New oilseed crops

Survey of Root Trait Variation in Lesquerella (*Physaria fendleri*) and Analysis of Response to Temperature Treatments

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Abstract

Manipulating plant root systems is believed very important to optimize plant growth and productivity. In addition to above ground morphological characters, roots directly influence the capacity of plants in utilizing available water and soil nutrients. Elucidating root system architecture and its corresponding trait inheritance have been the focus of numerous research studies in model plant species and commodity crops. In this study, we investigated the root system architecture of the new oilseed crop *Physaria fendleri* (syn. *Lesquerella fendleri*) to gather information on the available variability in the taxon. A limited set of eighteen *P. fendleri* accessions were grown in seed germination pouches for 21 days under two temperature regimens (21/13°C and at 30/21°C) that were previously found optimal for maximum plant productivity in the field. The seedlings were screened for eleven parameters pertaining to the main and lateral roots, as well as the designated growth regions. The results showed that a substantial variation exists in total root size in the taxon and that the trait has significant positive correlation to five other root parameters. Significant difference was observed only on root apical length, total root size, and average root diameter between the temperature treatments. This is the first report of root variation screening in *Physaria* and it provides information for future experiments aiming to understand the physiology and genetics of these traits in the crop.

Introduction

Physaria are herbaceous crucifers (Brassicaceae) with member species that has been identified as a promising new oilseed crop for the arid regions of the U.S. Southwest. To support ongoing breeding and cultivar development, *Physaria* germplasm collections have been established by the U.S. Department of Agriculture starting in the 1960's and later expanded through several collecting missions in the U.S. Southwest and in Mexico during the 1990's. Characterization of the lesquerella plant genetic resources collections have mostly focused on the oil content and above- ground parts. There has been no prior information about the root morphological variation in the species, nor reports about corresponding responses of lesquerella root systems to environmental stresses. We seek to determine this in the study to explore available root diversity in a limited set of germplasm as well as to get insight on root responses to temperature regimens that were previously found to significantly affect yield and seed production. Understanding key root traits are considered very important in helping increase productivity of plants especially in being able to utilize environments with poor growing conditions and under limited resources. It has been postulated that by modifying the root morphology and architecture of plants, there could be significant increases in their ability for nutrient and water uptake resulting to greater productivity. In the long term, we hope to make available germplasm root trait characterization data in the GRIN database.

Methodology

Seeds of 18 accessions were germinated in cyg™ Seed Germination Pouches (16.5x17.5 cm) and observed for 21 days after planting (DAP). Four seeds of each accession were transferred to a germination pouch with three pouches per replicate and three replicates per treatment of each accession. The pouches were filled with 15ml of distilled water and were positioned vertically inside hanging file folders suspended in racks and placed in growth chambers set at 21/13°C and another at 30/21°C, both with fluorescent light (2738 lux) during the high temperature cycle. The two alternating temperature settings were chosen as these have been reported by Dierig and Crafts-Brandner (2011) to have significantly affected branching, reproductive development and silique production in lesquerella and 21/13°C as more conducive for productivity. The pouches were checked regularly and topped with distilled water when the top of the pouches are drying.

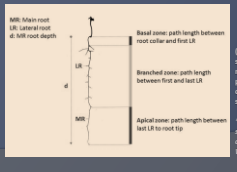
Lesquerella seedlings at 14DAP in growth pouches.

Passport information of *Physaria* accessions studied

Accession	Collection no.	Source	Latitude (N)	Longitude (W)	Elevation (m)
W6 20822	1809	AZ, USA	31.76	-110.06	134
W6 20858	1840	NM, USA	32.62	-104.40	1043
W6 20859	2297	TX, USA	30.28	-104.02	1463
PI 596434	1933	AZ, USA	33.27	-110.32	811
PI 596452	2277	TX, USA	29.78	-103.18	853
PI 596453	2278	TX, USA	30.20	-103.20	1311
PI 596454	2281	TX, USA	30.93	-101.87	640
PI 596455	2282	TX, USA	30.97	-101.97	549
PI 596456	2286	TX, USA	32.32	-102.50	808
PI 596457	2290	TX, USA	31.78	-103.27	853
PI 596458	2291	TX, USA	31.12	-103.72	945
PI 596459	2292	TX, USA	31.02	-103.73	1006
PI 596464	2299	TX, USA	30.15	-104.08	1402
PI 596466	2301	TX, USA	30.27	-103.90	1433
PI 641922	4006	COA, Mexico	28.88	-100.61	305
PI 641923	4007	COA, Mexico	28.61	-100.50	911
PI 293010	19233	TX, USA	31.67	-102.71	876
WCL-LO4	Gail	AZ, USA	-	-	-

*Source: ARS-GRIN (2012) (http://www.ars-grin.gov)

The pouches were opened at the end of the experiment and the lesquerella roots scanned at 600 dpi resolution. Root measurements were obtained using EZ-Rhizo software v.1 and WinRhizo Pro v. 2012b. The straightness and angle of the main and lateral roots were not measured since the plants were taken off the pouch to obtain better contrast during imaging. The data were analyzed using JMP v.9.

