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Evaluation of a visual vitality assessment to detect indicators for stress and yield for cacao

Background

- Pod development and harvest of cacao (*Theobroma cacao*) is stretched over the whole year. Assessing and evaluating internal and external yield determining factors is therefore complex and time intensive.
- Environmental surveys show that close observation of a variety of visually assessable vitality parameters (Fig. 1) could help to appraise quickly and non-destructively the complete physiological status of a tree. These parameters are used to detect stress factors such as diseases, pests and nutrient deficiencies and to forecast yield levels. In agricultural tree crops on the other hand, the term vigour so far mainly relates to maintenance efforts solely.
- The concepts of vigour and vitality are often used to define and describe the physiological condition of trees. Their definitions as well as methods on how to assess them, are numerous and vary considerably in their scope. For cacao no systematic assessment of tree vigour is known.

Figure 1a - d: Examples for vitality indicators for cacao: a) general tree vitality; b) dry leaves and dry twig tips; c) flowering; d) intactness of the bark

Objective

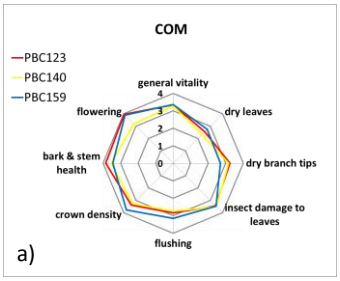
- To identify and measure suitable indicators of vitality
- To develop a tool to compare the physiological condition of cacao trees in quantifiable terms.
- The chosen vitality parameter(s) should
  - efficiently detect and reliably quantify stress factors
  - reliably show a high correlation with tree yield performance

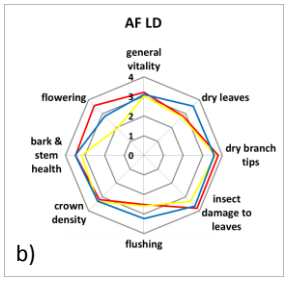
Material and methods

- In a randomized block field trial, situated on a commercial farm in peninsular Malaysia, the performance of cacao is evaluated under three production systems mainly characterised by diversification levels (mono culture (COM), low diversity agroforestry (AF LD) and high diversity agroforestry (AF HD)) on the basis of 3 clones.
- Visual assessments of vitality parameters was done half-yearly between June 2012 and December 2013 to develop the present method. Every tree was rated on a scale of 1 (low vitality) to 4 (high vitality) for each parameter. For evaluation the single parameters are displayed in spider diagrams.
- Overall vitality is evaluated by the single parameter 'general vitality' and by a biotic stresses score combining the external stress parameters 'dry leaves', dry branch tips', 'insect damage' and 'bark health', which are subjected to statistical tests (ANOVA with Tukey HSD post-hoc test).
- To assess influence of vitality parameters on yield performance we used Pearson correlations.

Table 1a, b: Assessment scores on tree vitality for three clones in three production systems on a scale of 1 (low vitality) to 4 (high vitality) of a) general vitality and b) biotic stresses in June 2013 (least squares means per production system and clone)

a)	COM	AFLD	AFHD	Ø
PBC 123	3.3	3.2	2.8	**3.1 a**
PBC 140	3.3	3.0	2.6	**3.0 a**
PBC 159	3.4	3.3	2.4	**3.0 a**
Ø	**3.3 a**	**3.2 b**	**2.6 c**	
b)	COM	AFLD	AFHD	Ø
PBC 123	3.3	3.5	2.9	**3.2 a**
PBC 140	3.1	3.2	3.0	**3.1 a**
PBC 159	3.1	3.6	3.1	**3.2 a**
Ø	**3.2 a**	**3.4 b**	**3.0 a**	





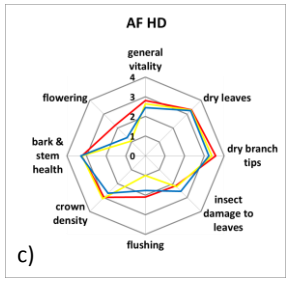


Figure 2a - c: Spider diagrams of the visually assessed vitality parameters for cacao in three examined production systems (COM; AF LD; AF HD) (data from June 2013; other dates not shown). Distinct differences between the production systems as well as between the three clones (PBC123; PBC140; PBC159) can be observed.

Results

- 8 different vitality parameters were assessed and evaluated (Fig. 2a – c). All parameters show distinct differences for both production systems and clones.
- The determination of general vitality by a single parameter allows the comparison of tree performance between production systems (Tab. 1a). A significant decline in vitality with increasing diversification can be observed.
- The biotic stresses score on the other hand, which focuses on the severity of external stresses mainly caused by pests and diseases, shows a small advantage for agroforestry systems (Tab. 1b).
- Flowering intensity in June 2013 (6 months before peak harvest), which is strongly correlated with general tree vitality (Chi^2 =66.0, p<0.0001), data not shown), correlates well with the following harvest (2013/14) (Fig. 3).

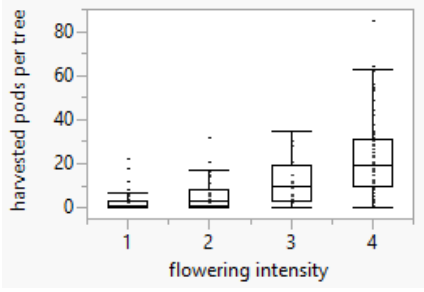


Figure 3: Flowering intensity in June 2013 qualifies as predictor of the total number of harvested pods in the following harvest 2013/2014.

Conclusion

- Monitoring stress levels plays an essential role part in good agricultural practices. Visual assessment of specific parameters relevant for cacao tree performance seems to be a reliable and relatively simple tool to identify potential problems.
- The correlation of tree vitality and yield parameter for the first assessment year is promising and will eventually allow us to predict tree yield performance for different production systems.
- In the 2nd phase of this field trial we will continue to evaluate and apply this approach.

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