COFFEE CROP COEFFICIENT PREDICTION AS A FUNCTION OF BIOPHYSICAL VARIABLES IDENTIFIED FROM RGB UAS IMAGES

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INTRODUCTION

- The irrigation has provided an increase in productivity
- For a better quantification of the amount of irrigation to be applied, the coffee water intake is estimated mainly by the use of climatological variables, with the crop coefficient (Kc)
- Several varieties of coffee, planting systems, and sizes exist; therefore, a single value of Kc should not be established, and agronomic experiments are needed.
- The present study aimed to develop a methodology for estimating the crop coefficient (Kc) in the short term by using relationships between Kc and biophysical parameters of coffee plants (leaf area, plant density, and weed management); this was achieved by using data already available in the literature and comparing it to Kc determined from RGB (Red, Green, Blue) UAS image data and from field data.

MATERIALS AND METHODS

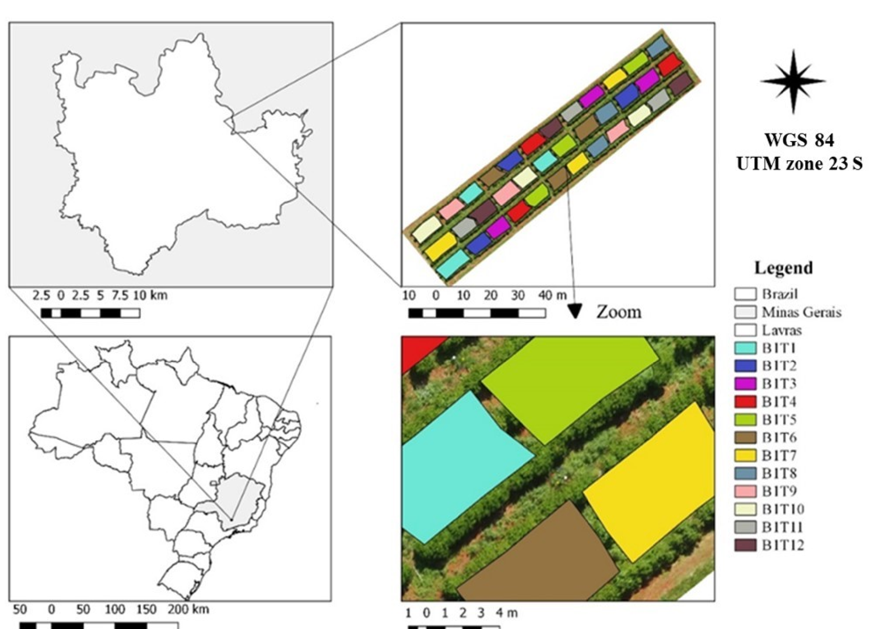

Figure 1. Study area location and treatment delimitation.

- The study was conducted in June 2017 and May 2018 in a 0.4 ha Travessia cultivar coffee plantation Fig. 1
- The tree height measurement (hm) data and the crown diameter measurement (dm) data were collected in the same period of image acquisition.
- We selected 144 plants, following the sampling methodology proposed by Ferraz et al. (2017).
- For the Leaf Area Index (LAI) was used, as reported by Favarin et al. (2002) Eq. (1)

$$LAI = 0.0134 + 0.7276 \times D_c{}^2 \times h \qquad (1)$$

where: Dc - crown diameter (m) and h - plant height (m)

- For Leaf Area (LA), Eq. (2) was used:

$$LA = LAI * (DR * DP) \qquad (2)$$

where: DR - Distance between rows (m) and DP - Distance between plants (m)

- For the estimation of the crop coefficients (Kc), Eq. (3) was used, as proposed by Villa Nova et al. (2002):

$$Kc = 0.347 \times LA \times \left(\frac{Np}{10000}\right) + kcd \times \left(1 - \frac{0.785 D_c{}^2}{DP \times DR}\right) \qquad (3)$$

where: Np - Number of plants (0.641 plants ha-1); LA - Leaf Area; Dc - Crown diameter (m); DR - Distance between rows (m); DP - Distance between plants (m), and Kcd - Crop coefficient representative of the plant cover between rows (Kcd = 1 in the presence of transpiring vegetation cover, and Kcd = 0.5 absence of transpiring vegetation cover).

