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The influence of sowing date on initial growth and development of selected lawn varieties of *Festuca arundinacea*, *Festuca rubra*, *Festuca ovina*, *Lolium perenne* and *Poa pratensis* on a roadside bank

Wpływ terminu siewu na początkowy wzrost i rozwój *Festuca arundinacea*, *Festuca rubra*, *Festuca ovina*, *Lolium perenne* i *Poa pratensis* na przydrożnej skarpie

Summary. The aim of the presented research was to assess the initial growth rate of selected 5 grass species in order to determine their suitability for quick and effective infestation of roadside embankments in two sowing dates (spring and late autumn). The research was carried out on a bank situated along the national road S17. Measurements of root length and height of seedlings of each species were made on 10, 20, 30, 40, 50 and 60 days from the date of sowing. It has been shown that in the conditions of the experiment the grass species assessed differ in the rate of initial growth. Sowing dates had significant impact on the rate of root elongation and growth of seedlings of the studied grass species, because on objects with late autumn sowing date, all species and varieties were characterized by the shortest roots and the lowest seedlings. In both sowing dates, regardless of year of research, *L. perenne* seedlings were characterized by the longest roots and the highest seedlings in comparison to other species. In turn, seedlings of *P. pratensis* regardless of the year of studies were characterized by the shortest roots and the lowest seedlings in comparison to other species.

Key words: lawn grass, initial growth and development, roadside embankment

INTRODUCTION

Soil of embankments and roadsides are strongly transformed in geotechnical and geochemical terms and they do not provide plants with good conditions for growth and development. As a consequence, this leads to uneven coverage of these soils and their insufficient protection against water and wind erosion [Cholewiński 2003, Haber et al.

2003]. In turn, embankment erosion threatens the road safety or causes destruction of objects, which entails high costs of repairs [Pietrzak 2008]. Sowing is the simplest and inexpensive way to biologically strengthen the banks and protect their surface from water or wind erosion, while the grasses are the basic species used to infest soil embankments and roadsides, where conditions for plant growth and development are unfavorable [Harkot and Czarnecki 1999, Harkot et al. 2002, 2009, Kostuch 2006].

Among the anthropogenic factors, the most important effect on seed germination and the growth and development of grass seedlings is the sowing date. The basic way to mitigate the impact of unfavorable weather conditions on the initial growth and development of grasses is to avoid sowing the seeds in terms considered risky [Kwarta and Maślankowska 1965, Skopiec 1979]. In Poland's weather conditions, the optimal sowing dates are: spring (until mid-May) and late (end of August – early September) [Rutkowska and Pawluśkiewicz 1996]. In practice, roadside banks are sown even in late autumn, shortly before the soil freezes. Powroźnik's [2010] research shows that late autumn seeding dates can ensure successful emergence and good planting, if the weather conditions after seed sowing are conducive to plant development or components of the seed mixture will be less sensitive to weather stress factors. Therefore, the correct selection of the sowing date and components for the seed mixtures intended for sowing the embankments and roadsides is therefore very important.

The aim of the study was to assess the effect of the sowing date on the initial growth and development of selected grass species in terms of determining their suitability for fast, effective and durable collection of roadside banks.

MATERIAL AND METHODS

The research was carried out in 2009–2010 on the banks along the national road No. 17 on the section Piaski – Łopiennik, on which 5 species of grasses were sown: *Festuca arundinacea*, *Festuca ovina*, *Festuca rubra*, *Lolium perenne* and *Poa pratensis*. A chosen species build grassland ecosystems of roadsides most often and in the largest part, were selected for the study [Wysocki 1994, Harkot and Czarnecki 1999, Stawicka 2003]. The research was carried out in two years (the first year of study 2009 and the second year of study 2010). In each year of tests, two sowing dates were used: spring (end of April) and late autumn (end of October). The experiments were established using the randomized block method in triplicate. The size of a single plot was 1 m^2 (1 × 1 m) in accordance with methodological recommendations of COBORU [Domański 1992, 1995, 1998ab] and IHAR [Prończuk 1993, Prończuk et al. 1997]. At every sowing date, the growth rate of seedlings was assessed on all plants based on measurements of root length and height of seedlings (in mm) on 10, 20, 30, 40, 50 and 60 days from the date of sowing. At each time, the measurements were carried out on 30 representative plants (10 in each replicate) from each plot.

