Moisture content determination for several Eucalyptus wood by NIRS: monospecific PLS models vs multispecies model

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MC (moisture content) of wood is crucial for the transformation sector. MC vary widely because of its highly anisotropic characteristics which has a direct influence on physical and mechanical properties, both as a raw material and when utilized in various forest products as lumber, paper, charcoal and composite panels. The MC determination can be estimated by NIRS associated to non-destructive sampling. Hence, with this objective, we built global NIRS models for MC by using Eucalyptus multispecies datasets from Brazil. We tested MC variability and NIRS to build robust MC model.

Experience

- We collected wood disks on 8 to 25 year-old C*orymbia maculata, Eucalyptus grandis, E. resinifera,* and *E. cloeziana* trees (10 per species). Diametric bands cut from the disks were divided in 15 x 20 x 20 mm samples. They were theoretically stabilized at 8, 10, 12, 14, 16, and 18% of MC. At each MC, we measured spectra on the same sanded longitudinal face and their weight. Spectra were measured under diffuse reflection using integration sphere of a Bruker MPA spectrometer, each spectrum constituted of 32 scans. Spectral analysis was performed within the 9,000–3,500 cm^{-1} range at 8 cm^{-1} resolution.

- The mass of oven-dry wood per unit of volume of green wood is expressed in grams per cubic centimeter. Real MC was calculated by taking into account the dry weight data. We used Unscrambler software 10.[3] (Camo, Norway) for PLS regression for MC, for all species or separately. Cross-validations with 5 groups of random samples were performed to build the models for each species and for the global model (Table I). Then, we used test set validations randomly selected along the MC variability and compare model performances. Finally, we compared on validation test set for the 4 species, the predicted values both by specific models and global model.

Table I: Results of cross-validation and test set validation for moisture content NIR model according to species.

Species	Ncal	Min	Max	SD	RMSEC	RMSECV	R^2
E. grandis	288	9.0	17.0	1.91	0.41	0.42	0.95
E. cloeziana	216	11.7	21.6	2.11	0.78	0.83	0.84
C. maculata	216	10.0	16.9	1.82	0.51	0.53	0.92
E. resinifera	201	9.8	16.4	1.78	0.45	0.46	0.93
4 species	921	9.0	21.6	2.52	0.72	0.73	0.92

Results and discussion

The real MC varied from 9.0 to 21.6%. Global models for MC including the 4 species, showed in validation RPD = 3.5 with RMSEP value of 0.7% (Table II). Depending the species, the validation of specific models showed a RPD from 3.5 to 4.5 with lower RMSEP from 0.4 to 0.5% (Table I, Figure 1A). The local models (or specific models) were more reliable in terms of prediction error than the global model (Figure 1B) in term of error of prediction because the local method appears to cope with the non-linearity and non-homogeneity associated with a large multispecies dataset. This is consistent with approaches developed with local models. The comparison between predicted values by local and global models showed r^2 from 0.89 to 0.98 with standard error 0.4 to 0.6% (Figure 2).

Table II: Results of test set validation for moisture content NIR model according to species.

Species	Nval	Min	Max	SD	RMSEP	r^2	RPD
E. grandis	71	9.2	16.2	1.87	0.41	0.95	4.5
E. cloeziana	53	12.8	20.2	1.93	0.55	0.96	3.5
C. maculata	53	10.1	16.65	1.77	0.50	0.92	3.5
E. resinifera	50	9.93	16.29	1.80	0.48	0.93	3.7
4 species	231	8.85	20.59	2.51	0.71	0.92	3.5