- Electronic spreadsheets were used to calculate Kc and organize the data, and the GeoDA free software was used for the spatial analysis (Anselin, 2006).
- Moran's global autocorrelation Index (I) proposed by Bailey and Gatrell (1995) describes the spatial arrangement of objects given by Eq. (4):

$$I = \frac{n}{W} \times \frac{\sum_i \sum_j W_{ij} z_i z_j}{\sum_i z_i{}^2} \ \forall\, i \neq j \qquad (4)$$

- The regression and correlation of the Kc data obtained in the field and by the UAS were performed using the average of the four plants from each block.
- The Root Mean Square Error (RMSE) were also calculated. The descriptive statistical analyses were performed in the statistical software R (R Core Team, Vienna, Austria).

RESULTS AND DISCUSSION

- The correlation was strong, with Pearson correlation coefficient with R equal to 0.85, coefficient of determination (R^2) equal to 0.73 was found for the Kc values in June 2017. In May 2018 Pearson correlation coefficient with R equal to 0.89, the coefficient of determination (R^2) equal to 0.79 was found for the Kc values (Fig. 2).

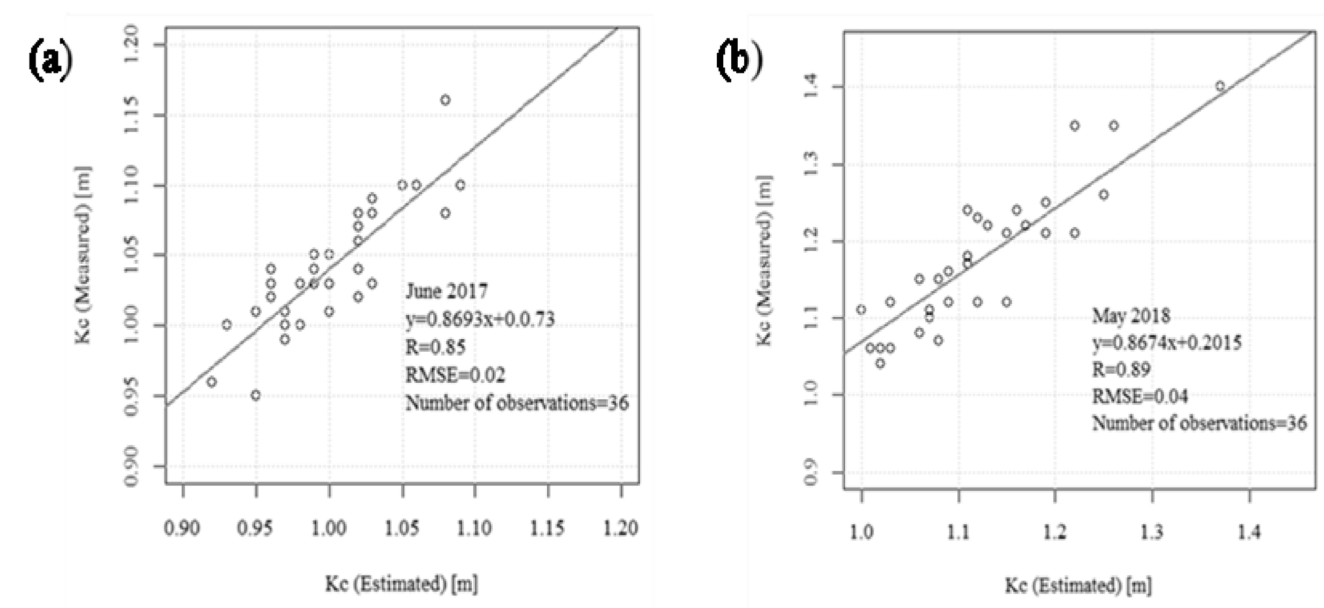

Figure 2. Regression between Kc data measured in the field and obtained by the UAS. a) of June 2017 and b) of May 2018.

