

Review Article

Lime Micro Dosing: A New Liming Strategy for Small Holder Farmers to Increase Crop Production and Productivity in Acid Soil Prone Areas of Ethiopia

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Abstract

Soil acidity has become a major constraint that threatens sustainable agricultural production in highlands of Ethiopia. Liming has been used as a soil amendments, to ameliorate the acidity problem, albeit it was challenging to apply recommended amount at once for small holder farmers due to inadequate availability, high cost, and poor infrastructure for lime transportation to the required agricultural land area. Hence, to address the problems, a new liming strategy and a precision technique referred to as microdosing, which involves application of small, affordable quantities of lime on an acid soil was evaluated across acid soil prone areas of Ethiopia. The objective of this paper was to summarize and document major research achievements recorded so far on different crops responses to lime micro dosing in acid soil prone areas of Ethiopia. Lime microdosing was evaluated at four lime application rates, including 6.25%, 12.5%, 25% and 33.3% of the recommended lime rate based on exchangeable acidity, which was compared to the traditional lime broadcasting strategy using 100% recommended lime rate in different regions of acid soil prone areas of Ethiopia. Averaged across all of the study, lime microdosing with 25% and 33.3% of recommended lime rate resulted in high yield for major crops (wheat, maize, barley, sorghum, fababean and soybean) in study area which was similar to that of the traditional lime broadcast techniques with a 100% recommended lime rate. Hence, the combined results of the study confirmed a promising positive influence of micro-dosing lime in ameliorating soil acidity and enhancing crop yield which could be suggested as a feasible new liming strategy for smallholder farmers seeking cost-effective and sustainable approaches to elevate agricultural productivity on acid soils. Therefore, micro-dose application of 25% recommended lime based on exchangeable acidity at planting time is the most economically affordable for smallholder farmers to improve soil acidity and increase crop production on acid soils of Ethiopia.

Keywords

Acid Soil, Liming, Micro-Dosing, Smallholder

1. Introduction

Soil acidity associated to Al toxicities, soil erosion and soil nutrient depletion are the main soil related constraints to agricultural development in parts of developing countries relying

on agricultural to feed their growing population [11]. The summation of different anthropogenic and natural processes including leaching of exchangeable bases, basic cation uptake

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by plants, decomposition of organic materials, application of commercial fertilizers and other farming practices produce acidic soils [4]. The major soil forming factors that includes; climate, vegetation and parent material, are among the major factors that increase soil acidity in the country [12]. In Ethiopia, huge surface areas of the highlands located at almost all regional states of the country are affected by soil acidity. From current [3] report it was estimated that about 43% of the total arable land in Ethiopia is affected by soil acidity. Soil acidity problem is significant in the north-western, south-western, southern and central regions of the country which receive precipitation high enough to leach down soluble salts and/or basic cations appreciably from the surface layers (root zone) of the soils. Some of the well-known areas severely affected by soil acidity in Ethiopia are Ghimbi, Nedjo, Hossana, Sodo, Chench, Hagere-Mariam and Awi Zone of the Amahara Regional State [3]. To promote food production among resource constrained acid prone areas, in the recent past; a lot of interest has been geared towards finding an efficient and sustainable fertilizer use [14]. Micro-dosing, which comprises of use of small and affordable amounts of lime (CaCO_3) at planting or top dressing. In Zimbabwe for example micro-dosing of 25 – 33% of the recommended N fertilizer increased maize grain yield in resource poor farmers fields [9]. This enhanced the adoption of fertilizer inputs among the resource poor farmers. Research has suggested that with an application of as little as 10 kg N ha^{-1} , farmers can increase their crop yield by 50-100% [9]. On acid soils, lower rates of fertilizers can be applied together with lime to achieve higher fertilizer nutrient use efficiencies since lime reduces soil acidity related constraints [11]. Most research on micro-dosing has been in different parts of the world using mainly inorganic fertilizers in combination with lime on acid soil. The main problem with most of the current acid soil management recommendations is that they target maximization of yields or profits without consideration of the agricultural risks and resource constraints faced by many smallholder households [17]. Hence, to address the problems, a new liming strategy and a precision technique referred to as microdosing, which involves application of small, affordable quantities of lime on an acid soil was evaluated across acid soil prone areas of Ethiopia. Therefore, the objective of this paper was to summarize and document major research achievements recorded so far on different crops responses to lime micro dosing in acid soil prone areas of Ethiopia.

