Carbohydrates as a nitrogen use efficiency indicator in cassava

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Introduction

With the increasing cost of fertilizers and rising environmental concerns, the effectiveness of nutrient application needs to be studied thoroughly for every crop, condition, and farming practice.

N improves radiation-use efficiency and promotes photosynthetic productivity (1). However, high levels of photosynthates, without corresponding transport, can signal that capacity for non-structural carbohydrates has reached its maximum.

N also promote vegetative growth, it increases the plant's shoot-to-root ratio (2), and could exhaust its transpiration capacity—supports high transpiration demand (3).

Hence, in a water-limited environment, high N levels could limit CO_2 intake (reduced stomatal conductance), and force plants to utilize their residual photosynthates in the canopy at the expense of root development and reproduction.

Thus, non-structural carbohydrate levels could indicate whether the N application matches the transpiration capacity of the plant.

Objective

To establish response of cassava to N and determine a physiological indicator to its effectivity on yields under fertigation

Materials and methods

The pot experiments were conducted in a greenhouse at Gilat Research Centre, Israel (31°20´ N and 34°39´ E). They were conducted in 2014 (Exp. 1) and repeated in 2015 (Exp. 2).

The treatments were 10, 40, 70, 100, 150 and 200 mg l^{-1} nitrogen (N). The concentration of N differentiated each fertigation solution treatment. The other minerals were held constant among treatments at 10 mg P l^{-1}, 100 mg K l^{-1}, 60 mg Ca l^{-1}, 30 mg Mg l^{-1}, 2 mg Zn l^{-1}, 0.3 mg Cu l^{-1}, 4 mg Mn l^{-1}, 3 mg B l^{-1}, 0.2 mg Mo l^{-1} and 8 mg Fe l^{-1}.

These treatments (replicated four times) were applied through uniform manual irrigation on 28-day old cassava planted in 60-l containers filled with perlite.

In the first 4 weeks, irrigation was 8 L per week; thereafter, it was increased by 1 L every week leading to a total of 227 and 357 L in 2014 (season 1) and 2015 (season 2) respectively at harvesting (at 120 and 158 days of treatment (DOT) in 2014 and 2015 respectively).

28-day old

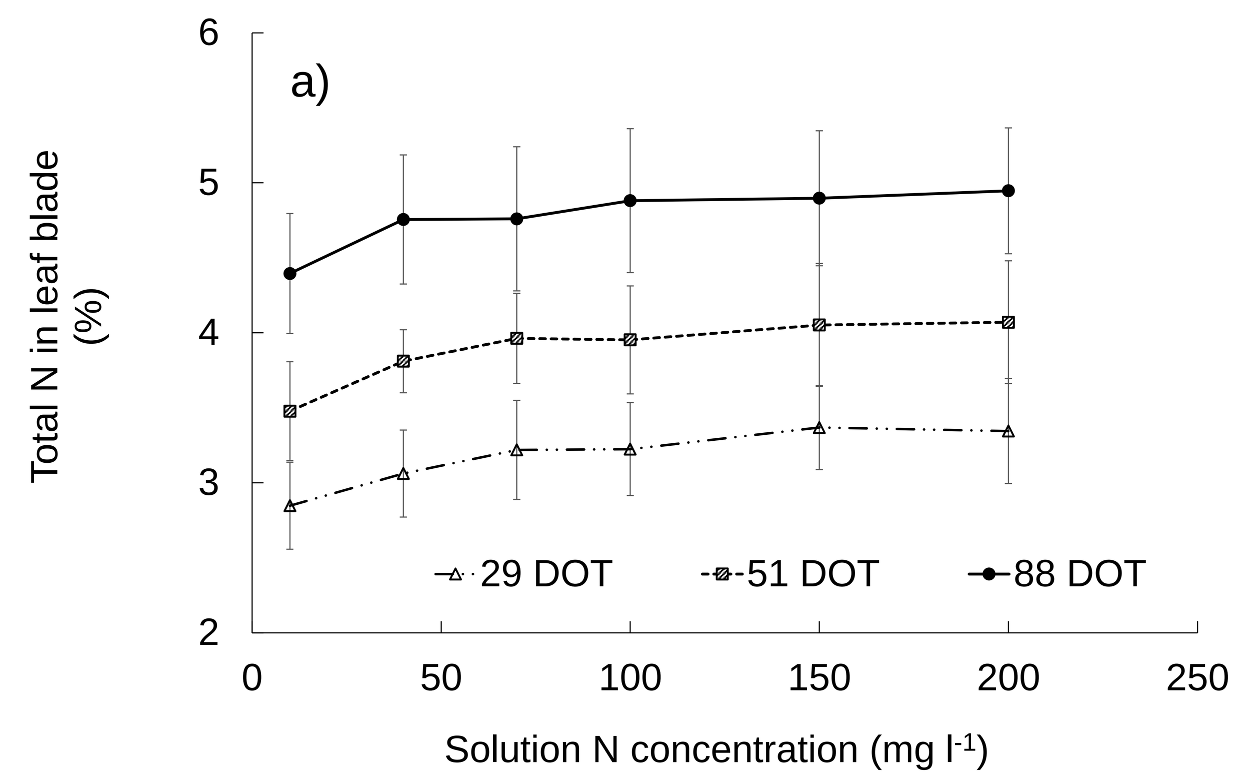
Field experiment consisting of various NPK combinations at International Institute of Tropical Agriculture (IITA), Lusaka, Zambia (15°30´ S and 28°30´ E).

