

SIZE MEASUREMENTS OF ALFALFA ROOT SYSTEM UNDER AGRICULTURAL TREATMENTS USING ELECTRIC CAPACITY

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ABSTRACT

The current study aimed at evaluation of Root system size (RSS) of alfalfa (*Medicago sativa* L.). Quantitative morphological characterization was done on two varieties (Hodonínka and Oslava). Two experimental locations were investigated. Two different cultivations spacing (50×50 and 25×25cm) were used. Size of root system was estimated by using electrical capacitance method, and the other agronomic characteristics such as fresh weight and height of the plant were determined. The results showed that the highest values at the 1st cut were achieved by Oslava (increasing 18% in RSS, 82.02 % in fresh weight), L2 (increasing 247.2% for RSS, 93.1% in plant height and 323.21% in fresh weight). Also for the 2nd cut the higher values were achieved by Oslava variety (increasing 3.92% for RSS, 20.17% in plant height and 43.40% for fresh weight), for the location Troubsko (increasing 102.07% in RSS, 31.77% in plant height and 43.40 % in fresh weight), for 50 x 50 cm row spacing (increasing 66.14% in RSS, 95.42 % in fresh weight) and for row spacing 25 x 25 cm (increasing 20.76% in plant height).

Key words: alfalfa, row spacing, root system size

INTRODUCTION

Alfalfa (*Medicago sativa L.*) is an important perennial forage legume crop throughout the world. Alfalfa is the most forage crop in the world. It can keep and restoring soil fertility, and for a low-input type of farming. It is often preferred for feeding ruminants, due to the high feed value, moreover, high forage yields, and drought resistance in areas (Russi *et al*, 1997) and (Dietz, 2003).

In a large part of the semiarid and arid regions like in the Yemen republic, alfalfa is the most important forage legume, and is grown for hay, and silage. (Mosanif, 2002).

Seedling emergence was usually higher in some varieties of alfalfa than others. On the other hand, all root traits were affected by plant spacing but no germplasm plant spacing interactions were found (Lamb *et al*, 2000).

Dalton (1995) studied nutrient solution using tomato (*Lycopersicon esculentum Mill.*) results showed a good correlation between plant root capacitance and root mass. Stage of development studies showed plant root capacitance measurements capable of detecting root development rate and suggested the method to be sensitive to root function. The size of root system of alfalfa can affect persistence, growth and forage yield (Chloupek *et al*, 1998).

Dostal *et al* (2009) measured the RSS of the barley during elongation, heading and grain filling. It was influenced by the location of the experiments (48-88%), by the variety (3-16%) and between 2-8% of the total variation was unexplained. Varieties with a greater RSS had a significantly higher yield in the dry year of 2007, which was characterized by a yield decrease of 18% for the four standard varieties in comparison to the other three years, at all 20 stations for both treatments ($r=0.480$ and 0.470 , respectively, $P<0.05$ for both).

Chloupek *et al* (2006) indicated that Root system size (RSS) was measured in field by its electrical capacity, which is suitable for plant breeding. Preliminary results showed that greater RSS of malting varieties was in dry and warm locations advantageous for yield level, overall for yield stability and for higher malt extract. However, the total malting quality was worse in lines with greater RSS.

Kupecsek and Molnarova (2009) studied that the RSC measurements in spring barley were done using the LCR – meter in growth stages of in the stage of four leaves, in full tillers, in the stage heading (BBCH 51) and at the stage of ripening. The results showed a positive correlation relationship between grain yield and fertilization ($r = 0.44^{***}$).

