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Groundcover Type and Irrigation Delivery Affect Soil Moisture Dynamics in the Landscape

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Summary

There is little research published on the effect ornamentals groundcovers have on soil health. Soil properties can be manipulated by groundcover growth habit and irrigation type. This research was designed to evaluate the effects groundcover form and habit have on soil moisture and temperature under different irrigation regimes. A bunching (*Liriope muscari* 'Big Blue') and matting groundcover (*Sphagneticola trilobata*) were planted in individual plots that were irrigated by either overhead or micro-irrigation. Soil volumetric water content (VWC) and temperature were monitored by soil sensors buried 15cm deep in each plot. Overhead and micro spray irrigation, along with groundcover growth habit, affected soil temperature and soil VWC. Plots with Wedelia had the largest increase in VWC during irrigation events, regardless of irrigation type. Soil VWC was found to be lower in planted treatments than fallow treatments. At each irrigation event, micro spray showed a greater increase in VWC when compared to overhead irrigation across all treatments. However micro spray irrigation soil VWC decreased at the same rate for the overhead irrigation. Soil temperatures fluctuations were reduced under both groundcover species, when compared

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to fallow plots. Irrigation delivery method was also found to influence soil temperatures. Micro spray irrigation caused a slight increase in temperature at each irrigation event, while there was no temperature increase with overhead irrigation events. Ornamental groundcovers can lower soil VWC and temperature through increased transpiration and shielding solar radiation. Furthermore, groundcovers mitigate the rapid fluctuations in temperature creating a more normalized soil dynamic.

INTRODUCTION

Sustainable practices are growing in popularity for the horticulture industry. Sustainable practices should focus on the financial gains, environmental advantages, and human enrichment (Doxon, 1996). However, landscapes are often slower to adopt sustainable practices than production agriculture (Doxon, 1996). With landscapes occupying millions of acres of land in the United States (Steinberg, 2005), it is critical that we not only continue to develop sustainable landscape practices, but we must implement more of these practices. The lawn is the ubiquitous in the American landscape, making up approximately 25 to 40 million acres of land (Steinberg, 2005). While there are many practices (reduced pesticide use, planting native species, water management) to include in sustainable landscapes - one is to include is planting and maintaining ground covers, which support reduced labor cost and maintenance, lowers water and fertilizer usage, and reduces landscape runoff. Encouraging the installation of landscapes that require fewer inputs (e.g., irrigation, fertilizer, and maintenance) may decrease negative environmental outcomes (Khachatryan, 2020). Fertilizing lawns can contribute to non-point pollution, produce algae blooms, and cause waterway degradation (Campbell et al., 2020). Fertilization mismanagement of urban vegetation represents a potential source of nutrients that may contribute to water quality impairment (Carey et al., 2012).

Water movement under different groundcover management systems (GMSs) has been well-studied under orchards. Several comprehensive reviews assessing the relative advantages and disadvantages of various GMSs have emphasized the need for additional information on the physiological, economic, and edaphic impacts of alternative orchard GMSs (Merwin et al., 1994). These are systems where various material or vegetation is used to cover bare soil to prevent erosion, add nutrients to the soil or cool soil temperature. Many studies cite groundcovers increasing water infiltration rates of soil (Folorunso et al., 1992, Krohn et al., 2005).

Groundcovers have been shown to reduce high soil temperatures, which factor into the rates of biochemical reactions and have strong influence on plant and root growth (Song et al. 2013). Vegetation cover has proven to have significant effects on soil temperature (Michelsen-Correa and Scull, 2005). Effects of groundcover canopies have been studied widely in vineyard management systems and orchards. Temperatures were found to be consistently cooler under a living groundcover system, Wimmera ryegrass (*Lolium multiflorum*), and vetch (*Vicia sativa*) in vineyards in South Africa (Van Huyssteen et al., 2017). Temperatures were also found to be lower under living mulch systems in vineyards than under conventional mulch systems. The groundcover treatments may have reduced soil temperatures because of the evaporative demand of the vegetation (Bavougian and Read, 2018). One study found that vegetation heights have an inverse relationship to soil temperatures (Song et al., 2013). Soil temperatures are lower under grass groundcover systems than bare soil (Wu et al., 2014).