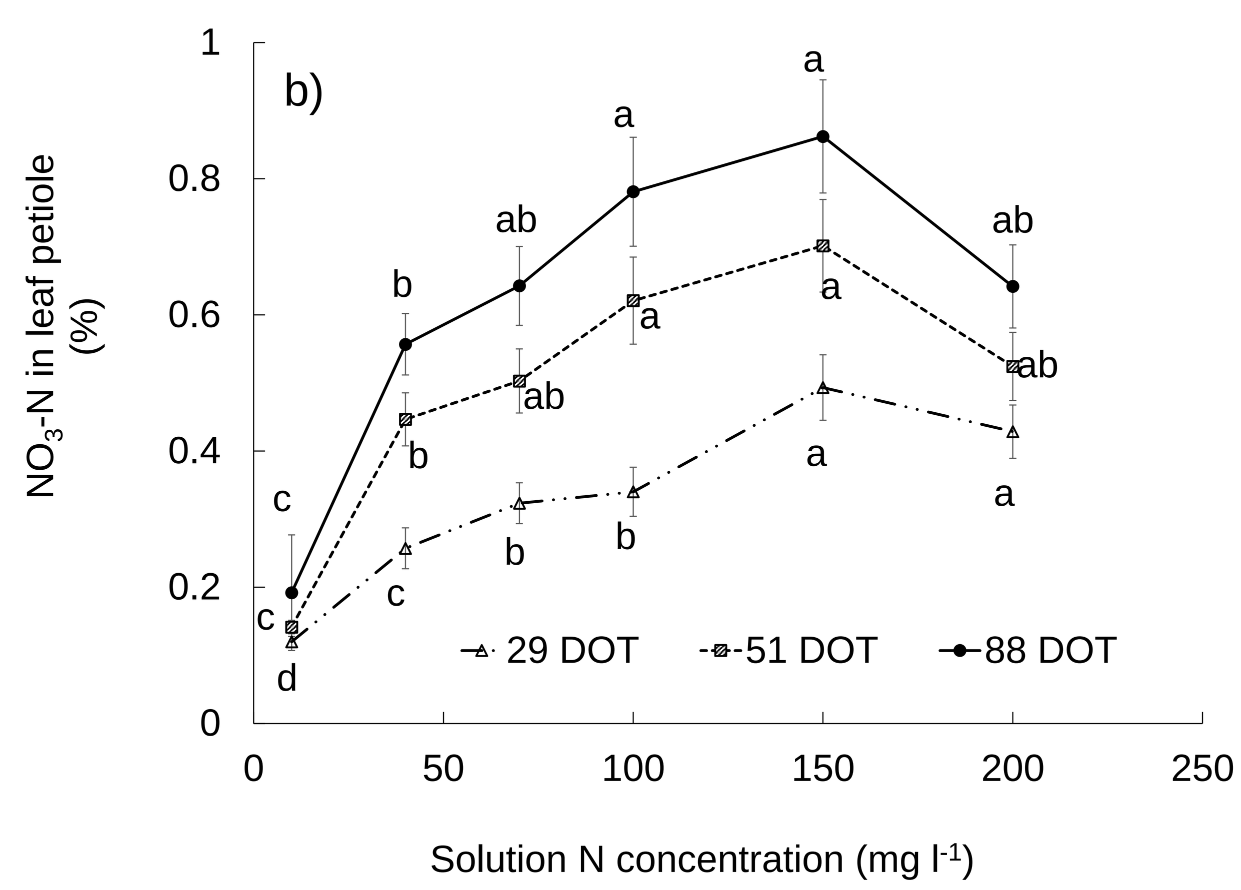
Results and Discussion

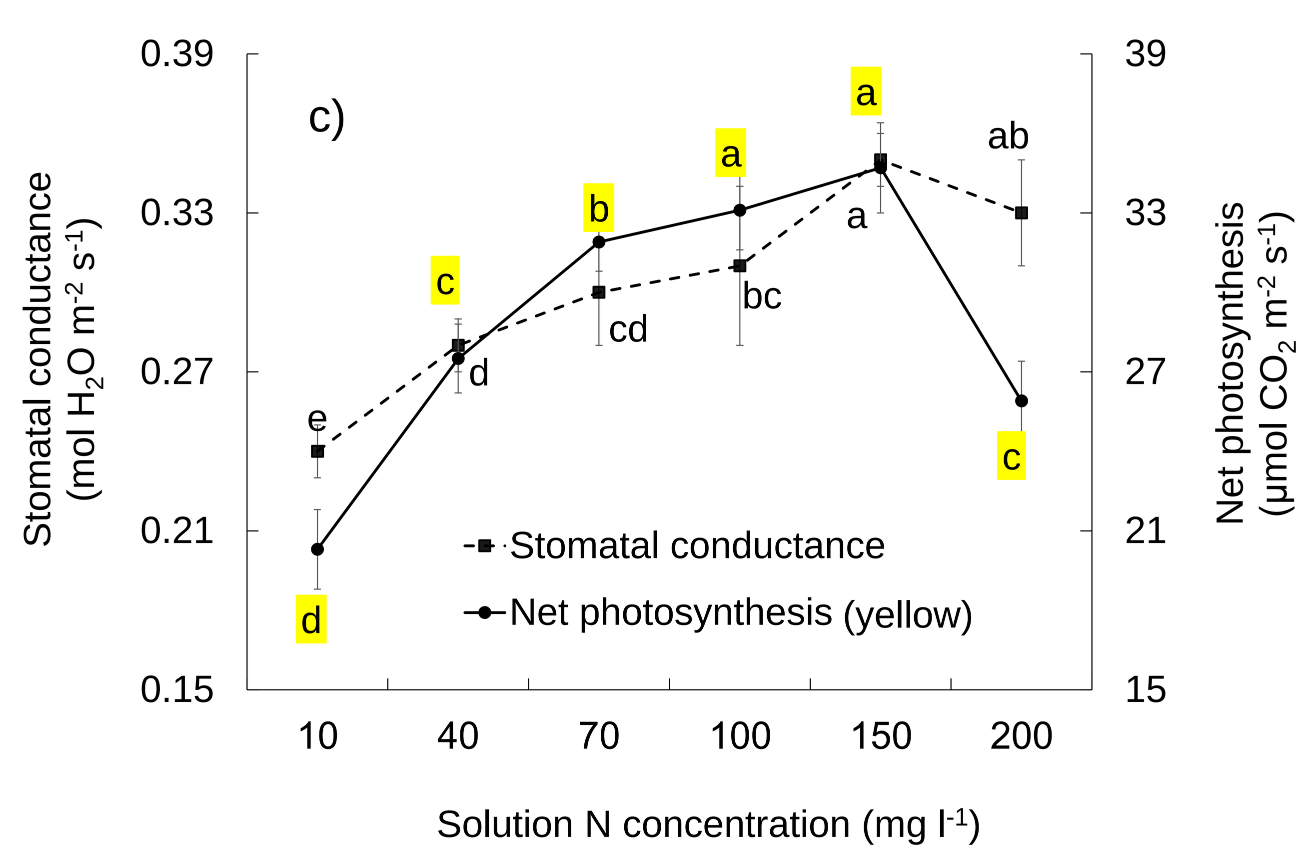
In both seasons, total N in leaf blade was not significantly different among N solutions (Fig 1a), while N-NO_3 in petioles significantly reached maximum at 150 mg N l^{-1} (Fig. 1b).

