Roots as drivers of the rotation effect?

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Abstract

Intro

Methods and Materials

Above-ground biomass

Treatments consisted of two contrasting maize-based rotations: a 2-year rotation of maize-soybean, and a 4-year rotation of maize-soybean-oat/alfalfa-alfalfa that periodically received cattle manure. Detailed accounts of plot management are reported elsewhere (Hunt). Each phase of the rotations was present every year in four replicate blocks within a 9-hectare experiment established in 2001 at the Iowa State University Marsden Farm in Boone County Iowa.

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| Measurement | Measurement years |  |
| Maize grain yield | 2013-2020 | Maize grain yield was determined using a 6-row combine equipped with a yield monitor and moisture meter. Sampling areas for yield were the middle rows of the plots, approximately 4.6 m x 84 m. All yields are reported on a dry weight basis. |
| Maize above-ground biomass | 2013, 2014, 2018, 2019, 2020 | Maize above-ground biomass was measured periodically throughout the season. Eight plants were cut at ground level, separated into leaf, stem, and reproductive components, dried at X deg C for at least X hours, then weighed. |
| Maize maximum rooting depth | 2018, 2019, 2020 | Maximum root depth was measured starting at 20, 23, and 41 days after planting in 2018, 2019, and 2020 respectively. Sampling was repeated approximately every 2 weeks until 84, 106, and 151 days after planting in 2018, 2019, and 2020, respectively. Four cores per plot were drawn in the planted row with a 19-mm-diameter soil probe. Maximum rooting depth was determined visually using the protocol of Ordonez et al. 20xx. A soil core was drawn with a 19-mm-diameter soil probe, white roots were identified, and their depth estimated to the nearest inch using a meter stick. Samples were taken from the same location until no white roots were identified. Four cores were taken per plot at each sampling date. |
| Soil moisture at 15 and 45 cm depths | 2018, 2019 |  |
| Penetration resistance | 2018, 2019, 2020 |  |
| Maize root mass 0-60 cm | 2019, 2020 | Maize root mass to a soil depth of 60 cm was measured at 3 and 105 days after planting in 2019, and at 4 and 117 days after planting in 2020. Four soil samples per plot were drawn at a location 10 cm from corn rows in 15 cm depth increments using a 32-mm-diameter soil probe. Soil from each depth increment within a plot was composited and roots were recovered using a sequence of elutriation (washing), flotation, recovery from organic debris using tweezers and a stereo microscope, drying, and weighing (Dietzel). |

Corn root mass to a soil depth of 60 cm was measured at 3 and 105 days after planting in 2019, and at 4 and 117 days after planting in 2020. Four soil samples per plot were drawn at a location 10 cm from corn rows in 15 cm depth increments using a 32-mm-diameter soil probe. Soil from each depth increment within a plot was composited and roots were recovered using a sequence of elutriation (washing), flotation, recovery from organic debris using tweezers and a stereo microscope, drying, and weighing. No year effect on corn root mass was detected (p=0.65). In contrast, we found a significant sampling date x rotation interaction (p=0.015). Corn root mass increased 108%, from 515 to 1,073 kg ha-1, in the 2-year rotation, whereas root mass increased 49%, from 782 to 1,160 kg ha-1, in the 4-year rotation. If the initial levels of root residue decayed at an equal rate in the two rotation treatments, or if they persisted equally in the two rotations, these results would indicate that the 2-year rotation added more root mass during the growing season than did the 4-year rotation.

Maximum corn root depth was measured throughout the 2018-2020 cropping seasons in both rotation systems. Maximum root depth was determined five times in 2018, seven times in 2019, and eight times in 2020, based on four cores per plot drawn with a 19-mm-diameter soil probe. Maximum root extension was determined visually and quantified with a meter stick. Maximum root depth differed among years (p<0.0001) and rotation systems (p=0.0013), but no year x rotation system interaction occurred (p=0.66). Averaged over rotation treatments, root depth was greatest in 2019 (102.5 cm), least in 2018 (53.7 cm), and intermediate in 2020 (90.0 cm). Averaged over years, maximum root depth was 14% higher in the 4-year rotation (87.4 cm) than in the 2-year rotation (76.7 cm). These observations corroborated our hypothesis that maximum corn root depth would be greater for corn following alfalfa in the 4-year rotation than following soybean in the 2-year rotation.

Corn grain yield was determined using a 6-row combine equipped with a yield monitor and moisture meter. Sampling areas for yield were 4.6 m x 84 m. For statistical comparisons, all grain yield data were adjusted to 15.5% moisture. Corn yield was affected by a significant year x rotation interaction (p=0.0096): yield was 23% greater (p=0.0006) in the 4-year rotation (14.0 Mg ha-1) than in the 2-year rotation (11.3 Mg ha-1) in 2018 but did not differ between rotation systems in 2019 (p=0.62) and 2020 (p=0.56). Averaged over rotation systems, mean corn yield in both of the latter two years was 12.6 Mg ha-1.

Results and Discussion