Results of plant measurements (root length and height of seedlings) were developed by the analysis of variance for a complete randomization system. To verify the significance of differences between the averages evaluated, multiple T-Tukey tests for $\alpha \leq 0.05$ were used.

BACKGROUND OF THE STUDY

The experiments were established on alkaline soil (7.60 pH in KCl), average P_2O_5 i K_2O (162 mg kg^{-1} i 120 mg kg^{-1}, respectively) and low magnesium (25 mg kg^{-1}). In the granulometric composition of the topsoil (0–20 cm), fine gravel predominated (68%), dust and clay fractions accounted for 16% each. The content of the alluvial grain fraction below <0.002 mm was 5%. According to the Polish Soil Science Society [2009], soils of this type are classified as anthropogenic soils with an undeveloped profile. As a result, in the years with low amounts of precipitation in soils of this type, a water deficit may occur.

Weather conditions during the research period (2009–2010) were based on data obtained from the Meteorological Station in Felin (Lublin district), about 18 km away from the experimental site. Monthly sums of precipitation and average monthly air temperatures have been referred to the value of these data from many years (1951–2010).

Table 1. Mean monthly and decade amount of precipitation (in mm) and mean air temperatures during the experimental period and for the years 1951–2010 according to the meteorological Station at Felin

Decade	Months, year																	
	IV		V		VI		VII		VIII		IX		X		XI		XII	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Sum of rainfalls (mm)																		
I	1.1	13.8	3.6	39.7	28.2	34.6	15.6	15.3	16.2	65.6	11.3	80.4	20.2	1.5	15.4	20.0	6.8	21.2
II	1.8	7.7	34.6	106.7	32.7	30.2	9.8	9.8	29.9	6.9	0.9	10.6	54.9	7.3	24.8	7.0	10.3	5.8
III	·	3.0	32.9	10.3	64.6	0.8	31.7	75.9	8.6	60.3	8.8	28.0	28.5	2.4	2.9	19.8	20.6	5.4
Mean	2.9	24.5	71.1	156.7	125.5	65.6	57.1	101.0	54.7	132.8	21.0	119.0	103.6	11.2	43.1	46.8	37.7	32.4
Sum 1951–2010	39.0		60.7		65.9		82.0		70.7		53.7		40.1		38.2		31.4	
Mean air temperatures (°C)																		
I	11.5	8.5	13.6	13.6	15.3	19.0	19.9	20.2	20.0	22.9	16.3	11.7	10.4	6.1	3.2	10.7	4.3	–4.9
II	9.3	9.5	13.1	14.5	15.0	17.9	20.5	24.0	18.9	18.1	15.6	13.2	3.7	4.7	6.4	8.5	–8.2	–6.3
III	13.5	10.2	14.2	15.2	19.1	17.1	19.3	20.7	18.2	17.1	14.2	12.5	6.8	6.0	6.8	0.1	–1.2	–2.8
Mean	11.4	9.4	13.6	14.5	16.4	18.0	19.9	21.6	19.0	20.2	15.3	12.5	6.9	5.6	5.5	6.4	–1.7	–4.7
Mean 1951–2010	8.0		13.8		16.5		18.7		17.9		12.9		7.8		2.5		–1.5	