Cover crops are well studied in production agriculture, with vast research quantifying their benefits on crop productivity and soil health. However, there has been little research in documenting the benefits of ornamental groundcover systems beyond aesthetics and other ecosystem services such as pollinator and wildlife support. However, as landscapes cover such a vast quantity of land, it is important to quantify the benefits of ornamental groundcovers on soil health. Thus, the objective of this experiment was to study the influence of ornamental groundcover on soil moisture and temperature. Additionally, this research aims to understand how the various groundcover growth habits (matting vs bunching) interact with different irrigation (overhead vs. micro spray) on these dynamic soil properties to quantify the benefits and develop best practices.

MATERIALS AND METHODS

This research was conducted at the Louisiana State University Agricultural Center Hammond Research Station located in Hammond, LA. A 68 m^2 area plot (4 x 17m) was prepared for this research. Wherein, the soil was tilled to a depth of 4 cm and amended with a locally sourced landscape mix consisting of pine bark, sand, and dolomitic lime. The plot was divided into 18 individual 1 m^2 plots, with half being irrigated by overhead sprinklers (Model 15 UH; U15Q, Rainbird, Azusa, CA) on 1 m risers, and the other half irrigated via micro sprayers (Model XS360TS Adj True Spray, Rainbird, Azusa, CA) on 30 cm straws. The plots were irrigated every three days with overhead irrigation plots receiving 15 min and micro spray plots receiving 22 min at each irrigation event. The difference was determined by calculating the total quantity of water applied and adjusting irrigation timing, so each section received the same volume of water per irrigation event. A VWC sensor (Teros 12; METERGROUP, Pullman, WA) was buried in the center of each plot at a depth of 15 cm to monitor soil volumetric water content and temperature. The sensors were attached to a data logger (CR1000x; Campbell Scientific, Logan, UT) along with a tipping bucket rain gauge (TR-525I; Texas Electronics, Dallas, TX). Data was collected every 10 minutes and hourly averages were recorded.

The entire research plot was mulched with pine straw at a depth of 7.5cm. Within each irrigation system, three randomly selected plots were planted with wedelia (*Sphagneticola trilobata*), three were planted with Big Blue liriope (*Liriope muscari* 'Big Blue'), and the remaining three were left fallow. The wedelia was selected as a quick growing groundcover that would spread and entirely cover the surface, potentially uniformly dispersing water, while the liriope was selected as a bunching groundcover that would potentially channel water. Each plot was fertilized with 100 g-controlled release fertilizer (Osmocote Plus 15-9-12, 5-6 months; ICL Specialty Fertilizers, Dublin, OH) spread uniformly across the entire 1 m^2 plot. Overhead photos were collected using a bracket (1 m x 1m) and stand that ensured the camera was positioned 150 cm high above the center of the plots so each photo was taken from the same height with the entire 1 m^2 plot within the frame.

RESULTS AND DISCUSSION

Soil Moisture. Data was collected over a period of one week, 7/12/2022-7/18/2022. Soil volumetric water content (VWC) started rising approximately 45 min after irrigation and reached a maximum approximately 2 hrs. after irrigation. The VWC gradually declined over the week with all treatments (Fig. 1). Although the decline of the liriope and fallow was relatively uniform across the week, the wedelia experienced more pronounced daily moisture depletion, indicating a greater transpirational reduction of moisture from the soil **(Fig. 1**).

