Factors contributing to and limiting vegetable crop productivity across an urban to rural transect in greater Chicago, Illinois

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Urban food production has gained popularity and many cities are now prioritizing food production as an urban land use. Little is known on the effects of the altered growing environment on vegetable food production. A field experiment was started in 2013 to assess the effects of increased pollution and urban microclimatic conditions on vegetable crops. Six experimental gardens with forty 0.89 m^2 raised beds containing a uniform compost, topsoil, and sand (50%, 40%, and 10%) mixture were established across a latitudinal transect of greater Chicago, Illinois. Seven vegetable crops (kale, brussel sprouts, pepper, tomato, beet, onion, and garden bean) were planted in early, mid, and late season plantings. Micrometeorological towers measuring temperature, light irradiance, wind, CO_2, and ozone were placed adjacent to each experimental garden. Structural equation models (SEM) were used to compare plant productivity to micrometeorological measures. Yield of early and late planted cole crops in 2013 and 2014 were greatest at urban sites. Onion yield was greatest at urban sites in 2014 and 2015, but yields were greatest at the most rural site in 2013. Yield of mid-season planted tomatoes and peppers were variable across the urban to rural transect without consistent trends. Beet yield was greatest at two peri-urban sites in 2013, but greater at urban sites is 2014 and 2015. Temperature was 1-2° C higher in the daytime and 2-4° C higher in the nighttime at urban sites compared to rural, but wind speed was greatest at rural sites. Ozone was 2× and 1.3× greater at peri-urban compared to urban and rural sites, respectively. Carbon dioxide concentrations were variable depending on season and traffic proximity. Measures of temperature (+), ozone exposure (-), light interception (+), and vapor pressure deficit (+) were correlated to productivity. Measures of ozone exposure most strongly correlated with plant production across crops and years. The urban heat island increased crop productivity, especially in early and late season crops. Increased tree canopy prevalence at peri-urban sites had a significantly negative effect on productivity. An SEM model including 2013 and 2014 explained 40% of all beet yield variation, showed ozone had 91% negative correlation with yield, and growing degree day accumulation had a 46% positive correlation with yield. Vegetable crop productivity is aided by the increased temperature and reduced ozone of an urban environment, but crops in suburban areas adjacent to cities may be hindered by elevated ozone levels and urban tree canopies.