

The CocoaSoils Core Trials: setup and early growth in 10 large-scale on-station cocoa nutrient response trials



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Introduction

Quantifying nutrient requirements in perennials such as cocoa is challenging and requires long-term, large-scale experiments. The CocoaSoils programme established a global network of large-scale cocoa nutrient response trials to improve fertiliser recommendations.

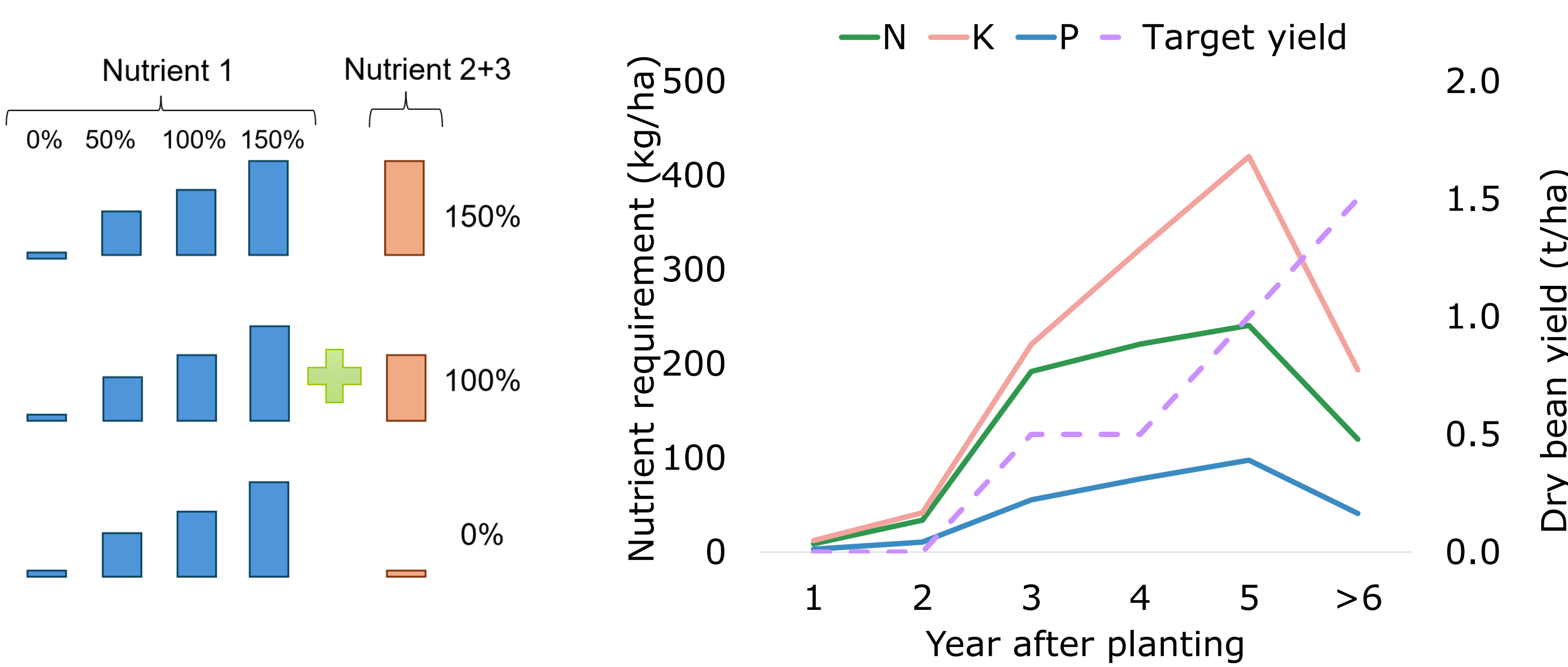


Figure 1. Experimental design of the CocoaSoils Core Trials.

Figure 2. Representative annual nutrient rates (@100% offtake) based on the offtake model, which incorporated vegetative growth and age-dependent target yields.