2. Research Achievements

2.1. Effects of Micro-Dose Application of Lime on the Yield and Yield Components of Soybean and Maize in Jimma Area

An experiment was carried out to determine the effects of lime microdosing on the yield and yield components of maize and soybean in Jimma area. The investigation revealed

that micro dose application of lime significantly affected maize and soybean yield in Jimma area. The highest mean of two years grain yield of 1421 kg/ha was obtained from plot treated with 33% with yield advantage of 15.7% over the control, 10.4% over treatment 1 (6.25%), and 8.4% over treatments of 12.5 and 25% of the Lime requirements (Table 1). Based on the data from 2020 season, the maximum pod/plant of 39 was obtained from 33% with increments of 29.7, 23.1, 18, 12.5% compared to the control, 6.25%, 12.5, and 25% lime treatments, respectively. The increment in plant height of soybean due to increased rate of micro dose of lime is also high, with 10.3 cm increment compared to the control treatment. Generally, the results of micro dosing of lime indicates that applications of 33% of the LR's determined based on exchangeable acidity of acid soils can be taken as an alternative option for resource poor farmers in order to improve soybean productivity on acid soils.

Table 1. Effect of micro-dose application of lime on the yield and yield components of soybean at Jimma.

Treatments	PH	NPPP	BY (t/ha)	GY (kg/ha)
Control (no lime)	52.22d	27.40b	5.20c	1198 ^b
6.25% Recommended lime	55.56cd	30.00b	5.46c	1274 ^b
12.5% Recommended lime	56.90bc	32.60ab	6.32b	1303 ^{ab}
25.0% Recommended lime	59.16ab	34.13ab	6.93b	1302 ^{ab}
33.3% Recommended lime	62.49a	39.067a	7.69a	1421 ^a
LSD (0.05)	3.45	7.014	0.65	121
CV (%)	3.2	11.41	5.52	4.96

Key: - CV= Coefficient of variation; GY=grain yield; BY=Biomass yield; LSD= List Significant Different; NPPP=Number of pod per plant; PH=Plant height. Mean values followed by the same letter(s) with in a column are not statistically significant at $P = 0.05$ probability level. Source: [16].

Another investigation of lime microdosing application indicated that there was statically significant different among the treatments for maize experiments. The maximum mean maize grain 5739.9 kg/ha were recorded from 33% of CaCO_3 treated plots (Table 2). Remediation of acidic soil with application of lime has been widely practiced and recommended by several researchers to reduce the negative effects of soil acidity on soil fertility and crop productions [2] and [4]. From these results it can be concluded that, on spot application of small amount of lime is very important than applica-

tion of huge amount of CaCO_3 on acidic soils when the short-term economic viability is considered. Even if the maximum mean grain yield was obtained from maximum rate of lime,

economically the best and feasible treatment was found to be 33.3% of the lime requirements of soils.

Table 2. Response of maize grain yield to micro dose application of lime.

Treatments	2019	2020	Mean
	GY (kg/ha)	GY (kg/ha)	GY (kg/ha)
Control (no lime)	3815.1 ^d	2980.4 ^c	3397.7 ^d
6.25% Recommended lime	4840.2 ^c	3359.1 ^c	4099.6 ^c
12.5% Recommended lime	5108.6 ^{bc}	4059.2 ^b	4583.9 ^b
25.0% Recommended lime	5377.8 ^b	4121.8 ^b	4749.8 ^b
33.3% Recommended lime	6392.7 ^a	5087 ^a	5739.9 ^a
LSD (0.05)	532.71	693.76	356.65
CV (%)	5.54	9.39	4.19

Key: - GY=grain yield; CV= coefficient of variation; LSD= least significant difference. Mean values followed by the same letter(s) with in a column are not statistically significant at $P = 0.05$ probability level. Source: [16].

