Understanding Variability in Maize Yield and Profitability under Fertiliser Microdosing Technology in Farmers' Fields in Northern Benin

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Introduction and objectives

- Fertiliser microdosing is currently promoted in semi-arid areas of sub-Saharan Africa as a means to increase crop productivity, profitability and resource use efficiency.
- However, little is still known regarding the main management and environmental factors that govern yield response to this technique in smallholder farmers' fields.
- The **specific objectives of our study** were: **(i)** to quantify the response of maize to fertiliser microdosing alone or combined with manure in smallholder farmers' fields, **(ii)** to determine the main factors that govern such responses and **(iii)** to evaluate the economic risk associated with each treatment based on the distribution of value-cost ratios.

Materials and methods

Study zone

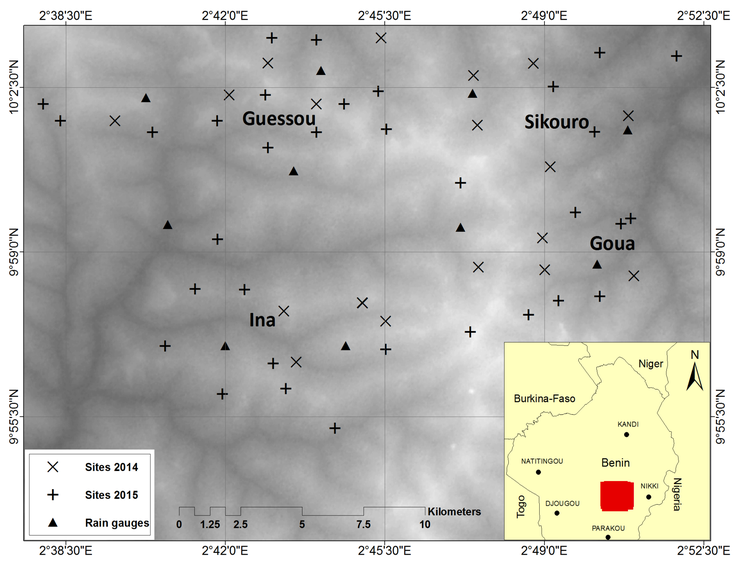
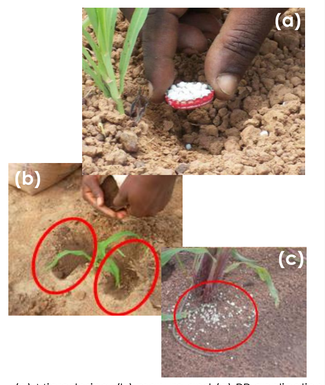


Fig. 1. Location of demonstration sites.

- **Ina district** (Municipality of Bembèrèkè, Northern Benin).
- **One rainy season:** May-October
- **Mean annual temperature:** 27.5 °C
- **Mean annual rainfall:** 900 and 1200 mm
- **Soils:** Lixisols (FAO classification)

Experimental design and treatments

- Multi-locational participatory farmer trials during two years (18 sites in 2014 and 32 in 2015) , one farmer field = one replicate with six treatments:
  - **i)** **Control** (no fertiliser, no manure),
  - ii) Microdosing option 1 (**M1**): 2 g NPK 15–15–15 per hill at 10-14 days after sowing, DAS) + 1g urea per hill at 45-50 DAS;
  - iii) Microdosing option 2 (**M2**): 4 g NPK 15–15–15 per hill at 10-14 DAS + 1g urea per hill at 45-50 DAS;
  - iv) M1 + hill-placed farmyard manure at 3t DM ha^{-1} (**M1+F**),
  - v) M2 + hill-placed farmyard manure at 3t DM ha^{-1} (**M2+F**) and
  - vi) Spot-placed recommended rate (**RR**): 200 kg NPK 15–15–15 ha^{-1} at 10-14 DAS + 100 kg urea ha^{-1} at 45-50 DAS.



(a) Microdosing, (b) manure and (c) RR application

- Maize (DMR-ESR variety) was planted at a density of 62,500 plants ha^{-1}.

