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The Root-System Distribution Patterns For Five Oat Varieties[1]

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Abstract. Dry weights of the root systems of 5 oat varieties were determined at 4-inch intervals to a maximum depth of 24 inches. The varieties produced a differential distribution of root dry weight at the various depths sampled. Over 60 percent of the root dry weights of the Corn Belt varieties, Clinton. Marion, and Andrew, was in the upper 4 inches of soil, whereas comparable values for Craigs-afterlea and A465 were 50 percent and 35 percent, respectively. The root dry weight to a depth of 24 inches was the same at the boot stage as at maturity.

Roots of plants have not been studied as extensively as aboveground parts, especially as related to genetic differences. Derick and Hamilton (1942) found the different crown and shallow root types among oat varieties, and Caffrey and Carroll (1938) related differences in root development of oat varieties to lodging resistance. These workers concluded that the root-type characteristics were controlled by genetic factors and that segregation for root type occurred. Both lodging and drought-resistance characteristics may be related to type of root system.

The present study was designed to determine whether root systems of oat varieties were differentially distributed in the vertical soil plane. The extent of the root-system development was determined by dry-weight analyses.

Materials and Methods

For the present study, 5 oat varieties—Marion, Andrew, Clinton, Craigs-afterlea, and A465[3]—were sown on April 24, 1959, at the agronomy farm at Ames, Iowa. They were sown at the rate of 3 bushels per acre in a split-plot design with 3 replications. Harvest stages and varieties occupied the large and split plots, respectively. The subplot size was 4 rows, each 8 feet long with a 1-foot spacing between rows. Ten days after planting, a 2-foot section in each of the center 2 rows in a plot was marked with pot labels and thinned to 50 seedlings. These row sections were used as the subsequent root-sampling sites. The root samples were taken from each variety

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[3]A short oat strain obtained from W. Hartley of Australia.

at 2 developmental stages, booting and maturity. The oats were sprayed with a fungicide at weekly intervals after June 1 to keep the plants free from foliar diseases that might retard root and top growth.

The techniques for root sampling developed prior to 1937 were reviewed by Pavlychenko (1937), who also developed the soil-block washing method. More recently other techniques that allow measurement of both amount and position of the roots have been developed (de Roo, 1957; Fehrenbacher and Alexander, 1955). All of the methods for separating roots from the soil involve washing with a stream of water (de Roo). Sometimes sodium chloride has been added to aid in dispersing the soil aggregates.

The soil-root samples were taken with a rectangular metal sleeve 6 x 12 x 24 inches wide, long, and deep, respectively, made from ⅛-inch steel and sharpened on one end. It was marked at 4-inch intervals to facilitate measuring the 24-inch sample depth into 6 subsamples.

Before a root-soil sample was taken, the tops of the plants in one 2-foot section of the plot were cut at the soil surface and discarded. The metal sleeve was positioned so that the soil-root core consisted of a 6-inch length of the row and an area of 6 inches on each side of the row. The sampler was driven 4 inches into the soil with a steel maul and then tipped out and the 4-inch subsample removed. If the soil did not break evenly, the remnants were collected with a shovel. The metal sleeve was then driven to a depth of 8 inches and the second subsample taken. This procedure was repeated until a root-soil core had been taken to a depth of 24 inches, giving 6 subsamples per core.

The root-soil subsamples were put in wire baskets made from door screen and soaked in a weak salt solution for 20 minutes. After being soaked, the roots and soil were kneaded by hand until the latter was washed through the screen wire. The roots were collected in a 2-quart crock, washed to remove foreign material, dried at 138° F. for 48 hours, and weighed.