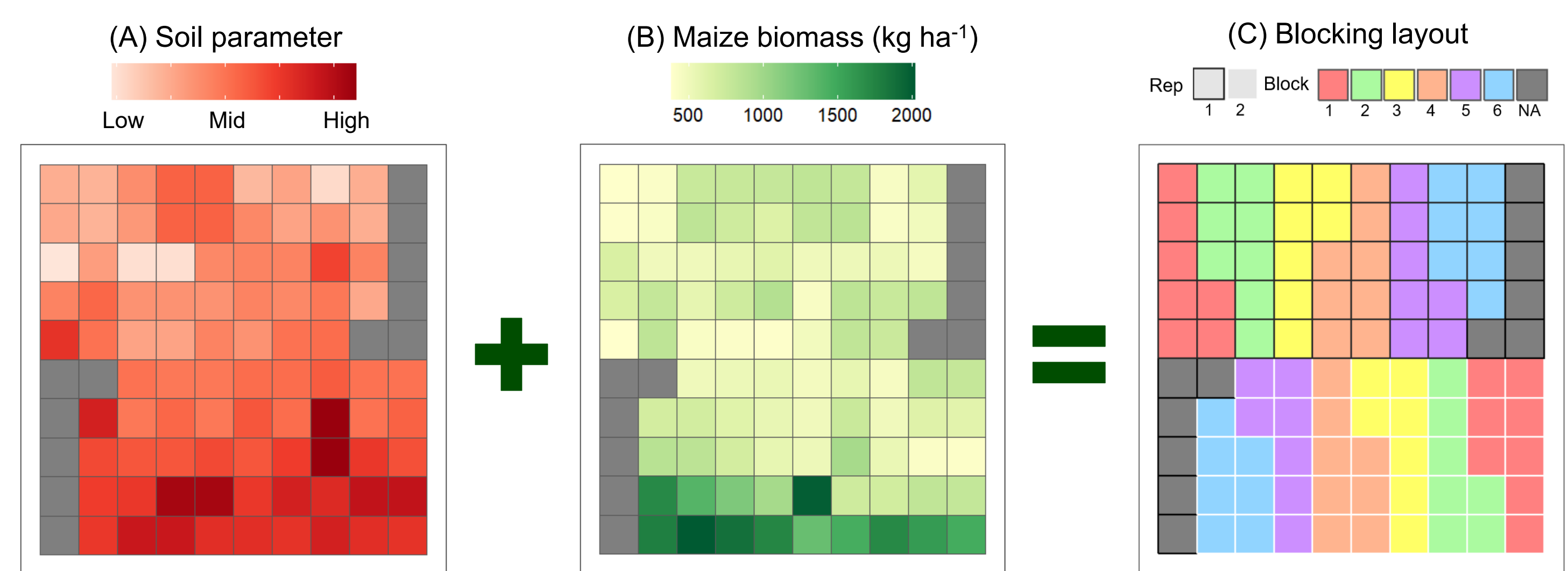


Figure 3. Visualisation of soil fertility using soil sampling (A) and maize biomass (B) for the blocking structure (C) of the Cameroon trial. Grey plots are excluded from the experiment.

Results

- Plot elevation had a greater effect on trunk basal area (BA) than N, P or K (Table 1 & Figure 5).
- Generally, plots with a lower elevation had larger BA than plots with a higher elevation. The effect was significant before fertiliser treatments were applied in 5 of the 7 Core Trials with pre-treatment data.
- The effects of N, P & K were site-specific (Table 1). The modelled BA (Figure 4) showed that:
 - K had a slight effect on vegetative growth 3 years after planting (YAP), and the relationship was linear.
 - The effects of P & N were only apparent after the 4th YAP.
 - The effect of P was linear after 4 YAP.
 - N followed a non-linear pattern: after 50% of the predicted N offtake, growth responses began to decline.

Table 1. Overview of the CocoaSoils Core Trials and growth responses*

Country/ Trial #	Elevation range (m)	Planting material	Planting date	Growth response			
				N	P	K	Elevation
Cameroon	671-678	Full-sib family	10/2020				-
Côte d'Ivoire 1	111-124	Hybrid	05/2020				+
Côte d'Ivoire 2	58-69	Clone & Hybrid	11/2020				
Côte d'Ivoire 3	103-108	Clones	11/2020				-
Ghana 1	220-230	Hybrid	10/2019				-
Ghana 2	182-214	Clone	06/2022				-
Nigeria 1	267-272	Clone	01/2020				
Nigeria 2	203-211	Hybrid	07/2019				+
Ecuador	60-68	Hybrid	11/2020	NA	NA	NA	-
Indonesia	46-51	Clones	08/2020				+

*Green cells indicate a significant nutrient and elevation effect from the linear mixed-effects model on trunk basal area at $p < 0.05$. +/- indicates the direction of the elevation effect. NA; no vegetative data have been submitted, and thus, no analysis was performed.

