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Rationalising the use of ^{13}C stable isotope & leaf temperature in screening of coffee variety for drought stress

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Abstract

Determining the critical thresholds for drought stress in perennial crops such as coffee is a significant challenge. ^{13}C isotope measurements of coffee leaves offer assessment of stress by tracking intrinsic changes. In addition, using leaf punch samples for ^{13}C measurements can enhance efficiency and reduce costs by eliminating the grinding process. Despite this, the use of isotopes to monitor drought stress in coffee remains limited. To note, isotopic sampling requires homogeneity to yield representative results. Therefore, documenting variations in the ^{13}C values of coffee leaves and developing a ^{13}C homogeneous sampling method tailored to the coffee is crucial. This study was conducted on 13 Robusta varieties, including six commonly grown old clones and seven Kitunza Resistant varieties (KRs). The six old clones are each on a 16-year-old 15×15 m trial plot while the KRs on a four-year-old 12×12 m plot, at the Kaweri Coffee plantation in Mubende, Central Uganda. The specific objectives of this study were to determine (i) which leaf provides the best indication of water stress, (ii) whether the leaf temperature in young leaf pairs is higher than that of other leaf pairs and, (iii) whether clones are more drought-resistant than KRs. Leaf temperature was measured before and after midday from young, below the young, and old leaf pairs (left and right). Leaf punch samples were collected from the apex, middle, and rare lamina on the same leaves. The findings reveal that ^{13}C is significantly ($p < 0.01$) different across different leaf age and variety. ^{13}C , leaf temperature, and Crop Water Stress Index (CWSI) are confirmed to serve as indicators of drought stress in coffee trees. Drought stress significantly influenced the ^{13}C and CWSI values. Notably, there was a significant difference in ^{13}C ($0.89 \pm 0.2\%$, $p < 0.001$) and predawn CSWI (0.14 ± 0.02 , $p < 0.001$) between the dry and rainy seasons. Old leaves exhibited higher ^{13}C values ($28.35 \pm 0.1\%$, $p < 0.01$) and CWSI (0.53 ± 0.2) values than young leaves.

Keywords: ^{13}C discrimination, drought stress, leaf temperature, Robusta, variety screening

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