ORIGINAL ARTICLE

STUDY OF THE EARLY ROOT DEVELOPMENT OF IMPORTANT ARABLE GRASS WEEDS IN MAIZE
I. LARGE CRABGRASS (DIGITARIA SANGUINALIS (L.) SCOP)
A KUKORICA FONTOSABB GYOMNÖVÉNYEINEK KORAI GYÖKÉRFEJLÕDÉSE
I. AZ UJJASMUHAR (DIGITARIA SANGUINALIS (L.) SCOP.)

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ÖSSZEFOGLALÁS

Az egyik legfontosabb gyomnövény, a Digitaria sanguinalis korai gyökérfejlõdését 1994-ben 1995-ben és 1997-ben klímakamrában, tenyészedényekbe 1 cm mélyen vetett 10-10 növényegyeden vizsgáltuk, három féle tápközegben (homok, barna erdõtalaj, tõzeg). Az elsõdleges, másodlagos és a harmadlagos gyökerek fejlõdése alapján megállapítható, hogy a gyökérváltás a vetést követõ 17-24. napon következett be. Ebben az idõszakban a hajtásonkénti átlagos levélszám 4 (3-5) volt.

KULCSSZAVAK: Digitaria sanguinalis, juvenilis gyökérzet, fejlõdés, gyökérváltás

ABSTRACT

We have studied the primary root development of the one of the most important grass weeds - large crabgrass (*Digitaria sanguinalis (L.) Scop)*. The primary, secondary and tertiary root development was studied in laboratory (thermostat), and in pots in 1994, 1995 and 1997. Each year we sowed the seeds 1 cm deep in the pots separately. The number of days required for the change of the early root system from the sowing 17 - 24 days. The average leaf number in the root change period was 4 and varied in between 3 to 5. We also observed that the date of sowing during the summer months (June, July and August) did not influence the change of the early root system.

KEY WORDS: Digitaria sanguinalis, juvenile roots, development, change of roots

Manuscript received: April 2, 2002.
Accepted for publication: June 5, 2002.

JOURNAL Central European Agriculture ISSN 1332-9049

DETAILED ABSTRACT

The early development of root system has been studied on the seedlings plotted 10 per pots of one of the most important weeds, large crabgrass (Digitaria sanguinalis) in lab (growing chamber) and field conditions. The appearance and growth of primary, secondary and tertiary roots was noted and measured in years 1994, 1995 and 1997. The period of root change is 17 – 24 days after sowing. The average leaf number is 4 (3-5) for this time. The summer sowing of seeds (in months from June to August) did not affect the pattern of early root development.

Root system is „hidden" functional constituent of plants. Variations in traits among several components of the root system of terrestrial plants affects their ability to cope with the complex and changing environment that they occupy. Research of roots is relatively limited to that of other organs of plants but there is more opportunity to control plant growth by altering the root environment as that of shoots in agronomic practice.

The root system of grasses is composed of a few types of roots as embryonal primary and other (from embryonal nodes emerging) seminal roots and, later developing adventitious nodal or crown roots of lower stem nodes. Roots of all types function for a long period and some of them may support the plant during the entire course of its life.

Not all the questions about the life span and contribution of seminal roots to the whole plant have clear answer yet. Seminal roots used to be regarded as either short-lived and making minor contribution to phytomass production on one hand or long-lived with major contribution to phytomass on the other.

Root change should be spoken about when the seminal roots loose and the adventitious take over the main part in the uptake of solutions and in heterotrophic plant metabolism. Its setting in depends on the vigour of the seedlings and the environmental conditions with emphasis on temperature, nutrient supply and competition. Crops and weeds prove to be very sensitive (vulnerable) during this important period of their life.

The aim of this work is to complete the knowledge about structure and functioning of the early root system of the seedlings in the stage of root change. The comparative study of the root system parallel with the development of the foliage on aerial shoots should be very important in weed control e.g. with herbicides.

The experiments were performed at the research sites of the Pannon University of Agricultural Sciences at Keszthely (1994-1995) and the Agricultural Research Institute of Hungarian Academy of Sciences at Martonvásár (1997). Seeds of large crabgrass were sown into Petri-dishes and pots of d = 16 cm, h = 16 cm filled with sand, mixture of sand, brown forest soil, peat as growing medium. 10 seeds per plot were sown in 1 cm depth. The number of replications was 4 per treatments. The seedlings were removed and their roots were carefully washed out. Number of primary, secondary and tertiary roots and that of leaves was counted, the length of roots was measured. The data were plotted against time and shown on diagrams. The crossing of graphs representing the growth of seminal and tertiary roots conferred with number of leaves respectively has been taken as the period of root change.