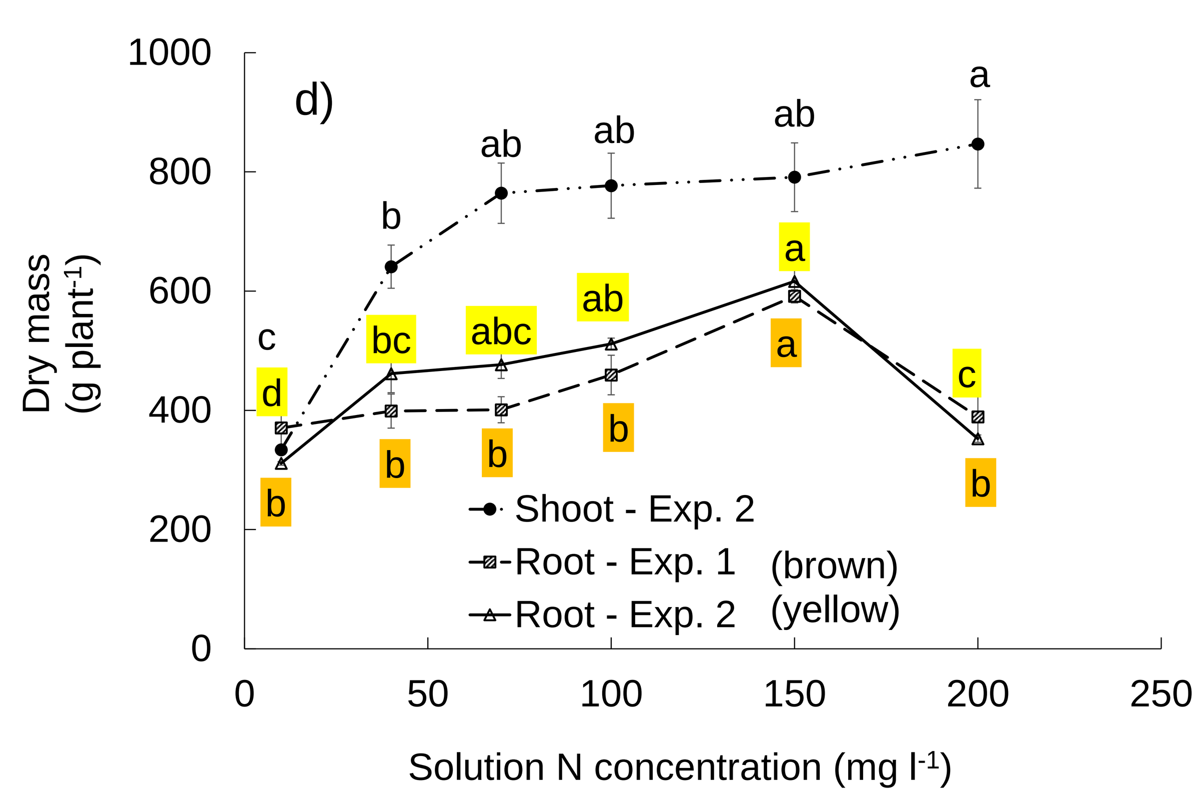
Also, from 10 to 70 mg N l^{-1} cassava increased photosynthesis and transpiration, but only to support the canopy's growth (Fig 1c). At 150 mg N l^{-1} cassava reached a threshold of sugar in the leaves (~49 mg g^{-1}), began to accumulate starch, and supported higher root yields (Fig 1d, e, f).

