TECHNICAL NOTE

In situ root distribution of *Echinacea angustifolia*

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Bantle, M.R.L., Crowe, T.G. and Carrier, D.J. 2001. **In situ root distribution of *Echinacea angustifolia***. Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **43**: 2.29-2.31. The vertical distributions of 2-year-old and 3-year-old roots of *Echinacea angustifolia* were studied at 2 different sites, with soils that included silt clay, clay loam, and sandy loam. The excavations of the three-year-old plants indicated that 64, 78, and 92% of the roots in the top 540 mm were within the top 270, 360, and 450 mm of soil, respectively. Data relevant to the two-year-old plants indicated that 90% of the available roots were collected using a digging depth of 270 mm.

La distribution verticale des racines de plants d' *Echinacea angustifolia* de 2 et 3 ans fut étudiée à 2 sites différents dont les sols étaient composés d'argile silteuse, de loam argileux et de loam sableux. On a constaté chez les plants de 3 ans que 64, 78 et 92% des racines dans les premiers 540 mm étaient respectivement localisées dans les premiers 270, 360 et 450 mm de sol. Pour ce qui est des plants de 2 ans, on retrouvait 90% des racines dans les premiers 270 mm.

INTRODUCTION

Herbal medicines are widely used in Europe. As an example, 80% of German physicians regularly prescribe herbal medications (Rawls 1996). Recently in North America, the interest and sales of herbal remedies have grown dramatically, and in 1995, Echinacea was the best-selling herbal medicine in the USA, claiming 10% of the market (Rawls 1996).

Echinacea angustifolia grows naturally in southeast Saskatchewan (Foster 1991), preferring dry areas with marginal soil conditions. However, natural production is unable to meet consumer demand, and commercial cultivation of *E. angustifolia* is the only viable method of production. Li (1998) has undertaken some investigations regarding cultivation of Echinacea, including *E. angustifolia*, in British Columbia, and researchers at the Crop Diversification Centre South, Brooks, Alberta have been conducting similar studies on the prairies (Personal communication: L. Russell, 1999, Special Crops Technologist, 209 P. Duncan Hargrave Building, Brooks, Alberta, T1R 1E6). Nevertheless, these research programs largely focused on agronomic studies, and little information is available regarding cultivation and harvesting of *E. angustifolia*. A key ingredient in the development of a harvesting system for *E. angustifolia* roots would be a sound understanding of the orientation of the plants' roots, within its growing environment. Thus the objective of this project was to investigate the in situ vertical distributions of *E. angustifolia* roots. The age of the plant (two- and three-year-old plants), propagation technique (transplants and direct-seeded plants), and soil type (clay loam, silt clay, sandy loam and loam soil) were factors of interest in this study.

MATERIALS and METHODS

Manual digs were conducted at two Saskatchewan farms, one (site H) located near Hearne (50.1ºN, 105.2ºW), the other (site S) immediately west of Saskatoon (52.2ºN, 106.8ºW). The digs were conducted on October 19-21, 1999 under dry conditions at site H, and on November 04, 1999, under very wet conditions at site S. Both two-year-old and three-year-old plants were excavated at site H, while only three-year-old plants were studied at site S.

The row spacing varied between 1000 mm and 1800 mm at site H. The spacing of plants within the rows varied from 75 mm to 150 mm for the transplanted plants, while the directed-seeded plants were 19 mm apart at the locations where manual digs were performed. Paired rows, 150 mm apart, spaced 810 mm on center were used at site S. The plants within the rows were also 150 mm apart, directly opposite plants in the adjacent row.

Prior to starting each excavation, a sample of soil from within 90 mm of the surface was collected and stored for subsequent particle size analysis, using a modified pipette procedure (Indorante et al. 1990). The excavation site included a rectangular area, 850 mm by 300 mm, with the 850-mm sides oriented perpendicular to the row (or pair of rows) and centred on the row (or pair of rows). Using shovels and other manual digging tools, the soil was excavated around the perimeter of the rectangular area, leaving a block of soil slightly larger than 850 mm by 300 mm and 540 mm high in three-year-old plants and 360 mm high in two-year-old plants.