A strong and vigorous primary (main) root and some less vigorous secondary roots were detected from the scutellar node. Some weaker secondary roots raised from mesocotyle. The first (seminal) nodal secondary roots were stronger. The importance of primary and secondary roots decreased or they died after the tertiary root system came into function.

The period of root change is characterised by 3-5 leave stage of stem elongation between 17-24 days after sowing.

INTRODUCTION

Root system means a congregate of several individual components that together constitute the functional „ hidden half „ of plants [3, 6, 12]. This attribute is of special importance for roots of terrestrial plants, which occupy a heterogeneous environment that varies both spatially and temporally [5]. Variation in traits among the various components of the root system of terrestrial plants affects the ability of these plants to cope with the complex and variable environment they occupy [4, 9]. The ability of plants to produce different types of roots is an aspect of the plasticity of the plant which has an important adaptive feature [1, 2]. Roots as major vegetative organs supply water, minerals, and substances essential for plant growth and development. Research on roots is relatively limited, compared with that of other plant organs. However, there is more opportunity to promote plant growth by changing the root environment than by changing the shoot environment. Air, water, and mineral phases of the rhizosphere (root environment) are relatively easy to alter by agronomic practices. The shoot atmosphere of crop plants, on the other hand, is difficult, or practically impossible, to change.

Several types of roots originate from different anatomical sources. The root system of grasses are composed of a few basic types of roots: embryonic roots (including the primary root and the other seminal roots that develop adventitiously from the embryonic nodes) and of roots that develop later from the lower stem nodes (adventitious, nodal, or crown roots). Roots of both systems remain active for long periods, and some of them support the plant during the entire course of its life [7, 8]. Nevertheless, during different stages of development, each of two groups of roots supports different allotments of the shoots: seminal roots support mainly the primary shoot, although some support is also given to the tillers. On the other hand, adventitious roots are basically connected only with one, or with very few, of their mother tillers. Thus because of their ramified connections with several parts of the shoots, seminal roots are more important for the survival of whole plants than the adventitious roots. The two groups also differ in their physiological performance, and the contribution of seminal roots to the whole plant exceeds what would have been implied from their fractal mass [11].

The question of the longevity and contribution of seminal roots to the total system seems unsolved. Although it is generally believed that seminal roots are short-lived and make a minor contribution, some studies have shown that they are long-lived and make a major contribution. Both views are correct, depending on the species and environment. Pavlychenko [10] observed that in a number of cool-season cereals under western Canadian conditions, the seminal roots not only were important but were the sole root system because crown roots did not develop in drought years. Competitive ability early in the season was related to the development of seminal roots. Spacing of plants did not appear to affect the number of seminal roots, but close spacing drastically reduced the number of primary and secondary branches on crown roots.

There is general agreement that in maize under field conditions the seminal roots are short - lived and make a relatively small contribution to the total because (1) the mesocotyl disintegrates after a few weeks, separating the seminals from the plant, and (2) the magnitude of the weight, volume, and length of adventitious roots is enormous, compared with seminal roots. Nevertheless, seminal roots are important to maize, especially for early support. The fineness and frequency of branching of the seminals result in high uptake efficiency, important in the early stages.

We can speak about root changing when the seminal root system had lost its main role in water, minerals and substances essential to the uptake, and the adventitious root system has taken over the main part from the primary root system. Root changing depends on environmental conditions - air and soil temperature, soil nutrients, plant residues, competition, etc. - which are affecting the development of the root system. Plants are the most sensitive to herbicides during root changing period, which is an important stage in the plant’s life. We should have to protect the crop against grass weeds in this stage.

Since not enough knowledge about roots and root changing is available, further studies are required to better understand how the root systems of grass weeds develop in the early developmental stage. To know the number of leaves during the root changing period should be very important because grass weeds are the most sensitive to herbicides in this stage

MATERIALS AND METHODS

Experiments were performed at the research sites of Pannon University of Agricultural Sciences at Keszthely (1992-1995), and in the Agricultural Research Institute of the Hungarian Academy of Sciences at Martonvásár (1997). We examined the early root development of large crabgrass (*Digitaria sanguinalis* (L.) Scop) under field conditions.

The seeds of large crabgrass were collected around Keszthely, and were kept dry and cool till the sowing date.

