

Supplementary Tables

Supplementary Table S1: List of peer-reviewed papers and NOTs

Table S1a. List of peer-reviewed papers used in the quantitative analysis

Authors/Year	Title
Asai et al. 2021	Application of a Bayesian approach to quantify the impact of nitrogen fertilizer on upland rice yield in sub-Saharan Africa
Atnafu et al. 2021	Effect of Nutrient Omission on Grain Yield and Yield Components of Maize (<i>Zea mays</i> L.) at Kersa District, Jimma Zone, Southwestern Ethiopia
Kenea et al. 2021	Variability in yield responses, physiological use efficiencies and recovery fractions of fertilizer use in maize in Ethiopia
Kihara et al. 2020	Micronutrient deficiencies in African soils and the human nutritional nexus: opportunities with staple crops
Rurinda et al. 2020	Science-based decision support for formulating crop fertilizer recommendations in sub-Saharan Africa
Andrade et al. 2019	A spatial framework for ex-ante impact assessment of agricultural technologies
Balemi et al. 2019	Yield response and nutrient use efficiencies under different fertilizer applications in maize (<i>Zea mays</i> L.) in contrasting agro ecosystems
Njoroge et al. 2019	Learning from the soil's memory: Tailoring of fertilizer application based on past manure applications increases fertilizer use efficiency and crop productivity on Kenyan smallholder farms
Saito et al. 2019	Yield-limiting macronutrients for rice in sub-Saharan Africa
Shehu et al. 2019	Balanced nutrient requirements for maize in the Northern Nigerian Savanna: Parameterization and validation of QUEFTS model
Kafesu et al. 2018	Comparative fertilization effects on maize productivity under conservation and conventional tillage on sandy soils in a smallholder cropping system in Zimbabwe N
Niang et al. 2018	Yield variation of rainfed rice as affected by field water availability and N fertilizer use in central Benin
Otieno et al. 2018	Effects of inorganic fertilizer application on grain yield, nutrient-use efficiency and economic returns of maize in Western Kenya
Shehu et al. 2018	Quantifying variability in maize yield response to nutrient applications in the Northern Nigerian Savanna
Njoroge et al. 2017	Strong spatial-temporal patterns in maize yield response to nutrient additions in African smallholder farms
Kihara et al. 2016	Understanding variability in crop response to fertilizer and amendments in sub-Saharan Africa
Kihara et al. 2016	Maize response to macronutrients and potential for profitability in sub-Saharan Africa
Kihara et al. 2016	Analysis of Crop Nutrient Response Patterns to Guide Site-Specific Fertilizer Recommendations
Kurwakumire et al. 2014	Maize productivity and nutrient and water use efficiencies across soil fertility domains on smallholder farms in Zimbabwe
Kihara et al. 2013	Phosphorus agronomic efficiency in maize-based cropping systems: a focus on western Kenya
Kaizzi et al. 2012	Maize Response to Fertilizer and Nitrogen Use Efficiency in Uganda
Nziguheba et al. 2009	Assessment of nutrient deficiencies in maize in nutrient omission trials and long-term field experiments in the West African Savanna
Tittonell et al. 2008	Yield gaps, nutrient use efficiencies and response to fertilisers by maize across heterogeneous smallholder farms of western Kenya

Table S1b. List of maize and rice nutrient omission trials (NOTS) available for combined analysis

Crop	Project	Country	Site Name	No of seasons	Status	Publication Name
Maize	AfSIS	Malawi	Kasungu	1	Published	Kihara et al (2016)
	AfSIS	Malawi	Nkhata Bay	2	Published	Kihara et al (2017)
	AfSIS	Malawi	Thuchila	1	Published	Kihara et al (2018)
	AfSIS	Tanzania	Mbinga	1	Published	Kihara et al (2019)
	AfSIS	Tanzania	Kiberashi	1	Published	Kihara et al (2020)
	AfSIS	Nigeria	Pampaida	1	Published	Kihara et al (2021)
	IPNI	Kenya	Sidindi	7	Published	Njoroge et al (2017)
	IPNI	Kenya	Embu	1	Unpublished	--
	IITA	Kenya	W. Kenya	1	Published	Vanlauwe et al (2006)
	Tamasa	Nigeria	Various	2	Published	Rurinda et al (2020)
	Tamasa	Ethiopia	Various	2	Published	Rurinda et al (2021)
	Tamasa	Tanzania	Various	1	Published	Rurinda et al (2022)
	??	Zimbabwe	Murewa		Published	Kafesu et al. (2018)
??	Togo			Published	Nziguheba et al. (2008)	
Rice						Saito et al. (2019)

Supplementary Table S2: Soils data from maize NOTs

Table S2. Soil type and median values of soil tests for maize nutrient omission trials were conducted

