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# Yield, quality and root growth analysis of cocksfoot (*Dactylis glomerata*, L.) submitted to different harvest times

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**SUMMARY –** The research has been carried out on an artificial meadow of cocksfoot with the aim to evaluate the effects of two harvest times (on average, 10 and 20 cm of plants height) on: (i) green forage and dry matter yields; (ii) neutral-detergent fibre, protein and mineral contents; and (iii) the dynamic of root system. The study of roots development was conducted using the not-destructive minirhizotron method. Measurements were taken during the plant vegetative cycle. The results have shown that with harvest time at 10 cm height the quantitative and qualitative parameters of production were not too good, roots grew slowly, reaching the greatest development when plants were latent and with early symptoms of senescence. With the cutting at 20 cm height, cocksfoot developed a higher root density in spring, showed a good viability, a higher yielding capability and a better neutral-detergent fibre content.

**Key words:** Cocksfoot, yield, quality, roots growth.

***RESUME –** “Production, qualité et croissance des racines de dactyle aggloméré soumis à deux époques de fauchage”. Cet étude a été menée avec le but d’évaluer les effets de deux époques de fauchage (10 et 20 cm) sur la production, la qualité et le développement des racines de dactyle aggloméré (*Dactylis glomerata*, L.), cultivé dans un pré permanent. L’étude de la croissance des racines a employé la méthode non destructive des minirhizotrons. Les mesures on été réalisées pendant le cycle végétatif du dactyle. Les résultats de notre recherche ont montré qu’avec le fauchage à 10 cm d’hauteur les paramètres quantitatives et qualitatives de la production n’ont été pas satisfaisants, que les racines ont poussé lentement, en rattrapant le plus grand développement lorsque les plantes étaient latentes, et avec symptômes précoces de sénescence. Avec le fauchage à 20 cm, le dactyle a concentré la plus grande densité des racines en été, a montré une bonne vitalité, une bonne capacité productive et un bon contenu de fibre du fourrage.*

***Mots-clés :** Dactyle aggloméré, production, qualité, croissance des racines.*

## Introduction

In the hilly areas of Southern Italy, an effective contribution to the improvement of fodder production can be given by the use of grasses with a good capability to grow under conditions of scanty water availability (Talamucci, 1971; Longo and Cassaniti, 1976; Rizzo and De Giorgio, 1982). In fact, in these environments, characterised by high summer temperatures and rains mainly concentrated in the winter months, the production of green forage is very poor because of the low number of summer mowing. The supplemental irrigation could improve the yields, especially if the relation watering time - cutting time is well evaluated (Cavallero and Ciotti, 1991; Asay *et al*., 2001; Asay *et al*., 2002; Duffkova, 2002). The frequency of cuttings can cause physiological variations, with effects both on the distribution of soil nutrients in the different parts of plant, and on the structure of turf-forming plants (Hodgson *et al*., 1981; Lemaire, 1988; Reyneri, 1990; Maiorana *et al*., 1995; De Giorgio *et al*., 2000). Nevertheless, these effects are more visible in the epigeous part than in the hypogean one. The different geometry of root system allows plants to find in the soil the elements indispensable for both growth and productive activity (Fitter, 1986; Lynch, 1995; Amato and Govi, 1996). Consequently, to study roots behaviour after mowing could be particularly useful for verifying the effect of treatments on the productions of artificial fodder crops, in which root system is submitted to a turnover, according to cuttings management and plants age. With the vegetative re-growth and the development of aerial part, roots re-balance their sizes so as to allow the growth of plants biomass.

Our three-year research was aimed to evaluate the effects of two harvest times on production and quality of forage and on the dynamic of roots development, in an artificial meadow of cocksfoot.

## Material and methods

The research was conducted at Rutigliano, in a typical hilly environment of Southern Italy, in the years 1992, 1993 and 1994.

The soil was a silty-clay soil classified as Rhodoxeralf Lithic Ruptic (Soil Taxonomy-USDA), with a depth soil above the water table ranging from 50 to 70 cm and a subsoil of cracked rock.

The climate is "accentuated thermomediterranean" (UNESCO-FAO classification). During the trial period, weather was characterised by an annual rainfall always lower than the long-term average 1977-1991 (465, 511 and 469 mm in 1992, 1993 and 1994, respectively, vs 624 mm).

