Doing more with less: Maize grown in complex rotations has lower root biomass but higher grain yields

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Abstract

It is well-established that maize grown in complex cropping systems requires less external nitrogen inputs and often exhibits higher grain yields compared to maize grown in simple systems. However, the driving mechanisms behind this phenomenon, or ‘the rotation effect’, are poorly understood. To examine the possible role of maize roots in the rotation effect we measured root biomass, maximum rooting depth, and grain yields in the maize phase of two contrasting rotations: a simple 2-year rotation of maize-soybean, and an extended 4-year rotation of maize-soybean-oat/alfalfa-alfalfa. Additionally, we measured soil penetration resistance, soil moisture, and performed a maize growth analysis. From 2013-2020, maize yields in the complex rotation were X Mg ha-1 higher than in the simple. The maximum rooting depth of maize in the complex rotation was consistently deeper, averaging X cm over the three years of measurement. Maize grown in the simple system had higher root biomass at maize flowering? Maturity? (check) compared to the complex rotation. The timing of the maize growth advantage in the complex system was not consistent across years. We posit that maize grown in the complex rotation achieved equal or better root resource-acquisition potential with less investment compared to maize grown in the simple rotation. Understanding whether these root differences reflect chemical, physical, and/or biological characteristics of the soil merits further investigation.

Intro

Over the past 50 years, socio-political systems incentivizing agricultural system output efficiency have driven the distillation of previously complex cropping systems into simple systems consisting of only a few crops. Advantages of diversified cropping systems have been well-documented on field, landscape, regional, and global scales (CITE). Despite being well-documented, in many contexts the mechanisms for diversity-derived advantages to crop production are not well-understood. In the Midwestern US, a substantial portion of the agricultural land is dedicated to maize-based systems. Consistent with global trends, these systems have XX from diversified rotations that included small grains and forage legumes to maize monocultures or simple alterations of maize and soybean (CITE). This simplification has had numerous consequences, including increased rates of soil erosion, XXX. Maintaining high productivity in simplified systems often requires larger investments in external inputs that are often accompanied by higher risks for negative environmental impacts with concomitant lower yield potentials. Understanding the mechanisms that allow diversified systems to use resources more efficiently will be crucial for designing systems that can support food production with limited land resources.

There have been numerous studies in the Midwest documenting and investigating changes in maize when grown in monoculture compared to in alteration with soybean (CITE). While the maize yield advantage of further extending rotations to include small grains and forage legumes has been well-dcoumented (CITE), to our knowledge there has been less work investigating driving mechanisms of those yield advantages. Researchers have found differences in the type of soil carbon and its distribution in simple and complex maize systems (Hanna, Pat), as well as differences in microbial community composition and distributions (Alison, Larry?). One study found differences in nitrogen cycling during the maize phase of simple and complex systems were small, and could not explain differences in maize yields (Osterholtz). XX found more maize roots from X-Xcm in XxX. Pat’s results too.