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# Water management for establishment of alfalfa (*Medicago sativa* L.)


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## ABSTRACT

This research was carried out in 1997, at the "Centro de Ciências Agrárias" of the "Universidade Federal de São Carlos", in Araras, SP, Brazil, to evaluate the behavior of three growth stages ($S_1$ = initial vegetative stage, $S_2$ = full vegetative stage, and $S_3$ = reprodutive stage) of the "Crioula" alfalfa cultivar, in the presence of four water levels ($L_1$ = 100%, $L_2$ = 80%, $L_3$ = 45-50% and, $L_4$ =20-25% of a sprinkler irrigation) in a field trial. Growth stages changed according to water levels, and $S_2$ stage was the most affected by water supply, while $S_1$ was the least one and water showed to be a negative factor to plant establishment.


**KEYWORDS:** Alfalfa, *Medicago sativa* L., growth stages, irrigation, behavior, water levels, establishment

## INTRODUCTION

Alfalfa production area in Southeastern region has recently been increased due to establishment of intensive dairy cattle production systems (Vilela, 1992). In addition, various studies reported that alfalfa is a forage characterized for its high yield (20 t of dry matter/ha/year) and dry matter quality (≥ 20% of crude protein) (Fontes et al., 1993; Botrel et al., 1996; Evangelista et al., 1997; Rassini, 1998).

However, in spite of the potential showed by this forage in Brazil, mainly in the Southeastern and Southern regions, more studies are necessary on water management through irrigation techniques, since requirements of water might change with plant development. It has to be mentioned that this is a very expensive agrarian practice in alfalfa production systems (CEPEA/FEALQ, 1994; Honda and Honda, 1999). Nevertheless, irrigation has been considered a standard procedure for production of alfalfa in Brazil. Therefore, alfalfa is regarded and studied as an "irrigated culture" and there are no consistent studies on water management in alfalfa fields.

The objective of this study was to evaluate the relationships among growth stages of plant and levels of water supplementation, in order to achieve maximum forage yield under the most rational water management.

## MATERIAL AND METHODS

This research was carried out over four months (July-October) of 1997, at the "Centro de Ciências Agrárias" of the "Universidade Federal de São Carlos", in Araras, SP, Brazil. Plots were established on a Dark Red Latosol (Hapludox) (EMBRAPA, 1999).

The "Crioula" alfalfa cultivar was sown on 16/07/97 at the rate of 20 kg of seeds per ha, inoculated with *Rhizobium melilotti*. Three growth stages ($S_1$ = initial vegetative stage, $S_2$ = full vegetative stage, and $S_3$ = reproductive stage) were studied in the presence of four water levels ($L_1$ = 100%, $L_2$ = 80%, $L_3$ = 45-50%, and $L_4$ =20-25% of a sprinkler irrigation) (Table 1). Experimental area measured 76.8 $m^2$, which was divided into four equal parcels of 3.0 x 6.4 m, yielding four blocks. Each of these blocks was split into four parcels of 1.6 x 3.0 m. Each of these 1.6 x 3.0 m - parcel then received the specific irrigation level according to its distance from irrigation line ("line source"). As a result, the experimental design was a randomized block design with four replications and eight treatments, as follows: **111, 110, 100,** 101, 001, 011, 010, 000, where **O** represented the period in which growth stage did not receive water, due to protection against rain; and number **1** represented stage in which water level was applied.

Water levels were measured through real ($Et_a$) and maximum ($Et_m$) evapotranspiration of alfalfa in each treatment. Soil samples were collected every other day on the depth of 0-20, 20-40 and 40-60 cm from soil surface, resulting the moisture profiles to calculate the amount of water stored to be used in the equation of hydric balance recommended by Reichard et al (1974).

At establishment, only one cut (dry matter/ha) was made, 10 cm above the ground level. Besides alfalfa dry matter yield data, five plants were collected of each treatment in order to evaluate root development.

