High resolution root-zone soil moisture (SM) maps are important for understanding the spatial variability of water availability in agriculture, ecosystems research and water resources management. Unmanned Aerial Systems (UAS) can flexibly monitor land surfaces with thermal and optical imagery at very high spatial resolution (meter level, VHR) for most weather conditions. We modified the temperature–vegetation triangle approach to transfer it from satellite to UAS remote sensing. To consider the effects of the limited coverage of UAS mapping, theoretical dry/wet edges were introduced. The new method was tested on a bioenergy willow short rotation coppice site during growing seasons of 2016 and 2017. We demonstrated that by incorporating surface roughness parameters from the structure-from-motion in the interpretation of the measured land surface-atmosphere temperature gradients, the estimates of SM significantly improved. The correlation coefficient between estimated and measured SM increased from not significant to 0.69 and the root mean square deviation decreased from 0.045 m³·m⁻³ to 0.025 m³·m⁻³ when considering temporal dynamics of surface roughness in the approach. The estimated SM correlated better with in-situ root-zone SM (15–30 cm) than with surface SM (0–5 cm) which is an important advantage over alternative remote sensing methods to estimate SM. The optimal spatial resolution of the triangle approach was found to be around 1.5 m, i.e. similar to the length scale of tree-crowns. This study highlights the importance of considering the 3-D fine scale canopy structure, when addressing the links between surface temperature and SM patterns via surface energy balances. Our methodology can be applied to operationally monitor VHR root-zone SM from UAS in agricultural and natural ecosystems.