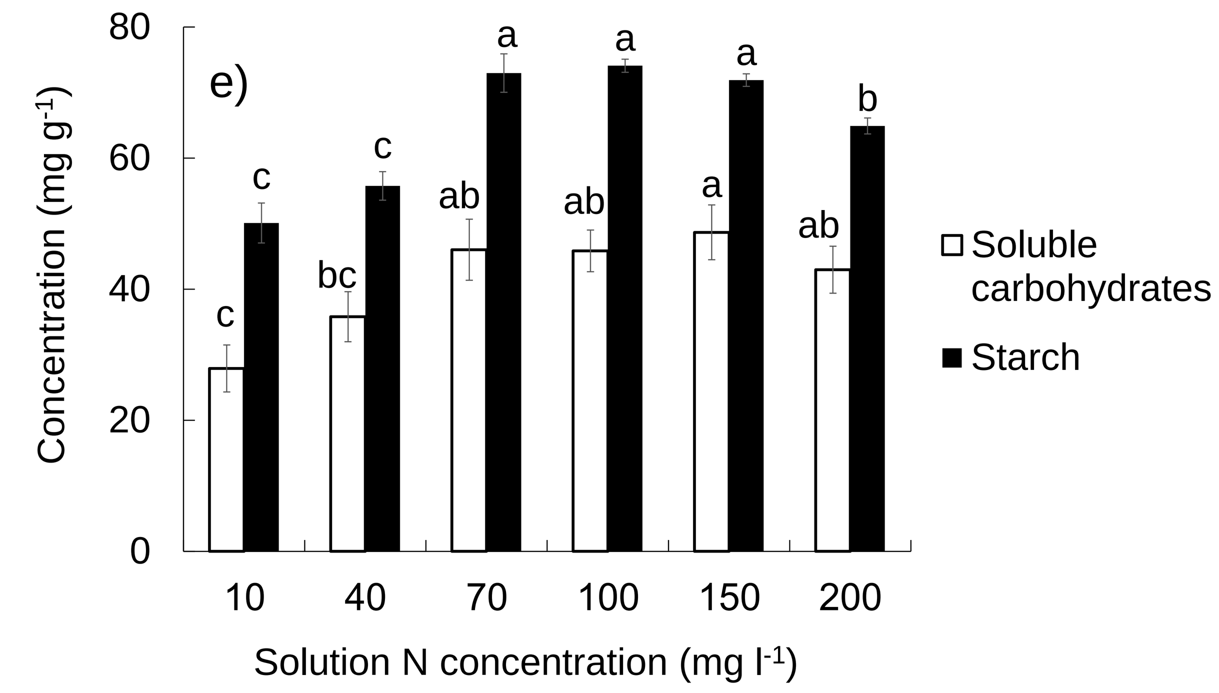
At 200 mg N l^{-1} water demand of the canopy increased causing restrained transpiration, reduced photosynthesis, less carbohydrates, and lower root yields.