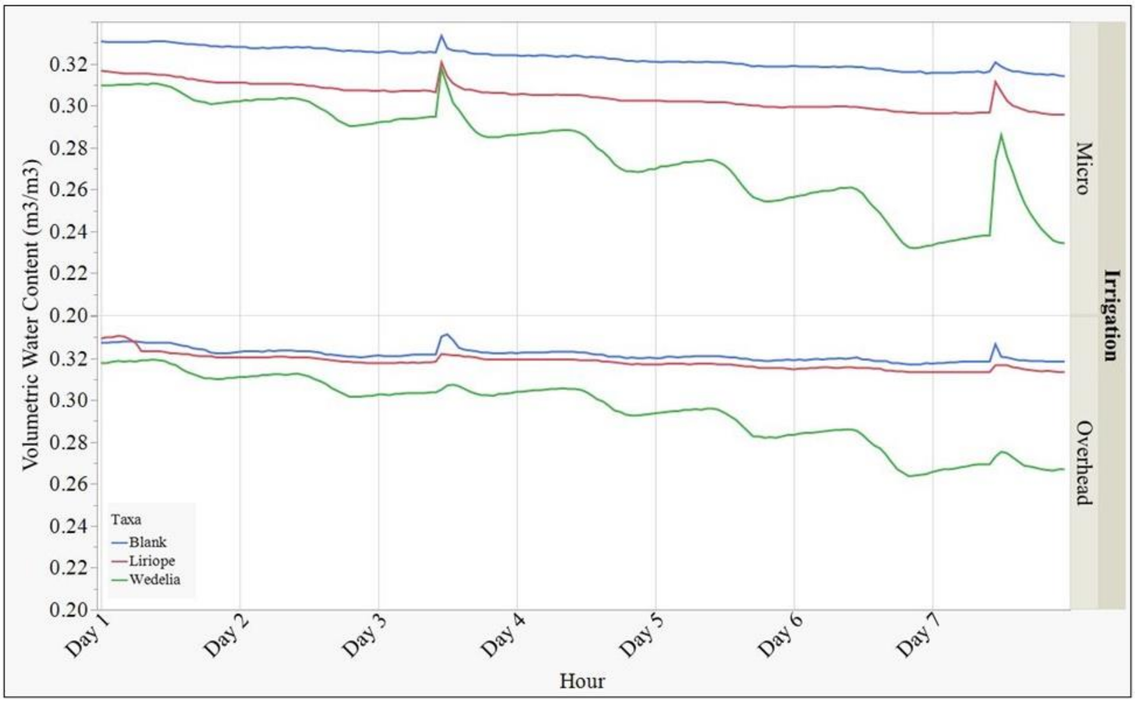

Figure 1. The change in volumetric water content over a 7-day period (7/12/22 to 7/18/22) under wedelia and Big Blue liriope with micro spray and overhead irrigation treatments with two irrigation events.

The wedelia has a faster rate of growth and greater canopy coverage than the liriope (**Fig. 2**), and thus the wedelia has more biomass to uptake water.

In cropping systems, cover crops reduce excess soil moisture, and work with the main crop to uptake more water from within the root zone (Kahimba et al., 2008).