· lack of germination

April was extremely dry in 2009 and dry in 2010 because the precipitation volumes were lower (13 and 1.5 times, respectively) than the multi-year mean precipitation volume for this month. The precipitation volume in May 2009 was close to the multi-year mean for this month (60.7 mm). May 2010 was extremely wet as the precipitation volume was over 2.5 times higher than the multi-year mean for this month. June 2009 was very wet as the precipitation volume was nearly 2 times greater than the multi-year mean precipitation volume for this month, and precipitation was distributed evenly. In June 2010, the precipitation volume was close to the multi-year mean for this month. July 2009 was dry as the precipitation volume was nearly 1.5 times lower than the multi-year mean precipitation volume for this month. In July 2010, the precipitation volume was close to the multi-year mean for this month. The precipitation volume in August 2009 was close to the multi-year mean for this month, while August 2010 was very wet as the precipitation volume was nearly twice as high as the multi-year mean precipitation volume for this month. September was very dry in 2009 and extremely wet in 2010 as the precipitation volumes were, respectively, 2.5 times lower and twice as high as the multi-year mean for this month. October was extremely wet in 2009, and very dry in 2010 as the precipitation volumes were, respectively, over 2.5 times greater and 3.5 times lower than the multi-year mean precipitation volume for this month. The precipitation volumes in November 2009 and 2010 were close to the multi-year mean for this month. The precipitation volumes in December 2009 and 2010 were close to the multi-year mean for this month.

April was extremely warm in 2009 and very warm in 2010 because the mean ambient temperature was higher (by 3.4 and 1.4°C, respectively) than the multi-year mean for this month. In May 2009, the ambient temperature was close to the multi-year mean for this month. On the other hand, May 2010 was warm because the mean ambient temperature was higher by 0.7°C than the multi-year mean for this month. In June 2009, the mean ambient temperature was close to the multi-year mean for this month, while June 2010 was abnormally warm because the mean ambient temperature was 1.5°C higher than the multi-year mean for this month. July was warm in 2009 and extremely warm in 2010 because the mean ambient temperature was higher (by 1.2 and 2.9°C, respectively) than the multi-year mean for this month. August was very warm in 2009 and extremely warm in 2010 because the mean ambient temperature was higher (by 1.1 and 2.3°C, respectively) than the multi-year mean for this month. September 2009 was extremely warm because the mean ambient temperature was higher by 2.4°C than the multi-year mean for this month. In 2010, on the other hand, the mean ambient temperature in September was close to the multi-year mean for this month. October was cold in 2009 and abnormally cold in 2010 because the mean ambient temperature was lower (by 0.9 and 2.2°C, respectively) than the multi-year mean for this month. November was very warm in 2009 and abnormally warm in 2010 because the mean ambient temperature was higher (by 3.0 and 3.9°C, respectively) than the multi-year mean for this month. December was slightly cold in 2009 and very cold in 2010 because the mean ambient temperature was lower (by 0.2 and 3.2°C, respectively) than the multi-year mean for this month.

RESULTS

In the spring sowing period, a significant effect of weather conditions prevailing in the first year of studies on the rate of root extension of the studied species seedlings was found (Tab. 2). In the first year of tests, all species rose to the 10th day from the date of sowing and no significant differences between root lengths were found in all measurement dates, except for 30 days from the date of sowing, when *L. perenne* seedlings had significantly longer roots compared to other species and 40 days from the date of sowing when *P. pratensis* seedlings were characterized by shorter roots than other species, but only significantly compared to *F. rubra* and *L. perenne*. In the second year of tests, the emergence of all species was later than in the 1st year of test, because in *F. arundinacea* and *L. perenne*, they appeared between 10 and 20 days from the date of sowing, and in *F. rubra*, *F. ovina* and *P. pratensis*, only from 20 to 30 days after the date of sowing. In all dates of measurements, *P. pratensis* seedlings were characterized by the shortest roots (30 days significantly compared to other species, on the 40th and 50th day significantly only compared to *F. rubra* and *L. perenne*, and in 60 days significantly compared to *F. arundinacea*, *F. rubra* and *L. perenne*). In turn, the roots of *L. perenne* seedlings were the longest, but actually only on day 50 from the date of sowing.

Table 2. Root length and seedling height of studied varieties (in mm) in 10, 20, 30, 40, 50 and 60 days after spring sowing date in I and II year of study (2009 and 2010)

