PROJECT TITLE

Phenotyping cadmium accumulation in Theobroma cacao L. towards mitigation by exploiting genetic differences between varieties

CONSORTIUM

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SUMMARY OF THE REPORT

Cadmium (Cd), a heavy metal that can accumulate in plants and be stored in their edible parts, poses a great threat to food safety and human health. Cacao (*Theobroma cacao* L.) is an accumulator of Cd, which is absorbed and stored in roots, shoots and beans. Cacao beans are a main ingredient in the production of chocolate and other confectionery. Beans from Latin America and the Caribbean (LAC) have elevated Cd due to high Cd soils, and is a source for Cd entering the food chain which is an important food safety issue. Furthermore, the European Union has implemented maximum allowable limits for Cd in chocolates. This has limited the export of beans from LAC into the EU market, affecting the livelihood of thousands of small-holder cacao farmers in LAC who depend on exporting fine/flavour cacao to Europe, as well as the European manufacturers who use the imports to produce premium quality chocolates.

The overall goal of this research is to reduce Cd accumulation in cacao beans through the identification of genetic markers linked to low Cd absorption and sequestration, from which molecular assays would be developed to rapidly screen varieties that can be used as rootstocks in the short term, and to support marker assisted breeding to develop new low-Cd varieties in the long term. The Cocoa Research Centre (CRC) is the custodian of the International Cocoa Genebank (ICGT), which has over 2400 cacao varieties, and is regarded as the largest and most diverse public cacao collection. The specific objective of this work was to screen cacao varieties from the ICGT to identify absorption and sequestration differences of Cd between varieties.

In the first phase of the project, which was supported by an EPPN 2020 grant, beans from 525 cacao varieties, representing the different cacao populations, were collected from the ICGT and bean Cd concentrations were determined using ICP-MS. In this second phase, Cd concentrations in the leaves of 493 varieties were analysed. Significant differences in leaf Cd were noted between varieties with more than a 10-fold difference between the highest and lowest leaf concentrations. Correlation analysis of leaf Cd from samples collected in 2013-14 and 2017-18, showed a moderate correlation in Cd levels, indicating that the concentrations in the leaves of the varieties were stable. Significant differences in Cd concentrations were observed between the leaf and bean (cotyledon and testa) fractions analysed. Cd was highest in the leaf, followed by the cotyledon and was lowest in the testa of the bean. Additionally, significant differences in Cd concentrations were also apparent between the different populations of cacao evaluated. Moreover, leaf Cd concentration strongly correlated with cotyledon Cd concentration (R= 0.71). Other strong correlations were observed among the other elements of the ionome in the leaf, cotyledon and testa. These findings are being used to identify markers linked to Cd accumulation in cacao.