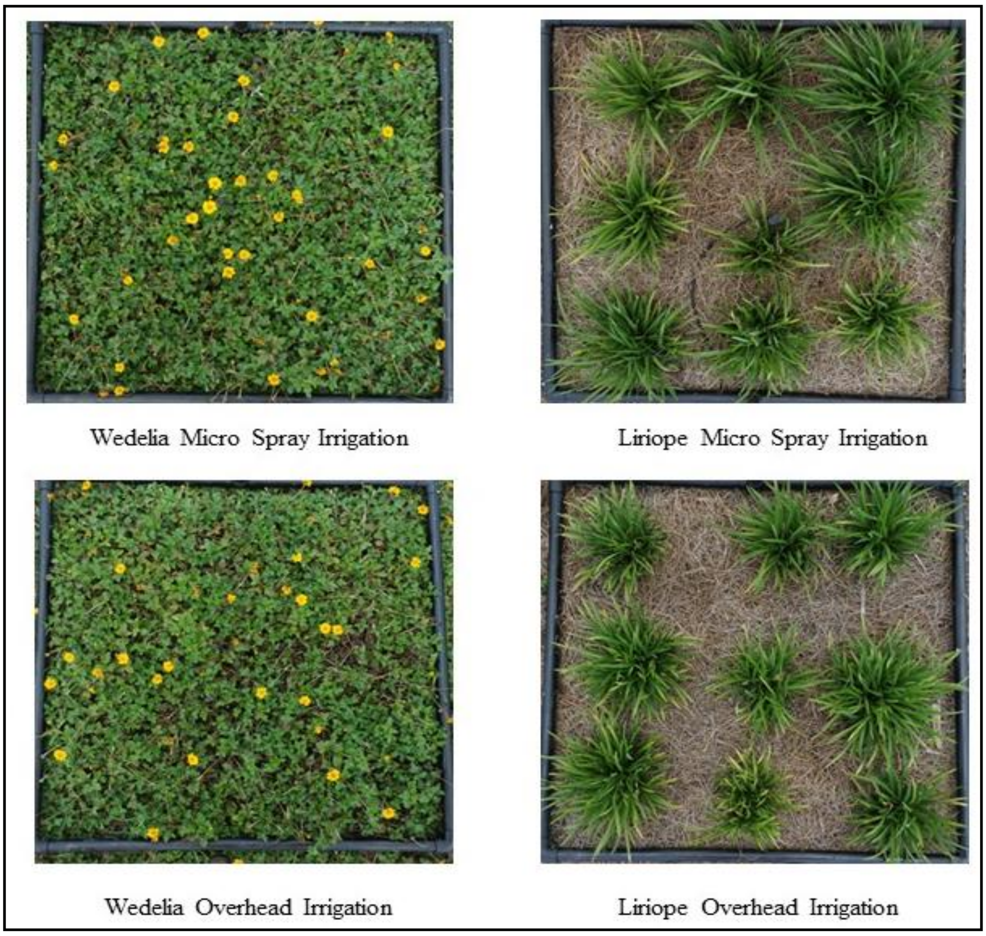

Figure 2. Comparing the different growth habits of wedelia and Big Blue liriope under overhead micro spray irrigation.

Overall, the wedelia has the lowest VWC value on average of all three treatments. The fallow plots had the greatest VWC value. After the irrigation events, these wedelia plots experienced the greatest increase in VWC. Cover crops have been known to increase water infiltration rates (Kahimba et al., 2008). The VWC started rising in the overhead irrigation plots approximately 30 minutes after the irrigation event and reaches its maximum within 2 hours (**Fig. 1**). The irrigation spikes in VWC were considerably smaller in the overhead irrigation treatments than the micro irrigation treatments. This is likely due to the uniform wetting of overhead irrigation in the soil profile. The micro spray irrigation coverage extended only to the edges of each plot. Even though both overhead and micro spay irrigation received the same volume of water, the irrigation distribution had an impact on VWC. Sprinkler irrigation is less efficient, and more water is placed where it is not needed by the plant (Wang, 2000). In the overhead irrigation treatments, the greatest spike was in the fallow plots. The fallow plots have no vegetative canopies to deflect the irrigation water, and thus all water enters the soil profile. Conversely, the planted plots will not only deflect the irrigation and retard its entry into the soil, but also allow for evaporation of moisture remaining on the foliage. Like the micro-irrigation treatment, the wedelia treatment had the most observable daily reduction in soil VWC, further indicating increased plant-water uptake (**Fig. 1**). The liriope treatments consistently decreased in VWC over the 7-day period similarly to the fallow plots.

Soil Temperature. Temperatures in the micro spray irrigation experienced more variation between treatments than the overhead irrigation (**Fig. 3**). Similar to the soil moisture values, plots with wedelia have the lowest temperature overall, while the fallow plots had the highest soil temperature. Holmes et al. (2008) showed that maximum soil temperature occurs shortly after solar noon at the soil surface, but lags in time with increasing depth (Holmes et al., 2008). In this research, the peak temperatures were consistently measured at 19:00. Soil temperatures were lowest at around 10:00. During the irrigation events temperature increased slightly and then decreased soon after (Fig. 3). Water is known to transfer solar heat from the surface as it infiltrates the soil profile, increasing subsurface temperatures in response to irrigation events (Hillel, 2004).