Species	Number of days from sowing											
	10 days		20 days		30 days		40 days		50 days		60 days	
	I	II	I	II	I	II	I	II	I	II	I	II
Root length												
Festuca arundinacea	15^{abcde}*	·	17^{a}	5^{bc}	·	18^{bcd}	28^{def}	23^{bcde}	34^{bcd}	29^{cdef}	38^{a}	36^{abc}
Festuca ovina	13^{cdef}	·	18^{a}	·	22^{def}	18^{bcd}	29^{fcde}	22^{bcde}	34^{bcd}	24^{ef}	49^{a}	31^{cd}
Festuca rubra	12^{cdef}	·	21^{a}	·	24^{bcde}	18^{bcd}	30^{bcde}	26^{bc}	35^{bcd}	32^{bcde}	44^{a}	36^{abc}
Lolium perenne	16^{abcd}	·	19^{a}	5^{bc}	31^{a}	18^{bcd}	34^{abcd}	28^{b}	38^{abc}	38^{abc}	52^{a}	41^{abc}
Poa pratensis	14^{bcdef}	·	16^{a}	·	20^{ef}	12^{g}	22^{f}	17^{e}	31^{bcd}	21^{f}	37^{a}	25^{d}
Seedling height												
Festuca arundinacea	22^{bcd}	·	31^{abcd}	7^{bc}	36^{bcdef}	22^{abcde}	41^{def}	28^{abcd}	44^{def}	39^{cdef}	52^{cd}	49^{bcde}
Festuca ovina	19^{cdef}	·	25^{cdef}	·	36^{bcdef}	24^{abc}	38^{def}	28^{abcd}	51^{abcde}	33^{def}	77^{ab}	36^{cdefg}
Festuca rubra	17^{cdefgh}	·	35^{ab}	·	41^{bcd}	18^{cdef}	46^{cd}	26^{ebcd}	55^{abcd}	42^{bcd}	71^{abc}	51^{bcd}
Lolium perenne	20^{bcde}	·	31^{abcd}	4^{cde}	44^{b}	22^{abcde}	47^{bcd}	35^{ab}	55^{abcd}	43^{bcd}	62^{bcd}	54^{b}
Poa pratensis	16^{cdefgh}	·	23^{def}	·	32^{efg}	12^{f}	32^{fg}	16^{e}	40^{efg}	25^{f}	55^{bcd}	28^{g}

* means with the same lowercase letter in the column indicate homogeneous groups
· lack of germination

The height of seedlings of studied grass species in the spring sowing date in the first and second year of tests was significantly different (Tab. 2). In the first year of tests in the initial period (up to the 10th day from the date of sowing) seedlings of all species were similarly high. On day 20 from the date of sowing, seedlings of *F. rubra* were higher compared to other species, but only significantly compared to *F. ovina* and *P. pratensis*. On 30, 40 and 50 days after the sowing date, *P. pratensis* seedlings were the lowest (significantly compared to *F. rubra* and *L. perenne*). On the 60th day from the date of sowing, the species did not significantly differ in the height of seedlings, except for *F. arundinacea*, which was characterized by the lowest seedlings, but only significantly compared to *F. ovina*. In the second year of research, in all measurement dates, the tested species did not significantly differ in the height of seedlings, except from

P. pratensis, the seedlings of which (similar to the first year of test) were the lowest (on 40 days significantly compared to *F. arundinacea*, *F. ovina* and *L. perenne*, and on day 50, only in comparison to *F. rubra* and *L. perenne*, and on 60 days compared to *F. arundinacea*, *F. rubra* and *L. perenne*).

In late autumn, seedlings of the studied species significantly differed in the rate of root elongation in the first and in the second year of tests (Tab. 3). In the first year of research in 10th 10 (as well as in 30th days) from the date of sowing, no significant differences were found between species at the root length. On day 20 from the date of sowing, *P. pratensis* seedlings were characterized by shorter roots compared to other species, but only significantly compared to *L. perenne*. On the 40th 50th and 60th day from the date of sowing, *L. perenne* seedlings were characterized by the longest roots (significantly compared to *F. ovina*, *F. rubra* and *P. pratensis*). In the second year of tests, on day 20th from the date of sowing, *P. pratensis* seedlings were characterized by the shortest roots (significantly compared to *F. arundinacea* and *L. perenne*). Also on day 30th from the date of sowing, *P. pratensis* seedlings were still characterized by the shortest roots, but only significantly compared to *F. arundinacea*, *F. ovina* and *L. perenne*. On the 34th day from the date of sowing, there were snowfalls and the snow cover remained until the end of the first decade of January 2011.