2.2. Effect of Micro Dose Application of Lime on Wheat Yield in Acidic Soils of Banja, North Western Ethiopia

At Banja district north wester Ethiopia, an experiment was carried out to investigate the effects of micro dose application of lime on wheat yield by [13]. According to his findings the effects of Calcite (CaCO_3) micro-dose application rates significantly affected yield and yield components of wheat (Table 3). The result from [13], findings showed that the effect of calcite micro-dosing at rates of 25% and 33% of recommended lime rate gave statistically comparable value of yield and yield components of wheat. Accordingly, application of 25% and 33.3% of recommended lime rate increased spike length by 42.9 and 40.4% against the control treatment, respectively (Table 3). The findings are in agreement with [15] and [10] who reported that spike length of wheat was significantly increased by application of lime.

Similarly significant differences were reported by [13], on biomass and grain yield of wheat due to the effect of different rates of micro dosing of lime. The findings showed that the highest biomass yield (BY) of 6258.3 and 6312.5 kg ha^{-1} were obtained from 25% and 33.3% of the recommended lime rate, respectively while the lowest yield (5083.3 kg ha^{-1}) was reported from the control treatment (Table 3). The percentage increase for the treatments were 23 and 24.2%. Similar to biomass yield, the highest grain yield (GY) of 2206.2 and 2221.5 kg ha^{-1} were recorded from application of 25% and 33.3% of recommended lime rate, respectively (Table 3); while the lowest (1187.4 kg ha^{-1}) was from the control plots. The corresponding percentage increments relative to the control were 85.8 and 87.1%. The results was in agreement with [16], who reported that grain yields of soybean and maize progressively increased with increased micro dose lime rates and the highest yields were obtained from 25% and 33.3% of the recommended lime rate in Jimma area.

Table 3. Yield and yield components of wheat as affected by micro dose application of lime at Banja.

Treatments	PH (cm)	PL (cm)	NSPP	BY (kg/ha)	GY (kg/ha)
Control (no lime)	70.04 ^c	6.53 ^c	29.26 ^c	3745.8 ^c	1187.4 ^c
6.25% Rec. lime	74.88 ^{bc}	7.18 ^{bc}	31.34 ^{bc}	4916.7 ^{bc}	1619.2 ^{bc}
12.5% Rec. lime	77.76 ^{ab}	7.85 ^b	34.89 ^b	5404.2 ^{ab}	1847.2 ^{ab}
25.0% Rec. lime	79.98 ^a	9.33 ^a	43.66 ^a	6258.3 ^a	2206.1 ^a

Treatments	PH (cm)	PL (cm)	NSPP	BY (kg/ha)	GY (kg/ha)
33.3% Rec. lime	80.07a	9.17a	41.63a	6312.5a	2221.5a
LSD (0.05)	4.902	1.156	5.346	1266.4	514.2
CV (%)	5.4	12.1	12.4	19.9	23.7
Significance	**	***	***	**	**

Key: - PH= plant height, PL= panicle length, NSPP= number of seed/plant, Rec. lime=recommended lime, *** Significant at $P < 0.001$, ** significant at $P < 0.01$, * significant at $P < 0.05$, Means along the column with the same letter are not significantly different. Source: [13].

2.3. Effects of Micro Dose Application of Lime on Wheat, Barley and Fababean Crop Yield in Acidic Soil of Central Ethiopia

At central Ethiopia, the response of wheat, barley and fababean crop yield to lime microdosing was evaluated by [6-8]. The trial result showed that lime microdosing significantly affected wheat, barley and fababean crop yield. The highest mean barley grain yield of 3925 kg ha⁻¹ was obtained from 33.3% of the recommended lime rate, which was statis-

tically at par with 25%. Application of 25 and 33.3% and full dose (100% of the recommended lime rate) increased grain yield by about 104, 114, and 98.1%, respectively, as compared to the control. Similarly, [1], reported significant higher grain yield of barley by application of 25 and 33.3% of recommended lime at Gedeo zone, southern Ethiopia. Thus, application of 25% of the recommended lime rate on acid soils on spot at planting was found to be agronomically efficient and economically viable management option for barley production in the central highlands of Ethiopia.

Table 4. Effect of lime micro dosing on grain & biomass yield of barley.