The study of root system was carried out on an artificial meadow of rain-fed cocksfoot (*Dactylis glomerata,* L.) submitted to two harvest times (when plants reached, on average, 10 and 20 cm of height).

A completely randomised block with three replications was applied on plots of 6 $m^2$ each.

Sowing was performed in December 1991, with a row spacing of 15 cm and with 50 kg/ha of seeds. During the trial period, cocksfoot was always cropped in pure stand.

At the sowing time, in each experimental plot two minirhizotrons 100 cm long were installed along the rows, with a 45 degrees angle.

Measurements were made using a microvideo camera inserted in minirhizotrons.

Roots growth was recorded through transparent surface of tubes, along their whole circumference and length. Images were recorded on videotapes, analysed for roots number per unit of surface and transformed in root length density (RLD), according to the method suggested by Upchurch and Ritchie (1983).

Three measurements were carried out every year (except in the second one, because of a camera breakdown) always after the cuttings, at different growing stages: (i) at the end of spring (season characterised by good climatic conditions and with full vegetative activity of plants); (ii) in summer (under climatic conditions close to water stress because of lack of rains); and (iii) in autumn (before the winter dormancy).

After each mowing, the green forage production was determined and, in samples of 1000 g oven-dried at 105 °C till constant weight, the dry matter content was measured; in samples of 100 g, after oven-drying at 80 °C for 24-36 hours, the contents of crude protein (N Kjeldahl x 6.25), neutral-detergent fibre (NDF, Van Soest) and minerals (Cottenie, 1980) were determined.

All experimental data (forage yield and quality, RLD values) were submitted to statistical analysis (SAS Institute, 1998). Differences among the averages were evaluated by means of the Snedecor-Newman-Keuls test.

## Results and discussion

Table 1, in which the most important parameters of production are reported, shows that cocksfoot gave good green forage and dry matter yields in the first year (11.9 and 2.5 t/ha, respectively) and fairly good responses in the third one (8.4 and 2.2 t); on the contrary, in 1993, the production was significantly lower, because plants displayed a severe suffering state at the vegetative resumption after winter break, due to a considerable lowering of temperatures in February.

In these conditions, cocksfoot showed not only the worst yielding ability, but also the lowest cuttings number of the three-year trial period: 3 and 2, respectively, for the two harvest times (Table 2). Besides, the trend observed for quantitative parameters repeated itself also for crude protein, that reached the significantly worst content (9.0%).

Table 1. Effect of experimental factors on quanti-qualitative parameters of production

| | Green forage (t/ha) | Dry matter (t/ha) | Protein content (%) | NDF† Content (%) | Mineral content (g/100g DM) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | K | Mg | Na | Ca | P |
| Years | | | | | | | | | |
| 1992 | 11.9 a | 2.5 a | 18.0 a | 45.8 b | 4.7 a | 0.41 a | 1.9 a | 0.30 | 0.29 b |
| 1993 | 3.0 c | 0.8 b | 9.0 c | 50.1 a | 2.4 b | 0.34 b | 1.0 b | 0.18 | 0.40 a |
| 1994 | 8.4 b | 2.2 a | 15.1 b | 47.9 ab | 4.2 a | 0.33 b | 1.6 a | 0.27 | 0.28 b |
| Harvest times | | | | | | | | | |
| 10 cm | 7.1 b | 1.7 b | 14.7 | 46.8 b | 3.4 b | 0.36 | 1.2 | 0.17 | 0.33 |
| 20 cm | 8.5 a | 2.0 a | 13.4 | 49.1 a | 4.1 a | 0.37 | 1.7 | 0.33 | 0.32 |

Values with different letters in columns are significantly different at $P \leq 0.05$ (SNK test).
† NDF = neutral-detergent fibre.