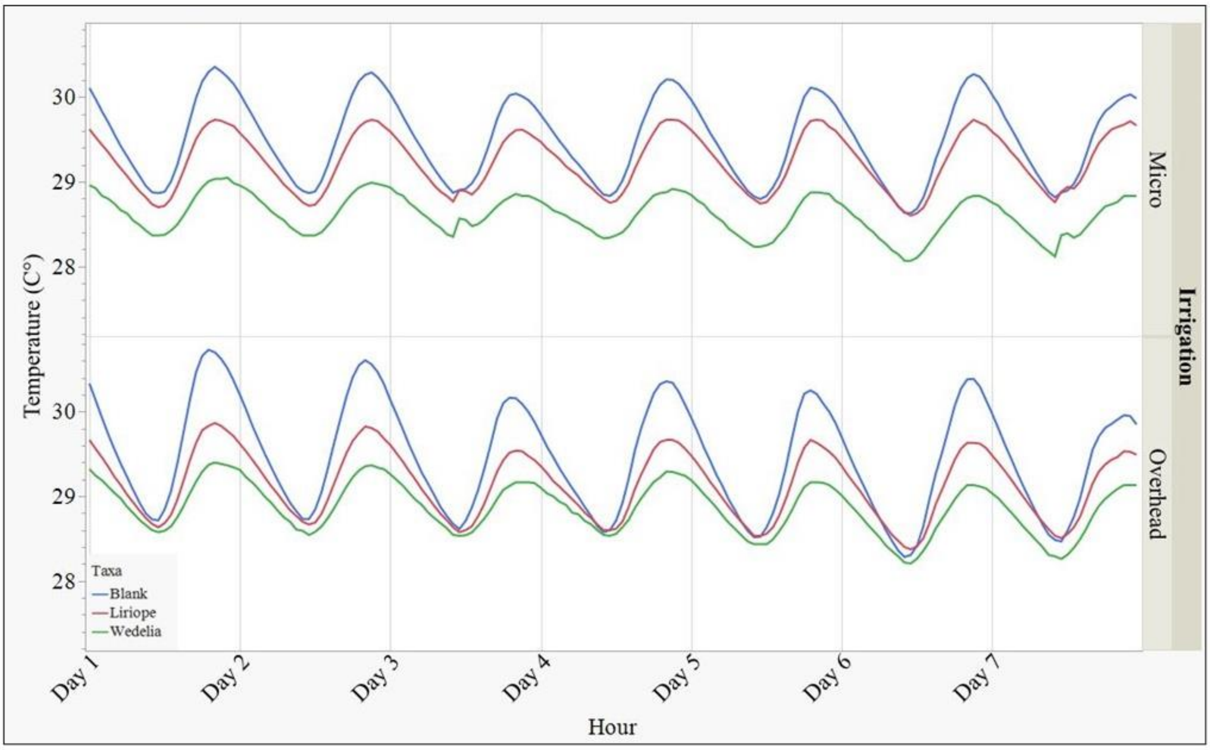

Figure 3. The change in temperature 15 cm below the soil surface over a 7-day period (7/12/22 to 7/18/22) under wedelia and Big Blue liriope with micro spray and overhead irrigation treatments with two irrigation events.

The more rapid soil temperature fluctuations in the overhead irrigated plots are likely a result of the increased water infiltration rate in the overhead irrigation systems. The overhead irrigation is wetting a larger area than micro irrigation. The temperature mitigating effect of the micro spray irrigation was likely due to the smaller irrigation area. Thus, more water entered the profile under the groundcover, raising the specific heat of the soil. Soil temperature is greatly affected by soil water content (Zhang et al., 2022).

Wedelia had the lowest temperature overall in the overhead irrigation system. Wedelia had a denser, closed canopy (**Fig. 2**) which blocked solar radiation reaching the soil surface. The fallow treatment had the highest temperature. The temperature of the wedelia treatment was similar to the liriope and fallow treatments in the overhead irrigation plot, than in the micro irrigated plot (**Fig. 3**). There may be due to the smaller droplet size of the overhead irrigation system – and evaporative cooling. Wherein the dense canopy likely deflected the water preventing some from entering the soil. But in addition to wedelia deflecting the water, the temperature was still the lowest because of the shade of the dense canopy. Unlike the micro spray irrigation system, the overhead plots had no observable soil temperature increases with each irrigation event. The soil profile was wetted over a larger area, but the wetting front most likely penetrated less than the micro irrigation. There was not a large enough influx of water to carry heat below the surface. In both irrigation systems, soil temperature increased, and decreases were less extreme in the planted treatments (**Fig. 3**). Vegetative canopies cool the environment by providing shade (i.e., reducing solar radiation) and by transpiration of water through leaves (Wu et al., 2014). Furthermore, the presence of the plants may provide small breaks in the mulch layer where evaporation (and subsequent evaporative cooling) may occur. This shading and the increased plot coverage in the wedelia is likely the reason be why the wedelia plots had the lowest temperature in both irrigation systems.

CONCLUSION

The objective of this study was to determine if groundcover growth habit and irrigation delivery method would affect soil moisture and temperature. Soil moisture and temperature were found to be lower in planted treatments versus fallow treatments. The irrigation delivery method also influenced soil temperature, with micro spray irrigation resulting in a more gradual daily flux than overhead. Groundcover habit also affected both soil temperature and VWC, with the matting groundcover (wedelia) shielding the plots from more solar radiation and deflecting more water than bunching (liriope) groundcovers. Our results can help support more informed decisions in residential and commercial landscapes through improving soil health. Finally, by incorporating ornamental groundcovers, there is increased sustainability of landscape systems -enhancing the ecosystem of urban areas.

