Measuring P deficiency in maize leaves: comparing spectral and wet chemical measurements under tropical conditions

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Abstract:
Phosphorus (P) is an essential plant nutrient, limiting crop production in tropical conditions. P, unlike nitrogen (N), is a finite resource, meaning that it should be used sustainably to ensure supply in the future. To improve understanding of P application and uptake relations, measurements of P concentrations in plants are needed. Destructive measurements are however time consuming and costly. Recently, a spectral device ('Spectracrop plant vitality and P tester') was developed to measure chlorophyll a fluorescence in the field in a so-called OJIP transient as a measure of plant P status via non-destructive assessments. Until now, the P tester has only been tested for tomato and barley grown in temperate climate conditions. This study tested the device for maize grown under tropical conditions.
In Western Kenya a Nutrient Omission Trial experiment was set up in 2014 at six different locations. The experiment started with a control, PK, NK, NP and NPK treatment. After six seasons, each plot was subdivided in four subplots with a freshly imposed PK, NK, NP and NPK treatment. In total, each location thus contained twenty different fertiliser treatment combinations with a different nutrient management history, resulting most likely in a range of P deficiencies. In the long rain season of 2018, the ninth season, spectral measurements were taken and leave samples were collected from all locations and treatment plots, at four and seven weeks after planting (WAP). Measurements at four WAP were invalid as analysis of the OJIP transients showed that plants were heat or light stressed, resulting in an abnormal OJIP transient (Fig. 1). P

status could therefore not be predicted based on these measurements. At seven WAP measurements were taken in the very early morning to avoid heat and light stress. Samples of one field were wet chemically analysed and compared to plant P status predictions to test our hypothesis that the plant vitality and P tester was not predicting P status accurately for our field conditions.

Treatment old	Treatment new	P (µg / g) wet chemical	Spectral measurement
control	PK	2109	C
control	NK	797	A
control	NP	2238	B
control	NPK	2025	A
PK	PK	1899	C
PK	NK	1899	B
PK	NP	2595	B
PK	NPK	1990	B
NK	PK	1634	C
NK	NK	1200	A
NK	NP	1705	C
NK	NPK	1768	B
NP	PK	1550	C
NP	NK	1755	B
NP	NP	1859	C
NP	NPK	2307	A
NPK	PK	1918	B
NPK	NK	1484	C
NPK	NP	2169	C
NPK	NPK	2090	B

Table 1. Wet chemical P concentration and spectral P status measurements. Red, yellow and green indicate P status as very deficient, somewhat deficient and sufficient respectively

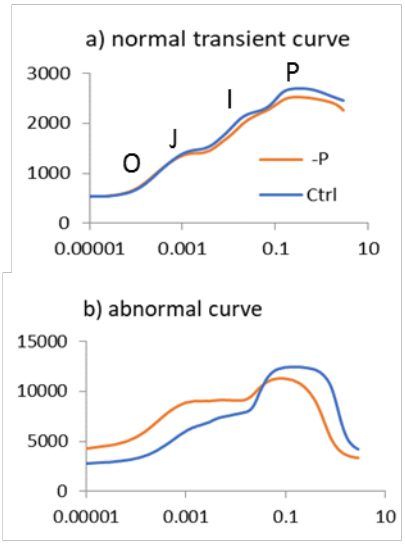

Figure 1. Normal transient curve (a) and abnormal transient curve (b). Blue and orange lines are transients of maize with sufficient and insufficient P respectively.

P tester values did not match wet chemical P concentration measurements (Table 1). Especially in plots where high P deficiency was measured with wet chemical analysis, P tester values were deviating (Table 1), while these are the most crucial situations to identify. So far we have no comprehensive explanation why the P tester was not able to assess plant P status accurately for maize in West Kenya. Most likely it was due to high temperature and high light intensity, which strongly affected the measurements even early in the morning, much more than is observed under temperate conditions. We therefore conclude that a re-analysis of the P tester values and comparison with the wet chemical measurements is necessary, to check whether re-interpretation or calibration of the measurements could lead to better P deficiency estimates with the P tester.