Table 2. Measurements of root length density (RLD)

| Harvest times | 1992 | | 1993 | | 1994 | |
|---|---|---|---|---|---|---|
| | CCN† | Date (M-D) †† | CCN | Date (M-D) | CCN | Date (M-D) |
| 10 cm | 3 | 6-9 | 2 | 6-22 | 2 | 5-31 |
| | 5 | 7-23 | 2 | 7-22 | 3 | 8-3 |
| | 6 | 11-10 | 3 | - | 3 | 10-13 |
| 20 cm | 2 | 6-9 | 1 | 6-22 | 2 | 5-31 |
| | 3 | 7-23 | 1 | 7-22 | 3 | 8-3 |
| | 4 | 11-10 | 2 | - | 3 | 10-13 |

† CCN = cuttings cumulative number.
†† M = month; D = day.

With regard to the values of plants mineral concentration (Table 1), it is possible to observe a significant increase of K, Mg, Na contents with the increase of green forage productions, while only phosphorus level decreased.

Between harvest times, the one carried out at 20 cm of height always showed the best results in all the parameters considered, especially for green forage and dry matter yields and NDF and K levels. The other mineral contents were not greatly different.

Table 2 shows, for harvest times, the cuttings cumulative number and the date when each root length density (RLD) measurement was taken during the trial period 1992-1994.

Figure 1 reports the roots development values. For their better understanding, the scale of RLD of the first year has a larger gradient.

Measurements began on 9 June 1992, after the third cutting made at 10 cm of plants height and the second one at 20 cm.

In this trial year, the most evident differences of roots growth between the two harvest times were found. In fact, in the first observation, with the cut at 10 cm of height, the greatest roots development (about 0.3 $cm/cm^3$) was observed around 20 cm of depth (Fig. 1) and then it decreased in the whole soil layer. In the second measurement, carried out after two further cuttings, cocksfoot behaved in a different way because the maximum roots growth was obtained at 30 cm of depth. In the last observation in November, roots showed the greatest development of the whole cocksfoot cropping cycle of 1992 (0.4 $cm/cm^3$) and, one more time, in the shallow layer.