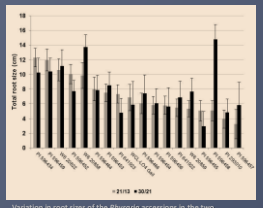


(left) EZ-Rhizo software root measurement parameters illustrated on a lesquerella seedling.

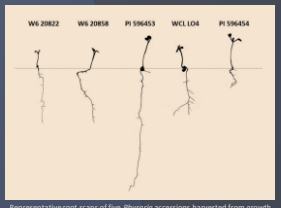
**Root diameter and surface area were obtained using WinRhizo.*

Results

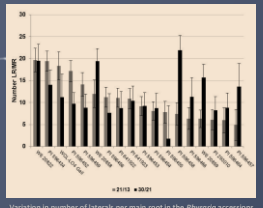
Substantial root variation was observed in *Physaria* seedlings after 21 days in the germination pouches. The average total root system size (based on measured path length) was 7.6cm. Among the accessions, W6 20858 had the biggest root system (12.1cm), followed by three more accessions with greater than 10cm values – PI 596434 (11.63cm), PI 596459 (11.6cm), and W6 20822 (10.8cm). The smallest root system was observed in PI 59647 (4.1cm). The number of accessions that have root systems that is above the average is about equal to the number of those with below the average value. The advance breeding line WCL-LO4 'Gail' had total root system size that was lower than average (6.6cm) in this set of accessions.



Variation in root sizes of the *Physaria* accessions in the two temperature treatments. Values shown are means and s.e.



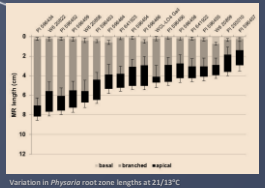
Representative root scans of five *Physaria* accessions harvested from growth pouches.



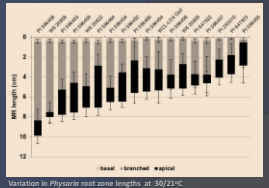
Variation in number of laterals per main root in the *Physaria* accessions grown in pouches. Values shown are means and s.e.

Only three root parameters were found to significantly differ between the temperature regimens. The average total root size was smaller (7.1cm) at 21/13°C than at 30/21°C (8.5cm). Eight *Physaria* accessions have larger average total root size when grown at 21/13°C, while ten accessions at 30/21°C. The length of apical zone was significantly longer at 30/21°C (2.1cm) than 21/13°C (1.5cm).

The average root diameter (0.23mm) observed on plants grown at 21/13°C was found significantly larger compared to those at 30/21°C (0.19mm). The average root surface area was determined to be equal on both temperature treatments at 0.42cm². No significant difference among the other eight root parameters was observed between temperature treatments.



Variation in *Physaria* root zone lengths at 21/13°C



Variation in *Physaria* root zone lengths at 30/21°C

We're still examining whether significant differences among shoot parameters exist. This will validate if the tissue level observation is independent of plant growth and development stage. Root phenotyping under water stressed condition is likewise ongoing.

Correlation among root variables measured by EZ-Rhizo (bold values indicate significance at alpha=0.05

Parameter	MR path length	Number LR/MR	LR path length	LR density/MR	Basal zone length	Branched zone length	Apical zone length	LR density/bz	Total root size
MR path length	1	**0.667**	**0.649**	-0.213	0.216	**0.909**	0.261	-0.441	**0.954**
Number LR/MR	**0.667**	1	0.464	**0.510**	-0.197	**0.829**	-0.311	-0.309	**0.754**
LR path length	**0.649**	0.464	1	-0.091	0.385	**0.580**	0.136	**-0.504**	**0.787**
LR density/MR	-0.213	**0.510**	-0.091	1	**-0.592**	0.127	**-0.739**	0.133	-0.038
Basal zone length	0.216	-0.197	0.385	**-0.592**	1	-0.001	0.336	**-0.531**	0.197
Branched zone length	**0.909**	**0.829**	**0.580**	0.127	-0.001	1	-0.157	-0.405	**0.941**
Apical zone length	0.261	-0.311	0.136	**-0.739**	0.336	-0.157	1	-0.003	0.063
LR density/bazal zone	-0.441	-0.309	**-0.504**	0.133	**-0.531**	-0.405	-0.003	1	**-0.491**
Total root size	**0.954**	**0.754**	**0.787**	-0.038	0.197	**0.941**	0.063	**-0.491**	1

UID: 74363
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