Seeds of large crabgrass were sown into Petri-dishes (d = 14 cm) in 1992-93, and into experimental pots (d=16 cm; h=16cm) filled with sand in 1994, and a mixture of washed out sand, brown forest (according to Ramann)-soil and mould of Pötrétei (1:1:1) in 1995 in Keszthely, and in mould of Pötrétei in 1997 in Martonvásár. We sowed 10 seeds in each pot, 1 cm below the surface. Treatments were repeated four times in each experiment.

We sowed the seeds of large crabgrass into the experimental pots in the months given in Table 1a., while temperature information is presented in Table 1b.

Table 1: Sowing date, observation time and temperature data in the experiments
1a: Sowing dates and observation times

year	sowing time	day of observation (DAS*)
1992/93	at winter/spring	3, 5, 8, 10, 16, 20, and 24
1994	27th June	5, 8,10,15,20,25, 30 and 35
1994	12th August	5, 8, 10, 15, 20, 25, 30 and 35
1995	19th May	20, 25 and 32
1997	30th June	5, 8, 10, 15, 18, 20, 25, 30, 32, and 35

[1]DAS, days after sowing

1b. Temperature in the experiment periods

Period	$T_{average}$ ^oC	T_{max} ^oC	T_{min} ^oC
1992/93, in thermostat	20.00	20.00	20.00
27th June - 1st August 1994	23.50	29.76	16.05
12th August - 16th September	19.75	25.68	13.84
19th May - 20th June 1995	17.30	21.98	12.26
30th June - 4th August 1997	19.26	25.25	13.25

10 plants were removed from every pot and their roots were carefully washed out with running water. The leaves, the primary, secondary and tertiary (corona) roots were counted and the length of the roots were measured.

We determined the date of the root changing withgraphs of these data. We can find the days of root changing when the graphs of primary roots cross the graphs of tertiary roots and there are leaf stages belonging to these days of root changing.

RESULTS

It was found that one strong and vigorous primary root and some less vigorous secondary roots also developed from the first scutellar node of the five examined grass weeds. Some secondary roots were observed in different numbers from the mesocotyl, too. These roots were weaker than the other secondary roots. We have identified the number and the length of tertiary roots originating from the second (coleoptyl) node. The mesocotyl did not stay in the seed (unless the seeds germinated on the surface). The length of the mesocotyl was different and depended on the sowing depth. We identified that the number of the secondary (mesocotyl) roots in the case of large crabgrass (*Digitaria sanguinalis* (L.) Scop) were between 0 to 1. Some secondary roots originated from the first (seminal) node. Results of the research showed that the number of the secondary roots in the case of large crabgrass (*Digitaria sanguinalis* (L.) Scop) were 0 to 1. These roots were stronger than the mesocotyl secondary roots. The secondary roots generally died together with the main root after the root changing when the tertiary root system took over the main functions from the primary root system. The importance of the secondary root system was insignificant during the growth of the plant at crabgrass because it had few secondary roots which were not strong enough.

During the research we counted the roots and determined their length, and we also counted the leaves in order to identify which developmental stage belongs to the time of the root changing. Data showing the root development and the number of leaves of large crabgrass (*Digitaria sanguinalis* (L.) Scop) are presented in Tables 2, 3, 4, and 5.

Table 2: Primary root length of large crabgrass in experiments

Date of experiment	Primary root length (mm), DAS*												
	3	5	8	10	15	16	18	20	24	25	30	32	35
1992/93	1.08	14.3	32.7	42.8	-	46.1	-	48.5	51.4	-	-	-	-
1994 (I.)	-	43.2	113.3	142.9	169.6	-	-	193.6	-	234.7	275.3	-	12.6
1994 (II.)	-	37.4	76.3	130.0	199.6	-	-	243.4	-	286.9	306.0	-	320.4
1995	-	-	-	-	-	-	-	179.8	-	232.1	-	244.6	-
1997	-	34.9	52.6	101.9	160.4	-	224.5	245.1	-	293.8	313.6	319.6	324.9

Table 3: Tertiary root length of large crabgrass in experiments

Date of experiment	Tertiary root length (mm), DAS*												
	3	5	8	10	15	16	18	20	24	25	30	32	35
1992/93	0.0	0.0	0.0	4.0	-	16.5	-	33.6	60.7	-	-	-	-
1994 (I.)	-	0.0	0.2	12.4	55.7	-	-	125.9	-	357.7	805.6	-	1396
1994 (II.)	-	0.0	0.0	0.0	21.3	-	-	100.7	-	375.4	525.7	-	1063
1995	-	-	-	-	-	-	-	148.0	-	695.4	-	1118	-
1997	-	0.0	0.0	16.1	118.6	-	219.2	307.7	-	666.4	1287	1509	1889