- Through linear regression, Eq. (5) is proposed to correct the coffee Kc data estimated from the UAS image, with the correlation of 72 numbers of observations, with an R value equal to 0.93 and a coefficient of determination (R^2) equal to 0.86.

$$Kc_m = 0.9618 \times Kc_e + 0.0879 \qquad (5)$$

- Kc map (Fig. 3) was proposed based on the biophysical characteristics of the coffee plants, following the methodology proposed by Villa Nova et al. (2002) and using UAS data.

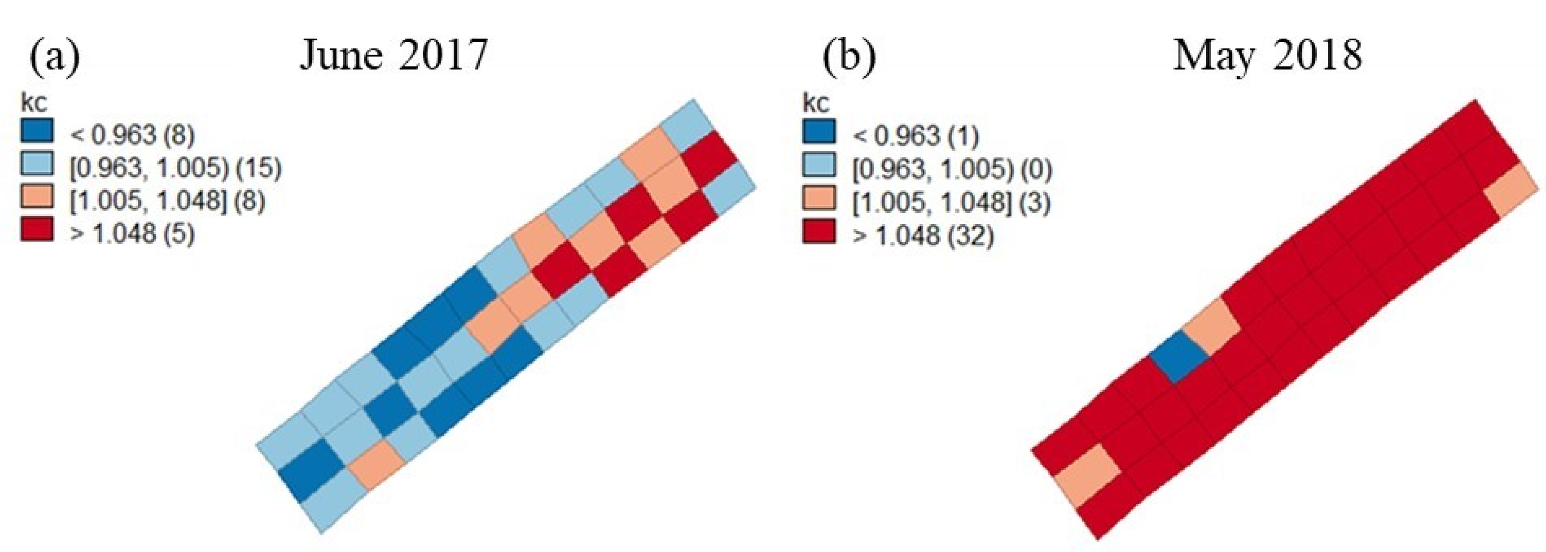

Figure 3. Kc map for the months (a) of June 2017 and (b) May 2018.

CONCLUSIONS

- This study developed a methodology for estimating Kc using biophysical data obtained remotely, being an indirect methodology of obtaining data and in a non-destructive way.
- The estimate showed a strong correlation, R of 0.93, making it possible to estimate the Kc of the coffee plant from the Kc data obtained by the aircraft. In addition, the Kc values found in the study ranged from 0.96 to 1.0 in the vegetative period and from 1.05 in the reproductive period.
- The data found were consistent with the literature; thus, this method is useful for estimating Kc and for assisting in irrigation management of coffee crops.

ACKNOWLEDGEMENTS

NESA Núcleo de Estudo de Sistema Agrícola · UFLA Universidade Federal de Lavras · FAPEMIG · CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico · CAPES · Università degli Studi Firenze