KANSAS STATE UNIVERSITY
Environmental Physics Group, Department of Agronomy, Kansas State University, 2004 Throckmorton Plant Sciences Center, Manhattan, KS 66506-5501, USA.

Root growth of a drought-resistant and drought-sensitive wheat under compaction.

M.B. Kirkham.

The four soil physical factors that affect plant growth are water, temperature, aeration, and mechanical resistance (compaction). The first three are well studied (Kirkham, 2005), but relatively little information exists concerning the effect of compaction on root growth. One way to achieve different compactions is to grow plants in glass tubes of different diameters, which regulate the rigidity of the pore structure (Wiersum 1957). The objective of this experiment was to determine if roots of a drought-resistant winter wheat cultivar KanKing and a drought-sensitive winter wheat cultivar Ponca varied in their ability to penetrate soil in glass test tubes of two different diameters.

Materials and Methods. The wheat seeds were germinated in soil, and 11 days after planting were transplanted into 24 test tubes of two different diameters (8 or 10 mm internal diameter; all test tubes were 200 mm long), one plant per test tube. The day of transplanting was designated "Day 0" of the experiment. The test tubes were filled with a commercial potting soil. The test tubes were placed in a growth room. The experiment was a completely randomized one with two cultivars, two compactions, and six replications. Root length was monitored at noon daily between 5 and 26 days after transplanting. (Days 6, 8, and 20-22 were not monitored, because I as out of town.) Temperature at time of measurement averaged 20°C. The flux density of incident light, provided by cool-white fluorescent lamps, was 260 μmol m^{-2} s^{-1} from 06:00 to 20:00 h. The plants were kept well watered during the experiment by adding a few milliliters of water (usually daily) to the tubes. The exact amounts were not recorded, but they were less than 5 ml. Shoots were harvested (cut) 26 days after transplanting, and roots were extracted by wet sieving the soil. Dry weights of roots and shoots were determined.

Table 1. Root length (cm) of a drought-resistant (KanKing) and a drought-sensitive (Ponca) winter wheat grown in test tubes of two different diameters (8 or 10 mm). Mean and standard error are shown (n=6).

Days after transplanting into test tubes	KanKing, 8 mm	Ponca, 8 mm	KanKing, 10 mm	Ponca, 10 mm
5	0.33±0.16	1.67±1.11	1.17±0.65	0.50±0.25
7	1.17±0.54	4.50±1.85	3.67±1.33	5.42±1.53
9	2.00±0.66	4.92±1.80	5.42±1.87	7.33±1.78
10	3.08±1.12	5.92±1.90	6.58±1.44	7.33±1.78
11	3.92±1.46	7.50±2.41	8.42±1.72	11.92±2.18
12	6.08±2.61	8.50±2.56	10.42±2.16	15.08±1.45
13	7.00±3.05	11.33±3.29	10.67±2.04	14.67±1.29
14	7.17±3.07	10.25±3.56	11.33±2.00	15.67±0.46
15	8.08±3.52	11.67±2.98	13.75±2.35	15.83±0.46
16	8.42±3.54	11.25±3.03	13.75±2.78	16.58±0.52
17	8.42±3.83	12.00±2.91	14.58±2.51	17.58±0.45
18	10.08±3.45	12.42±3.09	14.50±2.39	18.00±0.49
19	9.17±3.96	11.75±3.30	14.42±2.46	17.83±0.66
23	9.25±4.13	12.58±3.07	15.08±1.80	18.50±0
24	9.25±4.13	12.00±3.67	15.25±1.78	18.50±0
25	9.33±4.09	12.33±3.16	15.25±1.78	18.50±0
26	9.25±4.13	14.92±3.02	15.25±1.78	18.50±0

Results and Discussion. Results for root length are shown in Table 1. After the first day of measurement, Ponca had a longer root length than KanKing in both the 8- and 10-mm diameter test tubes. By the end of the experiment, the roots of Ponca had reached the bottom of the test tubes with the 10-mm diameter and they were still growing in the test tubes with the 8-mm diameter, but those of KanKing had stopped growing under both treatments. The better growth of Ponca compared to KanKing under well watered conditions agrees with earlier results (Kirkham, 1989).

The dry weights of the roots at harvest in the 8- and 10-mm diameter test tubes were as follows: KanKing (mean ± SE): 0.625±0.025 g and 0.639±0.037 g, respectively; Ponca: 0.601±0.015 g and 0.644±0.012 g, respectively. The dry weights of the shoots in the 8- and 10-mm diameter test tubes were as fol-

lows: KanKing (mean ± SE): 0.586±0.004 g and 0.597±0.003 g, respectively; Ponca: 0.588±0.003 g and 0.601±0.002 g, respectively. The differences in growth, observed in root length, were not observed in the dry-weight data. The dry weights of roots and shoots of KanKing and Ponca were similar under the two treatments, except for the roots of KanKing, which had a higher dry weight in the 8-mm diameter tubes than the roots of Ponca. This suggests that KanKing may have a wider root than Ponca, which makes penetration of its roots into a compacted soil more difficult. It also suggests that the drought resistance of KanKing may be due, in part, to a heavier, more slowly growing root compared to Ponca.

In conclusion, the data showed that a drought-sensitive cultivar of winter wheat, Ponca, was better able to penetrate soil in a restricted root volume than a drought-resistant cultivar, KanKing. The results suggested that Ponca may have a thinner root than KanKing, which allows its roots to penetrate more easily into the pore space between solid particles in a compacted soil compared to KanKing.

References.

Kirkham MB. 1989. Growth and water relations of two wheat cultivars grown separately and together. Biol Agric Hort 6:35-46.

Kirkham MB. 2005. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam. 500 pages.

Wiersum LK. 1957. The relationship of the size and structural rigidity of pores to their penetration by roots. Plant Soil 9:75-85.

News.

A new graduate student, Nicole A. Rud (nrud@ksu.edu), has joined the laboratory. She is getting her master's degree jointly under Professor Kimberly A. Williams (kwilliam@ksu.edu) in the Department of Horticulture, Forestry, and Recreational Resources and M.B. Kirkham (mbk@ksu.edu). Nicole is studying the causes of the physiological disorder, edema.

Mr. Prasanna Ayyaru Thevar (prasan@ksu.edu), a Master's degree student, continues his studies. He is determining the transpiration efficiency of different lines of sorghum.

Mr. Intkhab Hazoor Wahla, the Ph.D. student from the University of Agriculture, Faisalabad, Pakistan, who spent six months in the laboratory last year, has returned to Pakistan. The results of his study have been published (Wahla and Kirkham, 2007).

Publications.

Green SR, Kirkham MB, and Clothier BE. 2006. Root uptake and transpiration: From measurements and models to sustainable irrigation. Agr Water Manage 86:165-176.

Horn R, Bachmann J, Hartge KH, and Kirkham MB. 2007. Mechanical stresses in soils assessed from bulk-density and penetration-resistance data sets. Soil Sci Soc Am J 71:1455-1459.

Kirkham MB. 2008. Horizontal root growth: Water uptake and stomatal resistance under microgravity. Vadose Zone J (In press).

Wahla IH and Kirkham MB. 2007. Heavy metal displacement in salt-water-irrigated soil during phytoremediation. Env Pollution (In press).