Site name	Soil type	pH	SOC (%)	Total N (%)	Available P (mg/kg)	Exchangeable (cmol/kg)			SSI (%)
						K	Ca	Mg	
Adamitulu	Andosols	7.2	0.80	NA	NA	NA	NA	NA	NA
Affem	Acrisols	5.9	0.86	0.06	NA	NA	NA	NA	7.9
Aludeka	Acrisols	NA	0.73	0.66	NA	NA	NA	NA	NA
Bako	Nitisols	5.4	2.60	0.25	3.9	1.10	8.69	3.70	5.9
Bakori	Arenosols	6.1	0.81	0.04	4.65	0.27	2.84	0.83	3.2
Bulbula	Andosols	7.2	0.70	NA	NA	NA	NA	NA	NA
Bunkure	Lixisols/Plinthosols	6.3	0.59	0.03	4.8	0.20	1.61	0.44	3.6
Dandume	Arenosols/Lixisols	5.8	0.83	0.05	4.6	0.18	2.22	0.525	3.0
Doguwa	Lixisols/Plinthosols	6.1	1.18	0.06	3.1	0.21	3.89	0.89	3.5
Embu	Nitisols	5.8	2.80	NA	16.9	1.00	2.50	7.9	6.3
Emuhaya	Ferralsols	NA	1.28	1.17	6.025	NA	NA	NA	NA
Faskari	Arenosols/Lixisols	NA	NA	NA	NA	NA	NA	NA	NA
Funtua	Arenosols/Lixisols	6.0	0.88	0.04	3.9	0.15	3.10	0.70	3.1
Giwa	Lixisols	NA	NA	NA	NA	NA	NA	NA	NA
Hawasa	Luvisols	NA	NA	NA	NA	NA	NA	NA	NA
Ikara	Lixisols	5.8	0.79	0.04	5.8	0.24	1.98	0.41	3.3
Jimma	Vertisols	5.4	2.01	0.21	5.7	0.94	7.30	3.0	4.9
Kand	Nitisols	5.6	3.38	NA	16.7	NA	NA	NA	8.6
Kasungu	Lixisols	6.4	NA	0.05	67.6	0.41	4.14	1.13	NA
Kauru	Lixisols	NA	NA	NA	NA	NA	NA	NA	NA
Kiberash	Luvisols	6.1	NA	0.18	9.69	0.60	4.21	1.76	
Lere	Lixisols	5.8	0.61	0.04	3.29	0.18	1.50	0.415	2.4
Makarfi	Lixisols	5.5	0.91	0.05	3.29	0.14	1.85	0.69	2.9
Mbinga	Acrisols	5.6	NA	0.11	9.64	0.29	2.77	1.35	
Murewa	Cambisols	6.1	0.76	0.08	31.0	0.16	2.40	0.61	NA
NkhataBay	Leptosols	5.4	NA	0.08	22.1	0.35	2.15	1.04	
Pampida	Lixisols	NA	2.33	NA	NA	NA	NA	NA	11.7
Sessaro	Acrisols	6.3	0.81	0.06	NA	NA	NA	NA	6.8
Shinyalu	Nitisols	NA	1.75	1.56	5.41	NA	NA	NA	NA
Siaya	Acrisols	5.6	1.60	NA	10	0.23	1.16	3.68	3.7
Sidini	Acrisols	NA	3.03	NA	NA	NA	NA	NA	NA
Soba	Lixisols	6.0	1.02	0.05	3.595	0.16	2.45	0.62	3.7
Thuchila	Nitisols	5.6	NA	0.16	28.1	0.62	4.31	1.46	
Tofa	Lixisols	NA	NA	NA	NA	NA	NA	NA	NA
TudunWad	Lixisols	6.2	0.69	0.04	6.56	0.21	2.81	0.51	3.5

Green = values above critical value; Red = sites without the relevant data

Supplementary Table S3: Soils data from rice NOTs

Table S3. Soil type and median values of soil tests for sites where rice nutrient omission trials were conducted

Site name	Soil type	System	pH	SOC (%)	Total N (%)	Available P (mg/kg)	Exchangeable cations (cmol/kg)			SSI
							K	Ca	Mg	
Affe	Gleysols	IL	6.0	1.8	0.2	15.8	0.7	21.0	12.1	4.9
Ambohinary	Ferralsols	RL	5.2	2.7	0.3	9.4	0.4	3.9	1.8	6.6
Ankazomiriotr	Leptosols	RU	5.4	1.7	0.2	9.1	0.2	1.7	0.8	7.6
Bo&Kenema	Ferralsols	RL	5.1	1.7	0.2	13.7	0.2	1.3	0.3	7.9
CentralRiver	Gleysols	IL	6.0	1.2	0.1	9.3	0.3	8.5	3.6	3.4