Material and Methods

Morphological investigation was performed on alfalfa on three characterizations namely; plant height, wet weight of the plant and the size of roots. Quantitative comparison was carried out on two different varieties of alfalfa; Hodonínka variety (Old Moravian variety from 1940. S-LV from Moravia / Grimmova Vojteska) Gene Bank from Prague and Oslava (Agrogen Spol. s.r.o.). Sampling was done on 240 plants collected from two different locations, the first site was from the Field Research Station in Žabčice (Faculty Agronomy Mendel University in Brno), and the second site was the Experimental Station of The Research Institute for Fodder Crops Ltd. (Troubsko) During two successive mowing seasons 2008/2009 and 2009/2010. Alfalfa seeds were prepared for the germination by scoured to each other with rubbing surface. Germination process was carried out in four petri dishes. Each dish contains 200 seeds. Activation of germination continued for 48 hr. Newly germinated seedlings were transferred and transplanted in Peat moss cultivation plastic boxes 60x40x5 cm. Six weeks seedlings were transplanted on two different spacing distances as the following (50x50 cm and 25x25 cm).

The root system size was measured with ELC-131D LCR Meter at measuring frequency of 1 kHz in units of nf (nanofarad). Previous investigations indicated this as the optimum operating frequency for Alfalfa root system measurements. Electrical contact with the plant was established by connecting the negative electrode to the alfalfa stem via a battery clamp at 6 cm above ground level. The positive electrode was connected via a battery clamp to a copper ground rod 25 cm in length inserted into the soil positioned 5 cm away from the stem base.

The experiment was planted in April 25, 2008 after planting the seed in green house. The first and second cut was in May 14, August, 2009 respectively. Plant height, fresh weight of plant leaves and stems: at beginning of flowering, dry weight was determined after drying at 75° C for 48 hours.

Statistical analysis:

The collected data of each experiment were subjected to the proper statistical analysis of variance according to Snedecor and Cochran (1967) using the Computer and SAS program. L.S.D at 0.05 level of significance was used for comparing between means.

RESULTS AND DISCUSSION

Data recorded at cutting

Data presented in Tables (1-2) summarized alfalfa root system size, plant height and forage yields (fresh weight) recorded at each of 2 cuts as affected by the grown alfalfa variety, row spacing's, location and their interactions.

1st cut

Size of root system ,plant height and fresh weight of plant leaves and stems of alfalfa at the 1st cut as affected by varietal differences, location and row spacing's and their interactions are shown in Tables (1).

Table (1). *Alfalfa RSS, plant height, forage yields (fresh weight) of the 1st cut as affected by varieties (V), location (L), row spacing's (S), and their interactions.*

Characters		RSS		Mean	Plant height(cm)		Mean	Fresh weight		Mean
Variable		S1(50x50)	S2(25x25)		S1(50x50)	S2(25x25)		S1(50x50)	S2(25x25)	
V1	L1	0.698	0.322	0.510	60.00	48.00	55.00	0.096	0.028	0.062
	L2	1.752	1.470	1.611	95.00	106.00	101.00	0.248	0.150	0.199
Mean		1.225	0.896	1.061	78.00	78.00	78.00	0.172	0.172	0.089
V2	L1	0.728	0.320	0.524	51.00	49.00	50.00	0.070	0.028	0.049
	L2	2.494	1.464	1.979	104.00	99.00	102.00	0.414	0.136	0.275
Mean		1.611	0.892	1.252	78.00	74.00	76.00	0.242	0.082	0.162
L1		0.713	0.321	0.517	56.00	49.00	53.00	0.083	0.028	0.056
L2		2.123	1.467	1.795	100.00	103.00	101.00	0.331	0.143	0.237
Mean		1.418	0.894	1.156	78.00	76.00	77.00	0.207	0.086	0.146
LSD , 0.05 for:										
V		0.0788			V	3.038		V	0.02323	
L		0.0788			L	3.038		L	0.02323	
S		0.0788			S	3.038		S	0.02323	
V×L		0.1114			V×L	4.296		V×L	0.03285	
V×S		0.1114			V×S	4.296		V×S	0.03285	
L×S		0.1114			L×S	4.296		L×S	0.03285	
V×L×S		0.1575			V×L×S	6.076		V×L×S	0.04645	

* L1: Žabčice, L2: Troubsko, V1: Hodonínka and V2: Oslava.