A wooden frame, constructed from 38-mm by 90-mm lumber served as a guide, and a knife was used to shave the top 90 mm of the block to exactly 850 mm by 300 mm. This 90-mm slab was then removed in pieces, and root fragments were sifted from the soil, using a wire mesh screen with 11-mm square openings. The root fragments in each 90-mm layer were packaged separately and stored frozen for subsequent analysis. In three-year-old plants, five additional 90-mm slabs of soil were removed, while three additional slabs were removed for

Table 1. Distribution of root mass for three-year-old plants of *E. angustifolia*.

Site*-Soil class	Soil composition			Portion of total dry root collected to a depth of					Total dry root to 540 mm (g)
	Sand (%)	Clay (%)	Silt (%)	90 mm (%)	180 mm (%)	270 mm (%)	360 mm (%)	450 mm (%)	
H-silt clay	17	41	42	37	62	76	82	92	101.8
H-clay loam	26	31	43	20	45	64	81	92	84.2
H-sandy loam	76	9	15	13	36	59	82	93	144.7
H-sandy loam	71	7	22	21	52	66	78	90	112.2
S-loam	46	13	41	19	39	57	71	92	70.6
S-loam	40	23	37	21	39	60	76	94	102.2

*Site H was near Hearne, SK; site S was near Saskatoon, SK.
All sites included plants that were propogated as transplants.

Table 2. Distribution of root mass for two-year-old plants of *E. angustifolia*, near Hearne, SK.

Soil class	Planting method	Soil composition			Portion of total dry root collected to a depth of			Total dry root to 360 mm (g)
		Sand (%)	Clay (%)	Silt (%)	90 mm (%)	180 mm (%)	270 mm (%)	
Sandy	Transplant	68	8	24	51	72	91	26.5
Sandy	Transplant	62	12	26	30	64	89	39.1
Sandy	Direct seeded	77	14	9	39	71	86	61.3
Sandy	Direct seeded	74	10	16	22	79	92	72.3

two-year-old plants. In all excavations, no roots passed through the narrow plane of the block of soil (between adjacent rows). Thus, the mass of roots collected was attributed to 300 mm of length of the row(s).

Approximately one month after the excavations, the root samples were thawed, gently hand-washed, blotted dry using paper towels and weighed (Model PC2000, Mettler, Zurich, Switzerland) prior to being refrozen. After the roots had been refrozen, they were plunged into liquid nitrogen and placed in a freeze drier (Freezone 4.5 Model 77500, Labconco, Kansas City, MO) for 72 hours. The dry mass of roots within each frame was then recorded.

RESULTS and DISCUSSION

Soil class information in Tables 1 and 2 was based on the U.S. Department of Agriculture system (Hausenbuiller 1978). Excavations at site H had silt clay and clay loam soils, while all other samples collected at site H were classified as sandy loam. Loam soil was present at site S.

Table 1 lists the accumulated mass of roots collected from the manual digs in three-year-old plants. The total dry root to 540-mm depth was the total dry mass of roots collected for the manual dig. The average total dry mass was 102.6 grams, with less than 8% of this total collected in the lowest 90 mm. The roots of three-year-old plants extended below 540 mm, however these roots were small in diameter, with few laterals. The incremental quantity of root recovered decreased as a function of depth, at lower levels.

Table 2 lists the accumulated mass of roots collected from the manual digs in two-year-old plants, with the total dry root to 360-mm depth representing the total mass of roots collected for each manual dig. The average production from 2-year-old plants was 49.8 g, with a relatively low average (32.8 g) for the transplanted crop and a much higher average (66.8 g) for the direct-seeded plants.

Wahab (2000) reported that under dryland conditions (similar to sites H and S) the highest root yield was 2089 kg/ha for a seeding rate of 180 seeds/m^2. Using a mean row spacing of 1400 mm at site H, the root yield to the extreme depth of excavations (540 mm), was approximately 2600 kg/ha. Notably, the higher plant density (paired rows on 810-mm centers) at site S yielded approximately 3600 kg/ha, although the collected masses were relatively smaller (Table 1).

CONCLUSIONS

Results from manual digs indicated that on average, 64, 78, and 92% of three-year-old roots in the top 540 mm of soil were within 270, 360, and 450 mm of the surface, respectively. Small roots with few laterals extended below 540 mm in depth.

Similarly, 72 and 90% of two-year-old roots in the top 360 mm of soil were within 180 and 270 mm of the surface, respectively. The roots beyond the 360-mm level were very small, suggesting that the roots do not proceed much below this mark after 2 years of growth.

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