Materials & Methods

- The CocoaSoils program set up 10 long-term cocoa nutrient response trials in 6 countries (Table 1).
- Trials had a reduced factorial design with 4 levels of N, P & K (0, 50, 100 & 150% of predicted offtake; Figures 1 & 2).
- 30 N:P:K combinations were randomly assigned to 6 incomplete blocks with 2 replicates.
- Biomass of an unfertilized indicator crop (maize or plantain) and the results of soil sampling were used to inform the blocking structure of each Core Trial (Figure 3).
- Vegetative measurements were collected 2-3 times per year (Figure 4).
- Linear mixed-effects models were used for analysis.

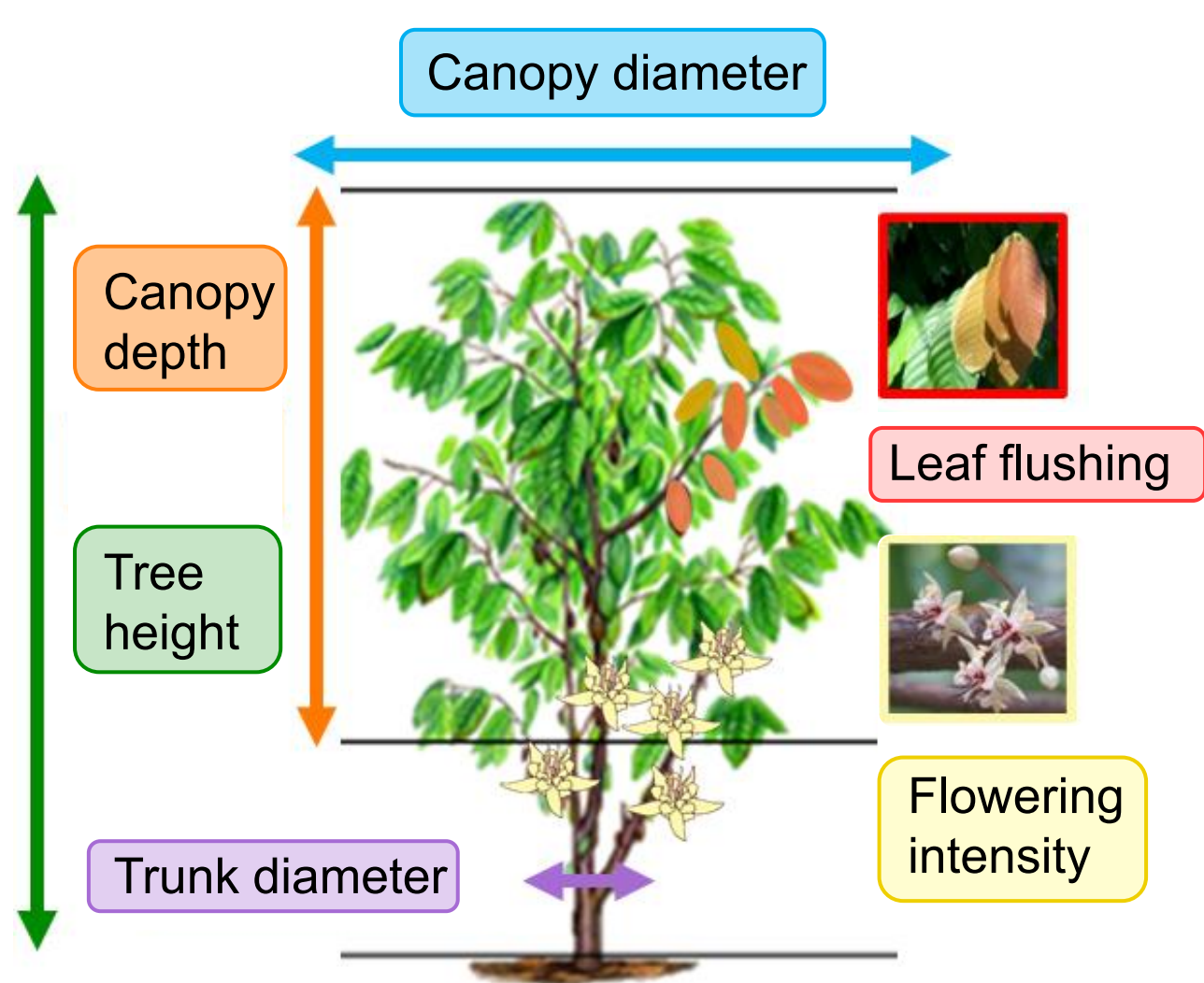


Figure 4. Vegetative measurements recorded for each Core Trial.