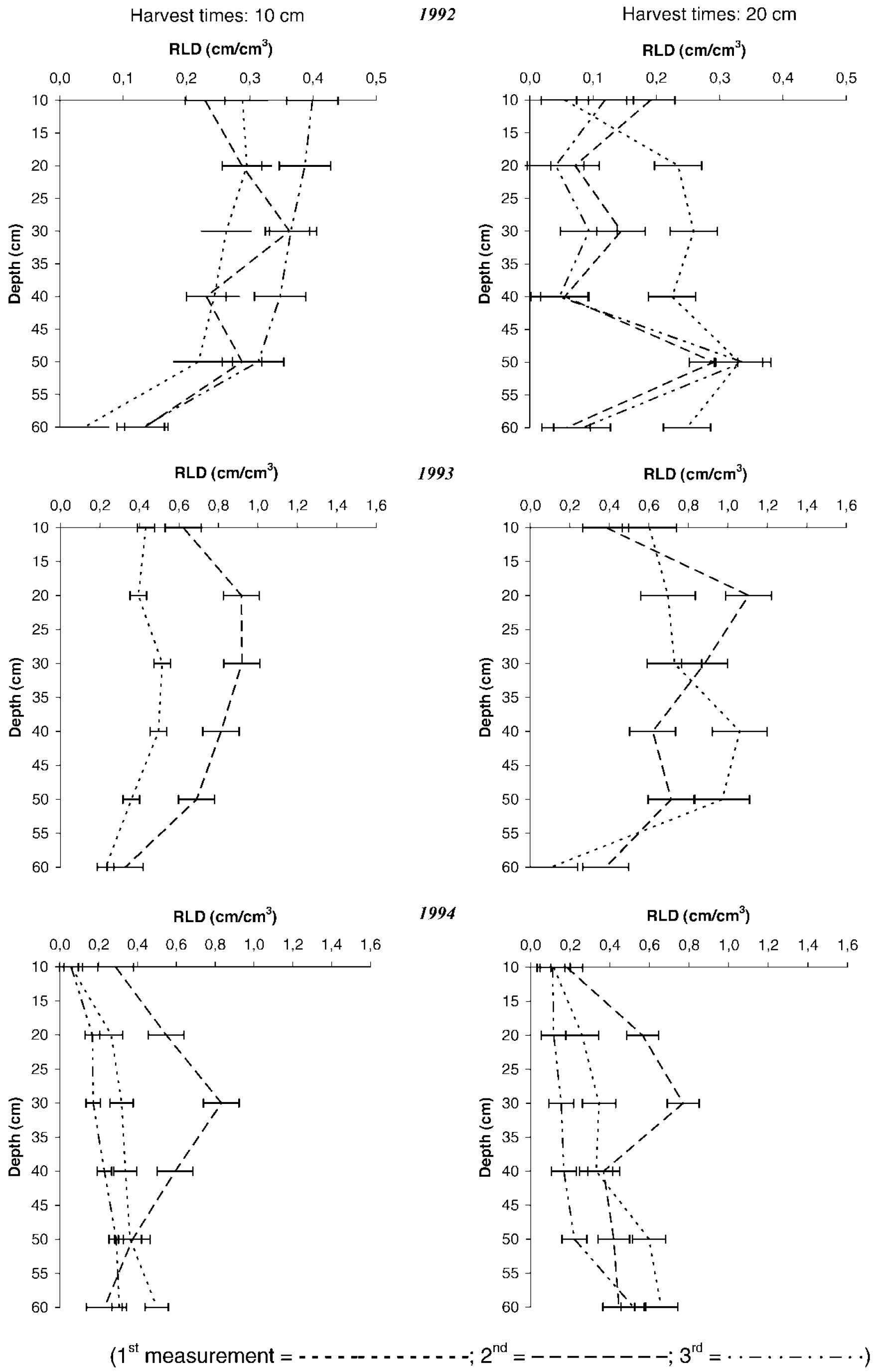


Fig. 1. Root length density of cocksfoot according to harvest time.

As mentioned above, the cutting at 20 cm of height gave different results that those observed in the cut at 10 cm; in fact, root length density reached the greatest value (over 0.3 $cm/cm^3$) in the first measurement, coinciding with the maximum vegetative and productive rankness, and in deeper layers (about 50 cm); in the following two observations, roots development decreased, showing trends similar to those of the first measurement.

In 1992, the highest number of cuttings made at 10 cm of height seemed to determine a greater RLD, while in the cut at 20 cm, the ability of cocksfoot to produce a higher vegetative biomass, caused an immediate growth of root system, which decreased over time, because of the scanty development of epigeous part of plants in summer.

In the second year, in which only two measurements were carried out, RLD reached the highest values of the three-year trial period (about 1.1 $cm/cm^3$ in the cut at 20 cm), showing trends not much differing from those recorded in 1992 in both harvest times.

In the last year (1994), roots development was similar in the two harvest times; in fact, it reached always the highest values (about 0.8 $cm/cm^3$) in the second measurement at 30 cm of depth and then decreased, reaching the lowest value of the year in both the cuts.

In the cutting at 20 cm of height, root system grew mostly in the deepest layers of soil and during the periods of highest productivity of plants, exploring a wider soil volume compared to that of the cutting at 10 cm. The ability of roots to deepen in the soil at the starting of plants growth or at the vegetative re-growth gave cocksfoot a good viability over the time and better yielding performances than the cut at 10 cm. In the latter, because of the highest cuttings number, root system was subjected to a more frequent turnover and, consequently, it slowed down its development, reaching the highest root density in autumn, at the end of plants cycle, involving both low forage productions and quality.

## Conclusions

During the three-year trial period, cocksfoot showed a fairly good yielding capability, except in the second one (1993), characterised by an unfavourable climatic pattern. The highest production and quality of forage were obtained in the first year. A large part of the qualitative parameters improved with the increase of productivity; only the neutral-detergent fibre content (NDF) showed an opposite behaviour.

Between the two harvest times, the one at 20 cm appeared the best, above all in quantitative characteristics. Besides, with this cutting, cocksfoot plants easily balanced their hypogean and epigeous parts, developed a greater roots density in spring, allowing plants a better viability and then a higher yielding capability.

With the cut at 10 cm of height, roots grew slowly, reaching the maximum development when plants were approaching dormancy, less productive and with early symptoms of senescence.

On the whole, the mowing at 20 cm of height can be considered the most suitable one, also because cocksfoot supplied both the best yields and NDF levels with lower prime costs, due to the lowest cuttings number.

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