## RESULTS AND DISCUSSION

A summary of irrigation water management and alfalfa yield is shown in Table 2. Dry matter yield was significantly ($P < 0.05$) affected by alfalfa developmental stage and water levels, as well as by interactions between these factors. Reduction of water supply led to yield decrease, mainly in $S_2$ stage (011 and 010). The highest yield occurred in 011 treatment with 100% of water level (3.10 t DM/ha), and the lowest in 100 treatment (0.51 t DM/ha). Evidence of the high responsiveness of alfalfa to additional supply of water in $S_2$ stage is shown by the fact that even under the highest water deficit ($D_D$ = 20-25% of a sprinkler irrigation) alfalfa yield did not differ ($P<.05$) from treatments with 100% of irrigation ($D_A$). These results agree with 33 FAO bulletin (Doorenbos and Kassan, 1994), as well as with findings reported by Cunha et al. (1994), who worked under similar conditions and verified that alfalfa evapotranspiration changed from 1.7 mm (beginning of growth) to 7.1 mm/day (full vegetative stage).

The results of this study allow to conclude that responsiveness of alfalfa to water supplementation changes according to developmental stage of the plant, and that $S_2$ stage (full vegetative) was the most affected by water supply, while $S_1$ (initial vegetative) was the least one, where water was a negative factor to alfalfa establishment.


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Table 1 - Water distribution during alfalfa establishment.

| TRE | I L | Irrigation (mm) Stage 1 | Irrigation (mm) Stage 2 | Irrigation (mm) Stage 3 | Irrigation (mm) P E | Precipitation (mm) Stage 1 | Precipitation (mm) Stage 2 | Precipitation (mm) Stage 3 | Precipitation (mm) P E | Total water (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 111 | $D_A$ | 103,8 | 122,1 | 93,7 | 319,6 | 0 | 52,0 | 90,8 | 142,8 | 462,4 |
| | $D_B$ | 80,7 | 103,0 | 65,1 | 248,8 | 0 | 52,0 | 90,8 | 142,8 | 391,6 |
| | $D_C$ | 41,3 | 57,4 | 36,4 | 135,1 | 0 | 52,0 | 90,8 | 142,8 | 277,9 |
| | $D_D$ | 15,8 | 28,9 | 17,3 | 62,0 | 0 | 52,0 | 90,8 | 142,8 | 204,8 |
| 110 | $D_A$ | 85,0 | 113,4 | 0 | 198,4 | 0 | 52,0 | 0 | 52,0 | 250,4 |
| | $D_B$ | 62,2 | 106,7 | 0 | 168,9 | 0 | 52,0 | 0 | 52,0 | 220,9 |
| | $D_C$ | 37,0 | 76,9 | 0 | 113,9 | 0 | 52,0 | 0 | 52,0 | 165,9 |
| | $D_D$ | 19,5 | 46,4 | 0 | 65,9 | 0 | 52,0 | 0 | 52,0 | 117,9 |
| 100 | $D_A$ | 79,5 | 0 | 0 | 79,5 | 0 | 0 | 0 | 0 | 79,5 |
| | $D_B$ | 55,9 | 0 | 0 | 55,9 | 0 | 0 | 0 | 0 | 55,9 |
| | $D_C$ | 30,5 | 0 | 0 | 30,5 | 0 | 0 | 0 | 0 | 30,5 |
| | $D_D$ | 12,9 | 0 | 0 | 12,9 | 0 | 0 | 0 | 0 | 12,9 |
| 101 | $D_A$ | 73,1 | 0 | 84,7 | 157,8 | 0 | 0 | 90,8 | 90,8 | 248,6 |
| | $D_B$ | 60,5 | 0 | 70,0 | 130,5 | 0 | 0 | 90,8 | 90,8 | 221,3 |
| | $D_C$ | 35,2 | 0 | 39,6 | 74,8 | 0 | 0 | 90,8 | 90,8 | 165,6 |
| | $D_D$ | 19,4 | 0 | 13,9 | 33,3 | 0 | 0 | 90,8 | 90,8 | 124,1 |
| 001 | $D_A$ | 0 | 0 | 77,2 | 77,2 | 0 | 0 | 90,8 | 90,8 | 168,0 |
| | $D_B$ | 0 | 0 | 57,0 | 57,0 | 0 | 0 | 90,8 | 90,8 | 147,8 |
| | $D_C$ | 0 | 0 | 25,8 | 25,8 | 0 | 0 | 90,8 | 90,8 | 116,6 |
| | $D_D$ | 0 | 0 | 9,1 | 9,1 | 0 | 0 | 90,8 | 90,8 | 99,9 |
| 011 | $D_A$ | 0 | 152,0 | 82,7 | 234,7 | 0 | 52,0 | 90,8 | 142,8 | 377,5 |
| | $D_B$ | 0 | 126,0 | 67,8 | 193,8 | 0 | 52,0 | 90,8 | 142,8 | 336,6 |
| | $D_C$ | 0 | 87,5 | 38,6 | 126,1 | 0 | 52,0 | 90,8 | 142,8 | 268,9 |
| | $D_D$ | 0 | 35,0 | 15,6 | 50,6 | 0 | 52,0 | 90,8 | 142,8 | 193,4 |
| 010 | $D_A$ | 0 | 149,9 | 0 | 149,9 | 0 | 52,0 | 0 | 52,0 | 201,9 |
| | $D_B$ | 0 | 127,3 | 0 | 127,3 | 0 | 52,0 | 0 | 52,0 | 179,3 |
| | $D_C$ | 0 | 95,0 | 0 | 95,0 | 0 | 52,0 | 0 | 52,0 | 147,0 |
| | $D_D$ | 0 | 45,0 | 0 | 45,0 | 0 | 52,0 | 0 | 52,0 | 97,0 |
| 000* | | | | | | 0 | 52,0 | 90,8 | 142,8 | 142,8 |
| | | | | | | 0 | 52,0 | 90,8 | 142,8 | 142,8 |
| | | | | | | 0 | 52,0 | 90,8 | 142,8 | 142,8 |
| | | | | | | 0 | 52,0 | 90,8 | 142,8 | 142,8 |