Table 3. Root lenght and seedling height of studied varieties (in mm) in 10, 20, 30, 40, 50 and 60 days after late autumn sowing date in I and II year of study (2009 and 2010)

Species	Number of days from sowing											
	10 days		20 days		30 days		40 days		50 days		60 days	
	I	II	I	II	I	II	I	II	I	II	I	II
	Root length											
Festuca arundinacea	15^{ab}*	·	18^{ab}	19^{a}	21^{ab}	20^{ab}	23^{bc}	–	26^{bcd}	–	28^{abc}	–
Festuca ovina	12^{abcd}	·	14^{abc}	14^{abcde}	15^{abcd}	21^{a}	16^{de}	–	21^{def}	–	22^{cde}	–
Festuca rubra	12^{abcd}	·	15^{abc}	14^{abcde}	17^{abcd}	16^{abc}	19^{cde}	–	20^{def}	–	22^{cde}	–
Lolium perenne	14^{ab}	·	19^{a}	16^{abc}	21^{a}	21^{ab}	28^{ab}	–	29^{abc}	–	31^{ab}	–
Poa pratensis	11^{abcd}	·	13^{bc}	10^{e}	15^{abcd}	13^{c}	20^{cd}	–	21^{cde}	–	23^{bcd}	–
	Seedling height											
Festucaa rundinacea	15^{bcde}	·	20^{bcde}	20^{abcd}	24^{bcd}	24^{a}	25^{cde}	–	26^{cdef}	–	28^{cdef}	–
Festuca ovina	15^{bcde}	·	20^{bcde}	19^{bcde}	25^{abc}	23^{ab}	24^{cdef}	–	26^{cdef}	–	30^{bcd}	–
Festuca rubra	13^{def}	·	17^{def}	17^{bcde}	21^{cde}	19^{abc}	22^{cdef}	–	24^{cdefg}	–	26^{cdef}	–
Lolium perenne	16^{bcd}	·	21^{bcd}	20^{abcd}	23^{bcde}	23^{a}	26^{bcd}	–	28^{bcde}	–	29^{cdef}	–
Poa pratensis	12^{efg}	·	15^{efg}	15^{def}	18^{ef}	17^{bcd}	19^{fg}	–	20^{fgh}	–	22^{efg}	–

* means with the same lowercase letter in the column indicate homogeneous groups
· lack of germination
– no measurements because of the snow cover

Seedlings of the studied species in the late autumn sowing date did not differ significantly in the growth rate in the first and in the second year of studies with the exception of *P. pratensis* (Tab. 3). On 10th and 20th days from the date of sowing, *P. pratensis* seedlings were lower but significantly only compared to *L. perenne*. Also in the following days, *P. pratensis* seedlings were the lowest (on 30th day significantly comparable to *F. arundinacea* and *F. ovina,* on day 40th significantly comparable to *F. arundinacea* and *L. perenne*, on day 50th only significantly comparable to *L perenne*, while on day 60th, significantly comparable to *F. rubra*). In the second year of tests (2010), on the 20th and 30th day after the sowing date, *P. pratensis* seedlings were the lowest (similarly to the 1st year of tests), but only significantly compared to *F. arundinacea* and *L. perenne*.

DISCUSSION

Conditions for the initial growth and development of plants on the roadside embankments were unfavorable, because during its formation the soil was strongly geotechnical transformed, which was the cause of the disturbance of water and air relations [Drozd 1998, Rybicki and Krokoszyński 2007, Głażewski et al. 2010] and the appearance of water stress, especially in periods of higher air temperatures and lack of rainfall. Such conditions occurred during the initial growth and development of plants in September 2009. Also in October 2010 (the second year of tests), low rainfall and air temperature (this month was defined as abnormally cool), therefore the conditions for initial plant development were good. The system of weather conditions after sowing the seeds had the strongest influence on root lengthening and the growth of seedlings of varieties on objects with the spring sowing date. Diversified system of weather conditions after seed sowing caused that the sensitivity of species to stress weather factors (drought, high air and soil temperatures) was revealed, which is confirmed by numerous studies [Rutkowska and Pawluśkiewicz 1996, Martyniak 2006, Powroźnik 2010].