Data collection and analysis

- ✓ Field history: previous crops, previous fertilization, distance from the village
- ✓ Soil and land characteristics, seasonal rainfall, cumulative rainfall between sowing and maturity, sowing date, weed pressure
- ✓ Maize grain yields (Gy),
- ✓ Economic analysis: [Value cost-ratio **VCR** = $\frac{(Gy_t - Gy_{control}) * \text{grain price}}{\text{Costs of fertilizer/+manure+labor}}$]

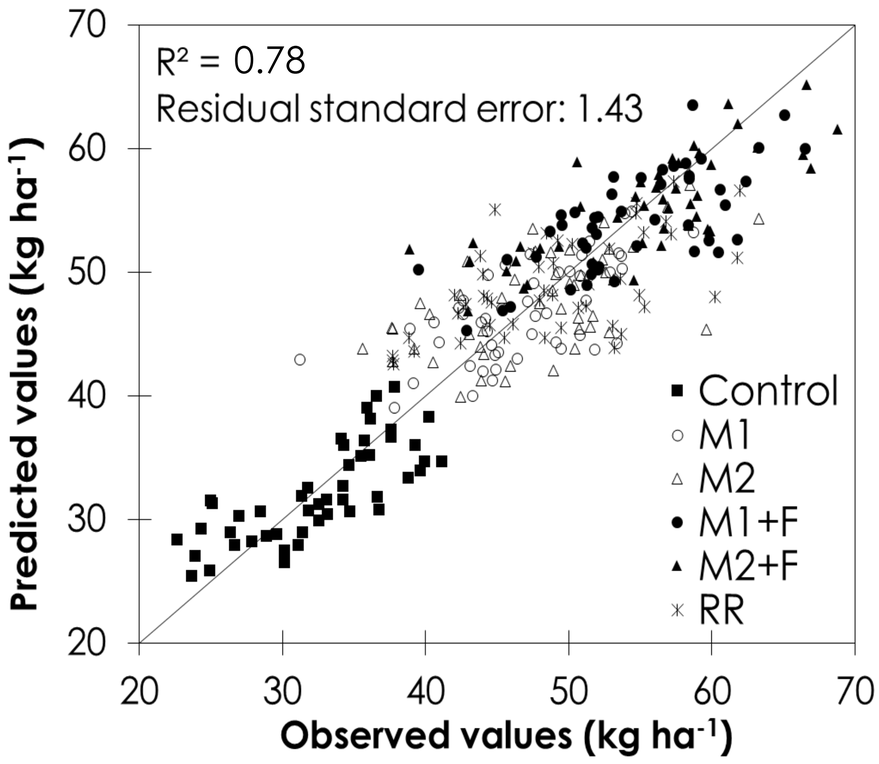
Results

Maize grain yields

Treatment	2014		2015	
	Mean	SD	Mean	SD
Control	1089a	264	1049a	351
M1	2240b	332	2183b	541
M2	2330b	343	2248b	677
M1+F	3072c	431	2889c	687
M2+F	3268c	206	3001c	862
RR	2590b	490	2319b	646
P value	***<0.001***		***<0.001***	

- Strong positive response at all sites to both M1 and M2 (+110 % on average).
- Adding manure further increase grain yield by 36% on average compared to the sole M1 and M2.
- There was a large variability in yields among farmers