1- Varietal differences:

Plants of Hodonínka variety were smaller in RSS than Oslava variety and lighter in fresh weight at first cut (Table, 1). As a result of increasing root system size and the subsequent forage (fresh) yields of Oslava markedly surpassed of Hodonínka (by 18% in RSS, 82.02 % in fresh yield) while there was no significant difference of plant height between varieties. **Nanjundappa et al (1998)**

and Drobna (1999) recorded marked differences among alfalfa varieties in plant height. Differences among alfalfa varieties were detected in plant weight and regrowth intensity (**Drobna, 1999**). Inter varieties differences were recorded throughout the world with respect to alfalfa productivity either for fresh and/or dry forage yields (**Pelikan, 1996; Patel et al, 1990 and Bahrani, 1990**).

2- Effects of row spacing:

Between spacing showed significant increase in alfalfa RSS where reached to 58.61% in RSS as well as forage yields (fresh weight) was increased with the spacing in the distance between rows. This increase was higher with the application of 50x50cm- spaced rows where reached to 140.7 % in fresh yield, than 25x25cm which has not a significant effect in plant height. Alfalfa plant height was not affected by the row spacing's of 15, 20, 30, or 40 cm as concluded by **Bollettini et al (1997)**. High vigorous varieties at high population density may be responsible for gaining higher yields. . It could be mentioned that although weight of alfalfa plant is increased with the increase in row spacing, but it was not enough to compensate the reduction in plant number (stand) per unit area in thin planting.

3- Effects of location:

There was a significant increasing in RSS of alfalfa, plant height and the subsequent forage (fresh weight) yields for both varieties in Troubsko location than Žabčice location markedly surpassed (by 247.2% between locations in RSS, 94.00 % between locations in plant height and 323.21% between locations in fresh weight).

4- Interaction effects:

The highest values at the 1st cut were achieved by Oslava × Troubsko × (50×50 cm) 2.494 nf in RSS, Hodonínka × Troubsko × (25×25cm) 106.00 cm in plant height, Oslava × Troubsko × (50×50 cm) 0.414 kg in fresh weight, Oslava × (50×50 cm) 1.611 nf in RSS, Hodonínka × (50×50 cm) 78.00 cm in plant height, Oslava × (50×50 cm) 0.242 kg in fresh weight, Oslava × Troubsko 1.979 nf in RSS, 102.00 cm in plant height and 0.275 kg. in fresh weight respectively, Troubsko × (50×50 cm) 2.123nf in RSS, Troubsko × (25×25cm) 102.835cm in plant height and Troubsko × (50×50 cm) 0.331kg. In fresh weight

2nd cut

Data of RSS, plant height and fresh weight of alfalfa at the 2nd cut as affected by varietal differences, location, row spacing and their interactions are allocated in Tables (2).

Table (2). *Alfalfa RSS, plant height, forage yields (fresh weight) of the 2nd cut as affected by varieties (V), location (L), row spacing's (S), and their interactions.*

