Root biomass of 18 alfalfa (*Medicago sativa* L.) cultivars in two different environments under organic management

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Abstract
Eighteen Iranian and European alfalfa (*Medicago sativa* L.) genotypes were assessed for root biomass production in two separate organically managed fields, namely irrigated and rain-fed trials. The cultivar effect was highly significant ($P < 0.001$) for root biomass (t ha^{-1}) and root mass density (mg cm^{-3}). Drought stress conditions reduced similarly root biomass and root mass density in the rain-fed experiment by 19.6 %. With regard to the averaged mean root biomass over two locations, Shorakat (9.26 t ha-1), Gharghologh (8.71 t ha-1), NS-Banat (8.29 t ha-1) and Vlasta (8.13 t ha-1) were the best genotypes.

Key word: Lucerne, Organic farming, Root biomass, Root mass density

Introduction
Roots play an important role in maintaining water and nutrient supply to plant tissues, and they also contribute in the maintenance of soil organic matter content and structure (Pietola and Alakukku, 2005), especially in low input farming systems such as organic farming. Alfalfa is a perennial legume with a very deep root system and forms the basis of many rotation systems in organic and low-input farming as it provides the nitrogen (N) necessary for following non-legume crops. This study was carried out to assess root biomass production and effect of drought stress on it in 18 Iranian and European alfalfa genotypes.

Materials and Method
The root biomass of 8 Iranian alfalfa ecotypes and 10 European cultivars was tested at two different organically managed fields, Gross Enzersdorf (irrigated) and Raasdorf (rain-fed) of the BOKU University, Vienna, Austria in September 2007. The field plots, in both experiments, were laid out in an α-lattice design with two replicates and three incomplete blocks in each replicate. In the irrigated trial, soil moisture was kept at field capacity with drip irrigation, whereas the only water source for Raasdorf (rain-fed) field was rainfall. Root biomass (t ha^{-1}) was determined by auger method with 9.1 cm diameter (Gregory, 2006, pp 45-52). Two samples were taken in each plot till 30 cm depth. After washing (0.75 mm mesh size of the sieve), fresh roots were dried at 60 °C for 48 h and their biomass values were converted to tons per hectare for each plot. Root mass density (mg m^{-3}) was calculated as dry matter of root per unit volume of soil in each plot. A combined analysis of variance was done by PROC MIXED in SAS software (SAS Institute, 2004), where location and cultivar were considered as fixed and incomplete block in replicate as random factors.

Results and Discussion
Total applied water in irrigated and rain-fed trial was 623.4 and 482.2 mm, respectively. Location (irrigation and rain-fed) effect on root biomass and mass density was significant ($P<0.05$) (data not shown). Water stress conditions in the rain-fed trial reduced root biomass and consequently root mass density of cultivars by about 19.6 % (Table 1). Highly significant effects ($P<0.001$)

were found for genotype and genotype by location interaction effects for both characters, indicating genetic variation among tested genotypes and different responses of genotypes to environmental changes. In irrigated conditions, the highest root biomass was produced by NS-Banat (10.58 t ha^{-1}), Ghargholoh (9.74 t ha^{-1}), Shorakat (9.70 t ha^{-1}) and Ordobad (9.40 t ha^{-1}) (Table.1). In rain-fed conditions, Vlasta (9.51 t ha^{-1}) and Shorakat (8.83 t ha^{-1}) reached the highest root biomass. Strong root development is a characteristic of lucerne cultivars adapted to dryland conditions (Guo *et al*., 2002). With regard to the average root biomass over two locations, Shorakat (9.26 t ha^{-1}), Gharghologh (8.71 t ha^{-1}), NS-Banat (8.29 t ha^{-1}) and Vlasta (8.13 t ha^{-1}) were the best genotypes. Despite of some irrigation, Iranian ecotypes were naturally selected under dry conditions. As a result, their root biomass on the average was higher than that of European cultivars (Tables 1).

Table 1. Mean of dry matter and mass density of root for tested genotypes.

Cultivar	Root DM (t ha^{-1}) IR		RN		Average		Root Mass density(mg/cm^3) IR		RN		Average	
Mohajeran	7.04	bc	5.53	ab	6.28	ac	1.81	bc	1.42	ab	1.61	ac
Khorvande	8.57	bc	5.07	ab	6.82	ac	2.20	bc	1.30	ab	1.75	ac
Famenin	7.53	bc	4.42	ab	5.97	ac	1.93	bc	1.13	ab	1.53	ac
Gharghologh	9.74	ac	7.67	ab	8.71	c	2.50	ac	1.97	ab	2.23	c
Ordobad	9.40	bc	5.73	ab	7.56	ac	2.41	bc	1.47	ab	1.94	ac
Shorakat	9.70	ac	8.83	ab	9.26	c	2.49	ac	2.26	ab	2.37	c
Ghara-aghaj	7.01	bc	6.83	ab	6.92	ac	1.79	bc	1.75	ab	1.77	ac
Hokm-abad	8.37	bc	7.48	ab	7.93	bc	2.15	bc	1.92	ab	2.03	bc
Sitel	5.30	ab	4.56	ab	4.93	ab	1.36	ab	1.17	ab	1.26	ab
Verko	8.87	bc	4.07	a	6.47	ac	2.28	bc	1.05	a	1.66	ac
Vlasta	6.75	bc	9.51	b	8.13	bc	1.73	bc	2.44	b	2.08	bc
Monz 42	6.27	bc	6.05	ab	6.16	ac	1.61	bc	1.55	ab	1.58	ac
Fix 232	8.90	bc	3.98	a	6.44	ac	2.28	bc	1.02	a	1.65	ac
NS_Banat	10.58	c	5.99	ab	8.29	c	2.71	c	1.53	ab	2.12	c
Sanditi	4.81	ab	5.34	ab	5.07	ab	1.23	ab	1.37	ab	1.30	ab
Alpha	4.52	ab	3.86	a	4.19	a	1.15	ab	0.99	a	1.07	a
Plato ZS	5.11	bc	6.94	ab	6.03	ac	1.31	bc	1.78	ab	1.55	ac
Niva	3.95	b	4.72	ab	4.34	a	1.01	b	1.21	ab	1.11	a
Mean	7.36		5.92		6.64		1.89		1.52		1.70	
SE		0.89			0.63			0.23			0.16	

IR= Irrigated; RN= Rain-fed; SE= Standard error of mean; Means with the same letter do not differ significantly; Mean comparisons were done by adjusted LSD at 0.05 probability level, separately for each column.

References

-Gregory P. J. 2006. Plant roots: their growth, activity, and interaction with soils. Blackwell Publishing Ltd. 381 pages.
-Guo Z. G., H. X. Liu, Y. R. Wang, S. M. Wang, and G. D. Cheng. 2004. Suitability of Lucerne cultivars, with respect to root development, to semi-arid conditions in west China. New Zealand Journal of Agricultural Research, Vol. 47: 51-59.
-Pietola L. and L. Alakukku. 2005. Root growth dynamics and biomass input by Nordic annual field crops. Agriculture, Ecosystems and Environment. doi:10.1016/j.agee.
-SAS Institute. 2004. SAS/STAT User’s Guide. SAS Inst. , Cary, NC.