TRE - treatments IL- irrigation levels PE – plant establishment
*Without Irrigation (control)

Table 2 - Irrigation water management and alfalfa yield

| Deficit | Experiments 111 | 110 | 100 | 101 | 001 | 011 | 010 | 000 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| $D_A$ | 1,64de | 1,51e | 1,18ghij | 1,27gh | 1,46ef | 3,10a | 1,62de | 1,11hijk | 1,61a |
| $D_B$ | 1,46ef | 1,22ghi | 0,95k | 1,18ghij | 1,59de | 2,90b | 1,76d | 0,98k | 1,50a |
| $D_C$ | 1,48ef | 1,13ghij | 0,72l | 1,02jk | 1,23ghi | 2,35c | 1,30fg | 1,11hijk | 1,29b |
| $D_D$ | 1,23ghi | 1,05ijk | 0,51m | 0,77l | 1,03jk | 1,52e | 1,07ijk | 1,18ghij | 1,04c |
| Mean | 1,45b | 1,23c | 0,84d | 1,06cd | 1,33bc | 2,47a | 1,44b | 1,09cd | 1,36 |

Means, with different letters are different (P< .05) by Tukey test.

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# Leaf elongation rate of mediterranean and temperate tall fescue cultivars under water deficit

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ABSTRACT
The leaf elongation rate of a temperate (*Festuca arundinacea* Schreb.) and a mediterranean (*F. arundinacea* var. *letourneuxiana*) tall fescue cultivar in response to water deficit was studied in a glasshouse experiment. Plants of both cultivars were grown in the same containers and received water daily with gradation in intensity of water deficit achieved by varying the daily water ration per container. Leaf