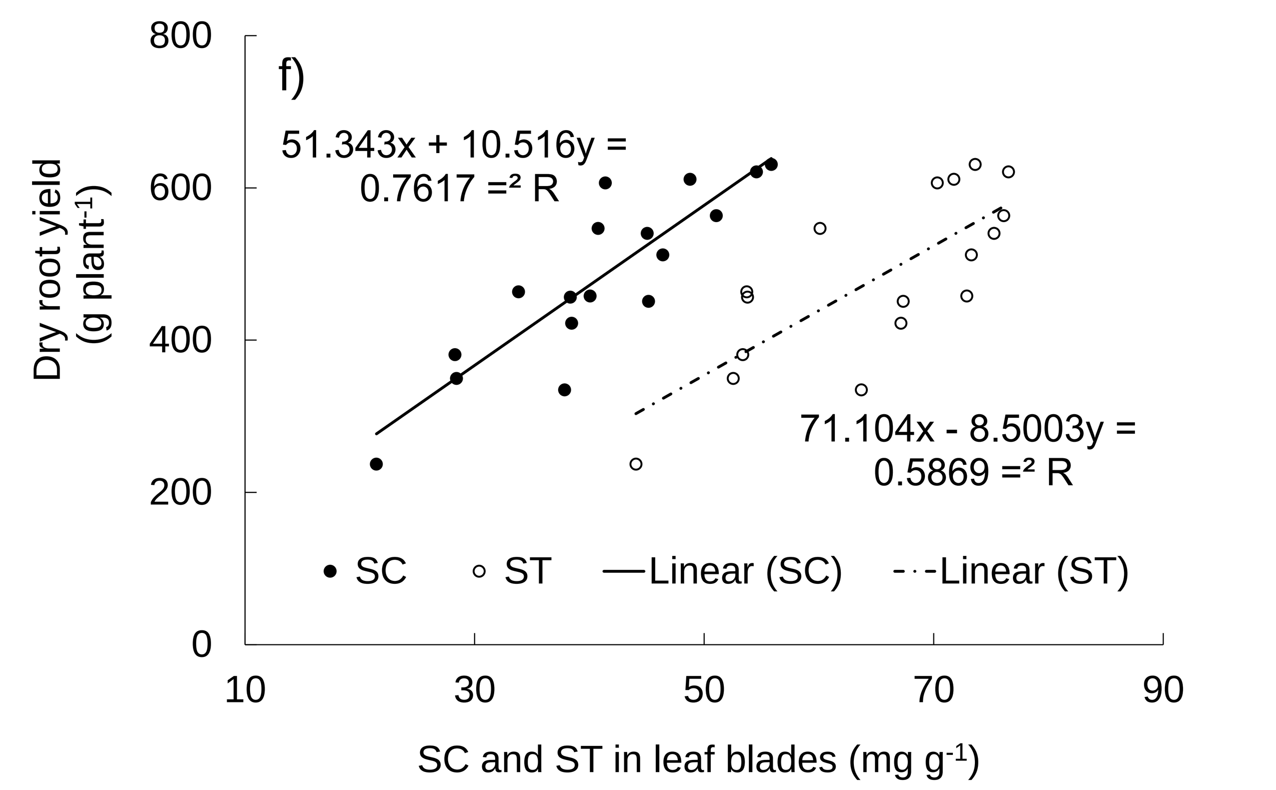


Fig. 1 Effect of fertigation of N on: a) Total N in leaf blades, b) N-NO_3 in leaf petioles, c) stomatal conductance and net photosynthesis, d) dry shoot and root yields, e) Soluble carbohydrates (SC) and starch (ST). f) relationship between SC, ST and dry root yield. DOT – days of treatment

Conclusion

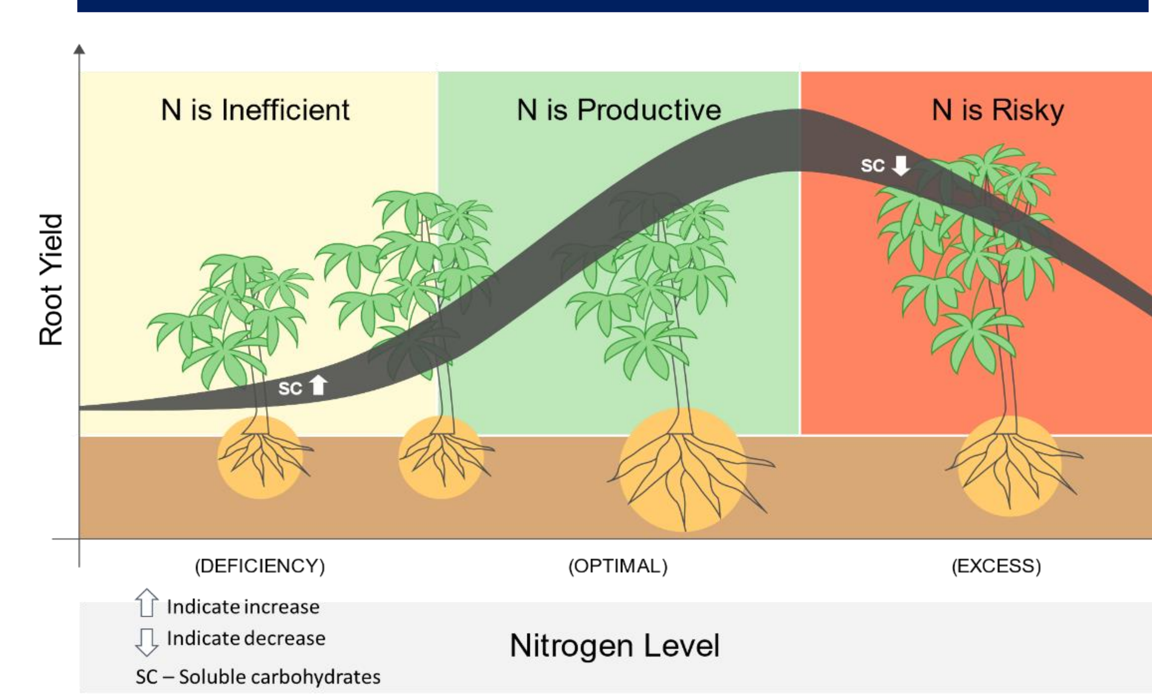


Fig. 2 Schematic summary of the three-phase response of cassava to N fertigation ranging from deficient to excessive. Line denotes the yield response, while its width represents changes in sugar (SC) levels in the leaves. Plant sizes illustrate the changes in root vs. shoot biomass and the background colours mark where N application is ineffective (yellow), productive (green), or wasteful and risky (red).

There are three phases of cassava's response to N that influence root yields: 1) growth that does not support root yields at low N, 2) productive N application, and 3) excessive use of N that depresses root yields.

While traditional assessments of N in the leaves failed to exhibit these responses, a simple and inexpensive carbohydrates analysis can determine whether N application is inefficient (possibly reducing farmers' profits) or is detrimental to root yields and a risk to the environment.

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4. African Development Bank (AfDB)

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