Treatments	Grain yield (kg ha ⁻¹)	Biomass Yield (kg ha ⁻¹)
Control	1836.3e	6784d
6.25% of recommended lime	2454.6d	8861c
12.5% of recommended lime	2906.8c	9220bc
25.0% of recommended lime	3736.2ab	10317ab
33.3% of recommended lime	3924.9a	10441a
Full recommended lime	3637b	10161ab
Mean	3082.6	9297.5
CV (%)	13.61	20.56
LSD (5%)	239.55	1091.9

Key: - CV= coefficient of variation; LSD= least significant difference. Mean values followed by the same letter (s) with in a column are not statistically significant at $P = 0.05$ probability level. Source: [8].

Similarly the highest wheat grain yield was obtained from 33.3% of recommended lime rate, which is statistically at par with full dose (Table 5). Compared to the control, the yield increment was 111.7%. Biomass yield was also significantly affected by the micro dose application of lime. The highest biomass yield was obtained by application of 25 and 33.3% of the recommended lime rate and full dose of lime, whereas the lowest was recorded from the control. Hence, mean bio-

mass yield of 10598, 10121 and 10449 kg ha⁻¹ were recorded from application of 25 and 33.3% of the recommended lime rate and full dose, respectively. The lowest biomass yield (6142 kg ha⁻¹) was recorded from the control plot. Compared to the control plot, the increase in BY from 25 and 33.3% of the recommended lime rate and full dose of lime were 72.6, 64.7 and 70.1%, respectively (Table 5).

Table 5. Effect of lime treatments on yield and yield components of wheat.

Lime rates	No of seeds per spike	Grain yield (Kg ha ⁻¹)	Biomass yield (Kg ha ⁻¹)
Control	36.4 ^c	1435.1 ^d	6142 ^d
6.25% of recommended lime	41.9 ^b	2374.2 ^c	9097 ^{bc}
12.5% of recommended lime	42.4 ^{ab}	2378.1 ^c	9035 ^c
25.0% of recommended lime	46.4 ^a	2764.6 ^b	10598 ^a
33.3% of recommended lime	43.9 ^{ab}	3038.6 ^a	10121 ^a
Full recommended lime	43.4 ^{ab}	2920.6 ^{ab}	10449 ^a
Mean	42.4	2485.2	9240.3
LSD (5%)	4.3	257	1051.5
CV (%)	10.6	10.8	11.9

Key: - CV= coefficient of variation; LSD= least significant difference. Mean values followed by the same letter(s) with in a column are not statistically significant at P = 0.05 probability level. Source: [7].

Table 6. Effect of lime micro dosing on the yield and yield components of fababean.

Treatments	No. of pods/ plant	No. of seeds/ pod	GY (kg/ ha)	BY (kg/ha)
Control	6.3 ^c	20.4 ^b	1640.5 ^c	5949 ^c
6.25% of recommended lime	10.5 ^b	26.5 ^{ab}	2500.6 ^b	8455 ^b
12.5% of recommended lime	11.0 ^{ab}	27.1 ^{ab}	2422.0 ^b	8930 ^b
25.0% of recommended lime	11.9 ^{ab}	30.8 ^a	3215.3 ^a	10112 ^a
33.3% of recommended lime	12.8 ^a	30.7 ^a	3148.2 ^a	10541 ^a
Full recommended lime	11.1 ^{ab}	22.9 ^b	2825.1 ^{ab}	9909 ^a
Mean	10.6	26.4	2625.3	8982.5
CV (%)	16.15	21.9	16.12	8.58
LSD (5%)	2.1	6.9	506.8	922.7

Key: - BY=biomass yield; GY=grain yield; CV= coefficient of variation; LSD= least significant difference. Mean values followed by the same letter(s) with in a column are not statistically significant at P = 0.05 probability level. Source: [6].

Similar to barley and wheat crop yield application of lime microdosing significantly affected yield and yield components of fababean crop (Table 6). Accordingly applications of 25% recommended lime rate gave the highest economic yield (3215 kg ha⁻¹), but was statistically at par with the yield from 33.3% of recommended lime (3148 kg ha⁻¹). The yield increment were linearly related as a function of increasing lime rates. Grain yields increased from 47.6% to 95.9% as compared to the untreated plots. The result confirms that micro dosing of lime is as effective as heavy dose applications under broadcast method. Similar to the grain yield the highest biomass yield of 10112 and 10541 kg/ha were obtained from 25% and 33% of the recommended lime rates, while the lowest from the control (Table 6).