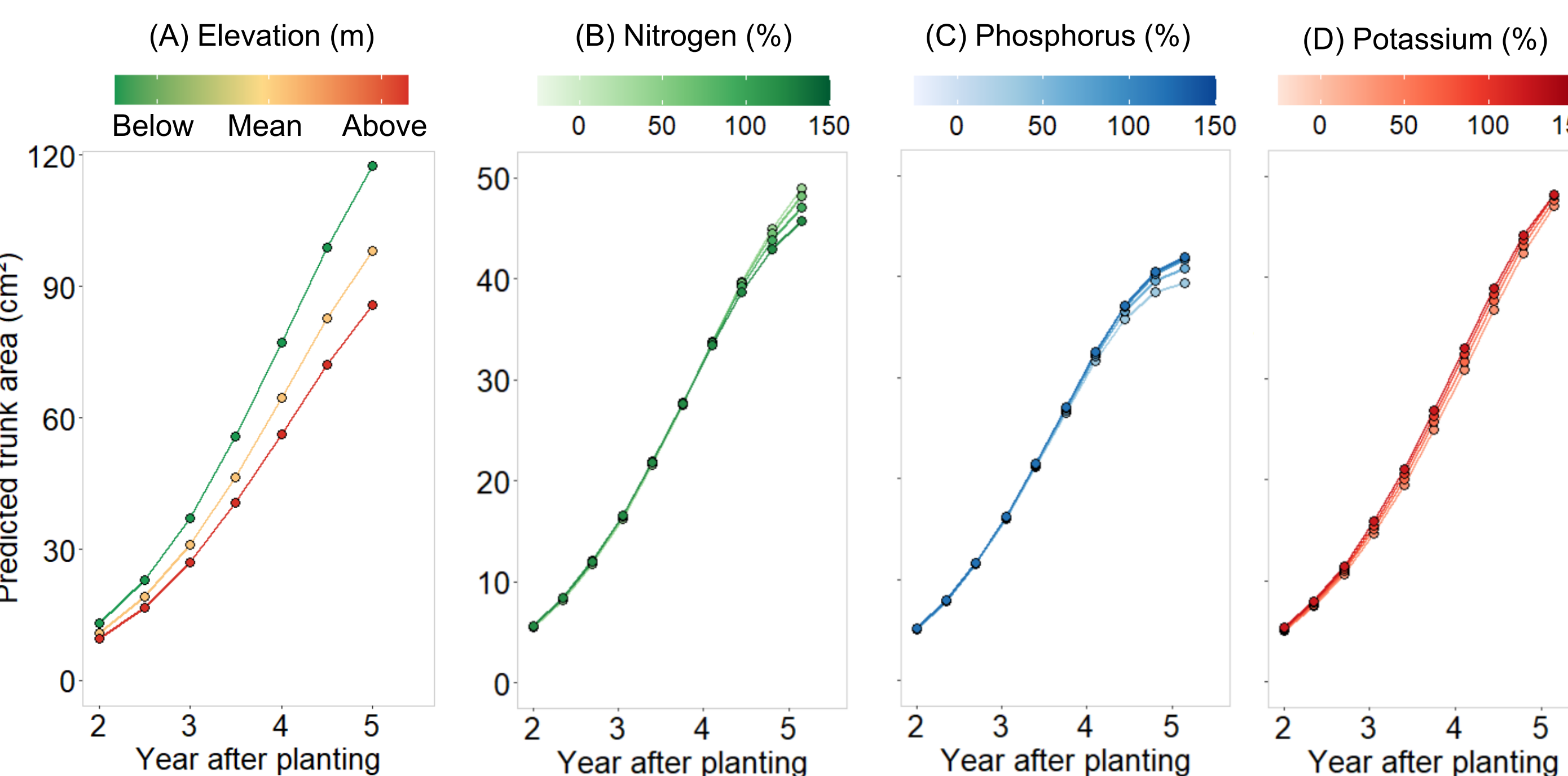


Figure 5. Modelled trunk basal area as a function of elevation (A), N (B), P (C), and K (D) levels. Elevation was standardised within each trial before analysis; all other model predictors were held at their mean values. Note: y-axis differs for elevation.

Summary

- Site characteristics had a stronger influence on growth than N, P, or K during the first five years after planting.
- K level showed a slight positive effect on predicted growth after year 3, while linear and non-linear effects of P and N were apparent after year 4, respectively. After 50% of the predicted N offtake, growth responses began to decline.
- Elevation influenced growth in most trials, although the direction of the relationship varied among sites, suggesting that elevation may serve as a proxy for local conditions.
- The CocoaSoils Core Trials have not yet reached peak yields. As nutritional effects begin to emerge in the fifth year after planting, continued monitoring of these trials is essential to refine fertiliser recommendations for cocoa further.