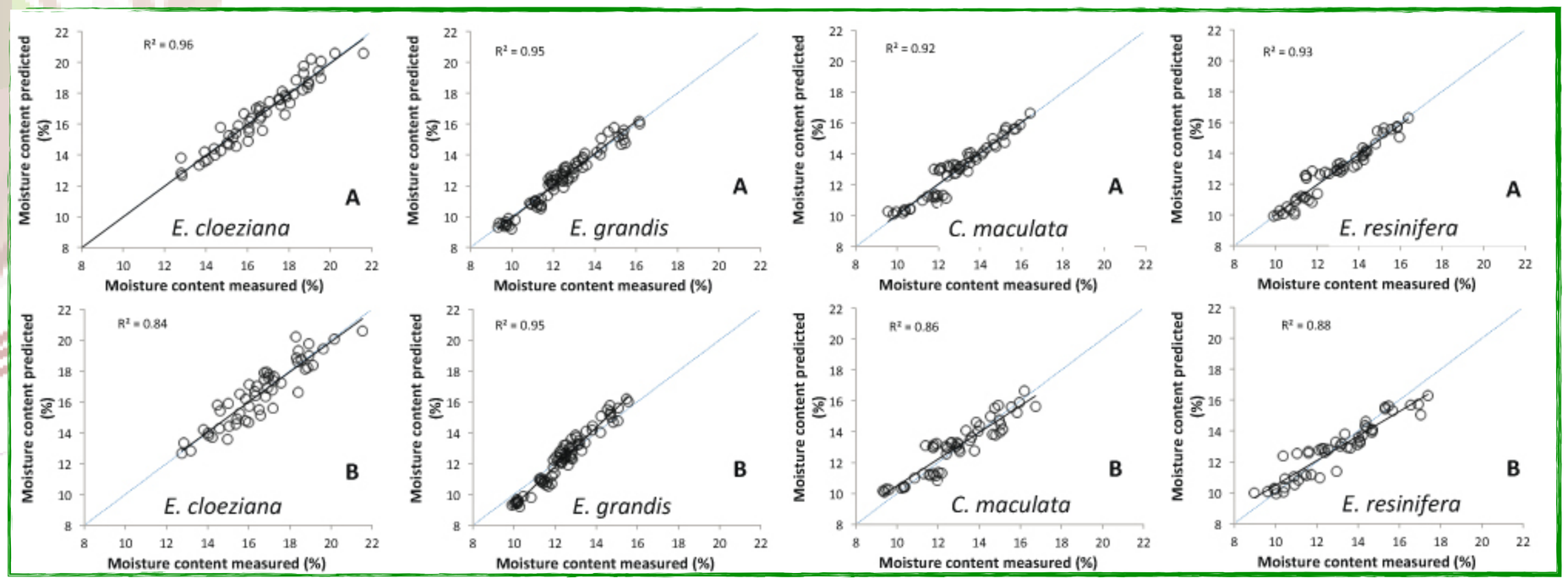

Figure 1: Comparison of measured values and predicted values by NIR (A: result of validation by test set with intra species calibration; B: result of validation by test set with multi-species calibration).

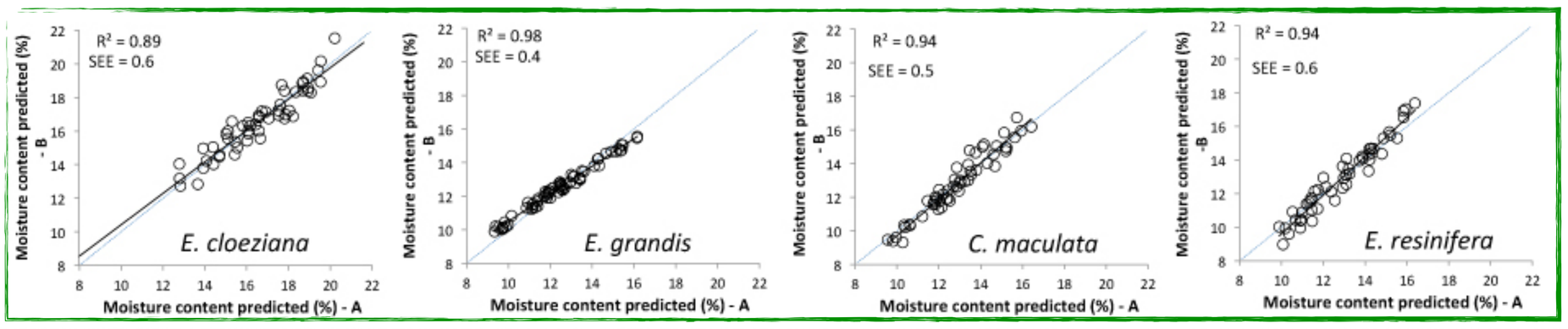

Figure 2: Comparison of predicted values by NIR with mono-species calibration (A) and multi-species calibration (B).

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