Eastern Uganda	Vertisols	IL	6.1	3.8	0.4	24.0	0.5	15.5	5.4	11.2
Fogera	Vertisols	RL	NA	NA	NA	NA	NA	NA	NA	NA
Gagnoa	Alisols	IL	5.4	1.2	0.1	12.1	0.2	3.2	1.0	7.7
Glazoue	Luvisols	RL/RU	5.7	0.7	0.1	13.3	0.2	3.4	1.0	4.5
HauteGuinee	Alisols	RU	5.5	0.9	0.1	12.8	0.2	2.0	0.7	5.1
Hauts-bassins	Luvisols	IL	5.8	0.7	0.1	9.5	0.2	3.2	1.1	2.9
Kahama	Ferralsols	RL	5.7	0.7	0.1	10.6	0.2	4.1	1.5	3.3
Kara	Luvisols	RL	NA	NA	NA	NA	NA	NA	NA	NA
Kouroumari	Vertisols	IL	6.9	0.3	0.0	4.8	0.2	4.7	2.2	1.3
Kumasi	Acrisols	RL	6.0	1.2	0.1	13.2	0.2	4.7	1.6	5.4
Lagdo	Luvisols	RL	5.9	0.8	0.1	11.2	0.3	3.2	0.9	3.3
Malanville	Arenosols	IL	5.8	0.8	0.1	9.5	0.2	4.2	2.1	3.2
Man	Cambisols	RU	5.3	1.7	0.1	12.4	0.2	2.4	0.9	8.8
Nasarawa	Luvisols	RL/RU	5.2	1.3	0.1	13.3	0.2	1.8	0.5	7.0
Navrongo	Luvisols	IL/RU	5.5	0.6	0.1	12.8	0.2	2.6	0.6	4.8
Ndop	Andosols/Nitisols	IL/RL	4.9	3.5	0.3	14.3	0.3	3.0	1.2	9.0
Ouinhi	Gleysols	RL	NA	NA	NA	NA	NA	NA	NA	NA
RegionMaritim	Luvisols	IL	6.1	0.9	0.1	9.7	0.5	8.9	5.2	3.4
RegionPlateau	Luvisols	RL	5.2	0.7	0.1	17.5	0.2	1.6	0.6	6.3
Rugeramigozi	Acrisols	IL	NA	NA	NA	NA	NA	NA	NA	NA
Rwasave	Ferralsols	IL	NA	NA	NA	NA	NA	NA	NA	NA
Savelugu	Luvisols	RL	5.7	0.5	0.1	15.1	0.2	1.7	0.5	2.6
Sikasso	Luvisols	RL/RU	5.4	0.6	0.0	9.2	0.1	2.1	0.7	2.7
Tandjile-Est	Vertisols	RL	5.9	0.4	0.0	10.4	0.2	2.1	0.6	3.9
Tillabery	Arenosols	IL	5.9	0.7	0.1	7.3	0.2	6.5	2.8	2.5
Tormabum	Fluvisols	RL	NA	NA	NA	NA	NA	NA	NA	NA

Green = values above critical value; Red = sites without the relevant data

Supplementary Table S4: Variance partitioning

Table S4. Variance explained (%) by the main variables

Crop	Sources of variation	Explained variance (%)		
		N response	P response	K response
Maize	Soil type	17.9	5.4	2.3
	AEZ	1.3	0.2	0.5
	Variety	3.3	1.9	0.1
	Error	77.5	92.5	97.1
Rice	Soil type	6.5	4.6	6.2
	AEZ	3.0	2.9	3.0
	Production system	0.8	0.1	0.4
	Variety	0.5	1.3	0.2
	Nutrient rate [‡]	0.1	0.9	0.0
	Error	89.2	90.2	90.1

[‡] In maize nutrient rate was aliased with other terms in the model

Supplementary Table S5: Random forests model evaluation

Table S5. Model fit criteria for judging predictions from the random forests with measured values

Crop	Cropping system	Variable	R ²	RPD	Bias	RMSE	%RMSE
Maize	Rainfed	Yield	0.641	1.67	0.008	1.52	37.1
		YRN	0.282	1.18	0.008	1.81	82.5
		YRP	0.164	1.09	0.004	1.75	87.7
		YRK	-0.085	0.96	0.000	1.58	789.5
		AEN	0.246	1.15	0.054	14.80	84.1
		AEP	0.103	1.06	0.196	43.60	178.0
		AEK	-0.090	0.96	0.185	33.80	637.7
Rice	Irrigated lowland	Yield	0.549	1.49	0.035	1.55	30.9
		YRN	0.229	1.14	-0.012	1.24	68.9
		YRP	0.029	1.02	-0.014	1.07	133.9
		YRK	0.169	1.10	-0.006	0.95	159.0
		AEN	0.231	1.14	-0.097	6.56	67.6
		AEP	0.073	1.04	-0.755	37.28	132.7
		AEK	0.232	1.14	0.075	10.70	144.6
	Rainfed lowland	Yield	0.311	1.21	0.028	1.70	41.4
		YRN	0.332	1.23	0.014	1.11	79.5
		YRP	0.254	1.16	-0.002	0.95	136.1
		YRK	0.132	1.07	0.013	0.88	145.9
		AEN	0.410	1.30	0.030	8.55	75.7
		AEP	0.313	1.21	-0.324	42.96	122.7
		AEK	0.207	1.12	0.210	15.04	147.5
	Rainfed upland	Yield	0.497	1.41	0.078	1.21	35.5
		YRN	0.182	1.11	0.031	1.00	100.3
		YRP	0.166	1.10	0.033	0.91	101.0
		YRK	-0.001	1.00	0.021	0.68	136.9
		AEN	0.198	1.12	0.149	8.36	95.0
		AEP	0.150	1.09	1.004	44.50	98.9
		AEK	0.010	1.01	0.480	12.80	134.7