.0	100.0	94.8	95.5
Seminal adventitious roots Przybyszowe korzenie nasienne	Control; Kontrola	2.0±0.00	2.0±0.00	16.2±0.21	18.4±0.36
	Drought; Susza	2.0±0.00	2.0±0.00	15.4±0.18	17.3±0.47
	%C	100.0	100.0	95.1	94.0
Nodal roots Korzenie węzłowe	Control; Kontrola	13.0±0.11	12.9±0.08	451.2±11.84	480.6±18.13
	Drought; Susza	11.5±0.18	11.7±0.11	355.8±18.13	428.2±11.12
	%C	88.5	90.7	78.9	89.1
Lateral roots L-type Korzenie boczne typu L	Control; Kontrola	688.1±9.10	713,1±7.13	3501.2 ±44.34	3932.1±38.81
	Drought; Susza	551.9±6.31	625.1±6.75	2850.0±35.13	3452.4±23.32
	%C	80.2	87.7	81.4	87.8
Lateral roots S-type Korzenie boczne typu S	Control; Kontrola	2510.1±32.23	2704.1±18.26	2410.1±59.13	3041.0± 27.2
	Drought; Susza	1984.9±21.71	2378.9±41.14	1935.3±63.47	2627.4± 45.0
	%C	79.1	88.0	80.3	86.4

Table 4; Tabela 4

Effect of soil drought on a root morphological characteristic in cultivars of field bean and field pea of different drought tolerances
Wpływ suszy glebowej na wybrane cechy morfologiczne korzeni odmian bobiku i grochu różniące się stopniem wrażliwości na suszę

Root trait Cecha korzeni	Treatment symbol Symbol obiektu	Field bean Bobik		Field pea Groch	
		Gobo	Victor	Solara	Baroness
Tap root; Korzeń palowy					
Number; Liczba	Control; Kontrola	1.0	1.0	1.0	1.0
	Drought; Susza	1.0	1.0	1.0	1.0
	% C	100.0	100.0	100.0	100.0
Length; Długość (cm)	Control; Kontrola	35.0	34.8	30.5	32.8
	Drought; Susza	32.9	31.0	28.1	28.2
	% C	94.0	89.1 *	92.1	86.0 *
Lateral roots; Korzenie boczne					
Number; Liczba	Control; Kontrola	182.6	155.2	58.5	52.3
	Drought; Susza	157.2	120.6	49.9	39.7
	% C	86.1*	77.7 *	85.3 *	75.9 *
Length; Długość (cm)	Control; Kontrola	4892.3	4231.0	2654.8	2770.3
	Drought; Susza	4080.2	3101.3	2399.8	2113.7
	% C	83.4 *	73.3 *	90.4 *	76.3 *

* – significant differences between treatments at the 0.05 level using t-test; różnice istotne przy poziomie 0,05 przy użyciu t-testu

According to other authors, the measurements of the depth of rooting are less applicable for screening of breeding forms. HAMBLIN and TENNAND [1987] argue that depth of rooting and rate of elongation growth is a better criterion for maximizing water uptake than the length of the roots, their dry matter or the density of the root system. In cereal plants, contrary to legume plants, this trait significantly correlated with intensity of water uptake, was the depth of rooting.

In the opinion of many authors, the relation between the dimensions of the top plant parts and those of the roots, is of vital importance for water balance in plants. It is believed that lower values of the shoot – root ratio are more advantageous for plants, especially in plants exposed to periods of soil drought. The importance of this parameter for the mechanism of drought resistance has also been indicated by the breeding work with resistant genotypes in which the breeders try to optimize the relations between dimensions of the top plant parts and the dimensions of the roots [PASSIOURA 1981; LORENS et al. 1987; WINTER et al. 1988; PASSIOURA et al. 1993; TARDIEAU 1993].

The obtained results confirm the existence of differences of root characteristics within cultivars of the examined plants species. However, further study is required for the use of morphological features of examined cultivars for the selection purpose of drought tolerance [WINTER et al. 1988; RISTIC and CASS 1991]. The results of our study may be helpful in determining of genetic reserves that exist in crop plants, concerning relations between plant root system structure and its water status. Similarly to the research of LARSSON and GÓRNY [1988], it may be concluded that the use of the seedling root characteristics as an indirect selection criteria appears to be a good tool for improvement of crop plant yield under drought stress conditions.