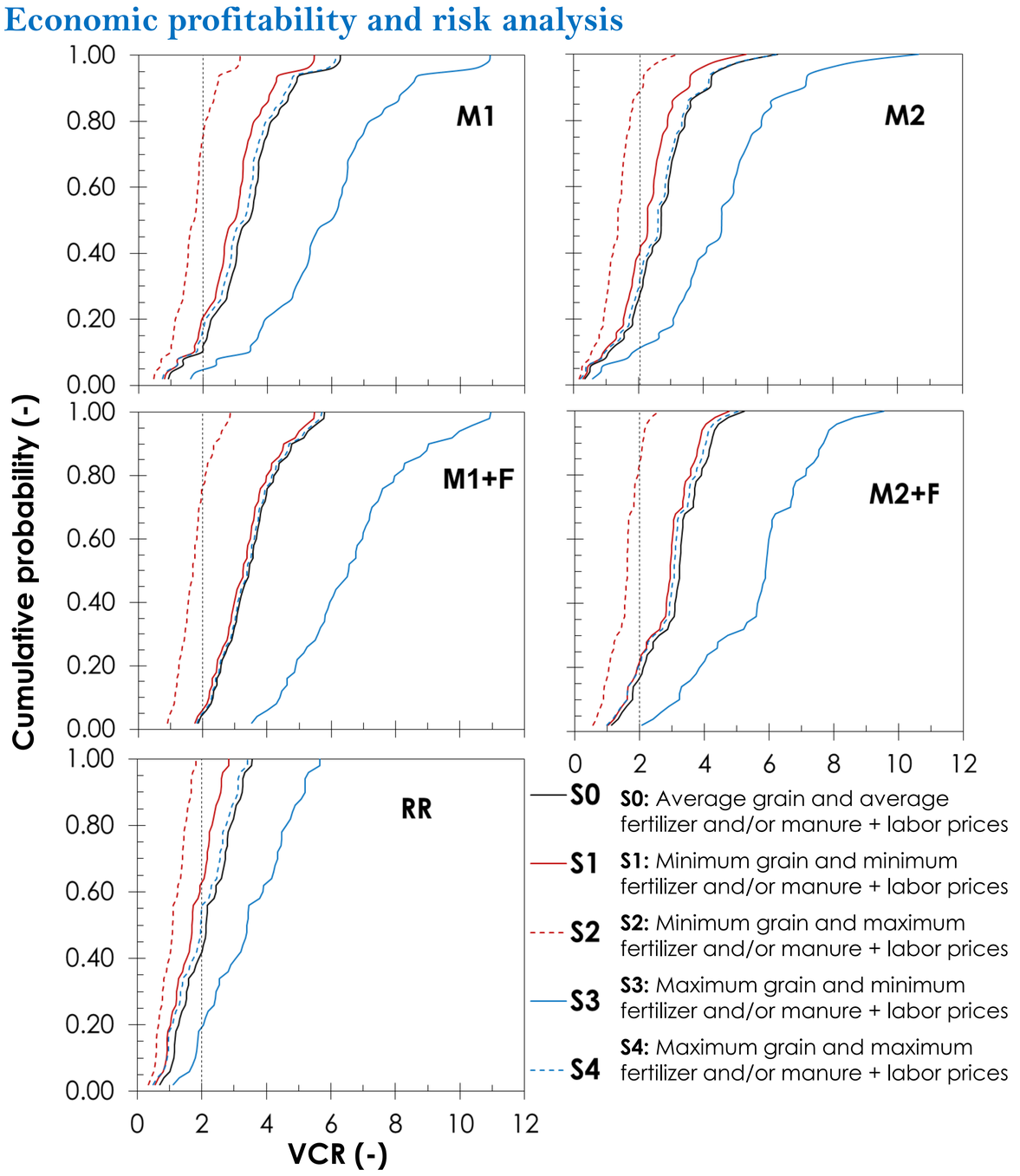
Factors explaining yield variability



Predicted vs. observed mean root transformed values

- In addition to the experimental treatments, yield variability can be explained by the rainfall and related factors, weed pressure, previous crop and some topsoil characteristics (distance from village, clay+silt, total N and C content).

Economic profitability and risk analysis



- For average input and output price (S0), VCRs were 2.1 and 1.5 times greater in M1 and M2 treatments, respectively, compared to RR ($P < 0.001$).
- Combining manure with M1 significantly decreased VCR by 1.0 compared to the sole M1 ($P<0.001$), while there was no significant difference between M2 and M2+F.
- Irrespective of the scenario, applying microdosing alone or combined with manure was economically profitable for more than 80 % of the sites (VCR ≥ 2), while only 60 % achieved a VCR ≥ 2 for the RR treatment.

Conclusions

- Fertiliser microdosing is better adapted to the realities of smallholder farmers than the recommended rate while still ensuring very significant yield increases and economic benefits.
- However, there is a need to evaluate this technology across a wider zone and for a larger number of farms to better predict crop responses.