Characters		RSS		Mean	Plant height(cm)		Mean	Green weight		Mean
Variable		S1(50x50)	S2(25x25)		S1(50x50)	S2(25x25)		S1(50x50)	S2(25x25)	
V1	L1	1.74	1.238	1.489	67.00	70.00	69.00	0.161	0.066	0.113
	L2	3.858	2.336	3.097	58.00	111.00	84.00	0.204	0.206	0.205
Mean		2.799	1.787	2.293	63.00	90.00	76.00	0.183	0.136	0.159
V2	L1	1.894	1.32	1.607	72.00	74.00	73.00	0.218	0.074	0.146
	L2	4.184	2.132	3.158	100.00	104.00	102.00	0.440	0.180	0.310
Mean		3.039	1.726	2.383	87.00	89.00	88.	0.329	0.127	0.228
LSD , 0.05 for:										
L1		1.817	1.279	1.548	69.00	72.00	71.00	0.190	0.070	0.130
L2		4.021	2.234	3.128	79.00	108.00	93.00	0.322	0.193	0.258
Mean		2.919	1.757	2.338	74.00	90.00	82.00	0.256	0.131	0.194
V		0.1143			V	3.281		V	0.01704	
L		0.1143			L	3.281		L	0.01704	
S		0.1143			S	3.281		S	0.01704	
V*L		0.1617			V*L	4.639		V*L	0.02410	
V*S		0.1617			V*S	4.639		V*S	0.02410	
L*S		0.1617			L*S	4.639		L*S	0.02410	
V*L*S		0.2287			V*L*S	6.561		V*L*S	0.03408	

* **L1:** Žabčice, **L2:** Troubsko, **V1:** Hodonínka and **V2:** Oslava

1- Varietal differences:

Oslava variety has superiority than Hodonínka variety reached to 15.79 % in plant height and 43.40 % in fresh weight at the second cut while there was no significant different at RSS between varieties.

2- Effect of row spacing:

RSS and fresh weight were significantly improved by spacing the row distance. The increases achieved due to increase the distance between rows from 25 to 50 cm were 66.14 % in RSS, 95.42 % in fresh weight and increase in plant height 20.00 % between S2 and S1 in the 2nd cut.

3- Effect of location:

Root size system, plant height and fresh weight of alfalfa were affected by site where Troubsko site excelled Žabčice site (102.07 % in RSS), (31.00 % in plant height) and (98.46 % in fresh weight) respectively at the 2nd cut.

4- Interaction effects:

The highest values at the 2nd cut were achieved by Oslava × Troubsko × (50×50 cm) 4.184 nf in RSS, Hodonínka × Troubsko × (25×25cm) 111.00 cm in plant height, Oslava × Troubsko × (50×50 cm) 0.440 kg in fresh weight, Oslava × (50×50 cm) 3.039 nf in RSS, Hodonínka × (25×25cm) 90.00 cm in plant height, Oslava × (50×50 cm) 0.329 in fresh weight, Oslava × Troubsko 3.158 in RSS, 102.8 cm in plant height and 0.310 kg. In fresh weight respectively, Troubsko × (50×50 cm) 4.021 in RSS, Troubsko × (25×25cm) 107.00 cm in plant height and Troubsko × (50×50 cm) 0.322 kg in fresh weight.

CONCLUSION

Oslava variety revealed the higher value in RSS 1.252 nf and fresh weight 0.162 kg at the 1st cut while there was no significant difference in height of the plant between varieties.

The 50×50cm row spacing recorded at the 1st cut the higher value in RSS 1.418 nf and 0.207kg in fresh weight while there was no significant difference in height of plant between row spacing. The high value recorded at the 1st cut in RSS (1.795 nf), plant height (101cm) and fresh weight (0.237kg) respectively in site Troubsko. Lower RSS and green weight were obtained from variety Hodonínka, being 1.061 nf, 0.089kg respectively for one plant.

For the 2nd cut the Oslava variety (*Medicago sativa* L.) indicated also the higher value 2.383 in RSS, 88.00 cm in plant height and 0.228kg in fresh weight.

The location Troubsko presented significant effect at location Žabčice (increase 3.128 in RSS, 94.00cm in height plant and 0.285kg in fresh weight).

The 50×50cm row spacing showed the higher value 2.919 in RSS and 0.256 in fresh weight, while the 25×25 cm row spacing gave the higher value in plant height (90.00 cm).

Measurement of root capacitance with hand-held meters provided a good assessment of root fresh mass for alfalfa plants grown in field conditions. Measure the size of root system using electric capacity as a method be particularly useful in the alfalfa plant although this method of measurement to the size of the root is a relative.

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