LITERATURE CITED

Bavougian, CM., and, Read, P.E. (2018). Mulch and groundcover effects on soil temperature and moisture, surface reflectance, grapevine water potential, and vineyard weed management. Peer 6:e5082. doi: 10.7717/peerj.5082.

Campbell, J., Rihn, A., and Khachatryan, H. (2020). Factors influencing home lawn fertilizer choice in the United States. HortTech. *30*:296-305.

Carey, R. O., Hochmuth, G. J., Martinez, C.J., Boyer, T. H., Nair, V. D., Dukes, M.D., Toor, G.S., Shober, A.L., Cisar, J. L., Trenholm, L.E., and Sartain, J. B. (2012). A review of turfgrass fertilizer management practices: implications for urban water quality. HortTech.*22*: 280-291. https://doi.org/10.21273/HORTTECH.22.3.280>.

Doxon, L. E. (1996). Landscape sustainability: environmental, human, and financial factors. HortTech. 6: 362-365.

Folorunso, O., Rolston, D., Prichard, P., and Louie, D. (1992). Cover crops lower soil surface strength, may improve soil permeability. Hilgardia 46:6:26-27. DOI:10.3733/ca. v046n06p26

Hillel, D. (2004). Soil temperature and heat flow, p. 215-233. Introduction to Environmental Soil Physics. Elsevier Academic Press, San Diego, CA.

Holmes, T. R. H., Owe, M., De Jeu, R. A. M., and Kooi. H. (2008). Estimating the soil temperature profile from a single depth observation: a simple empirical heat flow solution, Water Resour. Res., *44*: W02412, doi:10.1029/2007WR005994.

Kahimba, F.C., Sri Ranjan, R., Froese, J., Entz, M., and Nason, R. (2008). Cover crop effects on infiltration, soil temperature, and soil moisture distribution in the Canadian prairies. Appl. Engineer. Agricult. *24*: 321-333.

Khachatryan, H. (2020). Landscape aesthetics and maintenance perceptions: assessing the relationship between homeowners' visual attention and landscape care knowledge. Land Use Policy *95*:104645.

Krohn, N.G., and Ferree, D.C. (2005). Effects of low-growing perennial ornamental groundcovers on the growth and fruiting of `Seyval Blanc' grapevines. HortSci. *40*:561-568.

Merwin, I. A., Stiles, W.C., and van Es, H. M. (1994). Groundcover management impacts on soil physical properties. J. Amer. Soc. Hort. Sci. *119*:216-222.

Michelsen-Correa, S., and Scull, P. (2005). The impact of reforestation on soil temperature. Middl. States Geograp. *38*:39-44.

Song Y. T., Zhou, D. W., and Zhang, H. X. (2013). Effects of vegetation height and density on soil temperature variations. Chin. Sci. Bull. *58*:907–912. doi: 10.1007/s11434-012-5596-y

Steinberg T. (2005). Lawn and landscape in world context, 1945-2000. OAH Maga. Hist. *19*:62-68. doi:10.1093/maghis/19.6.62

Van Huyssteen, L., Van Zyl, J.L., and Koen, A. P. (2017). The effect of cover crop management on soil conditions and weed control in a Colombar vineyard in Oudtshoorn. S. Afri. J. Enolog. Viticul. *5*:1. https://doi.org/10.21548/5-1-2364

Wang, D., Shannon, M.C, Grieve, C.M., Yates, S.R. (2000). Soil water and temperature regimes in drip and sprinkler irrigation, and implications to soybean emergence. Ag. Water Manage. *43*:15-28.

Wu, J., Tang, C. S., Shi, B., Gao, L., Jiang, H. T., and Daniels, J. (2014). Effect of ground covers on soil temperature in urban and rural areas. Environ. Engineer. Geosci. *20*:225-237. 10.2113/gseegeosci.20.3.225.

Zhang, M., Li, Y., Liu, J., Wang, J., Zhang, Z., and Xiao, N. (2022). Changes of soil water and heat transport and yield of tomato (*Solanum lycopersicum*) in greenhouses with micro-sprinkler irrigation under plastic film. Agron. *12*:664. https://doi.org/10.3390/agroomy12030664