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in

Sulas L. (ed.).
Legumes for Mediterranean forage crops, pastures and alternative uses

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 45

2000
pages 157-160

Root growth analysis in sainfoin (*Onobrychis viciifolia* Scop.) submitted to different harvest times

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Summary - On a permanent meadow of sainfoin (*Onobrychis viciifolia* Scop.), cropped under dry conditions, the effects of two harvest times (when plants reached, on the average, 10 and 20 cm of height) on the dynamic of root development have been evaluated, by means of the non destructive method of minirhizotrons. The research was carried out at Rutigliano (Southern Italy) from 1992 to 1994, using a miniature video camera. Measurements were taken during the legume vegetative cycle. Images were analysed and transformed in R.L.D. (Root Length Density) and the values so obtained were submitted to statistical analysis. The root growth varied according to harvest times: with the cut at 20 cm height, sainfoin mostly concentrated rooting intensity in the upper layer of the soil, while with the one at 10 cm there was a deeper root development, but with small growing intensity.

Key-words: sainfoin, root growth, minirhizotrons

Résumé - *Cet étude a le but d'évaluer les effets de deux époques de fauchage (à 10 et 20 cm d'hauteur) sur la dinamique de développement des racines de mélilot jaune (*Onobrychis viciifolia *Scop.), cultivée sans irrigation dans un pré permanent. L'expérimentation a été menée à Rutigliano (Sud de l'Italie) de 1992 à 1994, en employant la méthode pas destructive des minirhizotrons. Les remarques ont éteés réalisées pendant le cycle végétatif du mélilot. Les images obtenues au moyen d'une caméra miniaturisée ont étées analysées et tranformées en R.L.D. (Root Length Density). Avec le fauchage à 20 cm d'hauteur, le mélilot jaune a concentré la plus grande densité des racines dans la couche superficielle du sol, alors que avec celui-là à 10 cm, les plus hautes valeurs de R.L.D. ont étées obtenues en profondeur.*

***Mots-clés:** sainfoin, croissance des racines, minirhizotons*

Introduction

The study of the root system of plants is very useful for better understanding the effects of agronomic treatments on the growth. The different geometry of root development allows plant to search in the soil nutrients for its maintenance and therefore for productive activity (Lynch, 1995; Amato, 1996). To study roots behaviour there are destructive and not destructive methods. These latter allow to control the evolution of roots growth without traumatic applications. This is particularly important in permanent fodder crops, in which plant age and cuttings management can affect the turnover of root biomass. Several researches showed that roots in alfalfa, after each cut, decrease their development, reducing number of ramifications, above all those of small sizes (Boyce and Volence, 1992; Liisa *et al.*, 1995). The close interdependency between epigeous and hypogean parts of plant is also confirmed by the correlation between the carbohydrate reserve of roots and plant vegetative resumption (Habben and Volence, 1990).

With reference to this matter, our research has evaluated the effects of two harvest times on the behaviour of root apparatus in a permanent meadow of sainfoin, applying the non-destructive method of minirhizotrons.

Materials and methods

The research was conducted from 1992 to 1994 at Rutigliano (122 m a.s.l.), a typical area of Southern Italy, on a clay soil (55.2%), with a depth soil above the water table of 50-70 cm and a subsoil of cracked rock. On a crop of sainfoin (*Onobrichis viciifolia* Scop.) submitted to two harvest times (when plants reached, on the average, 10 and 20 cm of height), the behaviour of plants hypogean apparatus has been evaluated.

A split-plot experimental design with three blocks was applied on plots of 6 m^2 each.

At sowing time (December 3rd 1991), in each plot two minirhitrozons 100 cm long were installed along the rows, with an angle of 45°. Every year and for the whole trial period, three measurements were carried out at the end of spring (season characterized by good climatic conditions and with full vegetative activity), in summer (under less favourable conditions), and in autumn (before the winter dormancy).

In the second year, because of camera breakdown, the third measure was not achieved. The observations were made using a miniature video camera inside minirhizotrons. Root growth was observed along the whole circumference and length of the tube. The images were recorded on videotapes and then analysed, calculating the roots number for unit of surface; afterwards, the different numbers so obtained were transformed in R.L.D. (Root Length Density), applying the method suggested by Upchurc and Ritchie, 1983, and submitted to statistical analysis. For a better understanding of the R.L.D. values, in Table 1 the cumulated productions of dry matter obtained before every observation on root growth are also reported.