Sowing dates significantly influenced the rate of root lengthening and growth of seedlings of the studied species. On objects with late autumn sowing date, all species were characterized by shorter roots and lower seedlings in relation to the spring sowing date. Weather conditions after sowing seeds on spring sowing date caused that up to the 20th day from the date of sowing, the roots of studied species were as short as on objects with late autumn sowing date. In other measurement dates, seedlings of the studied species were characterized by longer roots and higher seedlings as compared to those from the late-autumn sowing date. Indeed the longest roots and the highest seedlings were found in *L. perenne*. In the late autumn sowing dates, there were also the largest differences between the studied species at the root length and height of seedlings, as well as the largest impact of the years of research on seedling growth. What is confirmed by numerous studies [Skopiec 1979, Żyłka and Prończuk 1997, Harkot and Powroźnik 2010]. Slower rate of seedling growth in late autumn could have been due to the low intensity of the photosynthesis process, which was limited by lower temperatures [Erikson quoted after Milthorpe and Moorby 1979]. Sowing of grass seeds in late autumn dates is not recommended due to the risk of poor wintering of seedlings, if emergence occurs in the sowing year [Skopiec 1979, Powroźnik 2010].

In both series of studies, *L. perenne* seedlings were characterized by a rapid rate of root lengthening. Also in studies by Hayes [1976] and Harkot and Gawryluk [2010], *L. perenne* seedlings were characterized by a longer root system than that of other species. The ability of grass seedlings to quickly lengthen the roots very often determines their survival and, consequently, the success of sowing, especially in the case of drought (Hayes, 1976, Harkot and Jagiełło, 1993). In turn, seedlings of *P. pratensis* in both series of tests, regardless of the sowing date, were characterized by the shortest roots and the lowest seedlings in comparison to other species. Also in the studies by Dorywalski et al. (1984) and Domański (1995), varieties of *P. pratensis* were characterized by a slower rate of the root system elongation than varieties of *F. rubra* and *F. ovina*.

CONCLUSIONS

1. Weather conditions after sowing the seeds significantly influenced the rate of root elongation and growth of seedlings of the grass species studied.

2. The spring sowing date promotes root extension and the growth of seedlings, in particular *L. perenne* seedlings and proved to be better than the late autumn sowing date.

3. Sowing the tested grass species in late autumn showed a strong influence of weather conditions after sowing the seeds on root length and height of seedlings of the studied species was found, which proves the sensitivity of tested species to stress weather factors.

4. *L. perenne* seedlings were considered the least sensitive to stressful weather factors, irrespective of the sowing date, while *P. pratensis* seedlings were considered to be the most sensitive to stressful weather factors.

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Streszczenie. Celem prezentowanych badań była ocena początkowego tempa wzrostu wybranych 5 gatunków traw, w celu określenia ich przydatności do szybkiego i skutecznego zadarniania przydrożnych skarp w dwóch terminach wysiewu (wiosenny i późnojesienny). Badania przeprowadzono na skarpie usytuowanej wzdłuż drogi krajowej S17. Pomiary długości korzeni i wysokości siewek każdego gatunku wykonano w 10, 20, 30, 40, 50 i 60. dniu od daty siewu. Wykazano, że w warunkach prowadzenia doświadczenia gatunki traw różnią się tempem początkowego wzrostu. Terminy siewu miały istotny wpływ na tempo wydłużania korzeni i wzrostu siewek badanych gatunków traw, bowiem na obiektach z późnojesiennym terminem siewu wszystkie gatunki i odmiany charakteryzowały się najkrótszymi korzeniami i najniższymi siewkami. W obu terminach siewu, niezależnie od roku prowadzenia doświadczeń, siewki *L. perenne* charakteryzowały się najdłuższymi korzeniami i najwyższymi siewkami w porównaniu z pozostałymi gatunkami. Z kolei siewki *P. pratensis* w obu powtórzeniach charakteryzowały się najkrótszymi korzeniami i najniższymi siewkami w porównaniu z pozostałymi gatunkami.

Słowa kluczowe: trawy gazonowe, początkowy wzrost i rozwój, przydrożna skarpa

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