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Key words: triticale, maize, field bean, field pea, drought, root structure

Summary

The experiments were carried out on Polish and foreign cultivars of maize, triticale, field bean and field pea. Special attention was given to morphology of seedlings root exposed to soil drought. The root-box method was used to analyze out qualitative and quantitative variation of the plant root system structure. In control conditions, seedlings of the examined cultivars showed differences in the structure of the root system. The results demonstrated a relatively broad variation in the habit of the seedlings root system. However, in the examined cultivars, any common feature or features have not been found which might be essentially correlated with the value of their drought susceptibility index (DSI), except the relations between the dry matter ratio of top part to root (S/R), but found only in triticale and maize.

Drought stress reduced the size of the roots particular components. In the drought sensitive cultivars, changes in the number and length of roots were greater than in the drought resistant cultivars, and this referred primarily to the lateral roots. The results suggest that some root morphological traits of crop plant cultivars may be used in breeding practice as indirect selection criteria of plant drought resistance.

WPŁYW SUSZY GLEBOWEJ NA WZROST KORZENI SIEWEK CZTERECH GATUNKÓW ROŚLIN UPRAWNYCH

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Słowa kluczowe: pszenżyto, kukurydza, bobik, groch, susza, struktura korzeni

Streszczenie

Badania dotyczące różnych aspektów reakcji systemu korzeniowego roślin na działanie suszy są stosunkowo nieliczne. Jednym z powodów mniejszego zain-

teresowania badaniami systemów korzeniowych roślin są problemy metodyczne związane z ograniczoną liczbą metod pozwalających na niedestruktywne izolowanie z gleby wszystkich komponentów systemu korzeniowego a także z ich dużą pracochłonnością. Dodatkowym powodem mniejszego zainteresowania reakcjami korzeni roślin na działanie różnych czynników stresowych wydaje się być fakt, że środowisko glebowe, w porównaniu z atmosferycznym, charakteryzuje się większą stabilnością warunków. Z tego powodu typowe reakcje obronne korzeni na działanie czynników stresowych nie są tak wyraźne jak w organach części nadziemnych.

Doświadczenia przeprowadzono na krajowych i zagranicznych odmianach pszenżyta, kukurydzy, bobiku i grochu, które na podstawie wcześniejszych badań własnych charakteryzowały się zmiennością plonowania w warunkach ograniczonej zawartości wody w glebie. W doświadczeniach szczególną uwagę zwrócono na morfologiczne aspekty budowy poszczególnych komponentów systemu korzeniowego roślin poddanych działaniu okresowej suszy. W doświadczeniach wykorzystano metodę *root-box method* przy pomocy której wykonywano jakościową i ilościową analizę budowy systemu korzeniowego opartą o pomiary liczebności, rozmiarów i suchej masy poszczególnych komponentów wykształcanego systemu korzeniowego.

Stwierdzono, że w kontrolnych warunkach wzrostu siewek w obrębie badanych odmian ujawniają się ilościowe różnice w budowie systemu korzeniowego. Jednak zarówno u badanych gatunków jednoliściennych jak i dwuliściennych nie udało się znaleść wspólnej cechy, która byłaby istotnie skorelowana z wartością wskaźnika wrażliwości na suszę (DSI). Istotnie skorelowane ze wskaźnikiem DSI relacja suchej masy części nadziemnych do suchej masy korzeni była u pszenżyta i kukurydzy.

Susza glebowa powodowała zmniejszenie rozmiarów poszczególnych komponentów systemów korzeniowych. U odmian zaliczonych do grupy wrażliwych na suszę obserwowane zmiany liczby i długości poszczególnych komponentów wykształcanego systemu korzeniowego były większe niż u odmian odpornych i dotyczyło to przede wszystkim liczby i długości wykształcanych korzeni bocznych.

Uzyskane wyniki wskazują, że niektóre morfologiczne cechy budowy systemu korzeniowego siewek mogą być użyteczne w hodowli roślin jako pośrednie kryteria selekcji odmian odpornych na suszę

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