2.4. Effects of Micro Dose Application of Lime on Sorghum and Soybean Yield in Acidic Soil of Assosa, Western Ethiopia

Field experiments were conducted in Assosa area western Ethiopia to evaluate the effects of lime microdosing on soybean and sorghum yield. The result showed that the application of micro dose of lime significantly influenced the grain yield of soybean and sorghum (Table 7). Accordingly, the highest soybean grain yield of 2694 kg/ha was obtained from the plots that received 33.3% of the recommended lime rate, followed by 25%, which is statistically at par with 12.5% of

recommended lime rate. Similarly the maximum sorghum mean grain yield ($3337.0 \text{ kg ha}^{-1}$) was obtained from the plots that received 33.3% of the recommended lime rate; but, was statistically at par with the yield obtained from the plots

that received 25% (Table 7). Thus, the result indicated that micro dosing of lime at 25% of the recommended rate is the best option for improving the yields of soybean and sorghum on acid soils of Assosa area, western Ethiopia.

Table 7. Effect of micro dosing of lime on yield and yield component of soybean and sorghum.

No	Treatments	Soybean		Sorghum	
		BY (kg/ha)	GY (Kg/ha)	BY (Kg/ha)	GY (Kg/ha)
1	Control (No lime)	2779.6	1692.6 ^c	3364.2	2192.6 ^c
2	6.25% Recommended lime	2831.5	1807.4 ^c	3209.9	2407.4 ^c
3	12.5% Recommended lime	3106.5	2268.8 ^b	3425.9	2569.1 ^{bc}
4	25.0% Recommended lime	3041.7	2272.8 ^b	3580.2	3032.1 ^{ab}
5	33.3% Recommended lime	3125	2694.6 ^a	3672.8	3337.0 ^a
LSD		-	418.23	-	568.64
CV		17.65	8.93	12.02	11.15
Significance		ns	***	Ns	***

Key: - BY=biomass yield; GY=grain yield CV= coefficient of variation, LSD= least significant difference. Mean values followed by the same letter(s) with in a column are not statistically significant at $P = 0.05$ probability level. Source: [5].

3. Conclusion

The outcomes derived from this research review underscored that, application of small amounts of lime; for small holder farmers that can't afford to purchase full dose of recommended lime at once to reclaim their acidic soil, significantly increased crop yield suggesting that micro-dosing has the potential to ameliorate soil acidity and increase crop yield on acidic soil of Ethiopia. The results consistently demonstrated that application of 25% and 33% of recommended lime as micro-dose resulted in better crop yield across all the study area. The promising positive influence of micro-dosing lime on ameliorating soil acidity and enhancing crop yield represents a feasible new liming strategy for small holder farmers seeking cost-effective and sustainable approaches to elevate agricultural productivity on acid soils. Therefore, micro-dose application of 25% recommended lime based on exchangeable acidity at planting time is the most economically affordable for small holder farmers to improve soil acidity and increase crop production on acid soils of Ethiopia.

Abbreviations

BY	Biomass Yield
GY	Grain Yield
PH	Plant Height

PL	Panicle Length
NSPP	Number of Seed per Plant
NPPP	Number of Pod per Plant

Author Contributions

Bikila Takala is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

References

- [1] Abreham Y. (2024). Evaluation of Micro-dosing Lime Application on Selected Soil Chemical Properties and Barley Crop Performance at Gedeo Zone, Southern Ethiopia. *American Journal of Chemical Engineering*; 12(5): 117-122.
- [2] Anetor O. and E. Akinrinde. (2006). Response of soybean [*Glycine max* (L.) Merrill] to lime and phosphorus fertilizer treatments on an acidic alfisol of Nigeria. *Pakistan Journal of Nutrition*, 5: 286-293.
- [3] ATA (Agricultural Transformation Agency). (2014). Soil fertility mapping and fertilizer blending. ATA Report, Ethiopia soil information system. Ministry of Agriculture, Addis Ababa.