Table 4: Number of tertiary root of large crabgrass in experiments

Date of experiment	Number of tertiary roots, DAS*												
	3	5	8	10	15	16	18	20	24	25	30	32	35
1992/93	0.0	0.0	0.0	0.65	-	1.6	-	2.3	3.35	-	-	-	-
1994 (I.)	-	0.0	0.04	0.96	1.48	-	-	2.05	-	3.15	3.82	-	4.51
1994 (II.)	-	0.0	0.0	0.0	0.99	-	-	1.75	-	2.83	3.29	-	4.19
1995	-	-	-	-	-	-	-	3.63	-	4.73	-	6.68	-
1997	-	0.0	0.0	0.8	3.1	-	3.95	4.75	-	6.3	7.55	8.4	9.7

Table 5: Number of leaves of large crabgrass in experiments in

Date of experiment	Number of leaves, DAS*												
	3	5	8	10	15	16	18	20	24	25	30	32	35
1992/93	0.0	0.35	1.2	1.7	-	2.65	-	3.2	3.65	-	-	-	-
1994 (I.)	-	1.0	1.98	2.26	2.65	-	-	3.44	-	3.93	5.46	-	6.28
1994 (II.)	-	1.0	1.34	1.91	2.91	-	-	3.64	-	4.86	5.68	-	6.1
1995	-	-	-	-	-	-	-	3.63	-	4.72	-	6.68	-
1997	-	1.0	1.4	1.85	3.0	-	3.85	4.65	-	6.05	8.05	9.0	11.7

DAS*: days after sowing; -: no observation; 1994 (I.): 27th June - 1st August 1994; 1994 (II.): 12th August - 16th September 1994

We represented the data in graphs and determined the time of the root changing and the number of leaves belonging to the root change time (Figures 1-5).

Figure 1. Root development of large crabgrass in thermostat in 1992/93

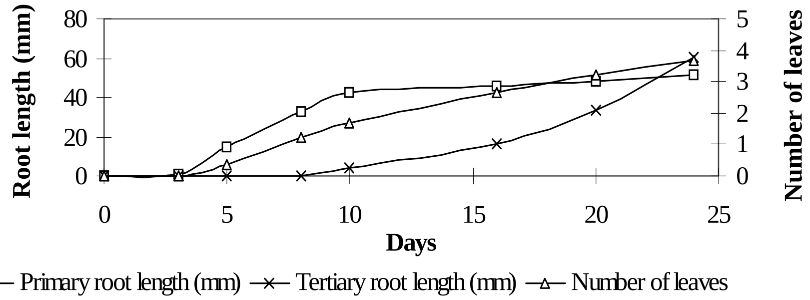


Figure 2. Root development of large crabgrass in pots from 27th June to 1st August in 1994

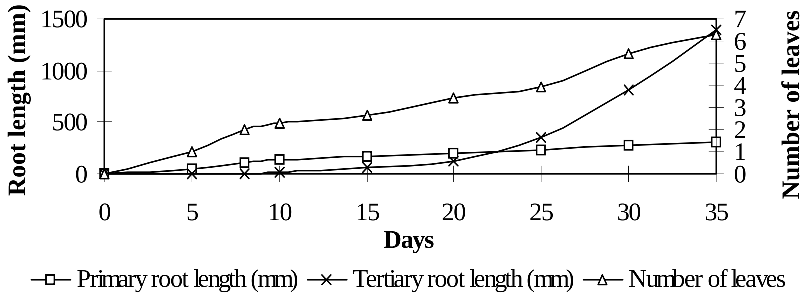


Figure 3. Root development of large crabgrass in pots from 12th August to 16th September in 1994

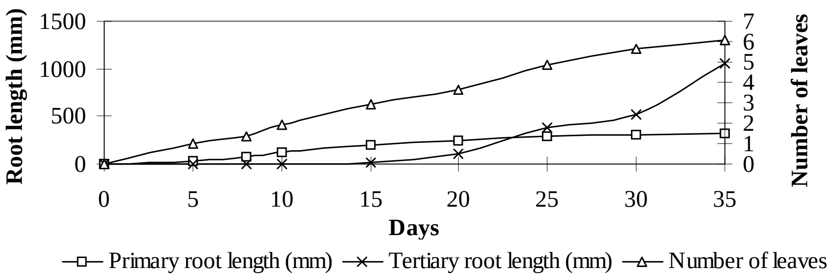


Figure 4. Root development of large crabgrass in pots from 19th May to 20th June in 1995