During the trial period, the weather was characterized by an annual rainfall always lower than the long-term average 1977-1991 (445, 511, 468 mm of 1992, 1993 and 1994, respectively, vs. 608 mm), with rains mostly concentrated in the winter months. The summer period was characterized by high temperatures and scanty rainfall.

Results and discussion

The first observation on root growth was carried out on June 9th 1992, after three cuttings made at 10 cm of plant height and one at 20 cm (Table 1).

Table 1 - Measurement dates of Root Length Density, cuttings number and dry matter production of sainfoin according to harvest time.

Harvest Time	1992 R.L.D. date (M-D)°	1992 Cuttings number	1992 Dry matter(1) (t ha^{-1})	1993 R.L.D. date (M-D)°	1993 Cuttings number	1993 Dry matter(1) (t ha^{-1})	1994 R.L.D. Date (M-D)°	1994 Cuttings Number	1994 Dry matter(1) (t ha^{-1})
10 cm	6-9	3	2.31	6-22	5	6.54	5-31	4	3.11
	7-23	1	3.22	7-22	0	6.54	8-3	2	3.90
	11-10	0	3.22	-	1(*)	7.29	10-13	0	3.90
20 cm	6-9	1	2.26	6-22	3	8.12	5-31	2	3.54
	7-23	1	3.71	7-22	0	8.12	8-3	2	4.94
	11-10	0	3.71	-	1(*)	9.83	10-13	0	4.94

(°) M = month - D = day. (*) Cutting carried out after the last R.L.D. observation.
(1) Cumulated production of cuttings made before each R.L.D. measurement.

The different number of cuttings determined in sainfoin a different degree of stress in adapting the hypogean development to that epigeous. In fact, with the cut at 10 cm, the greatest root development was observed in the shallow layer, about at 10 cm of depth (Fig. 1), then it decreased in the whole soil layer, showing values close to the zero in the following 30 cm. Instead, with the cut at 20 cm of height, R.L.D. was already higher in the first soil layers, with about double values compared to those before observed, it increased to reach 0.3 cm cm^{-3} at 20 cm, decreased (0.2 cm cm^{-3}) to 40 cm of depth and did not change in the remaining soil layer. In the second measurement, carried out at the end of July, after a further cutting in both cutting heights, sainfoin behaved in a different way according to harvest time; in fact, in the treatment at 10 cm height, it showed higher values (0.2 cm cm^{-3}) than those before obtained until 30 cm of depth, a maximum R.L.D. around 40 cm and therefore a decrement, with values equal about to 0.2 cm. In the cut made at 20 cm, there was a behaviour similar to that of the first observation, but with a great root density. At the end of autumn, in the last observation, a strong reduction of R.L.D. was observed in both cutting heights, clearer in that at 10 cm of plant height, with values next to zero, less evident in the cut at 20 cm, which reached a value of 0.1 cm cm^{-3} at 30 cm of depth. The better and more constant behaviour over the time of the highest cut (20 cm) is certainly to ascribe to its lower cuttings number, in comparison to that at 10 cm height, in which the need to store in roots nutrients during the inactivity of plants stage clearly reduced R.L.D. values.