Results

The mean dry weights per sample of roots were not significantly different at the boot and harvest stages (Table 1), indicating that root-system size within the sample volume was maximum at the end of the vegetative stage. However, the root system did not necessarily attain maximum size before the top growth, since the complete root system was not measured. An increase in root weight *may* have occurred at greater depths. The mean root weights for varieties were in 3 significance groupings: Clinton and Craigs-afterlea had the highest mean root weight, Marion and Andrew were intermediate, and A465 was lowest. In every sample roots penetrated below the 24-inch depth, but the extent of the penetration was not measured. However, with root weights as small as those in the deepest subsample (Table 2) it is very unlikely that A465 would produce enough root dry weight below 24 inches to make it equal to the total weight of the other varieties. Differential lateral root distribution of oat varieties was not variable since the root-soil core included half the distance between the row sampled and the adjacent rows.

The distribution of roots in the subsamples from different depths for the 5 oat varieties are given in Table 2. The major portion of the highly significant interaction for varieties x subsample depth was caused by the differential distribution of A465 roots in comparison with distribution of roots of the other 4 varieties. The 3 Corn Belt varieties, Clinton, Marion, and Andrew, even though

Table 1

Mean Dry Weight of Roots Sampled From 5 Oat Varieties At the Booting and Maturity

Variety	Stage at sampling: boot	Stage at sampling: maturity	Mean	Sig* groups
	(gms)	(gms)	(gms)	
Clinton	8.03	7.90	7.96	a
Craigs-afterlea	7.43	8.48	7.95	a
Marion	7.14	7.43	7.28	b
Andrew	7.30	6.45	6.45	b
A465	5.11	5.45	5.28	c
Mean	7.00	7.14		

*Determined by multiple-range test.

Table 2

Mean Dry Weights of Roots Sampled From 5 Oat Varieties At 6 Depth Intervals Below the Surface

Variety	Depth (inches below soil surface): 0-4	4-8	8-12	12-16	16-20	20-24
	(gms)	(gms)	(gms)	(gms)	(gms)	(gms)
Clinton	4.40	.131	1.04	.47	.38	.36
Craigs-afterlea	3.92	1.58	1.03	.57	.43	.43
Marion	4.30	.90	.78	.55	.40	.35
Andrew	4.28	1.03	.64	.35	.31	.26
A465	1.93	1.30	.80	.50	.38	.37

unequal in total root dry weight, had about the same pattern of depth distribution. About 62 percent of the root weight was in the top 4 inches and 80 percent was located in the top 8 inches. Craigs-afterlea was similar to the Corn Belt varieties except that a somewhat smaller proportion of its roots (50 percent) was located in the top 4 inches of soil. The dry weights of A465 roots were similar to those of the other varieties in the subsamples between 4 and 24 inches, but the dry weight in the 0- to 4-inch level was less than half as great as that of the other varieties.

The varieties used were selected to represent different areas of origin and adaptation. The Corn Belt varieties had similar patterns of root-depth distribution, even though no conscious effort was made to select for root characteristics. The root-distribution pattern of A465 may be related to the growing conditions characteristic of its area of origin, Australia. This strain is noted for its drought resistance, an important characteristics for successful crop production in Australia. Its root-distribution pattern would be adapted to drawing moisture from lower depths with less dependence on moisture derived from the top 4 inches of soil. In Iowa this pattern of root distribution would not be as advantageous as in a droughty environment, since except for occasional short dry periods the moisture supply in Iowa is generally adequate during the oat-growing season.

The oats in this experiment were grown on a highly productive Clarion-Webster soil. Grain yields were not taken, but adjacent plots averaged over 100 bushels per acre. There did not seem to be any barriers to root penetration into the soil. Roots were found below the 24 inches in each sample, and there were no points of root concentration that suggested a blocking of root penetration by a physical barrier such as a hard plow sole.

Only root dry weight was measured in this study. This attribute may or may not be related to absorption surface area or the ability of a variety to absorb moisture and nutrients efficiently. Obviously, the roots of each variety penetrated the complete depth of sampling, and, below 12 inches, the root dry weights of all varieties were approximately equal. Further studies should measure the maximum depth of root penetration and possible differences in absorption capacity of the oat varieties. Chandler (1958) found no relation between long-time surface fertilization practices and the maximum penetration depths of oat roots.

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