- [4] Brady N. C. and R. R. Weil. (2008). *The Nature and Properties of Soils*. 14th ed. Harlow, England: Pearson Education, Ltd.
- [5] Dessalegn T., Malefia D., Lijalem A. and Bekele A. (2022). Evaluation of Micro-dose Application of Lime on Soil Chemical Properties and Response of Soybean (*Glycine max* L.) and Sorghum (*sorghum bicolor* L.) in Acid Soil Prone Areas of Assosa, Benishangul Gumuz Region, Ethiopia. 349-356. In *Results of Natural Resources Management Research 2022*. (Ashenafi N., Dawit H., Solomon E., Musefa R., Tesfaye Sh., Reshid A., Sosina A., Dejene A. and Temesgen D. (eds.)) 2022. *Proceedings of the Natural Resources Management Completed Research*.
- [6] Getahun D., Geremew T., Musefa R., Yohanis H., Fekadu M. and Derib K. (2022c). Evaluation of Micro-Dosing Lime Application on Selected Soil Chemical Properties and Faba Bean Crop Performance in Acid Soil Prone Areas of Central Ethiopia. *J Plant Sci Curr Res* 6: 017.
- [7] Getahun D., Musefa R., Geremew T., Yohanis H., Fekadu M. and Derib K. (2022b). Lime Micro-Dosing Effect on Selected Soil Chemical Properties and Wheat Yield on Soil Acidity Prone Areas of Central Ethiopia. 289-299. In *Results of Natural Resources Management Research 2022*. (Ashenafi N., Dawit H., Solomon E., Musefa R., Tesfaye Sh., Reshid A., Sosina A., Dejene A. and Temesgen D. (eds.)) 2022. *Proceedings of the Natural Resources Management Completed Research*.
- [8] Getahun D., Musefa R., Yohanis H., Geremew T., Derib K. and Fekadu M. (2022a). Evaluation of Lime Micro-Dosing on Selected Soil Physicochemical Properties and Barley Performance on Acid Soils of the Central Highlands, Ethiopia. 300-310. In *Results of Natural Resources Management Research 2022*. (Ashenafi N., Dawit H., Solomon E., Musefa R., Tesfaye Sh., Reshid A., Sosina A., Dejene A. and Temesgen D. (eds.)) 2022. *Proceedings of the Natural Resources Management Completed Research*.
- [9] ICRISAT, - (2009) ICRISAT Archival Report 2008. Documentation. International Crop Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.
- [10] Kamaruzzaman, M., Mohammad, R., Nurul, I. (2013). Effect of lime on yield contributing characters of Wheat in Barind tract of Bangladesh. *Journal of Agriculture and Veterinary Science*: 2319-2372.
- [11] Kisinyo O. (2014). Long term effects of lime and phosphorus application on maize productivity in an acid soil of Uasin Gishu County, Kenya. *Sky Journal of Agricultural Research*, 5: 48-55.
- [12] Mesfin A. (2007). Nature and management of acid soils in Ethiopia. Addis Ababa, Ethiopia. 99p.
- [13] Mesfin K. (2022). Effect of Micro-Dose of Lime Application on Bread Wheat Yield and Yield Components on Acidic Soils of Banja District, North Western Ethiopia. 337-348. In *Results of Natural Resources Management Research 2022*. (Ashenafi N., Dawit H., Solomon E., Musefa R., Tesfaye Sh., Reshid A., Sosina A., Dejene A. and Temesgen D. (eds.)) 2022. *Proceedings of the Natural Resources Management Completed Research*.
- [14] Nziguheba, G. (2007). Overcoming phosphorus deficiency in soils of Eastern Africa: recent advances and challenges. *Advances in integrated soil fertility management in sub Saharan Africa: challenges and opportunities*, pp. 149-160.
- [15] Sultana, B. S., Mian, M. M., Islam, H., Rahman, M. R., Bikkash, M. M., Sarker C. and Zoha M. S. (2009). Effect of liming on soil properties, yield and nutrient uptake by wheat. *Current World Environment*, 4(1): 39-47.
- [16] Tolossa Ameyu. (2022). Split Application of Calcium Carbonate for Acid Soil Amelioration, Soybean and Maize Performance in Acid Prone Areas of South Western Ethiopia. *American Journal of Environmental and Resource Economics*, 7(2): 48-52.
- [17] Twomlow, S., Rohrbach, D., Dimes, J., Rusike, J., Mupangwa, W., Ncube, B. & Mahposha, P. (2010). Micro-dosing as a pathway to Africa's Green Revolution: evidence from broad-scale on-farm trials. *Nutrient Cycling in Agroecosystems*, 88(1) 3-15.