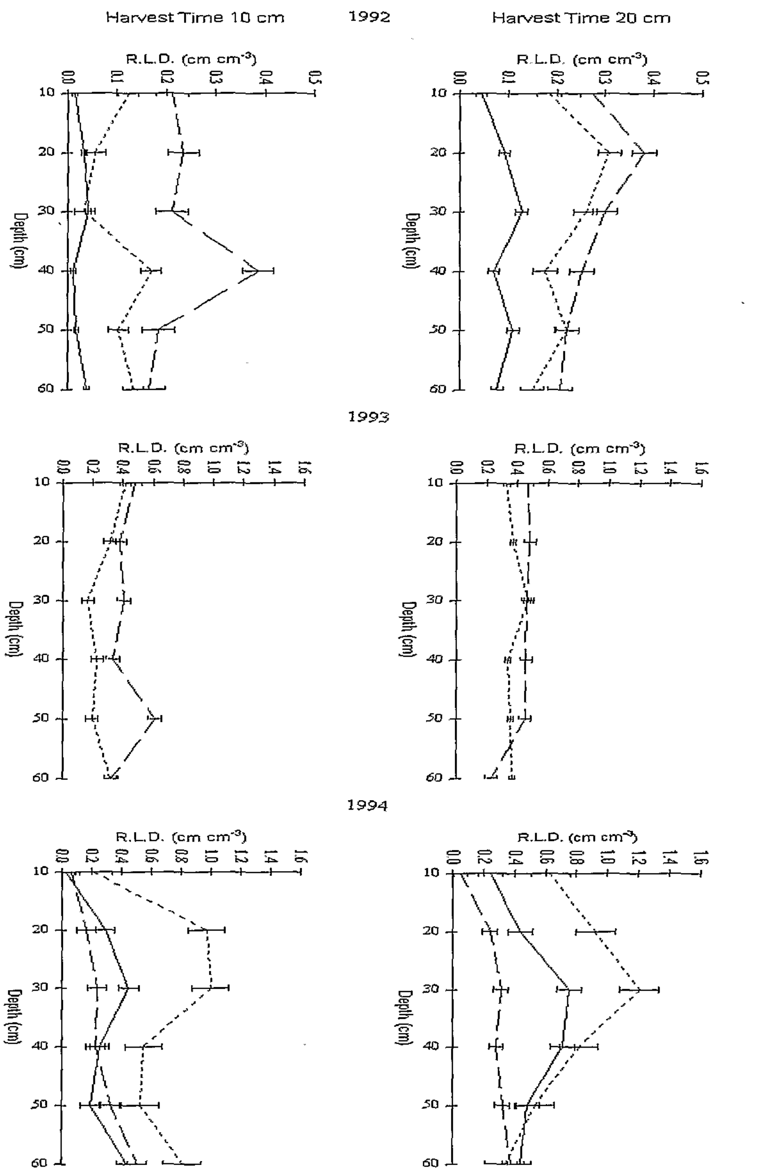

Figure 1. Root Length Density of sainfoin according to harvest time (Observation 1 = --------- 2 = — — 3 = ———).

The first measure of the second year (1993) was carried out late in June for technical difficulties. In this observation, made after five and three cuts, respectively for 10 and 20 cm treatments, R.L.D. values in the layer 0-10 cm were similar in both cutting heights.

Subsequently, in the cut at 10 cm, they decreased up to 30 cm, showing a light increase at the maximum depth (60 cm). In the cut at 20 cm, root development was almost constant along the whole profile, except a light increase recorded around the 30 cm of depth. However, in this period, even if finding very little differences on root growth, the best dry matter production was obtained by the cut at 20 cm; this probably depended on the delay of the first observation, carried out at the beginning of summer, when plants stop their vegetative stage. In the second measure of cut at 10 cm height there was a trend similar to that observed in 1992, and the highest R.L.D. of 1993 (0.6 cm cm^{-3}) was reached at 50 cm of depth. In the cut at 20 cm height, values were slightly higher than those obtained with the cut at 10 cm and more constant in the whole profile.

In the third and last trial year (1994), the cut at 20 cm differed from the lowest one, especially in the second and the third observations. The first measurement was effected late in May, after four and two cuttings for the two harvest times, respectively. In this year, the highest R.L.D. of the whole trial period was obtained. The cut at 10 cm of plant height showed a low root density in the 0-10 cm layer, it reached the best value (1 cm cm^{-3}) between 20 and 30 cm of depth and decreased between 30 and 50 cm. In the cut at 20 cm, R.L.D. values were higher than those at 10 cm height in the shallow soil layer, increased and reached the maximum value of 1.2 cm cm^{-3} to 30 cm and then decreased until 60 cm of depth. In the second observation, carried out after further two cuttings of sainfoin, there was a trend similar in both treatments along the soil profile, but with a root density very reduced. In the third and last measure, there was a clear resumption of root growth, chiefly in the cut at 20 cm, with a maximum value of 0.7 cm cm^{-3} at 30 cm of depth, value that then slowly decreased.

Conclusions

With the cutting at 10 cm of plant height, sainfoin developed a root density lower than the cut at 20 cm, especially when plants were in full vegetative stage, at the beginning of summer, and before the winter dormancy. On the contrary, in full summer, legume showed, in both cutting heights, a good capability of recovery, reaching the highest R.L.D. values. The different frequency of cuttings determined also a different distribution of roots along soil profile; in fact, with cuts at 10 cm of plant height, sainfoin reached the greatest root density in the deepest layers, while with those carried out when plant height was 20 cm, the greatest R.L.D. values were obtained in the shallow layers. Finally, dry matter yields were always better in the last frequent cutting, that at 20 cm height.

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Authors have equally contributed to this work.