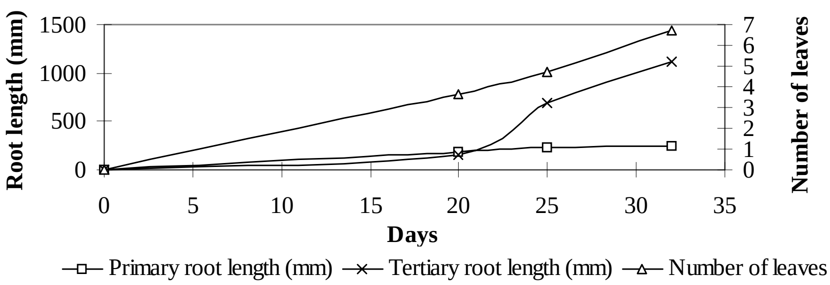
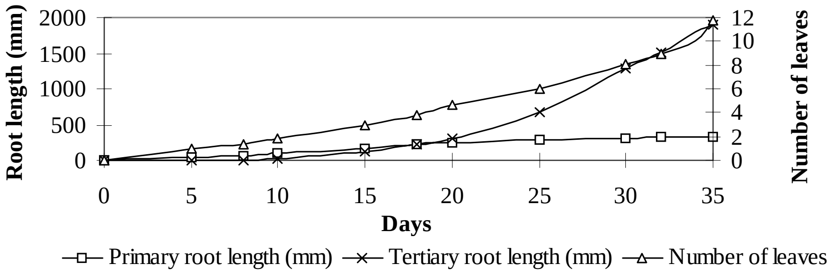


Figure 5. Root development of large crabgrass in pots from 30th June to 4th August in 1997



Change of the early root system of large crabgrass was found to be in the following periods in the experimental years:

- in 1992/93: 21.0-24.0 days, and 3.0-4.0 leaves;
- in July 1994: 22.0-23.0 days, and 3.0-4.0 leaves;
- in August 1994: 22.0-24.0 days, and 4.0-5.0 leaves;
- in June 1995: 20.0-22.0 days, and 3.5-4.5 leaves;
- in July 1997: 17.0-19.0 days, and 3.5-4.5 leaves stage.

We have determined the primary, and tertiary roots development of large crabgrass. The change of the early root system period covered around a week (average 21 days after sowing). The days required for root changes after sowing were 17 to 24 days after sowing (Figure 6). The average leaf number at the root change period was 4 leaves and varied between 3 to 5 (Figure 7). Date of sowing through summer months (June, July and August) did not influence the time of root changing.

Figure 6. Days of root changing of large crabgrass in different experiments

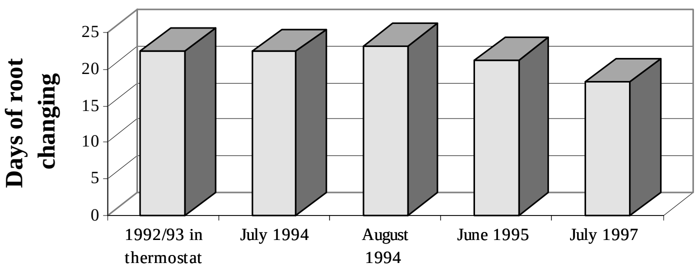
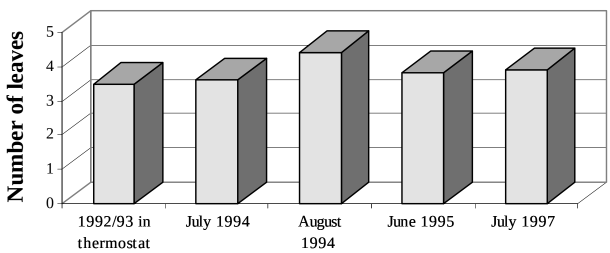


Figure 7. Number of leaves of large crabgrass in different experiments



DISCUSSION

The main result of the research is that the root change period covered around six days, and it occurred 21 days after sowing on average, independently of the sowing date and the temperature of the experimental periods. The average leaf number in the root change period was 4 leaves and varied between 3 to 5.

Since our experiments were made at different times, we came to a conclusion that the temperature did not have an effect on the duration of root changing - it was approx. 1 week -, however, we noticed that the plants liked higher temperature (when the temperature was higher, they developed longer roots and more leaves). After root changing, the development and the growth of the primary root system generally slowed down, and the development of the tertiary root system was approximately exponential.

After root changing, the development and the growth of the primary root system generally slowed down, and the development of the tertiary root system was approximately exponential.

These results provide important quantitative information on weed development, but further experiments have to be carried out to understand better the process of root changing to help agricultural plant protection.

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